AN ECONOMIC ENGINE

NIH Research, Employment, and the Future of the Medical Innovation Sector

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United for Medical Research

Executive Summary

Spending by the National Institutes of Health has consistently generated substantial economic benefits over long periods of time. Academic research and industry partners have long noted the strong, symbiotic relationship between NIH basic research funding and subsequent investment and innovation in the private economy.

But the economic benefit of NIH is more widespread. **First, NIH extramural research is an important source of income and employment around the country.** Over eighty percent of NIH funding supports research in each of the fifty states and the District of Columbia. Using the Regional Input-Output Modeling System (RIMS II) developed by the Department of Commerce, 2010 NIH research funding led to the creation of 484,939 jobs. Fifteen states experienced job growth of 10,000 or more due to this support. And while the costs of federal deficits must be considered when quantifying the jobs impact of any spending, analyses show that NIH funding has consistently generated positive returns that are strongly complementary with private investment, rather than an obstacle to it.

Second, the innovation and economic expansion that NIH supports goes beyond the immediate complementarities between NIH discoveries and their relevance to the life sciences industry. The knowledge created by NIH is embodied not just in new drugs, but in a wide range of goods and equipment, from cardiac stents that resist clotting to machines that assist in gene sequencing. Moreover, NIH's work leads to new tests and other laboratory procedures that show up not as pharmaceutical production, but as service output and employment, much as NIH research laid the basis, for example, of blood testing for substances. New drugs do not constitute the final outcome of NIH-generated knowledge. Rather, they are the center of a series of concentric circles that include new equipment, new procedures, and new treatments. This wider effect for the "medical innovation sector" — ranging from pharmaceutical and medicine manufacturing to medical equipment manufacturing to research and development laboratories in biotechnology — provided wages of over $84 billion in 2008.

Third, this medical innovation sector is increasingly under challenge. All of the industries and activities involved in health and the life sciences are now part of an ever more competitive global marketplace. This trend can be seen in a number of important indicators. Foreign medical schools and research institutions, benefiting from increased national investment, are steadily rising to the challenge of U.S. leadership. More medical services can be supplied by foreign providers, from telemedicine to "medical tourism" (the rapidly-growing practice of traveling across international borders to obtain health care). And the challenge is growing. Genetic sequencing, for example, is a new area where the U.S. played the internationally leading role in developing the technology as a result of strong NIH support. The knowledge created by that long-term investment led to new medicines, new treatments, and new equipment. But China now plans on buying enough of this equipment so as to leave it with one-third of the world's gene-sequencing capacity in the near future, a shift that would have implications for future innovation in that sector.

From the health of the U.S. population to the strength of the U.S. economy and its ability to consistently lead the globe in biomedical innovation, investment in NIH has been, and will remain, an important factor in driving U.S. success.

NIH investment in 2010

- Led to the creation of **484,939** quality jobs
- Produced **$69.190 billion** in new economic activity across the country
- Allowed 15 states to experience job growth of **10,000** jobs or more

The NIH is...

27 institutes and centers

funding nearly **6,000** in-house scientists,

50,000 annual external grants,

and **325,000** extramural researchers

at over **3,000** universities, medical schools,

and other research institutions, spurring countless more jobs in

every state and around the world,

which all adds up to

...an economic engine.*

* http://www.nih.gov/about/budget.htm

Overview

The National Institutes of Health (NIH) is the largest funder of public sector health research in the U.S., and the world's largest biomedical research funder. Longstanding support for NIH's role comes from a widespread understanding across industry and government that private research alone will not perform the economically rational amount of such work. This is because private researchers cannot appropriate the benefits such research generates, particularly at the early, basic stages of the research process (e.g., understanding the way diseases develop or are transmitted). Thus, the federal government, primarily through NIH, emphasizes basic research in life sciences and, therefore, sets the stage for the industry-led applied research and development that leads to new medicines and treatments. As the Congressional Budget Office recently found, "federal funding of basic research directly stimulates the drug industry's spending…by making scientific discoveries that expand the industry's opportunities for research and development."[1]

In fact, this conclusion has been reached by a broad spectrum of industry, academic, and government researchers. Moreover, this focus — exclusively on the pharmaceutical industry, is far too limiting. NIH research leads not only to new medicines, but to new tests and procedures (for example, blood tests for substances), new procedures (improved cardiac stents that substitute for surgery), and new equipment (gene sequencers). It is at the center of a series of ever-expanding activity that employs almost a million Americans each year.

This analysis focuses on the economic effects of federal support for research. In fiscal year 2010, NIH spent $26.6 billion for research awards, $21.96 billion of which came from the annual appropriations process, and an added $4.6 billion from the American Recovery and Reinvestment Act (ARRA).

In the short term, this research support creates new economic activity and employment throughout the country. There is substantial evidence, discussed below, that NIH research has historically been a productive investment that expands the economy's capacity to produce goods and services in the future. In the longer term, NIH funding is critical to keeping the U.S. "medical innovation" sector — not just pharmaceuticals, but specialized equipment and treatment providers — competitive in an increasingly challenging global marketplace.

Recent NIH Budget History

More than 80% of NIH's total annual budget directly funds extramural research that is performed outside of the NIH campus at non-governmental facilities across the country. This research is done by 325,000 scientists at more than 3,000 institutions in all fifty states and the District of Columbia. NIH awards extramural research grants after a thorough review of the scientific merit of submissions from universities and other research centers. These grant applications must pass the scrutiny of a two-pronged review that solicits the opinion of both non-federal scientists who have specific expertise relevant to the application and scientific and lay reviewers who have a more general background in matters related to health and disease.

Federally appropriated NIH funding — for extramural research, in-house research, and administration — has enjoyed the support of administrations of all political persuasions. The NIH budget rose to $27.9 billion by 2004 and reached $29.5 billion in 2008. It was supplemented by ARRA in both 2009 and 2010. The Continuing Appropriations Act of 2011 set its appropriation at $30.6 billion, which cuts funding from 2010 levels.[2]

When corrected for inflation (using the biomedical research and development price index calculated by the Bureau of Economic Analysis, an agency of the Department of Commerce), however, total NIH research support peaked in 2003 and declined by about 12 percent over the next five years. Research awards (excluding ARRA funds) to the 50 states, the District of Columbia and four territories of the U.S. grew by a sizable 57 percent from 2000 to 2005, or about 38 percent after inflation, and remained constant thereafter until the passage of ARRA. But inflation-adjusted NIH awards (excluding ARRA funds) fell by 5 percent from 2005 ($23.120 billion) to 2010 ($22.023 billion), or by 21 percent when corrected for inflation (which leaves 2010 non-ARRA appropriations equal to $18.307 billion in 2005 dollars). When ARRA is included, research awards are roughly equal in 2010 to what they were in 2004.

The Contribution of NIH Expenditures to STATE ECONOMIC ACTIVITY AND EMPLOYMENT

The policy objective of NIH research support has always been improving public health outcomes — leading to better medicines, procedures, treatments, equipment, and delivery systems to prevent and cure disease. But NIH expenditures also convey important economic impacts over two different time horizons. In the short term, NIH is a source of widely dispersed research funding that creates jobs and income throughout the economy. Relatively little NIH research funding occurs at its Bethesda, Maryland main campus — most (over eighty percent) is either distributed through extramural research grants or used at NIH's various research centers around the country. The long-term economic effect relates to the competitiveness of the medical innovation sector, and is discussed later in this report.

In fiscal year 2010, NIH awarded a total of $26.6 billion to universities and other research institutions in the 50 states and the District of Columbia. Table 1 (p. 12) provides data on this research support, listed by the state of the primary recipient organization (e.g., a university or other research facility). This total comprises $22 billion via the regular budget process, and an additional $4.6 billion via ARRA.

The value of NIH state awards in FY2010, via its regular budget, ranged from $3.3 billion in California and $2.4 billion in Massachusetts to $8.3 million in Idaho and $7.8 million in Wyoming (see table 1). Six states received more than $1 billion in research monies via the regular NIH budget — California, Massachusetts, New York, Pennsylvania, Texas, and Maryland. FY2010 awards were supplemented by an additional $4.6 billion via ARRA, including $0.69 billion in California and $0.49 billion in Massachusetts.

This research support, of course, has a variety of economic effects. Researchers pay salaries to highly-skilled professional staff and support staff who administer and maintain the research facility, provide care to laboratory animals, and other such tasks. To accomplish the goals of their research, scientists must also purchase related equipment, services, and materials. The income these expenditures generate, in turn, is cycled through the economy. This analysis estimates that NIH research funding, in total, produced $69.190 billion in new economic activity, of which $58.035 billion resulted from the annual FY2010 budget and $11.155 billion from ARRA. California experienced the largest gain in economic activity among the 50 states and the District of Columbia, with a gain of $11.1 billion, followed by Massachusetts ($6.7 billion), New York ($5.9 billion), Pennsylvania ($4.4 billion) and Texas ($4.1 billion).

Table 2 (p. 13) summarizes the output and employment effects of 2010 NIH extramural research funding by state. The methodology used to calculate these estimates is presented in the Appendix (p. 11).

This economic activity supported an estimated 484,939 jobs across the 50 states plus the District of Columbia. NIH's overall research support from its regular FY2010 budget supported an estimated 404,700 jobs, while ARRA funds supported an additional 80,239 jobs.

The number of jobs supported by NIH extramural research funding during FY2010 was greatest in California, with 71,734 jobs supported by NIH funding. NIH funding also supported 40,415 jobs in Massachusetts, 39,210 in New York, 31,072 in Texas, and 28,120 in Pennsylvania. In addition, NIH funding supported more than 10,000 jobs in each of the following states: Florida, Georgia, Illinois, Maryland, Michigan, Minnesota, North Carolina, Ohio, Tennessee, and Washington.

NIH INVESTMENT
at a Time of Fiscal Deficits

While NIH funding creates economic activity and employment around the country, it occurs at a time when the nation is confronted by fiscal deficits and growing public debt. Widespread concern over these deficits has focused on their inevitable economic cost — specifically, the concern that deficits would lead to "crowding out" private investment. Therefore, any estimate of output and employment created by government spending is naïve unless it accounts for the risks posed by this "deficit feedback" effect. But there is a compelling argument that NIH funding will trigger this effect far less than many other forms of federal spending, if not avoid it altogether. That is because NIH, by funding the basic research that maintains the knowledge base supporting innovation in the medical industries, has itself more of the character of investment than simple spending. NIH research provides the foundation for much of the private sector's research and development, leading to new medicines, equipment, and treatments. This means that NIH support for research has a positive rate of return. Rather than crowding out private investment, it leads to more of it, the reverse of the pattern we associate with public sector spending.

As a study by the Joint Economic Committee found in 2000:

> **Federal research and private research in medicine are complementary. As medical knowledge grows, federal research and private research are becoming more intertwined, building the networks of knowledge that are important for generating new discoveries and applications.[3]**

Thus, rather than crowding out private investment, the JEC concluded that NIH research support induced more private investment. The role of NIH-funded research in leading to these subsequent investments and innovations is well documented over many decades. The NIH research portfolio expands the life sciences knowledge base, which in turn creates opportunities for private research to build on this base — akin to passing a relay race baton from NIH-funded research findings to the commercial research agenda of pharmaceutical companies and other private entities. The JEC study cited findings that, of 32 innovative drugs introduced before 1990, 60 percent would not have been discovered or been markedly delayed, absent NIH support.[4]

A subsequent analysis found that 15 of 21 important drugs studied were developed with input from the public sector.[5] NIH work has supported outcomes as wide-ranging as the initial attempts at genetic sequencing and subsequent improvements in cost by orders of magnitude, to the development of anti-AIDS drugs, to the discovery of neurotransmitters (that led to the development of selective serotonin-reuptake inhibitors, or SSRIs, breakthrough drugs for the treatment of depression), to research resulting in treatments which reduce scar tissue formation around surgical stents and allow them to be substituted for more expensive coronary artery surgeries.[6]

A study by the National Bureau of Economic Research concluded that, in contrast to the pattern of public spending crowding out or displacing private activity in the economy, **a dollar of NIH support for research leads to an increase of private medical research of roughly 32 cents.[7]** A study by Dr. Robert Kneller, a professor at the University of Tokyo's Research Center for Advanced Science and Technology (RCAST), provided added context on the complementarity between NIH support and private medical research. It found that the universities supported by NIH play a more specialized and advanced role in the overall process of medical innovation. Using data from the results of the FDA's pharmaceutical approval process, Kneller showed that NIH-funded entities generally produce new pharmaceutical discoveries that are more advanced, more likely to be considered "novel," (as opposed to advances that are based on the existence of a pre-existing substance that is modified and resubmitted for approval), and more likely to be "orphan drugs," the substances that address rare diseases or conditions.

In fact, Kneller also found that research entities sponsored by NIH played the same role of producing discoveries regarded in the drug approval process as more "advanced," "novel," and related to "orphan diseases" *outside* the United States as well, demonstrating NIH's importance to the pharmaceutical industry's global competitiveness.[8] A similar investigation conducted by Professor A. A. Toole of Rutgers University concluded that the innovation spurred by NIH basic research produces an ongoing 43 percent stream of benefits, a remarkable return on investment.[9]

The complementary relationship between public and private sector is illustrated by the efforts of NIH and Celera, a private firm, to map the human genome in the late 1990s and early 2000s. NIH's effort was aimed at avoiding delay in placing the sequenced human genome in the public domain, where it would serve as a template for an entire new class of research and discovery. By achieving this objective, NIH fostered a more vigorous and competitive American private sector presence in developing new products based on knowledge of genetic sequencing. Triggered by NIH's work, the cost of sequencing a genome has fallen from over $100 million dollars at the beginning of the last decade to about $20,000 today.[10] Analysts project that the sequencing business will grow by 20 percent a year and become a $1.7 billion industry by 2015.[11]

The box on page 7 details the role of NIH funding in creating an entire new class of pharmaceuticals, diagnostic tests, cutting-edge procedures, and capital equipment — that of monoclonal antibodies.

Thus, NIH funding conveys output and employment benefits more enduring than those motivated by short-term spending — it is a critical source of support for the pharmaceutical, medical equipment, and bio-technology industries. It has the character of private investment, both in terms of its own returns and the actual private investment it motivates. Despite the justifiable caution surrounding federal spending at a time of sizable deficits and mounting debts, there is ample reason to believe that NIH support serves to expand the economy in the manner of any productive investment, and by so doing, leaves the economy *more* able to meet its future obligations, not less.

Case Studies: NIH Research Fueling Private Industry Across the Country

California*

Syntouch is developing a novel, robust tactile sensor array that mimics the mechanical properties and distributed touch receptors of the human fingertip. Initial applications being developed include tactile sensors for prosthetic hands. Syntouch was founded on the basis of research conducted at the University of Southern California (USC), with funding from the National Institute of Child Health and Human Development at NIH.

Pioneering work by researchers at the University of Alabama led to the development of Aegis Therapeutics in 2004 in San Diego, CA. Initially funded by NIH, this drug-delivery technology decreases costs and increases effectiveness by allowing previously "injectable-only" drugs to work effectively when delivered through the mouth, nose, or GI tract. For patients who will not or cannot endure injections, this could become a life-saving treatment.

New Jersey

PTC is a biopharmaceutical company that applies its expertise in RNA biology and drug development to pioneer novel oral treatments for patients living with serious and life-threatening conditions. PTC's internally discovered pipeline addresses multiple therapeutic areas, including rare genetic disorders, oncology, and infectious diseases. PTC has developed its pipeline through a variety of funding sources including traditional venture capital, and collaborations. Most notably, PTC has raised over $100 million in funding through grants from advocacy groups, foundations, and government agencies such as the National Institutes of Health, the Department of Defense, and Defense Threat Reduction Agency.

Alabama

Fueled by NIH grant awards from the American Recovery and Reinvestment Act and from the Small Business Innovation Research (SBIR) program, services revenue, and investment capital, DiscoveryBioMed, Inc. (DBM) specializes in human-cell culture and engineering and human-cell-based drug discovery to add value, biological relevance, and disease relevance to the drug discovery and development critical path. DBM has also identified lead therapeutic compounds for respiratory, metabolic, inflammatory, and hyperproliferative diseases. DBM is in its fourth year of operation in Birmingham, Alabama, operating in the life sciences and biotechnology space.

Virginia

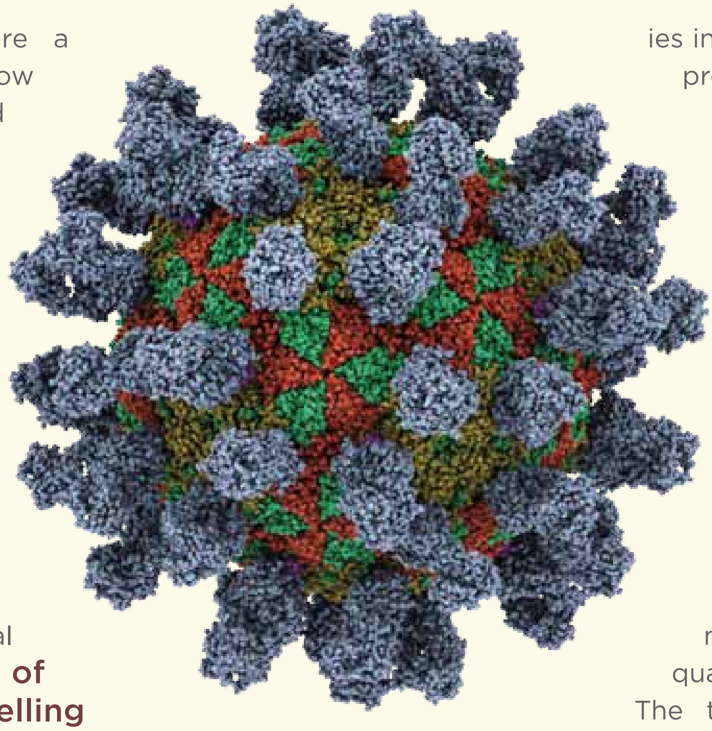
Phthisis Diagnostics, a biotechnology company based in Virginia, is developing a range of easy-to-use, cost-effective products to facilitate clinical adoption of modern, accurate diagnostics to improve DNA extraction, molecular diagnostics, and laboratory quality control. Phthisis has received two NIH Phase 1 STTR and one NIH Phase 2 STTR grants with the University of Virginia. Phthisis has also received one NIH Phase 1 SBIR grant and will apply for an NIH Phase 2 SBIR grant in 2011.

West Virginia

West Virginia-based Protea Biosciences, Inc, was founded on technologies that came from NIH-funded protein research in 2001. This technology has made it possible to improve the quality, reproducibility, and speed of processing protein samples: a new method of discovering novel protein targets to help develop new pharmaceuticals and improved ways to manage disease.

** For more information on California companies in the bioscience space, please see the joint report from the California Healthcare Institute, BayBio, and PricewaterhouseCoopers, entitled, "California Biomedical Industry: 2011 Report."*

MONOCLONAL ANTIBODIES



Monoclonal antibodies are a powerful example of how medical discoveries funded by NIH not only generate new knowledge, but also lead to the invention and production of new capital equipment, new tests, procedures, and treatments. There are currently more than twenty monoclonal antibody therapies approved by the FDA, with hundreds of others currently being tested in clinical trials.[a] **In 2010, five out of the top twenty bestselling drugs were monoclonal therapies, including Remicade, Humira, Avastin, Rituxan and Herceptin.[b]** Monoclonal antibodies are also one of the most commonly used tools in research and diagnostic testing. Worldwide, the monoclonal antibodies market generated revenues of $35 billion.[c]

The basic biology courses taught to most high school students outline the history of immunology, from Edward Jenner's discovery of a smallpox vaccine made from the related disease cowpox to Paul Ehrlich's discovery that the body produces antibodies in response to disease. Antibodies are proteins produced by the white blood cells in our immune systems, called B-cells. Antibodies provide specificity to the immune system by latching on to very specific targets, also called antigens, or invaders in the blood stream, such as the viruses and bacteria that cause disease. It is in this way that the immune system "recognizes" an infection and uses antibodies to effectively neutralize the cause of the disease. This response can also be triggered by a vaccine. The presence of antibodies in the blood is what provides protection from childhood diseases such as measles or chickenpox.

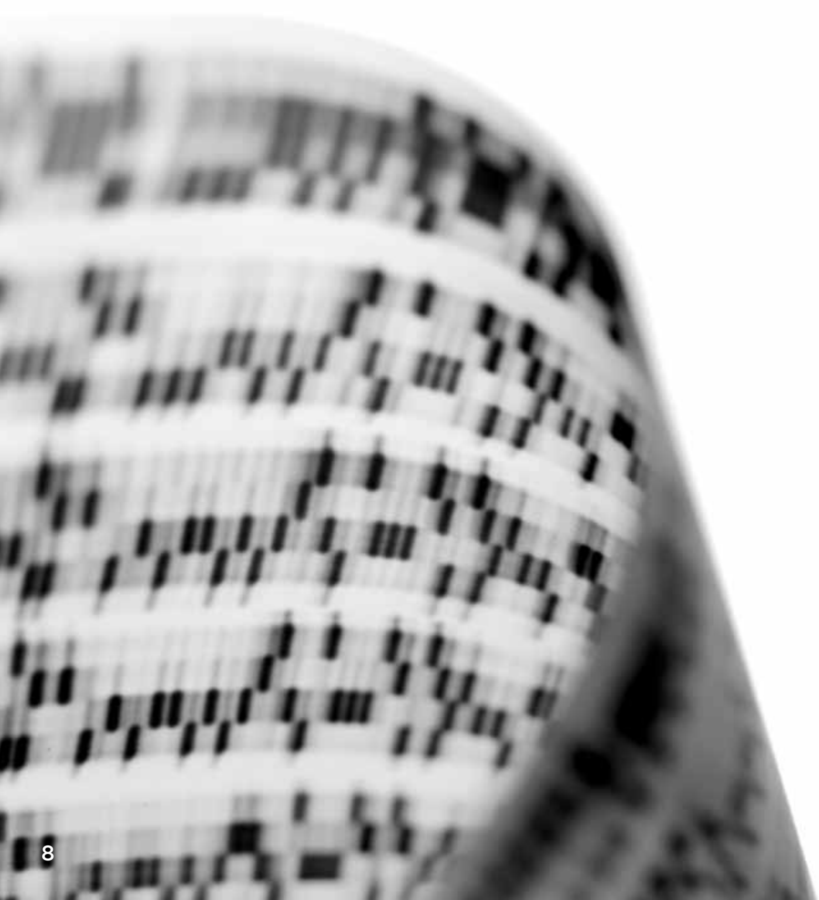
Monoclonal antibodies are produced when an antibody-producing B-cell is fused with a cancer cell, creating an immortal line of cells that can produce a single form of antibody. These fused cells, or hybridomas, essentially become factories for mass producing a very pure quantity of a specific antibody. The technique used to create monoclonal antibodies was awarded a Nobel Prize in 1984 and is largely credited to the work of Georges Kohler and Cesar Milstein. The mouse tumor cell line which was critical for the invention of the hybridoma technique was developed by NIH.[d] Since then, NIH-funded research has played an enormous role in transforming this promising technique into life-saving diagnostic therapies and diagnostics, working with industry partners to test and refine promising new monoclonal antibodies against a wide range of diseases. In fact, the most recently approved monoclonal antibody, called Ipilimumab, is a first-in-class therapy and a major breakthrough treatment for advanced melanoma.[e] Further, NIH-funded researchers recently developed a faster technique for monoclonal antibody production, shortening the time it takes to produce these extraordinary molecules from months to a few weeks.[f]

Monoclonal antibodies are one of the basic building blocks of medicine today and will continue to be in the future. **They are, at their root, a product of NIH funding.**

a. http://www.actip.org/pages/library/Table_Monoclonal_Antibodies.pdf
b. http://knol.google.com/k/krishan-maggon/top-ten-twenty-best-selling-drugs-2010/3fy5eowy8suq3/141#
c. RNCOS. (2010) Global Monoclonal Antibody Market Analysis. http://www.rncos.com/Report/IM279.htm
d. http://history.nih.gov/about/timelines_research_advances.html#1950s
e. http://www.medscape.com/viewarticle/739604
f. http://history.nih.gov/about/timelines_research_advances.html

NIH RESEARCH FUNDING
and the Long-Term Future of the Medical Innovation Sector

Consider the recent advances in genome sequencing: NIH has played a central role from the inception of the human genome project in 1990, to the first successful mapping of the human genome in 2003, to the ongoing discovery of new genetic causes of diseases. But China is now on the verge of becoming the world leader in genome sequencing. Its Beijing Genomics Institute, or BGI, which in 2003 first produced the genome of the virus that caused severe acute respiratory syndrome (SARS) and a resulting diagnostic tool, is now focused on mass-producing cheap, accurate genomic sequences that will lead to more genetically based diagnostic tests and medicines. Its recent purchase of 128 cutting-edge genome sequencers would give it the world's largest, next-generation sequencing capacity — more than the sequencing capacity of the entire U.S. — and the ability to produce human genome sequences for about $10,000 apiece. Their capacity will represent about a third of anticipated global capacity at the end of this year.



China's foray into genome sequencing is an example of a broader trend. **While the U.S. has been the world's leader in medical research, we face a variety of challenges as other nations race into the areas in which the U.S. scientific enterprise, often funded by NIH, has created new fields of medical innovation.** This will have repercussions for the medical innovation sector — the group of industries that innovate and compete by leveraging NIH research and the resulting knowledge base. These include not only pharmaceutical and medicine producers, but also research — and medical — equipment producers (such as the genome sequencers mentioned above), and other firms that perform research and development in biotechnology. All of these are related to the knowledge base triggered by NIH research grants, and NIH plays a key role in the training of their skilled personnel through graduate and post-graduate support.

Table 3 (p. 14) presents employment and wages for the medical innovation sector. Most broadly cast, this group of industries employs almost a million people and pays total wages of $84 billion, as of 2008. Moreover, these industries exported $90 billion of goods and services in 2010. Not all of these industries embody the latest technology themselves, but they all depend on the ability of the U.S. to invent new medicines, treatments, tests, and equipment. That is, they all ultimately rest on the fundamental discoveries funded by NIH.

Earlier in this report, various examples of the fruits of NIH sponsored research were cited — genomic sequencing, neurotransmitters, monoclonal antibodies, cardiovascular treatment, and the like. This knowledge filters through the medical industries, strengthening U.S. research and testing laboratories, pharmaceutical producers, equipment manufacturers, and, ultimately, practitioners and caregivers. But this knowledge base must be continually renewed and refreshed, because once it is created, it can be imitated.

That imitation is a standard part of how economists understand the process of trade. As first postulated by the economist Raymond Vernon in 1965, the "product life cycle" view of trade theorizes that advanced nations invent newer, more technologically advanced goods and services that are, together with the products that embody them, exported by those countries. But as these technologies become more widely available and are perfected and stabilized, their production will migrate to other parts of the world, where the advantages of cost and the ability to imitate innovations made elsewhere are more important. This pattern can be seen in a variety of industries, from semiconductors to aircraft to electronics.

And this trade pattern is already visible in some aspects of the medical industries. At the simplest level, "nighthawk" services now provide such medical basics as standard radiological diagnoses from places such as India and Israel; medical tourism facilities in Thailand treat 400,000 patients a year. But the pattern extends beyond these aspects of treatment. A recent *London Times* survey of the world's "best" 50 universities for life sciences placed 22 of them in the United States; but the remaining leading universities were located in countries such as Britain, Australia, New Zealand, Continental Europe, Canada, China, South Korea, Hong Kong, and Singapore. This reflects the changing distribution of research capabilities around the world.

This quandary is exacerbated by rising levels of income around the globe. As emerging economic powers increase their income levels, their populations will demand more medical and health-related services. This will strengthen their ability to carry a larger medical infrastructure of medical schools, research laboratories, pharmaceutical and medical equipment companies, and in some cases, state-sponsored research. This will leave these countries better able to not only serve their own markets, but to compete internationally.

The best response to this challenge is to continue to compete through innovation. Ultimately, to compete on the basis of price with providers, researchers, or manufacturers from India or China is to move toward their lower standard of living. **But staying ahead of these competitors through continued innovation allows the U.S. to maintain its position of leadership in the various medical innovation industries.**

NIH funding lies at the center of such an effort. It is the foundation of our nation's medical industries' response to this competitive challenge. In the short term, it clearly creates economic activity and employment. But in the longer term, it sustains far greater amounts of both output and employment by keeping the medical industries on a path of sustained innovation and global competitiveness.

PREVENTIVE MEDICINE FOR OUR ECONOMY

As the population in high-income nations ages, and as a new group of economies grows and gains discretionary income, the global health care market is likely to expand in the decades ahead. The U.S. has traditionally led that market due to its commanding technological and knowledge assets, in large part attributable to the central role NIH has played in understanding life sciences and the nature of disease. But as the opportunities for growth in that market expand in the years ahead, so will the challenges posed by new competitors, whether they are European medical schools, South Asian telemedicine practitioners, or Chinese genomic laboratories.

While other segments of the economy have slowed significantly in the face of the recent economic downturn, the bioscience industry remained strong and is rebounding at a much faster rate.[12] As a recent industry report from Battelle soberly noted, a declining U.S. research commitment, relative to our GDP, even as other nations commit to a higher investment in research and the life sciences, threatens the competitive landscape and "could make it more difficult for the U.S. to maintain its historic lead in the development and economic leverage of innovation" in diverse sectors of the economy.[13] This is certainly true for the life sciences, where federal support for basic research has been an integral part of American competitive success.

This puts the importance of NIH funding in a new light. Beyond its effects on employment in the short run, the knowledge base this funding creates spreads through the economy by capital equipment, new tests and procedures, new medicines, and other activities. And it allows the U.S. to stay in a position of leadership in an increasingly important — and competitive — global market for medical goods and services.

Simply put, NIH — and the research, jobs, technology, and business surrounding it — is nothing less than the title of this report states: an economic engine.

Endnotes

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Appendix

THE METHODOLOGY USED TO DEVELOP OUTPUT AND EMPLOYMENT ESTIMATES

These estimates were produced using the Regional Input-Output Modeling System, or RIMS II, which is estimated by the Bureau of Economic Analysis of the Department of Commerce. The RIMS II model, as its title explains, is based on an "input-output" (I/O) model of the U.S. economy, a model structured to present the amounts of all the other goods and services that are needed to make a particular type of good — it measures the *inputs* needed to produce a certain *output*. Moreover, the RIMS II model adds households — consumers — as if they were an industry, so that when production creates income, that income is spent using observed historical patterns, which then allows the model to understand what kinds of other production will be required to meet the bill of goods and services households purchase with their added income.

This so-called "requirements table" is then modified for particular regions by using what BEA terms a "location quotient," a measure of the extent to which a region's industries are capable of producing what is demanded within their own boundaries. These location measurements are taken from census surveys of economic activity by establishment. If a state can meet all of this added demand "internally," they are presumed in the model to do so. If they cannot, companies outside the particular state make up the difference — this "trade among the states" is then added into the calculations separately, as described below.

Using this process, the RIMS II model can compute the expected change in economic activity in any state if demand in a particular sector (for example, the scientific research and development industry, which is identified separately in the RIMS II I/O model) rises by a given amount, to the extent the firms in that state are capable of doing so. This coefficient — the ultimate change in state-based economic activity given an initial stimulus — is termed a "state multiplier." Insofar as the state multiplier depends on the ability of the state in question to satisfy new demand within its own boundaries, it is not surprising that the highest state multipliers are found in those states with diverse economic bases drawing from manufacturing, services, agriculture and resources, and other sectors. The highest state multipliers come from this kind of state economy. Texas has the highest state multiplier — a dollar of spending there leads to $2.47 dollars in additional state-level activity. Illinois follows with $2.43, and California with $2.39. At the other end of the distribution, a dollar of new spending in smaller state economies such as Wyoming, South Dakota, and the District of Columbia will lead to additional state-level economic activity of $1.60, $1.51, and $1.38, respectively.

But this procedure only captures the extent to which a state satisfies its own demand for goods and services — it does not capture "trade among the states." On average, about 84 percent of all economic activity in the RIMS II is satisfied in the state in which it originates. But there is no calculation in the RIMS II model of a "national multiplier" that informs us how much total national activity responds — that is, how much economic activity is created when states reach outside their borders to meet their production requirements.

To estimate this value, this analysis calculated a "national multiplier." We began by noting that, using the national input-output tables, the sum of all the transactions needed to produce $1.00 in new value added is about $1.73 *before* we add in the effect of workers spending their new wages. We also noted, by comparing other coefficients within the RIMS II model, that the expenditures needed to produce the actual goods and services required to satisfy most spending in the economy are about twice the level of expenditures created by effects of workers spending their wages. Thus, an all-in, total "national" multiplier should be about 50 percent higher than the sum of all the production requirements to produce that spending. So a good estimate of the national multiplier would be about 1.5 times 1.73, or roughly 2.6. Using another approach, the RIMS II model suggests that all intrastate activity (that which is measured by the RIMS II state multipliers) is about 84 percent, or five-sixths, of total national activity. Since the average state multiplier is 2.18, the national multiplier obtained by this method would also be about 2.6.

We use that value for this analysis. This means that about .42 of the $26.6 billion in NIH spending takes the form of the demand for goods and services in one state that is satisfied by production in another state, or $11.2 billion. The added value of "trade among the states" is apportioned to the 51 entities in proportion to their state Gross Domestic Products. These amounts are then added to the intrastate estimates using the original RIMS II state-level multipliers to obtain a final estimate of economic activity by state.

The RIMS II model will also produce employment multipliers that are based on the nature of the spending in question and the ability of each state to satisfy the demands that spending created. A fixed amount of spending can vary widely in this employment effect, depending on the composition of the state's economy and the average wage levels found in its industries. The fewest jobs created per unit of new NIH research spending occur in the District of Columbia, because new research awards do not change government activity — the vast bulk of NIH spending is sent out to facilities around the country. The jobs calculated using these multipliers are then adjusted for the level of activity in each state that comes from "interstate trade," as discussed above.

Table 1

Value of NIH Extramural Research Awards, Before ARRA ($millions)

State	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Alabama	202.2	244.2	267.3	324.3	322.0	297.0	283.7	273.3	253.3	237.9	242.9
Alaska	3.6	8.6	9.7	10.3	10.8	15.4	8.0	10.8	11.5	10.3	11.3
Arizona	111.2	119.2	137.8	153.2	160.5	176.0	164.0	175.4	161.9	157.7	155.3
Arkansas	38.8	44.6	53.1	51.3	56.2	62.3	61.6	60.6	58.1	65.1	64.7
California	2,235.8	2,516.9	2,899.9	3,385.2	3,598.0	3,628.7	3,622.0	3,680.2	3,944.1	3,213.6	3,332.4
Colorado	241.4	263.0	293.6	322.5	333.5	346.3	318.1	339.4	332.9	313.2	307.6
Connecticut	322.1	345.3	391.4	419.5	441.5	457.4	459.7	480.0	475.9	462.0	475.1
Delaware	14.9	17.4	25.1	28.2	29.2	26.5	30.0	28.9	29.7	30.0	31.8
Dist. of Columbia	170.7	213.6	248.9	227.1	211.8	231.6	203.7	223.9	226.2	185.8	177.5
Florida	225.8	249.6	291.1	318.4	351.0	372.9	340.0	408.1	418.4	364.6	391.0
Georgia	235.7	265.6	312.1	340.5	371.8	374.6	371.8	385.9	409.7	412.9	433.2
Hawaii	36.0	44.9	54.2	57.1	74.3	85.1	60.4	71.2	69.3	52.8	61.5
Idaho	4.2	5.8	11.8	10.7	10.7	11.5	11.6	10.9	10.1	10.7	8.3
Illinois	472.1	513.8	569.7	705.1	687.3	726.9	730.6	769.5	763.1	739.4	732.7
Indiana	142.0	159.4	172.1	185.2	202.1	218.4	212.3	214.5	207.6	216.7	209.7
Iowa	136.4	166.1	181.1	204.4	196.5	193.0	195.5	206.5	212.1	193.4	194.2
Kansas	53.2	66.2	77.2	78.9	75.4	76.8	80.1	88.3	97.1	103.2	104.4
Kentucky	81.9	96.0	110.9	122.4	140.5	165.0	143.0	146.4	151.1	154.3	143.0
Louisiana	78.7	85.8	122.5	158.1	157.2	185.0	169.3	139.7	134.0	126.8	133.3
Maine	44.8	60.5	67.9	71.2	72.9	66.7	68.9	71.7	65.9	66.3	64.5
Maryland	874.2	958.9	1,076.6	1,281.1	1,411.0	1,428.3	1,468.1	1,343.0	1,391.6	1,008.5	1,018.8
Massachusetts	1,553.3	1,719.6	1,889.6	2,221.5	2,293.9	2,289.5	2,299.4	2,329.6	2,338.6	2,331.0	2,447.3
Michigan	390.0	450.2	486.8	543.7	552.4	564.3	560.5	624.1	664.6	593.5	625.3
Minnesota	281.1	325.4	372.4	405.3	446.9	442.3	430.7	471.4	463.8	444.8	475.1
Mississippi	25.0	26.3	34.2	34.7	36.3	36.6	41.4	44.7	39.7	27.2	32.3
Missouri	367.4	409.9	483.3	520.6	497.5	511.8	495.5	491.6	497.9	470.4	477.4
Montana	19.0	21.2	26.3	33.8	36.6	48.4	40.9	35.8	37.1	36.6	31.3
Nebraska	41.4	52.5	61.6	66.7	74.1	75.6	78.2	74.1	80.9	89.6	90.2
Nevada	15.6	18.9	18.9	21.0	20.6	23.0	22.6	22.2	20.2	21.3	18.1
New Hampshire	57.2	66.0	80.4	97.9	99.0	97.9	93.6	90.7	86.9	85.3	90.0
New Jersey	193.0	192.5	215.8	267.9	281.3	294.7	272.1	286.5	261.6	258.3	251.6
New Mexico	64.5	75.7	87.1	92.6	97.9	114.5	115.3	129.6	125.0	109.9	109.9
New York	1,410.1	1,573.6	1,721.7	1,875.6	1,962.2	2,023.3	1,973.4	2,004.8	1,951.2	1,940.0	2,001.0
North Carolina	581.2	688.3	781.0	943.5	998.3	1,081.3	1,086.4	1,133.6	1,057.4	948.4	932.0
North Dakota	5.4	10.5	13.6	15.1	16.3	20.7	14.8	17.4	16.5	12.9	15.4
Ohio	446.2	506.5	585.3	664.6	695.2	724.5	692.5	708.1	678.5	640.7	662.4
Oklahoma	44.0	54.6	66.3	79.6	87.9	82.8	86.8	83.5	73.0	75.7	80.3
Oregon	186.1	205.5	233.5	245.9	258.0	276.6	285.5	279.8	270.5	280.6	293.6
Pennsylvania	947.1	1,083.8	1,216.0	1,305.5	1,355.2	1,409.6	1,411.3	1,418.2	1,383.2	1,380.9	1,405.9
Rhode Island	79.5	94.6	115.2	131.4	133.2	132.0	132.7	144.7	141.3	152.1	149.9
South Carolina	63.2	81.3	103.9	125.2	120.8	127.4	123.4	132.5	141.4	152.0	145.1
South Dakota	8.1	8.4	13.3	15.2	17.3	19.6	19.5	17.1	18.2	16.1	15.9
Tennessee	231.1	280.8	338.8	401.8	410.6	434.6	426.5	457.8	453.8	446.3	471.0
Texas	765.3	892.9	1,023.8	1,216.1	1,148.7	1,150.8	1,116.3	1,126.3	1,110.6	1,070.0	1,078.1
Utah	114.3	131.2	146.0	153.8	151.5	151.5	152.9	161.7	152.9	142.3	150.6
Vermont	49.2	58.5	63.8	70.4	69.2	67.0	63.9	67.3	66.2	59.1	60.1
Virginia	223.7	259.7	293.7	436.5	481.9	490.9	438.3	378.6	331.4	314.3	290.5
Washington	523.0	615.9	670.7	763.6	808.9	802.7	891.0	827.4	839.6	785.3	846.5
West Virginia	10.6	13.7	15.3	14.7	19.0	20.4	22.6	24.7	24.8	23.5	23.2
Wisconsin	253.5	283.1	339.6	376.0	393.0	387.8	390.5	388.7	395.0	379.9	389.1
Wyoming	4.7	7.5	7.3	7.6	8.1	6.3	7.1	7.4	7.4	8.9	7.8
50 states plus DC	14,679.4	16,654.4	18,879.2	21,602.5	22,485.7	23,053.9	22,787.9	23,107.9	23,153.1	21,422.3	21,960.0
American Samoa	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.3	0.4	0.4	0.0
Guam	0.4	1.2	1.2	1.6	1.2	0.5	0.8	0.9	0.5	1.6	1.8
Puerto Rico	41.4	44.7	65.9	63.9	59.8	64.4	62.7	59.9	59.1	56.9	59.4
Virgin Islands	0.1	0.7	0.7	1.0	1.3	0.8	0.9	1.8	1.9	2.0	1.9

Table 2

Jobs Supported by NIH Awards to States, FY2010

State	NIH awards (incl. ARRA), $M	Employment multiplier * (jobs per $1 change in NIH award)	Intrastate jobs	Added Interstate activity (%)	Interstate jobs	TOTAL EMPLOYMENT
Alabama	293	16.47	4,823	0.221	1,066	5,889
Alaska	21	16.49	349	0.965	337	687
Arizona	210	16.87	3,541	0.453	1,604	5,145
Arkansas	86	17.64	1,510	0.506	764	2,274
California	4,021	15.43	62,028	0.156	9,706	71,734
Colorado	377	16.08	6,070	0.225	1,367	7,437
Connecticut	571	11.69	6,679	0.151	1,007	7,686
Delaware	42	9.52	401	0.607	243	644
District of Columbia	223	2.15	479	0.256	123	602
Florida	509	17.84	9,078	0.519	4,712	13,790
Georgia	536	18.81	10,081	0.250	2,521	12,602
Hawaii	66	16.56	1,097	0.393	431	1,527
Idaho	14	14.69	203	1.720	350	553
Illinois	884	15.57	13,759	0.230	3,168	16,928
Indiana	274	16.56	4,540	0.358	1,624	6,164
Iowa	232	16.73	3,876	0.263	1,018	4,894
Kansas	123	13.86	1,709	0.434	741	2,450
Kentucky	190	17.62	3,342	0.311	1,038	4,380
Louisiana	162	18.13	2,929	0.525	1,539	4,468
Maine	72	19.57	1,407	0.283	397	1,804
Maryland	1,198	13.77	16,491	0.090	1,476	17,968
Massachusetts	2,935	13.18	38,685	0.045	1,730	40,415
Michigan	751	15.18	11,394	0.177	2,012	13,406
Minnesota	549	15.94	8,754	0.171	1,499	10,253
Mississippi	48	16.81	811	0.859	697	1,508
Missouri	563	13.47	7,586	0.156	1,187	8,773
Montana	54	17.86	958	0.293	281	1,239
Nebraska	122	15.00	1,824	0.322	588	2,412
Nevada	22	13.42	289	2.418	700	989
New Hampshire	113	12.77	1,444	0.207	299	1,743
New Jersey	305	13.42	4,099	0.543	2,226	6,324
New Mexico	140	15.27	2,134	0.222	475	2,609
New York	2,434	13.74	33,438	0.173	5,772	39,210
North Carolina	1,098	17.25	18,951	0.132	2,500	21,451
North Dakota	18	14.57	258	0.857	221	480
Ohio	796	17.37	13,833	0.205	2,841	16,675
Oklahoma	103	19.43	1,995	0.588	1,174	3,169
Oregon	357	16.93	6,043	0.176	1,066	7,108
Pennsylvania	1,691	14.97	25,312	0.111	2,808	28,120
Rhode Island	166	14.06	2,337	0.118	276	2,613
South Carolina	169	18.21	3,074	0.355	1,091	4,165
South Dakota	18	10.76	196	1.125	220	416
Tennessee	561	16.86	9,465	0.150	1,420	10,885
Texas	1,307	18.55	24,247	0.281	6,825	31,072
Utah	191	20.10	3,837	0.203	781	4,618
Vermont	73	17.15	1,253	0.148	185	1,438
Virginia	340	13.68	4,650	0.441	2,051	6,701
Washington	1,014	14.66	14,869	0.121	1,798	16,667
West Virgina	41	16.59	685	0.664	455	1,140
Wisconsin	469	16.54	7,764	0.199	1,544	9,308
Wyoming	8	15.31	121	2.359	285	406
50 states plus DC	26,560		404,700		80,239	484,939

* RIMS Type II multiplier — impact of spending based on how goods and services are supplied within the region plus the induced impact of purchases by employees, as calculated by the Bureau of Economic Analysis, U.S. Department of Commerce.

Table 3
Employment and Wages in the Medical Innovation Sector, 2008

	NAICS	Annual average employment	Number of establishments	Average # of employees per establishment	Total annual wages (in 000s)	Average weekly wage, $
Pharmaceutical and medicinal manufacturing	3254	299,585	2,686	112	27,729,840	1,780
Medicinal and botanical	325411	33,160	391	85	2,149,002	1,246
Pharmaceutical preparation	325412	221,380	1,637	135	21,802,395	1,894
In-vitro diagnostic substances	325413	19,131	314	61	1,491,050	1,499
Other biological products	325414	25,914	344	75	2,287,393	1,697
Medical equipment manufacturing *		279,532	5,881	48	17,013,762	1,170
Electromedical and electrotherapeutic apparatus	334510	61,985	931	67	5,188,972	1,610
Irradiation apparatus	334517	19,514	276	71	1,012,252	998
Surgical and medical instruments	339112	113,624	1,468	77	7,634,671	1,292
Surgical appliances and supplies	339113	99,216	2,768	36	5,976,714	1,158
Dental equipment and supplies	339114	16,218	525	31	845,665	1,003
Ophthalmic goods	339115	30,960	844	37	1,544,460	959
Research and development in biotechnology	541711	414,690	881	471	39,435,254	1,829
TOTAL		**993,807**	**9,448**	**105**	**84,178,856**	**1,629**

* *Employment and Wages: Annual Averages 2008*, Bureau of Labor Statistics, U.S. Department of Labor. http://www.bls.gov/cew/ew08chartsandmaps.pdf

About Dr. Everett Ehrlich

Dr. Everett M. Ehrlich is one of the nation's leading business economists. His firm, ESC Company, combines economic analysis, business development, and communications skills to solve a wide range of business problems. ESC's diverse clientele have included leading firms in the financial, accounting, pharmaceutical, automotive, and other industries, and such diverse organizations as the Pew Center for Global Climate Change and the Major League Baseball Players Association. He also recently served as Executive Director of the CSIS Commission on Public Infrastructure under co-chairmen Felix Rohatyn and Warren Rudman; a bipartisan bill to enact their recommendations was introduced in the 110th Congress.

Dr. Ehrlich served in the Clinton Administration as Under Secretary of Commerce for Economic Affairs, the principal economic policy official for Commerce Secretaries Brown and Kantor and chief executive of the nation's statistical system. As such, he led the first comprehensive strategic review of the nation's economic statistics in four decades, leading to a major modernization of featured measures of the economy. He supervised the redesign of the 2000 decennial census. He co-chaired the White House working group on the restructuring of the U.S. economy in the face of information technology, was a leader in the U.S. planning effort of the two G-7 "Jobs Summits," and oversaw the Administration's economic analysis of global climate change.

Prior to his service as Under Secretary, Dr. Ehrlich was Vice-President for Economic and Financial Planning, and for Strategic Planning, of Unisys Corporation, from 1988 to 1993. As such, he had responsibilities concerning corporate development and finance, formulating business strategy, and economic forecasting. He reported directly to two chairmen of the company. He has also been the Senior Vice-President and research director of the business-based think tank, the Committee for Economic Development.

Dr. Ehrlich earlier served as Assistant Director of the Congressional Budget Office, where he directed the CBO program in trade and technology, infrastructure and space transportation, energy and the environment, and agriculture. He joined CBO in 1977, after having served as a Legislative Aide to Congressman John Conyers, Jr., and having briefly taught economics at the university level.

Dr. Ehrlich is the author of two critically-acclaimed novels: Big Government (1998), and Grant Speaks (2000), both by Warner Books. He was, for eight years, a regular economics commentator on National Public Radio's Morning Edition, and his writings have appeared in *The Financial Times*, *Investors Business Daily*, *The Christian Science Monitor*, *The Washington Post*, *The International Economy*, *The New York Review of Books*, and other publications.

Dr. Ehrlich was born in New York City in 1950 and is a product of its public schools. He received a B.A. in 1971 from S.U.N.Y. Stony Brook and a Ph.D. in economics in 1975 from the University of Michigan. He lives in Bethesda, Maryland, where he and his wife of thirty years follow the exploits of their three grown children and root for the Washington Nationals.

About UMR

Because the scientific opportunities to improve human health have never been greater, and the economic benefits of biomedical research have never been more important, leading research institutions, patient advocates, medical professional organizations, and biomedical companies have united in support of robust funding for the National Institutes of Health (NIH).

The nation's investments in NIH have helped wipe out diseases that killed our grandparents. Those investments have led us to the brink of new discoveries in deadly and debilitating illnesses such as cancer, Alzheimer's, heart disease, diabetes, rare diseases, and many more.

Indeed, NIH's mapping of the human genome, and other advances in our understanding of the building blocks of life, have ushered in an exciting new era of discovery, unique in history. Scientists now have the opportunity to use new knowledge of biological structures and functions to beat back disease. They are no longer limited to describing an illness's symptoms, employing whatever tools are available, and watching to see what works. Instead, using the knowledge gained through more than 40 years of arduous study, researchers can now zero in strategically on a disease, identifying its triggers and crucial moments of development. Through recent discoveries and new technologies developed in the last decade alone, researchers more fully understand the molecular drivers of disease and how to affect them. This is a powerful moment in science, full of new hope for patients and new opportunities that scientists can pursue as fast as funding allows.

NIH is also an important economic engine. The large majority of NIH funding is awarded to more than 325,000 researchers in public and private research institutions across the U.S. In every state in the country, NIH-funded projects support new and experienced scientists, and numerous jobs in industries that provide research facilities, supplies, and equipment. Moreover, NIH-funded research is the foundation of the U.S. biotech and pharmaceutical industries, and a vital tool for reducing the burden of disease and its associated health care costs.

At this critical moment in our nation's history, sustained investments in biosciences through the only federal agency specifically designed for this purpose — NIH — is more important than ever.

United for Medical Research (UMR) is dedicated to seeking the NIH funding necessary for delivering on the promise of this historic moment in biomedical science.

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