The National Nanotechnology Initiative:

America's Investment in Nanoscale Science, Engineering, and Technology
(The Federal Part, and Interactions)

Philip H. Lippel, Ph.D.

National Nanotechnology Coordination Office

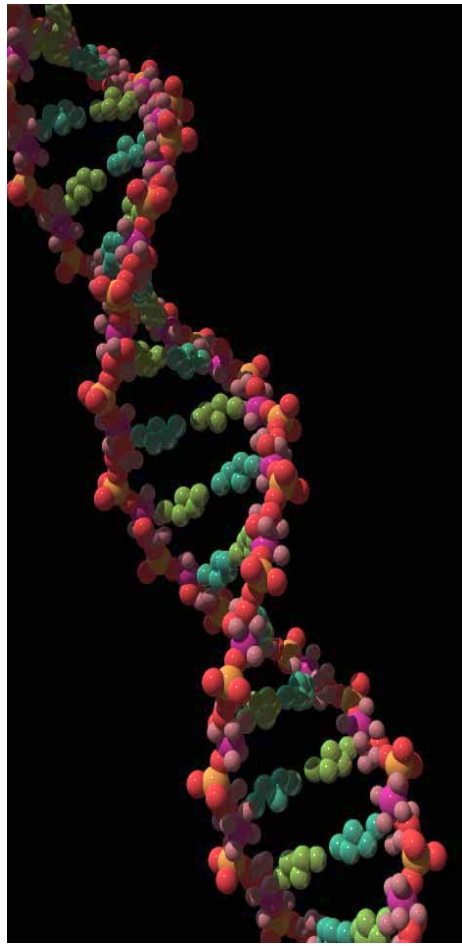
MITX Nanotechnology Commercialization Conference

4 December 2005

What Is the NNI?

The National Nanotechnology Initiative coordinates research and development, regulatory, and trade activities, in nanoscale science, engineering, and technology — or nanotechnology —across the Federal Government.

For FY 2005, R&D expenditures will total over $1 billion across 11 agencies. The organization and strategy laid out in FY 2001 has effectively shaped and guided the initiative over its first four years. A new strategic plan released in December 2004 serves to guide the agencies through the next five to ten years.



NNI Vision: A Revolution in Technology and Industry

The vision of the National Nanotechnology Initiative is a future in which the ability to understand and control matter on the nanoscale leads to a revolution in technology and industry.

Toward this vision, the NNI will expedite the discovery, development, and deployment of nanotechnology in order to achieve responsible and sustainable economic benefit, to enhance the quality of life, and to promote national security. In the process, the NNI will support the missions of the participating agencies, will ensure continuing leadership by the United States in nanoscale science, engineering, and technology, and will contribute to the nation's economic competitiveness.

Four Goals of the National Nanotechnology Initiative

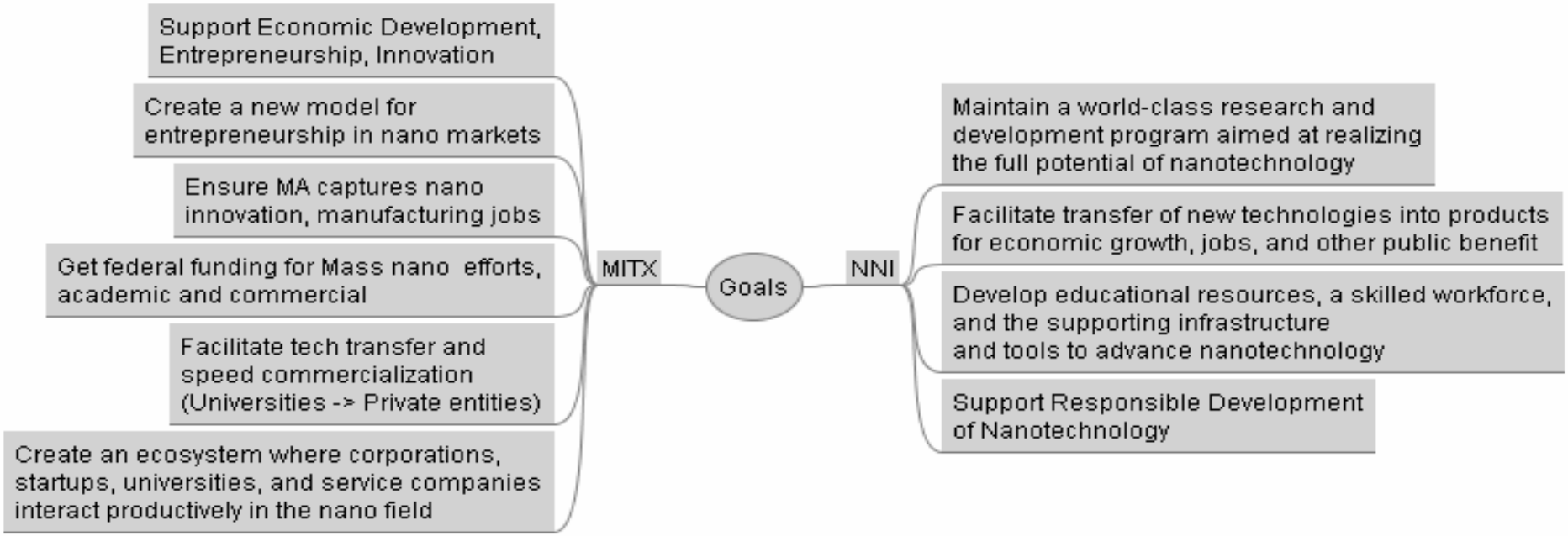
Maintain a world-class research and development program aimed at realizing the full potential of nanotechnology

Facilitate transfer of new technologies into products for economic growth, jobs, and other public benefit

Develop educational resources, a skilled workforce, and the supporting infrastructure and tools to advance nanotechnology

Support responsible development of nanotechnology

NNI and MITX Goals

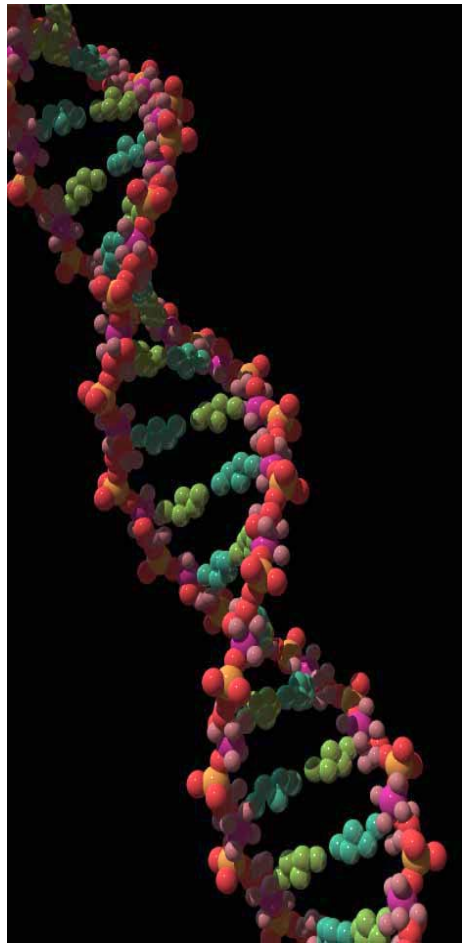


What Is Nanotechnology?

Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications.

Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale.

The physical, chemical, and biological properties of nanomaterials differ in fundamental and valuable ways from the properties of individual atoms and molecules or bulk matter. Nanotechnology R&D is directed toward understanding and exploiting those differences to create improved materials, devices, and systems.

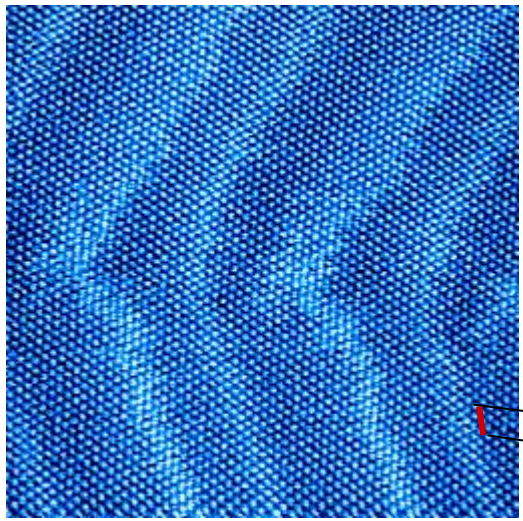


What is the Nanoscale? ~1 to 100 nanometers

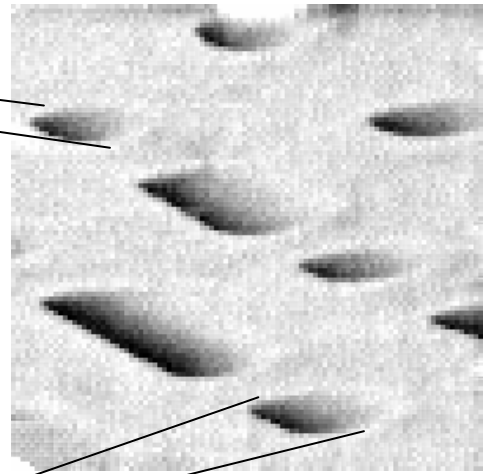
A nanometer

is a millionth

of a millimeter



x 1000



X 1000

Seven NNI Program Component Areas

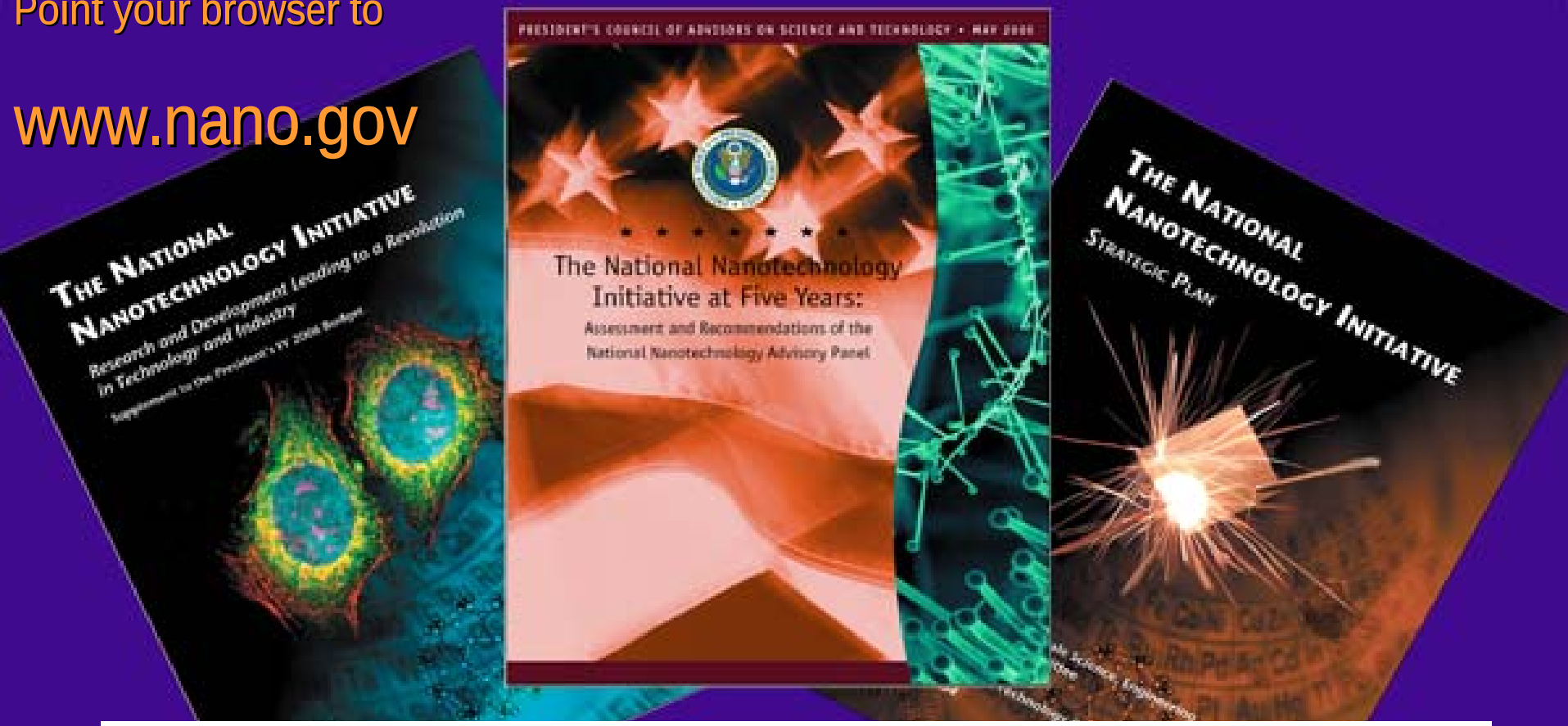
The 21st Century Nanotechnology Research and Development Act, passed by Congress and signed by the President in December 2003, requires that the participating NNI agencies report their nanotechnology activities by major subject areas. The December 2004 NNI Strategic Plan defines seven Program Component Areas, each an area where federal investment is essential to achieving the goals of the NNI

1) **Fundamental Nanoscale Phenomena and Processes**
2) **Nanomaterials**
3) **Nanoscale Devices and Systems**
4) **Instrumentation Research, Metrology, and Standards for Nanotechnology**
5) **Nanomanufacturing**
6) **Major Research Facilities and Instrumentation Acquisition**
7) **Societal Dimensions**

... for the NNI Strategic Plan, Budget Supplement, solicitations, and workshop reports

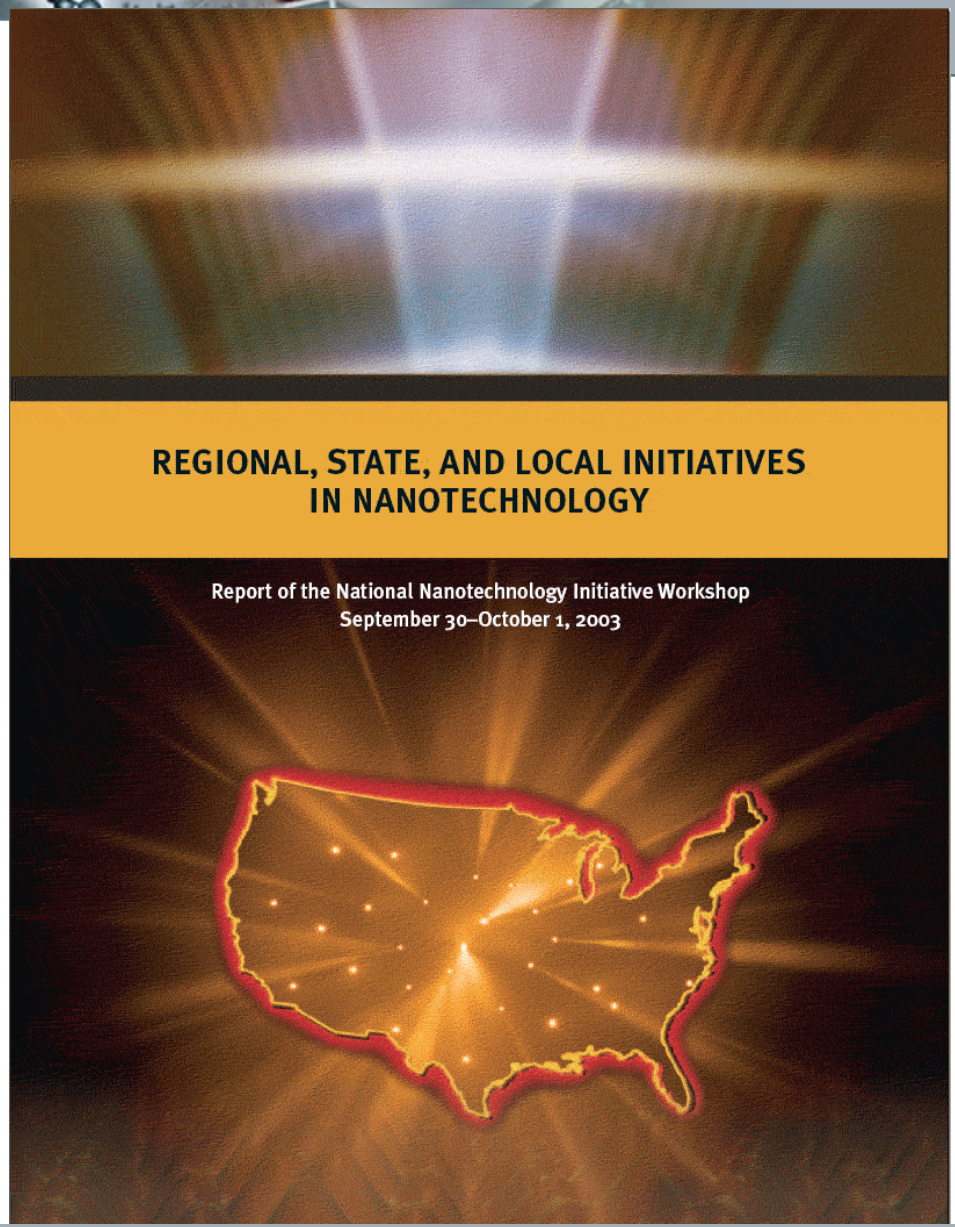
Point your browser to

www.nano.gov



http://www.nano.gov/NNI_Strategic_Plan_2004.pdf
http://www.nano.gov/NNI_06Budget.pdf
http://www.nano.gov/FINAL_PCAST_NANO_REPORT.pdf

For descriptions of representative State, Regional, and Local Initiatives, see:



http://www.nano.gov/
041805Initiatives.pdf

Follow-on workshop held November 2005 in Chicago; report in preparation

Which Federal Agencies Participate in the NNI?

Federal agencies with budgets dedicated to nanotechnology research and development

Department of Agriculture, Cooperative Research, Extension, and Education Service (USDA)
Department of Defense (DOD)
Department of Energy (DOE)
Department of Homeland Security (DHS)
Department of Justice (DOJ)
Environmental Protection Agency (EPA)
National Aeronautics and Space Administration (NASA)
National Institute of Standards and Technology (NIST, Department of Commerce)
National Institute for Occupational Safety and Health (NIOSH, Department of Health and Human Services/Centers for Disease Control and Prevention)
National Institutes of Health (NIH, Department of Health and Human Services)
National Science Foundation (NSF)

(more about these later...)

Other participating agencies

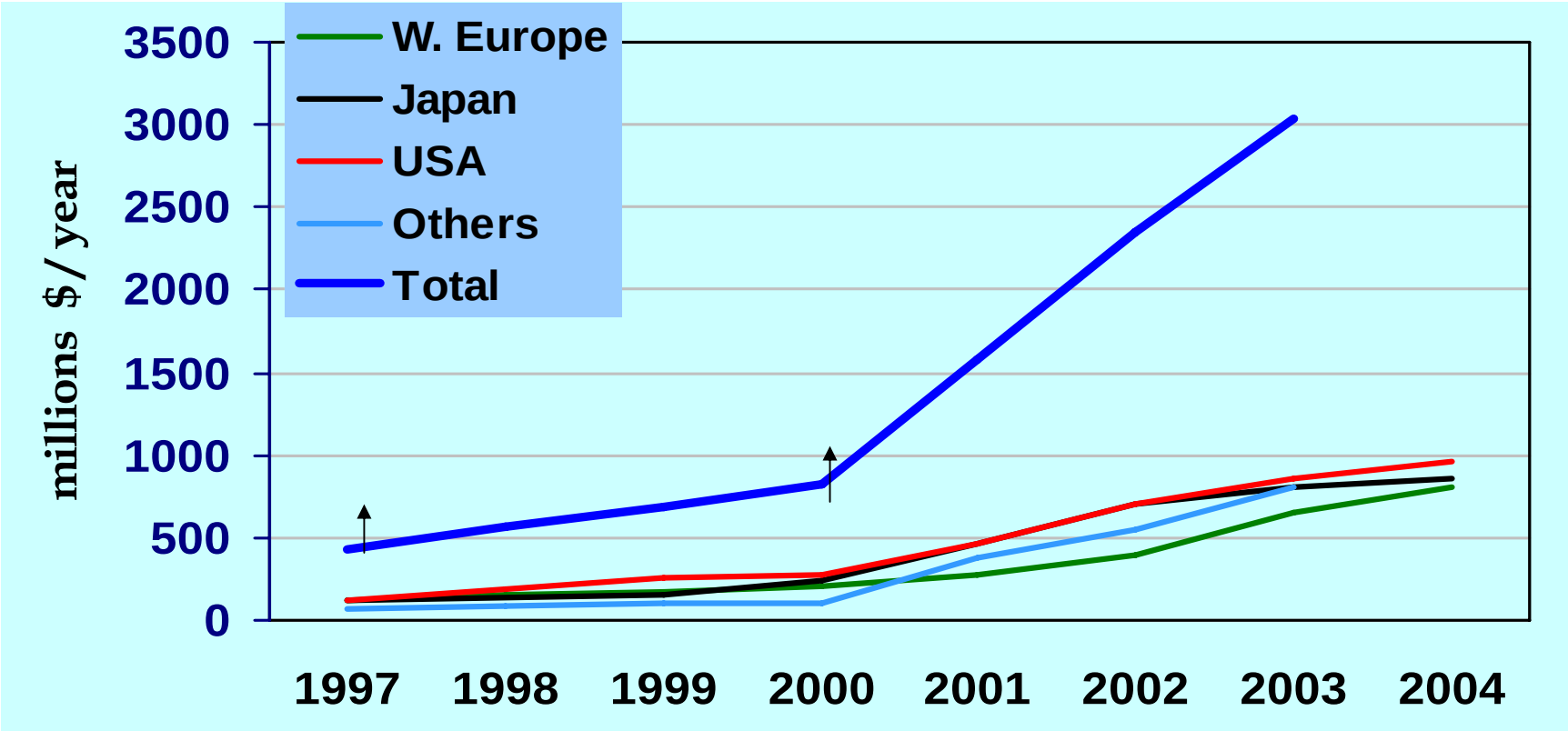
Bureau of Industry and Security (BIS, Department of Commerce)
Consumer Product Safety Commission (CPSC)
Department of Agriculture, Forest Service (USDA/FS)
Department of State (DOS)
Department of Transportation (DOT)
Food and Drug Administration (FDA, Department of Health and Human Services)
International Trade Commission (ITC)
Intelligence Technology Innovation Center, representing the Intelligence Community (IC)
Nuclear Regulatory Commission (NRC)
Technology Administration (TA, Department of Commerce)
U.S. Patent and Trademark Office (USPTO, Department of Commerce)
Forest Service (USDA)
Department of Labor

How much do the R&D agencies invest?

NNI Budget, 2004-2006 (dollars in millions)			
	2004 Actual	2005 Estimate	2006 Request
NSF	256	338	344
DOD*	291	257	230
DOE	202	210	207
HHS (NIH)	106	142	144
DOC (NIST)	77	75	75
NASA	47	45	32
USDA	2	3	11
EPA	5	5	5
HHS (NIOSH)		3	3
DOJ	2	2	2
DHS	1	1	1
TOTAL	989	1,081	1,054

Over 1 Billion $ US per year– more than twice what was being spent at the start of the initiative

Government investments 1977-2004 (estimation NSF)



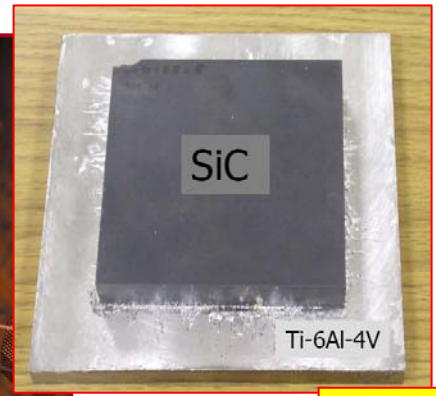
- U.S. begins FY in October, six months in advance of EU & Japan (in March/April)
- "Others" includes Australia, Canada, China, E. Europe, FSU, Israel, Korea, Singapore, Taiwan

Nanotechnology is 'Now'

Selected High Technology products

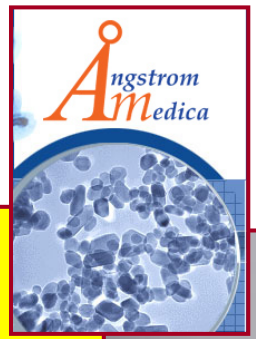
RNT

High Temperature, Local heat source



100 mm X 100 mm bond area

Ångstrom Medica

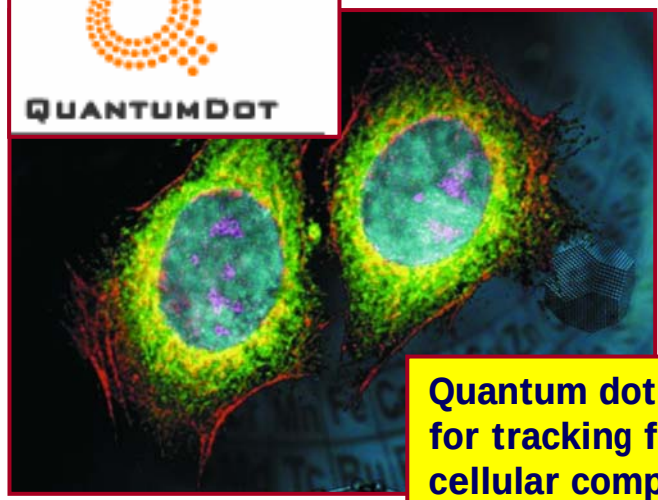


Biocompatible nanoceramic bonefiller

Bone bonding in 2 weeks and osseo-integration in 4 weeks

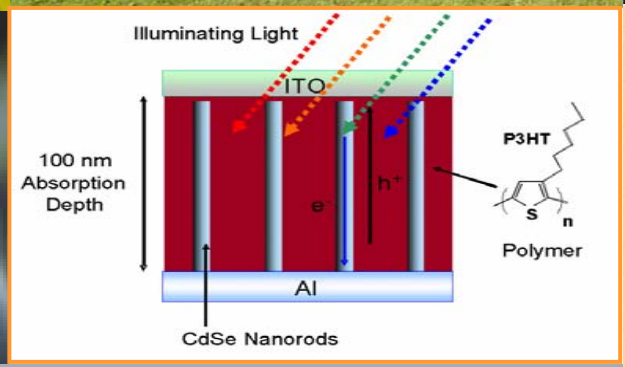
Screws and plates for orthopedic repair in development, eliminate stress shielding

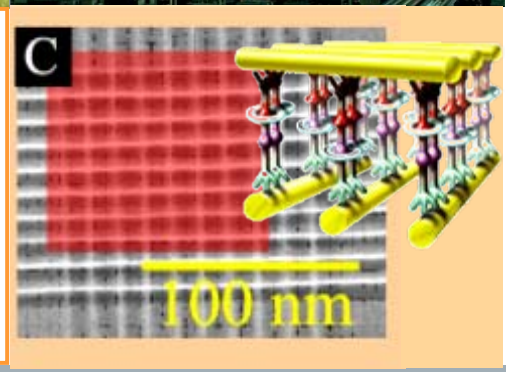
QUANTUMDOT



Quantum dot labeling for tracking five cellular components

Widespread Application Areas for Nanotechnology





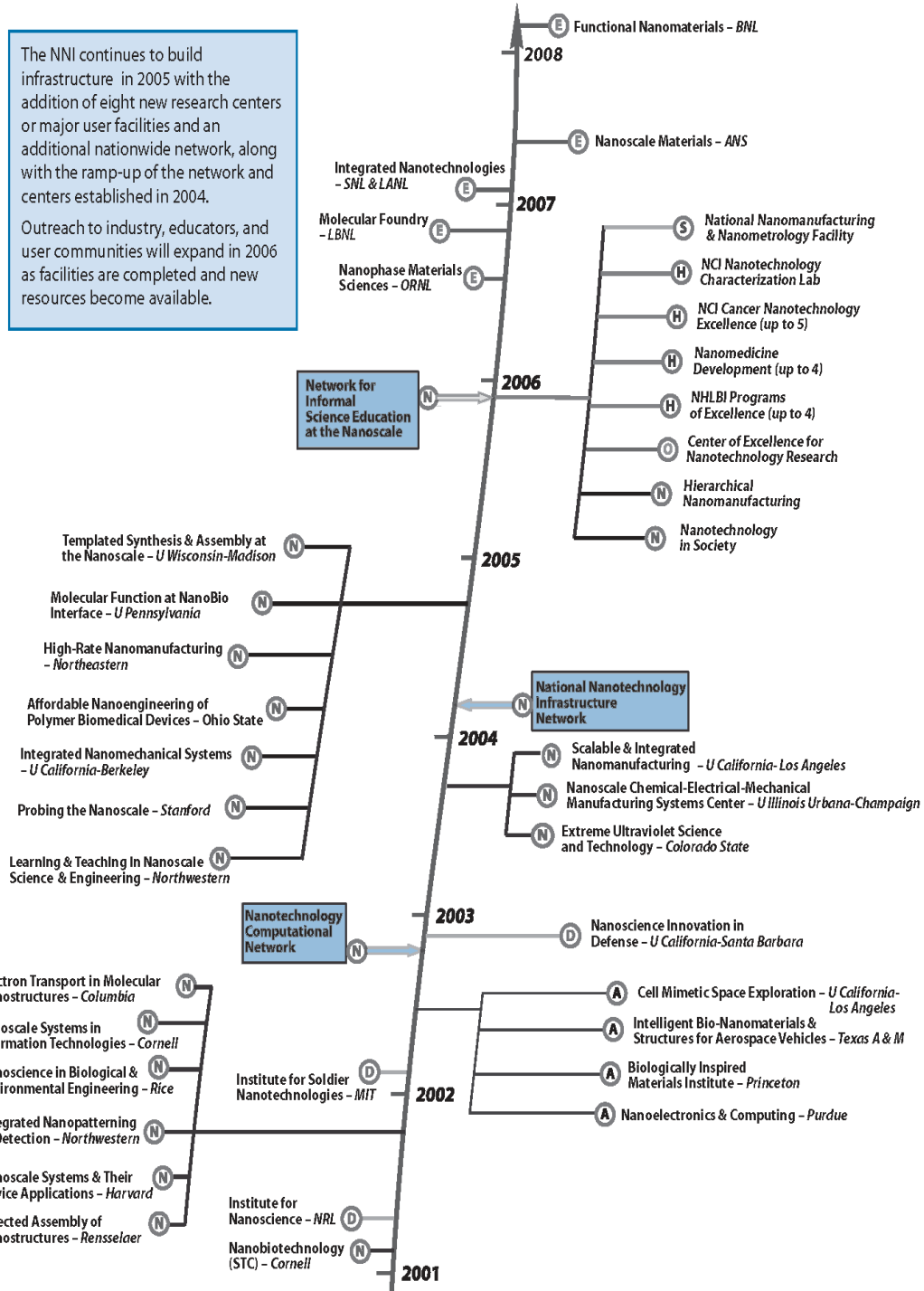
NNI Facilities and Infrastructure

- Support and encourage multidisciplinary and interdisciplinary research
  - Merging of nano and bio technologies
  - Systems involving mechanical, electrical, optical, fluidic, and biological components
- Support ever-increasing demands on instrumentation for higher spatial, temporal, and energy resolution measurement and characterization of materials
- Facilitate strong interactions between simulation, modeling, visualization and experimentation
- Anticipate increased use of remote operation of instrumentation along with higher levels of automation
- Anticipate possible transition from conventional lithography to alternative fabrication processes
- Anticipate possible incorporation of equipment and procedures to provide appropriate health and environmental implications in handling and processing nanoscale material

NNI Centers, Networks, and User Facilities

The NNI continues to build infrastructure in 2005 with the addition of eight new research centers or major user facilities and an additional nationwide network, along with the ramp-up of the network and centers established in 2004.

Outreach to industry, educators, and user communities will expand in 2006 as facilities are completed and new resources become available.



NSF	19 Centers 3 Networks	NIST	1 Center
DOD	3 Centers	NIOSH	1 Center
DOE	5 NSRCs	NIH	Up to 14 Centers
NASA	4 Centers		

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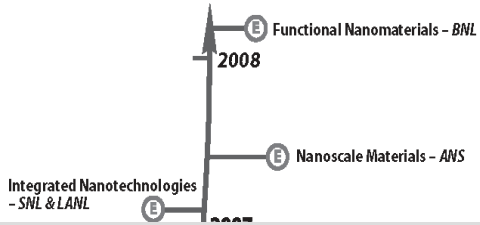
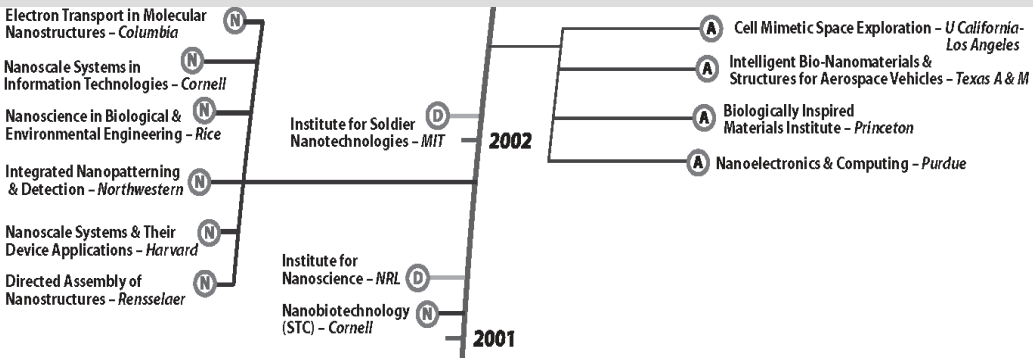


Massachusetts-based Centers:

Institute for Soldier Nanotechnologies (MIT)
Center for High Rate Manufacturing (Northeastern, UM-L, UNH)
Center Science of Nanoscale Systems and their
Device Applications (Harvard, MIT, Brookhaven, Delft....)
MRSEC on Polymers (UMass-Amherst)
Center for Imaging and Mesoscale Structures (Harvard, NNIN Node)
Harvard MRSEC
MIT MRSEC
2 new NIH centers (more info in later slide)
Many smaller awards, including
Harvard NanoConnections to Society (part of new NSF Societal Center)
NIRT: Complex Fluids Confined at the Nanoscale (Brandeis, BU, Harvard)...

— 1 Center
— 1 Center
— Up to 14 Centers



NHLBI Program of Excellence in Nanotechnology

5-year awards to:

Emory University and the **Georgia Institute of Technology** will together receive $11.5 million to establish a new research program focused on creating advanced nanotechnologies to analyze plaque formation on the molecular level and detect plaque at its early stages.

A partnership of 25 scientists from the **Burnham Institute, UC Santa Barbara**, and the **Scripps Research Institute** have been awarded $13.2 million to use nanotechnologies in the design of new ways to detect, monitor, treat, and eliminate "vulnerable" plaque, the probable cause of death from sudden cardiac arrest.

Massachusetts General Hospital and **Harvard University**, along with collaborating institutions **MIT**, the **Broad Institute**, and **Brigham and Women's Hospital**, have been awarded $15.6 million for a new center with the goal of developing and rapidly translating new nanotechnologies, including noninvasive imaging and sensing, targeted therapies, tissue repair and regeneration and drug delivery, to better diagnose and treat heart, lung, blood and sleep disorders.

A partnership of scientists from **Washington University** in St. Louis, **UC Santa Barbara**, and **UC Berkeley** has been awarded $12.6 million to develop nanoscale agents to provide early diagnosis and treatment of acute pulmonary and systemic vascular injury.

Nanomedicine Centers

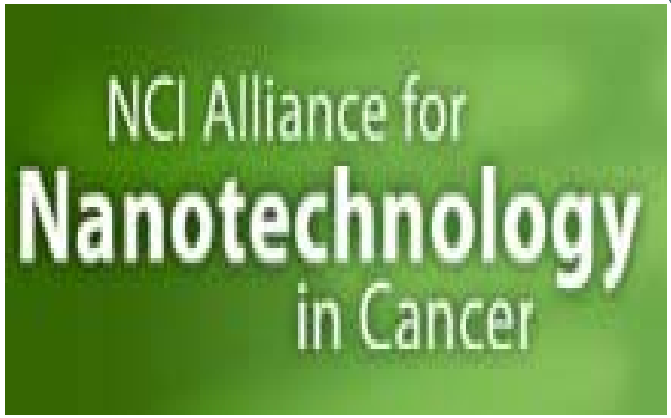
Nanomedicine Development Centers Awards (PN2)

BAYLOR COLLEGE OF MEDICINE Center for Protein Folding Machinery

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN National Center for Design of Biomimetic Nanoconductors

U. OF CALIFORNIA SAN FRANCISCO Engineering Cellular Control: Synthetic Signaling and Motility Systems

COLUMBIA UNIV NanoMedicine Center for Mechanical Biology



Seven Centers of Cancer Nanotechnology Excellence

Totaling $26.3 Million 1st year funding (October 05)

Carolina Center of Cancer Nanotechnology Excellence, University of North Carolina. This center will focus on the fabrication of "smart" or targeted nanoparticles and other nanodevices for cancer therapy and imaging.

Center of Nanotechnology for Treatment, Understanding, and Monitoring of Cancer, University of California, San Diego, Calif. This center will focus on a smart, multifunctional, all-in-one platform capable of targeting tumors and delivering payloads of therapeutics.

Emory-Georgia Tech Nanotechnology Center for Personalized and Predictive Oncology. This center will aim to innovate and accelerate the development of nanoparticles attached to biological molecules for cancer molecular imaging, molecular profiling and personalized therapy.

MIT-Harvard Center of Cancer Nanotechnology Excellence, Cambridge, Mass. This center will focus on diversified nanoplatforms for targeted therapy, diagnostics, noninvasive imaging, and molecular sensing.

Nanomaterials for Cancer Diagnostics and Therapeutics, Northwestern University, Evanston, Ill. This center plans to design and test nanomaterials and nanodevices to improve cancer prevention, detection, diagnosis and treatment.

Nanosystems Biology Cancer Center, California Institute of Technology, Pasadena, Calif. This center will focus on the development and validation of tools for early detection and stratification of cancer through rapid and quantitative measurement of panels of serum and tissue-based biomarkers. Principal investigator: James Heath, Ph.D. (California Institute of Technology).

The Siteman Center of Cancer Nanotechnology Excellence at Washington University, St. Louis, Mo. This center has a comprehensive set of projects for the development of nanoparticles for *in vivo* imaging and drug delivery, with special emphasis on translational medicine.

The Nanotechnology Characterization Laboratory (NCL) performs and standardizes the pre-clinical characterization of nanomaterials intended for cancer therapeutics and diagnostics developed by researchers from academia, government, and industry.

NCL activities are a formal scientific interaction of three Federal agencies: National Cancer Institute and U.S. Food and Drug Administration (FDA) of the Department of Health and Human Services, and National Institute of Standards and Technology (NIST) of the Department of Commerce.

See ncl.cancer.gov for information on the six objectives through which NCL will fulfill this mission, and detailed information on how to submit materials to NCL

DOE Nanoscale Science Research Centers

(NSRCs)

Center For Functional Nanomaterials at BNL

Summer '05

Center For Nanophase Materials Sciences at ORNL

Summer '03

Spring '04
Construction Starts

Center for Integrated Nanomaterials at LANL/SNL

Center for Nanoscale Materials at ANL

Molecular Foundry at LBNL

DOE NSRCs are all user facilities….

Open to industrial users (as well as academic users) through a merit review process, for both short and long-term studies

Combination of regional access to high-end “generic” facilities and national access to one-of-a-kind instruments

Industrial users can gain additional levels of intellectual property protection by paying for access on a full cost recovery basis

Nanoscale Informal Science Network

National Science Foundation Selects Museum of Science, Boston to Head $20 Million Network for Public Engagement with Nanotechnology

The Museum of Science, Boston in partnership with the Science Museum of Minnesota and the Exploratorium in San Francisco, has been selected by the National Science Foundation (NSF) to lead a $20 million effort to form a national Nanoscale Informal Science Education Network (NISE Network) of multiple science museums and research institutions. The NISE Network will collaboratively develop and distribute innovative approaches to engaging Americans in nanoscale science and engineering education, research, and technology. **The $20 million award** to the Museum of Science and its partners for the five-year effort **is the largest award NSF has ever given to the science museum community.**

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One of many Educational projects....

Middle School through college, community college, graduate school

NIOSH- Worker Safety Recommendations

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NIOSH National Institute for Occupational Safety and Health

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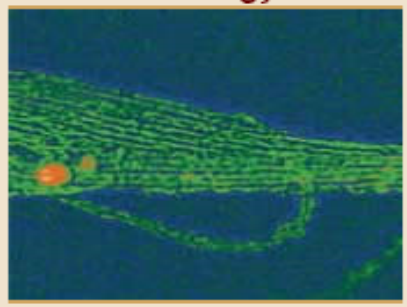
NIOSH Safety and Health Topic:

Nanotechnology

Nanotechnology Spotlights:

- For Public Comment: Draft Evaluation of Health Hazard and Recommendations for Occupational Exposure to Titanium Dioxide
- Strategic Plan for NIOSH Nanotechnology Research
- Approaches to Safe Nanotechnology: An Information Exchange with NIOSH
- "Focus on Nanotechnology" - a regularly updated electronic report on new NIOSH developments related to research on Nanotechnology and occupational health
- Final report from the First International Symposium on Occupational Health Implications of Nanomaterials, sponsored by NIOSH and the U.K. Health & Safety Executive
  (PDF); External Link: http://www.hsl.gov.uk/capabilities/nanosymrep_final.pdf
- NIOSH, Nanotechnology, and Occupational Safety and Health Research Frequently Asked Questions (FAQs)
- NIOSH Position Statement on Nanotechnology: Advancing Research on Occupational Health Implications and Applications
- NIOSH participates in NAS review of nanotechnology research needs
- Mechanisms of Action of Inhaled Fibers, Particles, and Nanoparticles in Lung and Cardiovascular Disease Conference - October 25-28, 2005

Nanotechnology



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- Strategic Plan for NIOSH Nanotechnology Research
- Frequently Asked Questions
- NIOSH Position Statement
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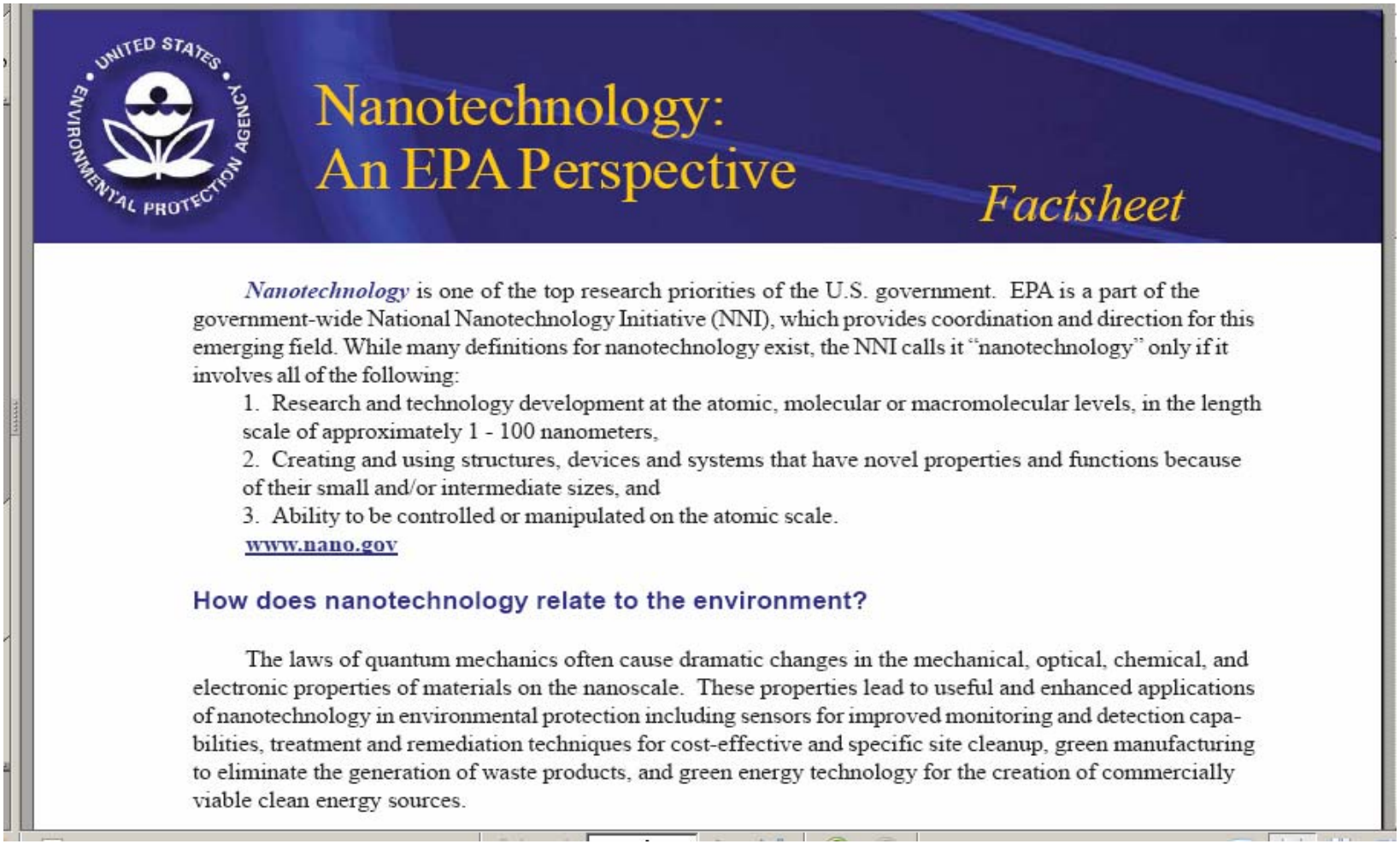
- Nanoparticle Information

Background

The past decade has seen intense interest in developing technologies based on the unique behavior of nanometer-scale (nanoscale) structures, devices and systems, leading to the rapidly expanding and highly diverse field of nanotechnology.

Nanotechnology is somewhat loosely defined, although in general terms it covers engineered

EPA– Research, Voluntary new materials program in review



Nanotechnology: An EPA Perspective

Factsheet

Nanotechnology is one of the top research priorities of the U.S. government. EPA is a part of the government-wide National Nanotechnology Initiative (NNI), which provides coordination and direction for this emerging field. While many definitions for nanotechnology exist, the NNI calls it "nanotechnology" only if it involves all of the following:

1. Research and technology development at the atomic, molecular or macromolecular levels, in the length scale of approximately 1 - 100 nanometers,
2. Creating and using structures, devices and systems that have novel properties and functions because of their small and/or intermediate sizes, and
3. Ability to be controlled or manipulated on the atomic scale.

www.nano.gov

How does nanotechnology relate to the environment?

The laws of quantum mechanics often cause dramatic changes in the mechanical, optical, chemical, and electronic properties of materials on the nanoscale. These properties lead to useful and enhanced applications of nanotechnology in environmental protection including sensors for improved monitoring and detection capabilities, treatment and remediation techniques for cost-effective and specific site cleanup, green manufacturing to eliminate the generation of waste products, and green energy technology for the creation of commercially viable clean energy sources.

NNI Website www.nano.gov

Plippel@nnco.nano.gov

Staff@nnco.nano.gov

Many faces of Zinc Oxide

Courtesy ZL Wang; Georgia Tech