by PHYLLIS WISE,
Chancellor of the University of Illinois at Urbana-Champaign

Research Universities POWER U.S. *Innovation and Prosperity*

We need to invest in these institutions to fuel future progress.

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If you use a GPS device, a mouse, or a microwave oven, take antibiotics, have an eye implant, or are reading this on a tablet, you can thank America's research universities.

These institutions, which have become a national network for innovation, are the envy of the world and are responsible for many of the products, services, and industries that have changed the way we live and yet we often take for granted.

The impact of our universities also is evident in how we address national priorities from security and defense, to public health and economic prosperity at home and competitiveness abroad.

Research universities—with their multifaceted mission of research, teaching, and service—are the key to educational access for millions and constitute the first link in a chain of basic knowledge leading to applications that have revolutionized modern life. They also underlie the economic and social growth that has seen our nation climb from a colony in rebellion to a global leader.

The future of this engine for innovation is uncertain—as the nation's long commitment to investment in scientific research and development has begun to erode under the pressure to provide short-term budgetary relief.

The concept of the research university in America emerged in the 19th century, but it was the Morrill Act of 1862 that established the nation's land-grant colleges and the first—uniquely American—*public* research universities. Not only did this landmark legislation serve to democratize educational opportunities and create new expectations of public access, it also charged these public universities with the responsibility of actively putting knowledge into practice. One hundred and fifty years later, these universities are home to the basic scientific research that is a foundation for both breakthroughs in technology and for economic development. Together with private universities, public research universities generate the vast majority of the nation's study of the pure basic science that is vital to our knowledge base.

The main source for investment in this endeavor is the federal government. In 2009, academic institutions accounted for more than half of the nation's basic research. And of the $32.6 billion in academic research and development funding from the government that year, about 60 percent was invested in public research universities.

I'll use my university as an example of the economic impact of public research institutions: A 2009 study of

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the University of Illinois and its medical enterprise showed a $13.1 billion impact on our state economy, including the creation of more than 150,000 jobs. Innovative research at the University of Illinois alone has led to 34 start-up companies and nearly 300 new patents over the last five years. This is a return from one university.

The numbers are compelling, but they don't tell the full story of how university-based research touches lives. Consider just a few of the products resulting from basic research by universities and colleges funded by the National Science Foundation: bar-code scanners, computer-assisted design, improved biofuels, fish farming, tissue transplants, forensic DNA analysis, revolutionary weather-sensing networks, and, from the University of Illinois, nuclear magnetic resonance imaging and the first graphical Internet browser.

The work of research universities is the bedrock of our nation's scientific, technological, and economic growth and of much of our commercial R&D. When industries have been unwilling to invest in the early stages of research where risks are high and returns are unknown, universities step in. And when their gambles are rewarded, the outcomes are added to the public domain where industries and corporations and private individuals build on them. Lasers, MRI technology, restriction enzymes, and many computer technologies are all discoveries that have been

A selection of innovations, supported through university research, that have improved our lives.

Product, University, Inventor	Use Today	Development	Impact	Fun Fact
MRI machine SUNY (Brooklyn, N.Y.) 1972 Raymond Damadian	MRI scanners are widely used to detect injuries, diseases, and other health issues.	Damadian published a 1971 paper claiming doctors could diagnose cancer by using nuclear magnetic resonance (NMR). Because tumors contain more water than healthy tissue, they can be identified in NMR images.	MRIs are useful in identifying tumors and other maladies. They also show soft tissues, such as the brain and other organs, much better than X-rays.	In 1937, Columbia University professor Isidor I. Rabi discovered NMR, which led to the invention of the MRI machine and helped earn him a Nobel Prize.
Polio vaccine University of Pittsburgh (Pittsburgh, Penn.) 1955 Jonas Salk	The polio vaccine is one of the most common immunizations given to children worldwide.	In 1952, Salk developed the first effective polio vaccine, which was then tested in the largest medical experiment in history, which involved 1.8 million U.S. children. Following a massive child immunization campaign launched in 1955, by 1961, there were only about 160 polio cases in the U.S.	The polio vaccine has virtually eradicated the once-common childhood disease. In 2010 there were fewer than 1,300 polio cases worldwide.	Salk also worked on vaccinations for influenza and AIDS.
General use computer University of Pennsylvania (Philadelphia, Penn.) 1946 John Mauchly and J. Presper Eckert	Computers are used in nearly every facet of our lives and have revolutionized communication, technology, and medicine.	The development of the first computer, called ENIAC, was originally designed to calculate artillery firing tables for the U.S. Army's Ballistic Research Laboratory. The machine was called the "Giant Brain" in the press and could be reprogrammed to solve a host of computing problems.	The creation of ENIAC led to continued development in computer science and engineering. More than 95 million computers were sold in the U.S. in 2011, leading to $85.5 billion in revenue.	Designing and building ENIAC cost $500,000 in 1946, which would be about $5.9 million today.
Internet MIT (Cambridge, Mass.) 1965 Lawrence G. Roberts	The Internet connects computers and users worldwide and has changed the way we communicate and how information is spread.	Building off of a fellow MIT colleague's research on packet switching theory, Roberts established the first computer connection between computers in Massachusetts and California with a dial-up telephone line. The Department of Defense then funded the development of ARPANET, a network of computers at research universities and laboratories across the nation, which was an early iteration of the modern Internet.	Over 30 percent of the world's population uses the Internet. Nearly 72 percent of U.S. households have Internet access.	The first four locations in the ARPANET network were UCLA, Stanford University, UC Santa Barbara, and the University of Utah.
Richter scale California Institute of Technology (Pasadena, Calif.) 1935 Charles Francis Richter, Beno Gutenberg	The Richter scale was the precursor to current systems used to measure the magnitude of earthquakes.	Inspired by the apparent magnitude system, which measures the brightness of stars, Richter designed the scale and originally intended it to only be used in a particular study in California. Gutenberg later modified the scale to measure earthquakes at great distances, thus creating the moment magnitude scale used today.	While the original Richter scale has been updated several times since its inception, it has changed the way earthquakes are measured worldwide.	While most people today still refer to earthquake magnitude measurements as being on the Richter scale, earthquakes are now technically measured on the moment magnitude scale.
GPS (global positioning system) Johns Hopkins University (Baltimore, Md.) 1959 William Guier, George Weiffenbach	GPS is most commonly used in cars as a navigation tool, but it is also used by hikers, sailors, and the military.	Following the launch of Sputnik, physicists Guier and Weiffenbach discovered they could identify and track the satellite's exact location. They then developed a way to pinpoint a specific location on Earth via a satellite. This project, later called Transit, was used by the U.S. Navy to track submarines and was the precursor to current-day GPS.	GPS is common in most cars and cell phones. The military uses GPS for search and rescue, reconnaissance, tracking, and missile guidance.	As of May 2013, 64 GPS satellites have been launched. The oldest GPS satellite still in operation was launched in November 1990.

used in ways that would astound those who discovered them. This is what some call the Innovation Ecosystem, which is essential to America's global economic and innovation status and rests on the nation's collective investment in research universities.

Yet funding for our public universities, which educate 70 percent of all undergraduates, has declined to the point where the cost of a college education rests increasingly on the backs of our students.

The Budget Control Act of 2011 mandates reductions in federal spending of about $1 trillion over the next nine years. This is a short-term budget fix with a devastatingly high cost to the long-term productivity of our economy and the vitality of our society. The result in 2013 alone: a $12.5-billion reduction in federally financed research and, according to the Information Technology & Innovation Foundation, the loss to the economy of an estimated 200,000 jobs.

America's global standing is enviable, but in danger of eroding. We simply can't afford to curb key research efforts and undermine university-powered economic activity. It is ironic and alarming that other nations are fast emulating the federal-government/research-university partnership that has made the United States the world's technological and scientific giant even as the danger of that model's systematic dismantling here at home becomes increasingly apparent.

Our strategic federal investment in our universities has provided immense dividends to the nation and to the world for generations now. It is a commitment we cannot abandon. ■

Top 25 research universities, 2013

1	**Harvard University**
2	**Stanford University**
3	**University of California, Berkeley**
4	**Massachusetts Institute of Technology (MIT)**
5	University of Cambridge (U.K.)
6	**California Institute of Technology (Caltech)**
7	**Princeton University**
8	**Columbia University**
9	**University of Chicago**
10	University of Oxford (U.K.)
11	**Yale University**
12	**University of California, Los Angeles (UCLA)**
13	**Cornell University**
14	**University of California, San Diego**
15	**University of Pennsylvania**
16	**University of Washington**
17	**Johns Hopkins University**
18	**University of California, San Francisco**
19	**University of Wisconsin, Madison**
20	Swiss Federal Institute of Technology Zurich (Switzerland)
21	University of Tokyo (Japan)
22	University College London (U.K.)
23	**University of Michigan, Ann Arbor**
24	Imperial College of Science, Technology, and Medicine (U.K.)
25	**University of Illinois at Urbana-Champaign**

U.S. INSTITUTIONS IN BOLD
SOURCE: SHANGHAI JIAO TONG UNIVERSITY

Top 10 universities reporting most R&D spending in all fields, 2011

1	Johns Hopkins University	$2.14 billion (includes Applied Physics Lab)
2	University of Michigan	$1.27 billion
3	University of Washington	$1.14 billion
4	University of Wisconsin, Madison	$1.11 billion
5	Duke University	$1.02 billion
6	UC San Diego	$1 billion
7	UC San Francisco	$995 million
8	UCLA	$982 million
9	Stanford University	$908 million
10	University of Pittsburgh	$899 million

SOURCE: NATIONAL SCIENCE FOUNDATION