



SNNI

SAFER NANOMATERIALS AND NANOMANUFACTURING INITIATIVE

ONAMI
OREGON NANOSCIENCE AND
MICROTECHNOLOGIES INSTITUTE



Environmental, Health, and Safety Aspects of Engineered Nanomaterials

*What are our research needs and
objectives?*

Bettye Smith Maddux

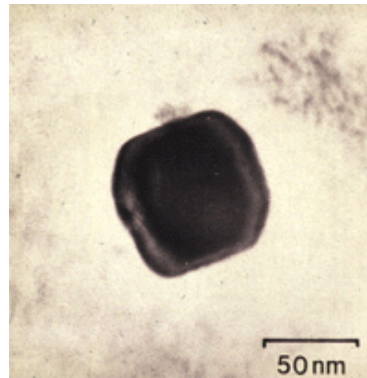
Assistant Director

Safer Nanomaterials and Nanomanufacturing Initiative

New properties at the nanoscale: Opportunities and uncertainties

Opportunities

Imaging agents
Nanoscale Optics
Cosmetics
Therapeutics
Drug delivery
Diagnostics
Nanoelectronic devices
Sensors and biosensors
Catalysis



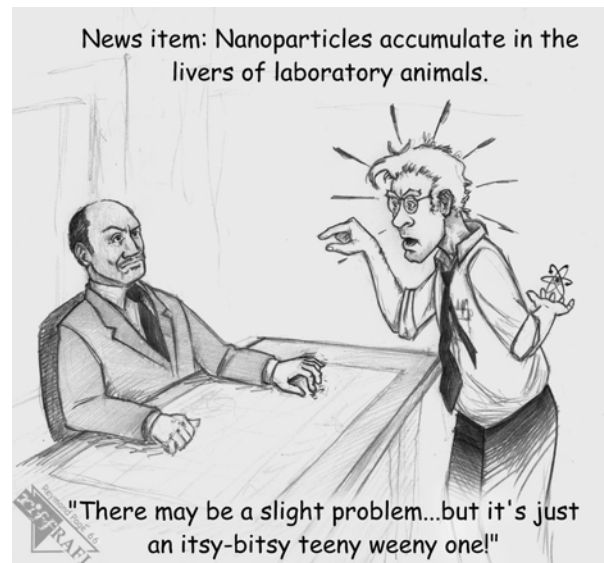
Uncertainties

Toxicity?
Ecotoxicity?
Persistence?
Transport?
Bioavailability?
Bioaccumulation?



General consensus regarding nanotechnology

- Nanotechnology has the power to revolutionize society (with a large scale impact)
- We need to understand the risks as well as the benefits (need data)
- Public perception matters



Research priorities

Proactive approach to nanomaterial design

- Methods to develop nanoparticle fabrication processes
- Methods to functionalize nanoparticles
- Purification assays
- Methods to characterize nanoparticles and assess purity
- Assays to test biological and environmental impacts and assess risks
- Design scheme that *simultaneously* incorporates biological/toxicity testing with product development to create inherently safer nanomaterials



A Proactive Design Strategy

Design nanomaterials that provide new properties and performance, but do not pose harm to human health or the environment

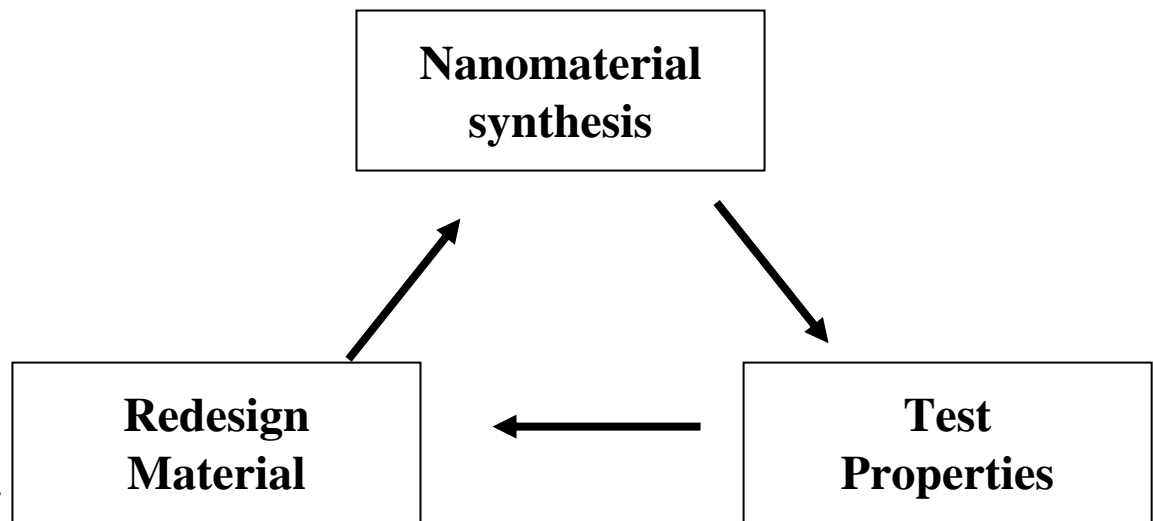
Manufacture complex nanomaterials efficiently, without using hazardous substances

Apply nanomaterials to the maximum benefit for society and the environment

Design and manufacture it
right the first time

No compromise necessary:
Higher performance,
cheaper and greener

Real solutions, right now!



www.greennano.org



“Green nanoscience”



Merges green chemistry and nanoscience to produce safer nanomaterials and more efficient nanomanufacturing processes for a wide range of applications.

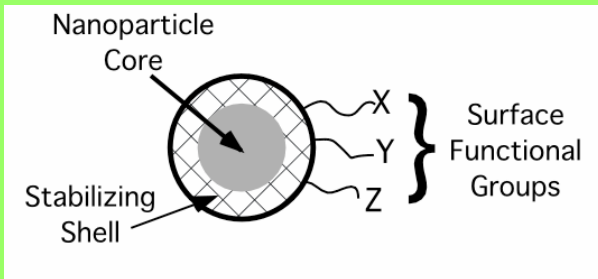
Creating high performance nanomaterials, that pose minimal harm to health or the environment by:

- Designing environmentally friendly nanomaterials and testing to assure bio- and eco-friendly nanomaterials are produced
- Developing greener nanomanufacturing of engineered nanoparticles
- Interfacing nanoparticles and nanostructures for device applications

ONAMI's Safer Nanomaterials and Nanomanufacturing Initiative

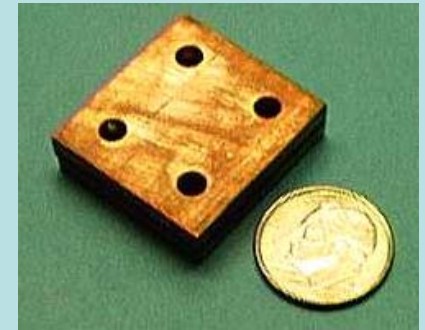
Thrust Group I

Designing Safer Nanomaterials



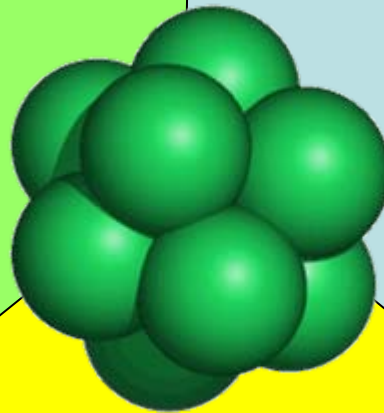
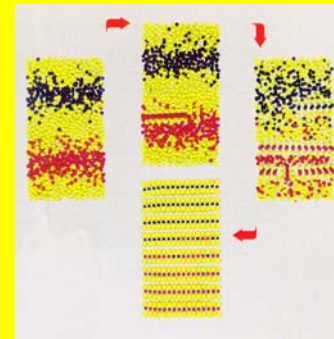
Thrust Group II

Greener Nanomanufacturing of Engineered Nanoparticles



Thrust Group III

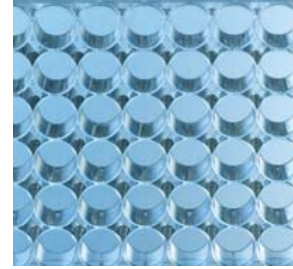
Interfacing Nanoparticles to Nano- and Macro-Structures for Device Applications



Testing the biological impacts of engineered nanoparticles

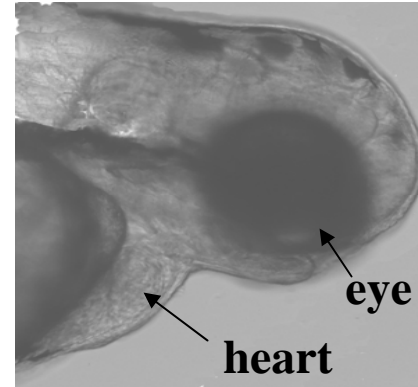
Tier 1: Toxicity Screening

- Toxicity testing in cells, tissues and whole organisms
 - *In vitro* (human cells, tissue cultures)
 - *In vivo* (vertebrate models)



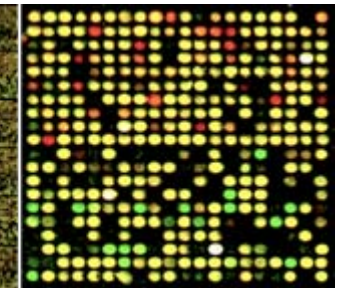
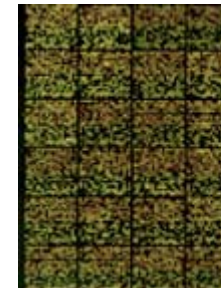
Tier 2: Cellular Targets and Distribution

- Defined *in vivo*
 - Fluorescent nanomaterials
 - Targeted assays



Tier 3: Molecular Expression

- Molecular (genetic) response
 - Whole animal gene expression profiles
 - Vertebrates



Nanomaterial Effects Database



Feed data back into design scheme

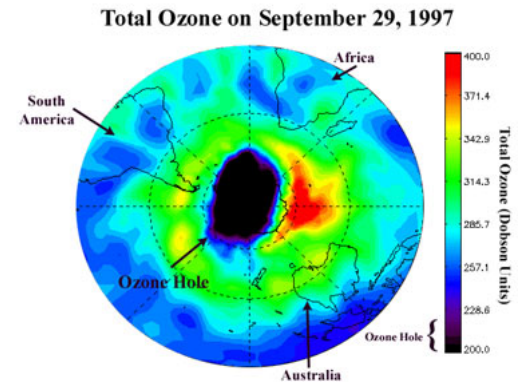
ONAMI-SNNI strategies and research needs assessment

- Precautions in the face of uncertainty
- Proactive design schemes - Design for safety
 - Chemical principles and first level risk assessment
 - Fact finding - assay development
 - Synthetic strategies and purity
 - Need for adequate materials characterization

<http://greennano.org/strategies.html>

Design for safety - First level risk assessment

- Examine properties of molecular and microscale analogs
 - Can we compare the hazards to molecular and microscale analogs as a first step?
- Understand the elemental composition and putative effects
 - Dispersal in the environment?
 - ecotoxic?
 - Human exposure? - toxic?



Precautions in the face of uncertainty

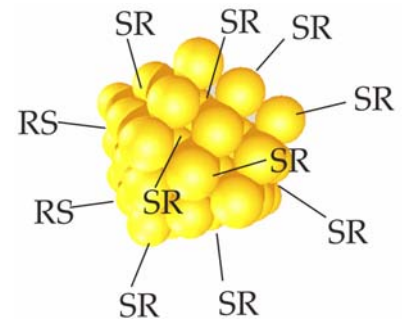
- If we have no available data on hazards, how is exposure measured for nanoparticles?
- What are the testing schemes for consumer products?
 - Need well-developed assays for testing commercial products - Who will develop?
 - Who will judge the quality of these approaches?

Design for safety - Fact finding

- **Develop tests** to ascertain impacts of nanoparticles on health and the environment
 - Standardize how concentration will be determined (molarity, surface area, particle number?)
- Need **well-characterized** nanomaterials (core composition, size, shape, etc)
 - Pure synthetic libraries
 - Commercially available, *but* must understand effects on impurities
- **Data needs to be shared** - database?
 - Needs to be managed to facilitate Structure-Activity Relationship studies (SAR)

Design for safety - synthetic strategies and purity

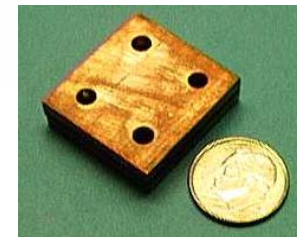
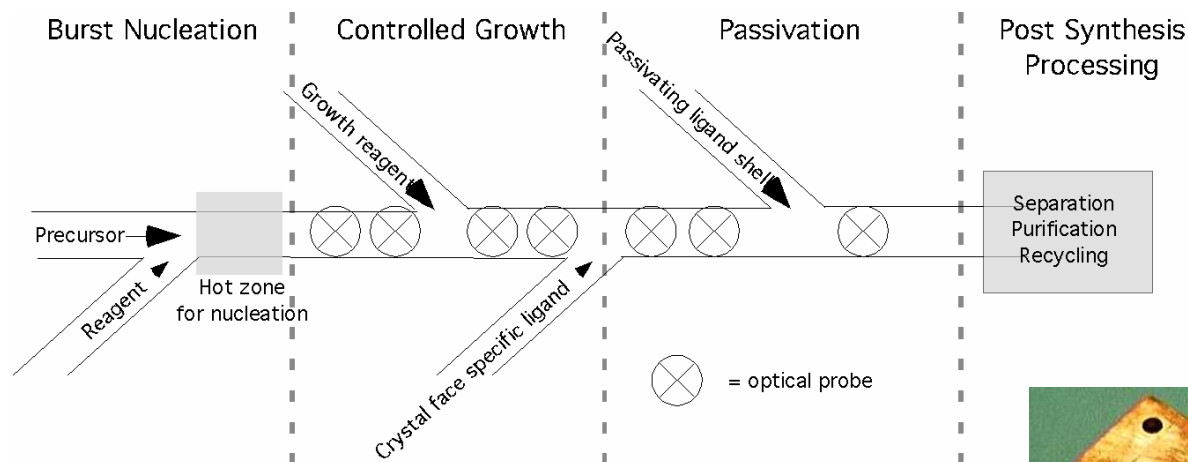
- Need methods to develop
 - nanoparticle fabrication processes (control core and shell size/shape)
 - functionalization methods
- Need methods to assess purity
- Need purification assays (e.g. nanofiltration)



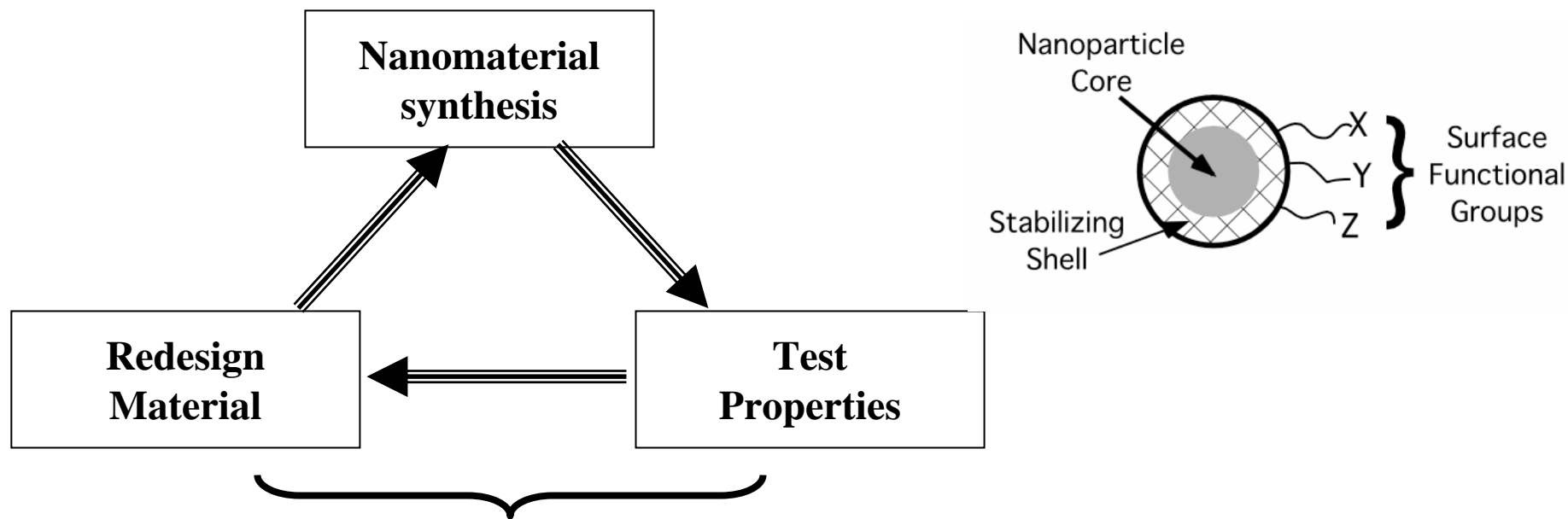
The lack of convenient purification and assessment methods are significant barriers to producing highly pure nanomaterials.

Design for safety - Materials characterization

- Need characterization tools and methods for each class of nanoparticles
- Need in situ methods to monitor syntheses (quality control over batch-to-batch variations)



Designing safer nanoparticles



Structure/Property Relationships:

Physicochemical properties and hazards

Nanoparticles have *widely* tunable properties - the key is to enhance performance and safety at the same time

Research priorities

Proactive approach to nanomaterial design

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Need to learn how to design nanomaterials that have the properties that we desire AND are designed to be safe for the environment and human health



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