



## **Welcome to the CLU-IN Internet Seminar**

### **The New Science of Sophisticated Materials: Nanomaterials and Beyond**

Delivered: November 8, 2011, 2:30 PM - 4:30 PM, EST (19:30-21:30 GMT)

*Presenter:*

*Dr. Andrew Maynard, University of Michigan School of Public Health (maynarda@umich.edu)*

*Moderators:*

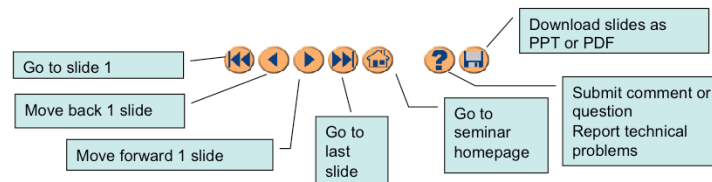
*Tom Burbacher, University of Washington (tmb@u.washington.edu)*

*Kira Lynch, U.S. EPA Region 10 Superfund Technical Liaison (lynch.kira@epa.gov)*

Visit the Clean Up Information Network online at [www.cluin.org](http://www.cluin.org)

# Housekeeping

- Please mute your phone lines, Do NOT put this call on hold
- Q&A
- Turn off any pop-up blockers
- Move through slides using # links on left or buttons



- This event is being recorded
- Archives accessed for free <http://clu.in.org/live/archive/>

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Although I'm sure that some of you have these rules memorized from previous CLU-IN events, let's run through them quickly for our new participants.

Please mute your phone lines during the seminar to minimize disruption and background noise. If you do not have a mute button, press \*6 to mute #6 to unmute your lines at anytime. Also, please do NOT put this call on hold as this may bring delightful, but unwanted background music over the lines and interrupt the seminar.

You should note that throughout the seminar, we will ask for your feedback. You do not need to wait for Q&A breaks to ask questions or provide comments. To submit comments/questions and report technical problems, please use the ? Icon at the top of your screen. You can move forward/backward in the slides by using the single arrow buttons (left moves back 1 slide, right moves advances 1 slide). The double arrowed buttons will take you to 1<sup>st</sup> and last slides respectively. You may also advance to any slide using the numbered links that appear on the left side of your screen. The button with a house icon will take you back to main seminar page which displays our agenda, speaker information, links to the slides and additional resources. Lastly, the button with a computer disc can be used to download and save today's presentation materials.

With that, please move to slide 3.

# The New Science of **Sophisticated Materials**

Nanomaterials and beyond

**Andrew D. Maynard**

**Director, Risk Science Center**  
University of Michigan School of Public Health

 UNIVERSITY OF MICHIGAN

University of Washington Seattle, Nov 8 2011



Deepwater Horizon spill, Gulf of Mexico

## G-MARINE Fuel Spill Clean-UP!

These plant derived ingredients are processed to form a colloidal micelle whose small particle size (1-4 nanometers) enables it to penetrate and breakdown long chain hydrocarbons bonds in oils and grease and holds them in a colloidal suspension when mixed with water.

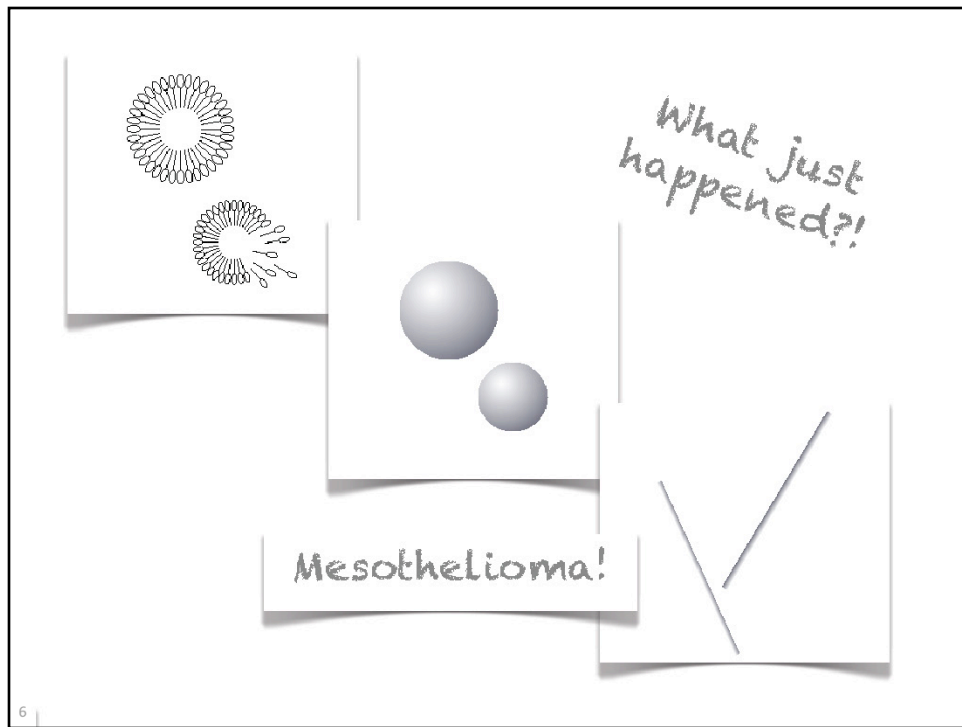
Green Earth Technologies, [www.getg.com](http://www.getg.com)

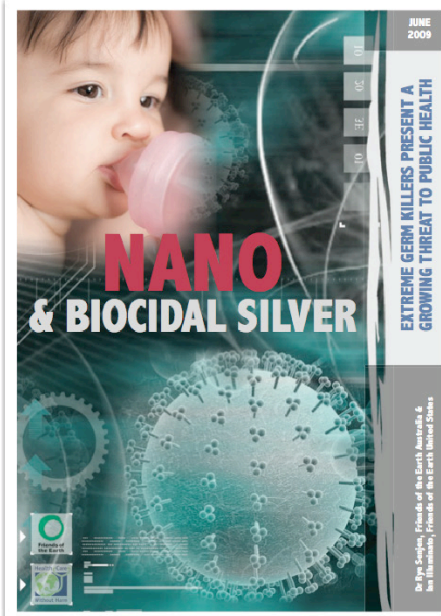
The undersigned public-interest organizations respectfully urge the EPA to deny approval of this and similar projects that seek to release nanoscale chemicals or chemicals measuring less than 300 nanometers into the environment. In this case the company claims their product is composed of particles measuring 1-4nm. ***Manufactured nanoparticles have been shown to be toxic to humans, mammals, and aquatic life.***

NGO Consortium, [www.foe.org/sites/default/files/EPAOpposeGETNanoDispersants.pdf](http://www.foe.org/sites/default/files/EPAOpposeGETNanoDispersants.pdf)

"A decision to use nanoparticle-based dispersants in the gulf is less an engineering or environmental decision, but more a public health and individual patient care issue. ***As does asbestos, nanoparticles have been shown to cause an aggressive cancer called mesothelioma***"

AOL Online, [www.aolnews.com/nation/article/scientists-to-epa-say-no-to-nanotech-dispersant-for-gulf-oil-spill-cleanup/19495279](http://www.aolnews.com/nation/article/scientists-to-epa-say-no-to-nanotech-dispersant-for-gulf-oil-spill-cleanup/19495279)



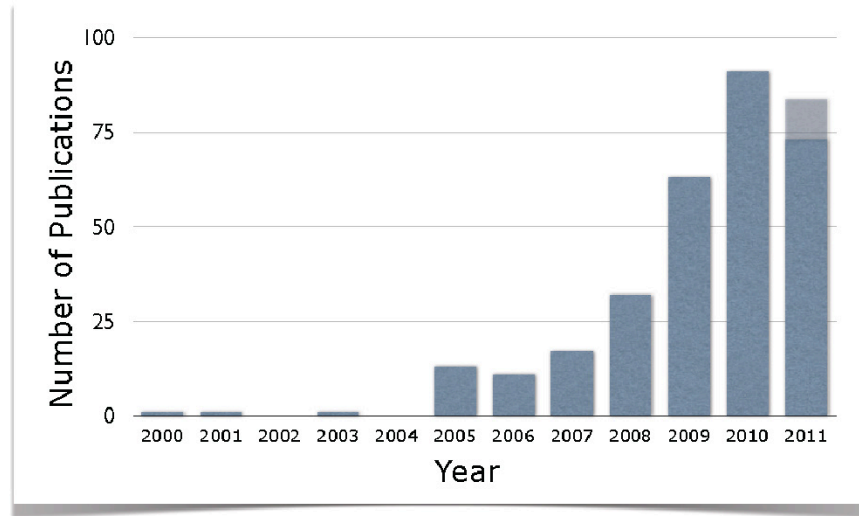


Friends of the Earth calls for an **immediate moratorium** on the commercial release of products that contain manufactured nanosilver until nanotechnology-specific regulation is introduced to protect the public, workers and the environment from their risks, and until the public is involved in decision making

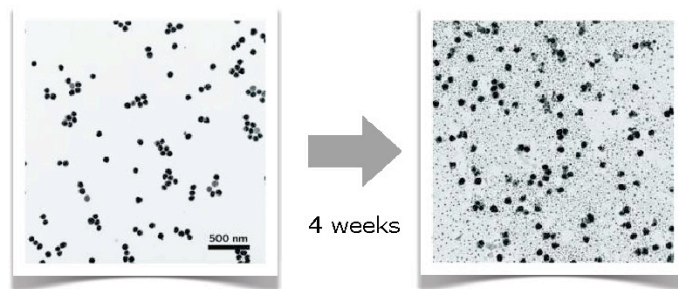
*Friends of the Earth Australia, 2009. Nano and Biocidal Silver – Extreme Germ Killers Present A Growing Threat to Public Health. Melbourne: FoE Australia.*

# Publications

Related to nano silver impacts



# Ubiquitous **Ag** Nanoparticles...



Glover RD, Miller JM, Hutchison JE. 2011. Generation of Metal Nanoparticles from Silver and Copper Objects: Nanoparticle Dynamics on Surfaces and Potential Sources of Nanoparticles in the Environment. ACS Nano 10.1021/nm2031319.

## Regulatory **Decision Making**

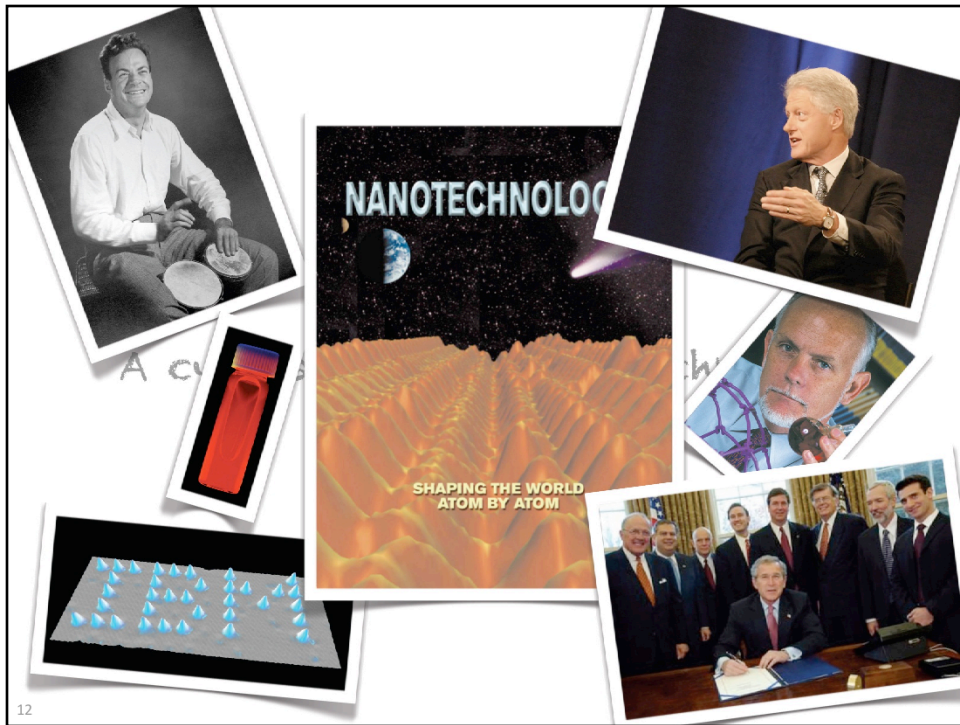
Laursen said that although the Commission would consider the public consultation and the advice of key scientific bodies such as the EU's scientific committee on emerging and newly identified health risks (SCENIHR), ultimately the definition [for regulatory purposes of an engineered nanomaterial] would be "a policy decision"

Euractiv.com, April 01 2011. <http://www.euractiv.com/en/innovation/commissions-nano-policy-lost-definition-news-503665>

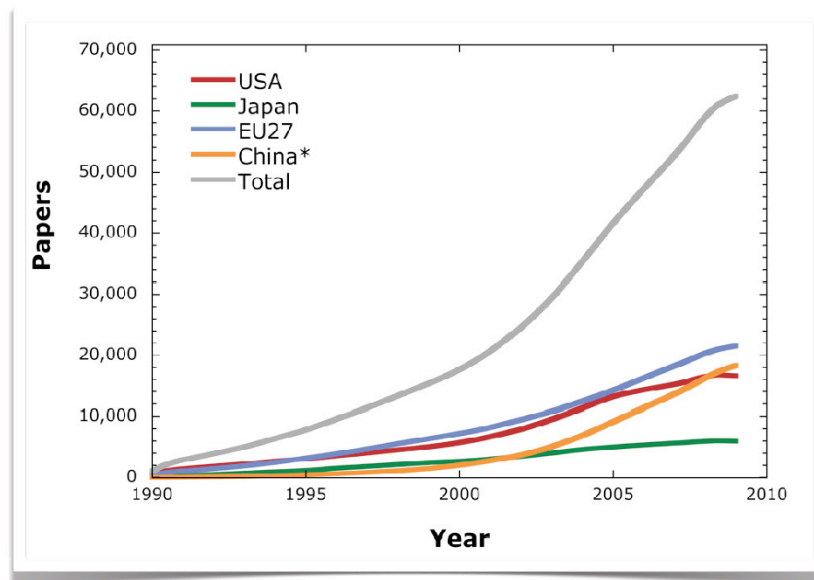
## We have A **Wicked Problem!**

**A Wicked Problem:** a problem “which [has] a multitude of stakeholders showing interest, but an inability for stakeholders to agree on either the nature of the ‘problem’ (to the degree that it exists at all), or on the most desirable solution to be applied”

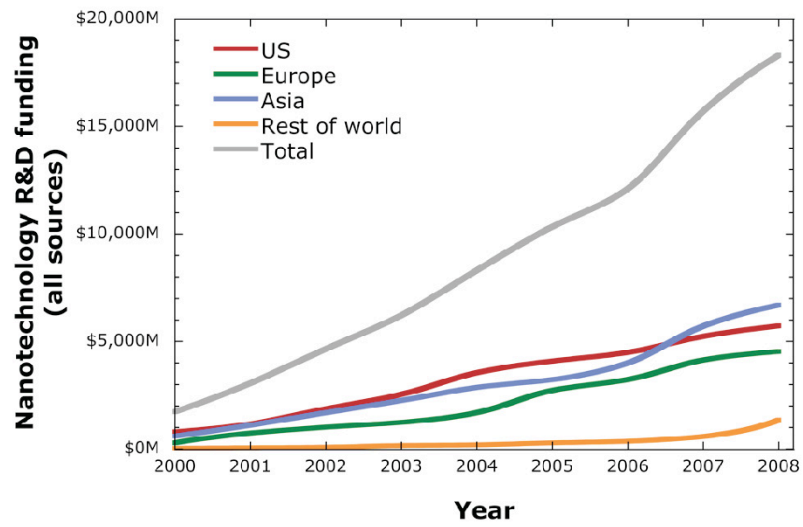
Klijn, E-H. (2008), *It's the Management, Stupid! On the Importance of Management in Complex Policy Issues*, Uitgeverij LEMMA: The Hague



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Source: PCAST (2010) Report to the President and Congress on the Third Assessment of the National Nanotechnology Initiative. Washington DC: President's Council of Advisors on Science and Technology.



Source: PCAST (2010) Report to the President and Congress on the Third Assessment of the National nanotechnology Initiative. Washington DC: President's Council of Advisors on Science and Technology.



## **Nano2:** *The next ten years of nanotech*

Nano-bio interfaces

Biology inspired technologies

Understanding interactions in complex nanosystems

Molecular understanding of biological processes

Interactions of nanostructures with external fields

Powerful, compact batteries

Interactive electronic books

Cognitive technologies

Next generation electronics

Artificial organs

Better disease treatment

Novel computing systems

Exploiting quantum effects

Self-assembling materials

Designing materials from atoms up

Smart prosthetics

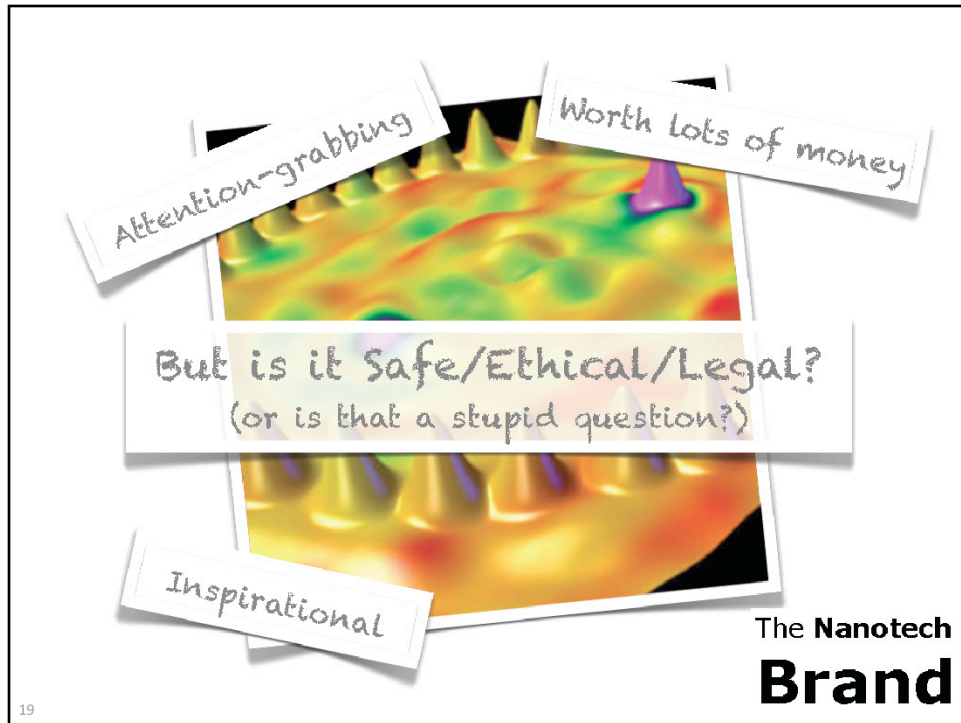
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Long-Term Impacts and Future Opportunities for Nanotechnology, 2000–2020. Draft report available at <http://www.wtec.org/nano2/>

Welcome to the Nanotechnology

BRAND





## *Nano presents a **Wicked Problem**!*

**A Wicked Problem:** a problem “which [has] a multitude of stakeholders showing interest, but an inability for stakeholders to agree on either the nature of the ‘problem’ (to the degree that it exists at all), or on the most desirable solution to be applied”

Hodge, G. A., D. M. Bowman and A. D. Maynard (2010). Introduction: The Regulatory Challenges for Nanotechnologies. *International Handbook on Regulating Nanotechnologies*. G. A. Hodge, D. M. Bowman and A. D. Maynard. Cheltenham, Edward Elgar.

## The ***Important*** Question...

How do we begin to address the potential **emergent risks** of substances that are **complex**, that are **dynamic**, and that exhibit **physicochemical form-related biological behavior**?

## *Defining* **Nanotechnology...**

“the understanding and control of matter at **dimensions** between approximately 1 and 100 nanometers, where **unique phenomena** enable **novel** applications.”

<http://www.nano.gov/html/facts/whatIsNano.html>

**...a stumbling  
block for safety?**

# Deconstructing Nanotechnology

What is **OLD**?



Generation

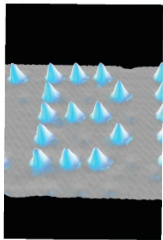


Utilization



Manufacture

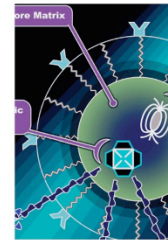
What is **NEW**?



Control



Strangeness



Sophistication

# *Reconstructing* **Nanotechnology**

Nanoscale Science  
and Engineering

# Reconstructing ~~Nanotechnology~~

What is **OLD**?



Generation



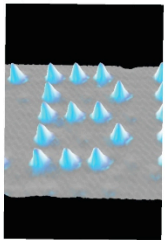
Utilization



Manufacture

Nanoscale Science  
and Engineering

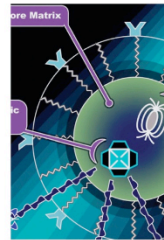
What is **NEW**?



Dexterity



Exploitation



Complexity

# *Reconstructing* ~~Nanotechnology~~

Nanoscale Science  
and Engineering

[ Playing around with *small stuff* to make the  
*big stuff* work better

## Nanoscale control: Adding value to products

*I wish* my sunscreen  
wasn't so unsightly



*I wish* my socks didn't  
smell so much!



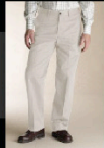
*I wish* my tennis  
racquet was lighter and  
stronger



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



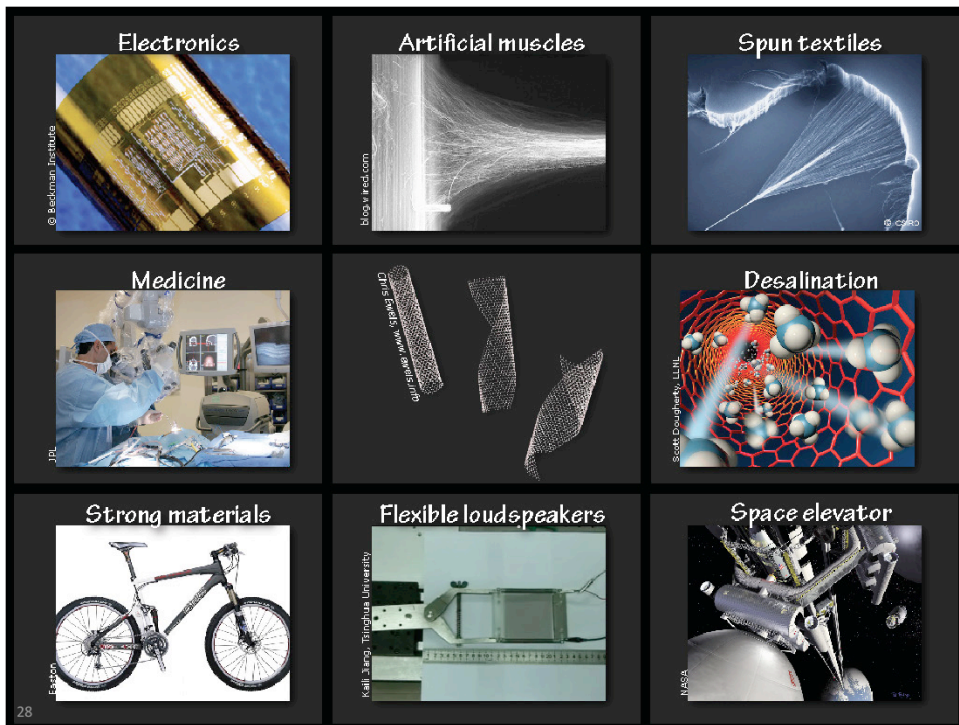
*I wish* spilt red wine  
would run off my pants  
without staining



*I wish* I could get more  
songs on my iPod



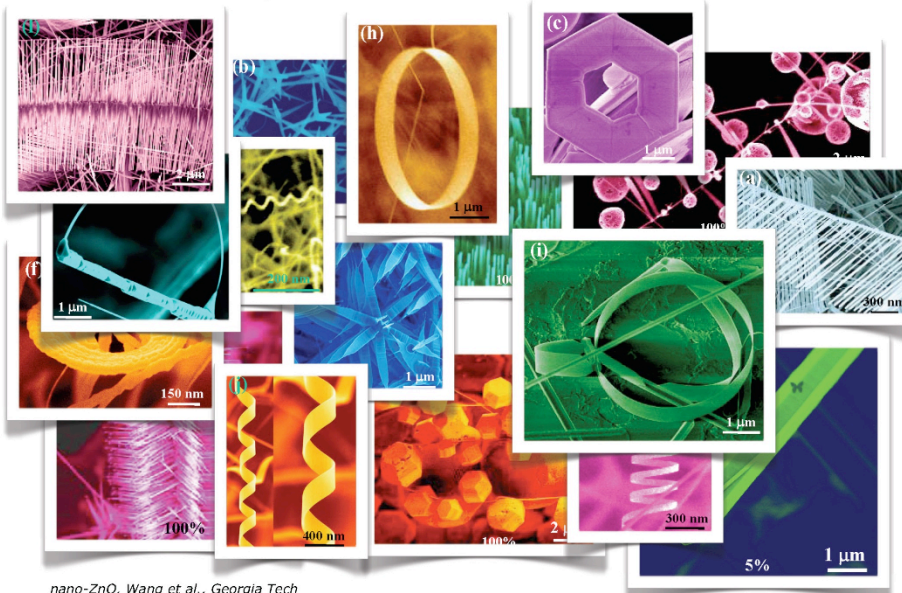
Over 1300 listed manufacturer-identified nanotech consumer products:  
[www.nanotechproject.org/consumerproducts](http://www.nanotechproject.org/consumerproducts)





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## Same Chemistry



*nano-ZnO, Wang et al., Georgia Tech*

Potentially Different Risks

# **Problem Formulation**

# Making sense of the **nanoscale**

**Nanotechnology** *n.* the understanding and control of matter at the nanoscale, at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications.

Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale.

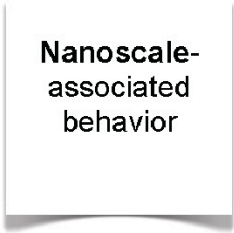
US National Nanotechnology Initiative

## Regulators: Don't define nanomaterials



Maynard AD. 2011. Nature 475: 31

# Making sense of the **nanoscale**



Nanoscale-  
associated  
behavior

Assumption that **size** leads to  
“novel” behavior

Attempts to define and  
**regulate** by size

Pressure to **fit** science to ideas

# Making sense of the **nanoscale**

**Nanomaterial** *n.* (regulation) a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 % or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm – 100 nm.

European Commission, October 2011

# Making sense of the **nanoscale**

Nanoscale-  
associated  
behavior

Assumption that **size** leads to  
“novel” behavior

Attempts to define and  
**regulate** by size

Pressure to **fit** science to ideas

Nanoscale  
science and  
engineering-  
associated  
behavior

Assumption that **design** leads  
to “novel” behavior

Possibility of defining and  
regulating by **behavior**

Opportunity to **develop** ideas  
from science

# Making sense of the **nanoscale**

Nanoscale  
science and  
engineering-  
associated  
behavior

In the regulatory context,  
“nanomaterial” is replaced  
by “**sophisticated**” or  
“**advanced**” material or  
product



Assumption that **design** leads  
to “novel” behavior

Possibility of defining and  
regulating by **behavior**

Opportunity to **develop** ideas  
from science

## Sophisticated Materials

“Undoubtedly, materials intentionally designed and engineered to behave in specific ways because of their fine structure are at the forefront of the new challenges being faced in toxicology. These materials increasingly demonstrate biological behavior that results from a synergistic interaction between chemical composition and physical form. But whether these new challenges can be confined to a narrow size scale implied by “nanotoxicology” is debatable.

Rather, we would argue that a broader perspective is needed on the challenges presented by novel and functional materials, that captures the idea of “**sophisticated materials**.”

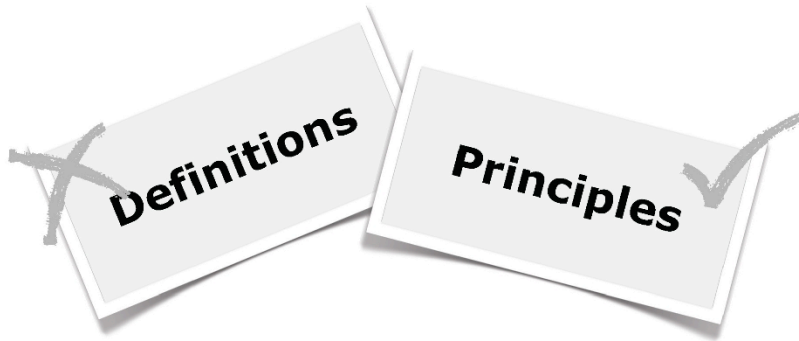
These are substances that arise at the intersection of scientific disciplines and technology platforms, and demonstrate novel and even time and context-dependent functionality based on their engineered and increasingly complex physicochemical structure.”

Maynard AD, Warheit D, Philbert MA. 2011. The New Toxicology of Sophisticated Materials: Nanotoxicology and Beyond. *Tox Sci* 120(Suppl 1): S109-S129.

## The Problem

Developing approaches to understanding and addressing the **novel health and environmental outcomes** arising from novel mechanisms of action and harm associated with **sophisticated materials**, including those that have been **designed** and engineered at the nanometer scale

## Overcoming the **Definitions** Hurdle



Maynard AD, Warheit D, Philbert MA. 2011. The New Toxicology of Sophisticated Materials: Nanotoxicology and Beyond. Tox Sci 120(Suppl 1): S109-S129.

## Criteria: **Emergent Risk**

The likelihood of a new material causing harm in a manner that is **not apparent, assessable or manageable** based on the current state of knowledge

## Criteria: **Plausibility**

The **science-based likelihood** (qualitative) of a new material, product or process presenting a risk to humans or the environment

## Criteria: **Impact**



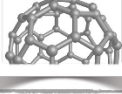
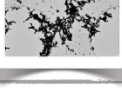

The **likelihood** of a new material, product or process having a **substantial impact** on human health or the environment

## Together, **they suggest that:**

[Special consideration should be given to the research into the potential impact and oversight of materials, products and processes that have **plausible potential** to cause **substantial** harm in a manner that is **not apparent, assessable or manageable** based on the current state of knowledge.]

## Materials which **Raise Concerns**

- Materials demonstrating **abrupt scale-specific changes in biological behavior** - specifically, materials that undergo rapid size-dependent changes in physical and chemical properties which in turn affect biological behavior
- Materials capable of **penetrating to normally inaccessible places**
- **Active materials** - materials that undergo a change in their biological behavior in response to their local environment, a received signal or a predetermined series of events.
- **Self-assembling materials** - materials designed to assemble into new structures in the body or the environment once released.
- Materials exhibiting a **scalable hazard** that is not captured by conventional risk assessments.

		Emergent Risk	Plausible Risk	Impact
Gray Goo		✓	✗	✗
Therapeutics		✓	✓	✓
C60		?	✓	✓
Nano Silver		✗	✗?	?
Nano CeO2		✓	✗?	✗

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# Novelty

**novel** *adj.* of a new kind of nature; strange; previously unknown

**familiar** *adj.* **a** well known; no longer novel. **b** common, usual; often encountered or experienced.

Oxford English Dictionary

# Domains of **Novelty**

Physical, Chemical  
and Biological  
**Properties**

**Mechanisms**  
of Action

**Harm**

**Health &  
Environmental**  
Outcomes

# Domains of **Novelty**

Physical, Chemical  
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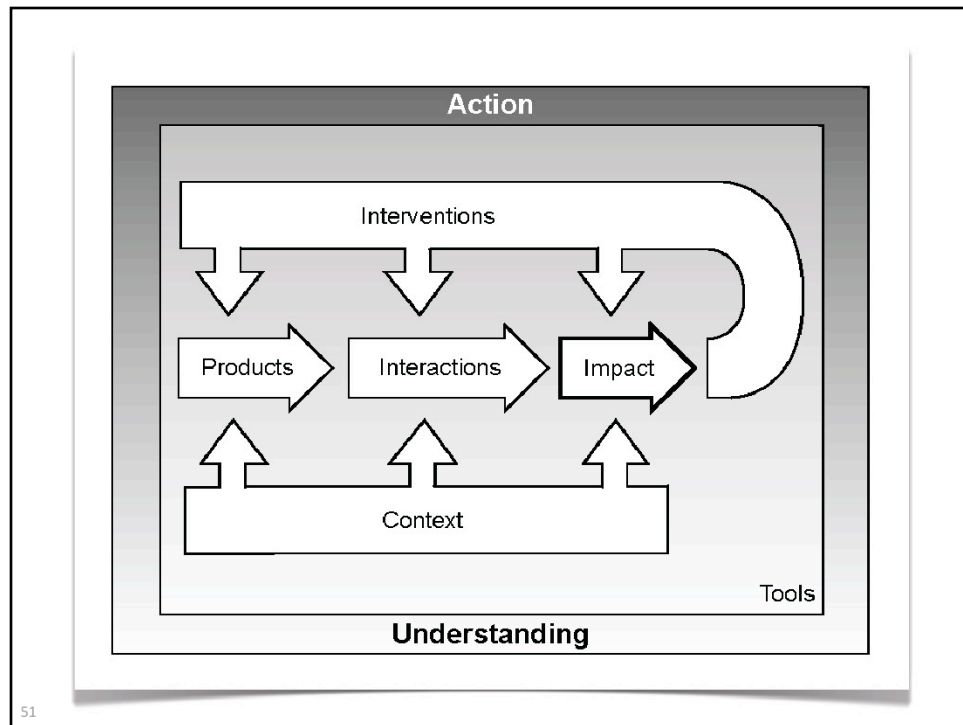
**Health & Env  
Outcomes**

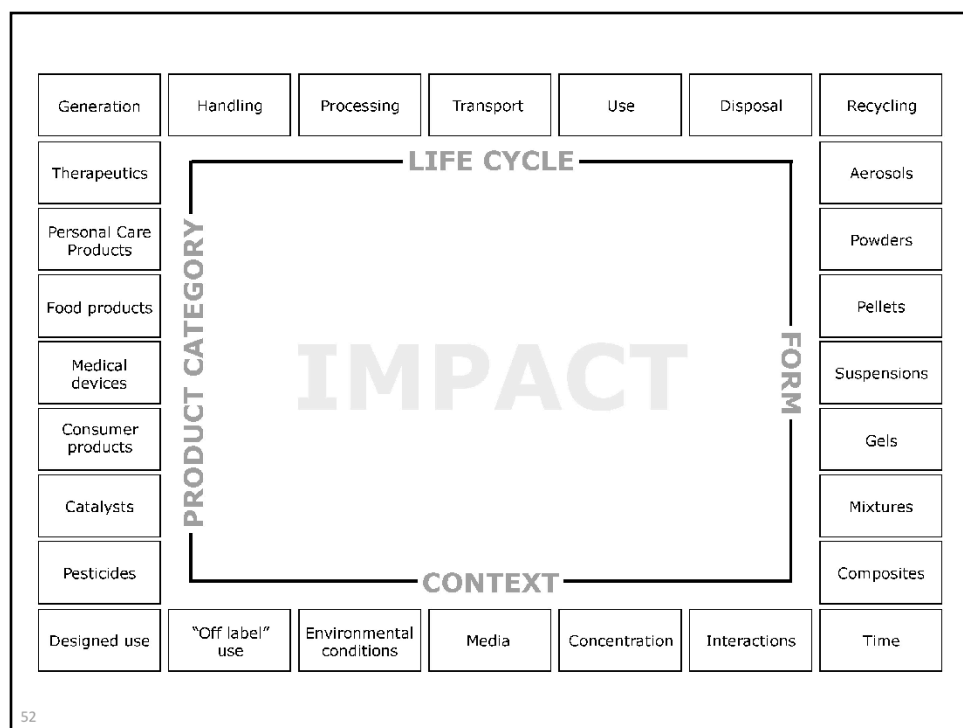
# Novelty and **Outcome**

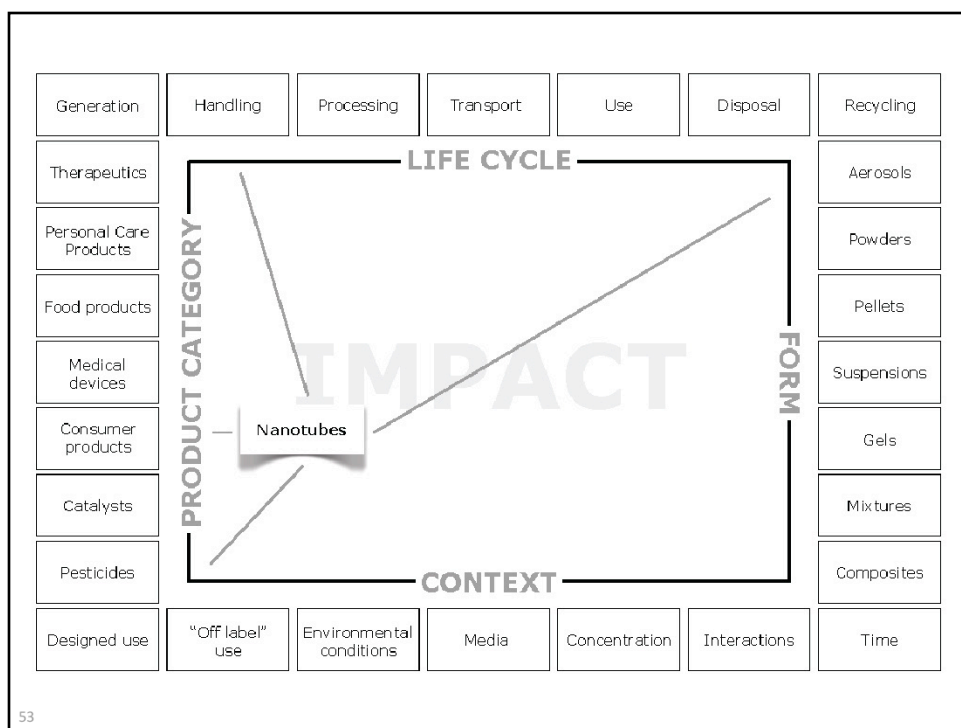
Risk of **adverse outcome**:

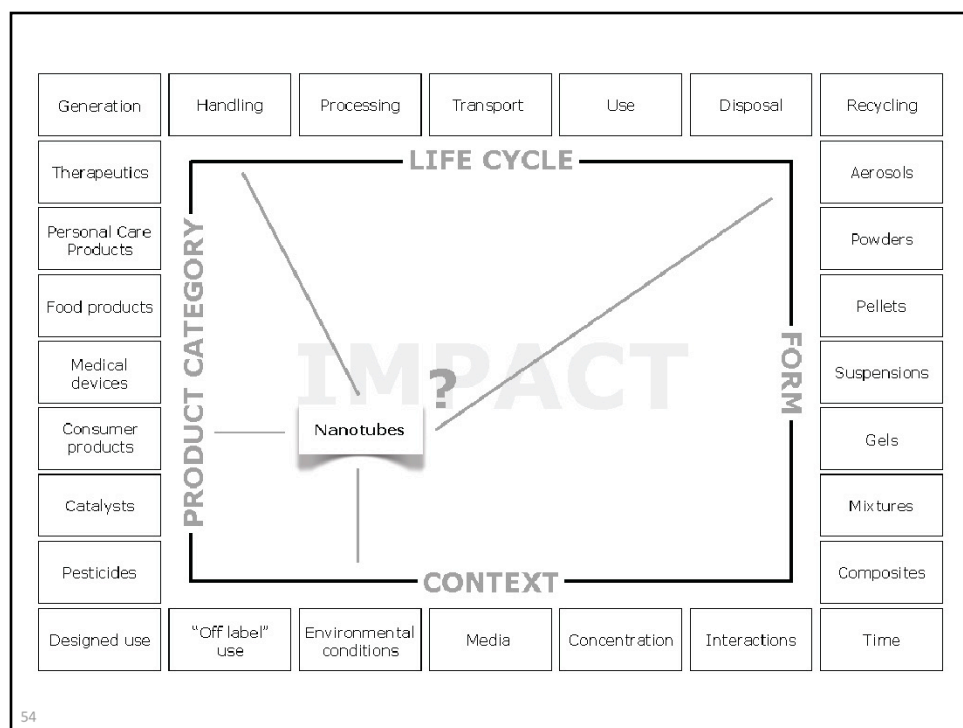
**F<sub>n</sub>**(Hazard, Exposure, Time)

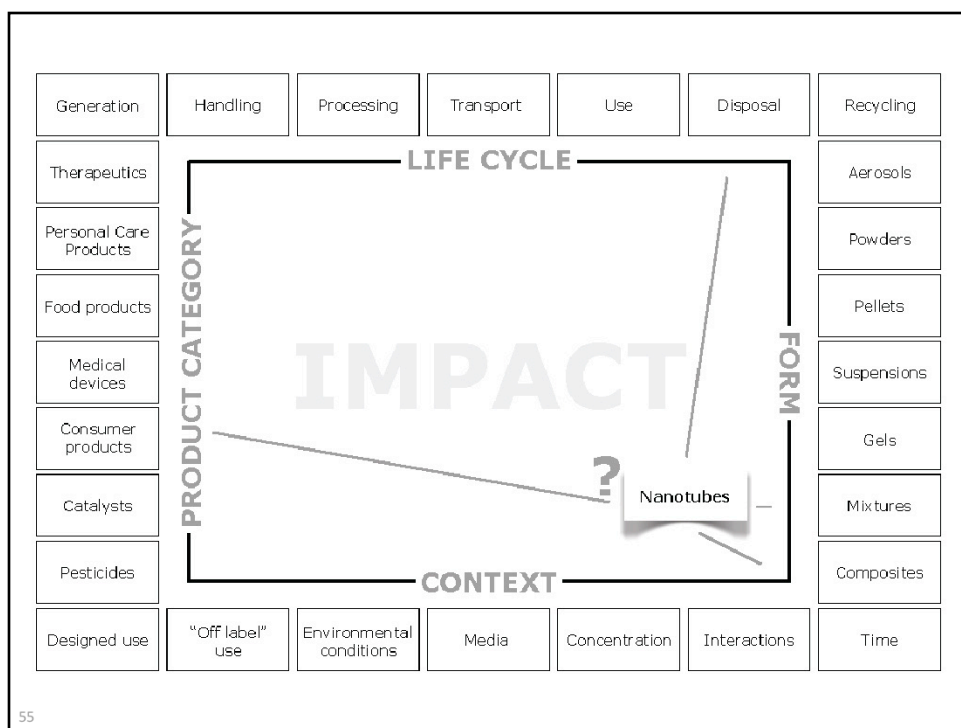
Persistence & Accumulation  
Transformation  
Activation











## So where does this leave us?

Some thoughts

Should focus on **Sophisticated Materials**, rather than Nanomaterials

Need to reframe potential health and environmental impacts in terms of **design**, instead of size

Should formulate problems that are grounded in science, based on evidence, and **responsive to new information**

Need to develop an **integrated perspective** on potential impacts within diverse, complex and dynamic systems

Mustn't get confused between brands and products!

**Andrew D. Maynard**

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Ann Arbor, MI 48109  
Email: [maynarda@umich.edu](mailto:maynarda@umich.edu)

Contact: Hilda McDonald, Tel: 734-615-3050, Email: [hildirls@umich.edu](mailto:hildirls@umich.edu)

*Risk Science Center:* <http://umriskcenter.org>  
*Blog:* <http://2020science.org>  
*Twitter:* <http://twitter.com/2020science>

# Links page

- Dr. Andrew Maynard ([maynarda@umich.edu](mailto:maynarda@umich.edu))
- University of Michigan, Risk Science Center:  
<http://www.sph.umich.edu/riskcenter/>
- University of Washington Superfund Research Program:  
<http://depts.washington.edu/sfund/>
- US EPA Region 10:  
<http://www.epa.gov/aboutepa/region10.html>
- National Institute of Environmental Health Institute (NIEHS)-  
Superfund Research Program  
<http://www.niehs.nih.gov/research/supported/srp/>

# Thank you for your time!

We ask you to take a minute to complete the [UWSRP Feedback Form](#) to help us evaluate the UW agency seminar series.

If you have additional questions or comments, please contact:

Katie Frevert, *University of Washington Superfund Research Program (UWSRP)*

[kfrevert@u.washington.edu](mailto:kfrevert@u.washington.edu)

Tel (206)685-5379



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Thank you again for your attention and comments. I want to remind each of you that we are looking for your specific responses to many of the issues discussed today in our feedback form following this session.

Also, there are several resources and related documents included in the links to more resources on this page.

If you have any additional questions or comments, please feel free to contact myself or fill out a comment form on CLUIN.

Thank you and have a great afternoon.

# Resources & Feedback

- To view a complete list of resources for this seminar, please visit the [Additional Resources](#)
- Please complete the [Feedback Form](#) to help ensure events like this are offered in the future

**EPA** United States Environmental Protection Agency  
Technology Innovation Program

U.S. EPA Technical Support Project Engineering Forum  
Green Remediation: Opening the Door to Field Use: Session C (Green Remediation: Field Use and Emerging)  
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and check box for  
confirmation email.