

# Nanotechnology: A Policy Perspective

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Office of Science and Technology Policy

*Frontiers in Nanotechnology*

*EPA \* 2 May 2005*



# Office of Science & Technology Policy (OSTP)

**Dr. John H. Marburger, III**  
**Director**



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**Assoc. Dir. for Science**



**Mr. Richard M. Russell**  
**Assoc. Dir. for Technology**





# Interagency R&D Priorities for FY 2006

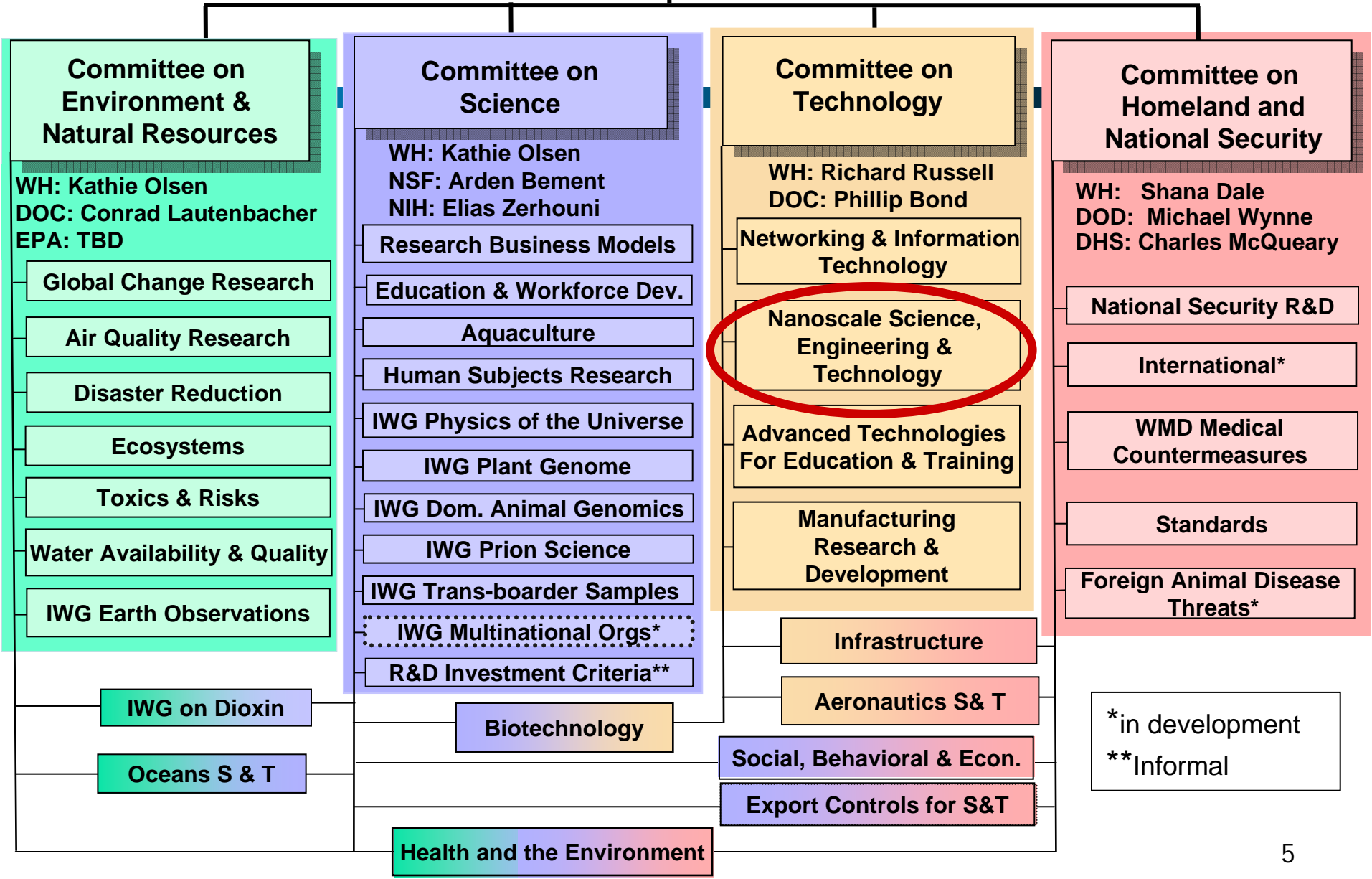
- Homeland security
- Networking and Information Technology
- **Nanotechnology**
- Physical sciences
- Biology of complex systems
- Environment and Energy
  - Climate Change
  - Earth Observations
  - Water Quality
  - Hydrogen Fuel



## Interagency R&D Priorities for FY 2006 Guidance Memo from OSTP and OMB

*“...In order to ensure that nanotechnology research leads to the responsible development of beneficial applications, agencies also should support research on the various societal implications of the nascent technology. In particular, agencies should place a high priority on research on human health and environmental issues related to nanotechnology.”*

**NSTC  
Director, OSTP**

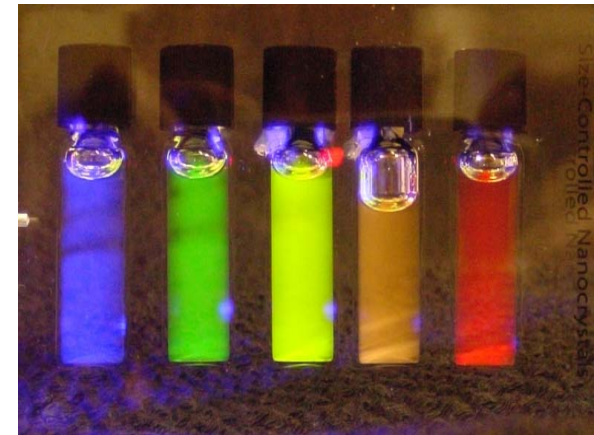


\*in development  
\*\*Informal



# What Is Nanotechnology?

- Working at length scales (~1–100 nanometers) at which new properties and functions arise
- Ability to control—to see, measure, and manipulate—matter on the atomic & molecular scale to exploit those properties and functions
- Ability to integrate those properties and functions into systems spanning from nano- to macroscopic scales





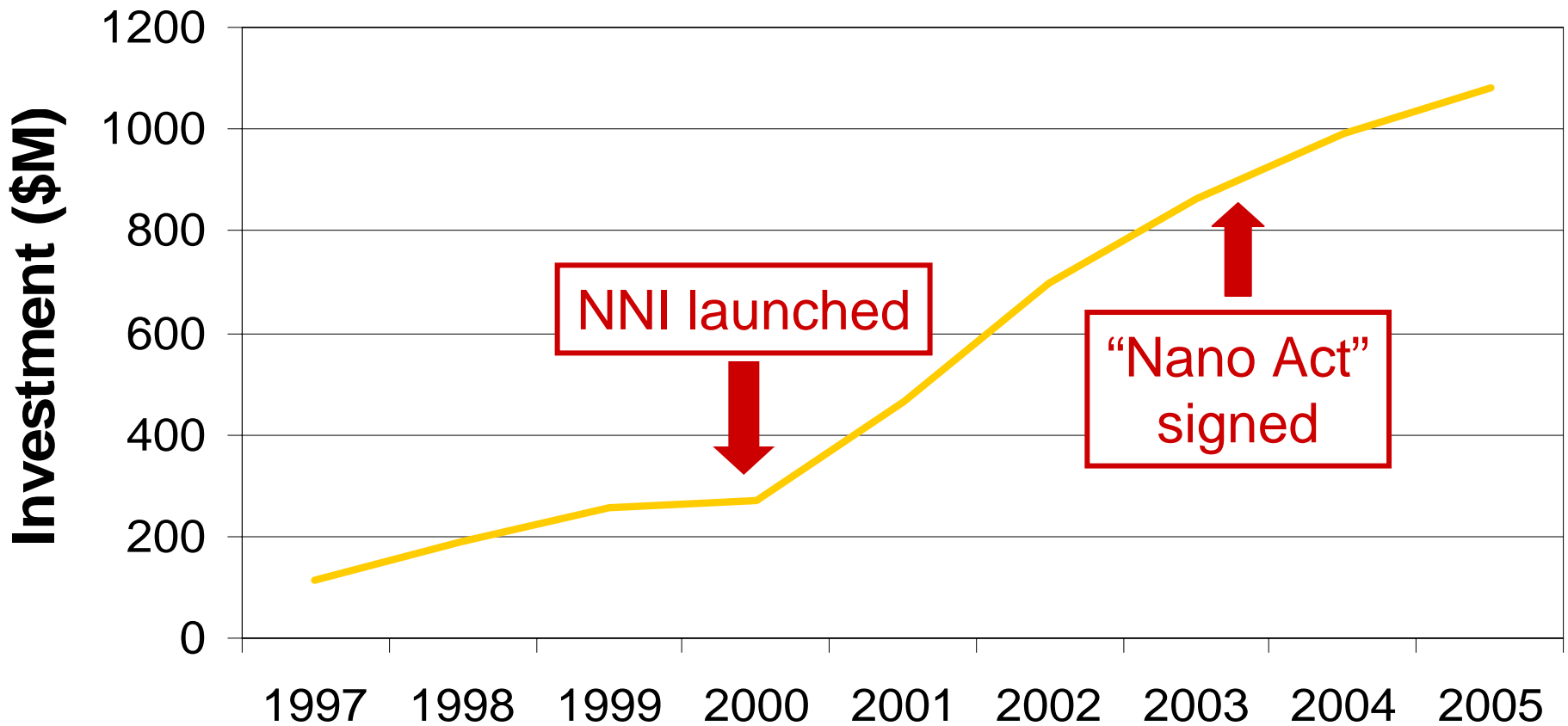


# Widespread applications





# U.S. Nanotech R&D spending







# 21st Century Nanotechnology Research & Development Act of 2003

- Signed by the President on Dec. 3, 2003
- Put into law ongoing activities
- Authorized \$3.7 billion in FY2005-FY2008 among 5 agencies (incl. EPA)
- “Established” a National Nanotechnology Coordination Office
- Calls for the President to establish or designate a National Nanotechnology Advisory Panel
- Calls for a triennial review by the National Research Council
- Calls for periodic planning and reporting by the NSET Subcommittee
- Calls for the NNI to ensure that environmental and other concerns are considered

One Hundred Eighth Congress  
of the  
United States of America

AT THE FIRST SESSION

*Begun and held at the City of Washington on Tuesday,  
the seventh day of January, two thousand and three*

## An Act

To authorize appropriations for nanoscience, nanoengineering, and nanotechnology research, and for other purposes.

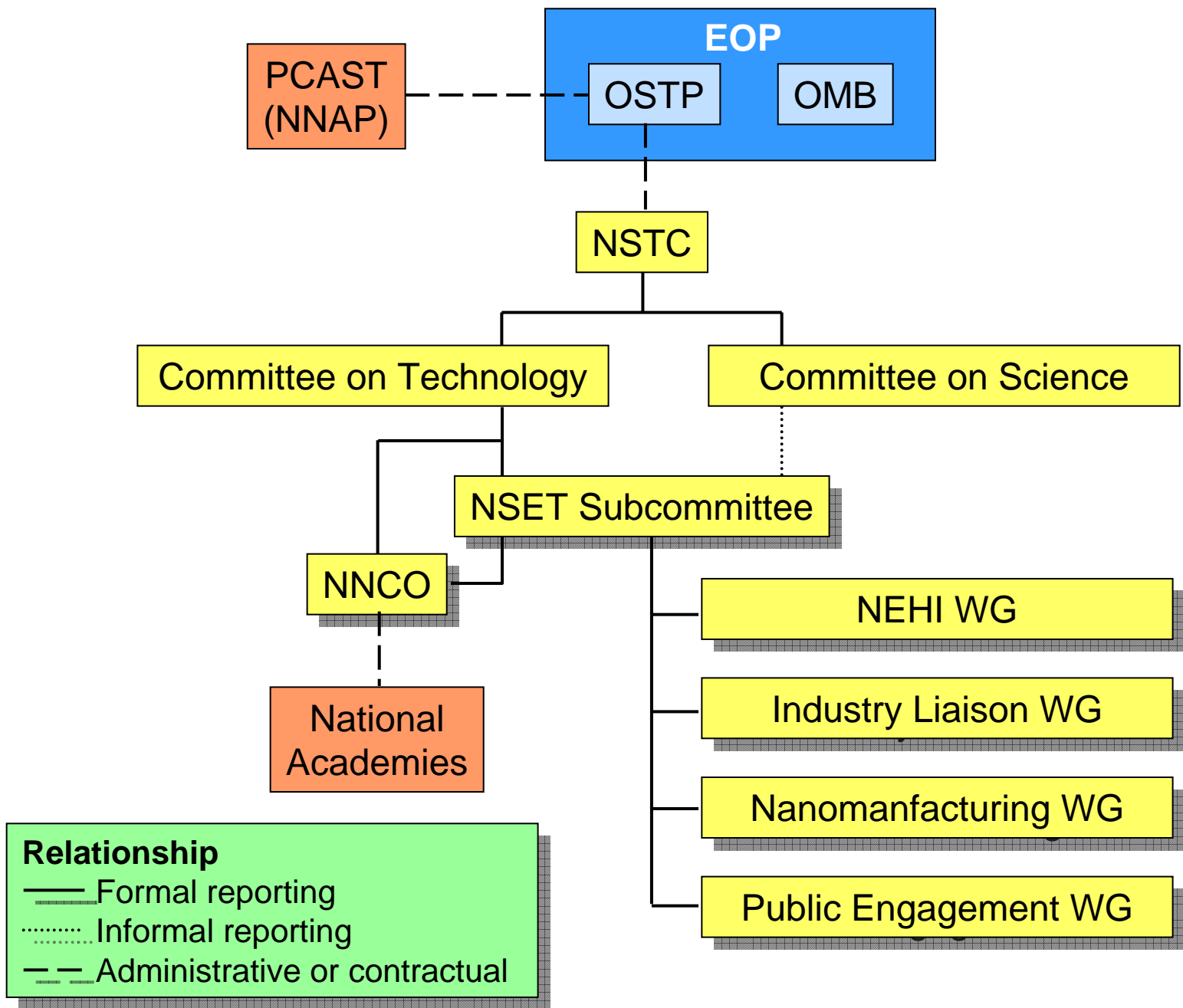
*Be it enacted by the Senate and House of Representatives of  
the United States of America in Congress assembled,*

### SECTION 1. SHORT TITLE.

This Act may be cited as the “21st Century Nanotechnology Research and Development Act”.

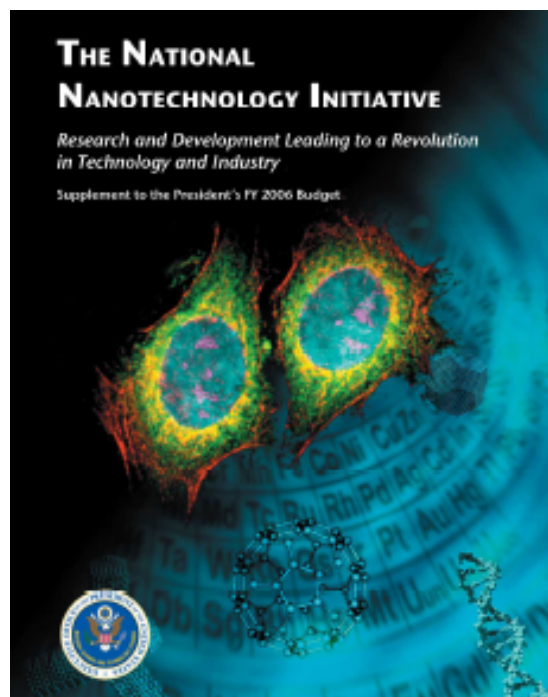
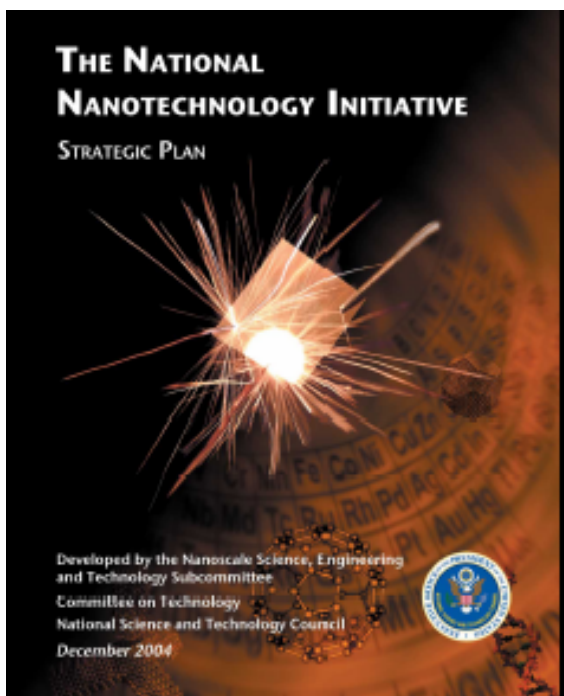


industry.  
(C) make use of existing expertise in nanotechnology in their regions and nationally;  
(D) make use of ongoing research and development at the micrometer scale to support their work in nanotechnology; and





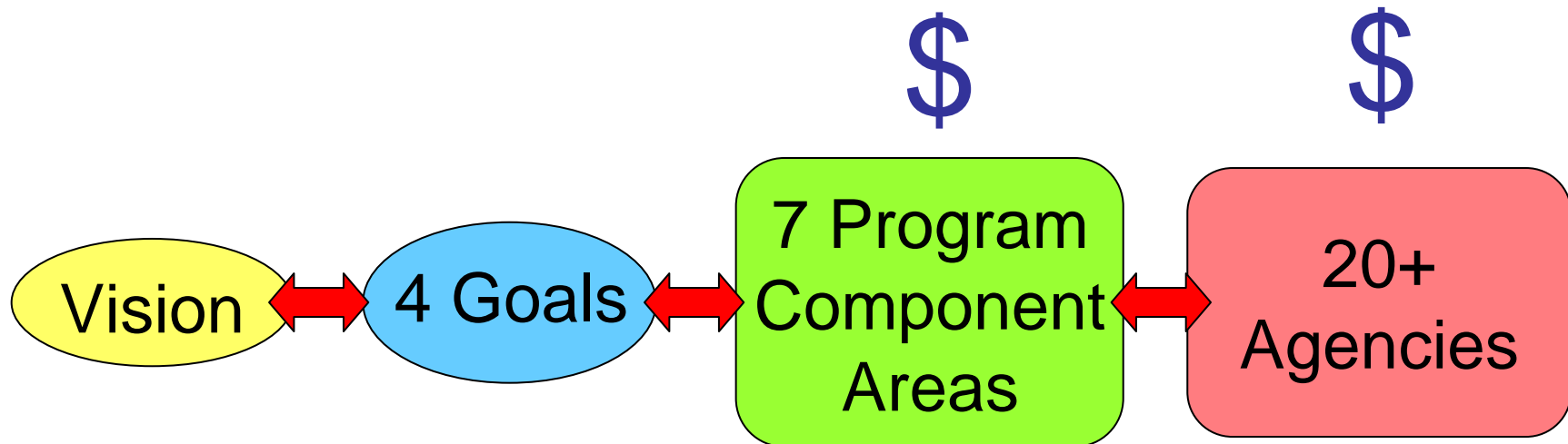
# NNI-related reports



Available at [www.nano.gov](http://www.nano.gov)



# NNI Strategic Plan (Dec 2004)





# NNI Vision

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*A future in which the ability to understand and control matter on the nanoscale leads to a revolution in technology and industry.*

Expedite discovery, development, and deployment of nanotechnology for:

- ❖ Economic benefit
- ❖ National & homeland security
- ❖ Improved quality of life



# NNI Goals

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- ***Sustain world class R&D***
- ***Facilitate technology transfer***
- ***Develop infrastructure: education; workforce preparation; facilities & instrumentation***
- ***Support responsible development of nanotechnology***





# Areas of investment (aka Program Component Areas)

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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 (EHS, ELSI, Educ.)

# Relationship of PCAs to Goals

<b>Program Component Areas:</b>	Goal 1: Maintain a world-class research and development program aimed at realizing the full potential of nanotechnology	Goal 2: Facilitate transfer of new technologies into products for economic growth, jobs, and other public benefit	Goal 3: Develop educational resources, a skilled workforce, and the supporting infrastructure and tools to advance nanotechnology	Goal 4: Support responsible development of nanotechnology
Fundamental Nanoscale Phenomena and Processes				
Nanomaterials				
Nanoscale Devices and Systems				
Instrumentation Research, Metrology, and Standards for Nanotechnology				
Nanomanufacturing				
Major Research Facilities and Instrumentation Acquisition				
Societal Dimensions				
<div style="display: flex; align-items: center; gap: 10px;"> <div style="width: 20px; height: 20px; background-color: #8B4513; border: 1px solid black;"></div> <span>critical to goal</span> </div> <div style="display: flex; align-items: center; gap: 10px; margin-top: 5px;"> <div style="width: 20px; height: 20px; background-color: #D2B48C; border: 1px solid black;"></div> <span>primary relevance</span> </div> <div style="display: flex; align-items: center; gap: 10px; margin-top: 5px;"> <div style="width: 20px; height: 20px; background-color: #F5DEB3; border: 1px solid black;"></div> <span>secondary relevance</span> </div>				

# Relationship between PCAs and NNI Agency Missions

● Primary  
 Secondary  
 Agencies w/  
 nano R&D \$\$

	Fundamental Nanoscale Phenomena and Processes	Nanomaterials	Nanoscale Devices and Systems	Instrumentation Research, Metrology, and Standards for Nanotechnology	Nanomanufacturing	Major Research Facilities and Instrumentation Acquisition	Societal Dimensions
CPSC	<input type="checkbox"/>	<input type="checkbox"/>	●	●			●
DHS	●		●	●		<input type="checkbox"/>	
DOC (BIS)	<input type="checkbox"/>	●	●	●	<input type="checkbox"/>		
DOC (NIST)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	●	●	<input type="checkbox"/>	<input type="checkbox"/>
DOC (TA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	●	<input type="checkbox"/>	●
DOC (USPTO)		●	●	●	●		
DOD	<input type="checkbox"/>	●	●	<input type="checkbox"/>	●	<input type="checkbox"/>	<input type="checkbox"/>
DOE	●	●	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	●	<input type="checkbox"/>
DOJ			●				
DOS							●
DOT	●	<input type="checkbox"/>	●		●		
DOTreas		●	●				
EPA	<input type="checkbox"/>	●	●	<input type="checkbox"/>	●		●
HHS (FDA)		<input type="checkbox"/>	●				●
HHS (NIH)	●	<input type="checkbox"/>	●	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>
HHS (NIOSH)		<input type="checkbox"/>			<input type="checkbox"/>		●
IC	<input type="checkbox"/>	●	●		<input type="checkbox"/>		<input type="checkbox"/>
ITC		●	●		●		●
NASA	<input type="checkbox"/>	●	●		<input type="checkbox"/>	<input type="checkbox"/>	
NRC			●				
NSF	●	●	<input type="checkbox"/>	<input type="checkbox"/>	●	●	●
USDA	<input type="checkbox"/>	●	●		<input type="checkbox"/>		●

## FY 2006 Budget Request (\$ millions) by Agency

	<b>2004 Actual</b>	<b>2005 Estimate</b>	<b>2006 Request</b>	<b>Change 2005 to 2006</b>
NSF	256	338	344	6
DOD	291	257	230	-27
DOE	202	210	207	-3
NIH	106	142	144	2
NIST	77	75	75	0
NASA	47	45	32	-13
USDA	2	3	11	8
<b>EPA</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>0</b>
NIOSH		3	3	0
DOJ	2	2	2	0
DHS	1	1	1	0
<b>TOTAL</b>	<b>989</b>	<b>1,081</b>	<b>1,054</b>	<b>-27</b>

## FY 2006 Budget Request (\$ millions) by Agency and Program Component Area

	Fundamental Nanoscale Phenomena and Processes	Nano-materials	Nanoscale Devices and Systems	Instrumentation Research, Metrology, and Standards for Nanotechnology	Nano- manufacturing	Major Research Facilities and Instrumentation Acquisition	Societal Dimensions	NNI Total
NSF	95	75	54	12	24	24	60	<b>344</b>
DOD	35	83	99	3	2	6	2	<b>230</b>
DOE	48	33	5	11	0	109	1	<b>207</b>
NIH	46	17	67	6	0	1	8	<b>144</b>
NIST	5	1	2	39	19	8	1	<b>75</b>
NASA	5	17	9	0	1	0	0	<b>32</b>
USDA	1	2	6	0	1	0	1	<b>11</b>
EPA	<0.5	0	<0.5	0	0	0	4	<b>5</b>
NIOSH	0	0	0	0	0	0	3	<b>3</b>
DOJ	0	0	0	0	0	0	2	<b>2</b>
DHS	0	0	1	0	0	0	0	<b>1</b>
<b>TOTAL</b>	<b>234</b>	<b>228</b>	<b>244</b>	<b>71</b>	<b>47</b>	<b>148</b>	<b>82</b>	<b>1,054</b>

NNI 2006 Investments (\$ millions)  
under PCA on Societal Dimensions

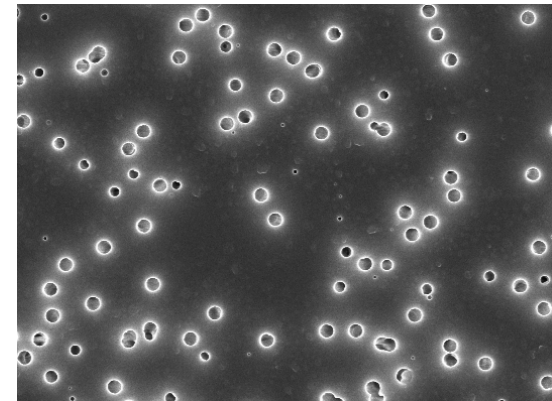
	EHS	Other
NSF	24	35.5
DOD	1	1
DOE	0.5	0.5
NASA	0	0
NIH	3	5
NIOSH	3.1	0
DOC	0.9	0
USDA	0.5	0.5
EPA	4	0
DOJ	1.5	0
DHS	0	0
<b>TOTAL</b>	<b>38.5</b>	<b>42.6</b>





# Nanotechnology for clean water

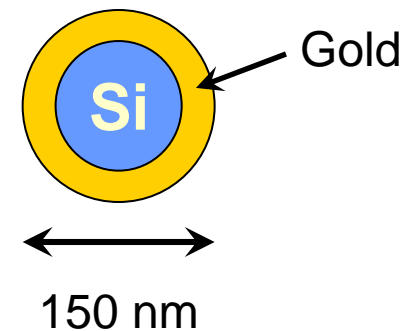
- Researchers at DOE's LLNL have developed "smart" membrane systems for targeted removal of pollutants using computer simulation and nanomembrane technology.
- Reduced voltage and selectivity reduces cost by up to half.





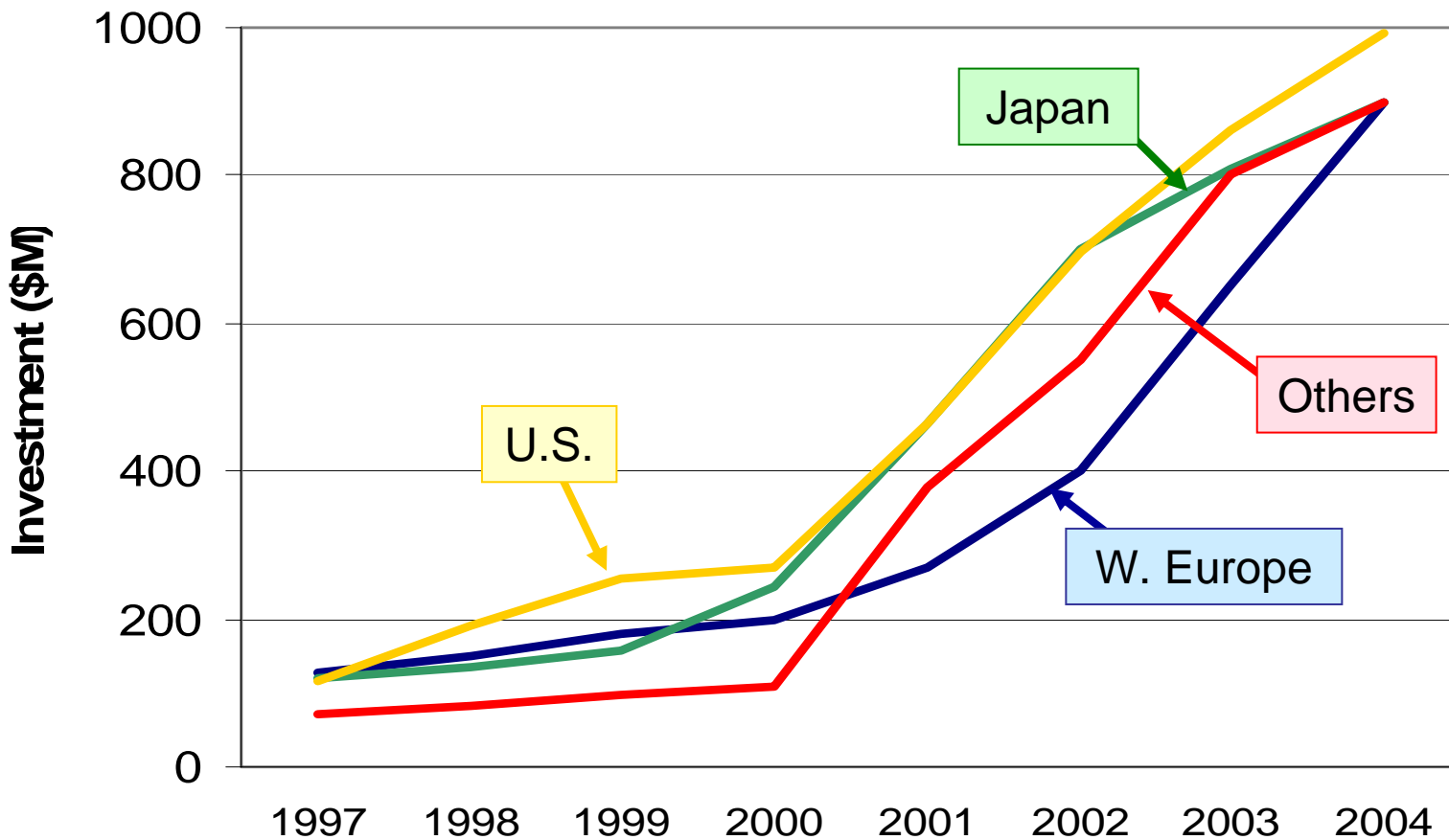
# Nanomaterials for treating cancer

- Gold nanoshells formed by depositing metal on silica spheres
- Size is *critical*
  - For reaching tumor
  - For absorbing IR energy
- *In vitro* and mice studies showed promising results.
- Technology developed at Rice Univ. with NSF \$\$; start-up company formed to commercialize.





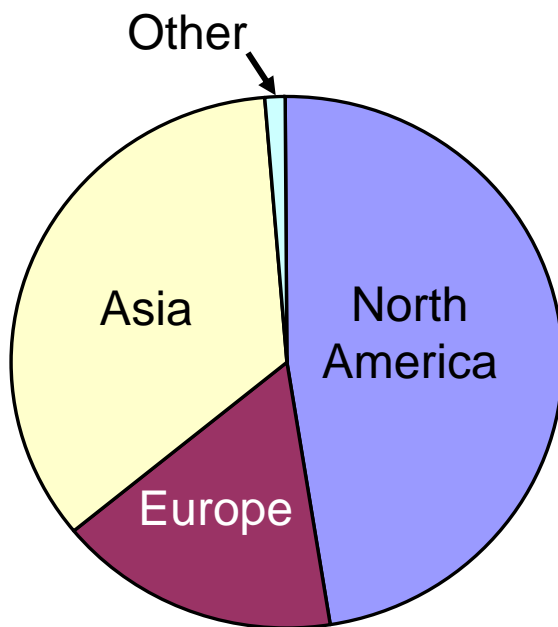
# International government spending



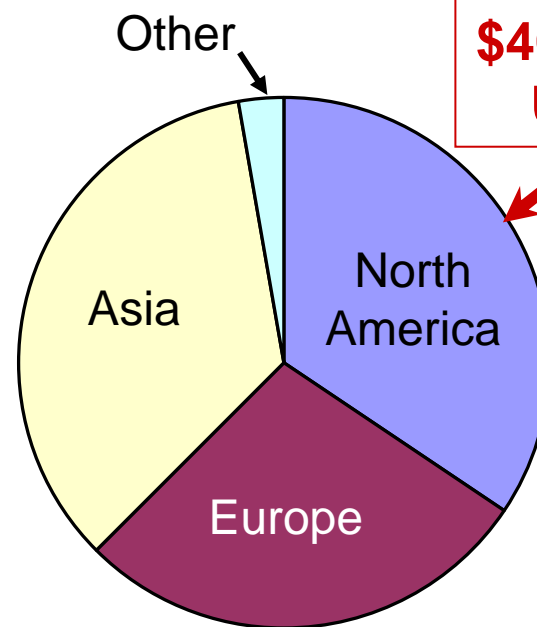
Source: M. Roco, National Science Foundation



# Global investments in 2004 (Total=\$8.6 billion)



Private (Corp. + VC)  
Total = \$4 billion



Public (National, regional, state)  
Total = \$4.6 billion

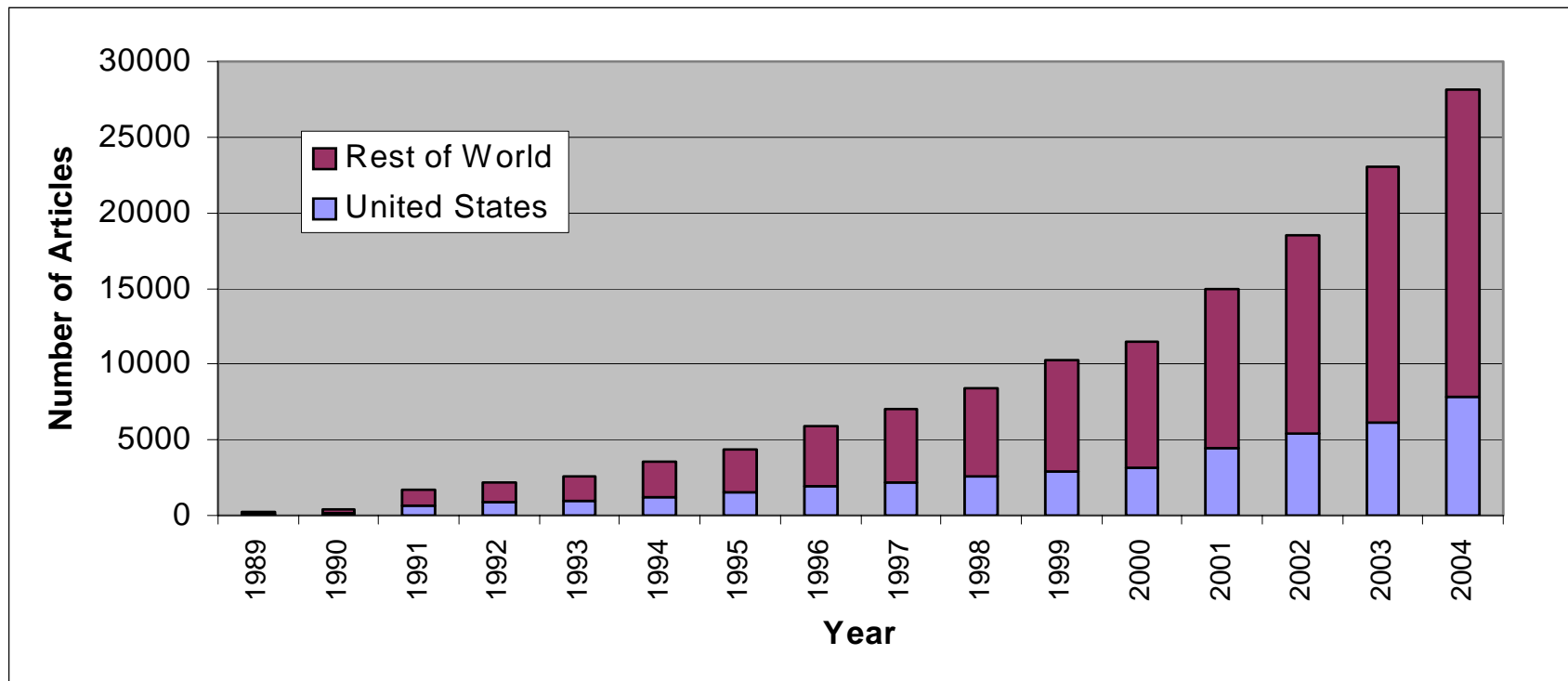
**\$400 million by  
U.S. states**

Source: Lux Research



# Measures of U.S. Competitiveness: Scientific Publications

★ U.S. fraction of publications mirrors fraction of investment.

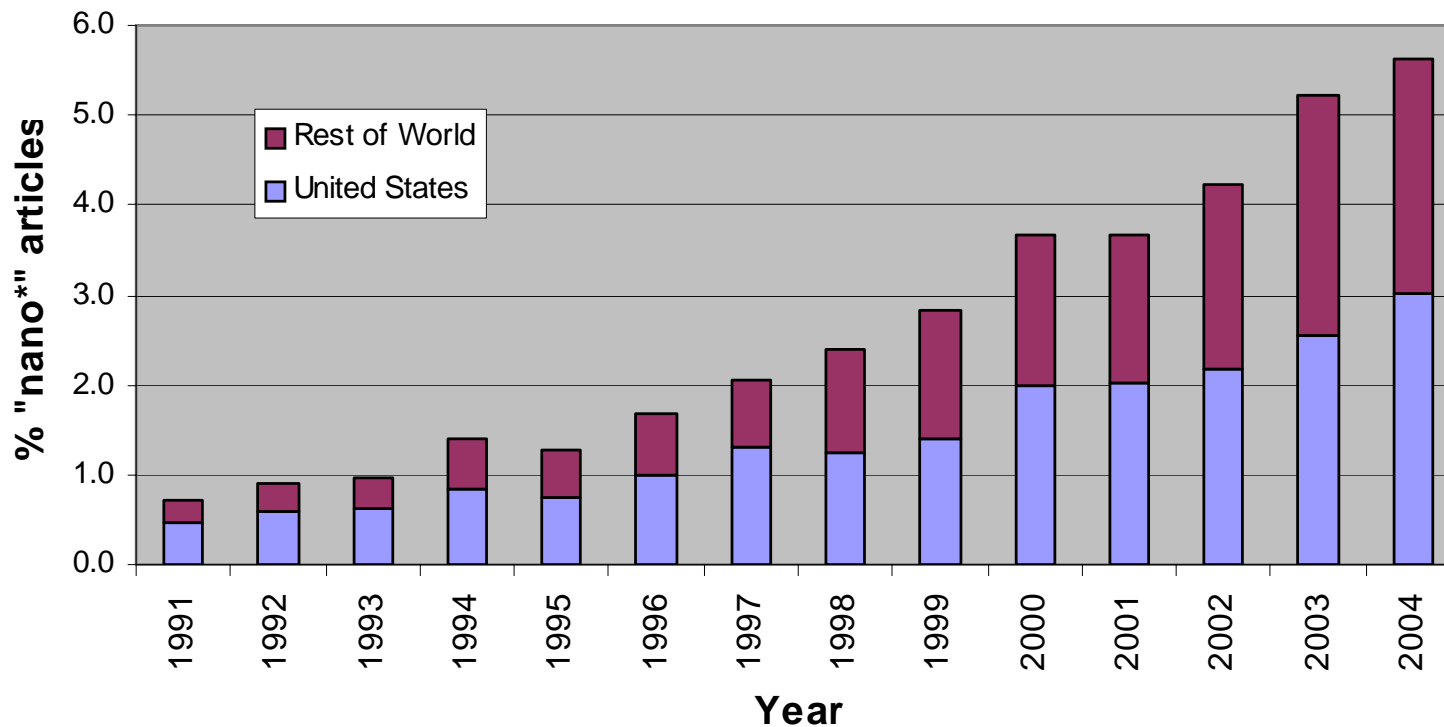


Source: J. Murday, U.S. Naval Research Laboratory; ISI search using “nano\*”



# Measures of U.S. Competitiveness: High Impact Scientific Publications

- ★ Growing % of articles in “high impact” journals\* are on nano
- ★ *U.S. share is >50%; even though U.S. investment is ~25%*



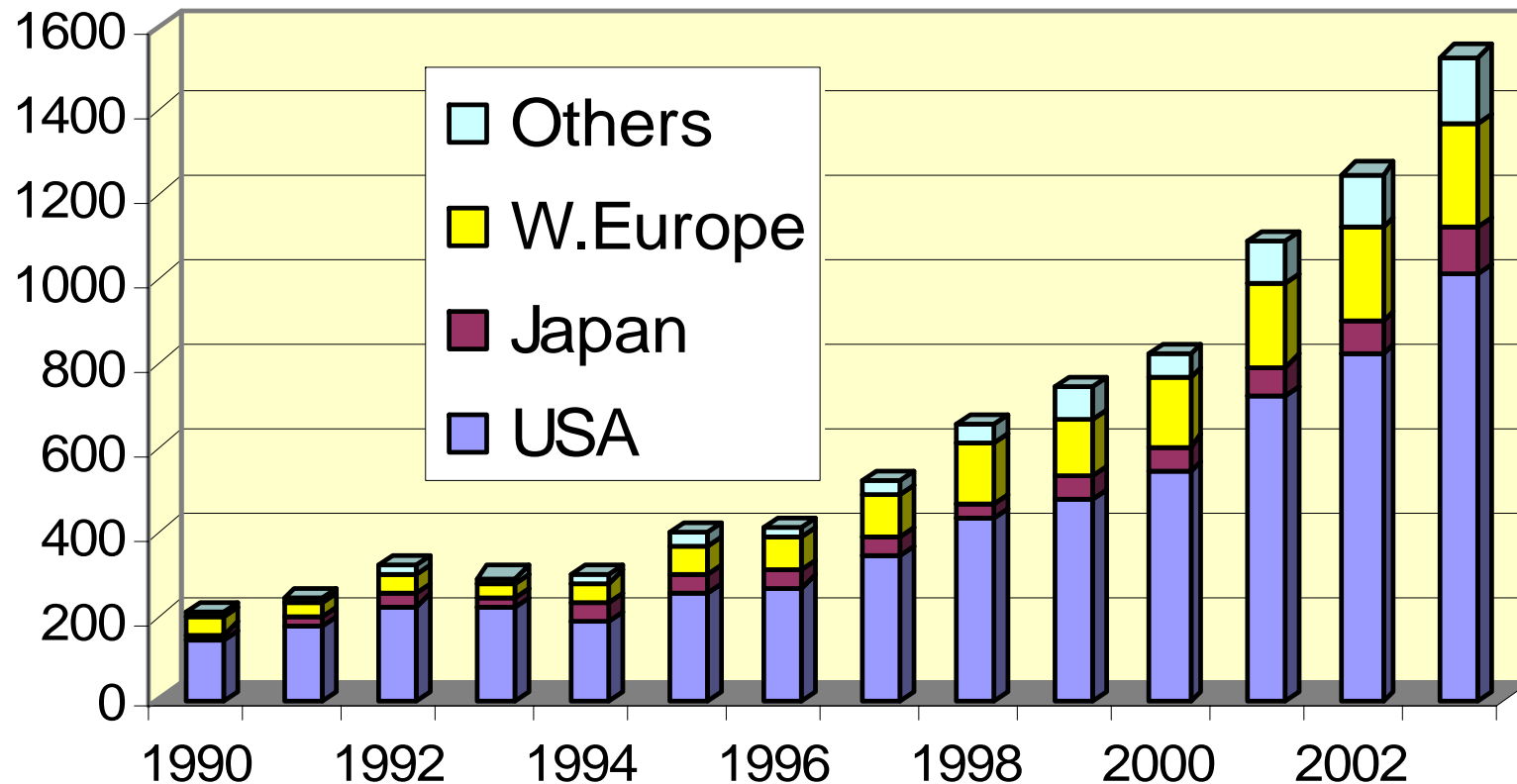
Source: J. Murday, U.S. Naval Research Laboratory

\* Search of *Science*, *Nature*, and *Phys Rev Ltr* using “nano\*”





# Measures of U.S. Competitiveness: Patents

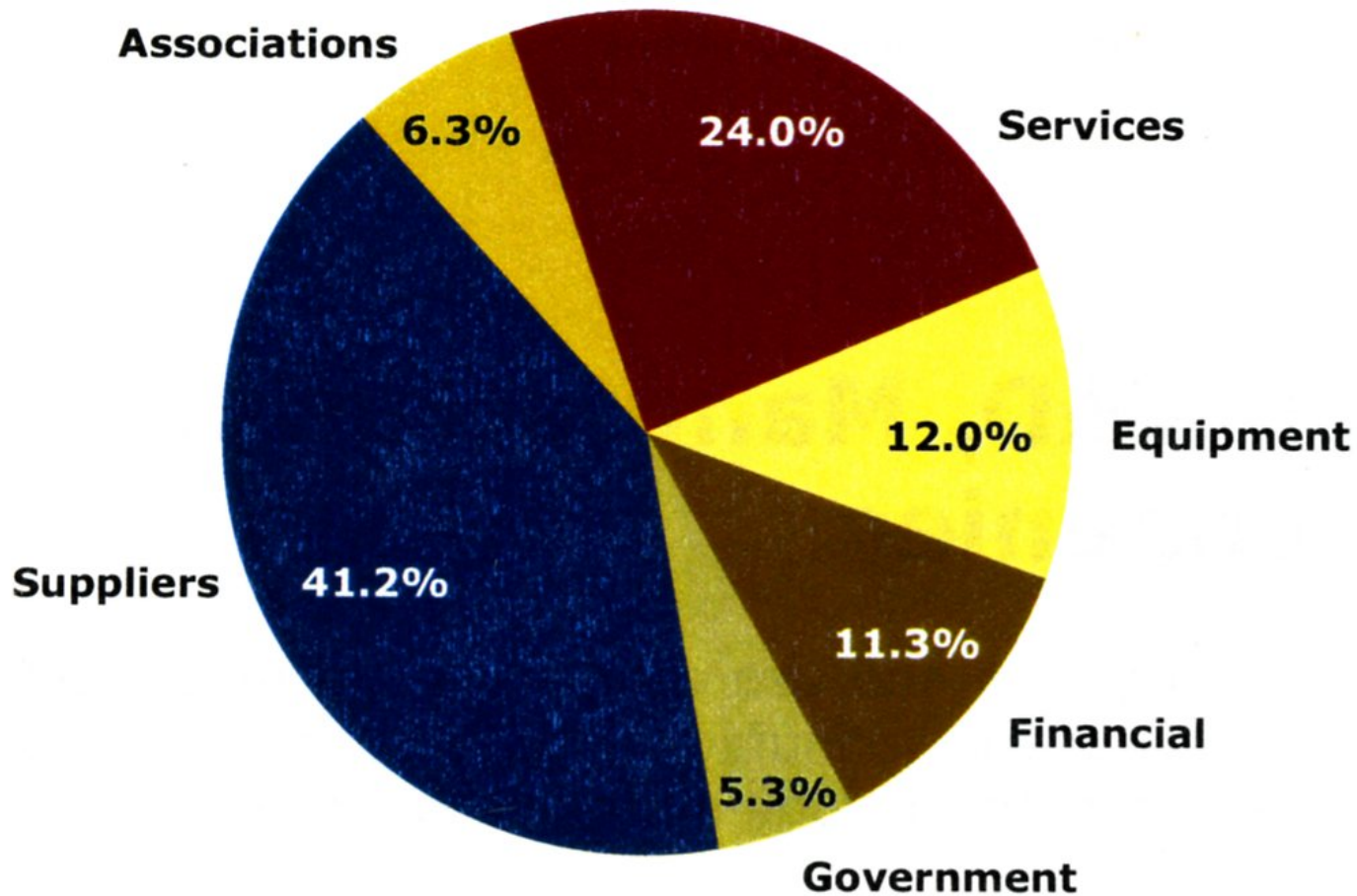


Source: Huang et al. (2004) J. Nanoparticle Research  
Nanotechnology keyword search of titles and claims of patents in USPTO database



# Nanotech business sectors

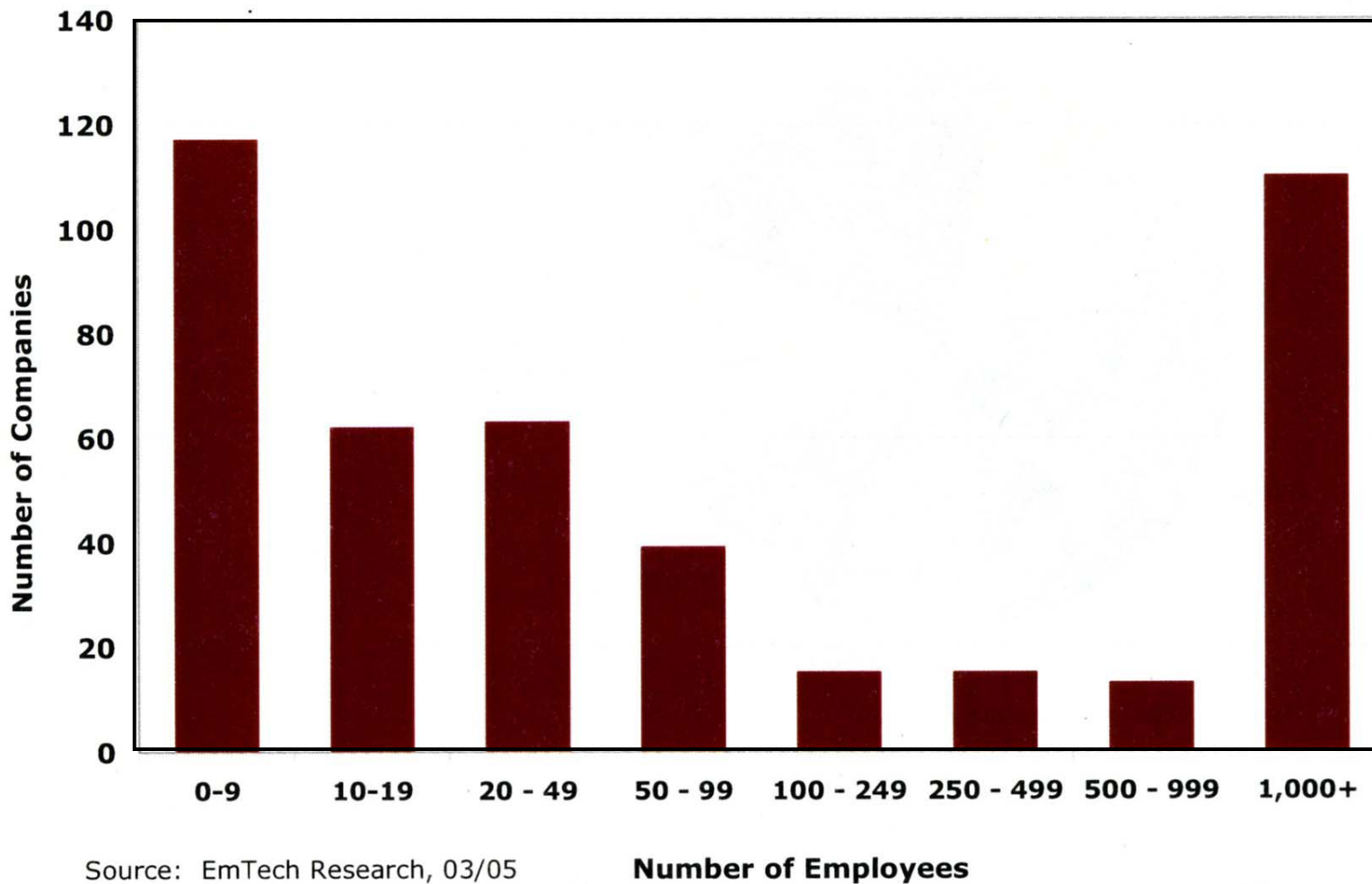
(Number of companies= 1455)



Source: EmTech Research, 03/05

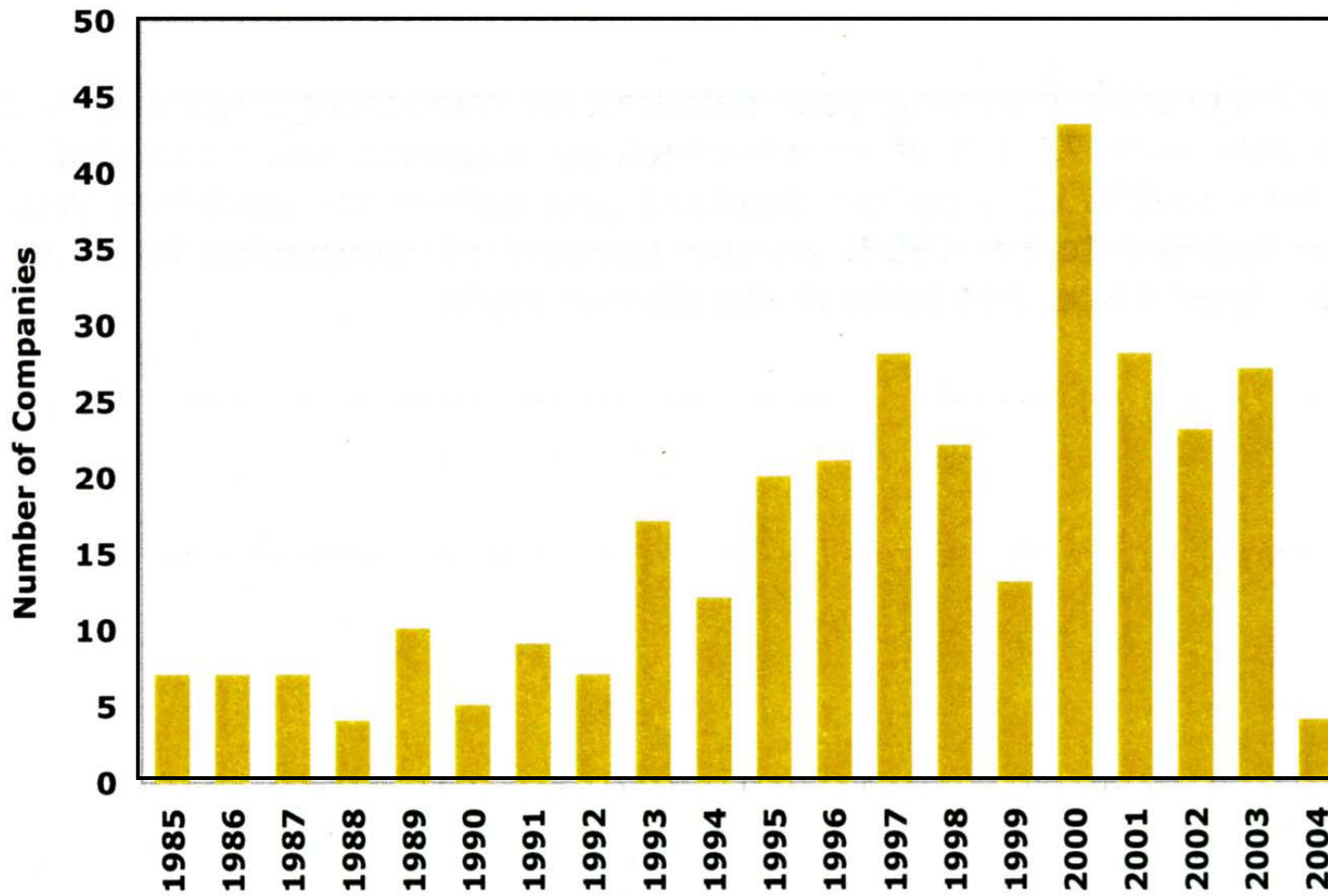


# Nanotech suppliers: Company size





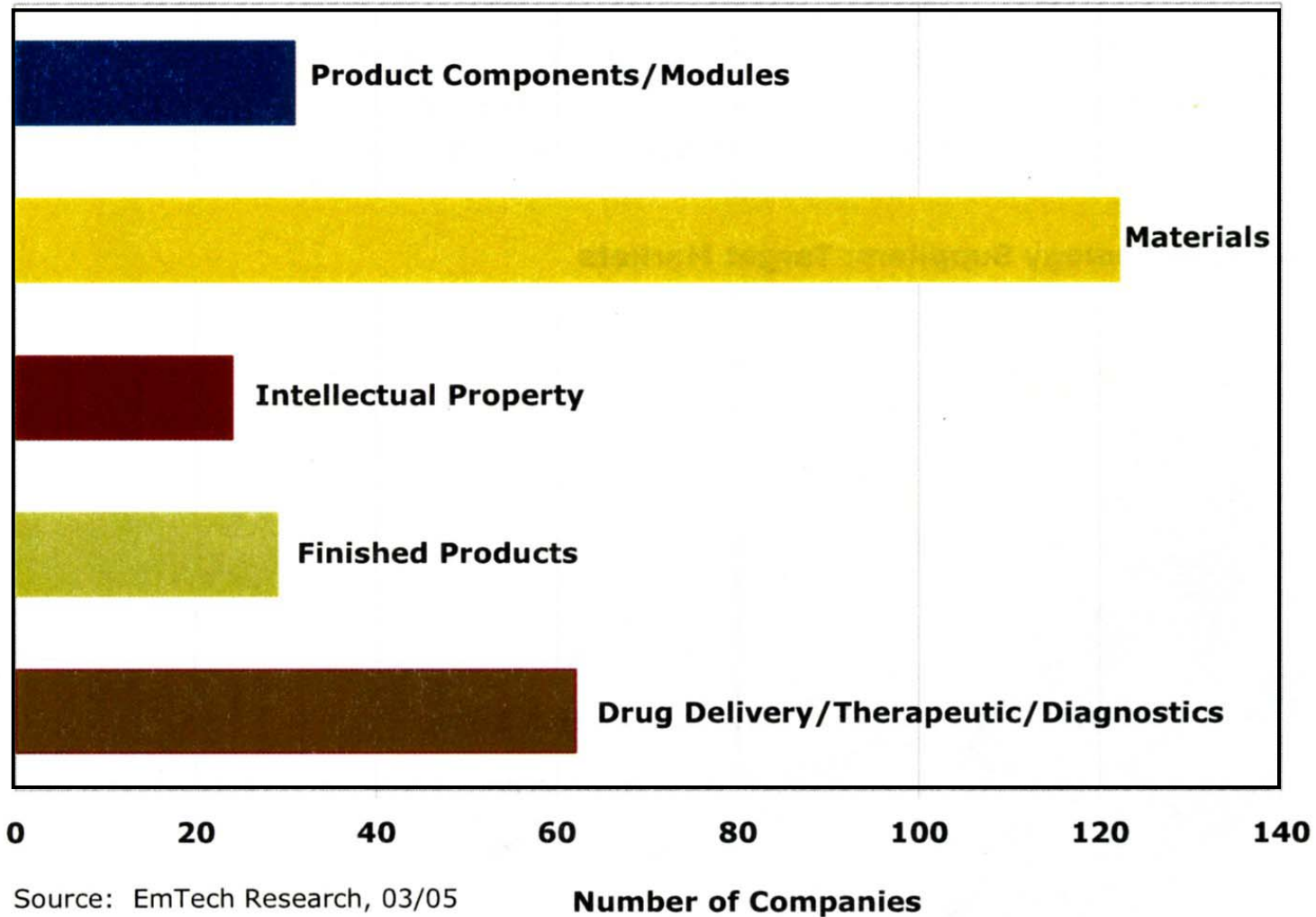
# Nanotech suppliers: Founding year



Source: EmTech Research, 03/05

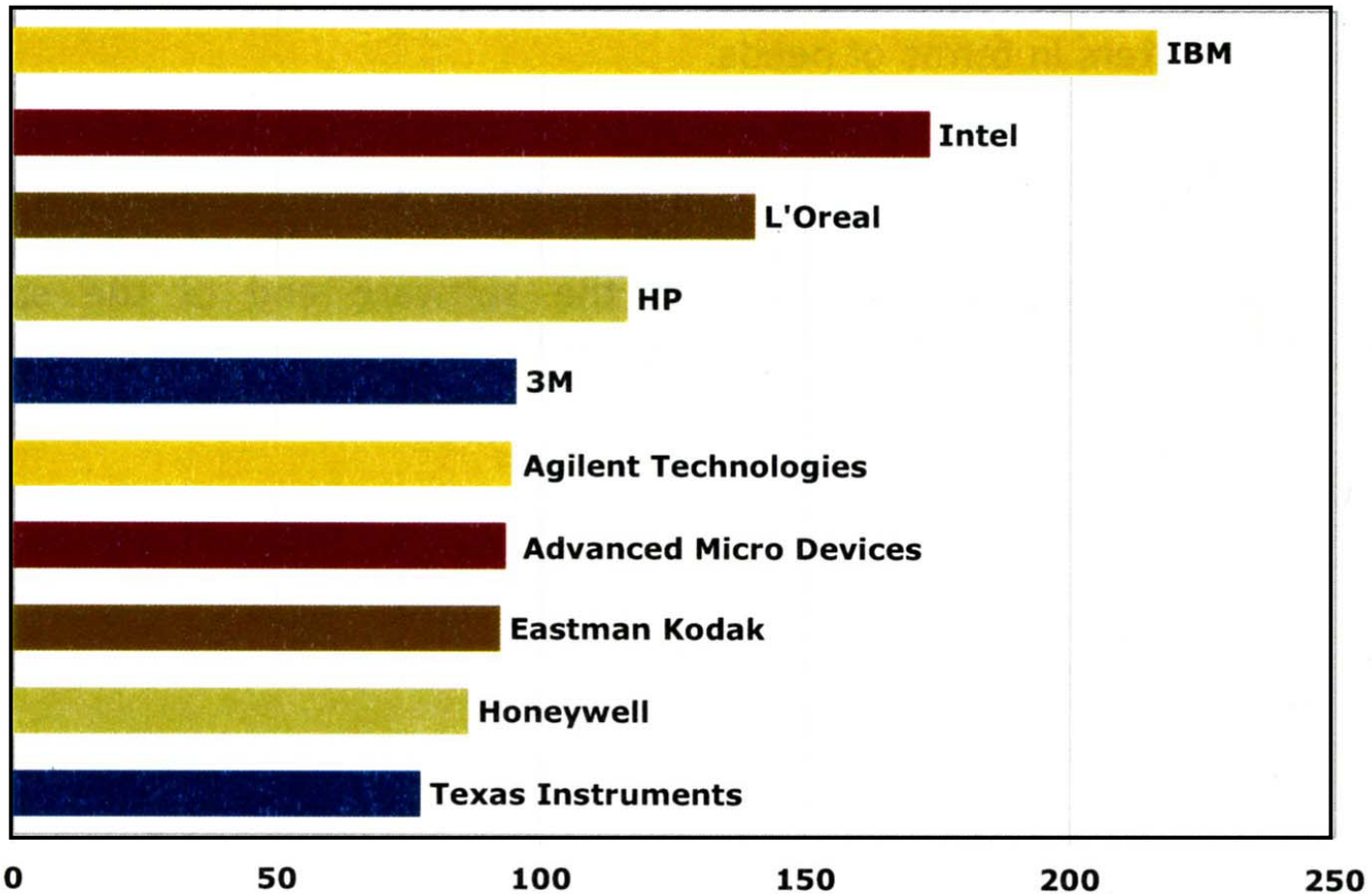


# Nanotech suppliers: Primary product





# Top patenters among nano suppliers



Source: EmTech Research, 03/05

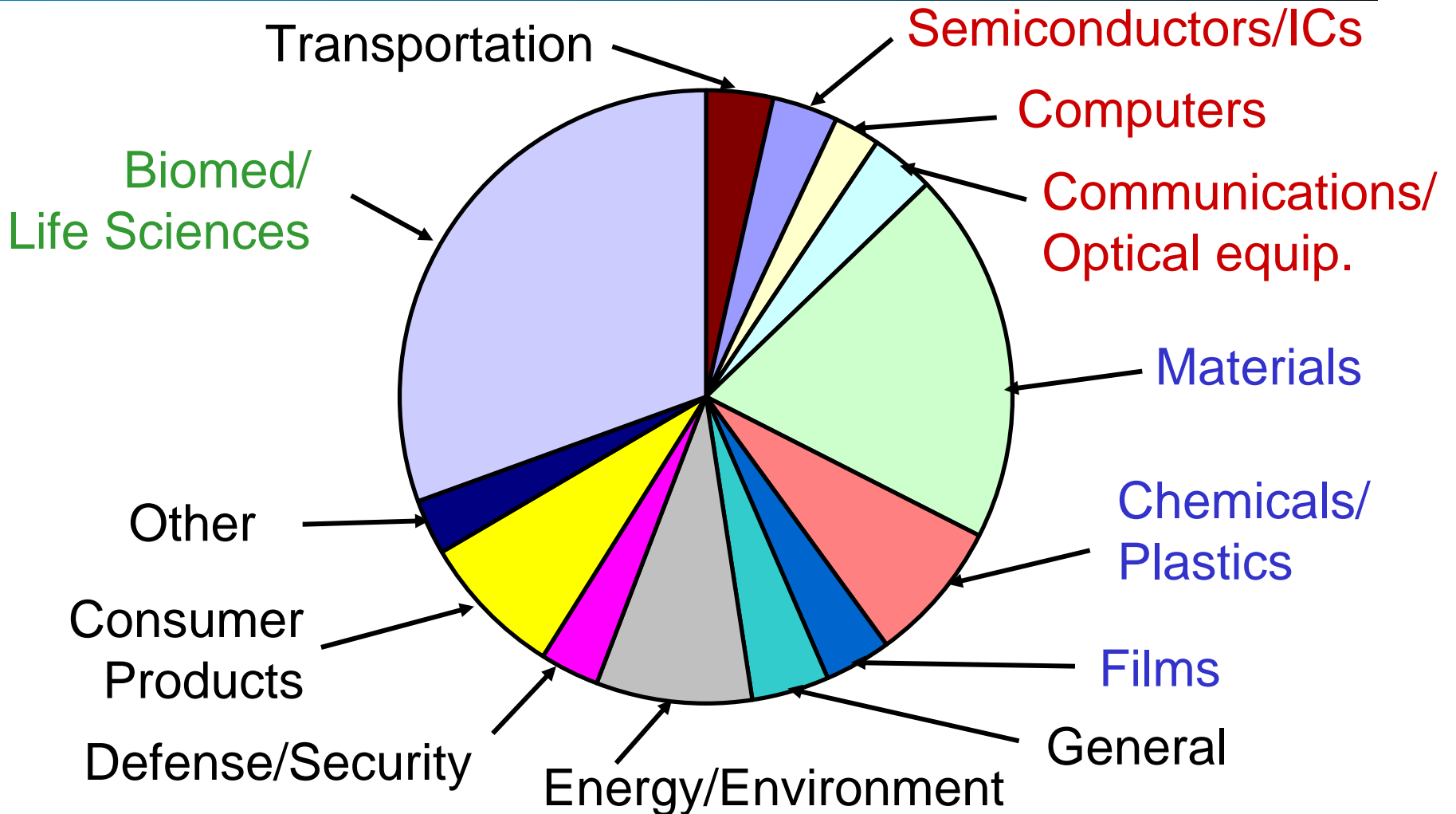
Number of Small Tech Patents





# Target industries for nano suppliers

(Number of companies = ~600)





## What about regulation?

- Existing statutes provide necessary authorities
- But implementation must be evaluated
- Research is underway to determine risks of specific nanomaterials and general characteristics related to interactions with the environment and the body.
- Need a coordinated approach among regulatory and research agencies.

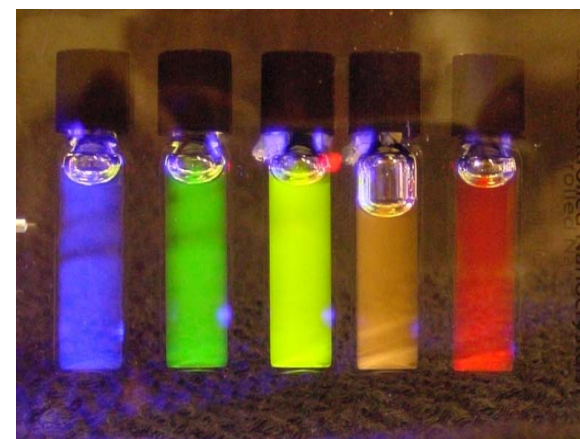
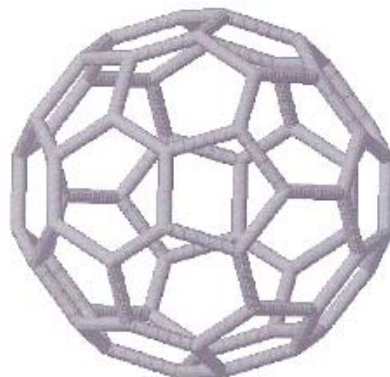
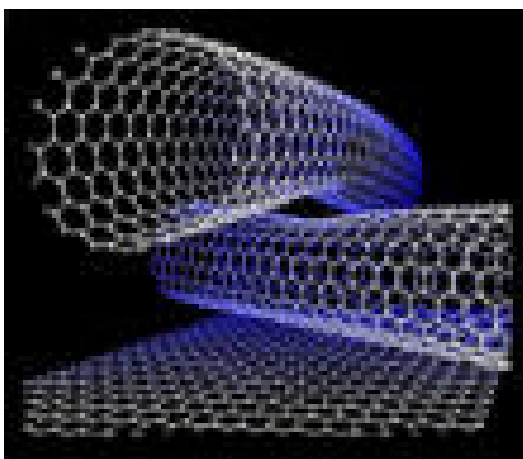




# National Toxicology Program: Nanotechnology Safety Initiative



- NTP initiating toxicology studies of:
  - Nanocrystalline fluorescent semiconductors (aka "quantum dots")
  - Carbon nanotubes (CNTs) & fullerenes
  - Nanoscale metal oxide particles (e.g.  $\text{TiO}_2$ )





# Nanotechnology Environmental and Health Implications (NEHI) Working Group

- Subgroup of the NSET Subcommittee
- Co-chaired by FDA and NIOSH
- Members from research and regulatory agencies
- Purposes
  - Provide for exchange of information
  - Facilitate identification, prioritization, and implementation of EHS research on nanotechnology
  - Promote communication of information related to EHS research on nanotechnology



# Nanotechnology standards

- Required for communication; accurate measurement and testing; reliability and quality control.
- ANSI Nanotechnology Standards Panel est. Aug 2004
- ISO Technical Committee on Nanotechnology--decision June 2005
- ASTM E56 Committee on Nanotechnology Standards est. Jan 2005



## NCSU survey >1500 adults finds...

- >50% haven't heard of nanotechnology
- >30% have heard "little"
- Nearly twice as many think benefits outweigh risks vs. the other way around
- 70% are "hopeful"; 80% are "not worried"
- 60% do not much trust business



# Summary

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- Nanotechnology is already here
- More complex nanotech devices and systems are on the way
- Responsible development means promoting benefits while managing risks
- For the latest on NNI activities and recent nanotechnology advances, go to

**[www.nano.gov](http://www.nano.gov)**



THE WHITE HOUSE  
WASHINGTON