Nanotechnology and human health impact

A framework for strategic research?

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THE PEW CHARITABLE TRUSTS

Project on Emerging Nanotechnologies
at the Woodrow Wilson International Center for Scholars

Challenge

- Nanotechnology has great potential
  - Revolutionary Technology
  - “Engine of Innovation”
  - Many societal and environmental benefits anticipated
- BUT..
  - There may be unanticipated roadblocks, including unexpected risk to human health and the environment
- Sustainable nanotechnology will depend on
  - Societal Acceptance
  - Minimizing risk
  - Maximizing benefits

Framework for Strategic Research
Human Health Implications

Sustainable Nanotechnology

Specificity	Existing Knowledge	Integration
Risk Assessment	Characterization	Interdisciplinary Collaboration

Global Partnerships	Rationality

Framework for Strategic Research

Human Health Implications

Sustainable Nanotechnology

Specificity

Specificity

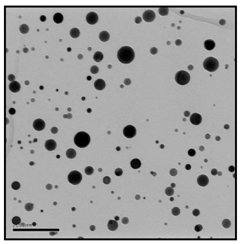
- Nanotechnology is:
  - Diverse
  - Enabling
  - Transient
  - Cross-disciplinary
  - Generic

- Implications-focused research must:
  - Be materials, devices and products-specific
  - Differentiate between materials and products presenting significant, marginal and no potential nano-specific risk

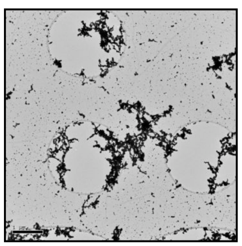
Setting Boundaries

Engineered nanomaterials which potentially present new challenges

- Criteria:
  - Nanomaterials capable of entering or interacting with the body
  - Nanomaterials which potentially exhibit nanostructure-dependent biological activity



Nanoparticles
Simple, complex, “smart”. Aerosols, powders, suspensions, slurries



Agglomerates
or aggregates of nanoparticles

Aerosolized suspensions
Including slurries and solutions of nanomaterials

www.osha.gov

Comminution
Aerosols from grinding, cutting, machining nanomaterials

www.picturearts.com

Degradation/Failure
Aerosols and suspensions resulting from degradation and failure of nanomaterials

?

Unintentional use
Potential exposure from unanticipated/unintentional use

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Specificity

Existing Knowledge

Existing Knowledge

- Nanotechnology is new, unique and innovative, but…

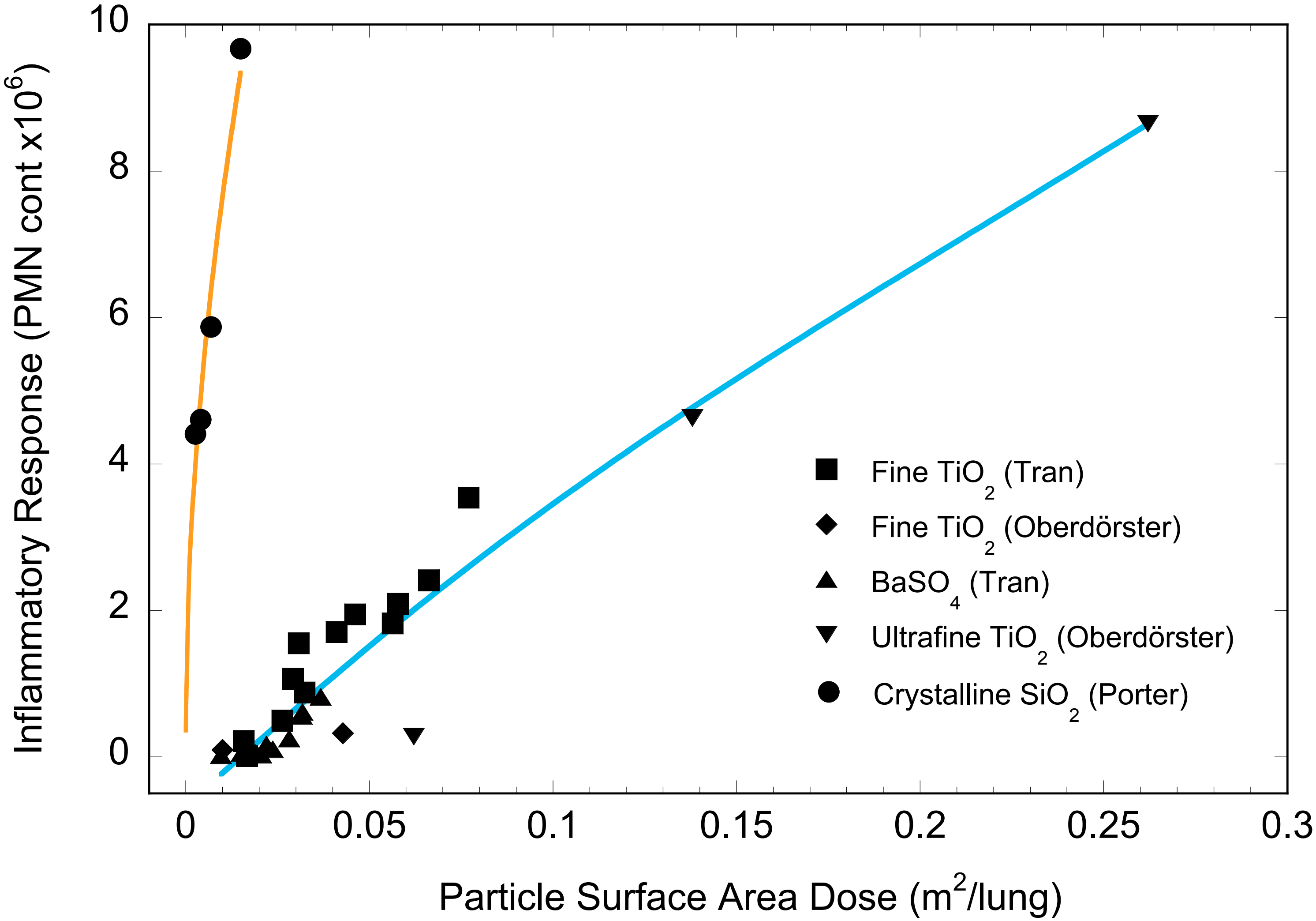
  …Over 100 years of health-impact knowledge counts for something

- Similarity, analogy and first principles:
  - Aerosol behavior
  - Exposure control
  - Health effects - general
  - Hazard - ultrafines
  - Physicochemical significance - e.g. asbestos and crystalline silica

- Extrapolation can be dangerous, but used wisely it can provide strategic direction

Lessons from "conventional" materials

Comparison of insoluble materials with different biological activities



Maynard and Kuempel (2005)

Framework for Strategic Research

Human Health Implications

Sustainable Nanotechnology

Specificity	Existing Knowledge	Integration

Integration

- The reactive, linear, compartmentalized model:
  - "Chemists make the stuff, Epidemiologists document who gets sick, Toxicologists tell us why, Risk Assessors quantify the likelihood of getting sick, and hygienists help reduce the chances of getting sick."
- This will not work for new technologies
  - Complexity
  - Emergent behavior
  - Unacceptable social burden
- The proactive holistic (systemic) model:
  - Integration of risk-based and applications-based research to pre-empt and proactively minimize adverse health impact.

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Human Health Implications

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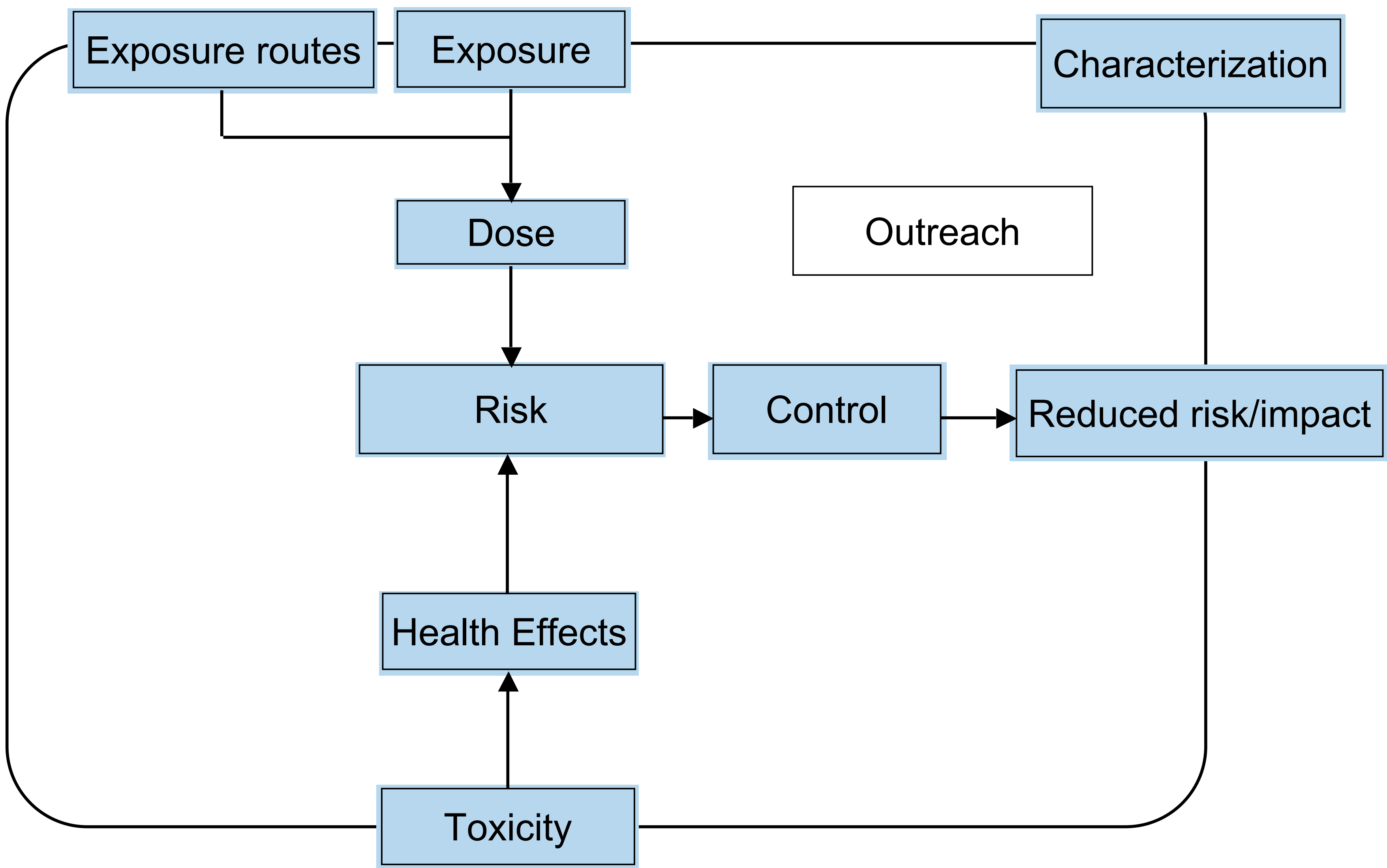
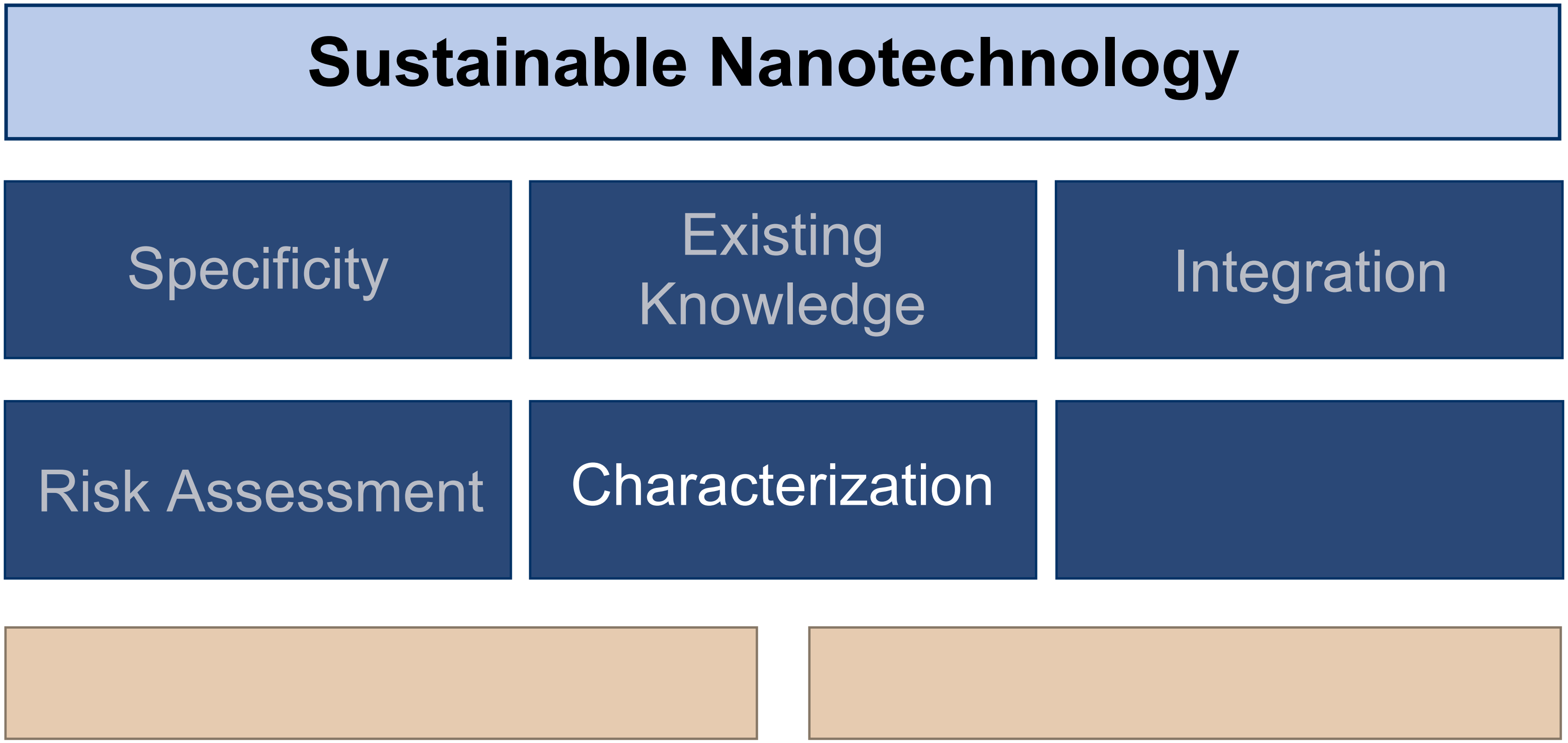
Specificity	Existing Knowledge	Integration
Risk Assessment		

Risk Assessment
(Simplified schematic)



Framework for Strategic Research

Human Health Implications



Characterization

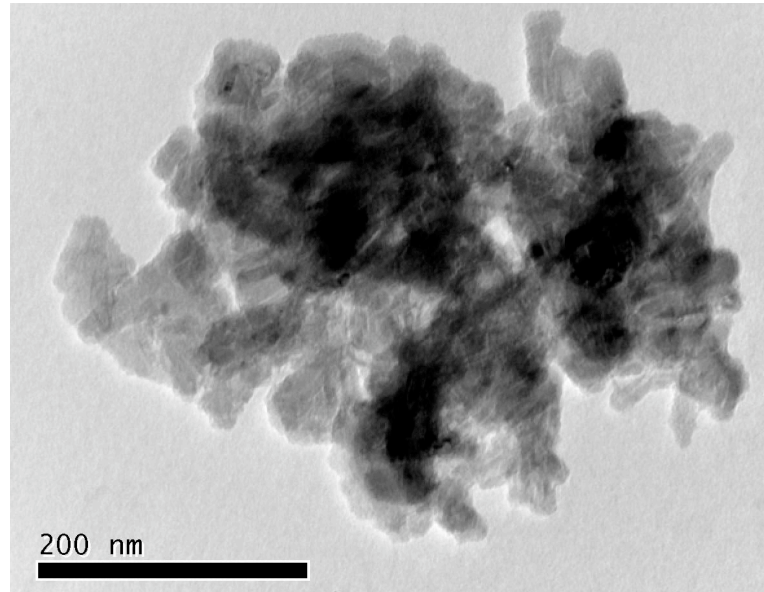
- Risk can not be quantified and quantitatively reduced without an accurate description of the materials and products being used.

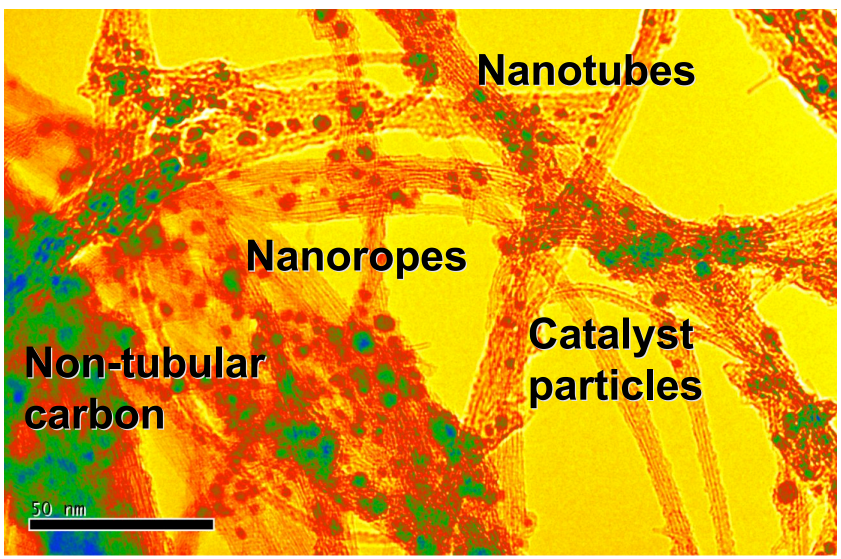
- The complexity of many nanomaterials demands sophisticated characterization - frequently beyond what is considered 'normal'

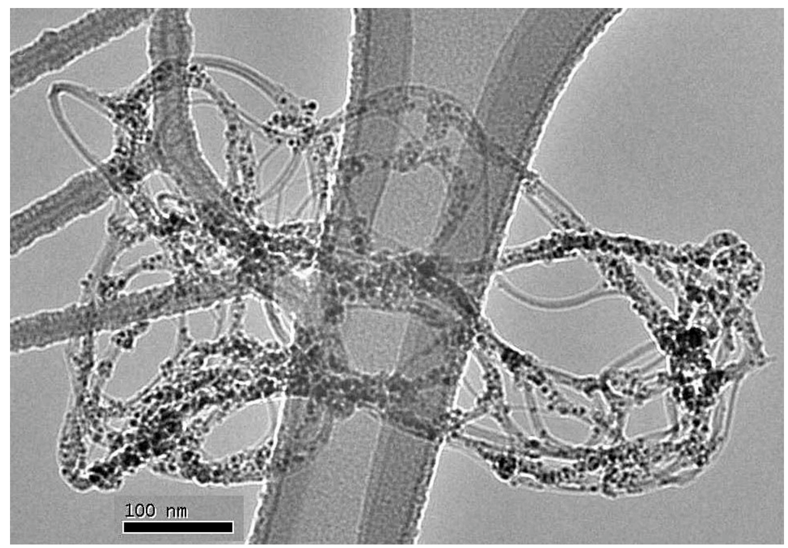
"The dependence of nanomaterial behavior on physical and chemical properties places stringent requirements on physicochemical characterization, and includes assessing a range of properties…"

Oberdörster et al. Particle and Fibre Toxicology 2005 2:8

Example
Airborne Single Walled Carbon Nanotubes







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Interdisciplinary Collaboration

- Major scientific breakthroughs occur in the grey regions between established disciplines and fields of research
- Nanotechnology is no exception
- Understanding implications to human health will also require working together in [sometimes] uncharted waters between disciplines

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Global Collaboration

- Global implications require global cooperation and collaboration
- Complex problems require coordinated approaches to finding solutions
- Resources are limited
- Synergism

Rationality

Cutting through the hype

- Nanotechnology is revolutionary…

  …but we've been through technology revolutions before

- Nanomaterials have unique properties…

  …but the body responds to foreign materials in limited ways

- Little is known about the health impact of engineered nanomaterials…

  …but we're not starting out from a point of total ignorance

Beyond the hype and confusion, sustainable nanotechnology will ultimately depend on scientifically valid questions being asked, and scientifically robust answers being found.

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