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An Overview of Initiative on Biosystems At the Nanoscale

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Acknowledgement: Mike Roco of NSF provided several slides for this presentation.

The National Nanotechnology Initiative

- The process
- Science and engineering research priorities
- Activities of the Interagency Working Group on Nanoscience, Engineering and Technology (IWGN)
- NSF Activities

History - NNI Timeline

• November 1996	Nanotechnology Group (bottom-up)
• September 1998	NSTC establishes IWGN
• January 1999	Workshop on research priorities
• March 1999	OSTP/CT presentation on NNI
• May-June 1999	Congress hearings
• July-Sept. 1999	Three background publications
• August 1999	First draft of the IWGN Plan
• Oct.-Nov. 1999	PCAST Nanotech Panel Review
• December 1999	PCAST Full Committee Consent
• December 1999	OMB Review
• January 2000	OSTP and WH Approval
• February 2000	Release of Initiative

M.C. Roco, NSF

Nanotechnology R&D Funding by Agency

	FY 2000 ($M)	FY 2001 ($M)	% Increase
National Science Foundation	$97M	$217M	124%
Department of Defense	$70M	$110M	57%
Department of Energy	$58M	$94M	66%
NASA	$5M	$20M	300%
Department of Commerce	$8M	$18M	125%
National Institutes of Health	$32M	$36M	13%
TOTAL	$270M	$495M	83%

NNI Report, Feb. 2000

Funding by NNI Research Portfolio

	Fundamental Research	Grand Challenges	Centers & Networks of Excellence	Research Infrastr.	Societal Implications/ Workforce	Total
FY 2000	$87M	$71M	$47M	$50M	$15M	$270M
FY 2001	$170M	$140M	$77M	$80M	$28M	$495M

NNI Report, Feb. 2000

Neal Lane
Testimony in Congress on April 1, 1998

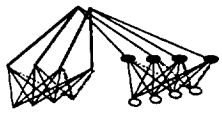
"If I were asked for an area of science and engineering that would most likely produce the breakthroughs of tomorrow, I would point to nanoscale science and engineering, often called simply, 'nanotechnology,' . . . only recently have scientists been able to glimpse Feynman's vision by creating rudimentary nanostructures."

Examples of Nanotechnology Applications

- Giant magnetoresistance in magnetic storage applications
- Nanostructured catalysts
- Drug delivery systems
- Nanocomposites: nanoparticle reinforced polymers
- Two examples of nanoelectronic devices
- LED lightning breakthroughs from nanotechnology
- National security: Bio detection
- Water purification and desalinization

Grand Challenges

- Nanostructured materials "by design" - stronger, lighter, harder, self-repairing, and safer
- Nanoelectronics, optoelectronics and magnetics
- Advanced healthcare, therapeutics and diagnostics
- Nanoscale processes for environmental improvement
- Efficient energy conversion and storage
- Microcraft space exploration and industrialization
- Bio-nanosensors for communicable disease and biological threat detection
- Application to economical and safe transportation
- National security



IWGN Publications
www.nano.gov

- *National Nanotechnology Initiative - Leading to the Next Industrial Revolution*
  Supplement to the President's FY 2001 Budget, 2/2000
- *Nanotechnology - Shaping the World Atom by Atom*
  Brochure for the Public
- *Nanostructure Science and Technology*
  Worldwide Study
- *Nanotechnology Research Directions*
  IWGN Workshop Report
- **15 Supporting Publications/Proceedings by Agencies for**
  - **Specific scientific topics (modeling, selfassembling, macromolecules)**
  - **Technological issues (synthesis, processing, nanofabrication)**
  - **Areas of relevance (energy, space, biomedicine, biotech, chemicals)**

Sampling the Programs at NSF

Mainly Seed Funds:

- Synthesis and Processing of Nanoparticles (since 1991)
- National Nanofabrication User Network (since 1994)
- Nanoscale Instrumentation (1995)

Larger Investments:

- Functional Nanostructures (1998)
- Biotechnology at Nanoscale (1999/00, exploratory), Nanoscale Modeling and Simulation Centers (2000)
- STTR and SBIR Solicitations on Nanotechnology (1999/00)

M.C. Roco, NSF

Nanoscale Science and Engineering
NSF Areas of Focus in FY00 and FY01

- Nano-Biotechnology
- New Phenomena and Structures, Quantum Control
- Integration at the Nanoscale: Systems and Architectures
- Interfaces in Environment at Nanoscale
- Nanoscale Theory, Modeling and Simulations
- Education and Society Implications

NNI Interagency Collaborative Activities
(Examples, to be Finalized After NNI Approval by Congress)

Agency	DOC	DOD	DOE	NASA	NIH	NSF
Fundamental research		x	x	x	x	x
Nanostructured materials	x	x	x	x	x	x
Molecular electronics		x (DARPA)		x		x
Spin Electronics		x		x		x
Lab-on-a-chip (nanocomponents)	x	x	x	x	x	x
Biosensors, bioinformatics (1)				x	x (NCI)	
Bioengineering		x (DARPA)	x		x	x
Quantum computing		x	x	x		x
Measurements and standards for tools	x	x	x		x	x
Nanoscale theory, modeling and simulation		x	x	x		x
Environmental monitoring			x	x		
Unmanned missions		x		x		
Nanofabrication user facilities	x		x	x		x

(1) NASA and National Cancer Institute (NCI) join effort to develop nano-explorers for the human body (MOU signed on 4/13/00)

From IWGN Implementation Plan

Biosystems at Nanoscale

- Principal Investigator: **Robert H. Austin**
- Institution: **Princeton University**
- Title:
  Cell Sorting Using Nanomagnetic Nanofabricated Devices
- Purpose:
  To fabricate nanomagnetic devices for cell capture and sorting

Examples of Exploratory Research on Biosystems at Nanoscale

Biosystems at Nanoscale

- Principal Investigator: **R. Bashir**
- Institution: **Purdue University**
- Title:

  Hybridization Based Assembly of Silicon Electronic Devices
- Purpose:

  To develop new approaches for fabrication and assembly of future hybrid bio-electronic devices based on the hybridization and specificity of DNA oligo-nucleotides.

Biosystems at Nanoscale

- Principal Investigator: **Elliot P. Douglas**
- Co-Principal Investigator: Laurie B. Gower
- Institution: **University of Florida**
- Title:

  Nanostructured Composites via Biomimetic Processing
- Purpose:

  Provide a new route to ceramic composites with controlled structure and properties by mimicking the structure of natural bone.

Biosystems at Nanoscale

- Principal Investigator: ***Ashutosh Chilkoti***
- Institution: **Duke University**
- Title:
  Elastin Nanobiosensors
- Purpose:
  To design, fabricate, and characterize a genetically encodable protein nanobiosensor for *in vivo* intracellular real-time measurement of temperature, pH, or kinase activity.

Biosystems at Nanoscale

- Principal Investigator: **Vicki Colvin** (chemistry)
- Co-Principal Investigator: George Phillips (Biology)
- Institution: **Rice University**
- Title:
  Protein Crystals as Templates for Nanoscale Materials
- Purpose:
  To develop chemical methods for replicating the intricate nanoscale architecture of protein crystals into solid materials.

Biosystems at Nanoscale

- Principal Investigator: **Andrés J. García**
- Institution: **Georgia Institute of Technology**
- Title:
  Structural Changes in Fibronectin Binding Domains upon Adsorption to Well-Defined Surface Chemistries
- Purpose:
  Integration of experimental and computational approaches to model structural and functional changes in binding domains upon adsorption to model surfaces.

Biosystems at Nanoscale

- Principal Investigator: **Vladimir Hlady**
- Institution: **University of Utah**
- Title:
  Creating Nanoscale Molecular Imprints Using 2-D Monolayer Templating
- Purpose:
  Goal of the research is to create monolayer surfaces with a custom, nanoscale-imprinted 2-D structure-function relationship.

Biosystems at Nanoscale

- Principal Investigator: **Eric W. Kaler**
- Co-Principal Investigator: Orlin D. Velev
- Institution: **University of Delaware**
- Title:
  Miniaturized On-chip Biosensors by In Situ Assembly of Colloidal Particles
- Purpose:
  A new method is extended to assemble microscopic on-chip biosensors from widely available latex particles used in agglutination assays.

Biosystems at Nanoscale

- Principal Investigator: **Richard A. Kiehl**
- Institution: **University of Minnesota**
- Title:
  Self-Assembly of Nanoparticle Arrays Using Two-Dimensional DNA Crystals
- Purpose:
  To develop a revolutionary technology for the self-assembly of electronic circuitry at the nanoscale.

Biosystems at Nanoscale

- Principal Investigator: **Russell J. Mumper**
- Institution: **University of Kentucky**
- Title:
  Pharmaceutically Engineered Nano-particles for the Targeted Delivery of Plasmid DNA
- Purpose:
  To engineer nanoparticles containing DNA from micro-emulsion precursors that can spontaneously form without the use of expensive and/or damaging methods.

Biosystems at Nanoscale

- Principal Investigator: **W. Mark Saltzman**
- Co-Principal Investigator: Dan Luo
- Institution: **Cornell University**
- Title:
  Modular Nanoscale DNA Delivery Systems
- Purpose:
  To create novel DNA delivery systems that are totally synthetic, modeled after certain characteristics of viruses, produced at the nanoscale in modular fashion, and based entirely on biocompatible polymeric materials.

Biosystems at Nanoscale

- Principal Investigator: **Sandip Tiwari**
- Institution: **Cornell University**
- Title:
  An Electronic Gain Cell for Monitoring Charge on Molecular Chains
- Purpose:
  Demonstrate proof-of-principle of a miniature single-electron charge sensitive semiconductor device with gain that can rapidly profile charge at sub-nm resolution on molecules flowing in a channel.