

Managing the Small Stuff

Ensuring the Success of Safe Nanotechnologies

Andrew D. Maynard

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

The
art and science
of building stuff
that does stuff
at the nanometer scale

Richard Smalley

Smallness



Strangeness



Picasso

Sophistication





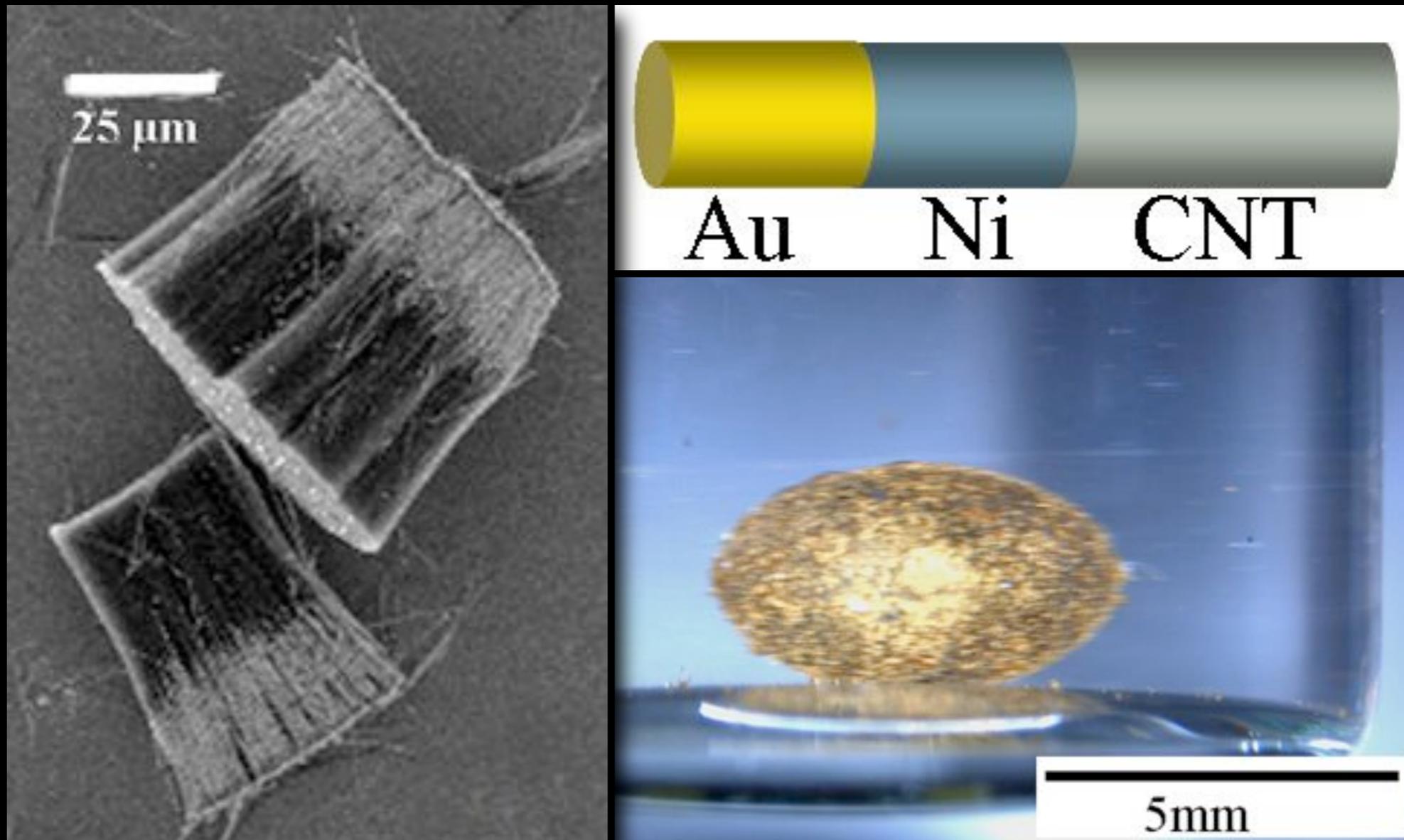


Nathan Sawaya

Figures are from a traveling exhibit - contact Nathan Sawaya for further details, at info@brickartist.com

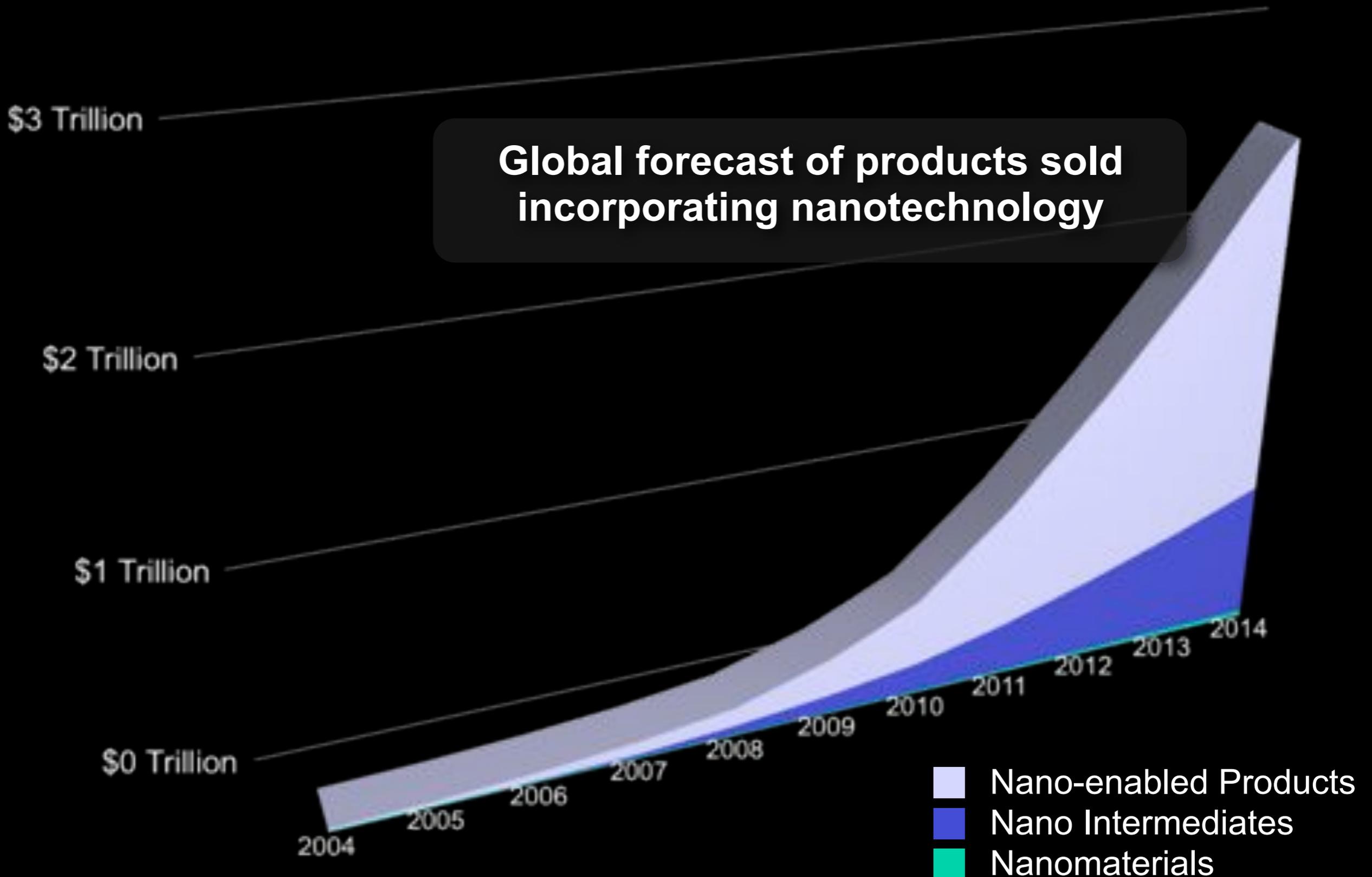
Sophistication

Engineering novel functional materials at the nanoscale



Ou, F. S., M. M. Shaijumon and P. M. Ajayan (2008). "Controlled Manipulation of Giant Hybrid Inorganic Nanowire Assemblies." *Nano Lett.* DOI:10.1021/nl080407i.

Nanotechnology can... *Generate Wealth*



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

Nanotechnology can... *Make better 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



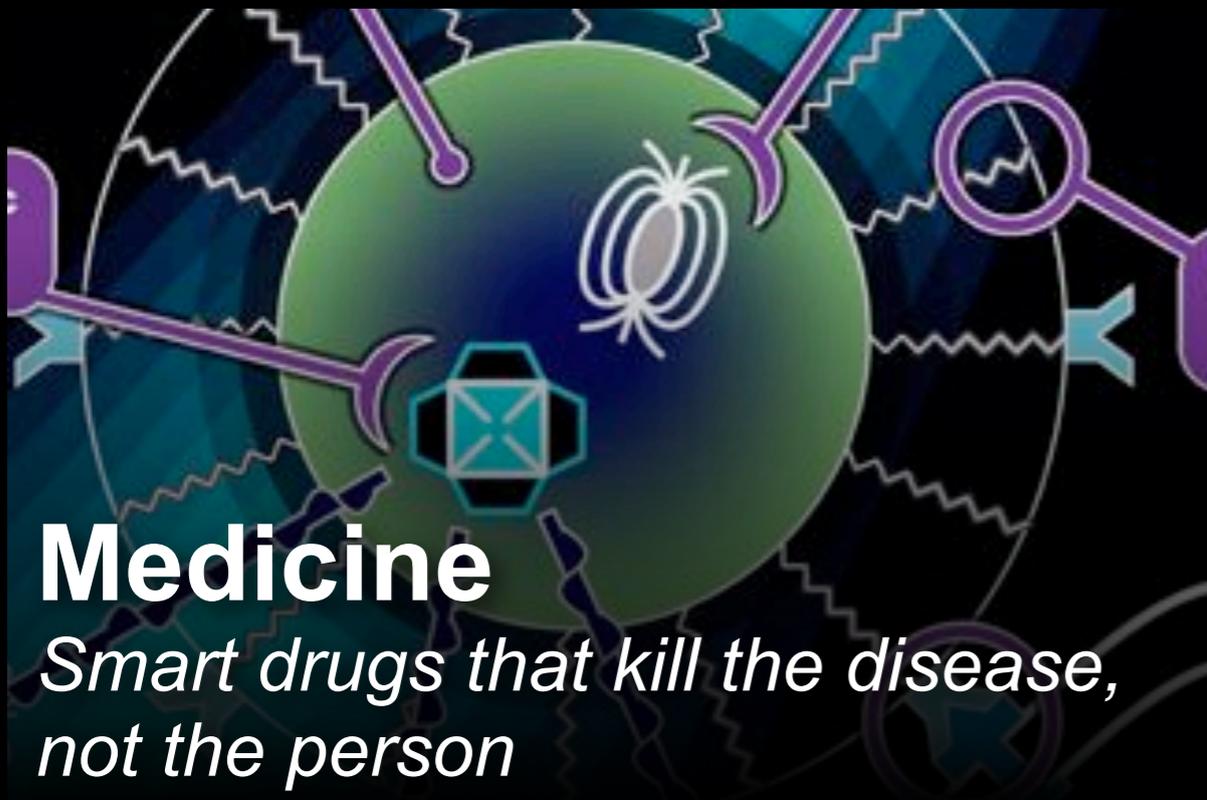
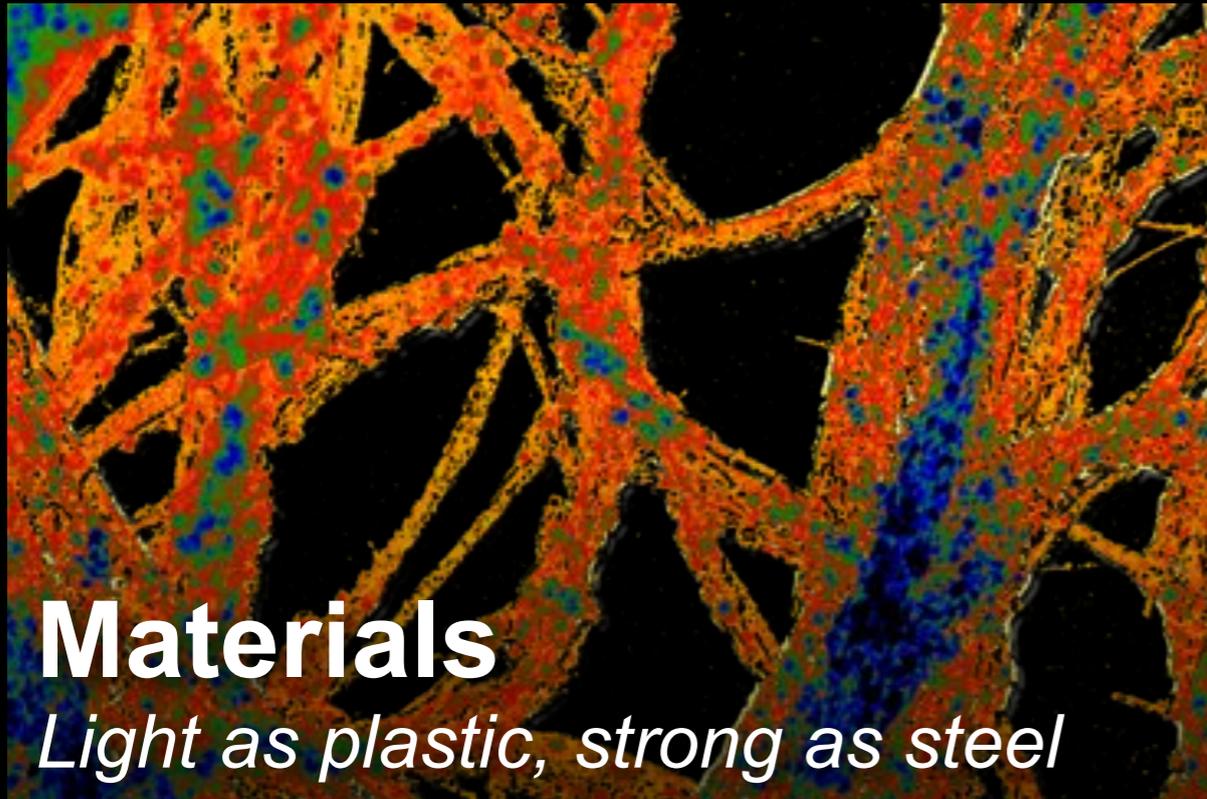
I wish I could get more songs on my iPod



Over 600 listed manufacturer-identified nanotech consumer products:
www.nanotechproject.org/consumerproducts

Nanotechnology can...

Improve our lives



There's no such thing as a
free lunch...

...and nanotechnology is no
exception

Developing sustainable nanotechnologies

The Three R's:

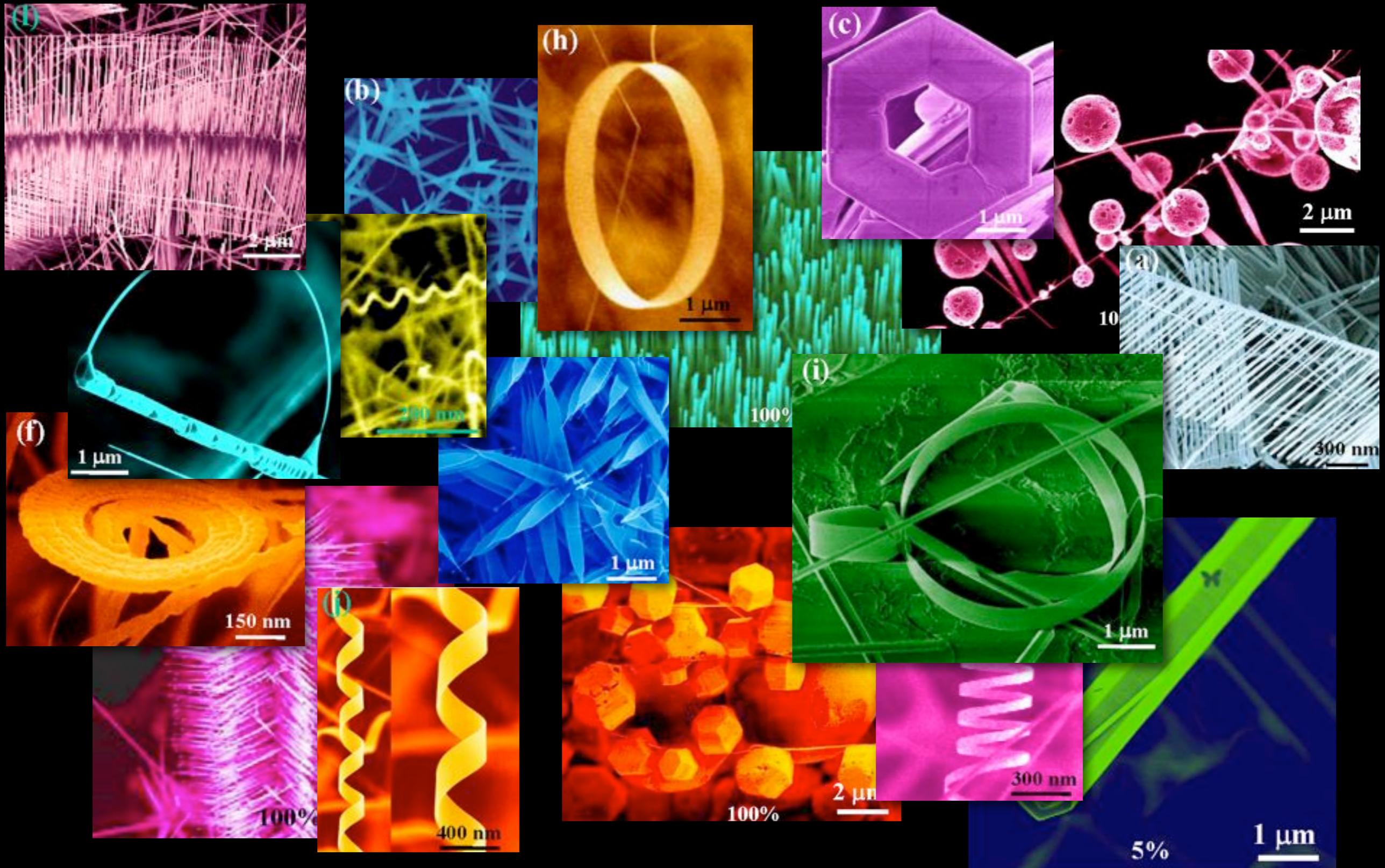
RISK

RESPONSE

REGULATION

RISK

...of causing harm to humans
and the environment

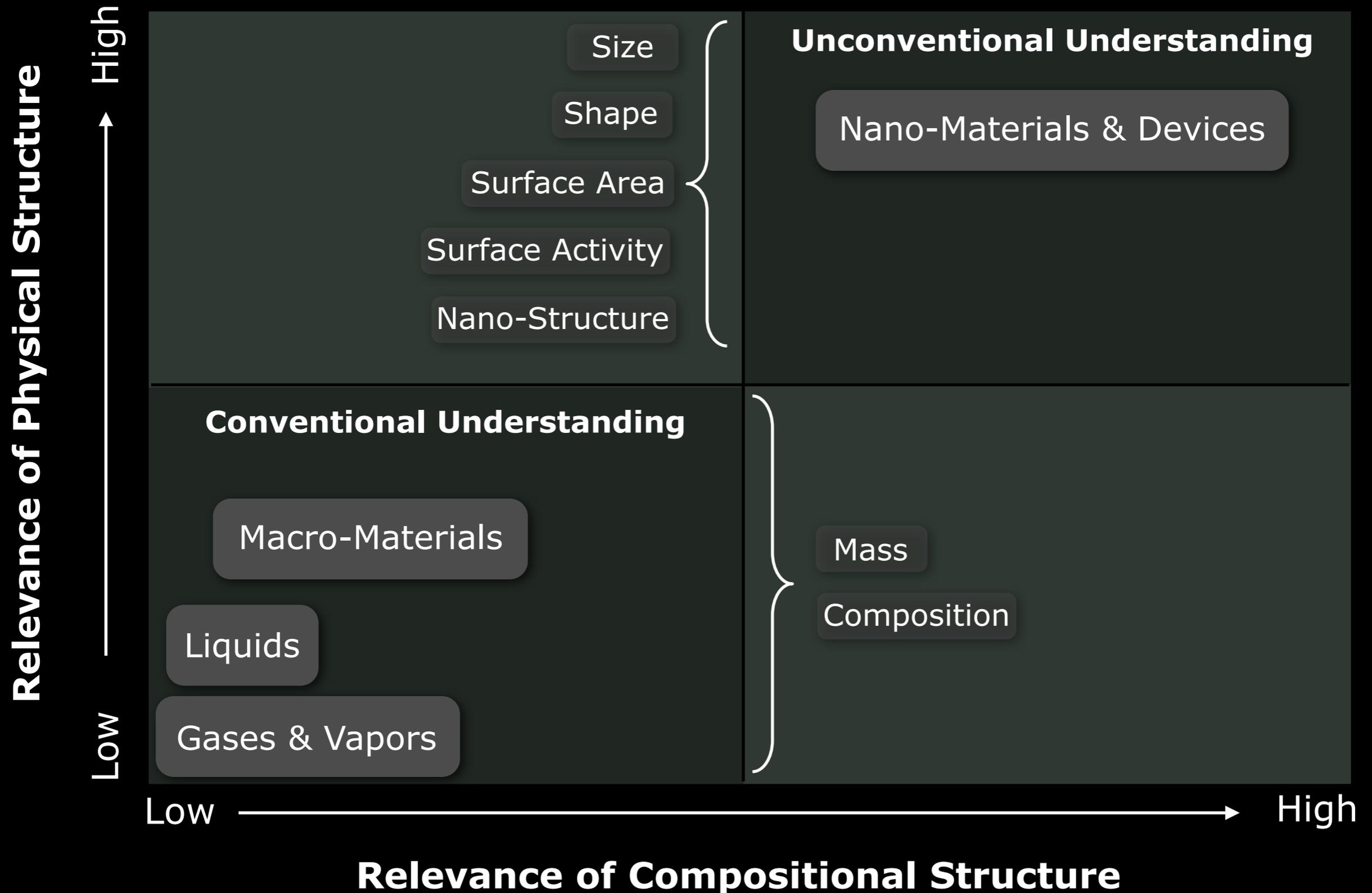


Nano-ZnO: One chemistry, many shapes

Courtesy of Prof. Z.L. Wang, Georgia Tech

A thought experiment

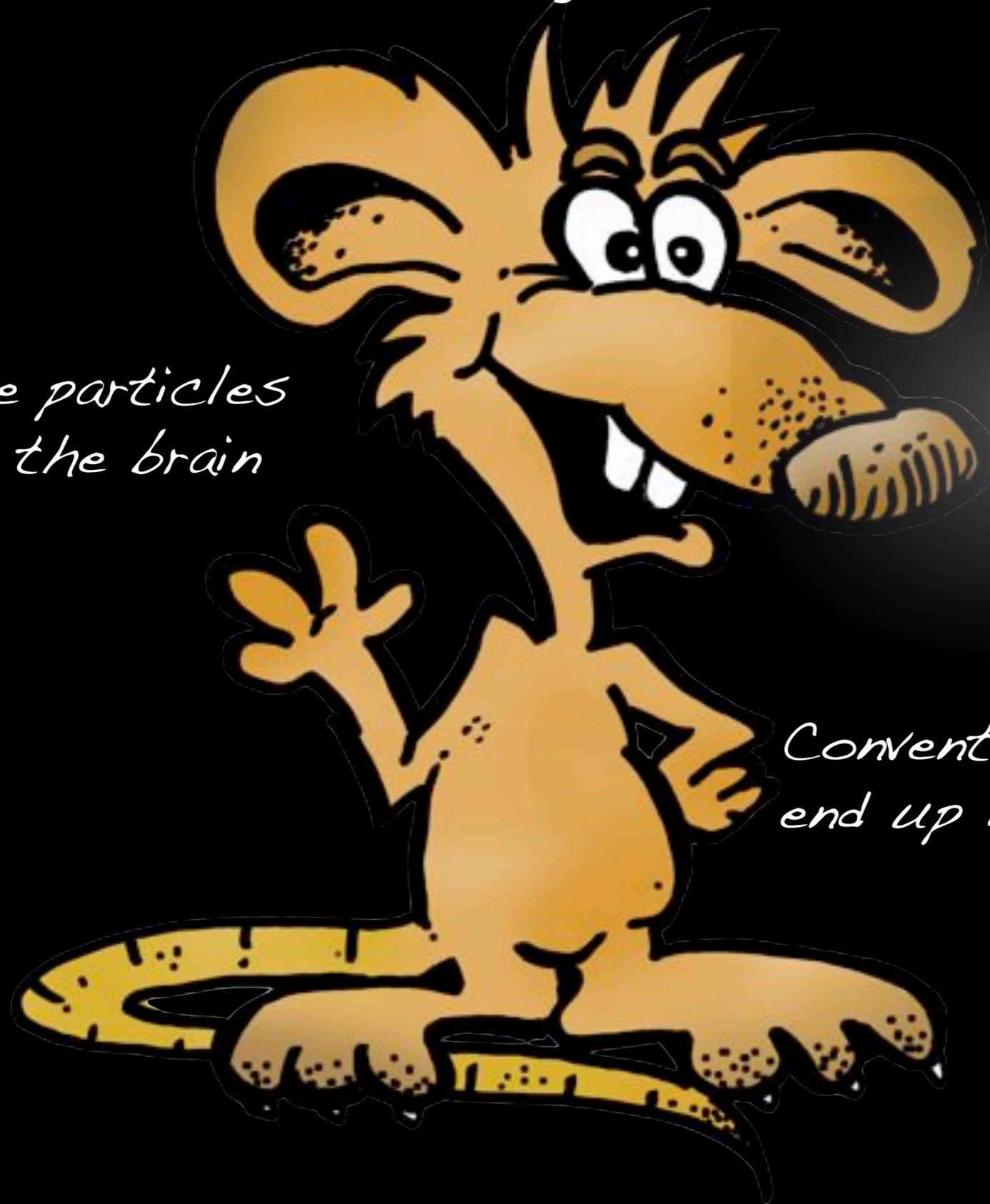
The potential significance of structure on nanomaterial impact



Smallness

Translocation following inhalation - Nose to Brain

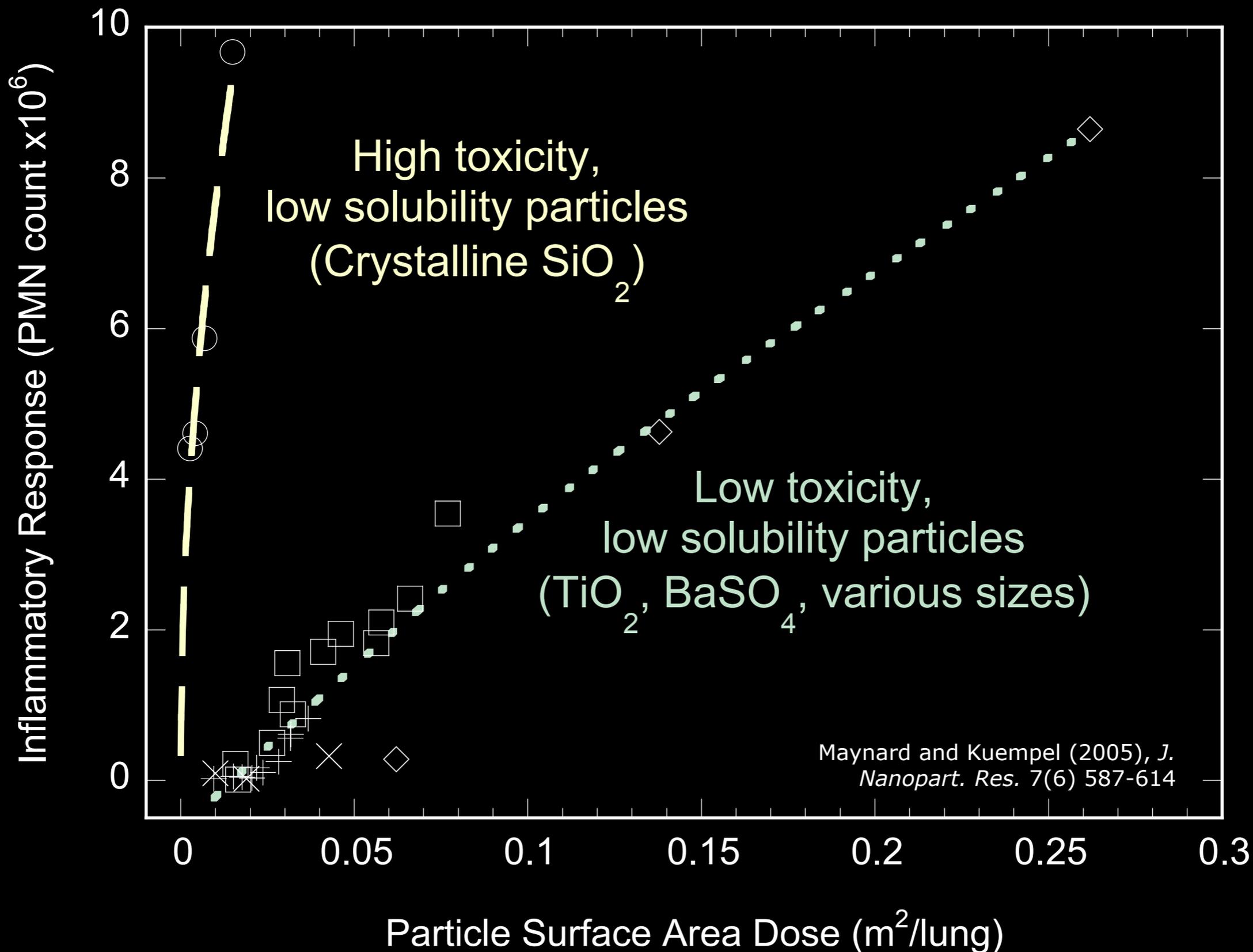
*Nanoscale particles
end up in the brain*



*Conventional particles
end up in the lungs*

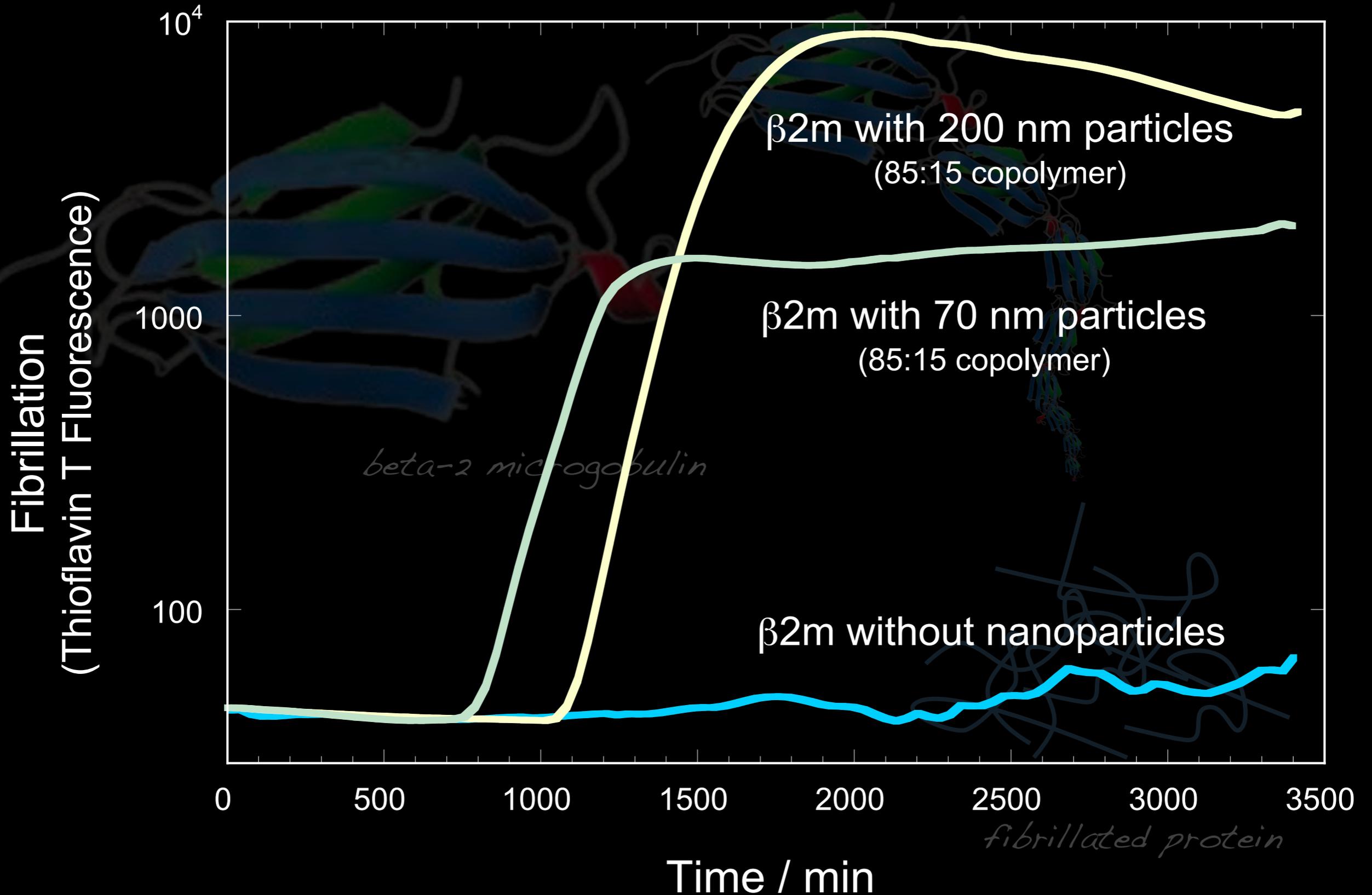
"Strangeness"

Unconventional behavior - lung installation in rats



Sophistication

Interfering with biology at the nanoscale

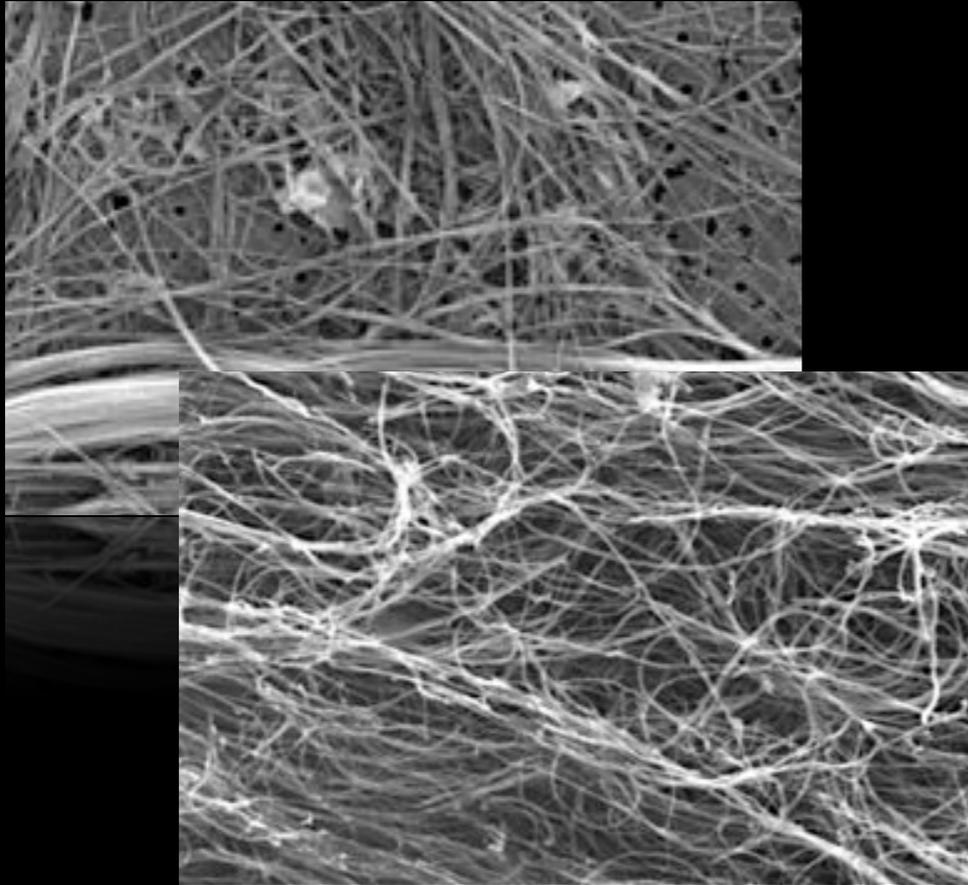


Sophistication

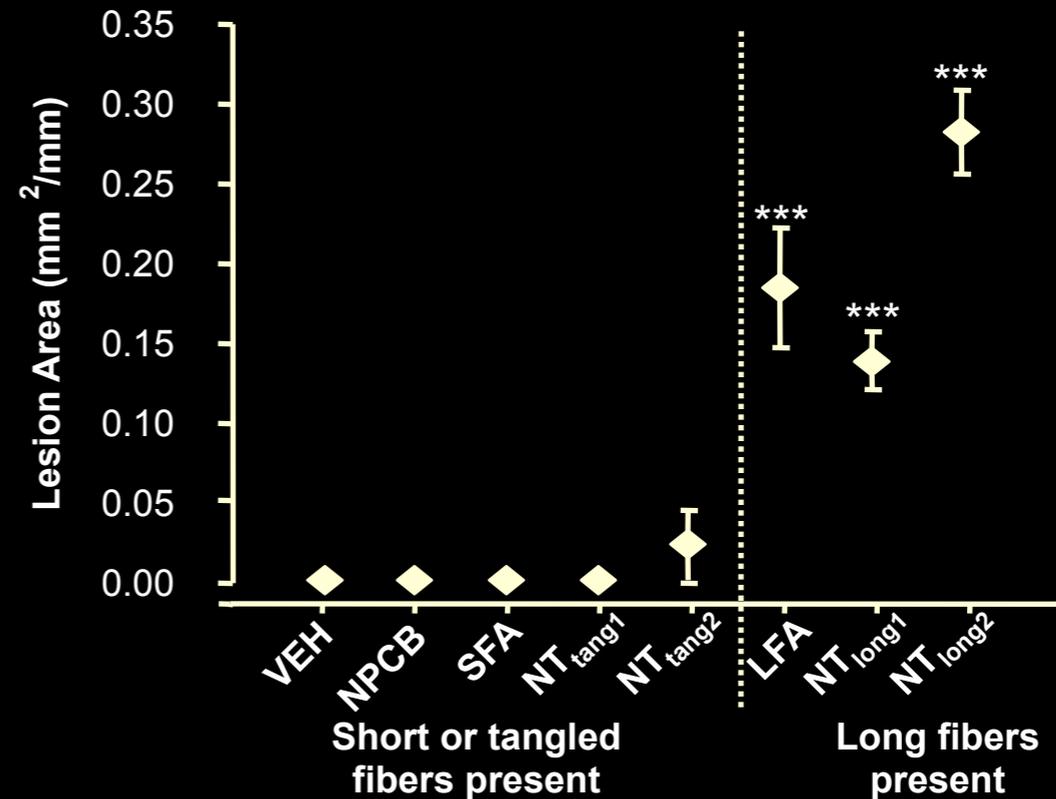
Changing the shape changes the risk profile

Asbestos

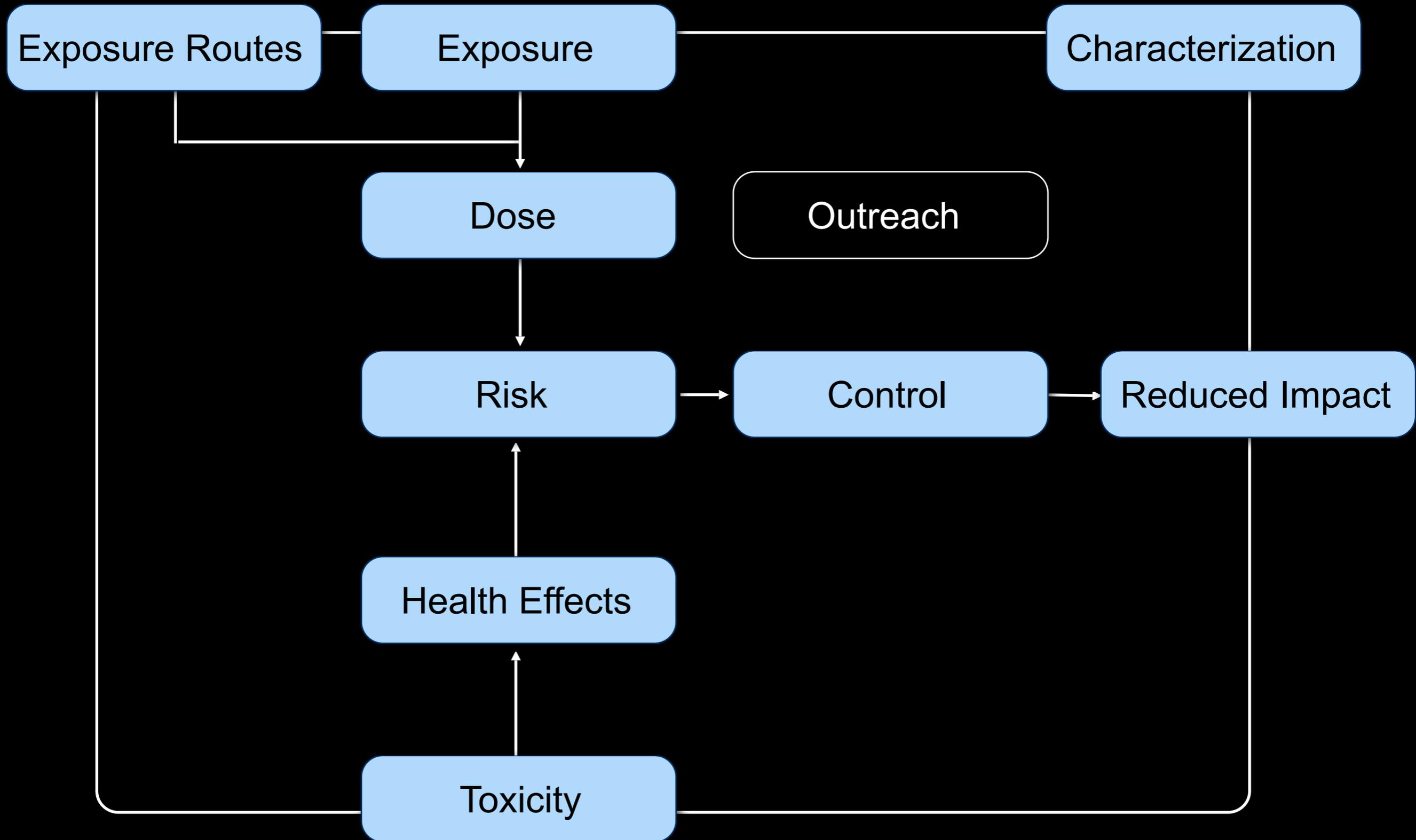
5 μm

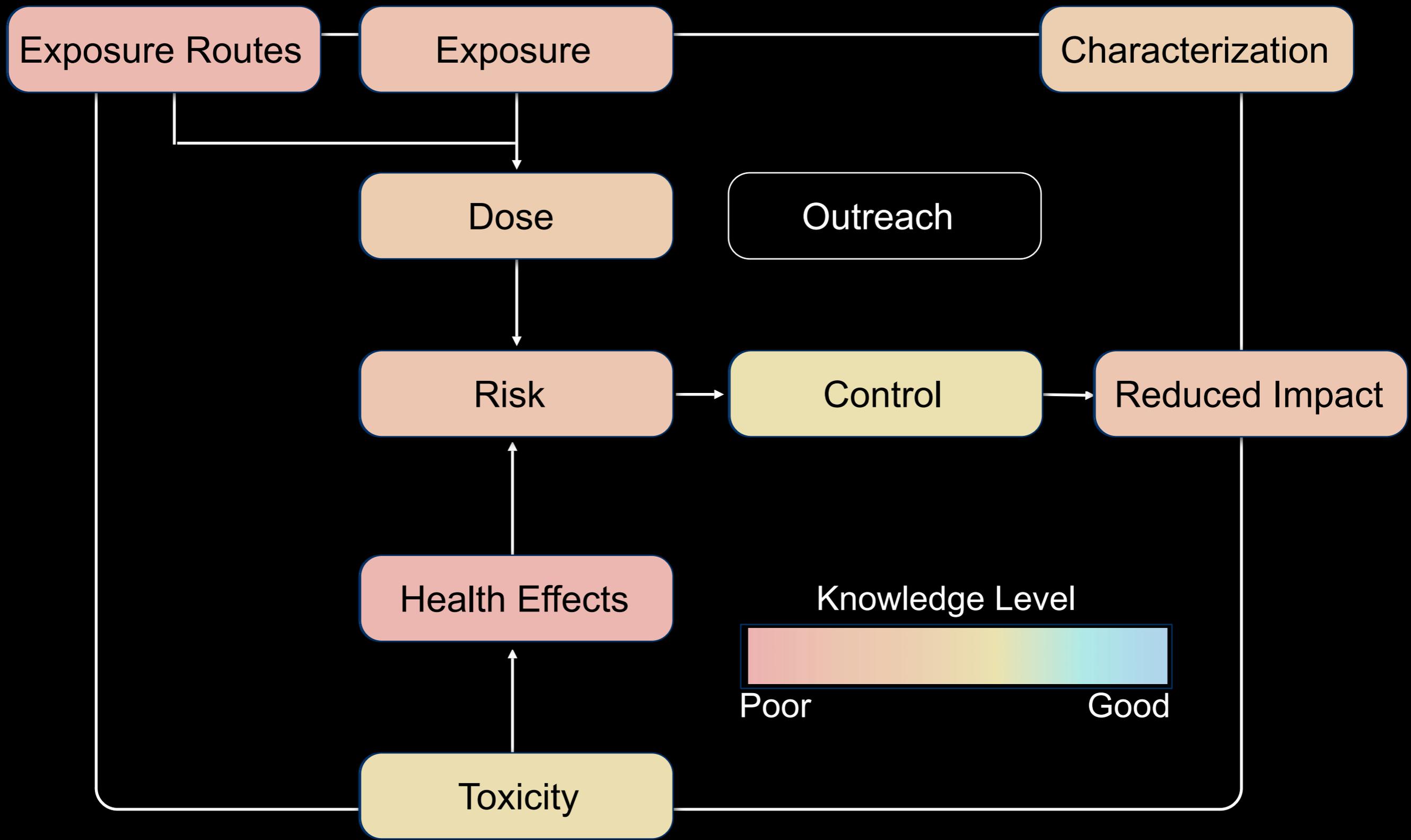


Carbon Nanotubes

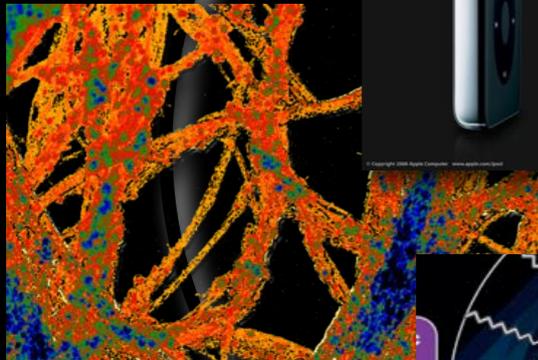


Carbon nanotubes that look like harmful asbestos fibers, behave like harmful asbestos fibers





Decoupling “Nanotechnology”



Decoupling into “nanotechnologies”



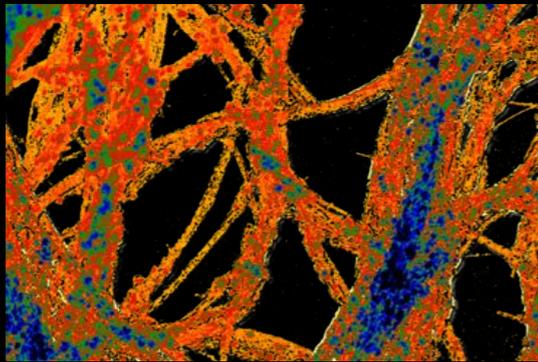
Electronics



Antimicrobials



Filtration



Composites



Photovoltaics



Textiles



Sunscreens

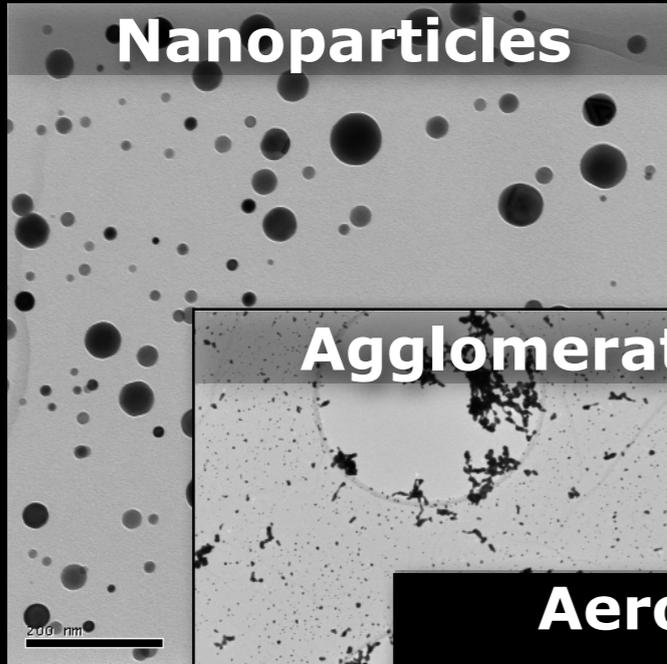


Therapeutics

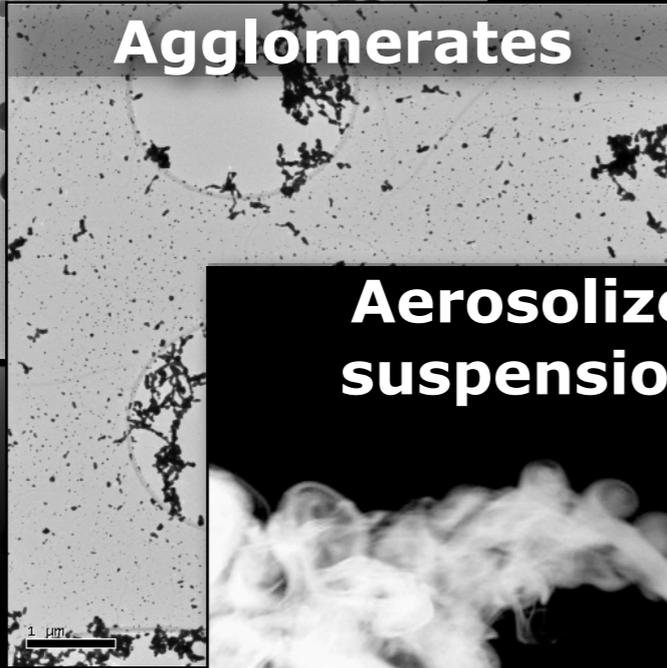
Setting Boundaries

Engineered nanomaterials which potentially present new challenges

Nanoparticles



Agglomerates



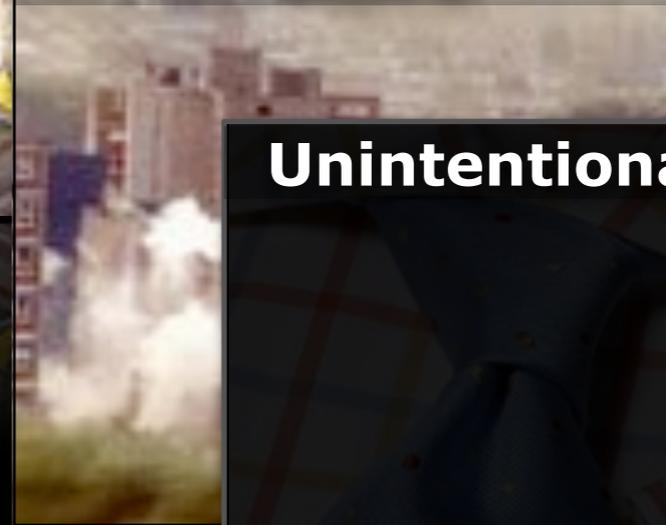
Aerosolized suspensions



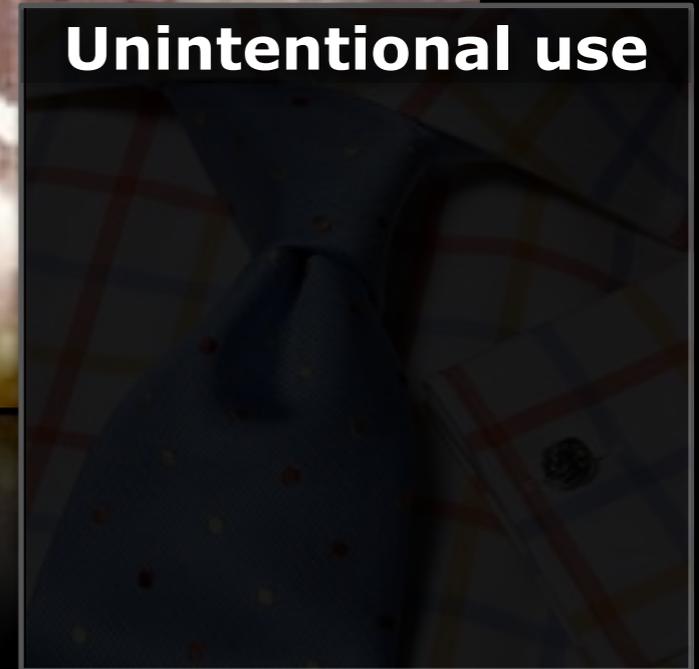
Comminution



**Degradation/
Failure**



Unintentional use



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.

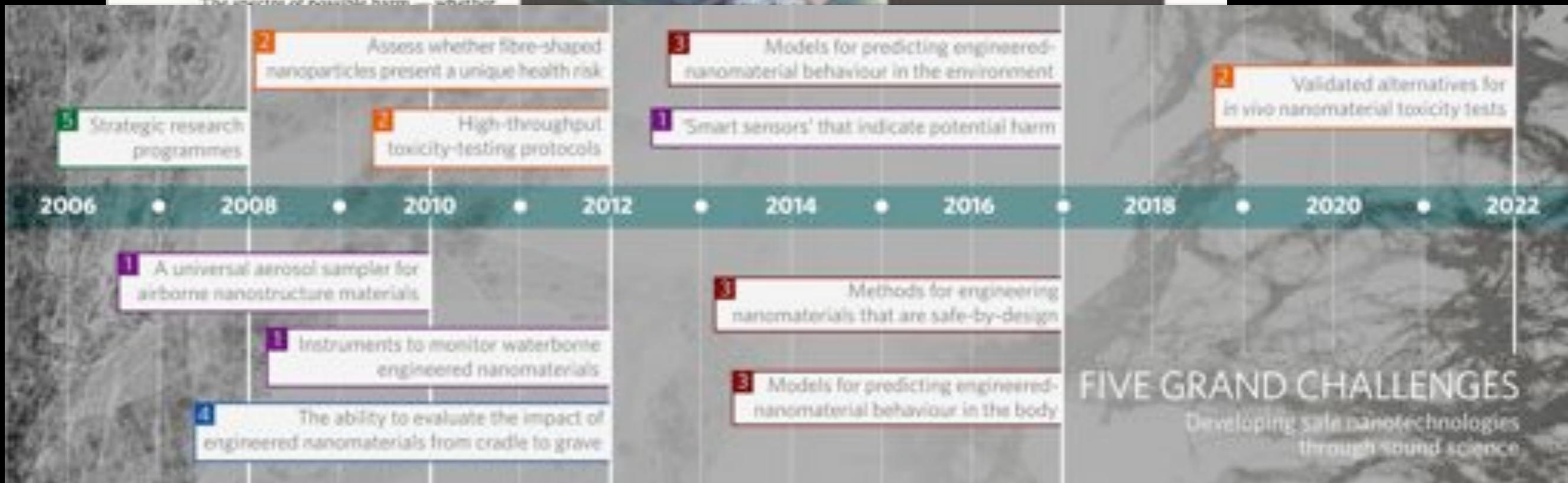
When the physicist and Nobel laureate Richard Feynman challenged the science community to think small in his 1959 lecture 'There's Plenty of Room at the Bottom', he planted the seeds of a new era in science and technology. Nanotechnology, which is about controlling matter at near-atomic scales to produce unique or enhanced materials, products and devices, is now maturing rapidly with more than 300 claimed nanotechnology products already on the market¹. 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 hazards².

The spectra of possible harm — whether



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Nature Vol.
444/16
November 2006





House Science Subcommittee on Research & Science Education
October 31 2007

RESPONSE

...of potential users and
“beneficiaries”



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SHOES

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PRODUCTS EVER!

PRODUCTS ELEKI
NATURAL BEAUTY
THE 32 BEST

MADONNA
OPENS UP
TO SIMON DOONAN
ON IT, KIDS, AND...
BEING FABULOUS

SOFTER
SMOOTHER
SKIN!
THE NO-PRESCRIPTION
BREAKTHROUGH

DRINK
MUCH?
ARE JUICE FASTS
A SMART WAY
TO LOSE WEIGHT—
OR A FAST TRACK
TO AN EATING
DISORDER?

OBSESS
MUCH?
WHEN YOU
TRADE ONE
PROBLEM
FOR ANOTHER
(AND HOW
TO STOP)

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SMALL WONDERS

When it comes to the latest in skin-care ingredients, size matters. Joanne Chen discovers why nanotechnology could be the next big thing

Manhattan hairstylist Patrick Melville gets a lot of free stuff. Media-savvy hair companies, hoping he'll pass on their potions to his starry clientele, send him an endless supply of goos, hot tools, pony-tail holders, and other goodies. This might sound like a dream come true to you, but Melville is a creature of habit, a twang skeptic who prefers his old standbys. A skeptic, that is, until he came across one particular hair dryer. "It's genius!" he tells me one afternoon. "It's powerful. It's light. And with thick hair like yours, I could be done in three swipes." Melville's magic tool, the FHI Heat Nano Salon Pro 2000 dryer, is powered in part by nanoparticles, ultrasmall bits of titanium and silver that ionize the air before it leaves the blower. The result: Hair dries faster and looks shinier.

Like Melville, the U.S. government and a host of eager entrepreneurs have developed a crush on nanotechnology, the science of substances sized one ten thousandth of a millimeter and smaller, or one hundred thousandth of the diameter of a strand of hair. Once downsized, common materials can take on almost supernatural powers. Nanogold transforms into a catalytic agent, and carbon, Clark Kent-like, suddenly acquires a strength 100 times that of steel. What's more, nanosilver, potentially the planet's most promising house cleaner, can mop up messy chemical and oil spills. This summer, Olympic staffers who brave Beijing streets will park their rental cars on lots coated with a nanopolymer that absorbs exhaust; gold medalists and armchair athletes alike can now wear socks laced with nanosize antibacterials.

Determined to take the lead globally, the Feds are pouring \$1.5 billion into nanotechnology-related research and development across multiple agencies in the coming fiscal year. There is no Department of Beauty Planning, of course, but cosmetics companies have been quick to steer these innovations into the skin- and hair-care realms to make shampoos silkier and creams creamier, and, in some cases, to superpower antiaging ingredients. Consider, for instance, the DHC Light & Smooth Shampoo and Conditioner, whose star ingredient is IRMEA, something its label describes as a "naturally occurring nutritive compound found in hair." By shrinking the conditioning oil molecules down to 50 to 70 nanometers, the formula offers extra hair protection. "With nanotechnology, we're able to fabricate little devices and delivery systems," says John Bailey, PhD, chief scientist at the Personal Care Products Council in Washington, DC. "This goes beyond any technology we've seen before. It's more sophisticated."

Sophisticated, yes, but probably already gathering dust on your bathroom shelf. Way back in the '90s, the FDA approved nanosize mineral sunblocks. Pulverized

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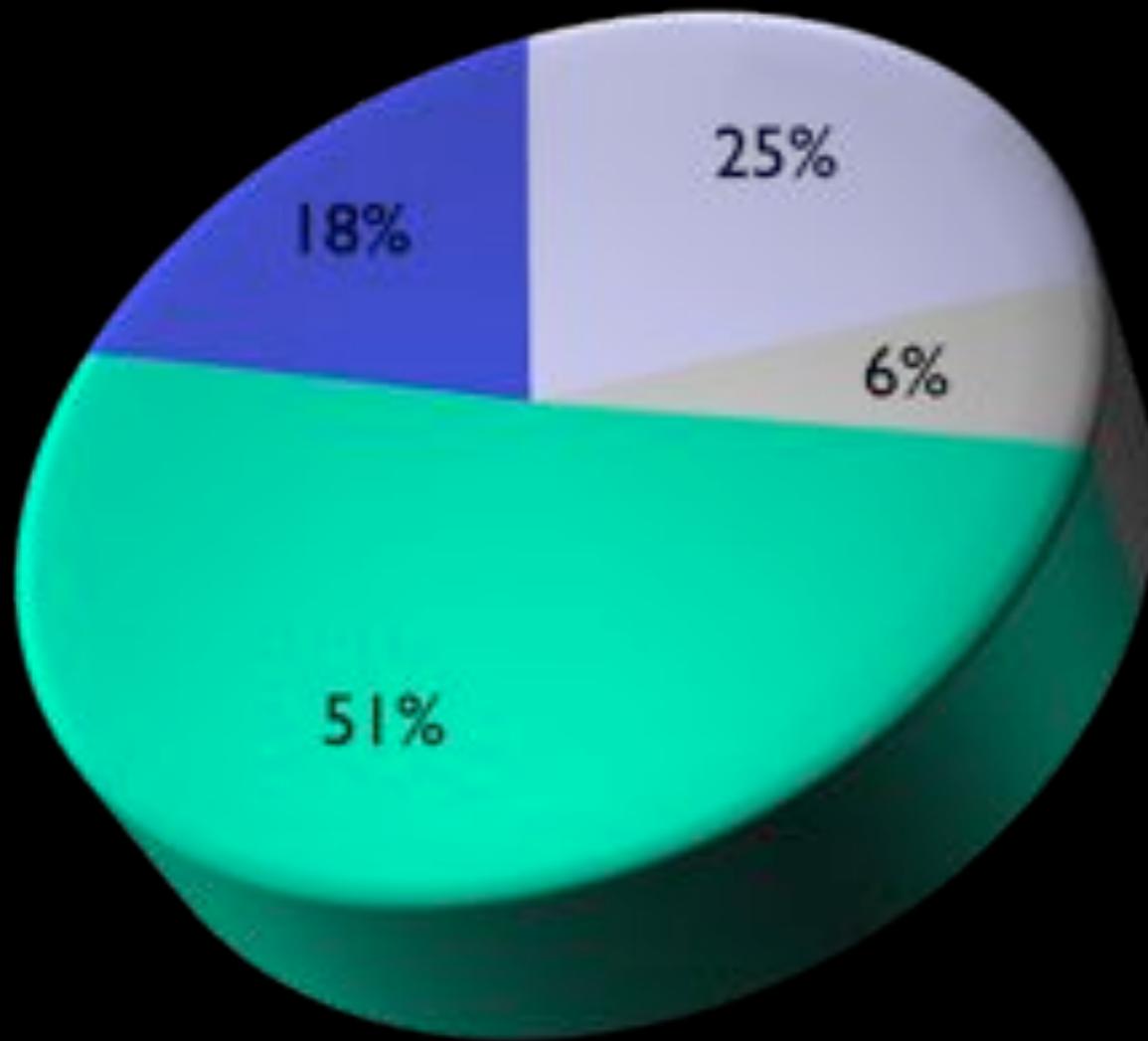
The cream's Energizing Cream has Energizing Cream

The cream's Energizing Cream has Energizing Cream

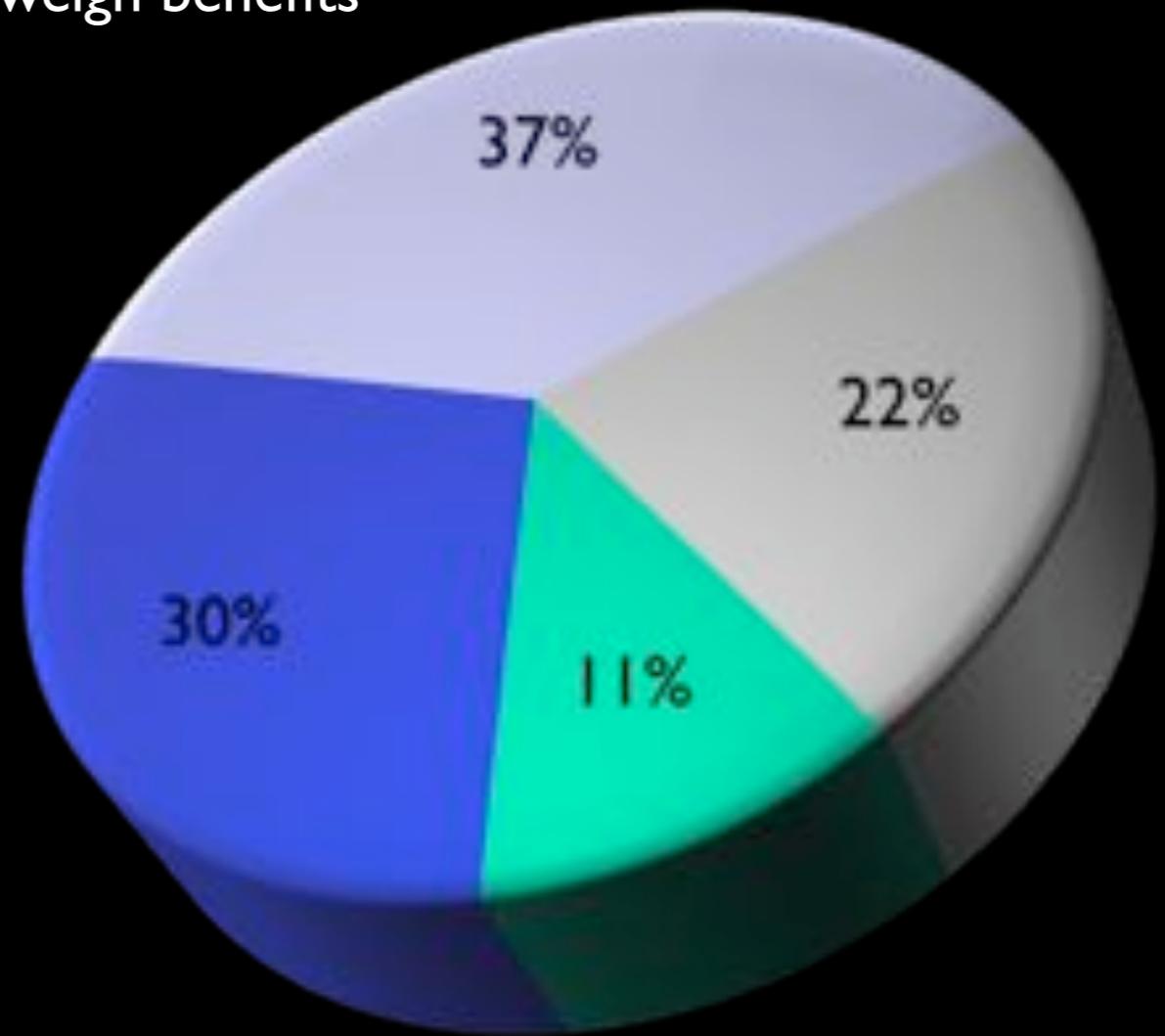
PHOTO: MARIO TESTA; HAIR: JACQUES TOFFI; MAKEUP: JACQUES TOFFI

Public Opinion Poll: Attitudes Towards Nanotechnology

- Not Sure
- Benefits will outweigh risks
- Benefits and risks will be about equal
- Risks will outweigh benefits



Initial impressions



Informed impressions

1014 adults polled

Hart Research Associated, published September 2007

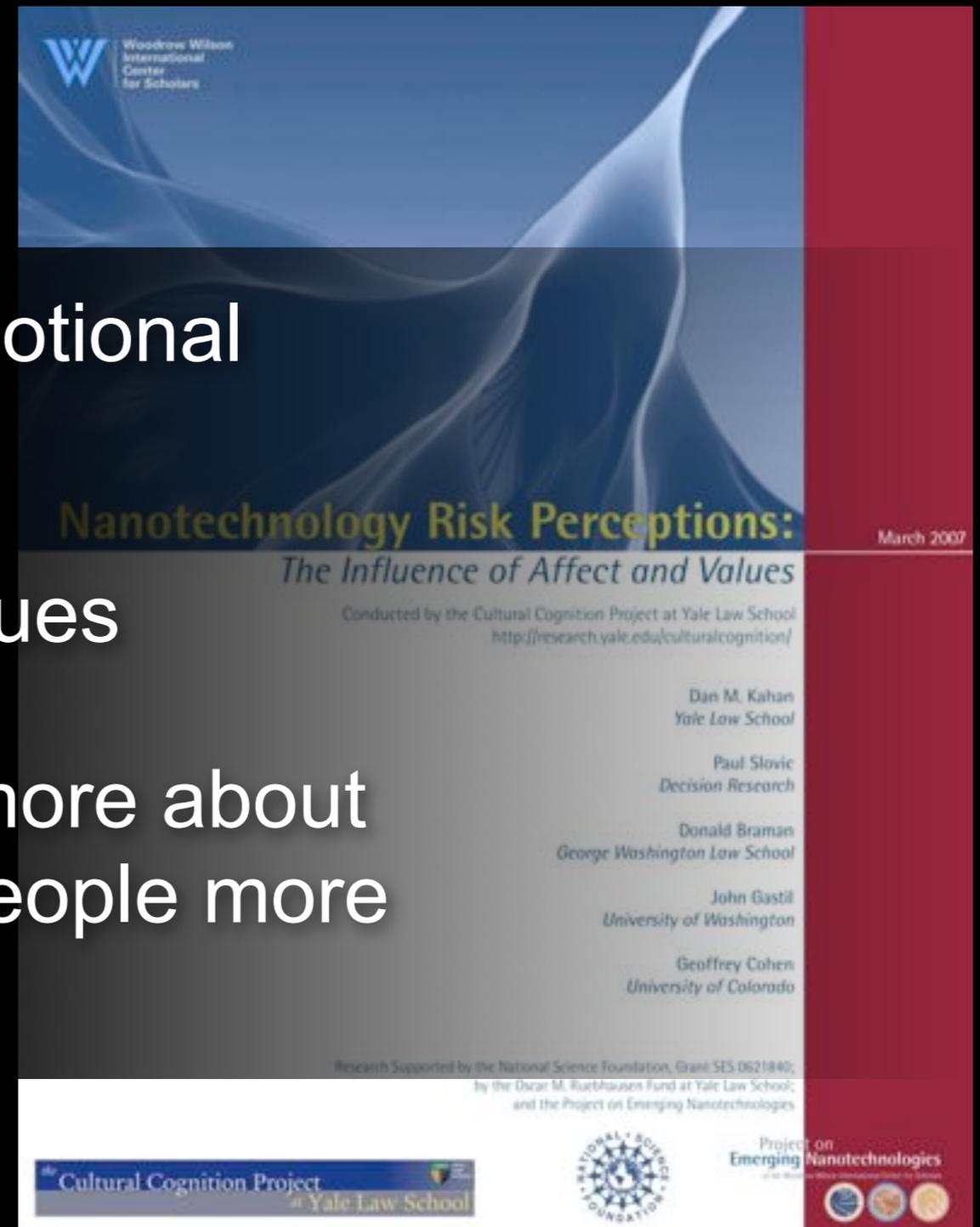
www.nanotechproject.org/138

Kahan et al. 2007

Initial attitudes derive from an emotional response

Informed attitudes depend on values

It does not appear that learning more about nanotechnology tends to make people more favorably disposed to it



Shouting
louder and longer
about research
does not lead to
effective science communication!

The Challenge:

Empowering people to make
informed decisions, and

Engaging people to inform
the decision-making process

REGULATION

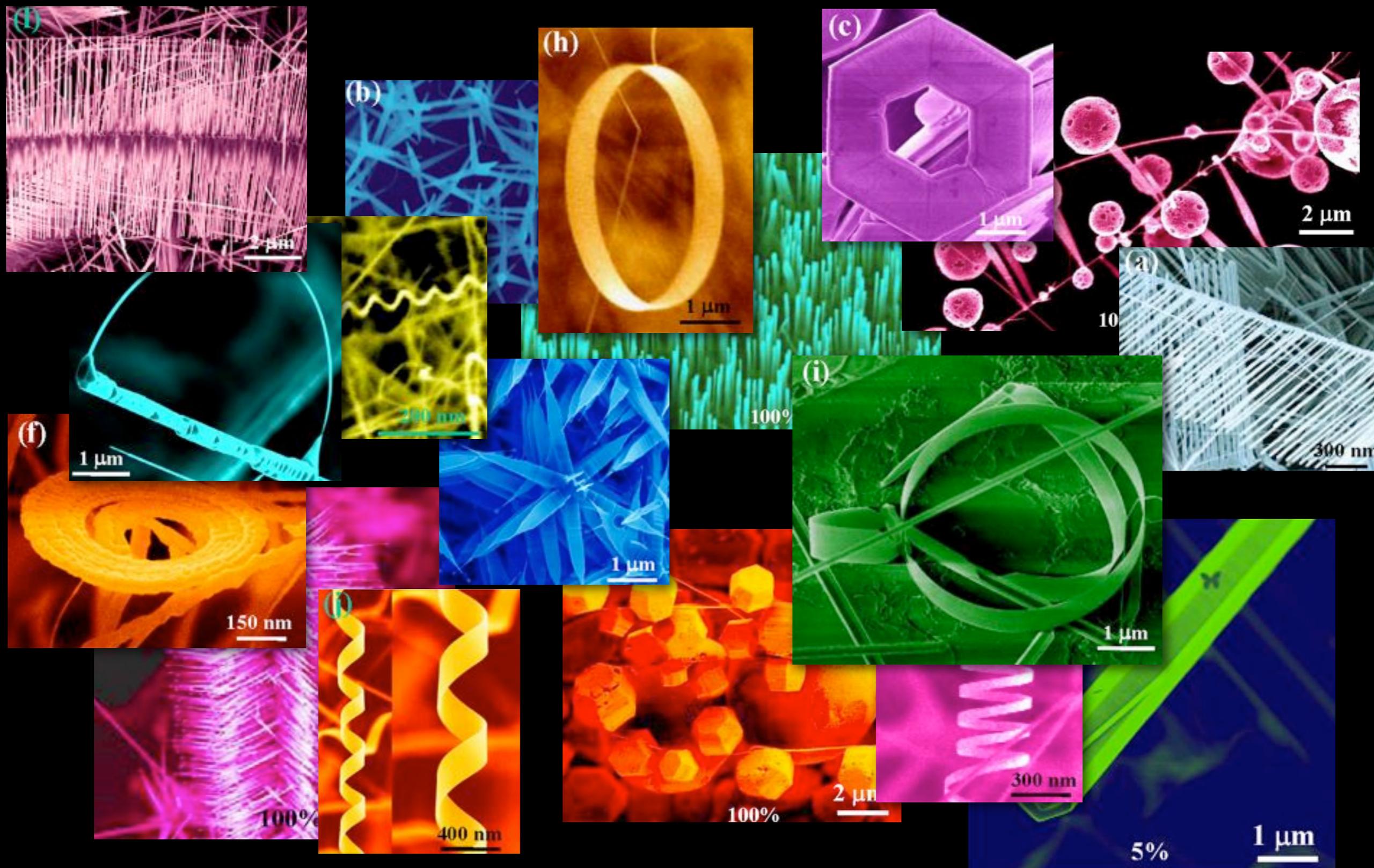
Avoiding undue risk through
appropriate oversight

Similar Chemistry



Different Risks

Similar Chemistry



Potentially Different Risks

Regulating Nano: What prompts new questions?

Strangeness

Smallness



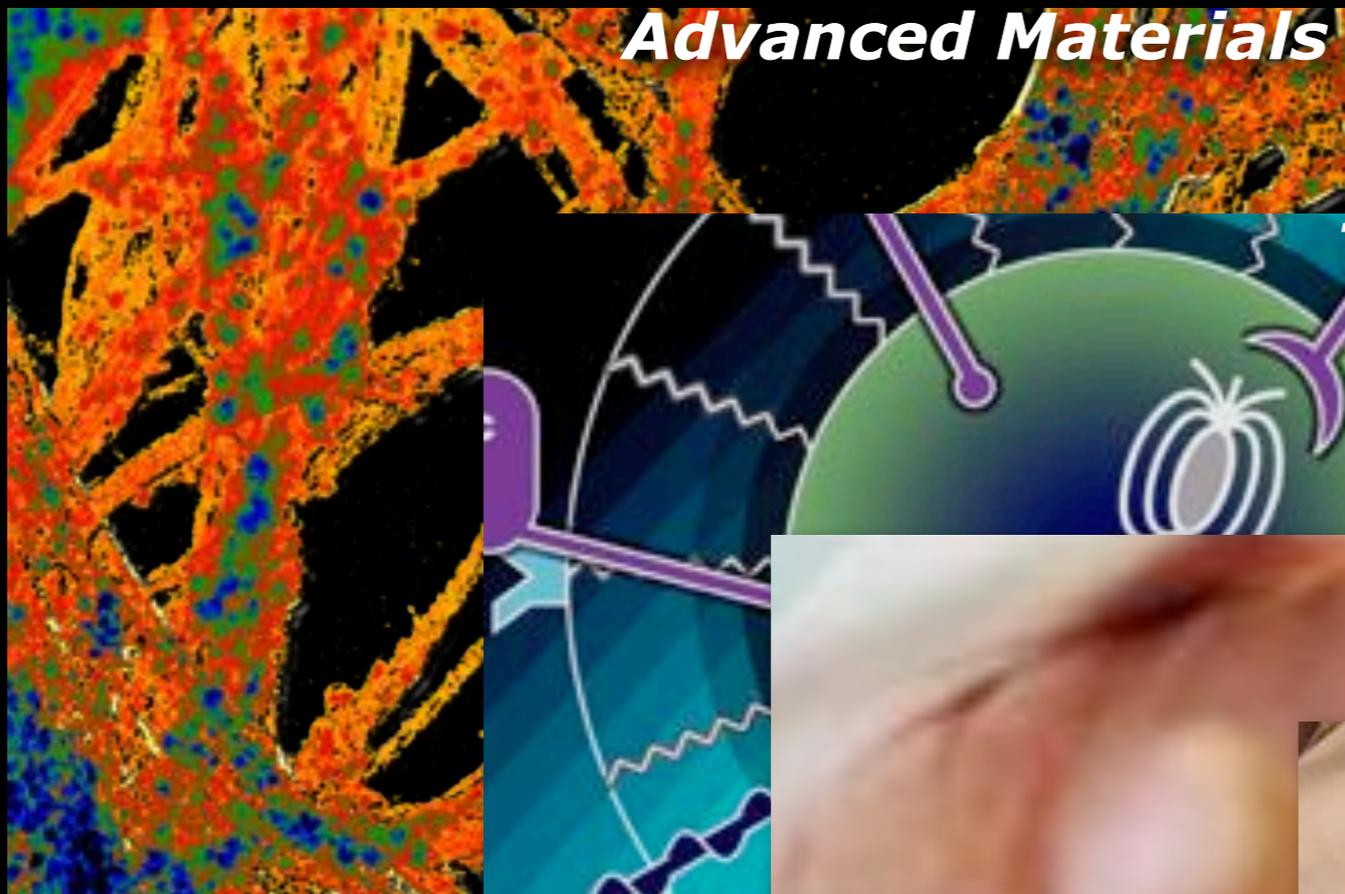
Sophistication

Smart Science



Think Differently
Engage Comprehensively
Act Strategically

Advanced Materials



Therapeutics



Renewable Energy



Clean Water



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Project on Emerging Nanotechnologies

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