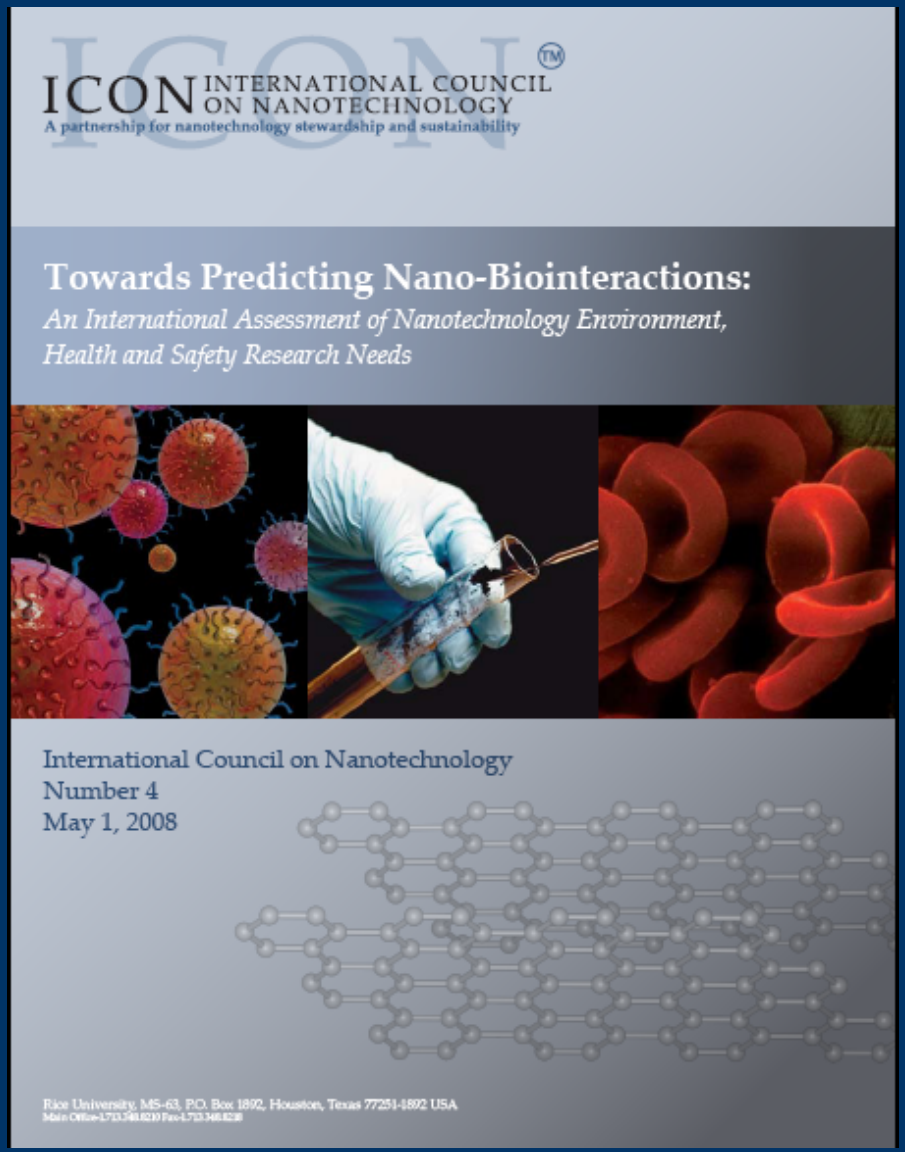

Towards Predicting Nano-Biointeractions:

An International Assessment of Research Needs for Nanotechnology Environment, Health and Safety

Kristen M. Kulinowski, PhD

1 May 2008

Washington, DC

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Acknowledgments

Workshop Steering Team Members

- Cate Alexander Brennan, National Nanotechnology Coordination Office
- John Balbus, Environmental Defense
- David Berube, University of South Carolina
- Vicki Colvin, Rice University
- Scott Cumberland, The Clorox Company
- Kenneth Dawson, University College Dublin
- Thomas Epprecht, Swiss Reinsurance Company
- Mike Garner, Intel Corporation
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- Kristen Kulinowski, Rice University
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- Sally Tinkle, National Institute of Environmental Health Sciences

- David Johnson, Rice University

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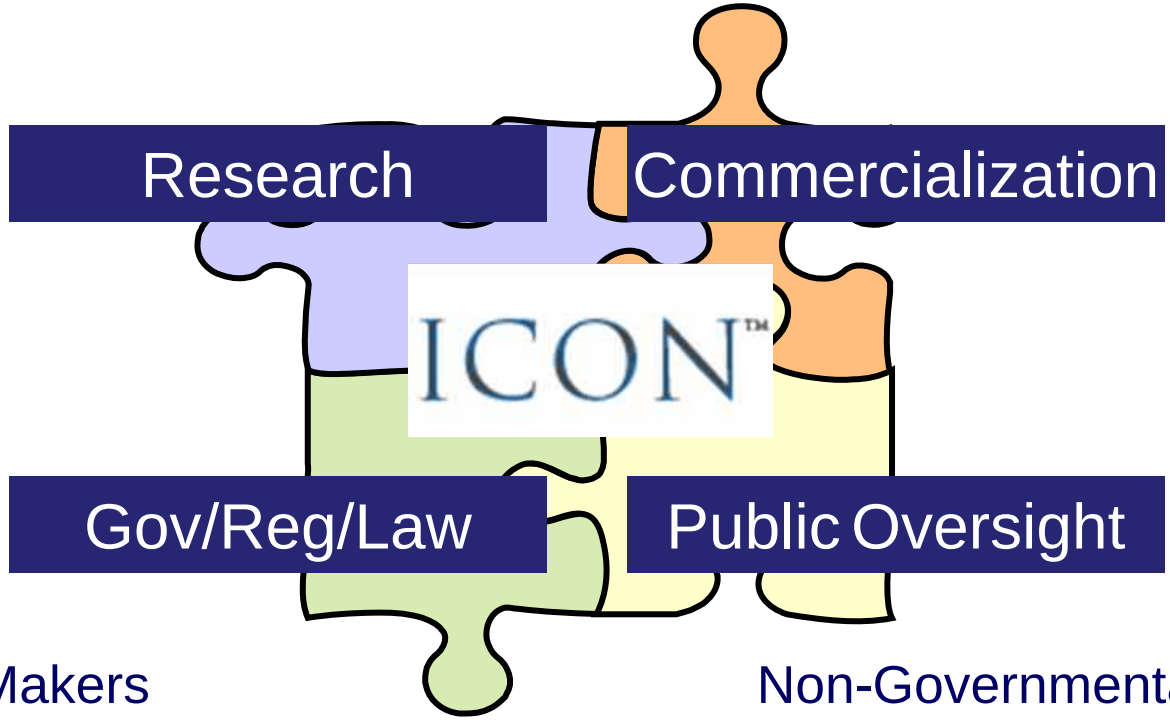
NSF Grant BES-0646107

In-Kind Sponsors

ICON: A New Model for Interaction

Academics
Industry
Government



Industry
Trade Groups

Gov Policy Makers
Regulators
Lawyers

Non-Governmental Organizations
Social/Ethical Researchers

Information regarding potential environmental and health risks of nanotechnology to foster risk reduction and maximize societal benefit.

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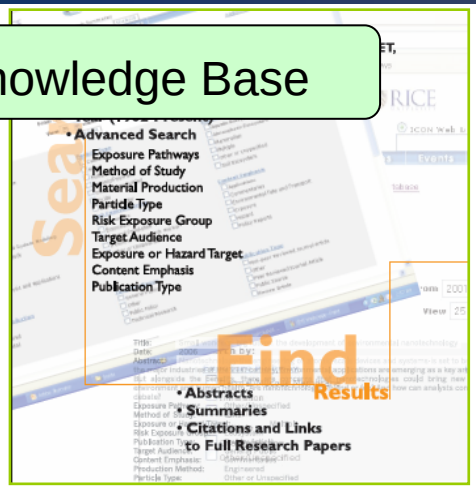
Quality Information about Risks & Benefits

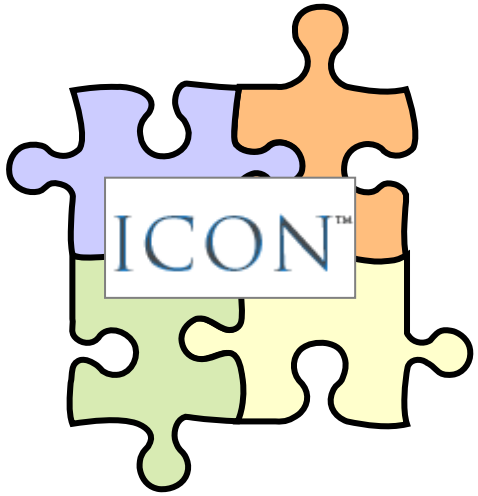
Knowledge Base



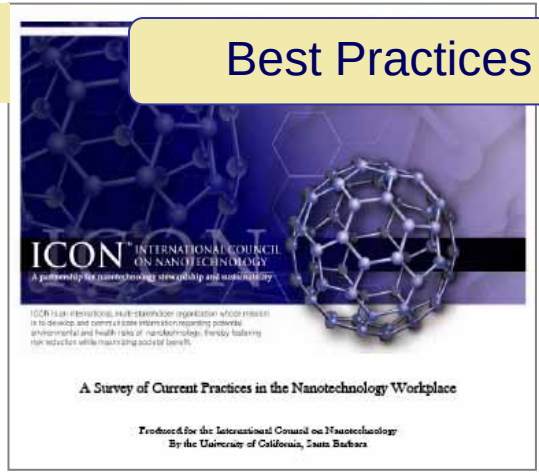
Database/VJ on nanoEHS research

International nanoEHS research needs assessment

New ES&T paper:
DOI: 10.1021/es702158q



Best Practices



Survey of current workplace practices

Communications

ICONsultations with diverse stakeholders

ICON Working Groups

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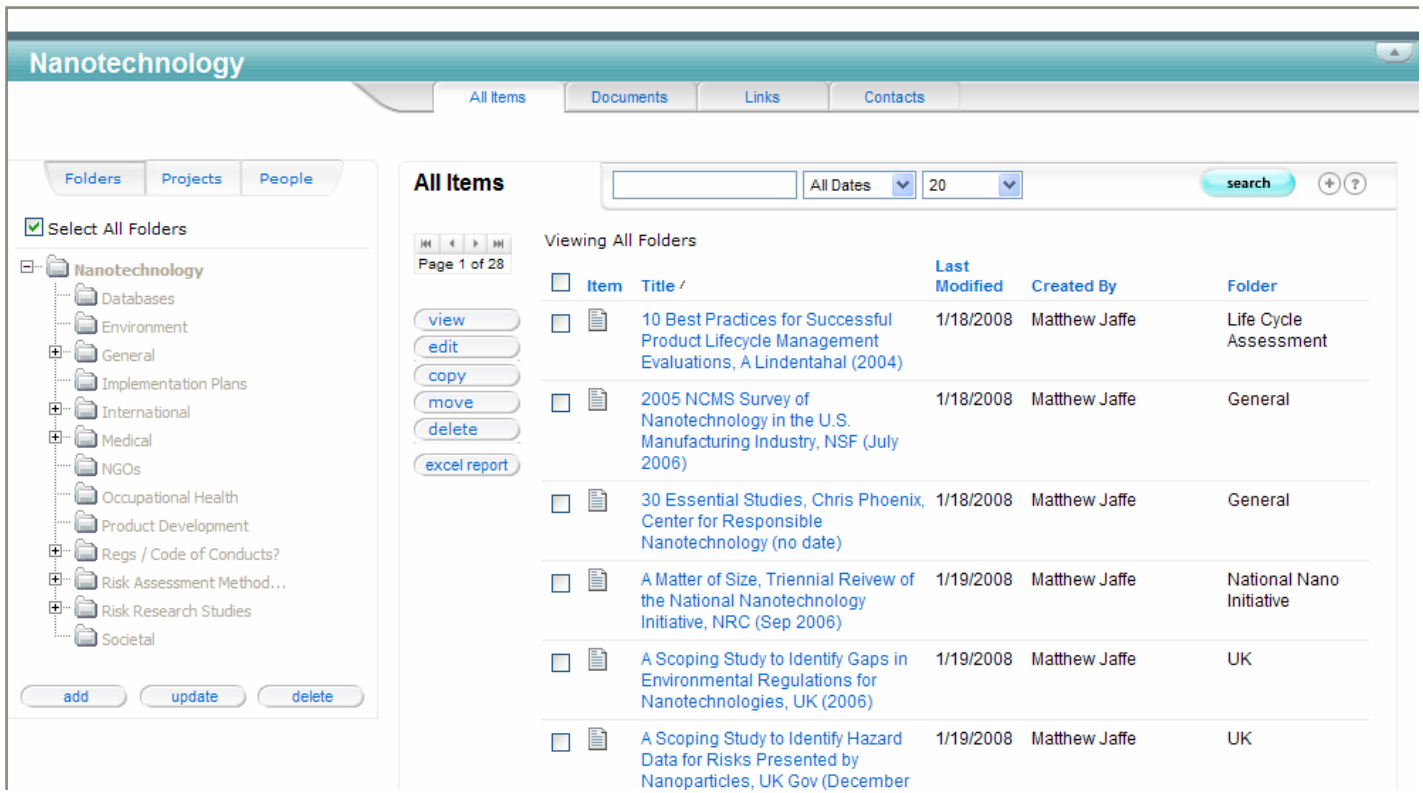
ICON Good Practices Wiki

New!

- Online collaborative information-sharing site on occupational issues
- Collect, discuss, debate, refine information, practices related to handling engineered nanomaterials
- Now recruiting for Planning & Implementation Team and beta testers



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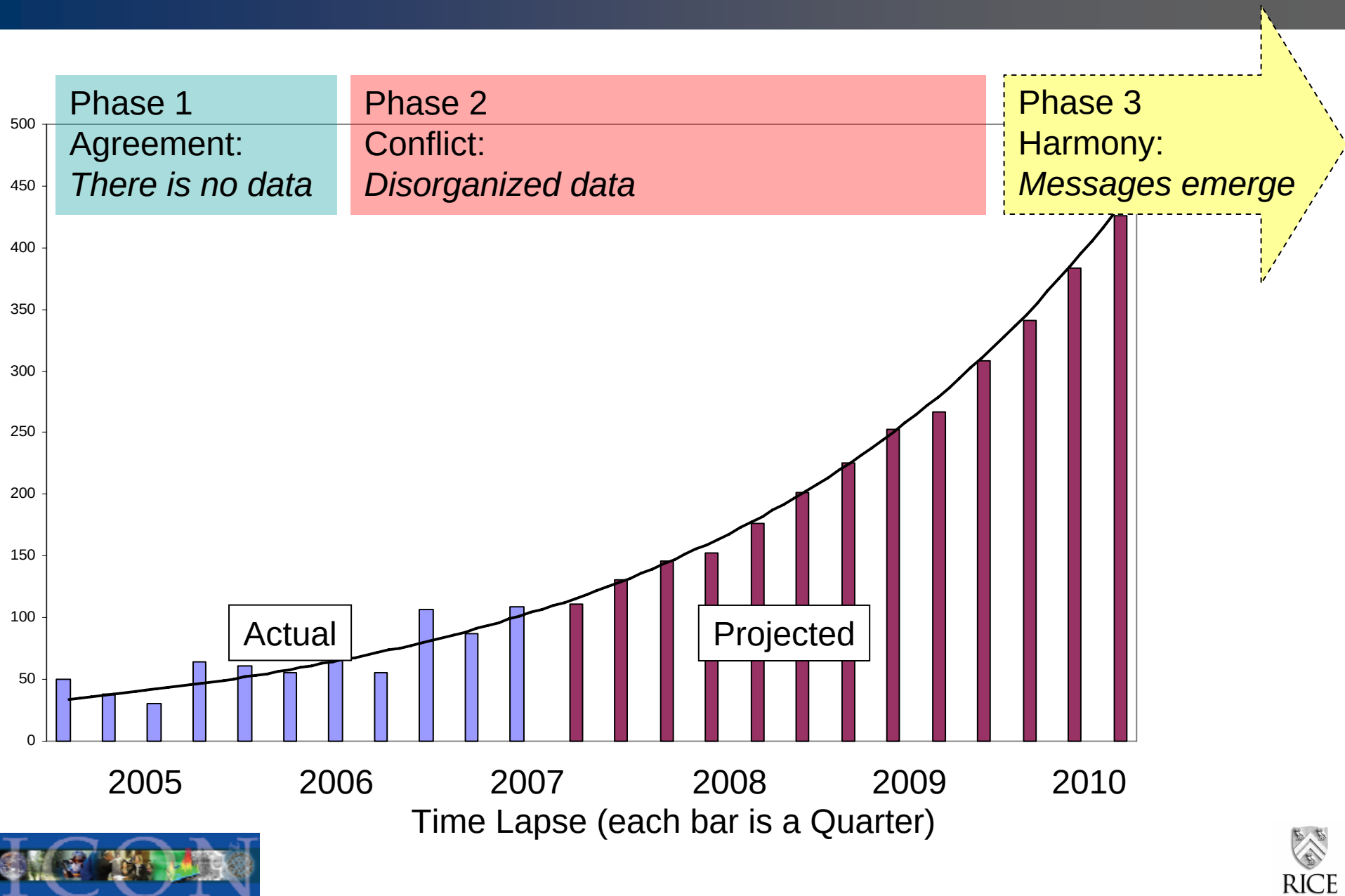
Growth Rate of ICON EHS Database



The Coming Data Explosion

RESEARCH
Creation of new information

INFORM	EDUCATE	FRAME
COLLECT	FILTER	SYNTHESIZE
VALIDATE	ORGANIZE	DEBATE
PRESENT	EXPLAIN	COMPARE
CRITIQUE	SUMMARIZE	

DECIDE
Write a policy position

More and more technical data becoming available

The GAP will only widen

More and more pressure to make decisions

V.Colvin

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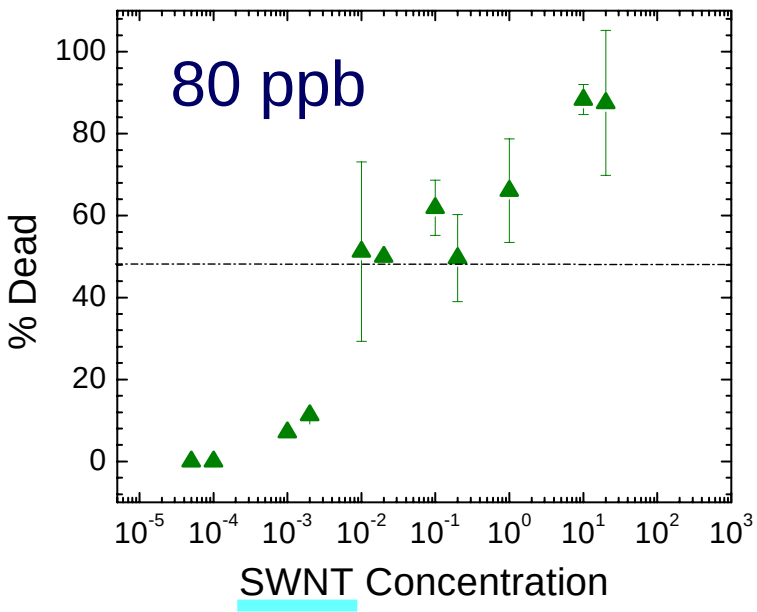
NM Diversity Complicates Risk Assessment

Are single-walled carbon nanotubes toxic?



Colvin, et al. unpublished

- 20 major types of SWNT
- 4 manufacturing types (trace impurities)
- Lengths ranging from 5 – 300 nm
- 5 methods of purification
- 10 possible surface coatings

> 50,000 SWNT samples

Policy question: How can better tools for predicting nanomaterial risk be developed?

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International NanoEHS Research Needs

GRAND CHALLENGE: Computational Models that Predict Interactions of Engineered Nanomaterials with Organisms and the Environment

Workshop 1: Towards Nanomaterial Classes

- Develop classification of NMs based on material type
- Determine present and future applications
- Describe potential hot spots in lifecycle
- Describe properties important to biointeraction

NIH Campus Jan 2007

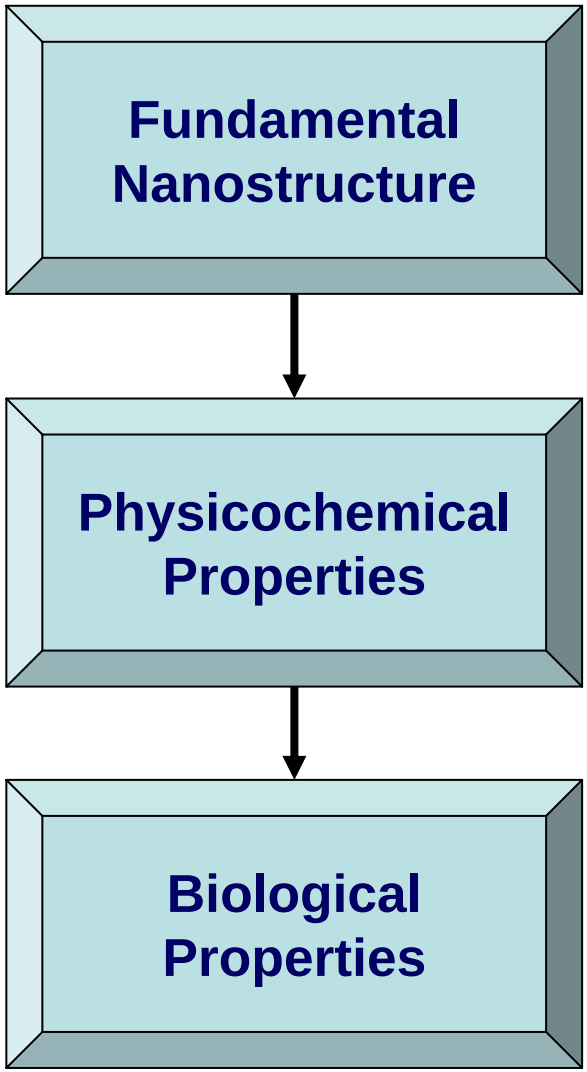
Workshop 2: Towards Predictive Models

- Elucidate mechanisms of nano-biointeractions
- Elucidate interactions at cell-free, cellular, tissue and whole animal levels
- Develop prioritized strategies and timelines

Swiss Re June 2007

OVERALL GOAL OF WORKSHOPS: Prioritized Research for Predicting Biointeractions for Nanomaterials of Commercial Relevance

Workshop 1 – Develop Hypotheses

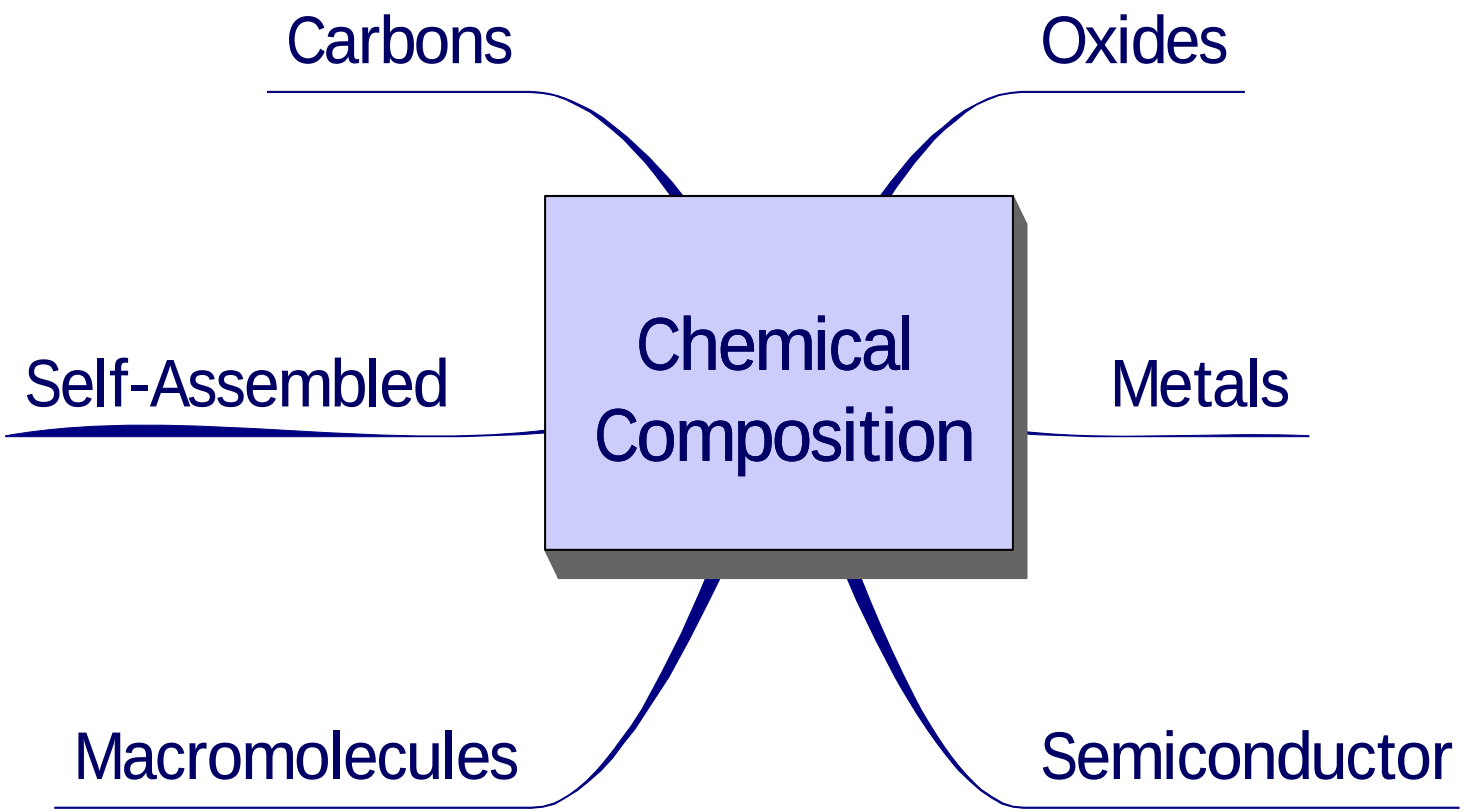


- Size
- Composition
- Surface coat
- Format
- Shape
- Charge
- Molecular purity
- Nanoscale purity
- Aggregation

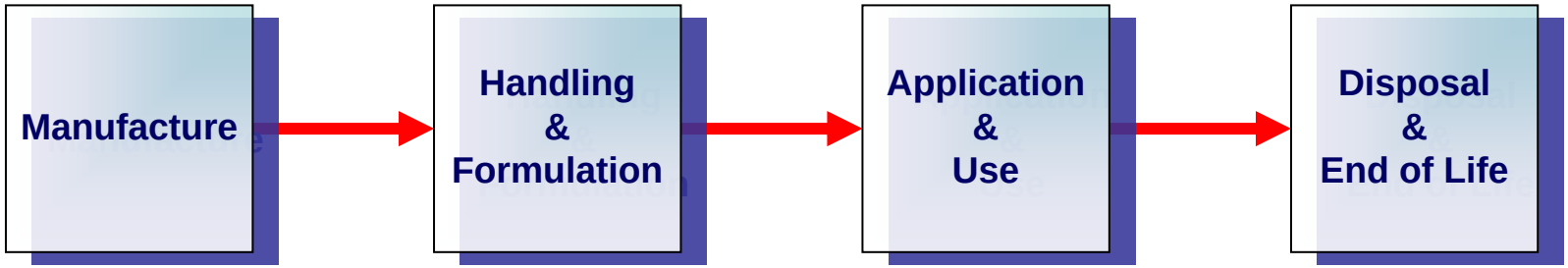
Which material features will matter the most for biological activity?

A Starting Point for Nanomaterial Classes

Charge to Breakout Groups: For your NM class, discuss common applications, hot spots and properties important to biointeraction



Potential Hot Spots in Lifecycle



Consider current & future potential applications with:

- High **exposure potential** to “free” nanomaterials
  - High concentration
  - Long term exposure
  - Identify likely exposure pathways
- High **hazard potential**
  - High chemical toxicity
  - High chemical reactivity
  - Other
- Are common coatings & formulations durable?

Workshop 1 Key Findings

CHALLENGE: Nanomaterial properties are not static throughout lifecycle

Tools and models must be developed that can describe the dynamic nature of nanomaterials throughout their lifecycle.

CHALLENGE: Chemical composition is not the ideal or sole property on which to focus

A set of screening tools is needed to correlate the functional properties of nanomaterials with their potential for biological interaction.

CHALLENGE: Exposure scenarios are too diverse to draw general conclusions

Exposure assessment studies are needed to enable predictions about implications of physicochemical properties for net dose.

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Workshop 2: Towards Predicting Nano-Biointeractions

GRAND CHALLENGE: Computational Models that Predict Interactions of Engineered Nanomaterials with Organisms and the Environment

Workshop 1: Towards Nanomaterial Classes

- Develop classification of NMs based on material type
- Determine present and future applications
- Describe potential hot spots in lifecycle
- Describe properties important to biointeraction

Workshop 2: Towards Predictive Models

- Elucidate mechanisms of nano-biointeractions
- Elucidate interactions at cell-free, cellular, tissue and whole animal levels
- Develop prioritized strategies and timelines

Swiss Re June 2007

OVERALL GOAL OF WORKSHOPS: Prioritized Research for Predicting Biointeractions for Nanomaterials of Commercial Relevance

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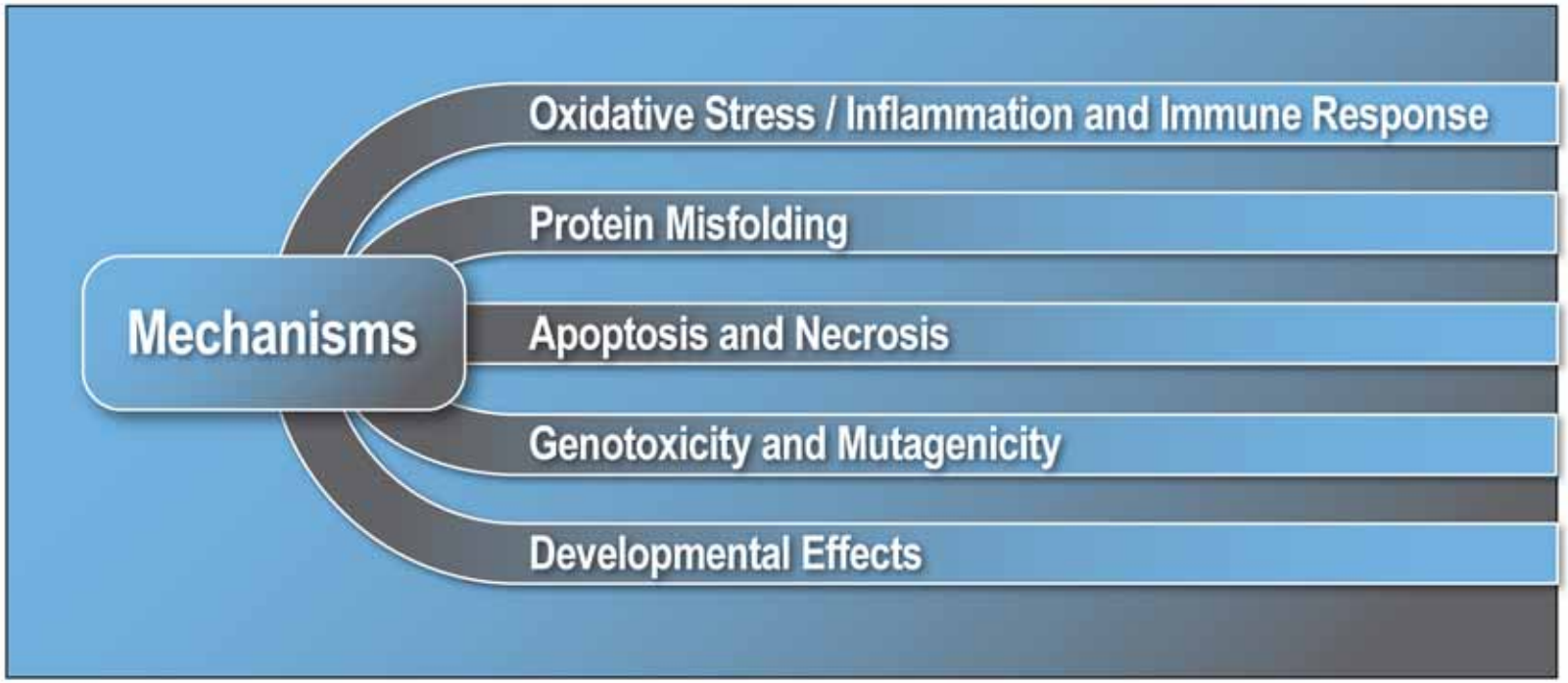
Breakout Session #1

Research activities for elucidating effects and **MECHANISMS** of nano-biological interactions.



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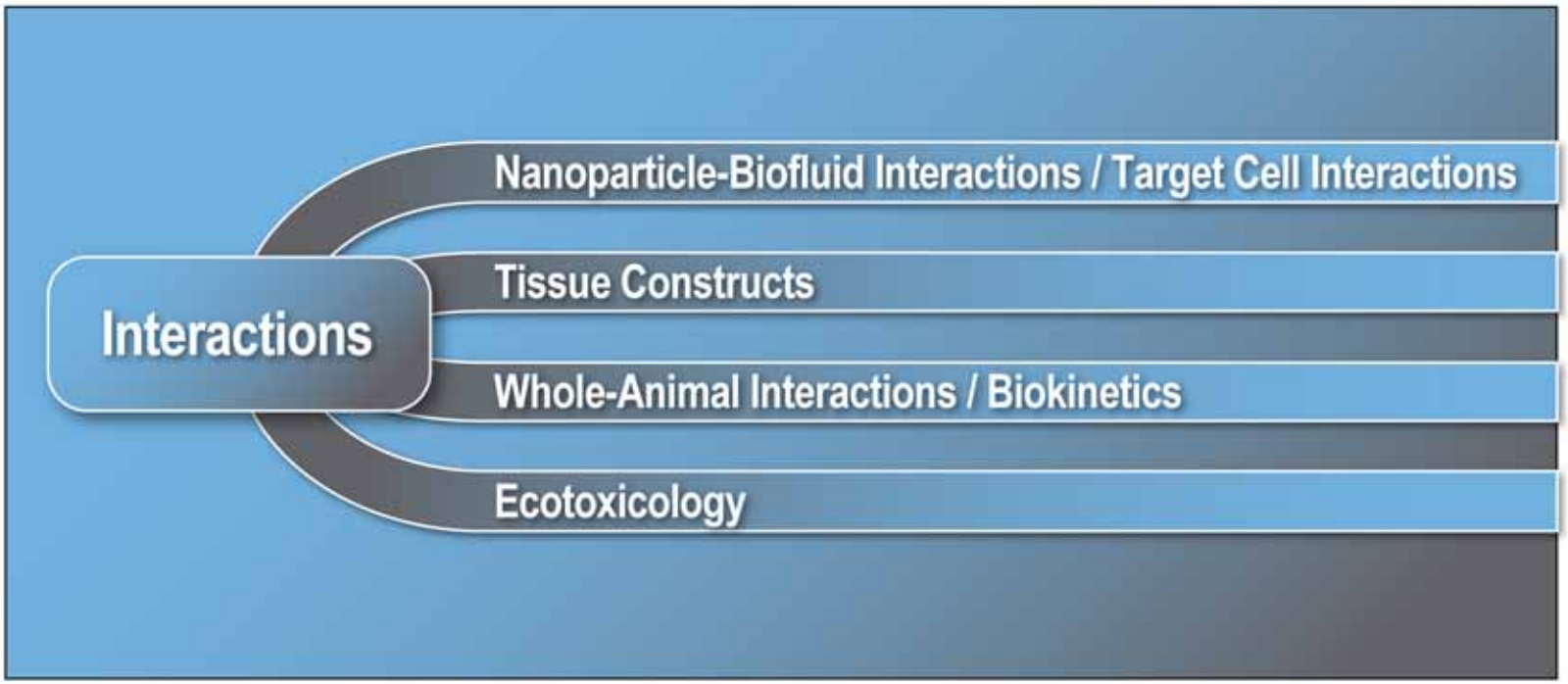
Breakout Session #2: Interactions

Research and testing strategies for understanding nano-biological **INTERACTIONS**.



GOAL: Produce a Request-For-Proposals-type document that lays out prioritized research over 2-, 5- and 10-year timescales.

Workshop 2 Key Findings

CHALLENGE: Nanoparticle surfaces undergo changes during interactions in biological environments

Quantitative models are needed to describe how the physicochemical properties of nanoparticles control the nature and extent of biomolecular interactions at their surface.

CHALLENGE: Existing mass-based metrics of measuring dose and dose rate may underestimate nanoparticle impacts

Dose and dose rate may need to be validated independently for nanomaterials.

CHALLENGE: In vitro assays are needed for practical purposes given nanomaterial diversity but may be poor predictors of in vivo endpoints

Better biomarkers are essential to address the vast diversity of nanoparticle types and to develop strong correlative models for predicting in vivo endpoints based on in-vitro results.

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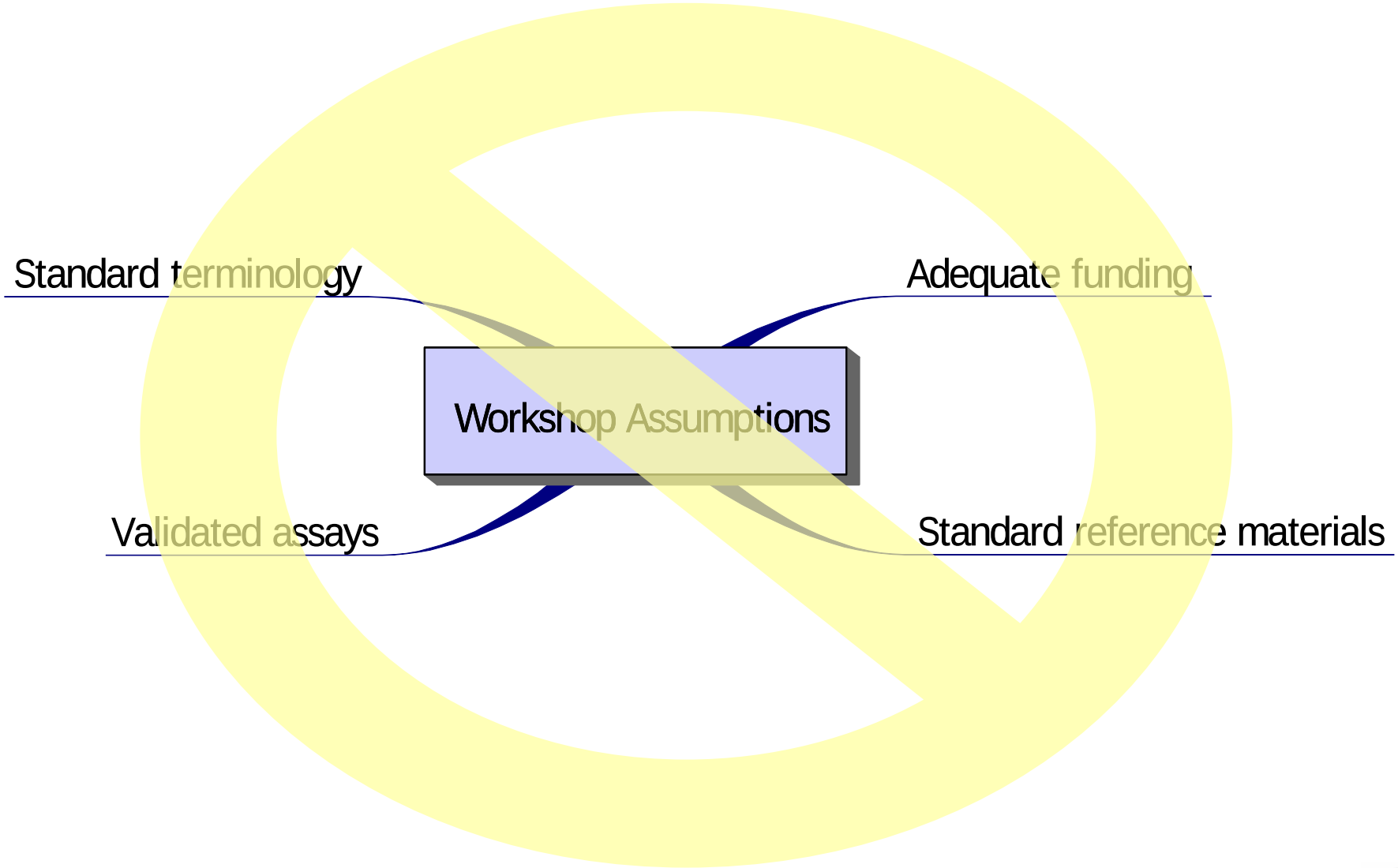
Workshop Assumptions



Cross-Cutting Issues between WS 1 and 2

Many outstanding needs

- Lack of standards for terminology, characterization, and materials
- Metrology and tools to characterize and measure nanomaterials and to monitor their presence in the environment and in biological media
- Test methodologies to characterize potential mobility of embedded nanomaterials
- Evaluation of the appropriateness of in vitro tests to characterize nanomaterial interactions more broadly,
- Standardization of biological materials used in testing
- Creation of a data-sharing framework to accelerate development of models

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Highest Priority Research

Research to Predict Nano-Biointeractions

- Understand which NM characteristics are most important for biointeractions
- Establish validated NMs that have been tested in vitro and in vivo
- Develop tools for in vitro testing that map onto in vivo endpoints
- Develop new techniques for imaging NMs in biological media and organisms
- Determine fate and interactions of NMs in reference organisms
- Design framework for data sharing and ontologies

Highest Priority Research

Research to Meet Risk Management Needs

- Identify/develop tools for detecting and characterizing presence of NMs in the workplace and the environment
- Validate the effectiveness of personal protective equipment in limiting exposure
- Establish test methods for evaluating the stability and mobility of NMs in liquid and solid matrices

For more information

Full report is available at

http://icon.rice.edu

http://icon.rice.edu/virtualjournal.cfm

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