Basic Research

Tackling America's 21st Century Challenges

DOE, NSF, NIST, and DOD Drive Innovation

Basic research, which depends on federal funding, produces fundamental knowledge that frequently leads to major technological advances. The discoveries resulting from federal funding of basic research in the physical sciences and engineering have strengthened national security, improved health care, advanced alternative energy and efficiency technologies, and fueled economic growth.

Economy

Federal investment in basic research pays huge dividends by boosting America's innovation capacity, strengthening our global competitiveness, and creating high-skill, high-wage jobs.

Education

The investment in basic research at America's universities and national labs not only produces new discoveries and ideas but also trains the next generation of scientists and engineers.

Health Care

Many advances in fighting disease are the result of cutting-edge technologies that come from basic research in the physical sciences and engineering at our universities and national laboratories.

National Security

Protecting our nation requires advanced technologies for equipping the modern soldier and providing homeland threat detection capabilities that require investing in basic research.

Energy and Environment

Developing alternative energy sources and improving energy efficiency will require research investments. Discoveries will lead to a reduction in U.S. dependence on foreign oil and improvements for the environment.

"At such a difficult moment, there are those who say we cannot afford to invest in science. That support for research is somehow a luxury at a moment defined by necessities. I fundamentally disagree. Science is more essential for our prosperity, our security, our health, our environment, and our quality of life than it has ever been."

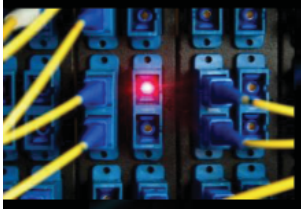
President Barack Obama
April 27, 2009
National Academy of Sciences

Examples of Laser Applications

1964 Laser Guided Weapons

1969 Laser Printer

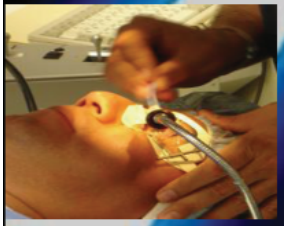
1970
Fiber Optic Communications



1974
Bar Code Scanner

1982
CD Player

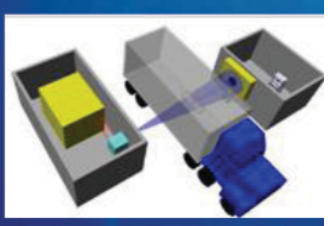
1987
Laser Vision Correction Surgery



1989
Hologram Authentication

1995
DVD Player

20??
(in development)
Detection of Nuclear Materials



The Laser – "A Solution Looking For a Problem"

Critics dubbed the laser "a solution looking for a problem." In fact, it took years for many potential uses of the laser to be recognized, and new laser applications are still being discovered today.

The basic research behind the laser was funded by the Department of Defense. Later applications were discovered as a result of other federally sponsored research and technological advances. Today, the laser has many everyday applications and is vital to the U.S. military, to health care, to consumer and business electronics, and to many other industries.

The laser is just one example of how basic research, which may begin with no specific technology or product in mind, can lead to important discoveries, life-changing inventions, and economic growth.

Invest in Basic Research: You Never Know Where it Might Lead…

Department of Energy Office of Science

The Office of Science, the largest funder of basic research in the physical sciences in the United States, maintains the nation's scientific infrastructure and ensures U.S. world leadership across a broad range of scientific disciplines. It helps the Department of Energy accomplish its missions in energy security, national security, environmental restoration, and science. The Office of Science's research investments have yielded a wealth of dividends, including significant technological innovations, medical and health advances, new intellectual capital, enhanced economic competitiveness, and improved quality of life for the American people.

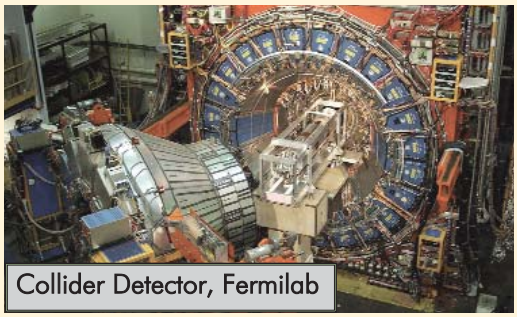

Solar Panels

Research supported by the Office of Science at U.S. national laboratories and at universities contributed to the development of the Internet; magnetic resonance imaging (MRI), CT scanning, and medical isotopes; composite materials used in military hardware and motor vehicles; and X-ray diagnostics of computer chips, solar panels, and other high-tech materials.

Additionally, the investments yielded the Nobel Prize-winning discovery of new forms of carbon that ushered in nanotechnology, non-invasive detection of cancers and other diseases, improved computer models for understanding global climate change, and new insights into the fundamental nature of matter and energy.

Office of Science-funded research also led to the development of DNA sequencing and computational technologies that made possible the unraveling of the human genetic code and the publishing of a complete draft of the DNA sequence of the human genome in 2001. The research is also responsible for key advances in positron emission tomography (PET), and single-photon emission computed tomography (SPECT) – all of which permit noninvasive and improved detection and diagnosis of medical conditions.

The Office of Science and its predecessor, the Atomic Energy Commission, funded the research that led to the discovery of quarks, one of the fundamental constituents of matter, which led to more than a dozen Nobel Prizes. The agency also supports polymer and nanoscience research aimed at improving lithium ion batteries for electric and plug-in hybrid vehicles by making them safer and increasing their density and lifetime.


Collider Detector, Fermilab


Magnetic Resonance Imaging (MRI)

Case Study: Energy Frontier Research Centers

The Office of Science sponsors research at Energy Frontier Research Centers (EFRCs) designed to accelerate the transformational breakthroughs needed to develop energy technologies for the 21st century.

Researchers at the EFRCs will employ nanotechnology, high-intensity light sources, neutron scattering sources, supercomputing, and other advanced instrumentation in an effort to lay the groundwork for advances in solar energy, biofuels, transportation, energy efficiency, electricity storage and transmission, clean coal and carbon capture and sequestration, and nuclear energy.

"Our previous investments in science led to the birth of the semiconductor, computer, and bio-technology industries that have added greatly to our economic prosperity. Now, we need similar breakthroughs on energy."

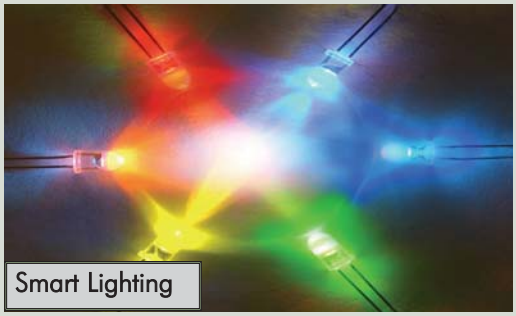
Steven Chu
Secretary of Energy
March 17, 2009
House Science and Technology Committee

What DOE Basic Research Has Given Us

Magnetic Resonance Imaging (MRI)
(in conjunction with NSF and NIH)
DNA sequencing
Advanced vehicle & solar technologies
Holographic imaging
Advanced sensors

National Science Foundation

The National Science Foundation (NSF) is an independent federal agency that supports fundamental research and education in science and engineering. From climate prediction, aircraft design, pioneering medical tools, and robotics, to discovering how children learn mathematics, NSF has played a key role in funding discoveries that have driven the nation's economy, improved our quality of life, and enhanced national security.

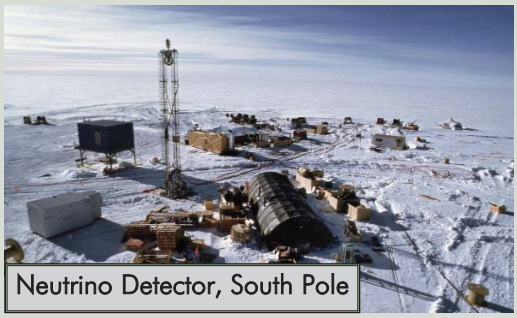

Smart Lighting

The agency also supports high-risk research and novel collaborations that could deliver exceptionally high rewards in the future. NSF ensures that all research is fully integrated with education to train tomorrow's top scientists and engineers. For example, Sergey Brin, co-founder of Google, began his work on search engines as an NSF graduate research fellow at Stanford University.

NSF provides more than 20 percent of the federal support for basic research at academic institutions. Because its mission is broad-based, its investments reach faculty and students in most departments, schools, and academic disciplines.

NSF supports roughly 10,000 new awards per year through merit-reviews of over 40,000 proposals received. Every year, an estimated 200,000 people, from undergraduates to senior faculty, participate directly in NSF research and education programs.

NSF also supports university-industry research partnerships, U.S. participation in international scientific efforts, and programs to improve K-12 instruction and undergraduate and graduate education.


Neutrino Detector, South Pole

Credit: Robert Morse/University of Wisconsin-Madison

Case Study: Engineering Research Centers

Since 1985, the NSF has sponsored Engineering Research Centers (ERCs), multidisciplinary university centers that involve academic and industry collaboration to address challenges in a range of complex engineering systems. Now in its third phase, the program funds ERCs designed to link discovery to technological innovation and train engineering graduates.

Current ERCs include research focused on: biorenewable chemicals, renewable electricity delivery and storage systems, improved communications networks, revolutionary medical implants, and smart lighting technologies.


Bar codes

"Science and engineering hold the key to solving the challenges facing our country in areas like energy, health care, and national security. The federal government's investment in basic research is critical to address these challenges and attract young innovators to science and engineering. Research conducted at universities and national labs underpins the new innovations that drive economic growth."

Richard K. Templeton
President, Chairman, and CEO
Texas Instruments
April 2009

What NSF Basic Research Has Given Us

- Web browsers
- Barcodes
- Fiber optics
- Internet routers
- Doppler Radar
- Web search engines

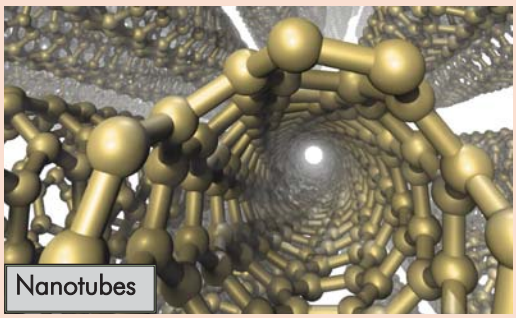
National Institute of Standards and Technology

The mission of the National Institute of Standards and Technology (NIST) is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. NIST labs work with industry and academia to address these research challenges. NIST scientists have received three Nobel Prizes in the past 11 years, all leading to the observation of the Bose-Einstein condensates, a new form of matter.

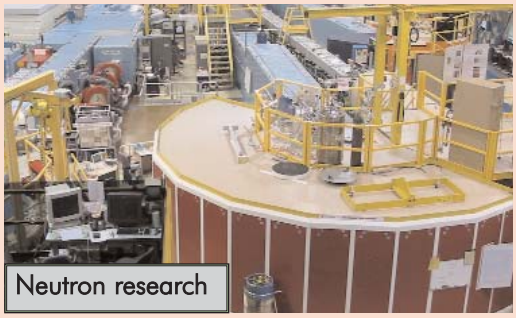

Atomic clock

NIST manages some of the world's most specialized measurement facilities-such as the Center for Neutron Research, where cutting-edge research is done on new and improved materials, advanced fuel cells, and biotechnology. NIST's Advanced Measurement Laboratory offers American researchers unparalleled opportunities for making the most sensitive and reliable measurements. NIST's Center for Nanoscale Science and Technology supports all phases of nanotechnology development, from discovery to production, and involves multidisciplinary teams from across federal agencies, industry, and academia.

The emerging area of nanoelectronics will have significant applications in information technology, communications, medicine, energy, and security. Nanoelectronics is the effort to extend and move beyond the physical limits of current semiconductor technology, and will require advances in measurement capabilities at ever smaller dimensions.


Nanotubes

Over the past 50 years, U.S. leadership in microelectronics has transformed our economy, been the major driver behind increased productivity, and made semiconductors one of the leading U.S. export categories. The country developing breakthroughs in nanoelectronics will likely lead this new era the way the United States has led for half a century in microelectronics.


Neutron research

Case Study: Nanoelectronics Research Initiative

NIST partners with the semiconductor industry on the Nanoelectronics Research Initiative (NRI), where NIST and industry jointly fund research at universities and NIST researchers collaborate with industry and academia. NRI was recognized by the National Nanotechnology Initiative as a successful model that involves funding partnerships with industry, NIST, NSF, and states to support nanoelectronics research at 30 universities in 18 states.

"There is tremendous interest in every part of the world to win the nanoelectronics race and reap the economic rewards that will go with it. For America to win, it will take radical collaboration between government, higher education and industry. Among the best examples of this type of collaboration is the important work going on in the Nanoelectronics Research Initiative at more than 30 universities with funding and participation from NSF, NIST, and major U.S. semiconductor companies and research institutions."

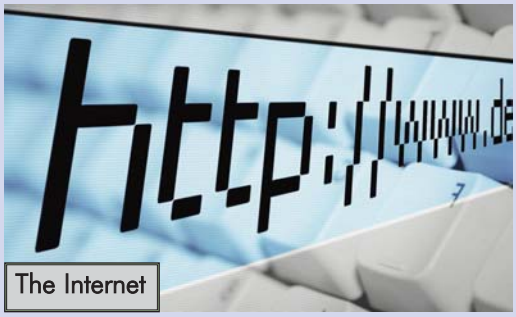
John E. Kelly III
Senior Vice President and Director of Research
IBM
April 2009

What NIST Basic Research Has Given Us

- The atomic clock
- Synthetic rubber
- Closed captioning
- Data encryption standards for financial transactions
- Panoramic X-rays
- Standards for radiation detectors at U.S. ports of entry

Department of Defense

Basic scientific and engineering research funded by the Department of Defense (DOD) has contributed significantly to our nation's economic and national security. It has helped make America's military the best-equipped and most effective in the world, and civilian applications of technologies intended originally for military purposes have become staples of the nation's economy and modern life.



The Internet

Past DOD investments in university basic research by agencies such as the Defense Advanced Research Projects Agency (DARPA) have led to such innovations as advanced cryptology; radar; lasers; fiber optics; satellite and global positioning system (GPS) navigation; DARPA Net, the predecessor to the Internet; precision guidance technologies; advanced composite materials; and stealth technology.

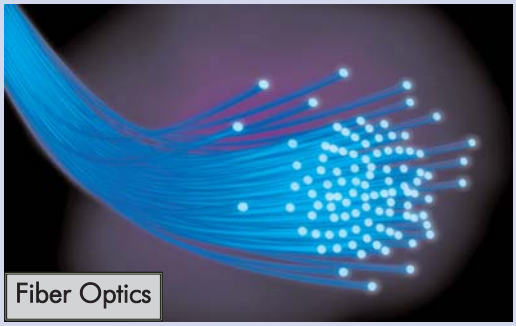
GPS navigation is an example of how basic research lays the foundation for unpredictable technologies. GPS relies on microwaves, understanding of the Doppler effect, atomic clock accuracy, and satellite technology. DOD has sponsored basic research in all of these areas, some of it decades ago.

In addition, DOD research underpins cutting-edge medical treatments and technologies developed for the battlefield but frequently applicable in civilian life.

In the last two decades, DOD shifted away from supporting long-term basic research – one of its hallmarks in the immediate post-WWII era – toward the more short-term objectives of technology development and deployment. However, the Department, with the support of Congress, has begun to reverse this trend. This emphasis on basic research funding should continue.

DOD supports academic disciplines vital to national security. DOD is the leading federal sponsor of university engineering research, providing 85 percent of all federal funding for mechanical engineering, 65 percent for electrical engineering, 33 percent for ocean sciences, and 27 percent for computer sciences.


Global Positioning System (GPS)


Fiber Optics

Case Study: Studying Seashells to Improve Soldiers' Armor

The U.S. Army Office of Research is sponsoring research at the Massachusetts Institute of Technology that seeks to better protect America's warfighters using the technology nature has used for eons to protect creatures like sea snails that live in perilous ocean environments. Scientists believe the nanoscale structural principles of the shells' mother-of-pearl lining can help design better body armor for soldiers, police officers, and others.

"Investments made in fundamental scientific research after World War II and during the Cold War have been essential to making our fighting men and women today the best equipped in the world. These previous investments and the new knowledge they generated also made enormous contributions to our economic vitality."

Former House Speaker Newt Gingrich and
House Science Committee Chairman Bart Gordon
The Washington Times
January 17, 2007

What DOD Basic Research Has Given Us

The Internet
Lasers
Global Positioning Satellites
Speech Recognition
Computer Aided Design
The Mouse

DOD Research: Empowering and Supporting Our Troops in Combat

a HEMCON BANDAGE: The HemCon bandage stops hemorrhaging within minutes. Research and development funded by the Army and performed by the U.S. Army Medical Research and Material Command.

b INTERCEPTOR BODY ARMOR: Flexible, lightweight, highly ballistic-resistant body armor system that protects soldiers in combat. Materials and engineering design research sponsored by the Marine Corps, Army, and DARPA.

c JOINT PRECISION AIR DROP SYSTEM: Improved air delivery drops food and equipment closer to soldiers, increases survivability of aircraft personnel and supplies, makes humanitarian relief more efficient. Joint Army/Air Force research.

d LASER DESIGNATOR: Laser sights increase precision of weapons in the field. Laser research started at Bell Labs in the 1950s and later sponsored by the Army and Air Force.

LUMINESCENT POLYMERS FOR EXPLOSIVE SENSING: DOD-sponsored research has identified nanotechnologies that detect hidden improvised explosive devices (IEDs).

e MEAL, READY-TO-EAT: Advanced technologies protect food rations from deteriorating in extreme environments, enhance soldiers' physical endurance, help detect food contaminates. Army-sponsored research at Natick Soldier Research, Development and Engineering Center.

f NIGHT VISION GOGGLES: Photoelectric effect allows soldiers to see images in very low light. Current night vision technology is result of DOD research.

g SOLDIER PERSONAL DIGITAL ASSISTANT: Soldiers receive situational awareness and other information using:

- **GPS:** Basic research funded by Air Force, Navy, and AEC (now DOE) led to global positioning system, which gives a soldier's specific location anywhere in the world.
- **WEARABLE SOLDIER RADIO TERMINAL:** Provides voice communications and links soldier's' personal digital assistant to FalconView software, which networks and maps soldiers on the battlefield. Research funded by several DOD offices.
- **LITHIUM PRIMARY BATTERIES:** Lighter, longer-lasting power source for soldiers built on basic research funded by DOE and applied research funded by Army and DARPA.

h SOLDIER TRAINING: Gaming technology and simulation of battlefield environments prepare soldiers for deployment and provide theater mission training. Underlying technologies developed from Army-funded basic research.

i TRANSLATION DEVICES: Highly accurate voice recognition technology allows soldiers to generate and interpret speech in other languages. Original technology resulted from DARPA-sponsored research and improved by other DOD agencies.

The Task Force on American Innovation, a coalition of businesses, trade associations, scientific societies, and higher education, was founded in 2004 to advocate greater federal investments for basic research in the physical sciences and engineering. The Task Force urges strong, sustained increases for research budgets at the National Science Foundation, Department of Energy Office of Science, National Institute of Standards and Technology, and Department of Defense.

www.futureofinnovation.org

Agilent Technologies

ASTRA

ACS Chemistry for Life™

1931-2006 AMERICAN INSTITUTE OF PHYSICS 75 Years of Service

AMS AMERICAN MATHEMATICAL SOCIETY

APS physics

ASA AMERICAN STATISTICAL ASSOCIATION

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

ASME SETTING THE STANDARD

APPLIED MATERIALS

acm Association for Computing Machinery

AAU ASSOCIATION OF AMERICAN UNIVERSITIES 1900

ASSOCIATION OF PUBLIC AND LAND-GRANT UNIVERSITIES

Battelle The Business of Innovation

BR Business Roundtable℠

COMPUTING RESEARCH ASSOCIATION CRA

CompTIA

Council on Competitiveness

Google

IBM

intel

IEEE★USA

LUNA INNOVATIONS

MRS Materials Research Society

Microsoft®

NUFO NATIONAL USER FACILITY ORGANIZATION

NAM National Association of Manufacturers

NORTHROP GRUMMAN

P&G

THE SCIENCE COALITION

SIA SEMICONDUCTOR INDUSTRY ASSOCIATION

SRC Semiconductor Research Corporation

SURA Southeastern Universities Research Association

TechAmerica WHERE THE FUTURE BEGINS
THE ASSOCIATION OF COMPANIES DRIVING INNOVATION WORLDWIDE

TIA

TEXAS INSTRUMENTS

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