Nanotech 2005
Anaheim, CA
9 May 2005

Thank you to the organizers of Nanotech 2005 for the invitation to speak today.

The U.S. National Nanotechnology Initiative—or NNI—is in its fifth year and now represents an annual investment of over one billion dollars across the Federal Government. I would like to provide an overview of the U.S. Federal policies and activities related to its investment in nanotechnology. Looking over the program for this conference, three aspects about nanotechnology are evident.

First, nanotechnology is truly multidisciplinary —depending on expertise from traditional areas such as chemistry, biology, physics, and engineering. Second, nanotechnology applications will impact a wide range of industries—from medicine and electronics to security and environmental improvement. Third, nanotechnology research and development is taking place throughout the research community—in university and government laboratories, in start-ups and large companies, and in countries around the globe. From a policy perspective, nanotechnology's "diversity" provides challenges and opportunities.

Despite the many applications being discussed at this conference, there is still much yet to be discovered in the area of nanoscale science, and a lot of basic research and development (or R&D) to be done. Federal funding for such R&D has made the United States a leader in science and technology for the last half century and is vital to sustaining our innovation ecosystem and growing our economy.

National Budget Priorities

- Promoting Economic Growth
- Protecting America
- Supporting a Compassionate Society
- Making Government More Effective

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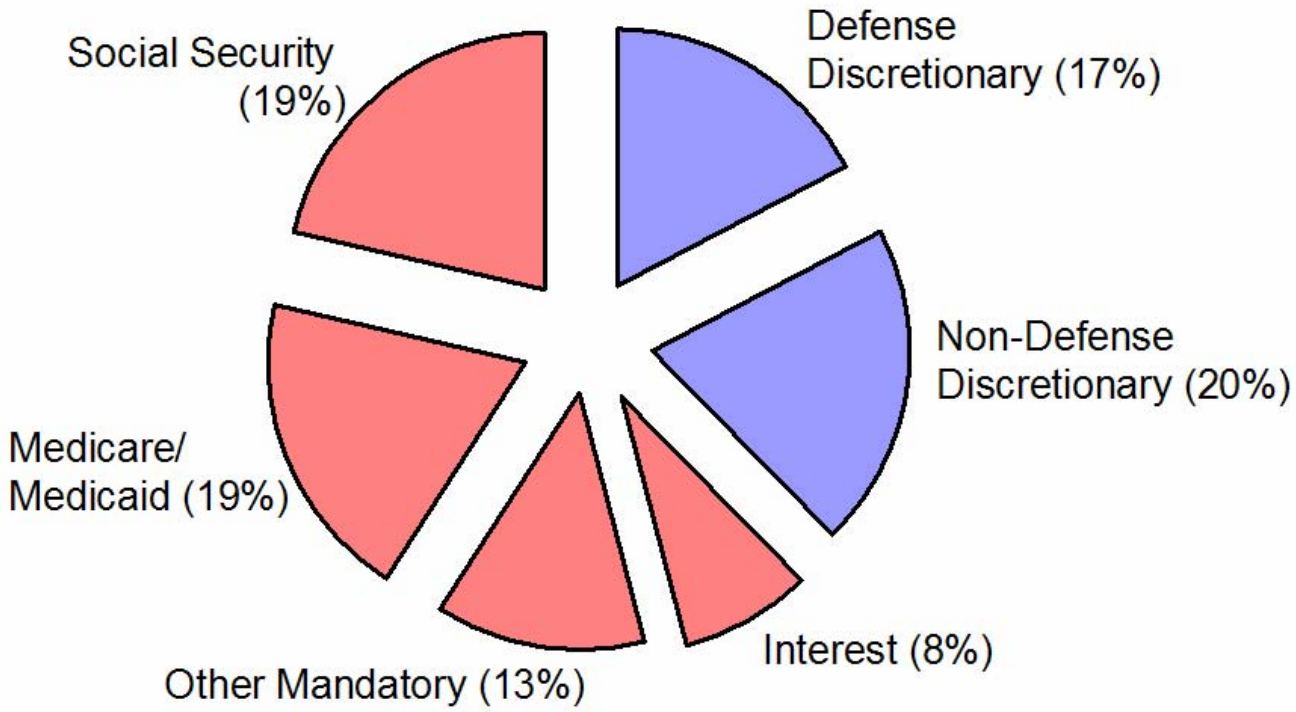
Let me begin by putting in context where the NNI fits within the broader national agenda. The President's 2006 Budget continues the progress the Administration achieved during the first term in the following areas: promoting economic growth, protecting America, supporting a compassionate society, and making Government more effective. Nanotechnology clearly will play a role, particularly in the first two areas.

President's 2006 Budget ($2.6 trillion)



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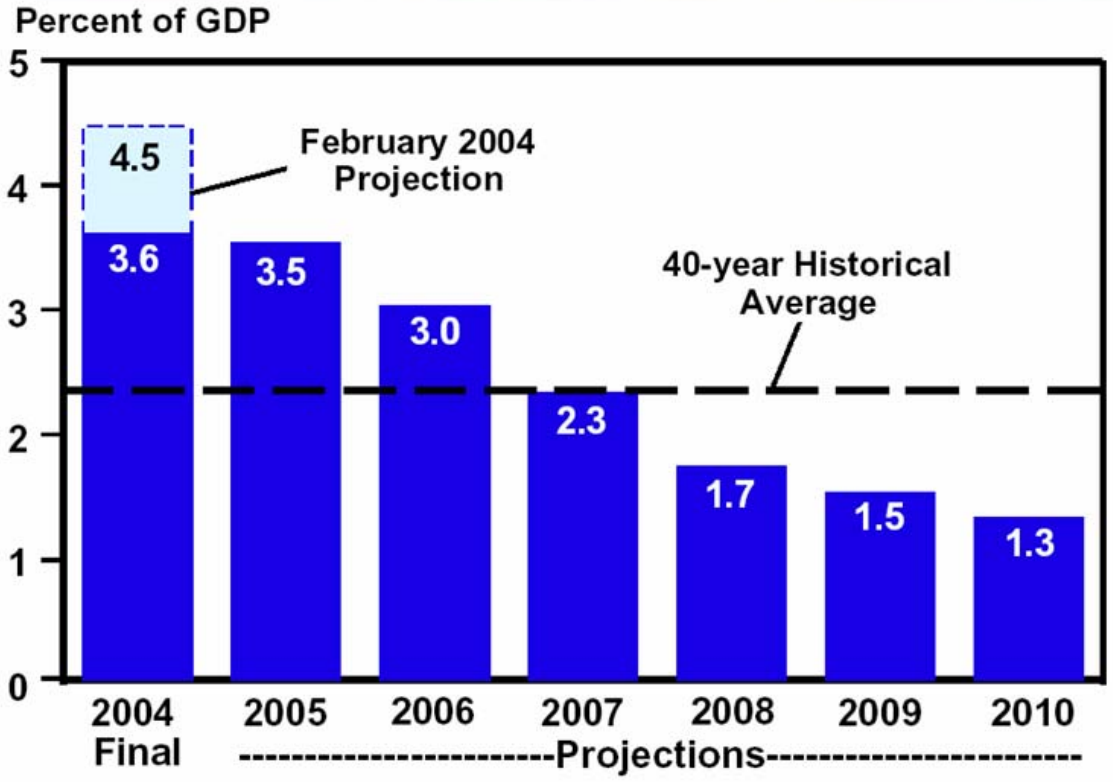
As many of you know, much of the Federal budget goes toward non-discretionary accounts, like social security and Medicare/Medicaid. Within the discretionary portion of the budget, the President is committed to spend what is needed to win the War on Terror and to protect the homeland. The discretionary Defense budget includes a substantial amount for R&D that supports the agency missions, and at the same time contributes to the Nation's technological leadership. As you will see later in this talk, Defense R&D also plays a significant role in the NNI.

Reducing the deficit



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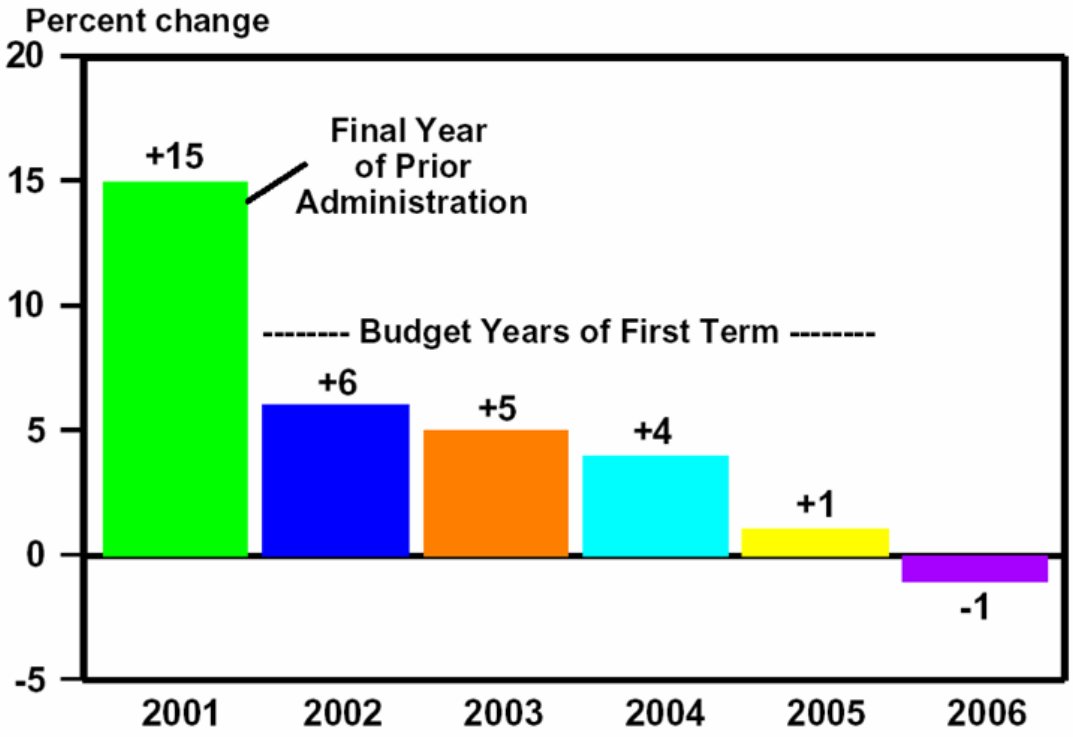
While addressing these priorities, the President is committed to reducing the Federal Budget deficit. The 2006 budget is consistent with the President's plan for cutting the deficit by half from the level in 2004. This reduction will bring the deficit down to well below the 40-year historical average of 2.3 percent of GDP, and is lower than all but seven of the last 25 years.

Discretional Spending Restraint



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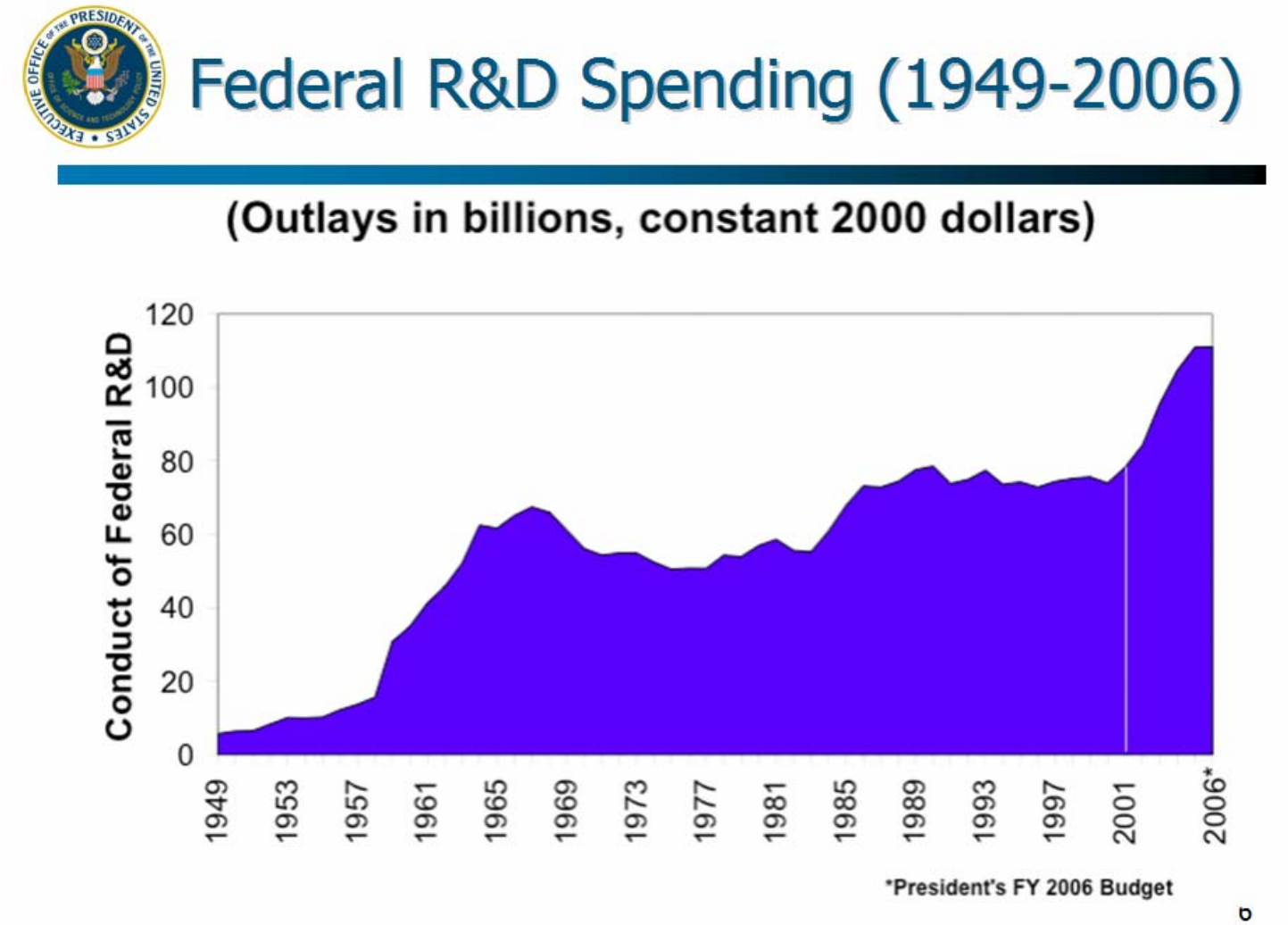
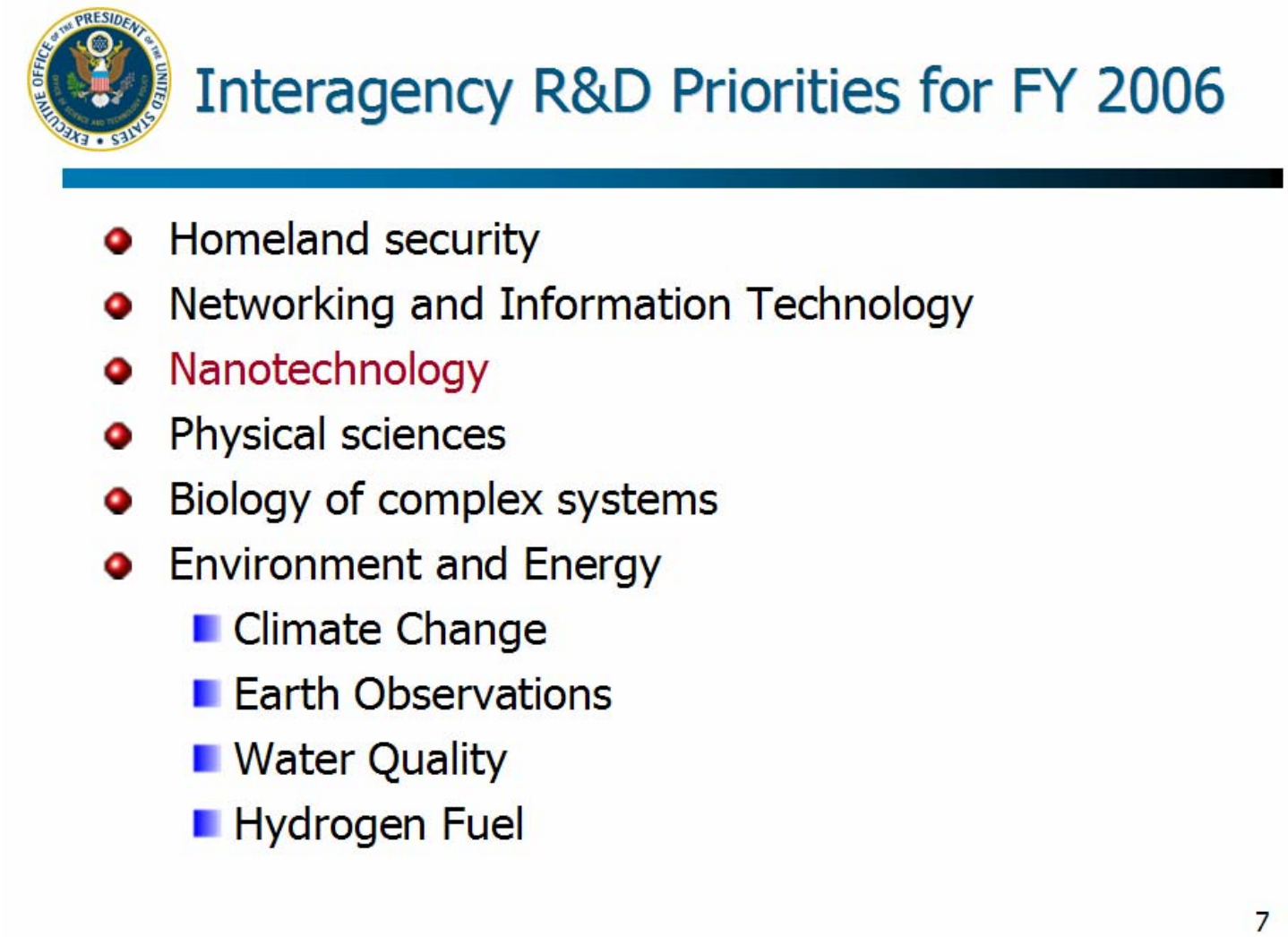
With these commitments, the President needs to enforce restraint in discretionary spending. The President has worked with the Congress in successfully bringing down the rate of growth in non-security discretionary spending each year of his first term, from the fifteen percent growth in the last budget year of the previous Administration, to just one percent growth in 2005. And the President's Budget reduces the non-security discretionary spending by nearly 1 percent in 2006.



These reductions to the discretionary budget are targeted at lower priority or lower performing programs. In contrast, high priority and well-performing programs continue to be supported. Analysis of Federal spending for R&D shows that despite constraints on discretionary budgets, the Administration's commitment to science and technology has been unprecedented since the Apollo program in the 1960's.

The President's FY 2006 Budget increases the funding for R&D by $733 million to a new high of $132.3 billion, which is 45% more than the $91.3 billion spent in FY 2001. The proposed spending for R&D represents 13.6 percent of the total discretionary spending (including for defense), the highest level since the Apollo program 37 years ago.



The Federal R&D programs that are funded within the discretionary budget are distributed among many of the Federal agencies. Each year around this time, the Directors of the Office of Science and Technology Policy and the Office of Management and Budget send the agency heads a memo providing guidance and emphasizing interagency R&D priorities for the coming budget cycle. The memo for FY 2006 includes nanotechnology among a small number of priority areas. Its inclusion in this "short list" is due to the promise of the scientific field and the recognition that approaches that leverage competencies across multiple agencies will be important in expediting progress in the discovery, development, and deployment of nanotechnology.

The memo states "The NNI should support both fundamental and applied R&D in nanotechnology and nanoscience, develop nanoscale instrumentation and metrology, and disseminate new technical capabilities to industry." Finally, the memo calls on the agencies to support research on societal implications, emphasizing that "agencies should place a high priority on research on human health and environmental issues related to nanotechnology."

21st Century Nanotechnology Research & Development Act of 2003

- Signed by the President on Dec. 3, 2003
- Put into law ongoing activities
- "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 interagency coordinating committee
- Authorized $3.7 billion in FY2005-FY2008 among 5 agencies

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".

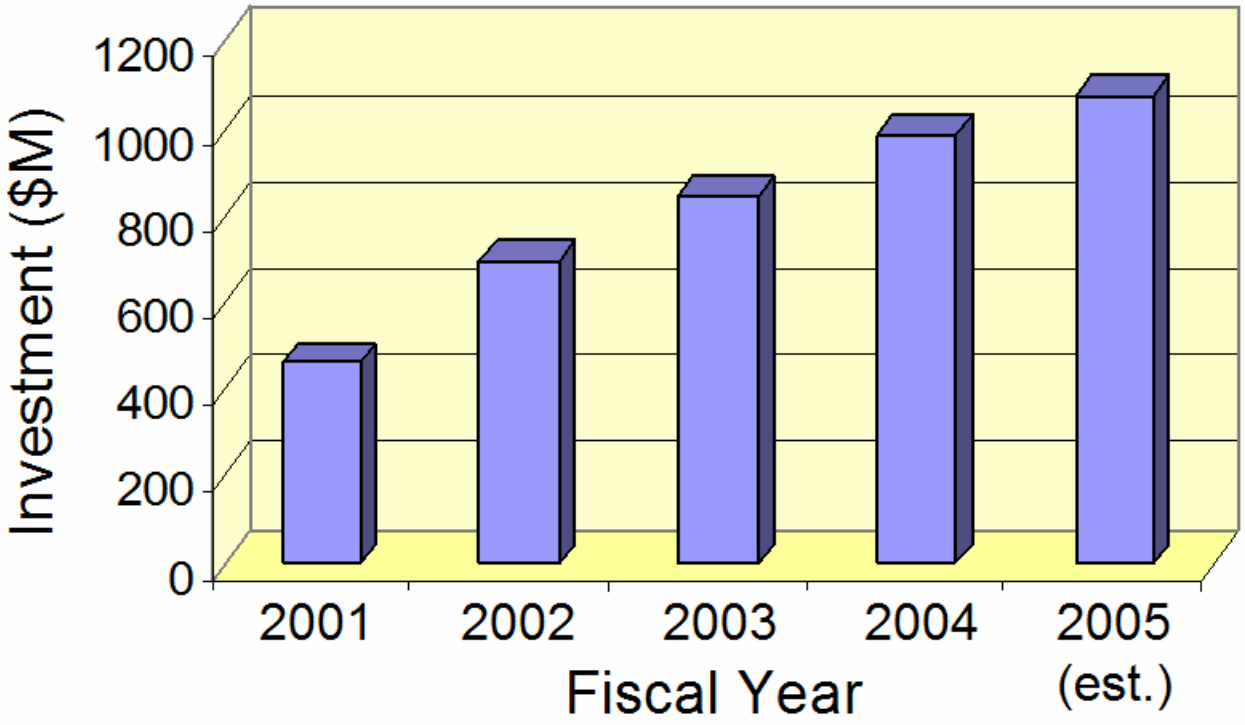
(C) make use of existing expertise in nanotechnology in their regions and nationally;

(D) make use of ongoing research and development at the micrometer scale to support their work in nanotechnology; and

In addition to the guidance provided by the annual R&D priorities memo, the NNI and various government bodies have certain responsibilities under the 21st Century Nanotechnology R&D Act of 2003, signed into law on December 3, 2003. This legislation put into law many of the ongoing activities of the NNI. It also made statutory the National Nanotechnology Coordination Office. The Director of that Office, Dr. Clayton Teague, is the keynote speaker on Wednesday. In addition, the law has provisions for various reviews. It calls for the President to establish or designate an outside advisory panel, which is to make periodic assessments and recommendations for improving the program. The President designated the President's Council of Advisors on Science and Technology (PCAST) as that advisory panel. PCAST, in their role as the National Nanotechnology Advisory Panel, approved a draft of their first report on the NNI at their meeting in March and the final document is expected to be released later this month. I will talk more about the PCAST draft report later.

Finally, the law calls for the National Research Council to perform a triennial review, and that process is underway, with the first report expected in early 2006. The law also authorized $3.7 million in FY2005 to FY 2008 among five agencies.

NNI Appropriations since FY 2001



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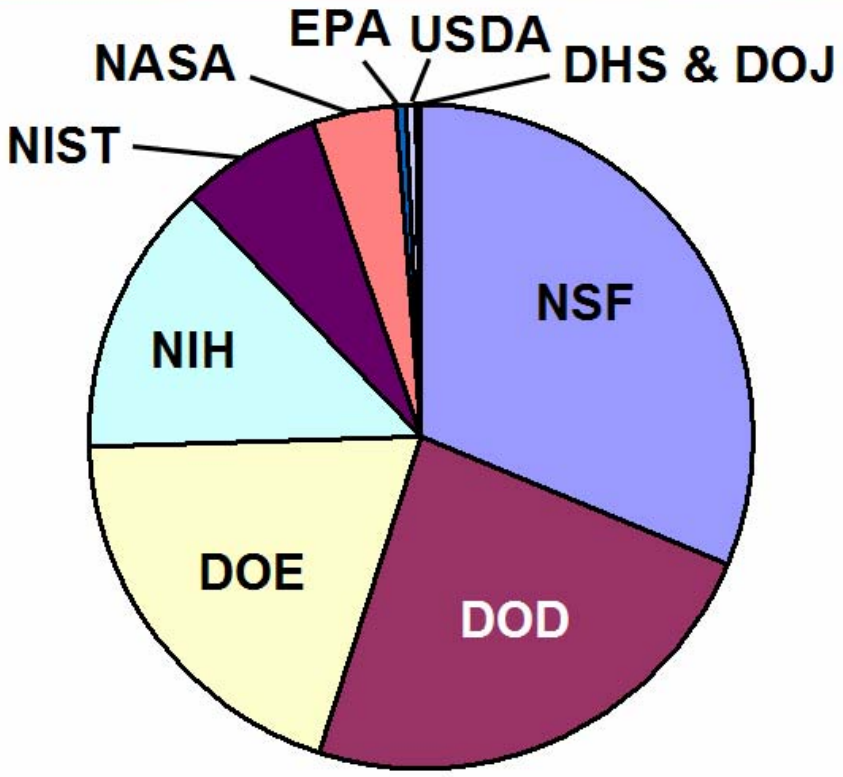
These authorizations by the Congress ratify the Administration's budgetary support for nanotechnology. As shown in this chart, funding for the NNI has more than doubled from $464 million in FY 2001 to over $1 billion in FY 2005.

NNI FY 2006 Budget Request

Total = $1,054 million



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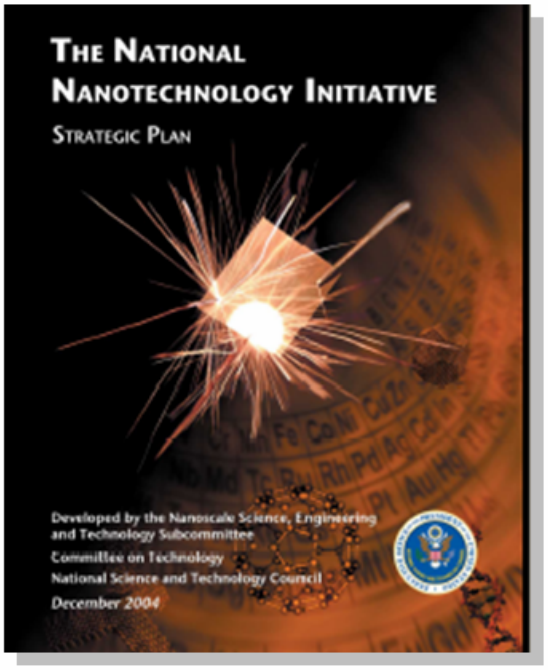
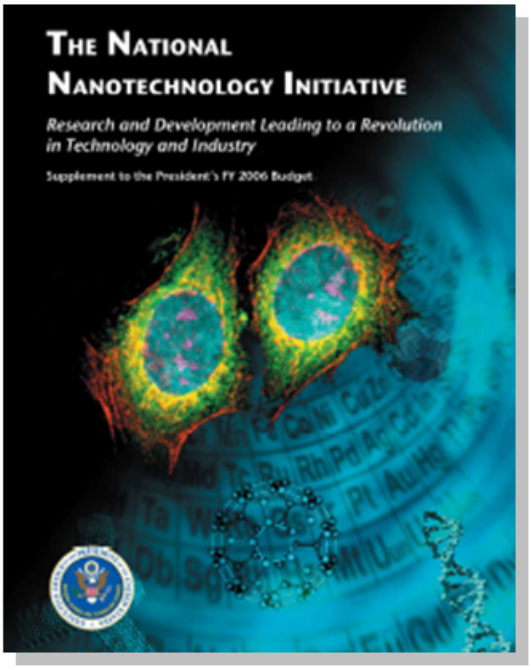
The President's Budget for FY 2006 requests $1.05 billion for NNI activities across eleven agencies. Nearly three-quarters of the total NNI budget is within three agencies—the National Science Foundation, reflecting that agency's mission to support fundamental research across all disciplines of science and engineering; the Department of Defense, which invests in R&D in materials, devices, and systems related to the agency's mission; and the Department of Energy, which is making a long-term commitment to nanotechnology R&D through its construction of five Nanoscale Science Research Centers, about which I will speak more in a few minutes. NIH is also making significant investment in nanotechnology R&D in the area of health and medicine.

NNI Reports





Available at www.nano.gov

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For additional information regarding the agency budgets for nanotechnology R&D, as well as detailed descriptions of the activities underway in 2005 and planned for 2006 at all 22 agencies that are participating in the NNI, I recommend the recently released Supplement to the President's 2006 Budget (shown on the right and available outside).

This annual report on the NNI budget is based on the strategic plan released in December 2004. The Strategic Plan (shown on the left) describes the vision and goals for the Initiative, and strategies by which those are to be achieved. Both are available at the NNI website: www.nano.gov.

NNI Goals

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

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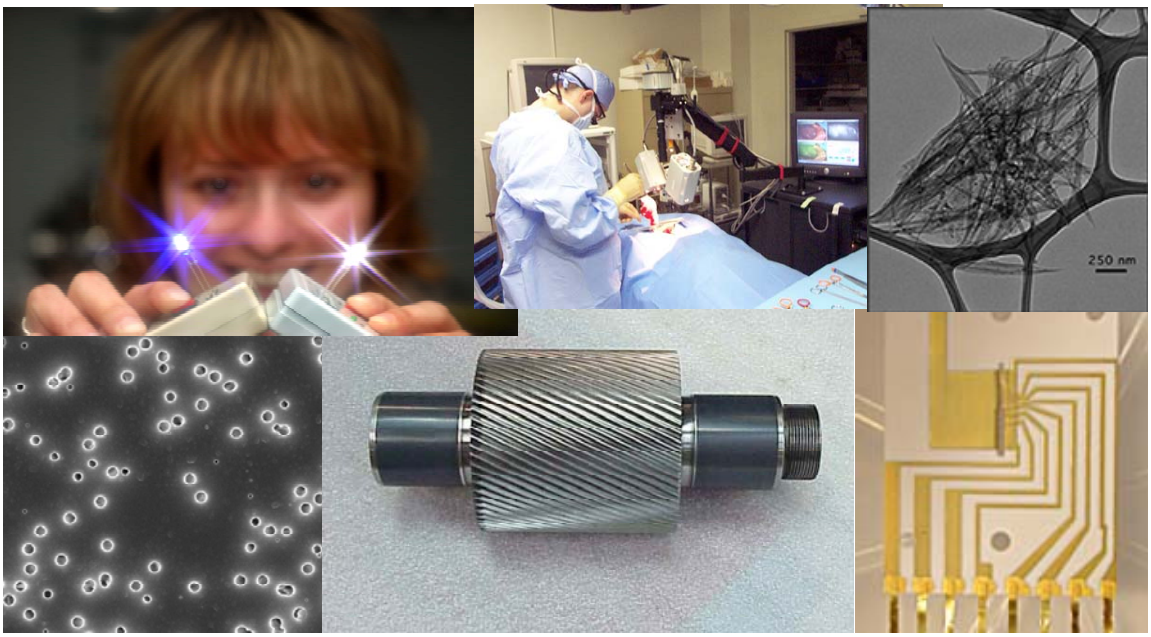
As detailed in the Strategic Plan, the goals of the NNI are: to sustain world-class R&D, facilitate the transfer of NNI research results to practical applications; develop the necessary infrastructure—that is provide advanced facilities and instrumentation, educational resources, and workforce preparation; and see that nanotechnology is developed responsibly.

These broad goals go beyond simply funding for principal-investigator-led projects at universities and federal laboratories.

NNI Goal: Sustaining world-class R&D



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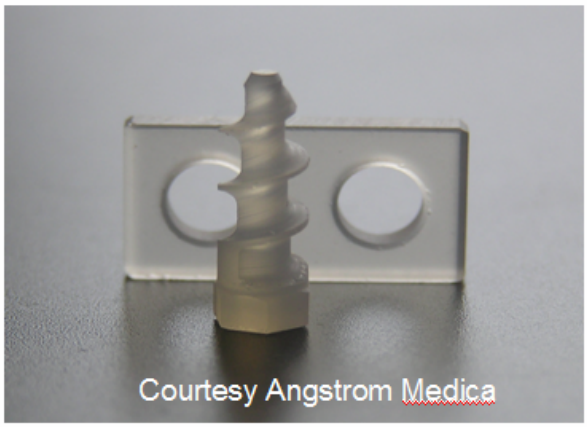
The core of the NNI is a broad array of R&D programs at the participating agencies, coordinated through the efforts of an interagency group chaired by the National Science Foundation with the support of the National Nanotechnology Coordination Office.

NNI activities include programs for basic (or knowledge-inspired) research, application (or use-inspired) research, and technology development. Examples of the areas of NNI investment are illustrated in this slide and include materials and coatings, energy efficient lighting, medical imaging, electronics, and information technology.

NNI Goal: Facilitate practical use

Technology Transfer mechanisms:

- License IP from university or Federal lab
- Federal grants and contracts
- SBIR/STTR



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The new knowledge and ideas derived from NNI R&D investments are just the first step in realizing the benefits of nanotechnology. However there is no one pathway by which a new technology finds its way from the laboratory to the marketplace. The process may involve many stakeholders, including researchers and their institutions, business partners, and investors.

I would like to take this opportunity to note that this year marks the 25th anniversary of the signing of what is known as the "Bayh-Dole Act," the seminal legislation that led to today's extensive university technology transfer activities.

By giving universities and small businesses the option to retain rights to the inventions made by their employees in the course of performing Federally funded research, Bayh-Dole encouraged researchers and the universities to actively pursue commercialization of those inventions.

Since the passage of Bayh-Dole in 1980, patent and license activity at universities has grown steadily, as has income from royalties and equity in start-up companies. The most recent survey by the Association of University Technology Managers reports that the 194 respondents collectively received over $1.4 billion in licensing income in FY 2003.

More importantly, nearly 800 new companies based on academic discoveries were formed in 2002 and 2003 and thousands of licensed products are commercially available, thanks in part to the incentives provided by the Bayh-Dole Act.

University and Federal laboratory licensing activities are just one component of the process by which research leads to commercial products. The Federal Government also provides support for innovation and product development through traditional contracts and grants and through the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs.

As many of you may know, the SBIR and STTR programs are funded by a percentage of the R&D budget within those agencies that have research activities. These funds are awarded to small businesses to demonstrate and prototype new technologies through a competitive process. Each agency manages its own SBIR/STTR programs in support of its own mission, specifying topics of interest along with the calls for proposals. Some agencies— including NSF, EPA, and NIH—have called out "nanotechnology" in their solicitations. A conservative estimate of the amount of SBIR funding for nanotechnology-related projects indicates that roughly $70 million are being spent annually.

An example of a technology that is proceeding from lab to market is a nanocrystalline synthetic bone material that is being developed by Angstrom Medica (and is shown at the bottom right). Based on the mineral that makes up natural bone the synthetic nanocrystalline version is more biocompatible and heals twice as fast as currently used materials. In addition, once healed, it is fully integrated—leaving the bone as good as new, unlike metal implants, which can become loose and require additional surgery.

The original research was performed at MIT, funded in part by the Office of Naval Research. In 2001, Angstrom Medica was founded to develop synthetic bone for medical use, and since then, the company has received SBIR grants from the National Science Foundation and the National Institutes of Health and raised several million in venture capital. In February 2005, Angstrom Medica received FDA approval to market its material for use as bone void filler, making it the first engineered nanomaterial specifically allowed by the FDA for medical use.

This is just one example of a technology transfer success story. I don't have time to describe the many others. But this example illustrates how the ability to control matter at the nanoscale is leading to real advances and new capabilities that are improving our lives today.

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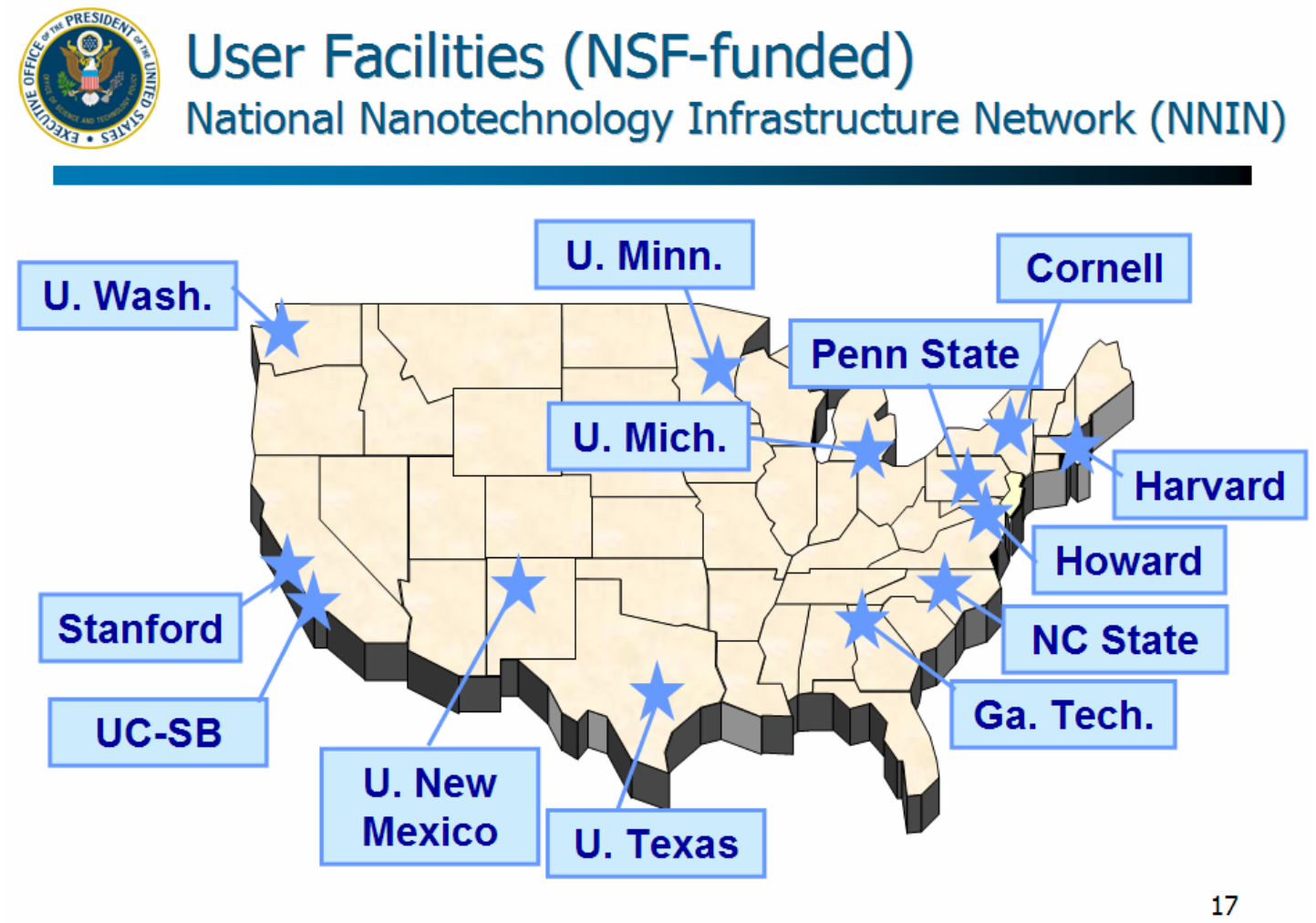
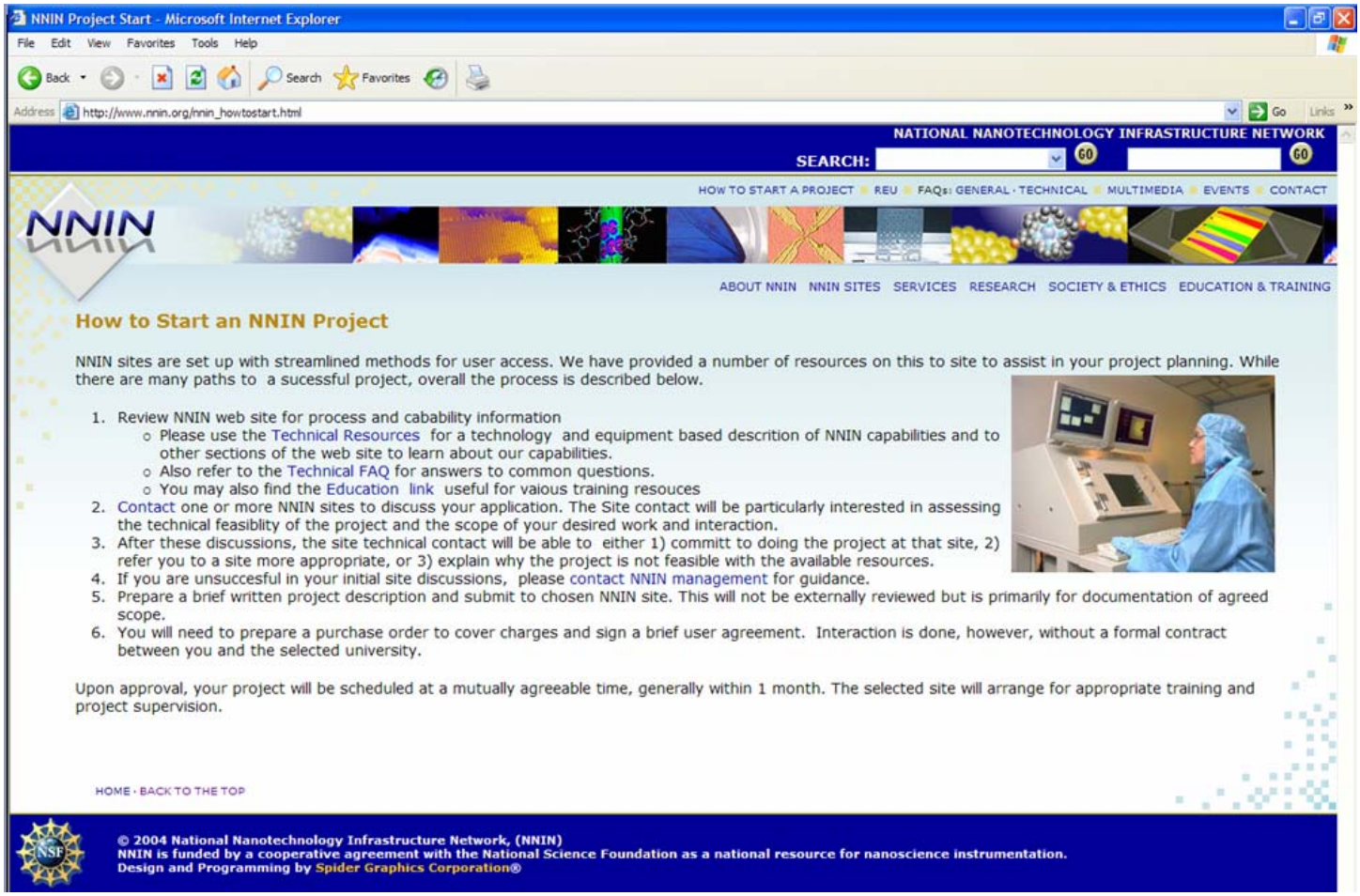
The research and technology development that I have described depend, in many cases, on multidisciplinary research involving researchers from many areas working together. Frequently, it requires the use of advanced—and often costly—facilities and instrumentation.

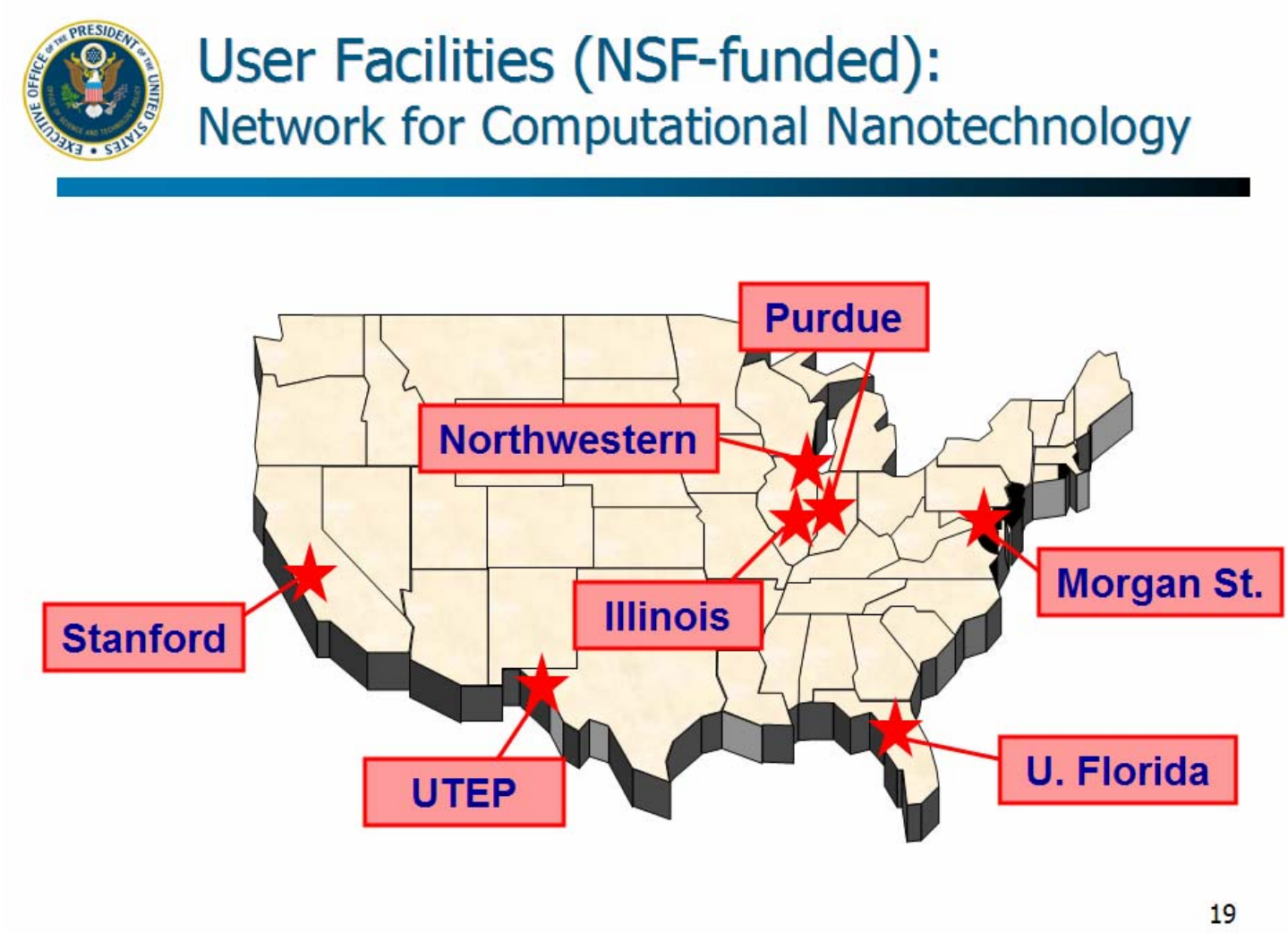
The NNI has addressed these needs by funding a number of university-led multidisciplinary research centers and user facilities. To date, over 30 centers and user facilities have been established, with participation by over 80 universities and Federal laboratories across the country. I would like to focus in particular on three groups of user facilities, which are accessible to the broad research community, not just researchers at the host institution.



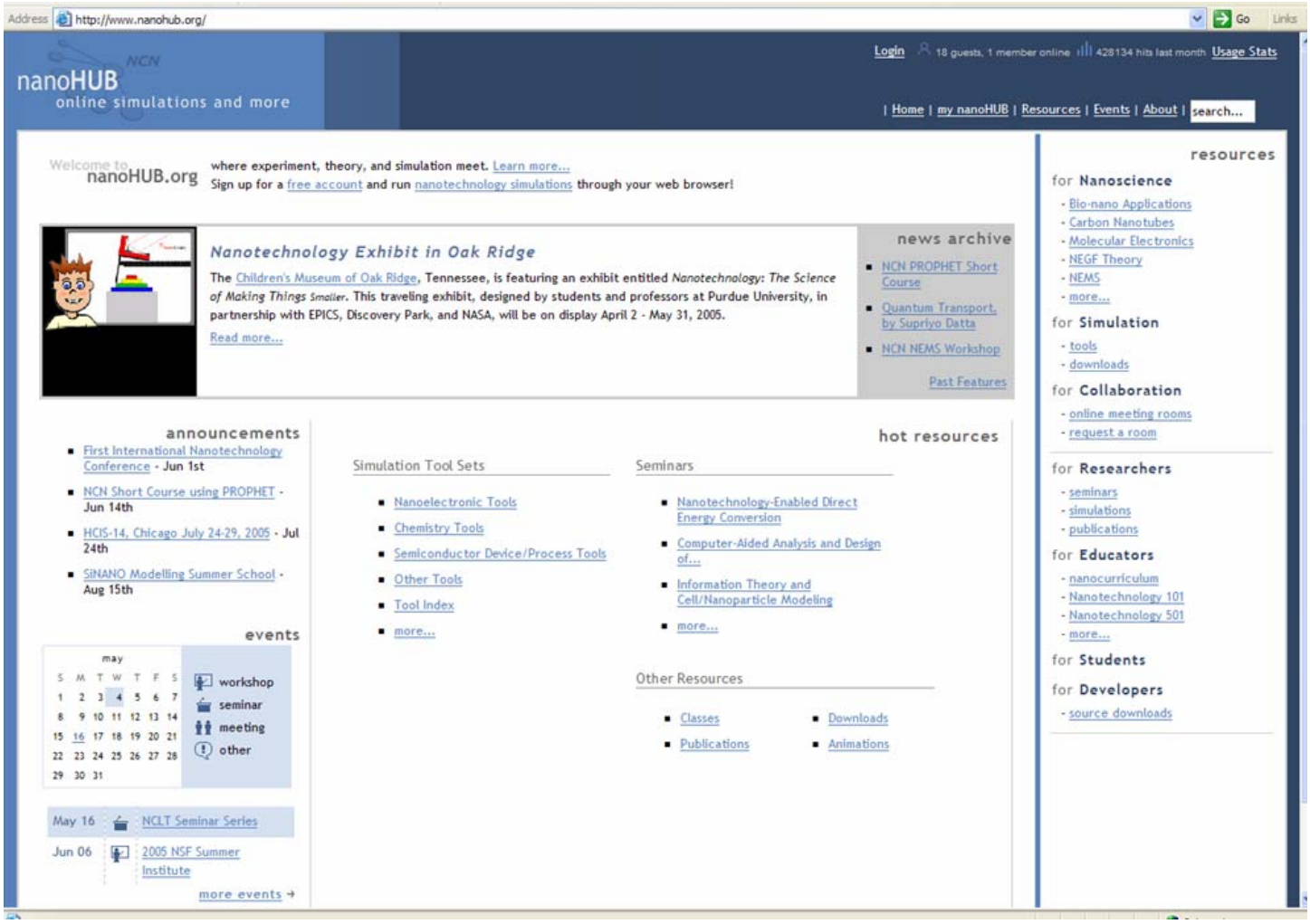
The National Nanotechnology Infrastructure Network (NNIN) is a network of 13 universities—led by Cornell—that is funded by the National Science Foundation.



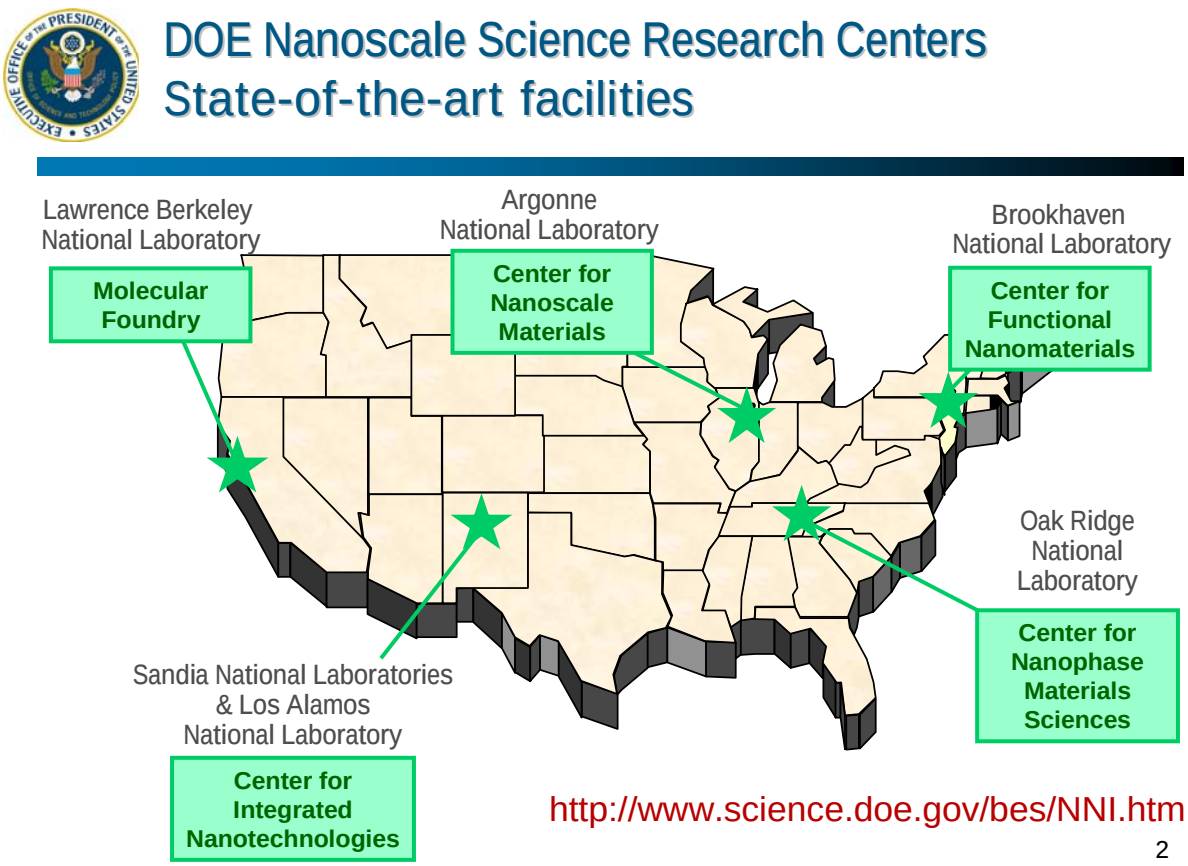
The NNIN provides support in nanoscale fabrication, synthesis, characterization, modeling, design, computation and hands-on training to all qualified users. Getting started is as easy as clicking on “How to Start a Project” on their website at NNIN.org.



The Network for Computational Nanotechnology (NCN), also funded by the National Science Foundation, is a network of 7 universities—led by Purdue University—that has a mission to connect theory, experiment, and computation to advance nanotechnology.



NCN investigators carry out research and provide on-line resources including a web-based computational user facility that makes research-grade software easily accessible. The NCN's Nanohub has links to simulation tools for nanoelectronics, chemistry, and semiconductor devices. Resources are aimed at a variety of users, including researchers, educators, students, and software developers.

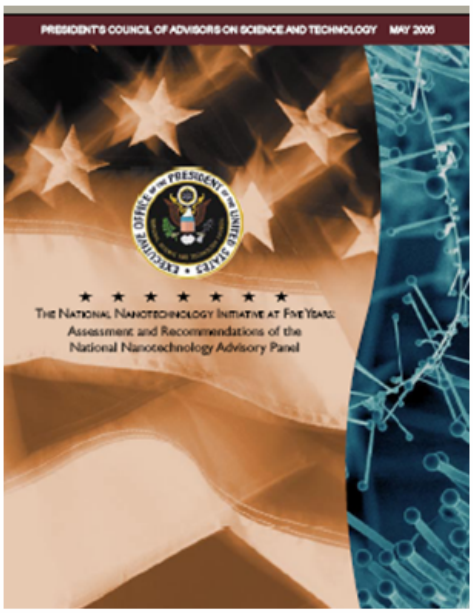


The Department of Energy Nanoscale Science Research Centers (NSRCs) are state-of-the-art research facilities for the synthesis, processing, and fabrication of nanoscale materials. They will be collocated with existing DOE user facilities to provide sophisticated characterization and analysis capabilities. The five NSRCs are under construction at Oak Ridge National Laboratory, Brookhaven National Laboratory, Argonne National Laboratory, Lawrence Berkeley National Laboratory, and Sandia National Laboratories (in conjunction with Los Alamos National Laboratory).

The NSRCs will provide specialized equipment and support staff not readily available to the research community. The NSRCs will be operated as user facilities and available to *all researchers* through a peer-reviewed process. The first center that will be fully completed will be the Nanophase Materials Sciences Center at Oak Ridge National Laboratory. In fact, even as I speak, equipment is being installed and staff scientists are moving into the new lab space. Although still in various stages of construction, all five centers are already funding nanoscale research through their "jump start" programs. For more on the NSRCs, I encourage you to go to visit the DOE Office of Basic Energy Sciences website and to attend Kristen Bennett's talk tomorrow afternoon.

PCAST/NNAP report (May 2005)

- How are we doing?
- Is the money well spent and the program well managed?
- Are societal implications being addressed?
- How can we do better?



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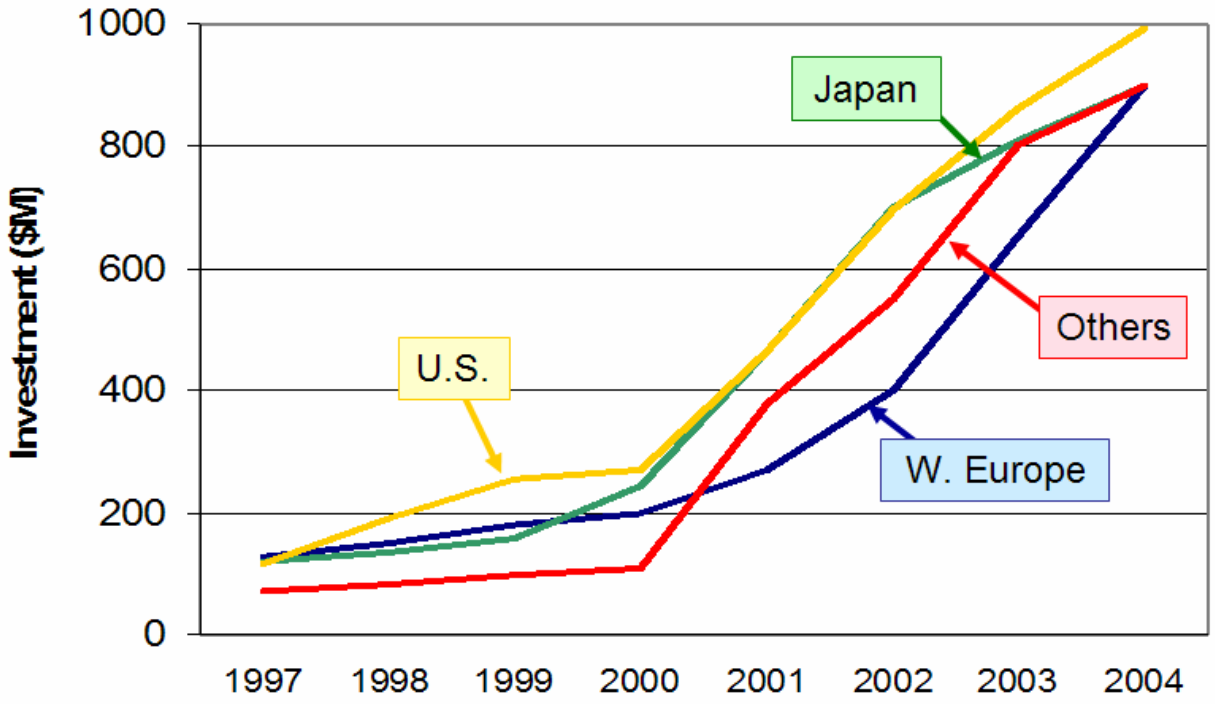
As you can see, a lot has been accomplished over the first five years of the National Nanotechnology Initiative. With the maturing of the program and as called for by the law passed in late 2003, PCAST in its role as the National Nanotechnology Advisory Panel has completed a review of the NNI. In their draft report, PCAST addresses four basic questions relative to the Federal investment in nanotechnology R&D that the Council believes the President, the Congress, and the American people would like answered:

1. Where Do We Stand? That is, what is the competitive position of the United States?
2. Is This Money Well Spent and the Program Well Managed?
3. Are We Addressing Societal Concerns and Potential Risks?
4. How Can We Do Better?

I would like to take a few minutes to consider the first question addressed by PCAST—"Where do we stand?"

International government spending



Source: M. Roco, National Science Foundation

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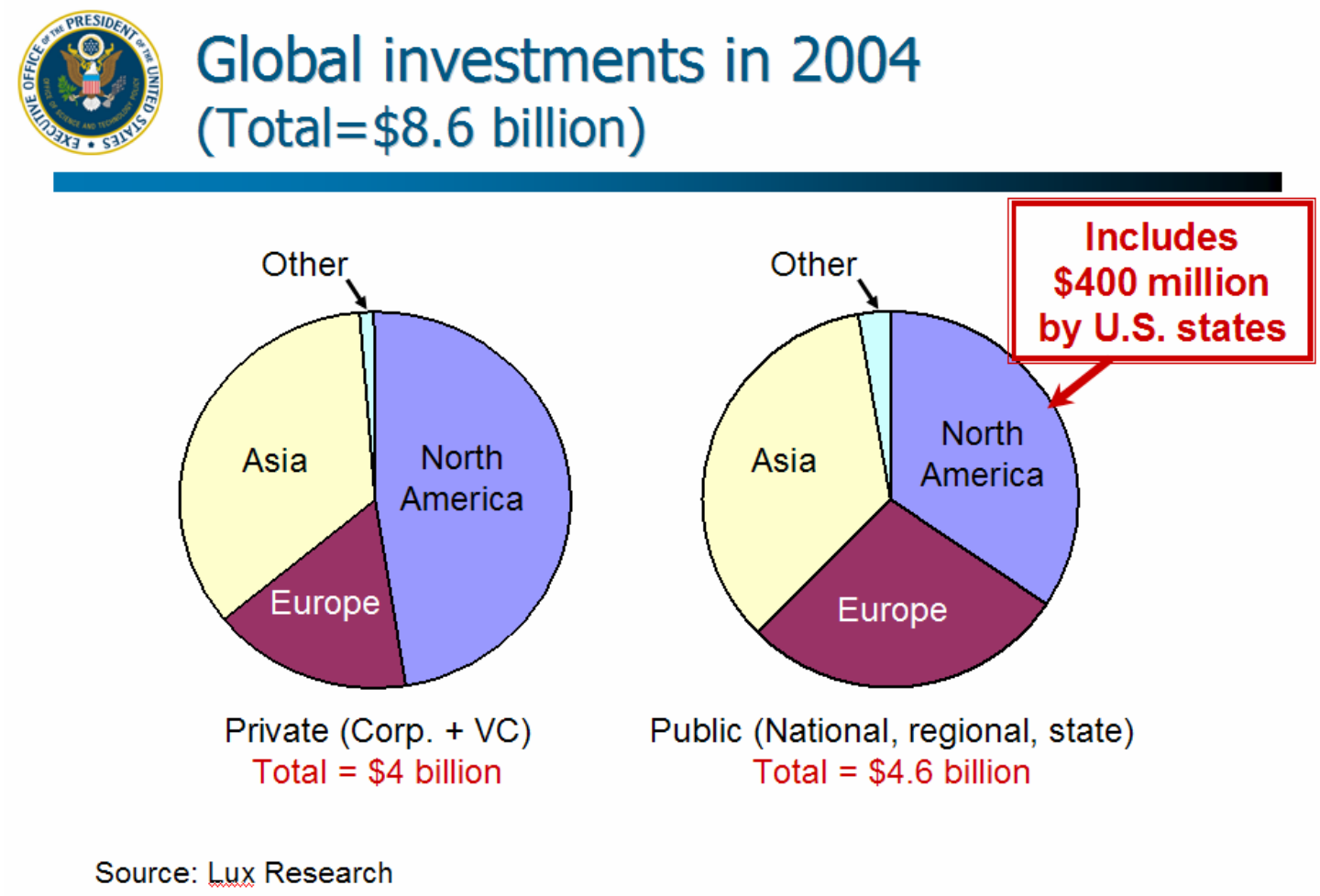
To assess the United States' competitive position, PCAST surveyed available data on global investments. Such figures are not entirely comparable, for example, due to differences in R&D accounting and costs of doing research from country to country. Estimates of international spending levels vary, but all show similar trends. Shown here are data from Mike Roco of the National Science Foundation, which indicate that the United States' Federal investment comprises roughly one-quarter of the investment by nations worldwide. Japan and the combined Western European countries each invest similar amounts. The category labeled 'Other' consists of a growing number of countries, including Australia, Israel, Taiwan, Russia, and many others.

At OSTP we have the opportunity to meet with our counterparts from around the world and based on those meetings, it appears that every country that has an organized science and technology program is focused in some way on nanotechnology.

To illustrate the global distribution of activity, this map shows the 25 countries that participated in an International Dialogue on the Responsible Research and Development of Nanotechnology last year in Alexandria, VA. While there was strong participation by countries in the European Community, there were also representatives from every other continent. Not surprisingly, the global nature of nanotechnology activity is not just at the Federal level.

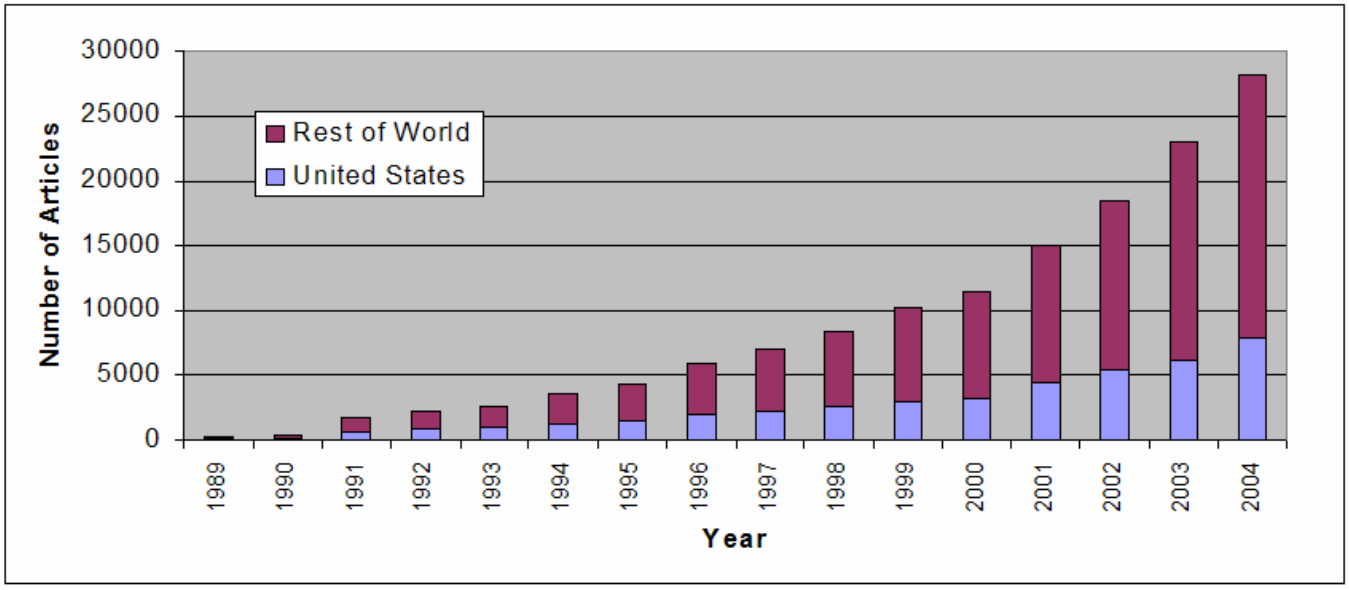


A study last year by Lux Research reported that the private sector, including corporations and venture capital firms, invested nearly $4 billion worldwide, almost one-half of that spending being made by North American businesses. Although the data from Lux Research indicate that businesses in the United States are reporting the largest fraction of investments, "nanobusiness" conferences are taking place around the world, and global industries, such as chemical and pharmaceutical companies, are investing in nanotechnology R&D and will be implementing nanoscale products and processes in their facilities worldwide.

Lux Research also estimated that North America, which is dominated by the United States, is making about one-third—or $1.6 billion—of the government investment worldwide. The difference between this and the chart on the previous slide is primarily due to the inclusion of investments by the U.S. States, which collectively funded $400 million in nanotechnology R&D projects in 2004. Not unlike their Federal counterparts, state legislators view nanotechnology as having the potential for economic benefits and are spending heavily, especially for facilities at state universities and business incubators. By all accounts, the United States is the leader among nations in total investments in nanotechnology R&D.

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*"

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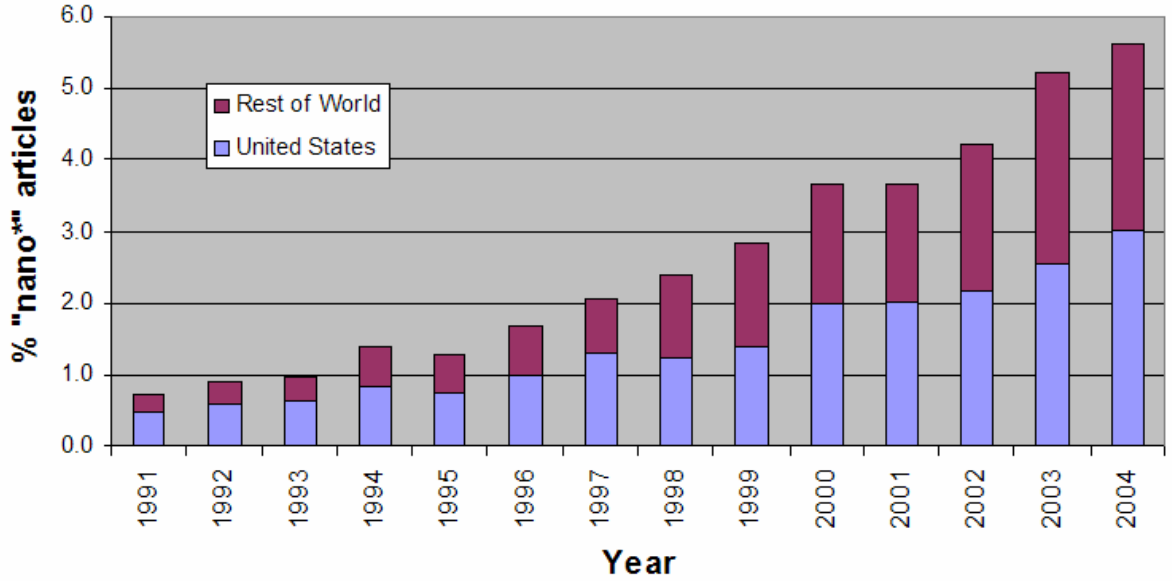
The amount of R&D investment is one metric PCAST used for tracking competitiveness; however, it is not a measure of research output or amount of innovation. This is much harder to measure. One frequently used measure of output is the number of scientific publications.

PCAST cited a search of the ISI Database by Dr. James Murday of the U.S. Naval Research Laboratory, which shows that (1) the number of papers on nanotechnology is growing exponentially, and (2) the fraction by U.S. authors is roughly proportional to the fraction of Federal investment globally.

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*"

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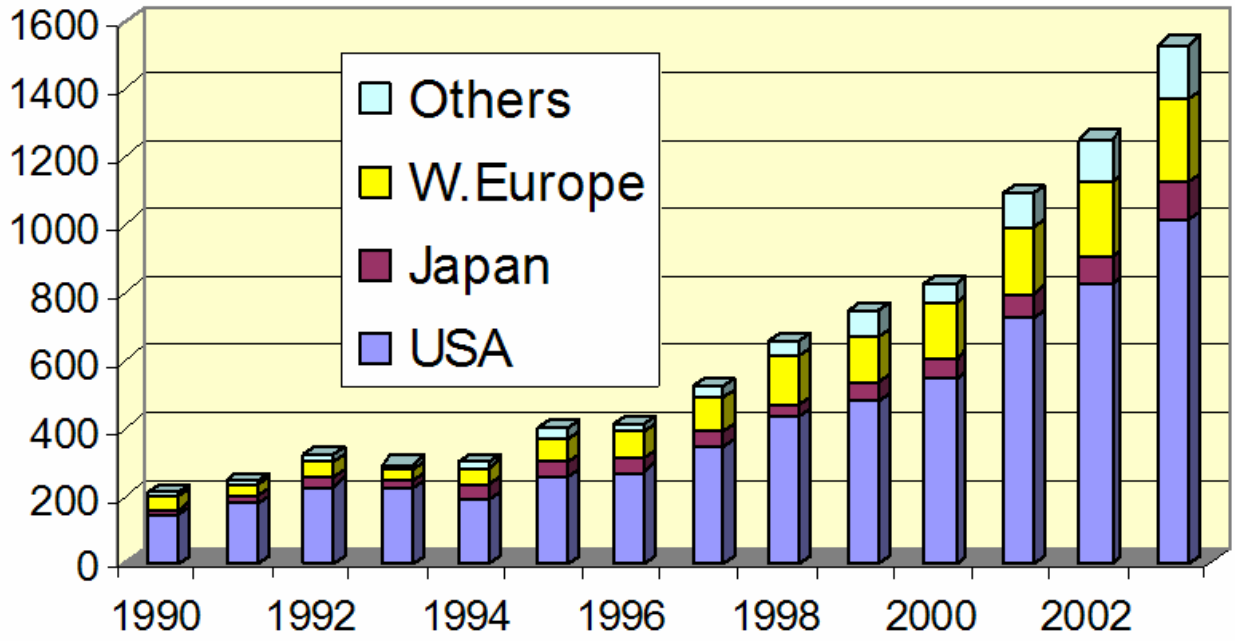
Whereas the number of publications found by searching the ISI Database, which includes some 5400 publications, is indicative of the quantity of research output, PCAST looked at the number of papers in the most highly regarded and widely read scientific journals--*Science*, *Nature*, and *Physical Review Letters*—as an indicator of quality of output. As was observed in the search of the broader database, the percentage of articles on nanotechnology in these high impact journals has risen markedly, doubling in the last five years alone.

U.S. authors, however, are publishing a larger fraction—over 50%—of the papers in these journals than in the broader literature. Factors such as the country in which the journal is published (*Science* and the *Physical Review* are published in the United States, and *Nature* is published in the United Kingdom) and the fact that all three are English language publications may play a role in the difference between the two datasets. However, it appears that the United States is getting more "bang for its buck" in terms of research impact as measured by these publications.

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

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PCAST also looked at the number of patents related to nanotechnology as another measure of the output of research. A study by researchers funded by the National Science Foundation found significant growth in the number of patents issued by the U.S. Patent and Trademark Office that have "nano" in the title or claims. The high percentage of U.S. assignees compared to that observed in the broad search of publications is likely due in part to generally lower costs associated with filing in one's home country.

Based on levels of both input (i.e. funding for nanotechnology R&D) and output (i.e., publications and patents), the draft PCAST report concludes that the United States is in a leadership position, but that other nations are making great strides.

PCAST/NNAP Recommendations

- Expand Federal-industry interaction
- Increase Federal-State interaction
- Coordinate with Departments of Education and Labor to improve education and training

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On balance, PCAST found the NNI to be well managed and reports that the U.S. investment in nanotechnology R&D is money that is well spent. The Council, which is made up of leaders from industry, academia, and research institutions, emphasizes that the Federal spending should focus on basic research. At their meeting in March, one PCAST member stated that technology transfer of nanotechnology discoveries would not be a problem; that industry is ready to pull the advances made under the NNI into commercial products.

At that meeting, PCAST discussed how the NNI could be further strengthened. Despite the comment I just noted, many of their recommendations are aimed at enhancing the likelihood of commercialization and economic benefits from nanotechnology.

In that meeting, the Council acknowledged the current NNI liaison activities with various industry sectors and encourages expanding those activities where appropriate. By establishing channels for exchange of information among Federal agencies and industry, the results of NNI R&D can be made known and the needs of industry can inform the agencies as they plan their programs.

PCAST also noted the sizable investment being made at the State level and encourages the NNI to do more to reach out to the state and regional nanotechnology initiatives so as to leverage the investments being made by both parties. Such regional and State programs are particularly focused on economic development, and therefore are in a position to help nurture the seeds of innovation that are produced by Federal R&D to provide jobs and other economic benefits.

Finally, PCAST recognizes that the widespread application of nanotechnology will drive a need for skilled technical workers in a variety of industries and teachers at all levels. The pipeline that produces skilled technicians and teachers is fed by a stream of primary and secondary students. The NNI is funding programs to develop material aimed at teaching and training from "K to gray." PCAST feels that now is the time for the NNI to coordinate with the Departments of Education and Labor to transition resources developed through research programs so as to improve the education and training of qualified teachers and skilled technical workers. The good news is that anecdotal evidence indicates that students of all ages are excited by nanotechnology and that the NNI is helping to attract bright young minds into careers in science and engineering.

As with any new technology, there are potential risks along with the benefits. In its March meeting PCAST noted the activities that the NNI is taking to address the possible risks of this emerging technology. PCAST members noted that as the NNI strives to advance nanotechnology, it must be mindful to communicate with various stakeholders, including the general public.

A number of surveys have shown that the public is not especially well-informed about nanotechnology. Some probably associate nanotechnology with business reports—such as the cover story a couple of months ago in Business Week. Others may learn about it from Hollywood, or from an interest group. However, despite little understanding of nanotechnology, the same surveys reveal that a majority are optimistic about the benefits of nanotechnology, especially in medicine.

In order to provide information about the Federal nanotechnology program and about nanotechnology in general, to all interested parties—including researchers, students, educators, the press, and the general public—the National Nanotechnology Coordination Office makes available information on the website "nano.gov" and through it publications (some of which you can pick up at this conference).

The President on Innovation

White House photo by Eric Draper

"The role of government is not to create wealth; the role of our government is to create an environment in which the entrepreneur can flourish, in which minds can expand, in which technologies can reach new frontiers."

--President George W. Bush

July 12, 2002

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I hope that I have been able to communicate to you not only the goals and priorities of the Federal nanotechnology program, but also the strong support within the Administration. Continued investment by the Federal government in nanotechnology research will advance knowledge and maintain the United States as a leader in this growing area of science and technology.

When it comes to innovation, the President feels strongly (as indicated in the quote shown here) that it is the Government's role to create an environment in which innovation can flourish. It is ultimately the private sector—and all of you who risk your time, capital, and livelihoods—that will bring nanotechnology products to market. Events such as Nanotech 2005 help make connections between those generating new ideas and those who can help bring them into our daily lives.

Thank you very much.