Federal Funding for Biomedical and Related Life Sciences Research
FY2009

Federation of American Societies for Experimental Biology
Prepublication
FEDERAL FUNDING FOR BIOMEDICAL AND RELATED LIFE SCIENCES RESEARCH
FY 2009

FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY
The American Physiological Society
American Society for Biochemistry and Molecular Biology
American Society for Pharmacology and Experimental Therapeutics
American Society for Investigative Pathology
American Society for Nutrition
The American Association of Immunologists
American Association of Anatomists
The Protein Society
American Society for Bone & Mineral Research
American Society for Clinical Investigation
The Endocrine Society
The American Society of Human Genetics
Society for Developmental Biology
Association of Biomolecular Resource Facilities
American Peptide Society
Society for the Study of Reproduction
Teratology Society
Society for Gynecologic Investigation
Environmental Mutagen Society
International Society for Computational Biology
American College of Sports Medicine

Recommendations for:
National Institutes of Health
National Science Foundation
United States Department of Agriculture
Department of Energy
National Aeronautics and Space Administration
Department of Veterans Affairs
Founded in 1912, the **Federation of American Societies for Experimental Biology** (FASEB) represents 21 biomedical research societies with a combined membership of more than 80,000 individual scientists and scholars, making it the largest life science organization in the United States. FASEB’s mission is to advance biological science through collaborative advocacy for research policies that promote scientific progress and education and lead to improvements in human health. By doing so, FASEB enhances the ability of biomedical and life scientists to improve, through their research, the health, well-being, and productivity of all people. FASEB is a coalition of independent Member Societies that serves the interest of biomedical and life scientists, particularly those related to public policy issues.

Federal funding for basic research generates fundamental knowledge necessary for improving the nation’s health and its quality of life. While life science research most obviously leads to biomedical advances, without the underlying understanding and technologies developed through research in mathematics, physics, chemistry and computer science, the potential to utilize biological breakthroughs for medical progress would be significantly diminished. Our national investment in basic research is one of our greatest opportunities to advance the health and well-being of the United States.
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Science and innovation have long been the lifeblood of our nation, as the United States has maintained a proud tradition of supporting scientific discovery and technology development. The research funded by the federal government has driven our economy, established our dominance in the global marketplace, and improved the quality of our daily lives. Yet at a time when the scientific opportunities have never been greater, when the world is striving to imitate our investment in fundamental research, our nation’s research agencies are threatened by flat or reduced budgets.

Whether through our national laboratories or via the scientists at institutions throughout the country, the United States’ model for funding science has been both extraordinarily successful and unique. In every state in the nation, scientists compete fiercely for research funding, ensuring the highest quality of scientific exploration. In many ways our nation’s researchers are symbolic of the global race for scientific preeminence. Just as scientists struggle to survive in an increasingly competitive funding environment, so too the United States is facing growing competition from other nations who are rapidly investing in scientific research. To address these new challenges, a renewed commitment to the scientific enterprise, that has served our citizens so well, becomes imperative.

The Federation of American Societies for Experimental Biology (FASEB) represents 21 scientific societies comprising over 80,000 biomedical and life science researchers. This report speaks with the voice of the working scientist and attests to progress made, knowledge gained, and the opportunities at hand. These recommendations, for six federal research agencies, identify what is needed to spur the technological and medical advancements that will contribute directly to our economic prosperity, world competitiveness, health, and longevity.

**EXECUTIVE SUMMARY**

**National Institutes of Health (NIH)**
- In order to fulfill the extraordinary scientific and medical promise of biomedical research, FASEB urges Congress to make the National Institutes of Health a priority and respectfully requests that NIH receive $31.2 billion in FY 2009.

**National Science Foundation (NSF)**
- In keeping with the America COMPETES Act of 2007, FASEB recommends an appropriation of $7.33 billion for the National Science Foundation in FY 2009.

**Department of Energy (DOE)**
- In keeping with the America COMPETES Act of 2007, FASEB recommends an appropriation of $4.8 billion for the DOE’s Office of Science in FY 2009.

**Department of Veterans Affairs (VA)**
- FASEB recommends funding the VA Medical and Prosthetics Research Program at the $555 million level in FY 2009 with an additional $45 million for VA laboratory space renovation.

**United States Department of Agriculture (USDA)**
- FASEB supports funding the USDA’s National Research Initiative Competitive Grants Program in FY 2009 at the $257 million level recommended in the President’s 2008 budget and the Agricultural Research Service at $1.377 billion, which restores the FY 2005 level, adjusted for inflation.

**National Aeronautics and Space Agency (NASA)**
- FASEB recommends that Congress increase funding to for Life Sciences Research (Ground Research, Ground Facilities, and Flight Research) to $39.65 million.
NIH: Our Nation’s Medical Research Agency

The National Institutes of Health (NIH) is the world’s premiere sponsor of medical research and is the federal agency responsible for conducting and supporting the basic and clinical science that drives development of treatments and cures for disease and injury. A component of the Department of Health and Human Services, NIH comprises 27 Institutes and Centers, which collectively fund more than 325,000 scientists at more than 3,100 universities and institutions in every state. Researchers receiving NIH funds are united by a compelling desire: to investigate the underlying biology of human disease and use this knowledge to improve our health and save lives.

Research funded by the NIH also contributes to the nation’s economic strength and competitiveness, which is driven by basic science generating commercially viable products and technologies. Biomedical research advances scientific knowledge while also creating a high-technology workforce that enhances innovation at the country’s private sector companies.

Through its competitive peer review system, which is emulated throughout the world, NIH ensures support of the highest quality research and seeks input from more than 30,000 scientists and members of the public who serve on NIH advisory boards, review groups, and expert panels. Scientists funded by NIH lay claim to 122 Nobel Prizes, including the 2007 Nobel Prize recipients in physiology or medicine: Mario R. Capecchi, Ph.D., of the University of Utah School of Medicine and Oliver Smithies, Ph.D., of the University of North Carolina. Drs. Capecchi and Smithies, together with their colleague, Sir Martin Evans, Ph.D., of Cardiff University, developed the immensely powerful gene “knockout” technology, which allows scientists to create animal models of human disease and study gene function. Over the past 50 years, the research supported by NIH has been and continues to be responsible for the revolutionary medical and health advances that have taken place.

NIH Research Has Led to Improved Health

Thanks to NIH-funded scientists, working at universities and institutions across the nation and on the NIH campus in Bethesda, Maryland, many previously deadly or debilitating diseases have been transformed into manageable conditions. Below are only a few select examples of how the research funded by NIH has saved and improved the lives of millions of Americans and provided doctors with tools to prevent and/or treat disease:

- More than one million lives per year are saved due to therapies to prevent death from heart attack and stroke, resulting in a nearly four year gain in American life expectancy. Decades of NIH-supported fundamental research on cholesterol synthesis, clot-busting agents, and the basic biology of the cardiovascular system has culminated in blockbuster drugs such as statins that are utilized worldwide and have improved the health of more than 25 million Americans. The recent discovery that the anti-cancer drug Taxol, when used to coat the wire-mesh stents used during angioplasty, can prevent blockage of arteries, is expected to substantially reduce the more than 350,000 annual open-heart bypass surgeries.

- Since 2002, deaths from cancer have been steadily reduced, dropping an average of two percent per year. In December, 2005, as a result of the work of hundreds of NIH-funded scientists studying strategies to block the cell signals that cause tumors to grow, Sorafenib was identified as a promising treatment for kidney cancer. Less than a year later, the FDA approved the use of a vaccine against human papillomavirus (HPV) which has the potential to prevent 70% or more of cervical cancer, the cause of 300,000 deaths per year. The connection between HPV and cervical cancer which led to development of the vaccine was made through the research of NIH-supported scientists. And in one of NIH’s most powerful success stories, the survival rate for
childhood cancers, which not long ago claimed the lives of more than half their victims, is now nearly 80% and improving.

- NIH-funded discoveries revealing the fundamental nature of the immune system and the diseases that challenge it have vastly improved the quality of life for patients with conditions ranging from rheumatoid arthritis to multiple sclerosis to HIV/AIDS. Drugs which block the actions of tumor necrosis factor alpha (TNF-α) have dramatically improved the quality of life for some rheumatoid arthritis patients, eliminating symptoms, increasing energy, and decreasing inflammation while halting the progression of joint destruction and promoting repair of tissue damage. For those suffering the debilitating effects of multiple sclerosis, several new treatments that modulate the immune system are available, their discovery and development having been funded in part by NIH. HIV/AIDS, once a terminal illness, has been transformed through drug therapy into a chronic disease, with AIDS drugs estimated to have saved three million years of life in the United States alone.

- NIH-funded research on the effects of lifestyle changes is helping to teach Americans how to prevent diabetes, reverse serious heart disease risk factors, and slow the signs of aging. Diet and exercise changes have been shown to reverse diabetes and metabolic syndrome, strengthen bones and prevent osteoporosis, and even reduce the risk of dementia. Studies have shown that people who exercise regularly in middle age are one-third less likely to get Alzheimer’s disease in their 70s as those who did not exercise. And even people who begin exercising in their 60s have their risk reduced by half. In addition, NIH-funded research in nutrition is exploring the linkages between micronutrients such as Vitamin D and cancer, raising new questions for scientists and laying the groundwork for future health milestones.

**INVESTMENT IN NIH BRINGS HOPE, TREATMENTS ON THE HORIZON**

Arguably, the two trends of greatest consequence for American health in the twenty-first century are the rapid aging of the population and the unprecedented progress in medical research that is helping us to live longer, healthier lives. The life sciences revolution that has taken place over the past two decades has led us to the brink of developing new treatments and strategies for confronting our greatest health challenges, including those of the over-65 population, soon to number 70 million. Investment in NIH has already unlocked the secrets of the human genome and allowed scientists to gain new insight into how disease works at the most basic levels within our bodies. Researchers are arming themselves with this knowledge to identify targets for new drugs, therapies, and vaccines, which can halt the progression of disease before irrevocable damage occurs:

- **Blindness**: The prospect that it may someday be possible to restore vision in some people who have lost most or all of their eyesight was strengthened when scientists were able to help blind mice regain some ability to see after receiving transplants of cells taken from the eyes of other mice. NIH-supported researchers showed for the first time that light-detecting cells in the retina can orient themselves properly after being injected into a blind eye, connect to other nerve cells and communicate appropriately with visual centers in the brain. Moreover, researchers have discovered the genetic flaws that underlie a major type of glaucoma, a leading cause of blindness. Similarly, scientists have identified a genetic abnormality that accounts for up to 50 percent of Age-Related Macular Degeneration (AMD) cases, a blinding disease for which more than 8 million older Americans are at risk. By pinpointing what goes wrong in these conditions, these findings may provide a basis for devising new treatments.

- **Alzheimer’s disease**: A team of NIH-funded scientists developed a test that was about 90 percent accurate in distinguishing the blood
of people with Alzheimer’s from the blood of those without the disease. The test was about 80 percent accurate in predicting which patients with mild memory loss would go on to develop Alzheimer’s disease two to six years later. In addition, basic and genetic studies describe some of the processes involved in Alzheimer’s, revealing numerous targets for new drug development. Such discoveries shed light on why toxic molecules build up in the brain and lead to the plaques and tangles characteristic of Alzheimer’s, and how brain cell-signaling systems affecting memory are disrupted.

- **Drug resistant tuberculosis and staph:** Nearly one-third of the world’s population is infected with *Mycobacterium tuberculosis*, the infectious agent that causes TB, and more than one million people die of this disease each year. In recent years, TB has presented even more serious challenges, with the emergence of multiple drug resistant and extensively drug resistant TB. NIH has developed a drug known as SQ109, in partnership with the biotech company Sequella, which is currently undergoing FDA-approved clinical testing for treatment of drug resistant TB. The recent epidemic of methicillin-resistant (drug resistant) *Staphylococcus aureus* (MRSA) has underscored the critical importance of research to seek new ways to counter and prevent the emergence of “super bugs.”

The American Public Supports Medical Research

Polls have shown that Americans are extremely concerned about their health and health care, setting these as priorities above keeping their jobs, paying their mortgage, or even being protected from a terrorist attack. The popular press, from television to newspapers and magazines to Internet blogs, is filled with reports of new medical research findings and advice about staying healthy. NIH drives the engine of medical research discovery, addressing public health priorities and funding the cutting edge science that captures our national attention. This is why the people of the United States overwhelmingly support medical research:

- Surveys have found that 83 percent of Americans would be **more likely to vote** for a candidate who supports increased funding for research to find cures for and prevent disease.

- A majority of Americans (78%) choose medical research as the best strategy for reducing health care costs. Data supports their belief: NIH-funded advances in coronary heart disease alone are estimated to have generated $2.6 trillion in economic return for a total cost of about $110 per American over a 30 year span.

- More than three-quarters (76%) of U.S. respondents thought that it was very important that the **U.S. remain a global leader** in scientific research.

**NEW THREATS Emerge As Funding Lags Behind**

Emerging diseases and new health threats dominate our headlines – from **drug resistant staph infections** (“MRSA”) to SARS, West Nile Virus, and **avian influenza** – while our aging population lends a new sense of urgency to meeting the challenges of **Alzheimer’s disease**, **osteoporosis**, and **macular degeneration**. Yet even as the need to

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3 Ibid
prevent disease becomes greater and the opportunities to succeed become more numerous, our nation has begun to neglect our commitment to medical research. Never before has science been more poised to advance the discoveries that will improve our health, yet never before have we been more in danger of squandering our scientific talent and delaying critical breakthroughs:

- Flat funding of NIH, combined with the effects of inflation, has eroded the purchasing power of the agency by about 13%. With every excellent unfunded idea, we stand to miss or delay the critical discovery leading to therapies for our most debilitating health conditions.

- The NIH funding situation threatens to affect an entire generation of young researchers. The 60,000 postdoctoral researchers, or “postdocs,” who represent America’s scientific future and are on the path to a lifelong career in research are being negatively affected by the decline in NIH’s budget. Specifically, the funding cuts are resulting in fewer hires, lower salaries, and increased layoffs. Many of the postdocs see their scientific mentors struggle to maintain grant funding from NIH and are beginning to question whether they should invest in such a risky career. Many of our best and brightest scientists are seeking more promising opportunities outside of the lab or in other nations.

- Over the past generation, the average age at which American biomedical researchers with Ph.D. degrees succeed in obtaining their first research project grant award (R01) from the NIH has increased from 34.2 to 41.7 years of age. Furthermore, the percentage of NIH proposals receiving funds will likely be cut nearly in half by the end of 2007, as compared with levels just six years ago. While a career in medical research may always be riskier than other career paths, some hope for a sustainable future is essential to attract and retain talented individuals.

- After more than a half-century of unchallenged superiority in virtually every field of science and technology, from basic research to product development, the United States is starting to lose ground to other nations. While we continue to lead the world in scientific innovation, the recent years of declining investment in NIH and fresh competition from abroad threaten to end our supremacy. If the United States is to continue its leadership role in achieving scientific progress, the President and Congress must commit to adequately supporting the basic, fundamental research that underlies technological advancement.

WE MUST FULFILL THE PROMISE: NIH AT THE CROSSROADS

Over the past 50 years, NIH and its grantees have played a major role in the explosion of knowledge that has amounted to a revolution in biology. This knowledge has led to an unprecedented number of medical breakthroughs and discoveries that promise to improve the health and extend the lives for millions of people.

The good news is that – mainly due to medical advances in the treatment of heart disease, cancer, and stroke – we’re living longer and healthier lives. In September 2007, the National Center for Health Statistics said a baby born in the U.S. in 2005 should expect to live nearly 78 years on average. That’s a record, up nearly three percent from a decade earlier, and only the most recent rise in a consistent gain in life expectancy.

During the next 25 years, the number of Americans with chronic diseases is projected to reach 46 million. If we are to successfully confront the health care challenges associated with a growing elderly population, it’s going to require sustained support for basic and clinical research.

In the last five years, however, the NIH budget has failed to keep up with inflation, and we are in danger of sacrificing our nation’s dominance in biomedical research and biotechnology as well as risking the status of our research institutions as the envy of the world. New opportunities for path-breaking research are going unfunded, and there is a real chance that
the number of new therapies under development will begin to decrease. Therefore, it is imperative that we renew our commitment to medical research and to fulfill the hope of the American people by making NIH a national priority.

FASEB Federal Funding Recommendation

In order to fulfill the extraordinary scientific and medical promise of biomedical research, FASEB urges Congress to make the National Institutes of Health a priority and respectfully requests that NIH receive $31.2 billion in FY 2009.
MISSION

The ability of our nation to remain competitive in the global economy depends on our capacity to develop new knowledge, train dedicated scientists, and provide the resources that fuel discovery and innovation. Funding for the National Science Foundation’s (NSF) scientific research and education programs is essential to meet these goals.

NSF’s mission is “to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense.”

Although NSF receives less than 5% of the federal research and development (R&D) budget, it takes a leading role in advancing U.S. science, technology, engineering, and mathematics (STEM). In addition to providing necessary support for unique, large-scale research facilities, NSF funds approximately 20% of all federally sponsored basic research and at least two-thirds of federally-sponsored non-medical basic research conducted at America’s colleges and universities. Each year, this funding results in grants to more than 200,000 scientists, teachers, and student researchers for cutting-edge projects at thousands of institutions across the country. NSF is also a major force in science education and training. The agency supports education research and funds initiatives to prepare teachers, develop curricula, and engage students in the process of scientific discovery—activities that are critical for strengthening our scientific workforce.

NSF’s support of high quality science and education across STEM disciplines and its emphasis on integrating research and education make it unique among federal sponsors of research. Its broad approach enables NSF to stimulate the flow of ideas across scientific boundaries, bringing new insight to bear on perplexing research questions. In addition to advancing the frontier of science, NSF’s pioneering research investments have led to the development of marketable technologies, processes, and methods.

A recent National Academy of Sciences report warns that as other countries make R&D spending a top priority, the scientific and technological building blocks critical to U.S. economic leadership are eroding. Expressing a similar sentiment, the U.S. Office of Science and Technology Policy stated that “keeping our competitive edge in the world economy requires policies that lay the ground work for continued leadership in innovation, exploration, and ingenuity.” Although Congress recognized NSF’s contribution to the science and technology enterprise when it authorized a doubling of the agency’s budget by 2007, the vision of this legislation was not fulfilled: NSF’s budget remains far below the amount specified in the NSF Authorization Act of 2002.

With the passage of the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Science, and Education (COMPETES) Act, Congress renewed its

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2 Ibid.
commitment to U.S. science and technology through its support for NSF. Signed into law in August 2007, America COMPETES puts NSF on a path to doubling its budget by 2015, enabling the agency to expand its support for scientific research, education, and training programs. These critical investments in NSF will ensure that the U.S. continues to be at the forefront of scientific discovery and technological innovation.

**SELECTED ACCOMPLISHMENTS IN RESEARCH AND EDUCATION**

The research funded by NSF traverses the sciences, captures the imagination, and improves our quality of life. Following are just a few highlights of the innovative research and education projects supported by NSF.

**Nanotechnology**

Nanotechnology is a multidisciplinary field in which objects and even machines are designed and built with the dimensions of individual atoms and molecules. This new research area is revolutionizing everything from computers to health care, and NSF is leading the charge.

- **Biologically Inspired Nanocapsules**: Basic research on the origin, structure, and function of naturally occurring nanocapsules is providing scientists with the information necessary to engineer these molecules for medically-relevant tasks. Such molecules may be used to deliver drugs directly to cancer cells, correct genetic mutations, or extract toxins from cells.

- **Developing Medical Nanosensors**: Scientists have developed nanosize chemical sensors that can detect glucose in human tissue. This research is paving the way for the development of a class of biosensors that could improve the way diabetes patients monitor blood sugar and facilitate the tracking of a variety of other molecules, such as hormones, cholesterol, and drugs.

- **Cleaning Chemical Hazards**: Chemically manufactured nanopowders have been designed to absorb toxic chemicals, including nerve gas and acid spills, with rapid action to minimize exposure to these hazardous conditions.
- **Disrupting Cancer Development**: Scientists have found that antisense DNA, the molecular opposite of DNA, can be used to disrupt the production of cancer-causing proteins within cells. New research shows that attaching gold nanoparticles to the antisense strands enhances their ability to disrupt the production of these proteins.

- **High-End Computing and Advanced Networking**: NSF-funded research in computational science is driving discovery in critical scientific fields. Employing high-end computing and advanced networking, scientists are able to make fundamental breakthroughs in our understanding of biological systems and apply that knowledge to pressing health, environmental, and social concerns.

- **Developing HIV Drugs**: Harnessing the power of super-computers, scientists are modeling the structure and movement of molecules to determine how they behave inside cells. Basic research in computer modeling has led to practical applications; detailed modeling of the structures of enzymes that allow HIV to survive and proliferate has guided the development of new drugs that target these essential proteins.

- **Alleviating Urban Traffic Congestion**: Using high-powered computing tools, researchers have developed an advanced system to track evolving patterns of traffic congestion. Employing a vast statistical database and traffic information from 14,000 sensors, this software provides users with personalized, continuously updated traffic information, including alternate route suggestions. Even better, this information can be sent directly to users through their mobile phones.

- **Networking Biodiversity Data**: The establishment of the Global Biodiversity Information Facility has created a worldwide network of biodiversity data making it possible to access a vast array of information—including genetic and ecological data—on the earth’s myriad species. This information can be used to predict the spread of disease, identify the sources of disease-resistant crop genes, and track the spread of invasive species.

- **Materials Science and Engineering**: Nature produces an array of materials with structural properties unrivaled by those created in the lab. Basic research into the structures of these materials is helping engineers to develop new products with medical and industrial applications.

- **Developing Artificial Joints and Limbs**: Basic research on the biology of the unique cartilaginous skeletons of sharks may help researchers design biological materials suitable for the development of artificial joints and limbs.

- **Large Scale Silk Production**: Spiders produce a variety of high performance silk fibers with mechanical properties superior to some of the best synthetic fibers produced by modern technology. Scientists are studying the molecular basis of spider silk production and silk’s structural properties in an effort to develop large scale silk production processes.

- **Medical Uses of Collagen**: Researchers working at the interface of materials science and medicine have discovered ways to modify collagens, an important connective tissue component and the most common protein family in the body. Such modifications may be useful for blocking the formation of unwanted scar tissue, controlling the growth of tiny new blood vessels in tissues destined for implantation, and developing better infection-fighting bandages.

- **Biologically Inspired Vehicles and Robots**: Studies of locomotion in fish, birds, insects, and marine invertebrates are advancing research on biomaterials, control systems, and design principles. This work provides engineers with useful models for the development of autonomous and semi-autonomous vehicles for a wide variety of tasks, including search and rescue, firefighting, mining, and military reconnaissance and weapons delivery.
Basic Physiological Processes

Though it may not seem like it at first glance, humans share much in common with species as diverse as fungi, frogs, and bears. Due to similarities at the genetic, cellular, and physiological levels, studying these and other organisms can yield insights into human health and disease. NSF support for this basic scientific research helps us to understand the human body and paves the way for medical advances.

- **Advancing Organ Transplant Technology:** Researchers discovered that in freezing temperatures certain frogs produce an “anti-freeze” that prevents cells from being damaged by the chemical changes that occur when they are frozen. As a result, these frogs can survive for months in freezing weather even though their major organs have come almost to a halt. Research in this area may lead to technologies that enable human organs to be preserved longer, resulting in improved transplantation success rates.

- **Using Baker’s Yeast to Study HIV:** Yeast cells are not only structurally similar to human cells, but they contain harmless retrovirus-like elements that are used to model HIV. Working with baker’s yeast, scientists discovered a mechanism within these retrovirus-like elements that may be the missing link to retrovirus replication. If the same process is used in HIV replication, scientists will have a new target for the development of HIV drugs.

- **Understanding Muscle Maintenance:** Hibernating animals such as bears maintain strength and muscle integrity even after months of prolonged confinement and starvation. Understanding the physiological mechanisms that account for muscle maintenance under these conditions will help researchers to determine how humans can adjust to prolonged bed rest, limited activity, or extended space travel.

Science Education and Training

One of the most important contributions that NSF makes in support of the nation’s STEM infrastructure is in its contribution to science education. NSF programs are cultivating the next generation of scientists and engineers by developing research-based curricula, engaging K-12 and undergraduate students in science, providing support for graduate and postdoctoral researchers, and improving teacher training.

- **Math and Science Partnership (MSP) Program:** This program supports innovative, educational partnerships between universities, local school systems, businesses, and informal science organizations. Partnerships have resulted in new instructional materials, teacher training programs, and parental engagement in science education. Early analyses of this initiative demonstrate that participating students show improvements in math and science proficiency.

- **Science, Technology, Engineering, and Mathematics Talent Expansion (STEP) Program:** The STEP program aims to increase the number of students obtaining undergraduate degrees in STEM disciplines through grant support to academic institutions that provide students with innovative learning opportunities. With STEP funding, colleges and universities have developed programs to engage women and minorities in science, provide students with research opportunities, and introduce them to scientific careers.

- **Integrated Graduate Education Research and Training (IGERT) Program:** This initiative supports 125 doctoral degree programs that foster collaborative and interdisciplinary training in emerging scientific domains. IGERT trainees have produced important scientific and technological breakthroughs including a handheld imaging device that can detect breast

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tumors, a new process for creating strong and flexible plastics, and “bio-transformable” materials that can be implanted into the body to deliver drugs or open blood vessels.

**Investing in the Future**

NSF’s strategic plan for the future outlines the agency’s approach to building our nation’s research capacity. Combining sustained support for basic research, education, and training with investments in emerging areas of scientific interest and need, NSF will ensure that the U.S. has the infrastructure and talent to maintain its role as a leader in science and technology.

**Fundamental and Transformational Research**

NSF will continue to support both transformational research and development and the basic science upon which it is built. The agency is emphasizing interdisciplinary, systems-based investigation in areas such as neural bases of behavior and natural hazards, promoting energy and climate research, and developing and examining the safety of nanomaterials. Through its investments in computer science, mathematics, and statistics, NSF will advance research in all STEM disciplines and enhance our ability to make future discoveries.

**Systems Biology**

Support for NSF is critical for advancing new areas of biological discovery, including systems biology. NSF is taking a leading role in the development of this emerging field, which brings together biologists, chemists, engineers, mathematicians, and physicists to study how complex properties arise from the components of biological systems. Combining experimental biology with computational and modeling techniques, systems biologists are developing a better understanding of living systems and their interactions with the non-living world. A comprehensive understanding of such processes is essential if we are to understand the global impact of phenomena such as climate change.

**Research Facilities and Instrumentation**

NSF is increasing its support for large and mid-scale research instrumentation and working with the community to determine the equipment and facilities needs of the future. NSF’s support for research instrumentation, facilities, and equipment will ensure that scientists have access to the tools essential to their research, such as high-resolution electron microscopes, advanced brain imaging devices, and particle accelerators.

**Education and Training**

With increased funding for initiatives such as MSP, STEP, and IGERT, NSF will continue to foster innovative approaches to science education. The agency’s focus on integrating research and education, bridging gaps between K-12, undergraduate science, and technical education, and expanding partnerships between academia and industry will broaden interest and participation in science careers.

**Recommendation**

If we are to continue to lead the world in innovation and prepare for future prosperity, continued funding for the National Science Foundation is essential. As NSF Director Arden Bement, Jr., has said, “America’s sustained economic prosperity is based on technological innovation made possible, in large part, by fundamental science and engineering research. Innovation and technology are the engines of the American economy, and advances in science and engineering provide the fuel.” Without a greater commitment to NSF, our country faces the grave possibility of losing its global dominance in science and technology.

In keeping with the America COMPETES Act of 2007, FASEB recommends an appropriation of $7.33 billion for the National Science Foundation in FY 2009.

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“[P]ublic agricultural research undertaken today will begin to noticeably influence agricultural productivity in as little as 2 years and…its impact could be felt for as long as 30 years.”


Greater investment in basic and applied agricultural research is essential, as threats proliferate and demands for a more nutritious food supply continues to increase. The United States Department of Agriculture (USDA) funds research through its intramural arm, the Agriculture Research Service (ARS), and competitive grants program, the National Research Initiative (NRI). The ARS support allows optimization of the competitive funds offered through the NRI by providing essential research facilities via its research centers across the country. These symbiotic programs provide the infrastructure and continuous generation of new knowledge that allow for rapid progress towards meeting national needs.

A recent report by the Economic Research Service (ERS) found “strong and consistent evidence that investment in agricultural research has yielded high returns per dollar spent” citing mean rates of returns of 53 percent. However, our nation’s investment in agricultural research has been declining (Figure 1), threatening our ability to sustain the vitality of our research portfolio. The NRI has not yet reached even half of its initial authorization of $500 million, and ARS funding has been waning. Continuation of this neglect will inevitably undermine the success of the USDA’s research programs. Thus it is imperative that the breadth and competitive nature of the NRI portfolio be maintained and expanded to ensure our nation’s excellence in agricultural research and the well-being of all Americans.

Agriculture and the research which advances it remain of crucial importance to our economy and quality of life. Research supported by USDA contributes to our understanding of the nutrition that underlies our health; it protects human life and our food supply from pandemic disease and introduced pathogens; it allows us to respond quickly to emerging issues like Colony Collapse Disorder or foot-and-mouth disease; and has led the way in development of bioenergy resources. Below are a few examples of the important contributions resulting from USDA-funded research.

Figure 1: Research at the USDA has been declining in relation to total federal spending on non-defense research & development (R&D), putting our competitive portfolio of agricultural research at serious risk.

Human Nutrition, Health, and Policy

Nutrition is the foundation upon which human and animal health is built, and whose mysteries fascinate the American people like no other aspect of science. This is perhaps most evident in the daily news stories that seek to uncover the optimal diet required to maximize health or minimize risk of disease. Research has identified the critical role that nutrition plays in a myriad of health conditions, from cancer to heart disease to diabetes. Perhaps the most striking evidence of the importance of nutrition to health is the alarming increase in the rates of obesity in this country, especially in children and adolescents. Further research is essential as we seek to understand the causes, both innate and environmental, of this public health crisis.

The USDA is uniquely positioned to conduct nutrition and food-related research because of its singular perspective on the entire food system, from crop to livestock to food supply to human consumption. No other agency has the capacity to understand the connections among food, the food supply and its production, and the health of our nation. Through its research programs, the USDA is making the connection between what we eat and the healthfulness of our lifestyle.

- **Folate and colon cancer:** Folate, a B-complex vitamin, is strongly implicated in the prevention of colorectal cancer. It has been estimated that the risk of developing colorectal cancer in people consuming the largest amounts of dietary folate is 30-40% lower than in people consuming less folate. NRI-supported scientists are investigating the mechanisms by which differences in folate intake can protect against cancer and other diseases, which may provide evidence for increasing the Dietary Reference Intake values for folate. This is a necessary first step in developing effective public health measures which would use folate as a cancer preventive measure and improve the health of the nation.

- **Obesity:** Our country is facing a rising storm of health problems related to increasing rates of obesity, in both adults and children, including diabetes, hypertension, and heart disease. The direct and indirect costs of obesity represent a $100 billion annual burden on the U.S. economy. The USDA is funding cutting-edge research at universities across the nation, where scientists are examining genetic and metabolic factors that influence obesity, including the balance of protein, fat, and carbohydrate, dietary calcium and milk intake, the roles of the hormones leptin and ghrelin, as well as the effects of conjugated linoleic acid, and new and genetically modified foods. Unique research projects linked to dietary interventions are being carried out in rural towns in three states in the West, in African American communities in the South, and in Native American communities.

- **Functional foods for disease prevention:** Antioxidants have been shown to be of primary importance in preventing age-related disease and health problems, including cancer and coronary heart disease, two of our nation’s leading causes of death. USDA-funded scientists are working to develop functional foods, rich in antioxidants, which could provide nutritional benefit while protecting against disease. Scientific data suggests that processing of wheat could maximize the antioxidant capacity of this cornerstone of our food supply. Researchers have developed a processing procedure to enhance the antioxidant availability in wheat-based food ingredients that involves no chemical or organic solvents and generates no waste. These processing procedures require no special equipment or operation and may be easily scaled up for commercial production.

Safety of Our Food Supply

Over the past year, our national attention has focused on food safety and the security of our food supply. The research programs of the USDA are at the forefront of developing new technologies to protect our food supply and discovering new ways to detect and neutralize threats to our crops, livestock, and food products. Research activities range from foodborne illnesses to microbial resistance to food processing safety to biosecurity at our borders.
Moreover, projects funded by NRI and ARS are addressing concerns not only related to our domestic supply of foods, but also those items that we import from international partners. As the United States forges new ties and reinforces existing relationships in our increasingly global economy, it becomes even more critically important to ensure agricultural research is delivering the knowledge to protect our citizens and the foods they eat.

- **International food safety:** Concerns have been raised about the safety of food products and goods imported from other nations. Researchers at the University of Minnesota are setting up models to examine the role of imported food products in the local and global dissemination of food-borne pathogens. Using epidemiological data, these models will enable development of intervention to reduce the risk of disease outbreaks due to food imports. Meanwhile, another team of NRI-funded scientists is developing edible food sensors, made of luminescent nanoparticles. These tiny sensors will be able to screen foods for a host of safety and quality issues, from presence of bacteria and toxins to pH, in a rapid, easy-to-use and inexpensive manner.

- **Preventing Salmonella outbreaks:** The multibillion dollar American poultry industry loses 10 to 15% of its potential income to disease annually. Additionally, microbes that infect poultry represent a major human health risk, particularly *Salmonella* which causes over one million cases of illness and results in 500 deaths in the U.S. each year. Using sophisticated DNA technologies, USDA-funded scientists are identifying the genes related to disease resistance and response in poultry. Understanding the genetic basis for the immune response to *Salmonella* and other diseases may lead to breeding of disease-resistant birds, as well as vaccine development.

- **Biohazard detecting cloth:** Through use of nanotechnology, NRI-funded scientists at Cornell University have created a cloth that has the ability to detect bacteria, viruses, and other biohazards. When the cloth contacts a contaminant or hazardous substance, a dye is released, providing a rapid response test that allows visualization of the threat with the naked eye. This has applications in detecting foodborne diseases at food preparation or manufacturing sites, screening for bioterror agents like anthrax, and even confirmation that operating rooms or medical facilities are clear of pathogens.

**RESPONDING TO EMERGING THREATS**

When beekeepers across the country began to report the alarming and mysterious loss of 50-90 percent of bees from their hives, the USDA took the lead in mobilizing research resources to find the source of what is now know as Colony Collapse Disorder (CCD). This is only one example of how a unique and emerging agricultural threat can swiftly challenge our nation’s economy, health or food supply. A new outbreak of foot and mouth disease in Europe, the looming specter of pandemic avian flu, and the continuing threat of mad cow disease all illustrate the need for the research resources required to address new and emerging pathogens and diseases. Only with an adequately funded agriculture research infrastructure can our nation be prepared to react and rapidly counter threats to our health and food supply.

- **Virus implicated in colony collapse disorder:** Scientists funded by the USDA have recently announced discovery of a virus that may be linked to Colony Collapse Disorder (CCD), which has decimated bee colonies across the country. Bees are essential for the pollination of nearly 100 fruit and vegetable crops worldwide, and play an integral role in U.S. agricultural products representing an estimated economic value of more than $14.6 billion. Identification of Israeli Acute Paralysis Virus (IAPV) as a marker for CCD is a breakthrough step in solving this major agricultural problem. The USDA has also announced a strategic CCD Research Action Plan which will focus, among other things, on ways to improve the general health of bees to reduce their susceptibility to IAPV, CCD, and other disorders.
- **Avian influenza:** Avian influenza is a threat to both the multibillion dollar U.S. poultry industry and to human health. A major challenge in dealing with this disease is being able to differentiate between infected birds and vaccinated birds, as well as to be able to rapidly differentiate between different strains of avian flu. Through DNA microarray technology, USDA funded scientists are developing fast and accurate tests that will be cost effective for producers and allow more rapid response to outbreaks of avian influenza worldwide.

**Bioenergy and Climate Change**

Bioenergy has the potential to not only reduce our dependence on foreign oils but to provide a clean, sustainable fuel source that may help mitigate global climate change. The USDA funds research projects that produce science-based knowledge and technologies supporting the efficient, economical, and environmentally friendly conversion of biomass, specifically agricultural residuals, into value-added industrial products and biofuels. Furthermore, USDA-funded research is responding to the issue of climate change by contributing to our understanding of the causes and effects of this phenomenon and how to best protect our natural resources. Agricultural and forestry resources are vitally important to both our development of biobased resources and our ability to address the threat of climate change. As such, agricultural research is essential to addressing these national priorities.

- **From switchgrass to biofuels:** Switchgrass has great potential to be a major biofuel source for the U.S. – it grows quickly, is readily adaptable to diverse conditions, and it efficiently captures the energy of the sun, converting it to cellulose which can be used as a clean alternative fuel source. Unlike other crops, we know very little about the genetics of switchgrass, information that is critical for enhancing breeding and maximizing the potential of this important bioenergy crop. University of Georgia scientists, funded by the NRI, are creating a genetic resource library and mapping out genetic traits that will allow producers to select lines with higher biofuel potential.

- **Cost effective biodiesel:** Biodiesel is a clean burning and renewable fuel produced from plant oils and animal fats. Unfortunately, biodiesel is currently expensive to produce because of high feedstock costs, high manufacturing costs, and the requirement to dispose of a low-purity glycerol byproduct. NRI-funded researchers are seeking ways to improve the biodiesel production process and develop alternative approaches for the byproduct glycerol. Through use of sophisticated distillation technologies and catalysts, they are developing manufacturing process that will lower the costs of producing biodiesel, lead to a better-quality biodiesel product that exceeds current standards, reduce waste formation, and eliminate the troublesome by-product.

- **Predicting the effects of climate change:** Global climate change is likely to affect the croplands on which we are dependent for food. At the USDA’s Rainfall Manipulation Plots facility, researchers are able to alter temperature and precipitation over grasslands to simulate estimated climate change outcomes. These long-term studies are providing invaluable information on how crops will react to complex ecosystem changes associated with climate change. Understanding the impact of this phenomenon can greatly enhance the ability of producers and policymakers to prepare for or mitigate negative effects.

**A Vision for the Future**

The focus on agricultural research resulting from reauthorization of the Farm Bill presents a unique opportunity to strengthen and enhance our national system of agricultural research.

- **National Institute of Food and Agriculture:** FASEB fully endorses the establishment of a National Institute for Food and Agriculture (NIFA), within the USDA, dedicated to funding competitive, peer-reviewed basic research in agriculture. This is an unparalleled opportunity to enhance our system of supporting high quality, fundamental research, allowing advancement of current knowledge and bolstering the superiority
of American agriculture. However, in order to ensure success of such an endeavor, NIFA must be fully funded, in contrast to the current trend of underfunding that has plagued current agricultural research programs.

THE UNITED STATES IS BEST SERVED THROUGH INVESTMENT IN AGRICULTURAL RESEARCH

From the critical basic research supported at universities throughout the nation to the important work carried out by the Human Nutrition Research Centers, USDA research programs deserve to be supported at the highest level possible. We must maintain and magnify the breadth and competitive nature of the agricultural research portfolio, to ensure the United States’ economic vitality and the well-being of all Americans.

FASEB FEDERAL FUNDING RECOMMENDATION

FASEB supports funding the USDA’s National Research Initiative Competitive Grants Program in FY 2009 at the $257 million level recommended in the President’s 2008 budget and the Agricultural Research Service at $1.377 billion, which restores the FY 2005 level, adjusted for inflation.
**MISSION**

The Department of Energy’s Office of Science (DOE Sc.) is committed to “invest[ing] in some of the most exciting and daring research that humankind has ever conceived, from explorations into the origins of our universe and the constituents of life, to the scientific knowledge that will deliver new, clean, and abundant sources of energy to meet world needs for 10 billion people by the year 2050.” This bold statement, taken from the *Office of Science Strategic Plan*,1 highlights DOE Sc.’s unique role in serving as a catalyst for discovery in basic energy research, environmental and life sciences, and computational science. The research programs and facilities supported by DOE Sc. enable cutting-edge science and technological innovations that safeguard our nation, strengthen our economy, and improve the daily lives of the American people.

The DOE Sc.’s extraordinary system of national laboratories and advanced research facilities is used each year by more than 25,000 researchers from universities, other government agencies, and private industry. As the most advanced research system of its kind, unparalleled throughout the world, these state-of-the-art facilities allow DOE to support unique and vital programs in climate change, geophysics, genomics, materials and chemical sciences, and life sciences. The Office of Science is situated at the interface of many scientific disciplines, and its emphasis on interdisciplinary research allows DOE Sc. to support and extend basic research sponsored by other federal agencies. Many research activities funded by non-DOE science agencies could not take place in the absence of the highly specialized research infrastructure created and managed by DOE.

The research and scientific contributions of the DOE Sc. are certainly not limited to the national laboratories. The Office of Science is also a principal supporter of graduate students and postdoctoral researchers early in their careers at U.S. colleges and universities. Almost 50 percent of the DOE Sc.’s research funding goes to support research at more than 300 colleges, universities and institutes nationwide (Figure 1).

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**Figure 1: DOE Office of Science Base Research Dollars**

![Figure 1: DOE Office of Science Base Research Dollars](source: DOE Office of Science, http://www.science.doe.gov/News_Information/News_Room/2007/Budget/SC-DOE_DrOrbach_FY08BudgetTestimony_March212007-v1.pdf)
CLEANER AND MORE SECURE ENERGY FUTURE

Fundamental discoveries in basic energy sciences funded by DOE Sc. are already having an impact on the energy we use daily and are continuing to pave the way for the next generation of environmentally-conscious, sustainable energy sources. As a recent report on future energy needs produced by DOE stated, “Major new discoveries are needed, and these will largely come from basic research programs.” The following are some examples of the real world discoveries supported by DOE Sc.:

- **Building better batteries**: DOE Sc. discoveries resulted in lithium batteries which offer high-energy storage capacity in an environmentally benign package. Lithium batteries are widely used in both consumer and defense applications, such as cellular telephones and notebook computers. Moreover, DOE researchers have generated a solid-state, fluoride-based battery that is safer than traditional batteries in high-temperature applications such as oil, gas, and geothermal drilling.

- **Clean and efficient fossil fuels**: New, coal-fired technology, which uses a high-tech, gas recirculation system developed by DOE-funded scientists, is saving small businesses more than $1,000 per day, while surpassing environmental standards and eliminating the need for expensive, external emissions controls.

- **Hydrogen technologies**: At the Argonne National Lab, scientists have constructed the world’s fastest commercially producible hydrogen sensor, which can be used in hydrogen-powered cars to detect unsafe levels of hydrogen, as well as developing materials resistant to metal dusting degradation, which will be used to make more durable equipment in plants that manufacture hydrogen.

Reducing our dependence on foreign oil and developing sustainable fuel and energy solutions with minimal impact on the world around us has become imperative. Indeed, the mission of the DOE Sc. is “to deliver the remarkable discoveries and scientific tools that transform our understanding of energy and matter and advance the national, economic, and energy security of the United States.” Never before have the scientific opportunities been greater towards achieving this goal.

- **Advanced bioenergy research**: DOE Secretary Samuel Bodman recently announced DOE Sc. funding of three new Bioenergy Research Centers that will accelerate basic research in the development of cellulosic ethanol and other biofuels. A major focus will be on understanding how to reengineer biological processes to develop new, more efficient methods for converting the cellulose in plant material into ethanol or other biofuels that serve as a substitute for gasoline.

- **Harnessing the power of the sun**: In an effort to increase the amount of solar power in the nation’s energy supply, the DOE Sc. is investing in research aimed at improving conversion of solar energy to both electricity and chemical fuels. Scientists at universities across the country will be working on a comprehensive, balanced portfolio of basic and applied research and technology development aimed at significantly advancing the use of sunlight as a practicable solution to meet our compelling need for clean, abundant sources of energy.

- **Increasing the feasibility of hydrogen fuel**: In April 2006, the DOE Sc. announced a multi-year commitment to support basic hydrogen research in order to spur scientific breakthroughs and help build a hydrogen fuel-based economy. Fundamental research awards have been made to institutions nationwide as scientists work to overcome key hurdles in hydrogen production, storage, and conversion. Researchers are focusing on five technical focus areas: novel materials for hydrogen storage; membranes for

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separation, purification, and ion transport; design of catalysts at the nanoscale; solar hydrogen production; and bio-inspired materials and processes. For example, researchers have recently shown that it is possible to selectively extract pure hydrogen from ethanol, a renewable fuel made from biomass, in a matter of microseconds. Advances in this hydrogen production process might provide an alternative to current methods, perhaps resulting in an economically feasible hydrogen production process for the future.

**Improved Health & Well-Being**

DOE Sc. funds innovative science that provides solutions to challenges in modern medicine. Often working cooperatively with other federal agencies, such as the National Institutes of Health, National Aeronautics and Space Administration, and the United States Department of Agriculture, DOE supported scientists have uncovered a wealth of basic biological knowledge and enabled astounding health-related technologies. The following are select examples of how DOE Sc. is improving the medical care and quality of life for us all:

- **Restoring function to disabled patients:** DOE Sc.-funded science led to the bion® microstimulator, a miniature, self-contained, rechargeable implantable neurostimulator that may benefit the estimated 50 million Americans who suffer from debilitating conditions by stimulating viable nerves and muscles to prevent muscles from deteriorating and to help restore nerve and muscle function. The device is designed to treat a wide variety of diseases, including incontinence, chronic headaches, peripheral pain, angina and epilepsy. Epileptic patients will also be helped by the DOE Sc.-supported development of SeizAlert®, a low-cost, compact, non-invasive, wearable prototype device designed to alert the wearer and medical personnel of an impending epileptic seizure. Epilepsy affects millions of people in the U.S. alone, and because many cannot currently be treated with medication or surgery, SeizAlert has significant medical and economic importance.

- **Mitigating the impact of low dose radiation:** The DOE Low Dose Radiation Research Program funds basic research to determine the responses induced by exposure to low doses of radiation. It has long been known that ionizing radiation, which can be found in a wide range of occupational settings including health care facilities, research institutions, and nuclear reactors, can lead to breast cancer by causing genetic mutations. Recent investigations have revealed that this is not the only damage done. DOE-funded research has shown that exposure to ionizing radiation also acts as a carcinogen by affecting the cell proteins responsible for cell to cell communication and cellular structure. Thus, exposure may result in breast or other types of cancer, even when genetic mutations cannot be detected, and this damage can be passed on to subsequent generations of cells, amplifying the damage. Understanding the fundamental cell biology of radiation exposure allows development of treatments and protections against low-dose radiation.

- **Targeted cancer therapies:** DOE scientists have developed the Cesium-131 Brachytherapy Seed, one of the most significant advancements in brachytherapy (short distance treatment involving the use of carefully placed, radioactive “seeds”) for cancer treatment in nearly 20 years. In treating prostate and other cancers, it delivers a highly targeted therapeutic dose of radiation to the tumor quickly with potentially fewer side effects.

Although the discoveries made by DOE Sc.-funded researchers are already positively impacting our lives and health, even more exciting are the opportunities hovering on the horizon. Scientists are on the brink of breakthroughs that can help solve the challenge of some our most pressing medical needs.

- **Artificial retina and beyond:** The DOE Sc. has been at the scientific forefront of neural prostheses, which can restore sight or movement to those stricken by illness or injury. An ongoing initiative involving DOE national laboratories,
universities and the private sector is developing an artificial retina that can restore sight in blind patients with macular degeneration, retinitis pigmentosa, and other eye diseases. The technology that is being developed in the DOE Artificial Retina Project may be applied not only to the treatment of blindness but also in the general field of neural prostheses. It may be adapted to help persons with spinal cord injuries, Parkinson’s disease, deafness, and almost any other neurological disorder. In addition, the DOE Sc.-supported Neural Matrix, initially designed to help scientists learn how neurons in the human nervous system communicate, is the first step in creating combined biological and electronic chip implants that can provide neural networks of interconnected nerve cells for testing drugs and sensing toxins for homeland security and, someday, restoring the use of limbs, eyesight, and improved mental functions in patients.

- **Cooling technologies to aid stroke and heart attack victims:** Researchers at the Argonne National Laboratory and University of Chicago are using specially engineered ice slurry to cool organs, which may help save patients suffering from stroke or cardiac arrest. Rapid cooling slows down the destruction of heart and brain cells, which gives doctors and paramedics time to revive the patient while minimizing the risk of permanent damage. This technology may also have application for surgeons performing minimally invasive laparoscopic surgery. These surgeries frequently require stopping blood flow to vital organs, such as the kidneys. Cooling the organs before cutting off the blood supply would give surgeons more time to operate before the onset of cell death in the organs due to lack of blood and oxygen.

- **Realizing the potential of stem cells:** By using silicon nanowires embedded into living cells, scientists may one day be able to guide embryonic stem cells into forming neurons, heart cells, muscles cells, lung cells, or other specific types of cells and tissues which can be used to treat a host of debilitating diseases and conditions. DOE-funded scientists at Berkeley Lab have accomplished the crucial first step by developing techniques in which these tiny wires can be embedded into cells, with no apparent harm. These wires can then be used to provide electrical stimulation, which can help unleash the full regenerative potential of stem cells, as well as possibly providing a way to deliver genetic information to specific parts of the cell or connect diagnostic devices to individual cells.

Recognizing The Importance of DOE Research
The passage of the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education and Science (COMPETES) Act renewed Congress’s commitment to U.S. science and technology, establishing a seven year doubling path for the budget of the DOE Office of Science. Signed into law in August of 2007, America COMPETES will enable the DOE to greatly enhance its groundbreaking research portfolio, enabling it to confront current and future energy and health challenges. Scientists funded by DOE Sc. have made, and our continuing to make, extraordinary breakthroughs that contribute to the quality of our lives and facilitate the technologies that drive our nation’s innovation-based technologies.

**FASEB Federal Funding Recommendation**

In keeping with the America COMPETES Act of 2007, FASEB recommends an appropriation of $4.8 billion for the DOE’s Office of Science in FY 2009.
MISSION

“NASA is in the inspiration business... There is so much we simply do not comprehend. We must convey that sense of wonder, adventure, and discovery to our children and grandchildren.”

Michael D. Griffin, NASA Administrator

Pioneering the future in space exploration, scientific discovery, and aeronautics research is the mission of the National Aeronautics and Space Administration (NASA). Fundamental to this mission are the development and communication of scientific knowledge of Earth and the universe, and the utilization of the space environment for research. In the past, NASA has funded basic and applied biological research into the effects of gravity, radiation, and space flight on the development and function of biological organisms, as well as investigations of the origin, evolution, and distribution of life throughout the universe. NASA-sponsored research in the life sciences has also significantly extended our understanding of the short- and long-term responses of the human body to space flight conditions, which has important applications for human health on Earth.

SCIENTIFIC ADVANCES AND RECENT ACCOMPLISHMENTS

NASA is a leader in providing support to the scientific community for research dealing with the biological effects of microgravity. NASA funding has enabled the microgravity research community to identify and help mitigate the deleterious effects of space travel on human health, including motion sickness, deterioration of bone and muscle structure function, cataract formation, impaired immune function, kidney stones, and cardiovascular dysfunction. The fundamental cell and animal based studies supported by the agency have advanced our understanding of the basic mechanisms that living systems use to sense and adapt to changes in gravity. This knowledge also has relevance to human health on Earth, with applications to conditions such as sleep disorders, heart disease, osteoporosis, and the age-related disease of sarcopenia, also known as muscle wasting. Some recent findings from NASA-sponsored programs are highlighted below.

- Lack of exercise and nerve stimulation often leads to muscle atrophy. Using a rat model, NASA-funded scientists recently showed that an inflatable boot could be used to stimulate the foot and reduce atrophy associated with space travel. This research may mitigate the risk of foot muscle atrophy in astronauts during extended missions, such as those planned for expeditions to the Moon and Mars. Additionally, patients who are bedridden or physically unable to achieve sufficient exercise and nerve stimulation will also benefit from these findings.

- Increased urinary calcium losses and decreased fluid intake increase the risk of kidney stone formation during and after space flight. The use of potassium citrate is being studied as a countermeasure to prevent formation of kidney stones in flight crewmembers. Data from these studies will not only be useful during long-duration space flights, but will also advance broad understanding of the mechanisms by which renal stones form in otherwise healthy individuals on Earth.

- While obesity is a major health threat in many societies, this critical health issue continues to elude solution. Studies in altered gravitational environments have demonstrated that sensory signaling alters energy metabolism and fat tissue storage levels. These studies will be important for both long-term space exploration, as well as general human health.

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2 www.NASA.gov
When cells grow in the human body, they normally adopt a three-dimensional structure. However, in the laboratory, cells generally grow in flat sheets that may behave differently than they would in the body. Cells grown in microgravity arrange themselves in structures that more closely resemble the three-dimensional structures found within the body. This provides a unique and important opportunity to study cell differentiation and function. Recent experiments carried out aboard the International Space Station (ISS) have focused on understanding the mechanisms of development of kidney disorders, colon cancer, and ovarian cancer. Cell lines from these abnormal tissues are being grown and allowed to differentiate in microgravity where patterns of growth may more closely resemble those found in actual disease.

- Astronauts may have increased rates of bacterial infection and reactivation of specific viruses. Studies of how the spaceflight environment affects opportunistic bacteria such as Salmonella have shown that altered gene expression increases virulence, including reduced antibiotic sensitivity. Host responses to microgravity, such as attenuated inflammatory cell function and marked impairment of antibiotic absorption in the gastrointestinal tract, also appear to underlie increased rates of bacterial infection associated with space flight. Strategies to reduce this threat of opportunistic infections are important for long-term space missions and the habitation of space.

- Sudden reductions in blood pressure and fainting upon assuming an upright position, known as orthostatic intolerance, are evident in astronauts after long-term space flight. This aberrant cardiovascular response may interfere with astronaut function and may limit the ability of an astronaut to exit a landed spacecraft unaided during an emergency. Recent research on animals exposed to simulated microgravity suggests that, in addition to the diminished pumping ability of the heart and reduction in effective blood volume, there is a loss of contractile proteins in the walls of blood vessels and an impaired capacity of these vessels to constrict. These findings have relevance to a wide range of diseases including heart disease, hypertension and diabetes.

- Recently, NASA signed a Memorandum of Understanding (MOU) with the National Institutes of Health (NIH), which designates the U.S. portion of the ISS for use as a National Laboratory and provides a framework of cooperation between the two agencies. This five-year agreement recognizes the potential of ISS to contribute to biological and biomedical understanding of physiological systems and diseases.

Organizational and Budgetary Changes

In January 2004, President Bush announced his Vision for Space Exploration³, which outlined ambitious objectives for NASA, including completion of the International Space Station, an extended human expedition to the Moon, and human travel to Mars. The President’s vision has led to both structural and budgetary changes, which have had significant impacts on life sciences research at NASA. As a result of NASA’s new mission focus, nearly 90% of fundamental biological research was terminated, although a reauthorization of the agency in 2005 included a directive to reinstate some fundamental life and microgravity science research budget, maintaining it at a level equivalent to 15% of the ISS research budget. This newly authorized initiative, the Non-Exploration ISS Research Program in Fundamental Biology, has included eleven spaceflight opportunities for life scientists, sponsored ongoing, collaborative research on Russian biosatellites, funded experiments on the ISS, and supported the development of satellites utilizing advanced biotechnologies.

Beyond the Non-Exploration Research Program, biological research is funded through the Human Research Program (HRP), which supports NASA by investigating and seeking methods to mitigate risks to human health during space flight exploration. The

³ http://www.whitehouse.gov/infocus/space/
HRP has identified six development areas around which the program is structured.

- **Space Radiation**: This program supports basic research into the health effects of space radiation and explores technologies and protocols to decrease risk during space travel. Research in this program has specific implications for understanding cancer causes and mechanisms.

- **Exploration Medical Capability**: Planned extended missions to the Moon and Mars will require medical capabilities to prevent, monitor, diagnose, and treat illness while inhabiting the space environment. This program seeks to develop those technologies, informatics tools, clinical capabilities, and pharmaceuticals. The program collaborates extensively with industry, academics, and other government agencies such as the Department of Defense, and could have implications for improved health technologies for both the civilian and military population.

- **Behavioral Health and Performance**: Mitigating risks related to stress, lack of sleep, and the physical environment and conditions encountered during space travel are the main focuses of this program.

- **Human Health Countermeasures**: Focused on developing and using countermeasures to mitigate physiological and psychological risks during space flight, these projects address many parameters of health and well being, including physical health and nutritional factors.

- **Space Human Factors and Habitability**: This program is develops tools and measures to ensure that spacecraft provide healthy, comfortable, and productive environments for space crew. Examples include developing limits for bacterial, fungi, chemical, and dust exposure during space travel.

- **ISS Medical Project**: The International Space Station provides space for HRP activities, including exploring human health problems and risks to space crew in the space environment.

The President’s FY 2008 Budget requests $183.3 million to fund HRP, a slight increase over the estimated FY2007 level. Many are concerned that the emphasis placed on returning to the Moon and planned missions to Mars has significantly harmed NASA funding of basic and biological research. For example, in 2005, NASA terminated all of its new biological equipment on the ISS, including its Plant Research Unit, research animal

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<th>FY 2006 Actual</th>
<th>FY 2007 Estimate</th>
<th>FY 2008 Budget</th>
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<td>Human Research Program</td>
<td>$415 Million</td>
<td>$172 Million*</td>
<td>$183 Million (+6.4%)</td>
</tr>
<tr>
<td>Non-Exploration ISS Research: Fundamental Biology</td>
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<td>$6.1 Million (-9%)</td>
<td>$1.5 Million (-75.4%)</td>
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*Source: American Association for the Advancement of Science Report XXXII: Research and Development FY 2008 and NASA budget documents.*
facilities, and cell culture provisions. Additionally, funding of biomedical research at NASA has declined drastically since 2005. Given the high cost of facilities and operations, insufficient funding will be unable to sustain the type of cutting-edge biological research that ensures the safety of space crew and provides new understanding of disease and physiological systems. A budgetary increase, even the modest one suggested for the HRP in FY2008, might allow some stabilization in the program and may provide the structure for NASA to set priorities in its biological sciences program.

*The Human Research Program is a combination of the Human Health and Performance Program and the Human Systems Integration Program, under the former Human Systems Research and Technology Theme. The FY 2007 PB Request represents the combined requests of the two former programs.

**CHALLENGES**

**NASA- NIH Partnership:** While the joint NASA-NIH MOU formalizes a potentially fruitful partnership between NIH and NASA and recognizes the importance of research in a microgravity environment, it is potentially limited by two factors:

- No obligation of funds is required.
- No formal plan of implementation is currently in place.

In addition, the five-year agreement would require the use of the Space Shuttle, which is due to be retired in 2010, and no replacement vehicle is scheduled to be operational until 2014.

**Bioastronautics Roadmap:** To facilitate the proposed missions to the Moon and Mars, NASA developed the Bioastronautics Roadmap (BR). BR is described by NASA as “the framework used to identify and assess the risks of crew exposure to the hazardous environment of space.” However, in 2005, the Institute of Medicine (IoM) and the National Research Council (NRC) reviewed BR and concluded that, “Current resources are unlikely to be sufficient to complete the BR mitigation plan in a timeframe that enables the exploration class missions envisioned by NASA.” Furthermore,

The committee recommends that NASA initiate an aggressive program, including the use of animal models, analog environments, and space flight to significantly accelerate the progress of all Countermeasure Readiness Levels and Technology Readiness Levels that are essential to support the proposed exploration agenda. Countermeasure and technology at an undefined or low state of readiness (the majority of the current portfolio) should receive renewed attention. The committee notes further that failure to do so will jeopardize the exploration program outlined in the President’s vision for exploration of January 2004.

FASEB applauds the language in the FY2008 Omnibus bill instructing NASA to “establish an ongoing relationship” with the National Academies for the purpose of “independent project review.” Ensuring an independent scientific review of NASA’s future course of action in the life sciences will help Appropriators direct adequate funding to critical research programs. This is a positive step in improving the transparency and oversight of science funding at the agency.

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The space environment provides a unique biological research environment that cannot be fully replicated on Earth. Additionally, NASA-funded biomedical research both on Earth and in space has the potential to lower and eliminate space flight risks to astronauts and to better understand disease that affects the lives of all Americans. It is important that NASA continue to fund cutting-edge research and develop technologies that will protect our astronauts and contribute to our nation’s health and economy.

**FASEB Federal Funding Recommendation**

NASA must reinvigorate fundamental biomedical research in the Human Research Program using a broad range of cell, tissue, and animal models that underpin the development of human countermeasures.

- Congress should direct NASA to give the NIH-NASA Memorandum of Understanding a high priority by providing a strategic and funding plan for implementation.

NASA must also reinstate a robust ground-based and spaceflight fundamental biology program that will build U.S. understanding of the effects of spaceflight on biological systems, particularly in view of President Bush’s ambitious objectives for NASA, all of which involve extended human space travel including completion of the International Space Station, an extended human expedition to the Moon, and human travel to Mars.

- We recommend that Congress increase funding to for Life Sciences Research (Ground Research, Ground Facilities, and Flight Research) to $39.65 million.
**MEDICAL AND PROSTHETICS RESEARCH PROGRAM**

The Department of Veterans Affairs (VA) research program is the only federal program that focuses on discovery in diseases and conditions that affect our veteran population. Fundamental research is critical to the VA clinical mission. The VA research program is exclusively intramural, with awards restricted to only VA employees. This framework provides VA with an extremely powerful tool for recruiting and retaining the highly qualified clinician-investigators who provide quality care to veterans, focus their research on conditions prevalent in the veteran population, and educate future clinicians to care for veterans. The Veterans Affairs’ Medical Centers (VAMCs) excel at providing expert medical care for veterans, particularly those whose medical problems develop in the line of duty. VA medical research program funding makes important contributions to patient care, especially the care of veterans suffering from the physical and psychological traumas of military service, and attracts the highest caliber physicians to the VA medical system.

Unfortunately, chronic under-funding of VA research has placed these accomplishments in jeopardy. The number of patients actively cared for by the VA continues to grow. The VA is projected to care for 5.8 million veterans in FY 2008. Between FY 1995 and FY 2006 (the most current service data) the number of patients actively cared for by the VA increased 117% (Figure 1).

Adjusted for inflation, the VA’s medical research budget is now less than what it was in 1985 and has been cut during each of the past four years. As a result, research grants for VA physician-scientists have become smaller, shorter in duration, and more

![Figure 1. Number of patients cared for by VA, FY 1995 - 2008](image)

*Patient estimates

The number of veteran patients actively cared for by VA has more than doubled since 1995.

Department of Veterans Affairs (VA)
difficult to obtain. Little money is available to recruit and support the next generation of VA researchers. Despite an influx of hundreds of new veterans with traumatic brain injuries, post-traumatic stress disorder (PTSD), and amputations as well as tens of thousands of veterans with stress-related illnesses, the VA’s medical research appropriation per patient decreased from approximately $100 in 1995 to $52 in 2006 (Figure 2). This is wasting the tremendous potential to improve medical care by following basic research leads and translating them into improved therapies. Although considerable investment in research infrastructure is required to support cutting edge research, funding for VA research infrastructure is so low that, at present funding levels, it would take 75 to 100 years to replace or appropriately renovate the VA’s existing research facilities.1

The FY 2008 President’s budget ($411 million) continues this trend. However, the $480 million in the FY2008 appropriations bill agreed to by the House and Senate would begin to restore the resources the VA needs to sustain capacity and build upon research opportunities.

**While VA research remains a highly productive program, the consequences of under-funding are becoming critical.** The decreased likelihood of grant funding means that VA physician-scientists spend less time performing research that could improve patient care. Frustration with facilities and funding drives even established VA physician-scientists to abandon the VA for academia, industry, and private practice, and young physicians often forego research training and association with the VA.

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**Figure 2. VA research appropriation per VA patient, FY 1995 - 2008 (in constant 1995 dollars)**

![Graph showing VA research appropriation per VA patient, FY 1995 - 2008](image)

* Patient estimates
** Adjusted for Biomedical Research and Development Price Index; constant 1995 dollars

* Increasing numbers of veteran patients cared for by VA each year coupled with stagnant Congressional appropriations for the VA research program means that funding per VA patient has declined by almost half since 1995.

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1 Data provided by Timothy O’Leary, Director of VA Biomedical Laboratory Research and Development
to pursue other federal and academic careers. Without the best and brightest to train them, the education of the next generation of physicians will be compromised. Ultimately, VA patients may not have ready access to the expert care they need.

**Research Accomplishments and the Need for Additional Research**

VA researchers have made extraordinary contributions in research in the areas that are important to the health of veterans. In addition to its invaluable contributions in basic and clinical research, the VA also makes unique contributions to health care delivery through its study of outcomes of treatment and diagnostic procedures. Furthermore, the VA is a leader in the technological infrastructure that is enabling cutting-edge research in areas such as genomics. Following are highlights of recent research accomplishments and opportunities for further advancement.

**Brain and spinal cord injury, amputation, and prosthetics:** Researchers supported by the VA have recently demonstrated that infusion of bone marrow stem cells can protect against brain trauma, a common injury found among veterans returning from combat. Amputees are also benefiting from VA-sponsored research: the ongoing development of an ankle-foot prosthesis and a flexible prosthetic wrist will promote greater mobility and more lifelike interaction with objects. Moreover, scientists have identified the molecular basis and approach for reducing the phantom limb pain felt by amputees.

The need for additional research

- Improved diagnoses and treatment of PTSD and other mental health disorders for current and future veterans will require research on prevention, physiological mechanisms, and genetic and environmental stressors that could lead to the development of improved drug therapies

**Infectious diseases:** VA research is making great strides in preventing and treating infectious illnesses relevant to veterans. Research sponsored by the VA has provided a new target for vaccine development by demonstrating that hepatitis C virus uses the low density lipoprotein receptor to infect cells. Moreover, VA researchers discovered that people with a below-average number of copies of an immune-response gene have a greater chance of acquiring HIV and progression to AIDS, a critical discovery for protecting those at high-risk. Making progress towards protecting military personnel against infectious agents VA scientists demonstrated that low doses of smallpox vaccine reduced vaccine-associate morbidity without decreasing its effectiveness. This means that soldiers and veterans can receive protection against the disease, without worrying about potentially fatal side effects of the vaccine, findings that may translate to other infectious diseases, as well.

**Mental health:** More than one-third of veterans report at least one mental health care diagnosis. Depression is the most common, followed by post-traumatic stress disorder (PTSD), and other anxiety disorders. VA research contributed to establishing new treatment for PTSD by revealing the mechanisms involved in nerve transmission and brain circuitry when stressed or threatened and found that prazosin, an inexpensive generic drug for blood pressure and prostate problems, reduces nightmares for veterans with PTSD. Furthermore, VA researchers discovered a protein in the blood that may identify those at risk for developing Alzheimer’s disease, a serious concern in our rapidly aging veteran population.

The need for additional research

- Improved diagnoses and treatment of PTSD and other mental health disorders for current and future veterans will require research on prevention, physiological mechanisms, and genetic and environmental stressors that could lead to the development of improved drug therapies
The need for additional research

- Hepatitis C is a chronic virus that infects 5-10% of VA patients, and the optimal way to treat this disease is to prevent it with a vaccine. Support is needed for vaccine development in order to take advantage of discoveries by VA investigators of important vaccine targets. The hepatitis B vaccine has reduced new cases of hepatitis B by over 90% in the U.S., and a hepatitis C vaccine could have a similar impact.

- VA is the largest single provider for HIV care in the U.S., and further research is needed in order to improve prevention and treatment of the disease.

**Chronic obstructive pulmonary disease (COPD) and lung cancer:** COPD is a disease that affects one-fifth of VA patients. Lung cancer is the leading cause of cancer death for both veterans and non-veterans in the U.S. VA researchers have elucidated the physiological responses of smoking (most common cause of COPD and lung cancer) and tobacco addiction, leading to the development of the nicotine replacement patch. VA-sponsored research has also identified COPD-associated bacteria and appropriate antibiotic treatment, while researchers at the Harry S. Truman Veterans Hospital are investigating the role of inhaled toxic nanoparticles in pulmonary complications in Gulf War veterans.

The need for additional research

- Research is vital to developing animal models of COPD that would allow researchers to better understand COPD pathophysiology and identify novel drugs to block damaging lung inflammation.

- Greater knowledge of genetic variation and gene expression are required to identify patients who are most likely to develop COPD and are most likely to respond to specific therapies.

**Alcohol and drug addiction:** Alcohol and drug addictions are more common in veterans than the general population. This is why VA researchers took the lead in conducting animal studies that provided the rationale for the first clinical trials of an opioid receptor blocker, naltrexone, in the treatment of alcoholism. This drug is now FDA approved and used throughout the world. Scientists supported by VA also identified a gene that predisposes carriers to severe problems with alcohol withdrawal, which is important knowledge in treating alcoholism. In addition, at the James A. Haley VA Medical Center in Tampa, FL, VA researchers utilize the latest technological devices for genetic research and protein analysis to study all 30,000 genes and their proteins to identify “markers” of drug use, genetic factors that dispose people to addiction, and on finding ways to disrupt the biochemical reactions involved in addiction.

The need for additional research

- Additional studies are required to determine the molecular mechanisms that are involved in alcohol and drug addiction, test new candidate drugs for treatment of these disorders, and identify patients who will or will not respond to treatment.

**Osteoporosis:** Hip and spine fractures are an increasingly important problem for our aging veteran population and stress fractures are of growing significance in new recruits. The VA research program played a role in developing new anabolic agents to restore lost bone and bone strength, as well as helping to show that statins, drugs used to lower cholesterol, decrease fracture risk. VA researchers also demonstrated that hydrostatic pressure on cartilage cells could stimulate the formation of collagen, which may be important in reversing the effects of osteoporosis.

The need for additional research

- Better drugs are needed to promote new bone formation and block bone resorption.

- In order to move towards effective therapies, we need to understand the causes of osteoporosis, including the bone loss accompanying disuse, alcoholism, drug abuse, and aging, through the use of novel genetic and animal approaches.
Heart disease, hypertension, and stroke:
Hypertension is one of the most prevalent medical problems in the U.S. and in the VA health care system. Moreover, heart failure is the most common diagnosis causing veteran hospitalizations while more than 15,000 veterans each year are hospitalized for stroke. Researchers funded by VA helped determine blood pressure levels at which treatment becomes required and developed Guidelines for Drug Therapy of Hypertension. Moreover, VA researchers have also observed that umbilical cord stem cells could significantly reduce the effects of heart attacks in rats and identified a class of antioxidants, which enhanced cardiovascular regulation and function in mice with high cholesterol, that may help treat hypertension in patients.

The need for additional research
- Research could lead to better understanding of the underlying pathophysiology of hypertension, its link to the metabolic syndrome, and the deterioration of kidney function. It will be crucial to determine the optimal target blood pressure for patients who have hypertension and early heart, kidney, and cerebrovascular disease.

- More research is necessary to identify the genes that make patients with hypertension likely to develop heart disease, kidney disease, and strokes and to identify the genes that determine whether patients with hypertension respond to or resist treatment with specific types of antihypertensive medication.

Diabetes:
One-fourth of veterans receiving primary care in the VA have diabetes. Complications of diabetes (including coronary artery disease, foot infections, kidney failure, and blindness) result in extraordinarily high costs for medical care. Fortunately, VA researchers demonstrated that linezolid, a new antibiotic, effectively treats diabetic foot infections, a leading cause of amputations. In addition, a group of VA researchers have identified seven genes that are associated with risk of diabetes, which may serve as important diagnostic tool, as well as providing targets for therapies and interventions. With co-funding from the Juvenile Diabetes Foundation International, the VA has created several diabetes research centers where researchers aim to identify causes of insulin resistance and vascular and renal complications of diabetes, design new therapies, and study the processes by which intensive therapy reduces insulin resistance, and the role of exercise in improving treatment.

The need for additional research
- Fundamental research into the cause of type 2 diabetes is needed to develop interventions that prevent or treat the disease.

FASEB Federal Funding Recommendation
FASEB recommends funding the VA Medical and Prosthetics Research Program at the $555 million level in FY 2009. Outstanding quality patient care in VAMCs can be directly correlated with the availability of VA research funding and the close relationships with affiliated medical schools. Therefore, it is essential to maintain the VA’s investment in medical research to provide the best care for current and future veterans.

As a first step to address the deterioration resulting from years of neglect, a minimum of $45 million for renovation, major equipment, and new research buildings is required. Furthermore, a mechanism needs to be established to provide the VA research enterprise with specific, long-term infrastructure funding. The current use allowance for research facilities is calculated using a 50-year lifetime. FASEB recommends infrastructure funding at the level required to renovate and replace the VA research infrastructure at least every 50 years rather than the current rate of once every 75 to 100 years.

Our soldiers deserve the best medical care possible. Increasing research and infrastructure funding to at least the recommended levels is necessary to improve the quality of care provided.

2 OMB Circular A-21 J.12.c(1)
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