NANOSCALE SCIENCE AND ENGINEERING

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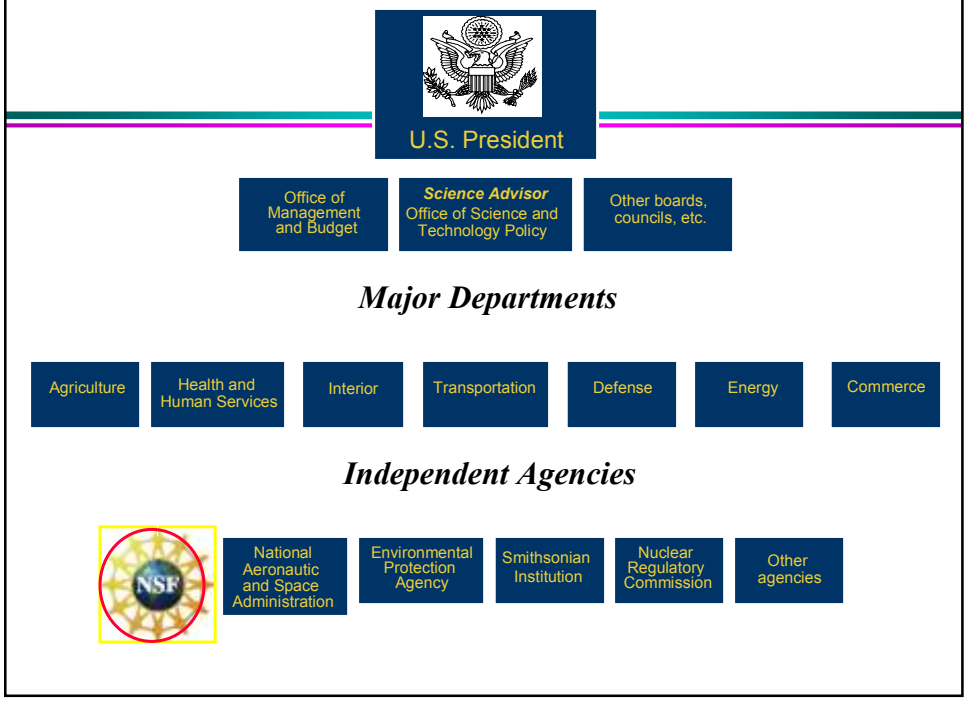
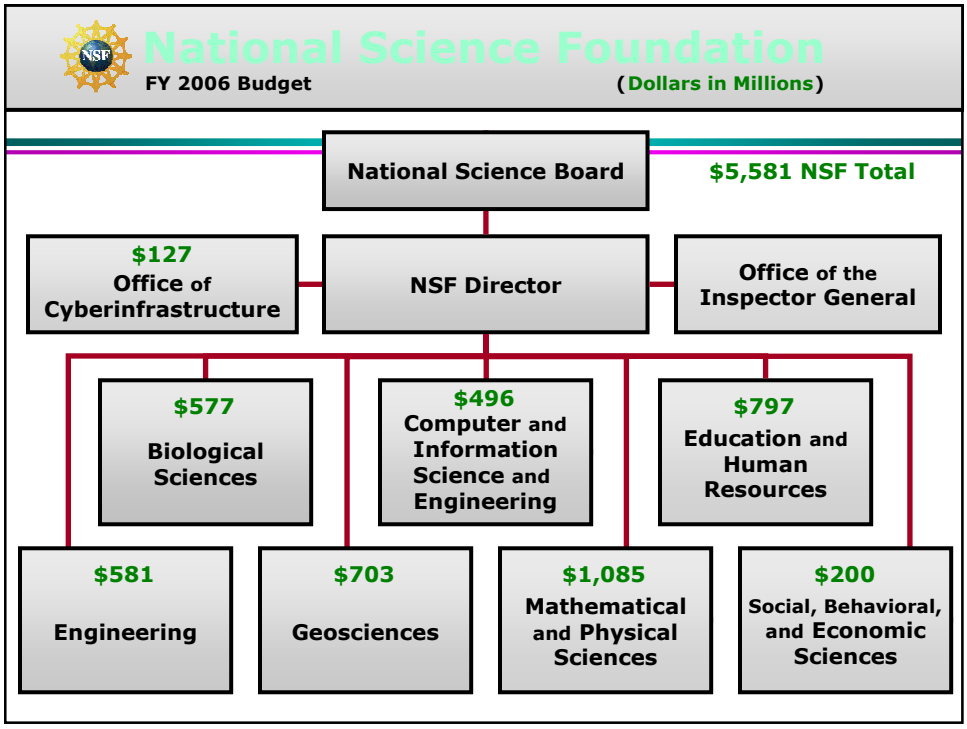
www.nsf.gov



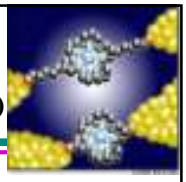


Some examples of advances initiated by NSF funding

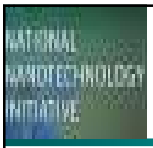
- Computer-aided design (CAD)
- Microelectromechanical systems (MEMS)
- Fiber optics
- Tissue engineering
- Doppler radar
- The Internet
- MRI/NMR
- Thin films; electronic materials

Nanotechnology

Definition on www.nano.gov/omb_nifty50.htm (2000)



- **Working at the atomic, molecular and supramolecular levels, in the length scale of approximately 1 – 100 nm range, in order to understand, create and use materials, devices and systems with fundamentally new properties and functions because of their small structure**
- **NNI definition encourages new contributions that were not possible before.**
  - novel phenomena, properties and functions at nanoscale, which are nonscalable outside of the nm domain
  - the ability to measure / control / manipulate matter at the nanoscale in order to change those properties and functions
  - integration along length scales, and fields of application



First NNI strategic plan (2001-2005): R&D funding by Agency

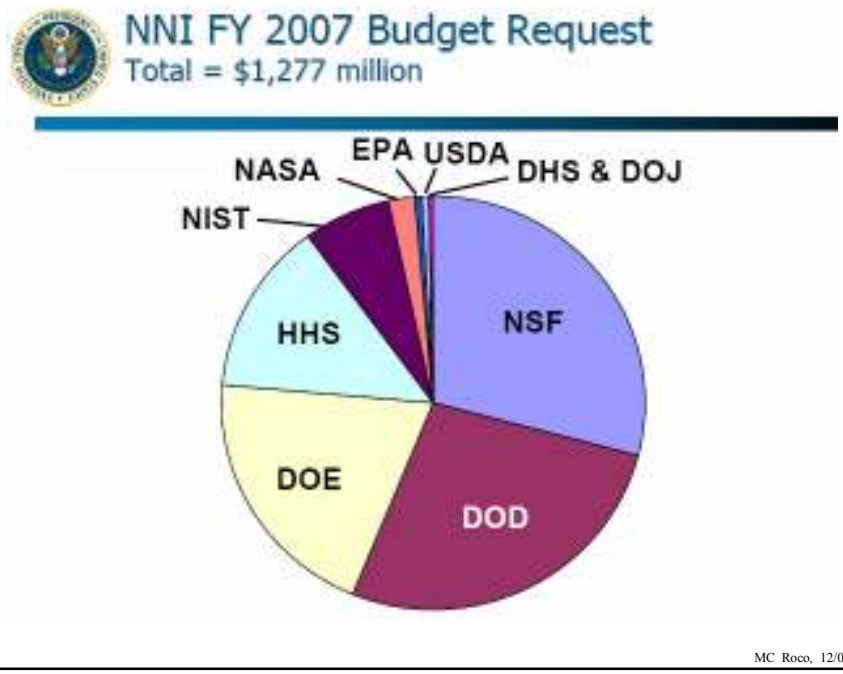
Fiscal year (all in million $)	*2000* Actual	*2001* Enact/Actual	*2002* Enact/Actual	*2003* Enact/Actual	2004 Req./Actual	2005 Req/Est.
National Science Foundation	97	150 /150	199 /204	221 /221	249 /256	305/338
Department of Defense	70	110 /125	180 /224	243 /322	222 /291	276/257
Department of Energy	58	93 /88	91.1 /89	133 /134	197 /202	211/210
Health and Human Services	32	39 /39.6	40.8 /59	65 /78	70 /108	89/145
NASA	5	20 /22	35 /35	33 /36	31 /47	35/45
NIST	8	10 /33.4	37.6 /77	66 /64	62 /77	53/75
EPA	-	/5.8	5 /6	5 /5	5 /5	5/5
Homeland Security (TSA)	-		2 /2	2 /1	2 /1	1/1
Department of Agriculture	-	/1.5	1.5 /0	1 /1	10 /2	5/3
Department of Justice	-	/1.4	1.4 /1	1.4 /1	1.4 /2	1/2
Congressional ads-ons at DOD				80	103	150
TOTAL	270	422 /465	600 /697	770 /942	849 /1094	982/1231
		+72%	+50%	+35%	+16%	+ 13%

- Industry, state and local organizations: about 1.5 times NNI budget in 2003
- 22 NSET departments / agencies, including: OSTP, NSTC, OMB, DOC, DOS, DOT, DOTreas, FDA, NRC, DHS, IC, NIOSH, USPTO; partnerships with others
- 2004 NNI budget: 65% to academia; 25% - R&D labs; 10% - industry (7% SBIR)

MC Roco

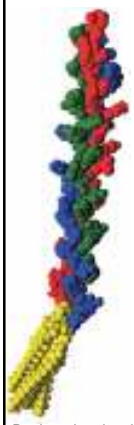
Areas of investment in FY2006
(Program Component Areas)

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



MC Roco, 12/04/06

National Nanotechnology Initiative at NSF



Designed molecule for selfassembling (UCSB)

- Coordination with other 24 agencies in the NNI (WH priority, NSTC/NSET subcommittee, OMB cross-cut, several working groups, and joint R&D activities)
- Nanotechnology is a priority element of the American Competitiveness Initiative (ACI)
- New research priorities (change focus from passive nanostructures to active nanostructures and nanosystems)
- Supports a strong infrastructure through 24 large centers, networks and user facilities, as well as research equipment
- Interaction with industry (with electronic, chemical and other industry sectors, small business support, private sector – academic partnerships)
- International collaboration (International Dialogue, OECD, bilateral agreements, workshops, awards)

MC Roco, 12/04/06

NSE: Role of Engineering

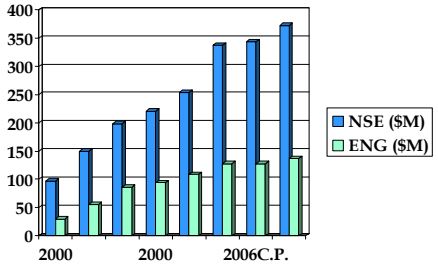
Engineering has a leading role in NSE because:

- nanotechnology deals with systems at nanoscale
- integrative, interdisciplinary
- transforming tool

Collaboration with NSF Directorates: MPS, CISE, BIO, GEO, SBE, HER
Also, NNI - 24 departments and agencies (DOE,DOD, NASA, NIH, NIST, EPA, etc.)

Changing engineering disciplines (research, education, relevance)

Fiscal Year	NSF	ENG
2000	$97M	$30.0M
2001	$150M	$55.3M
2002	$199M	$86.3M
2003	$221M	$94.4M
2004	$254M	$108.9M
2005	$338M	$127.8M
C.P. 2006	$344M	$127.8M
R. 2007	$373M	$137.2M



Nanoscale Science and Engineering program (FY 2001 - FY 2005)

- **FY 2001-2005 budget: $1,162M, of which $368M for solicitations ($344M for NSE & $24M for NSEE)**
- **Outcomes of the NSE solicitation**

  (8 research themes, 3 modes of support)

  4083 **proposals (with submission limits), 647 awards**,

  - **Nanoscale Interdisciplinary Research Teams**
    259 awards ($61.5M) (2128 proposals, Limit 4 / university)
  - **Nanoscale Science and Engineering Centers**
    16 centers for 5 yr (205 proposals, 1 / university)
  - **Nanoscale Exploratory Research**
    373 awards ($7.9M) (1813 proposals, Limit 2 / univ.)

  Success rate NSE (awards / proposals):
  - No. proposals: NIRT – 12%, NSEC – 8%, NER – 20%
    (< NSF success rate despite of limitation # proposals / university)

Nanoscale Science and Engineering support at NSF in FY 2006

The budget Request to Congress: $342M

- **Program solicitations (about $45M, about 1/8)**
  - **Active Nanostructures and Nanosystems (ENG and SBE) $42M**
  - **Nanotechnology Undergraduate Education (ENG and EHR) $3M**
- **Support in the core program (about 7/8) with focus on single investigator & other core**

  Various research and education programs in all directorates
  Interdisciplinary fellowships; STC, MRSEC and ERC centers
  Instrumentation (REG, MRI); Collaboration industry (GOALI, PFI)
  Network for Computational Nanotechnology ($2.8M/yr)
  National Nanotechnology Infrastructure Network ($14M/yr)
  Nanoscale Informal Science and Education (NSF 03-511)
- **SBIR/STTR** (additional ~ $10M)

MC. Roco, 8/30/05

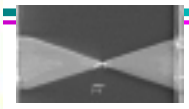
NSF Program Emphasis in FY 2007

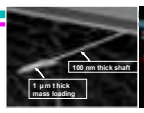
Increased investments will be dedicated to research and education on:

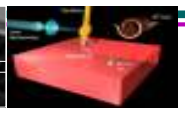
- Increased focus on complex large nanosystems. Research on nanoscale devices and system architecture, dynamic and emerging behavior, and their respective fabrication, will be emphasized
- Increased focused on three-dimensional measurements of domains of engineering relevance with good time resolution
- Converging science, engineering and technology from the nanoscale, by integrating nanosystems into applications (in manufacturing, information systems, medicine, environment, etc.)
- Expanded joint research program addressing potential implications of nanotechnology with NIOSH, EPA and FDA, USDA and NIST
- Earlier educational programs and teaching materials, including for K-12, by using remote access to NSF educational networks (NU, NISE, NNIN)
- Expand partnerships of academic researchers with industry, medical facilities and states through two programs (GOALI, PFI), using the CBAN (Collaborative Board for Advancing Nanotechnology)

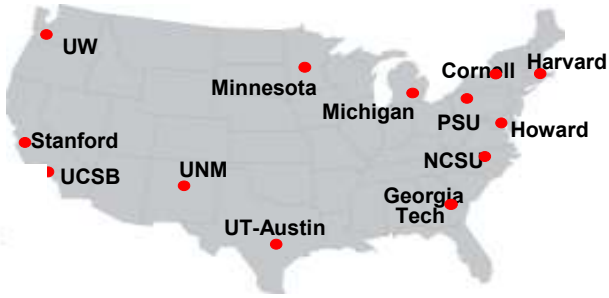
National Nanotechnology Infrastructure Network (NNIN)

NNIN
www.nnin.org
Nanoscale Science, Engineering & Technology





Cornell U (Lead)
Stanford U
U Michigan
Georgia Tech
U Washington
Penn State U
UC Santa Barbara
U Minnesota
U New Mexico
U Texas –Austin
Harvard U
Howard U
No. Carolina State U

An integrated national network of user facilities providing researchers open access to resources, instrumentation and expertise in all domains of nanoscale science, engineering and technology

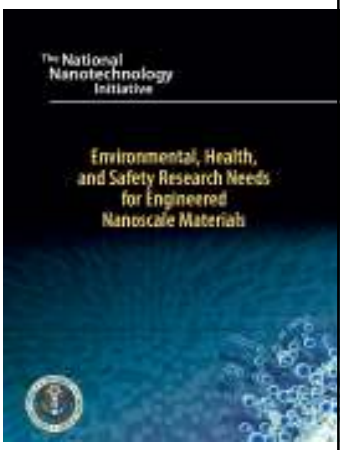
http://www.NNIN.org

ENVIRONMENTAL, HEALTH, AND SAFETY RESEARCH NEEDS (NNI, Sept. 21, 2006)

Purpose of the document:
is to identify for the Federal Government environmental, health, and safety (EHS) research and information needs related to understanding and management of potential risks of engineered nanoscale materials

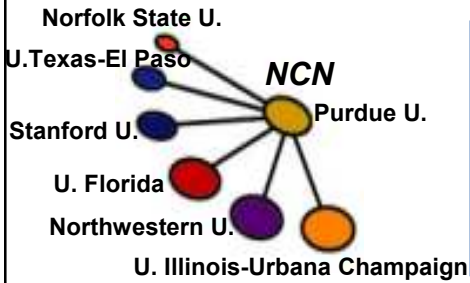
Key topics:

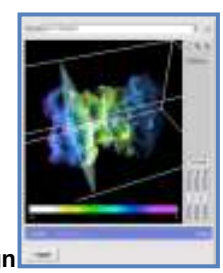
Instrumentation, Metrology, and Analytical Methods
Nanomaterials and Human Health
Nanomaterials and the Environment
Health and Environmental Surveillance
Risk Management Methods
- Risk Management Approaches
- Reducing Exposure in the Workplace
- Minimizing Environmental Exposure and Hazard
- Life Cycle Assessment
- Risk Communication Methods

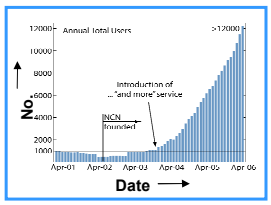


Network for Computational Nanotechnology (NCN)

A National resource to accelerate the transformation of nanoscience to nanotechnology through theory, modeling, and simulation and collaboration enabled by cyberinfrastructure







NSF Infrastructure and Research Network

http://www.nanoHUB.org

Infrastructure Outcomes of 2001-2005: NSF R&D Networks and User Facilities

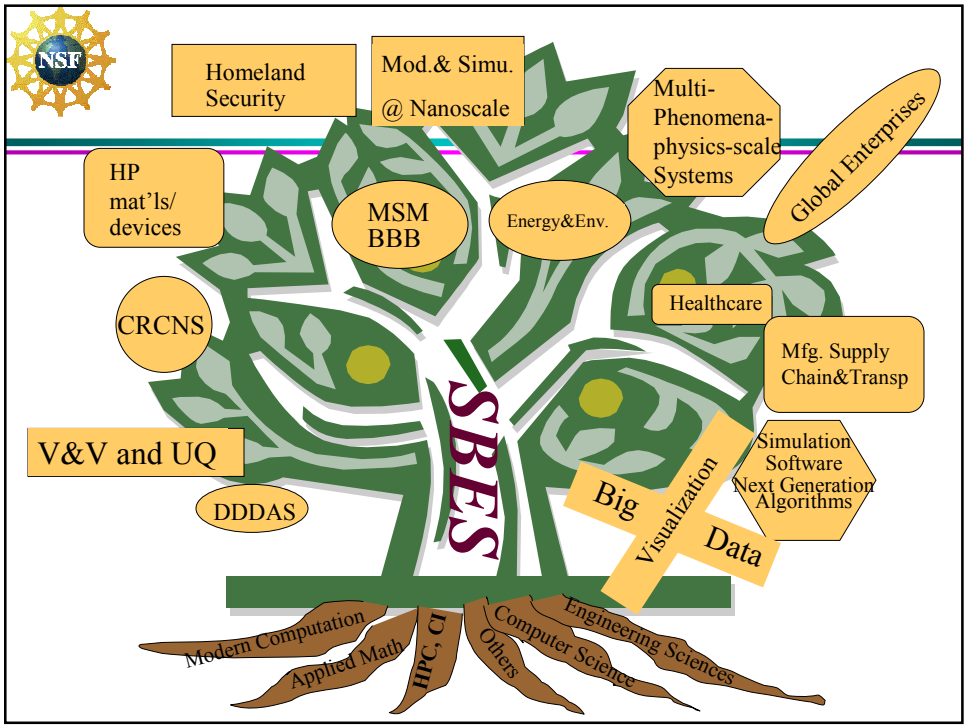
- **Network for Computational Nanotechnology (NCN)**
  - **Seven (7) universities (Purdue as the central node)**
  - **Nanoelectronic device simulation/modeling**
- **National Nanotechnology Infrastructure Network (NNIN)**
  - **13 universities with user facility**
  - **Development measuring & manufacturing tools, including NEPM Education and societal implications**
- **Oklahoma Nano Net (EPSCoR award)**

Centers:

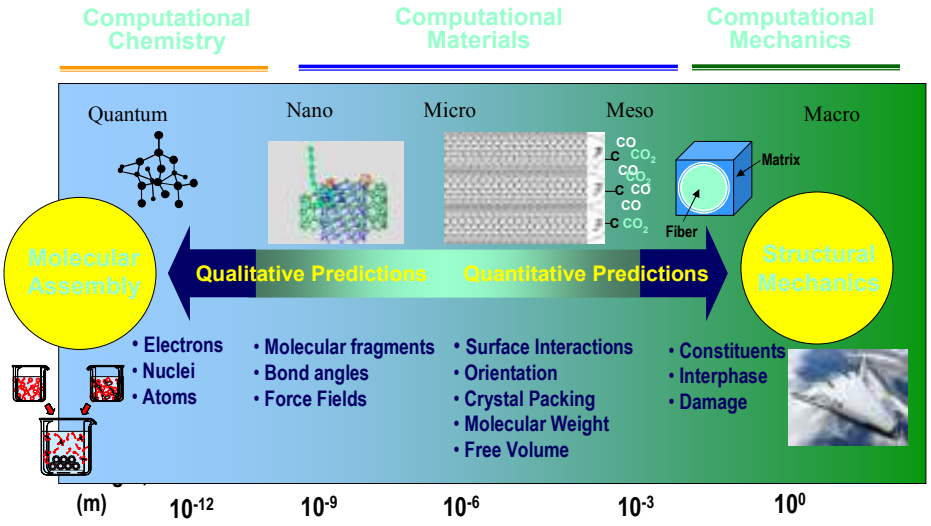
16 Nanoscale Science and Engineering (NSEC) - 6 (2001); 2 (2003); 6 (2004); 2 (2005)

1 Nanotechnology Center for Learning and Teaching (NCLT)

6 new Materials Research Science and Engineering Centers (MRSEC)

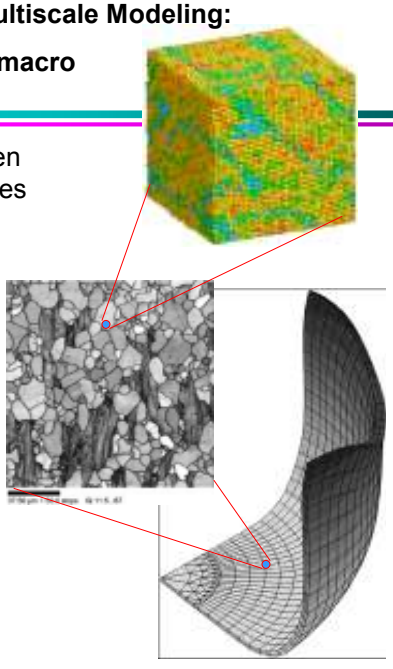


NASA Langley Research Center
Nanotechnology Modeling and Simulation



Overarching Framework for Multiscale Modeling:

atomistic → micro → meso → macro



One Key: interfaces/exchanges between models at different length and time scales

Questions:

- What *information* needs to be transferred from one model segment to another?
- What are the *correct* and *most effective* ways to achieve such transfer of information?
- What physical principles must be satisfied during the transfer of information or simulation results?

Need a set of logical, mathematical, and physical rules to govern information transfer across the interfaces

Defining the vision for the second strategic plan (II)

National Nanotechnology Initiative

2004

2004: 10-year vision/plan

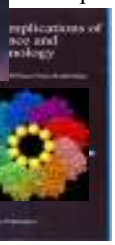
Government Plan (annual)

Survey manufacturing

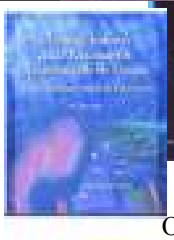
Agriculture and Food

Energy

Societal Implications 2004



Reports



Other topical reports on www.nano.gov

2004: Update 10 year vision, and develop strategic plan

MC Roco, 3/16/05

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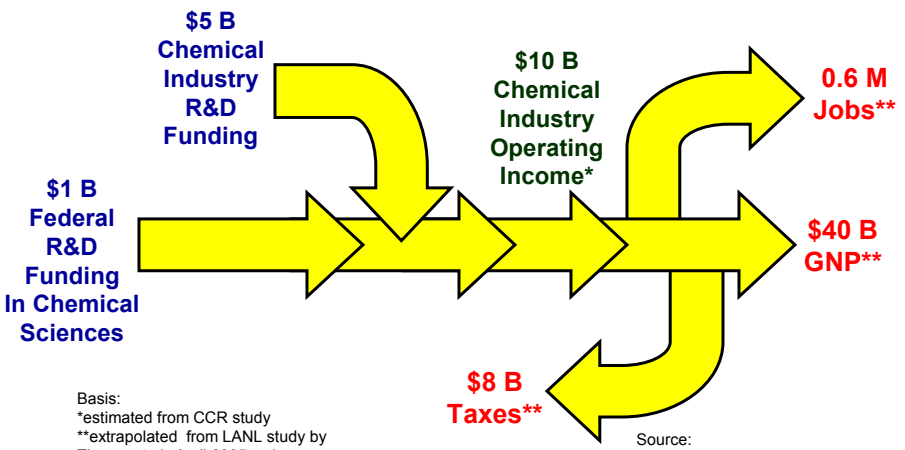
Impact of Federal Investment in Basic Research

Macroeconomic Implications



Basis:
*estimated from CCR study
**extrapolated from LANL study by Thayer *et al.*, April 2005, using REMI economic model

Source:
Measure for Measure: Chemical R&D Powers the U.S. Innovation Engine, p. 8, 2005, The Council for Chemical Research

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Chong, K. P., " Nanoscience and Engineering in Mechanics and Materials", *J. Phys. Chem. Solids*, 65(2004) 1501-1506 (Elsevier)
[No. 1 on *ScienceDirect* TOP25 Hottest Articles]

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http://tam.northwestern.edu/summerinstitute/Home.htm

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The author would like to thank his colleagues and many members of the research community for their comments and input during the preparation of this presentation.

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