Harnessing the Power of Nanotechnology for Human Health: The NIH/NIEHS Perspective

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NIH Mission

NIH is the steward of medical and behavioral research for the US.

Science in pursuit of

• fundamental knowledge about the nature and behavior of living systems.
• application of that knowledge to prevent, detect, diagnose, and treat disease and disability.
Research Framework

Environmental Exposure → External Contact → Internal Dose → Biological Response → Early Markers of Disease → Clinical Disease

Adapted from the National Research Council, 1987

Exposure
- Routes of Exposure
- Biomarkers of Exposure
- Fate of Material on Entry

Cellular and Molecular Mechanisms
- Biomarkers of Disease/Progression
- Imaging and Sensor Technology
- Therapeutics

Implications

Applications

Interaction of Engineered Nanomaterials with Biological Systems
Harnessing the Power of Nanotechnology for Biology and Medicine
Biological systems as templates for nanoscale and nano-enabled products

Courtesy of Jeffrey Schloss, Ph.D., NHGRI/NIH
Nanoscale sensors for detection and analysis of biological processes

M. Di Ventra, 2006, Nano Lett. 6:779-782
Multi-functional nanoscale structures for diagnostics and therapeutics

Jolanta F. Kukowska-Latallo, et al., *Cancer Research* 65, 5317-5324, June 15, 2005
Harnessing the Power of Nanotechnology to Minimize Risk
Translating the Research Framework to Nanotechnology

Material Synthesis

Environmental Exposure ➔ External Contact ➔ Internal Dose ➔ Biological Response ➔ Early Markers of Disease ➔ Clinical Disease

Susceptible Populations

Dose Structure

Response Activity

Predictive Models

Risk Assessment
Integrating the Science and the Framework

Interaction of Engineered Nanomaterials with Biological Systems

Structure  Activity

Predictive Models
Risk Assessment

Implications  Applications
Traditional Extramural Research Mechanisms with Improved Federal Agency Cooperation

RFA:
Fundamental Interactions in Biological Systems

Partners:
5 NIH Institutes, EPA, NIOSH, NSF

e.g., Membrane dynamics
Systemic transport
Subcellular localization
Phenotypes
Is This Getting Us Where We Need to Go?
Taking the Next Steps…

- Build on the NIH investment and core competencies
- Pool expertise across government, industry and academia to pursue the very best science
- Target questions within a shared research strategy
- Leverage investment for research efficiencies
- Consistent with US goals for safe commercialization and innovation

...Building the NanoHealth Enterprise
NanoHealth Initiative: Research Themes for the NanoHealth Enterprise

**Materials Science Research**
- *characterization* of the physical and chemical properties of ENM in relevant biological systems;

**Basic Biology Research**
- determination of the relationship of nanoscale size and physicochemical properties to *biological response* at the cellular, molecular and systemic levels;

**Pathobiology Research**
- investigation of the relationship of nanoscale size and physicochemical properties to ENM-induced *pathophysiologic endpoints* and the development of disease;

**Informatics Resource (NIBIB)**
- *collection and organization* of ENM data to facilitate data sharing and data mining to discover structure-function relationships; and

**Training Program**
- education of scientists to work on *cross-disciplinary and interdisciplinary research teams*, and to develop research programs that integrate materials science, biology, and pathobiology research.
Exploratory Research: Targeted Questions with Basic Biology Answers

- Material Synthesis
- Environmental Exposure
- External Contact
- Internal Dose
- Biological Response
- Early Markers of Disease
- Clinical Disease
- Interaction with Biomolecules
- Membrane Dynamics
- Interaction with Biological Fluids
- Homeostatic Mechanisms and Pathways
- Disrupted Homeostasis
- Exacerbation of Existing Disease

Engineered Nanomaterials Informatics Resource
Expanding the Definition of Research Products

- Biologically and clinically relevant design principles
- Curated data sharing framework
- Network of research partners
- Strategic product design and development
- Shorter time from concept to manufacture
- Data for hazard identification
- Standards setting

Scientific Foundation of an Emerging Science
Public-Private Partnerships: Expanding the Way We Do the Business of Research

• Leverage scientific expertise and funding
• Promote dialogue and coordinated effort
• Accelerate high priority projects by packaging and procuring services in new ways
• Facilitate delivery of technology developed by private entities

• Bring collaborative, entrepreneurial approach to large and complex problems and programs
Flexible and Modular Mechanisms
Shared Leadership

International Collaborators  Administrative Team of Funding Partners  Advisory Committee

Scope Of Research

Management Team

Steering Group  Steering Group  Steering Group  Project Team  Project Team  Project Team

Standard Peer Review  Accelerated Peer Review

RESEARCH
Building the NanoHealth Enterprise

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