



## CHAPTER NINE

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# Research

Photo: Lick Observatory, Mt. Hamilton, exterior view.



### 1887

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The Hatch Act dedicated federal funds for agricultural research for two main purposes: creating agricultural experiment stations, and disseminating new information about soil and plant growth.

### 1888

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Lick Observatory is accepted by the Regents as the Lick Astronomical Department of the University of California, becoming the first permanently occupied mountain-top observatory in the world. The 91-centimeter (36-inch) refracting telescope is first used on January 3, 1888 and remains the world's largest of its kind.

# RESEARCH

## History

Nineteen years after the University of California was chartered in 1868 as California's land-grant institution under the Morrill Act, the Hatch Act of 1887 linked research and public service to instruction as inseparable elements of the University's mission. It allocated federal funds to land-grant colleges for research at agricultural experiment stations and making the latest agricultural methods publically available. The Hatch Act, after many reauthorizations and expansions, still provides UC funding for agricultural research and cooperative extension.

Federal research funding in the early part of the 20<sup>th</sup> century focused on agriculture and later, aeronautics, with other fields supported by industrialists, philanthropists and the University's own funds. This changed in the lead-up to World War II, when President Roosevelt recognized the military importance of science and technology research, funding initiatives such as the Manhattan Project. This wartime effort drew upon the talents and research findings of UC scientists and engineers, including teams from UC Berkeley's Radiation Laboratory, founded in 1931 by physicist Ernest O. Lawrence, a UC Nobel Prize Laureate.

The early post-war years saw the creation of the grants program at the National Institutes of Health and the formation of the National Science Foundation. These federal agencies are UC's two largest single sources of sponsored project funding, providing about 44 percent of the roughly \$5 billion in research support UC received from external sources in 2016-17. Thanks in major part to the long history of federal funding, the University of California system has grown into the world's largest and most prominent university research system, with more than 800 research centers, institutes, laboratories and programs that span ten campuses, five medical centers, three national energy laboratories and numerous research facilities.

## Evaluating the research enterprise

This chapter presents a largely quantitative description of UC's research activities. The sources of research funding influence the nature of the research. Federal support initiated UC's research mission and currently provides more than half of all research funding (9.1.1). Most research funds pay the salaries and benefits of UC's research community, of which faculty are only a small proportion (9.1.2). While UC's research spans many disciplines, medical research is the largest expenditure component, and its share has grown over the last two decades (9.1.3).

UC performs nearly one-tenth of the nation's academic research (9.1.4). Compared to other research universities, UC has a higher rate of research expenditures per ladder-rank faculty (9.1.5), especially at UC campuses with medical schools (9.1.6). Three National Energy Laboratories are affiliated with the University of California, conducting research that is vital to the nation's security and energy future.



1910

UC establishes the Imperial Valley Experiment Farm (also known as the Meloland field station), an agricultural research station in the parched desert near the Mexican border.



1933

Prohibition ends, allowing the gradual resumption of research and instruction in wine making at Davis. The viticulture program had been shut down since the start of prohibition in 1919.

This chapter considers the impact of this research on society. One of the goals of research is the dissemination of its findings; the global distribution of downloads from UC's eScholarship Repository (9.2.1) indicates how eagerly this knowledge is sought. The frequency at which UC research is cited is another indicator of its quality and importance (9.2.2). UC research advances the economy and technology through licenses and startups resulting from UC's patents (9.2.4, 9.2.5).

These measures, however, do not capture the wide range of curiosity-driven research at UC. Quantitative measures emphasize fields that receive sizable funding and produce large numbers of publications, such as medicine, physical and material sciences, and engineering. These measures underrepresent research achievements in the arts, humanities, social sciences and theoretical sciences, where work leaves less of a financial footprint, and where results are disseminated in books or performances rather than journal articles.

Quantitative measures cannot capture how UC research contributes indirectly and over time to the state and to the nation through discoveries that improve health, technology and the quality of life; how involvement in research, and hearing about discoveries from the world's foremost researchers enhances the learning experiences of UC's graduate and undergraduate students; or how thoughtful work in the arts and humanities furthers our understanding of ourselves as one species among many on this planet.

### The size and scope of UC's research programs

Over the course of a century and a half, breadth of vision has been a virtue of UC's research. All forms of intellectual inquiry are represented in the research enterprise: the architecture of atoms and the structure of the universe; the study of human cognition and the development of machine learning; the study of human pathogens and the creation of disease-resistant crops. The diversity of this vision contributes to society in ways often hard to predict at the outset. Research represents the creation of new knowledge that can be communicated and curated to benefit society.

While research expenditures track only some of this activity, they can indicate how research changes in scope and focus over time, and can provide some relative sense of how research institutions compare to one another. During 2016-17, direct expenditures for research at UC totaled over \$4.5 billion, with federal funds providing about half. Private sources account for about 17 percent — 11 percent from nonprofit organizations and 6 percent from corporate sponsors. About one-quarter represented the University's own funds derived from gifts, endowments, general funds and other sources. Nearly two-thirds of research expenditures in 2016–17 went to salaries and benefits. Of this, about one-quarter went to faculty; the majority supported staff researchers, and about one-fifth went to students and postdoctoral scholars.

Budgets for externally funded research include both a direct cost component — the actual amount spent on salaries, benefits, equipment and materials directly linked to the project — plus a percentage to cover the facilities



1952

UC Berkeley establishes the Lawrence Livermore National Laboratory, an extension of the UC Radiation Laboratory at Berkeley and a complement to the Los Alamos lab in New Mexico.



1957

UC's Air Pollution Research Center is organized as a part of the Citrus Experiment Station at Riverside. In 1961, it is made into a universitywide center to support pollution research across UC.



and administration required to support the research project, including debt service, maintenance and libraries. These facilities and administration costs are called “indirect costs.”

In 2016–17, UC’s indirect cost recovery was just over \$1 billion, with the great majority from research activities. (Other forms of sponsored projects, such as service and training grants, also include indirect cost components.) The true indirect costs of research, however, are typically higher than the rate that research sponsors are willing to pay. Rates negotiated with federal agencies range from 53 to 57 percent across UC campuses, but this is still 18 to 20 percentage points below the true indirect costs. Non-federal research sponsors, including corporations, nonprofits and the state of California, have policies that limit indirect cost rates to well below federal rates. The true costs of UC research exceed recovered amounts by hundreds of millions of dollars annually, which must be made up from other sources.

The research community

Research funds principally pay for people’s time. Of the roughly 155,000 full-time equivalent (FTE) employees at the University, nearly 27,500, or about 18 percent, were paid with research funds.

UC’s Research Workforce, 2016-2017, FTE

Students	4,310.6	16%
Postdoctoral researchers	4,337.6	16%
Other staff	11,203.0	41%
Other academics	4,546.6	17%
Faculty	3,068.4	11%
<b>Grand total</b>	<b>27,466.2</b>	<b>100%</b>

While faculty serve as Principal Investigators for research projects, submitting proposals and managing the research, they make up only 11 percent of the research community, as measured in terms of compensated time. However, this figure, principally representing projects with research grants, underrepresents the time faculty spend on research. Virtually every faculty member at UC engages in research, often involving no expenditures other than the faculty member’s time. As in all research universities, career advancement at UC (including tenure), requires a significant body of scholarly or creative work. The research community includes over 4,300 FTE postdoctoral researchers, representing about 6,400 individuals (many post-docs either teach or are less than full-time). As shown in Indicator 5.1.4 of this report, postdoctoral scholars are most prominent in medical research and life science fields.



1968  
Scripps Institution of Oceanography establishes the Deep Sea Drilling Program, recovering ocean cores for research into the dynamics of continental drift, earthquakes and volcanism.



1975  
The UC Santa Cruz Predatory Bird Research Group forms when only two nesting pairs of peregrine falcons remain in California. The falcon is removed from the endangered species list in 1999.

## Research results — enhancing instruction

UC's research enhances the student experience. Faculty incorporate their research into their courses, providing students with access to insights and discoveries, sometimes before they are published. Postdoctoral scholars, representing one-sixth of the research workforce, contribute to instruction by working with graduate students while on their own instructional journey towards becoming the next generation of faculty and researchers. Students make up another one-sixth of the research workforce, mostly graduate students. In 2015–16, of UC's 56,000 graduate students, about 15,000 were employed as paid research assistants. UC undergraduate students also participate in the research community; the 2016 UC Undergraduate Experience Survey found over 40 percent of UC students had been involved in faculty-directed activity other than coursework, such as research or creative projects.

## Research results — spurring the economy

Many businesses in California are based on technology developed at UC or rely on the skills of UC graduates. Over the past two decades, UC has secured more licensable patents than any other U.S. research university. Since 1976, over 1,000 startup companies have been founded around UC inventions, with about 85 percent based in California. UC researchers submit nearly five new inventions a day in areas spanning from agriculture, technology, biotech and clean energy. The discoveries made through research become public knowledge through publications and the patent process. These innovations enhance industries, stimulate economies and improve health and well-being.

## Research results — communicating and curating knowledge

Publications are perhaps the most visible results of research. Between 2012 and 2017, UC campuses produced about one-twelfth of the nation's research publications. This chapter compares the volume and impact of UC research publications to nationwide averages and to the output of peer AAU institutions.

The books, periodicals and journals in which research findings are published are costly and beyond the reach of many researchers, students and journalists, especially in developing regions. To ensure that research findings become public, UC has adopted Open Access (OA) policies that are the most comprehensive of any academic institution in the United States. All UC employees must now deposit their research papers, upon publication, in the eScholarship repository operated by UC's California Digital Library (CDL) and grant a non-exclusive license to UC to make those materials openly available.

The UC academic community leads the country in advocating for an open scholarly communication environment that emphasizes immediacy, sustainability and expansive access to research. Their advocacy sends the message that the academic community wants to own/control its own work, resist the skyrocketing costs of journal subscriptions, and ensure global access to research findings. These policies sit within a broader effort at UC to



1983

UCSF clinicians and researchers start the country's first outpatient AIDS clinic and inpatient ward at SF General Hospital and mount a multidisciplinary effort to fight the disease.



1990

The U.S. Department of Education establishes the National Center for Research on Cultural Diversity and Second Language Learning at UC Santa Cruz.

reconceive the scholarly publishing environment and restructure its economics to better support open dissemination. CDL is further advancing this effort systemwide by negotiating agreements that reduce or eliminate the costs of publishing OA with publishers, developing models to transition subscription journals to open access, and supporting tools and services to disseminate research.

UC also disseminates its research directly. In 2018, UC is celebrating the 125<sup>th</sup> anniversary of the founding of the UC Press. In 1893, the University's governing board funded a non-profit publishing program, establishing the UC Press. Today, the UC Press is among the six largest university publishers in the United States, and publishes approximately 200 books and 40 multi-issue journals annually. Of the nation's top university presses, UC press is the only one associated with a public university.

### Research results — improving health

Clinical research projects are another example of cultivating new knowledge to benefit society. During 2016–17, UC began more than 1,000 new clinical trial research projects in addition to the 2,500 already underway. These projects represent a crucial stage in the journey from a scientific discovery to an effective treatment. Of the research dollars that came to UC from businesses during 2016-17, 57 percent was directed toward clinical trials.

### Research results — assessing climate change and charting the energy future

UC is a national and global leader in research on climate science, including monitoring atmospheric changes and global temperature rise, as well as assessing the impacts of climate change on marine and land-based ecosystems and the built environment. UC scholars and students carry out some of these studies at UC's 39 Natural Reserve System (NRS) sites around California. Most of UC's climate science work is funded by federal agencies. Each year, the University, together with the UC-affiliated Lawrence Berkeley and Lawrence Livermore National Laboratories, receives an average of \$218 million in federal funding to pursue climate research.

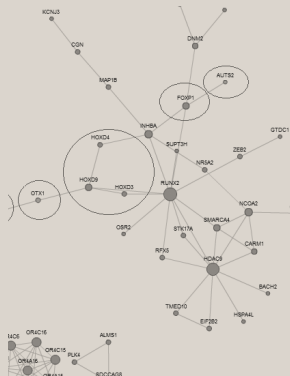
### UC National Laboratories — science in the national interest

The three University of California-affiliated National Laboratories — Lawrence Berkeley (LBNL), Lawrence Livermore (LLNL) and Los Alamos (LANL) — are among the nation's premiere multi-disciplinary research and development (R&D) laboratories for energy and national security. The University has played a public service role as a manager of these three Department of Energy (DOE) national laboratories, with annual budgets of over \$5 billion and a combined workforce of more than 22,000. The Laboratories also support UC's educational mission. At LBNL, 23 percent of employees are student assistants, graduate research assistants or postdoctoral scholars. At LLNL, three percent of the workforce are postdocs and, at LANL, almost 16 percent are postdocs or student assistants.



2003

A University Affiliated Research Center (UARC) at NASA Ames is initiated at UC Santa Cruz, established to increase the safety, effectiveness and scientific impact of NASA's missions.



2005

The Autism Research and Training Center at UCSB receives \$2.35-million to provide enhanced facilities for one of the nation's leading centers for the diagnosis, evaluation and treatment of autism.

## Looking forward –uncertainties in federal research funding

With federal funding supporting more than half of UC's research, the vitality of UC's research enterprise is dependent on agencies whose funding is reviewed annually. The current federal budget, passed in March 2018, calls for increased support for academic research through the current fiscal year. This boost to federal funding contrasts with the President's Budget Proposal, which would have drastically reduced all agency appropriations for research, including a cut of over 21 percent at the National Institutes of Health, UC's largest single source of research funding. Given this difference, the long-term prospects for federal sponsorship, particularly for climate and environmental science, but including fundamental medical research, are uncertain.

Whatever changes in priorities are embodied in the federal budget, one certainty is that the competition for federal funding is becoming increasingly competitive. At the National Institutes of Health, only one proposal is funded for every five received, compared to about 32 percent fifteen years ago, even though total appropriations for research have increased. UC is competitive in garnering these awards, but this comes at a cost. The administrative effort of drafting, reviewing, submitting and tracking proposals is one of the less-visible costs of conducting research — costs that are not fully recovered from federal sponsors.

## For more information

UC's Budget for Current Operations 2017–18:

[ucop.edu/operating-budget/\\_files/rbudget/2017-18budgetforcurrentoperations.pdf](http://ucop.edu/operating-budget/_files/rbudget/2017-18budgetforcurrentoperations.pdf)

UC's office of Research and Graduate Studies: [ucop.edu/research-graduate-studies](http://ucop.edu/research-graduate-studies)

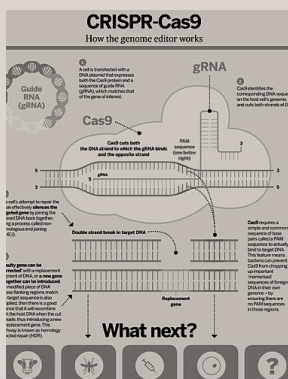
A map of the economic impact of UC research activity in California: [ucop.edu/institutional-research-academic-planning/\\_files/UC-research-impacts-in-california.pdf](http://ucop.edu/institutional-research-academic-planning/_files/UC-research-impacts-in-california.pdf)

More information about UC's research enterprise, including quarterly updates on UC's research funding:

[ucop.edu/institutional-research-academic-planning/content-analysis/research/index.html](http://ucop.edu/institutional-research-academic-planning/content-analysis/research/index.html)

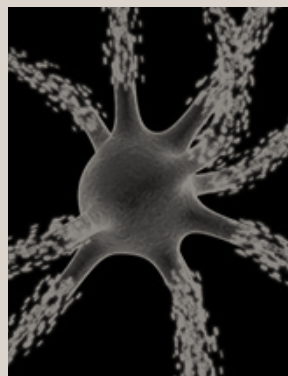
An interactive data visualization showing UC's research award history since 2001:

[universityofcalifornia.edu/infocenter/awards-and-proposals](http://universityofcalifornia.edu/infocenter/awards-and-proposals)



2012

The discovery of the century: the revolutionary gene-editing tool known as CRISPR-Cas9, is discovered by UCB biochemist Jennifer Doudna and researcher Emmanuelle Charpentier.



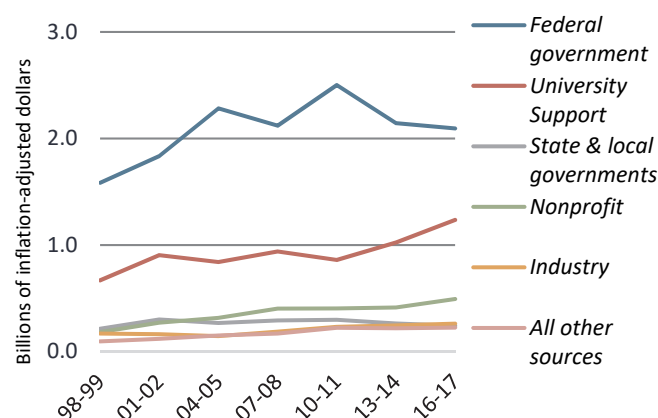
2017

Researchers at UC Riverside devise a method to selectively erase specific fear memories by weakening the connections between the nerve cells (neurons) involved in forming these memories.

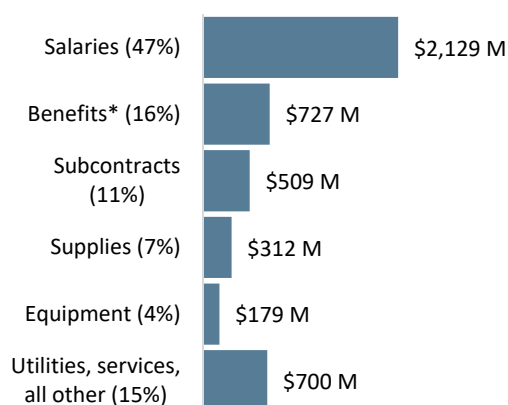
## 9.1 RESEARCH EXPENDITURES

### Federal funds support most of the research work done at UC. Salaries and benefits represent more than half of all research expenditures.

**9.1.1** Direct research expenditures by source  
Universitywide  
1997–98 to 2016–17



**9.1.2** Total research expenditures by type  
Universitywide  
2016–17



Source: UC Corporate Financial System<sup>1</sup>

\*Does not include post-employment benefit accruals

UC's direct research expenditures during 2016–17 were about \$4.5 billion. Of this, 46 percent came directly from federal agencies. This is the same percentage as last year, lower than any other time in the previous 16 years. A further seven percent represents federal flow-through funds that came to UC as sub-awards from the state, corporations, nonprofit organizations or other universities. Together, about 53 percent of UC's research expenditures started as federal funds. About three-quarters of UC's federal research support was provided by two agencies: the National Institutes of Health and the National Science Foundation.

University support accounted for almost 27 percent of 2016–17 research expenditures. These funds derive from a variety of sources, including UC and state general funds, endowment income and gifts. When over \$1 billion in recovered indirect costs are included, UC's research expenditures during 2016–17 amounted to about \$5.5 billion, representing almost one-fifth of UC's total expenditures.

Fluctuations in federal appropriations have a major impact on UC's research. Cutbacks at federal agencies starting in 2006 ended a long period of growth. This downturn was temporarily reversed during 2009–10 by the American Recovery and Reinvestment Act, which provided over \$1 billion in research funds to UC. Federal appropriations have been relatively stable for the last three years, but this may change with the current administration.

The majority of research expenditures pay for the salaries and benefits of UC's research workforce. About a quarter of research salaries went to faculty, as shown below.

#### Research salary distribution (\$ millions)

Faculty	573	27%
Academic researchers	317	15%
Other staff	773	36%
Postdoctoral researchers	269	13%
Students	198	9%
<b>Total</b>	<b>2,129</b>	<b>100%</b>

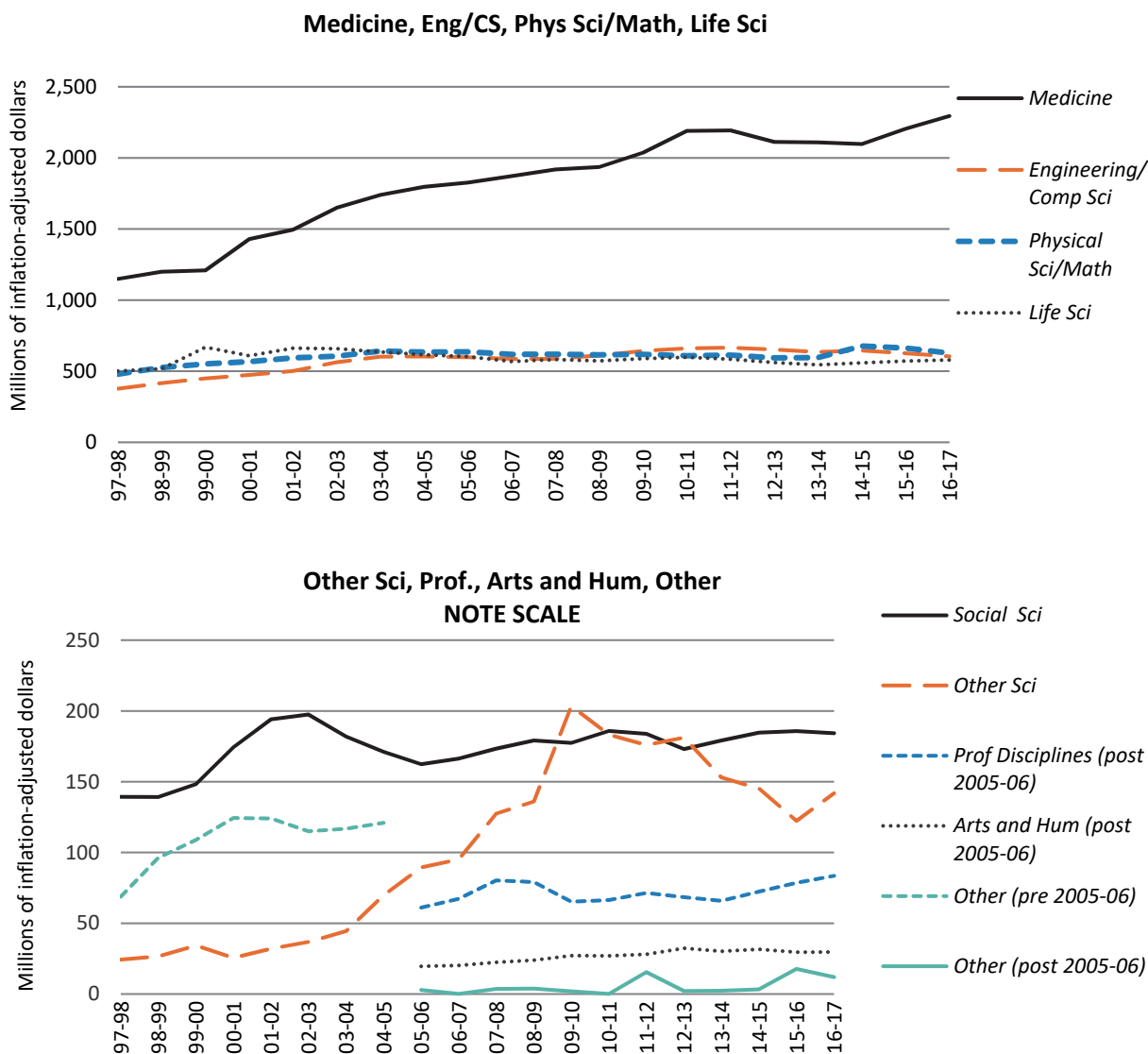
<sup>1</sup> Direct amounts have been adjusted for inflation and do not include accrual funds for postemployment retirement benefits or indirect cost recovery funds.



## 9.1 RESEARCH EXPENDITURES

**Inflation-adjusted expenditures for research in the medical fields have doubled since 1997–98, compared to an average of 42 percent for all other disciplines.**

### 9.1.3 Direct research expenditures by discipline Universitywide 1997–98 to 2016–17



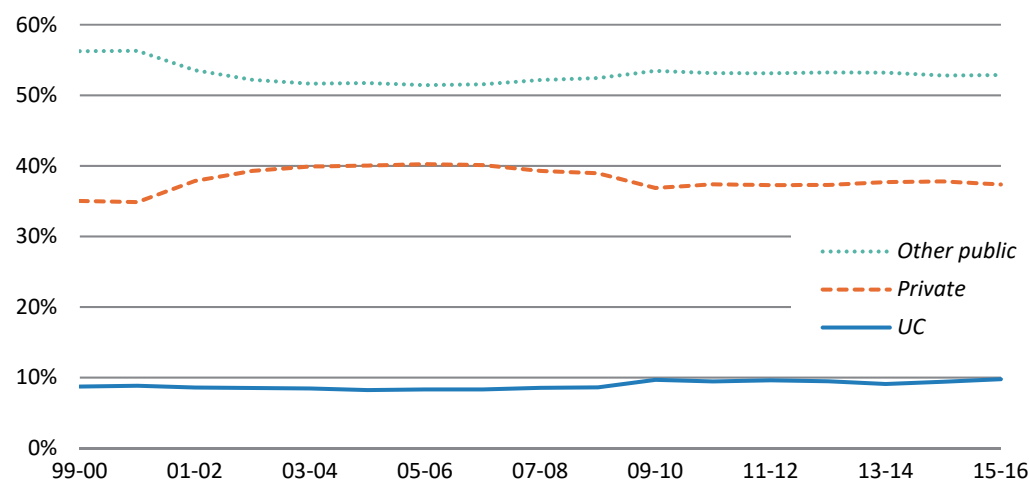
Prior to 2005–06, “Other” included professional and arts and humanities. Source: UC Corporate Financial System

Research expenditures in all STEM (Science, Technology, Engineering and Mathematics) and medical fields represented over 90 percent of total research expenditures each year during the past decade. This reflects the availability of funding and parallels the nationwide pattern.

Measures based on expenditures substantially underrepresent research activity in the arts and humanities, social sciences and professional disciplines, which make important contributions to scholarship and the quality of life, yet have relatively little access to external funding.

## The University of California performs nearly one-tenth of all the academic research and development conducted in the United States.

**9.1.4** UC share of U.S. research expenditures  
Universitywide  
1999–2000 to 2016–17



Source: IPEDS

Universities have been responsible for much of the innovative research activity that has led to the nation's global leadership in science, technology, and the arts and humanities. The scale of the US academic research enterprise has expanded greatly in recent years, increasing from about \$36 billion at the turn of the millennium to nearly \$56 billion in 2015-16, after adjusting for inflation. More than half of the nation's funding for research comes from the federal government.

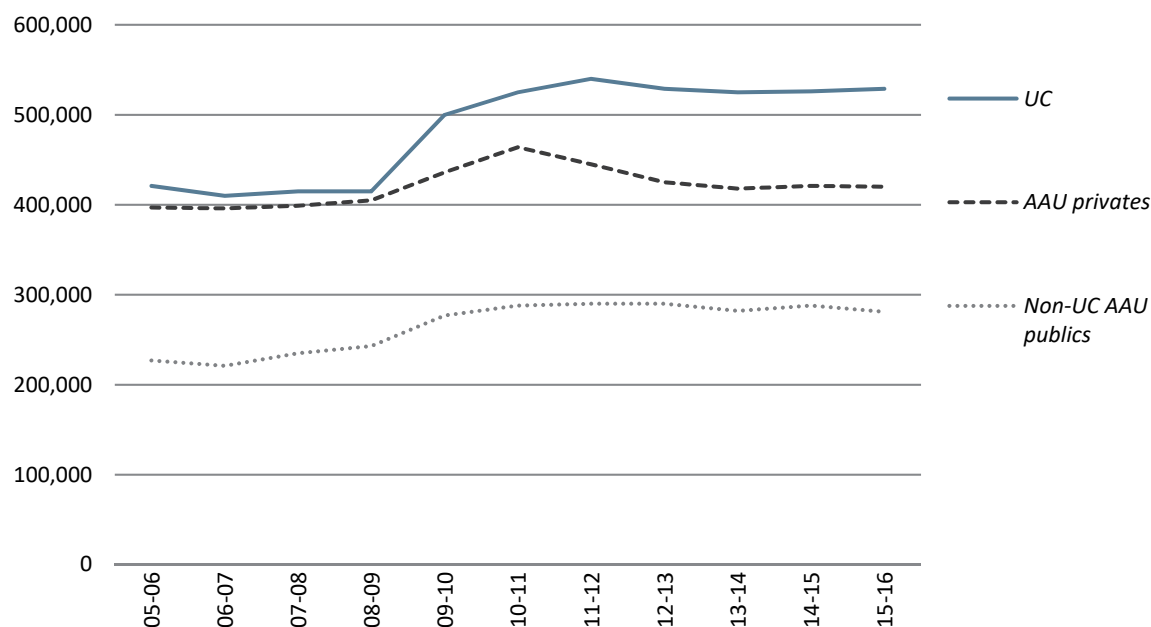
The University of California is the world's largest academic research system, and over the last decade has consistently performed between nine and ten percent of the academic research and development activity in the United States.

This reflects both UC's continuing competitiveness in securing federal awards and UC's ongoing successful relationships with the private sector. UC is the largest single recipient of funding from the two federal agencies principally responsible for academic research: the National Institutes of Health and the National Science Foundation. UC generally receives 5 to 6 percent of NIH's annual appropriations for research and 7 to 8 percent of NSF's annual appropriations.

## 9.1 RESEARCH EXPENDITURES

**Average research expenditures per ladder-rank faculty are higher at UC than its comparison peers.**

**9.1.5** Average inflation-adjusted research expenditures per ladder-rank faculty  
UC and AAU comparison universities  
2005–06 to 2015–16



Source: IPEDS

UC faculty are extremely successful at attracting research support from both government and private sponsors. On average, UC annually conducts \$529,000 in research per tenured and tenure-track faculty member, which surpasses the average of \$420,000 per faculty member for Association of American Universities (AAU) private institutions, and \$281,000 for AAU public institutions.

The largest single source of research sponsorship is the National Institutes of Health, and campuses with medical schools and hospitals are in the best position to compete for these funds. UC's second-largest source of research support is the National Science Foundation.

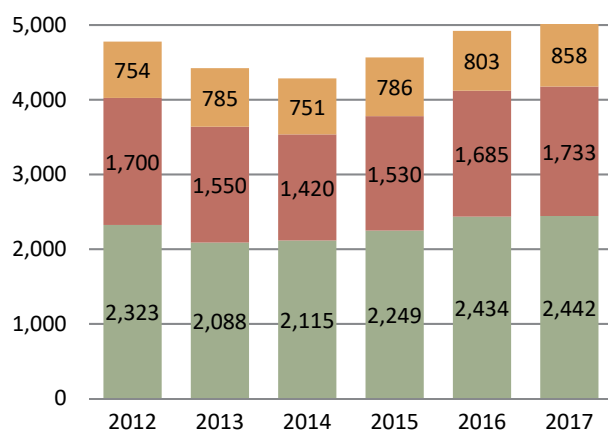
<b>UC Location</b>	<b>Research expenditures per ladder-rank faculty</b>
San Francisco*	\$3,368,000
San Diego	\$713,000
<b>UC AVERAGE</b>	<b>\$529,000</b>
Los Angeles	\$515,000
Berkeley	\$488,000
Davis	\$451,000
Irvine	\$280,000
Santa Barbara	\$255,000
Santa Cruz	\$257,000
Riverside	\$206,000
Merced	\$168,000

\*UC San Francisco is an exclusively health sciences campus, where many non-ladder rank (clinical) faculty conduct significant research.

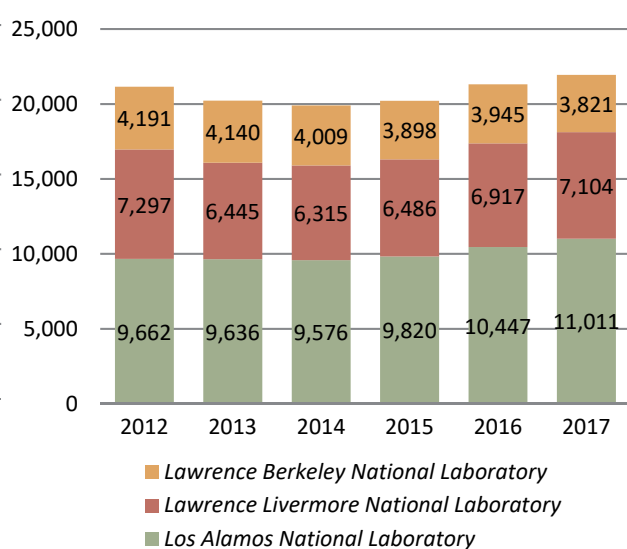
## 9.1 RESEARCH EXPENDITURES

The three UC-affiliated DOE National Laboratories conduct critical research on national nuclear security, alternative energy, conservation technologies and climate science.

**9.1.6** Annual expenditures, \$ millions  
UC-affiliated National Laboratories  
2012 – 2017



**9.1.7** Workforce headcount totals  
UC-affiliated National Laboratories  
2012 – 2017



Source: UC National Laboratories, US DOE

Of the 17 National Laboratories funded by the US Department of Energy, three are managed by the University of California. Lawrence Berkeley National Laboratory conducts unclassified research across a wide range of disciplines, including new energy systems, quantitative biology, nanoscience environmental solutions and integrated computing as a tool for scientific discovery.

Lawrence Livermore and Los Alamos National Laboratories are national security laboratories, working to ensure the safety, security and reliability of the nation's nuclear deterrence, to reduce global threats and to solve emerging energy challenges.

Together, the three labs operate annual budgets of over \$5 billion with a combined workforce of nearly 22,000.

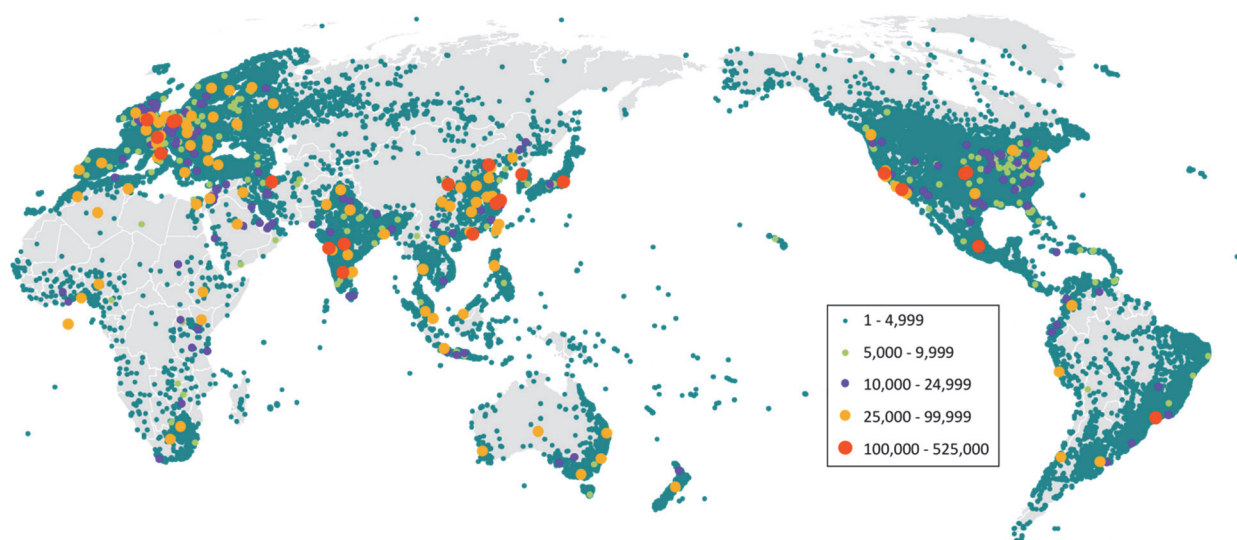
The National Laboratories also offer specialized research facilities accessible to UC faculty and the broader academic community. They provide researchers with some of the nation's most advanced tools of modern science, including cutting-edge, high-performance computing platforms for scientific research, advanced light sources and neutron sources. The three UC-affiliated National Laboratories offer nearly forty such facilities, including LBNL's National Energy Research Scientific Computing Center, LLNL's National Ignition Facility, and the Los Alamos Neutron Science Center.<sup>1</sup>

<sup>1</sup> <https://energy.gov/technologytransitions/technology-transitions-facilities-database>



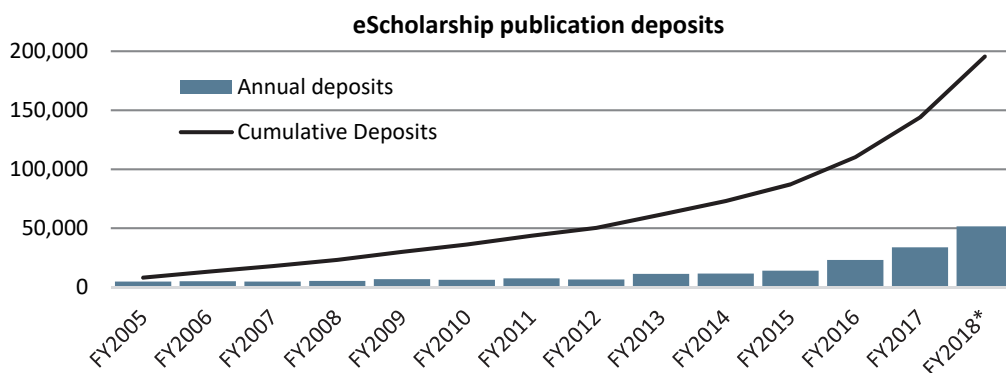
**UC's Open Access policies continue to add to a growing body of freely available research publications in eScholarship, UC's open-access repository and publishing platform, expanding the global reach of UC's research findings.**

**9.2.1 eScholarship downloads and deposits**  
Universitywide  
Through March 2018



This map shows the geographic distribution and concentration of article views for scholarly materials deposited in eScholarship, UC's open access (OA) repository managed by the California Digital Library. Since 2002, UC research in eScholarship has been viewed and/or downloaded over 40 million times by readers around the world. The repository contains nearly 200,000 individual items, including many articles, research reports, working papers, and the over 70 OA journals that are published on the platform.

Deposits to eScholarship have increased exponentially since the adoption of the UC Academic Senate's Open Access Policy in 2013, with faculty submitting nearly 12,000 articles under the policy in 2016-17 alone. The success of this policy has also helped encourage deposit of over 20,000 additional (non-policy related) scholarly materials in that same period - making even more UC scholarship publicly accessible to the world.



## 9.2 RESEARCH IMPACT

**The University of California is a major research presence at both the state and national levels, producing about nine percent of the nation's research publications.**

### 9.2.2 UC research publication performance, by Field-Weighted Citation Impact (FWCI) and discipline group Universitywide 2012 to 2017



Source: SciVal® database, Elsevier B.V., <http://www.scival.com> (downloaded April 19, 2017)

As a premier research university, UC creates and disseminates new knowledge. From intellectual exploration in the classroom and laboratory to pushing research findings out into the world through academic journals and other venues, the publication of UC's research findings creates an ever-growing foundation for scientific discovery and social impact.

Publication databases can be analyzed to develop measures of the output and impact of UC researchers. Using Elsevier's SciVal® tool, we can establish quantitative metrics that assess the University's research performance. SciVal's data analytics capabilities are built on Elsevier's Scopus® database, which contains 38 million publication records from over 20,000 journals and 5,000

publishers worldwide. It provides metrics and data visualizations on the University's research publications, citations, and usage data, enabling the University to identify research strengths, benchmark progress over time, and to identify and analyze opportunities for collaboration both across UC and with other institutions throughout the world.

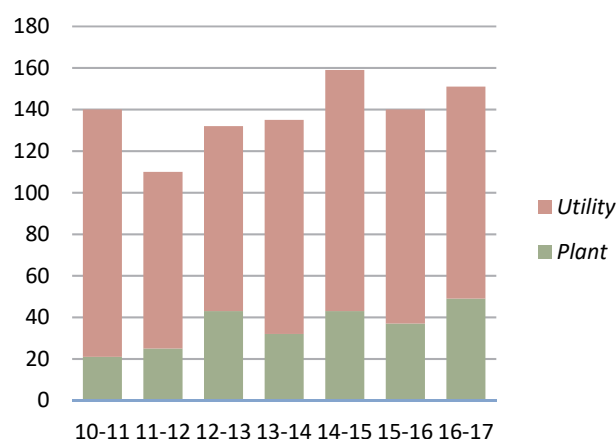
The quality and impact of UC research publications can be measured as well. One particularly useful metric is the Field-Weighted Citation Impact (FWCI), which takes into account the differences in research behavior across disciplines and normalizes publication impact against a global baseline. The FWCI can be used to benchmark the impact of individual or groups of publications regardless of differences in publication length, discipline, age and type. In any given disciplinary area, the global average FWCI is equal to 1.00; publications with FWCI greater than 1.00 have been cited more

frequently than would be expected based on the world average for similar publications, while publications with FWCI less than 1.00 have been cited less than would be expected based on the world average for similar publications. UC's average FWCI across the nearly 320,000 publications produced by its research workforce between 2012-17 is 2.02, or 102 percent greater than the global average.

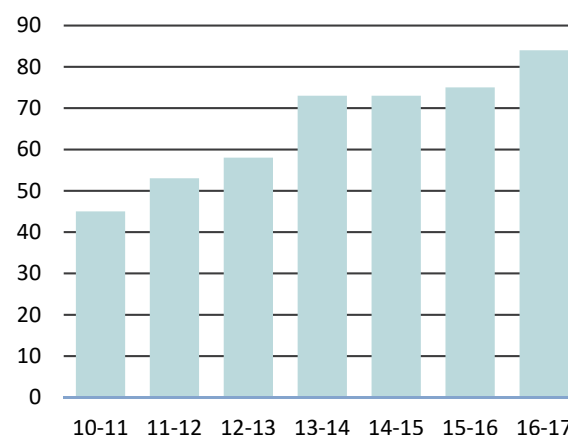
UC's publication impact is particularly high in the fields of arts and humanities, economics, computer science, engineering and medicine. Additionally, UC's multidisciplinary publications have a relatively high FWCI of 3.18, which indicates that UC research is at the forefront of discovery in emerging fields related to multiple traditional disciplines.

## Licenses issued in California contribute to successful businesses. The number of active plant and utility licenses in California is growing.

**9.2.3** New licenses for UC technology issued to California businesses  
2010–11 through 2016–17



**9.2.4** UC startups formed per year in California  
2010–11 through 2016–17



Source: UC Office of Innovation & Entrepreneurship

Research is part of UC's mission, and much of this research is basic, foundational research. Some UC research leads directly to new inventions and innovations; bringing them from the lab to the marketplace is part of UC's public service mission. Innovations from UC take two paths to the marketplace: they may be licensed to an existing company or they may become the cornerstone of a new startup. Both ultimately benefit the economy.

University inventions are classified as utility licenses or plant licenses. Utility licenses cover inventions protected by utility patents, such as processes, machines, manufactured items or compositions of matter. Utility licenses are often issued exclusively to the licensee. Plant licenses cover plant varietals, and are often licensed via nonexclusive licenses to nurseries and distribution centers. From the high-tech centers of San Diego and Silicon Valley to the agriculture of the Central Valley, UC technology is licensed throughout California. As of 2017, UC's license portfolio in California included 1,333 utility and plant licenses to 635 separate companies.

### UC technology licenses active in California, 2017

	Utility	Plant	Total
Active licenses	739	594	1,333
Number of licensees	484	151	635

UC startups are independently operating companies that were formed to commercialize a UC technology. The number of startups formed annually in California increased to 84 companies in 2017.