

RESEARCH

610 active startups

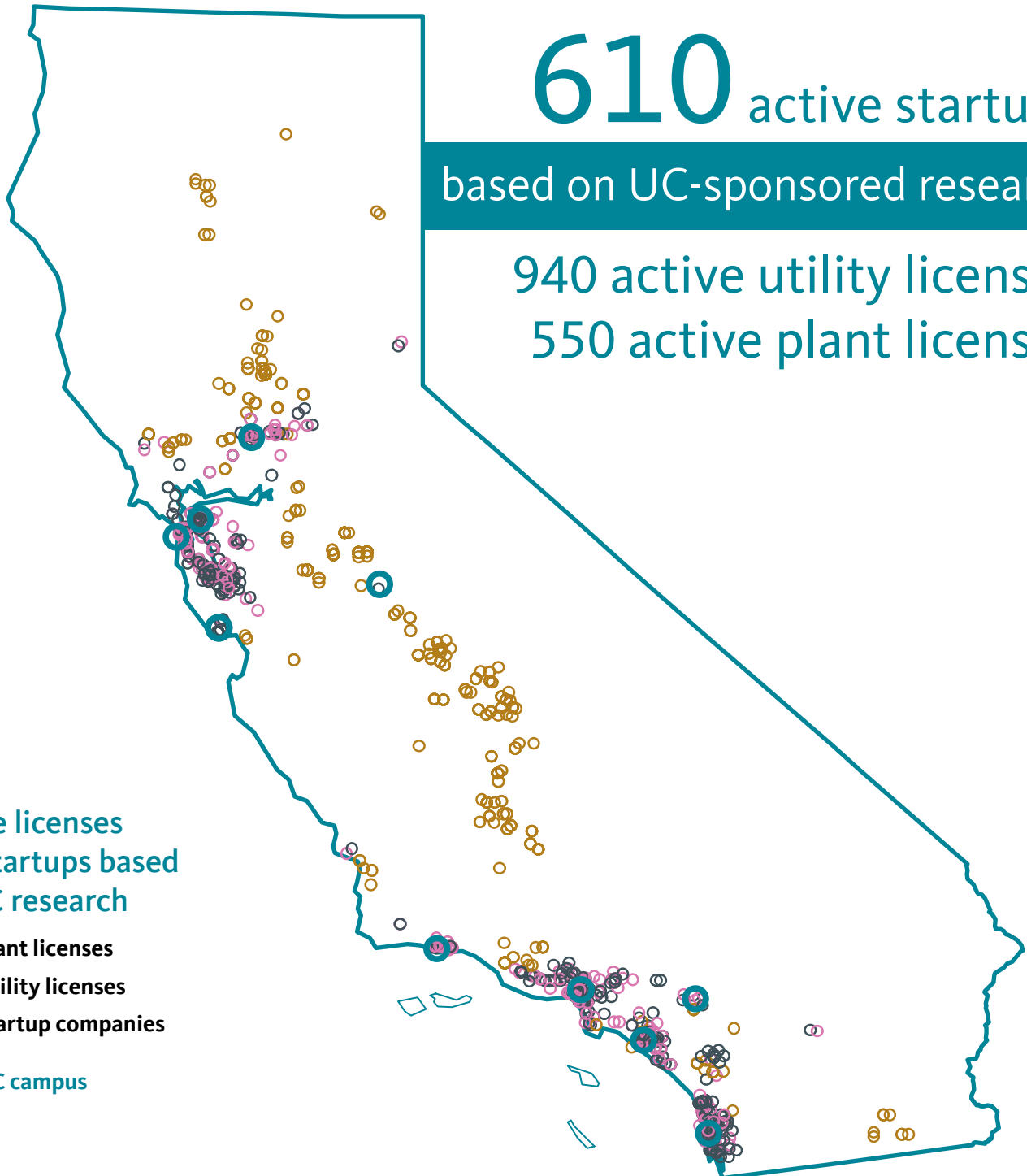
based on UC-sponsored research

940 active utility licenses

550 active plant licenses

Active licenses
and startups based
on UC research

- Plant licenses
- Utility licenses
- Startup companies
- UC campus



RESEARCH

The broad scope of UC research

The California Master Plan for Higher Education designates the University of California as the primary State-supported academic agency for research. UC research contributes to the state and to the nation through discoveries that improve health, technology, welfare, and the quality of life. Research represents the creation of new knowledge, which can be communicated, curated, and cultivated to benefit society.

UC has more than 800 research centers, institutes, laboratories, and programs that span ten campuses, five medical centers, three Department of Energy National Laboratories, and numerous other research facilities.

Breadth of vision has been a virtue of UC's research since the University's founding more than a century and a half ago. 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 understanding of ancient and modern histories, cultures, and languages; and mitigation strategies for climate change. The diversity of this vision contributes to society in ways often hard to predict at the outset.

As one example of this vision, UC's Research Grants Program Office (RGPO) oversees a broad grant-making portfolio of approximately \$110 million annually from a variety of sources, with over 500 active research awards that provide first-mover advantage to UC and California investigators. RGPO grants catalyze advances in new areas yet to be supported on a large scale by federal and other sources; they also aim to enhance research capacity and excellence across California, making it easier to attract and retain outstanding faculty, to further the careers of undergraduate, graduate, and postdoctoral researchers, and to promote research collaborations.

Evaluating the research enterprise

This chapter presents a largely quantitative description of UC's research. The sources of research funding influence the nature of the research. As California's land-grant university, UC's research enterprise has always received federal support for research, which today accounts for nearly half of all research funding at UC (9.1.1). Most research funds pay the salaries and benefits of the UC research community, of which faculty are only a small proportion (9.1.2). While UC 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 (9.2.4). Three Department of Energy national laboratories are affiliated with the University of California: Lawrence Berkeley National Lab, Lawrence Livermore National Lab, and Los Alamos National Lab. The national labs conduct research that is vital to the nation's security, energy future, sustainability, and human health.

This chapter also presents the impact of this research on society. One of the goals of research is the dissemination of important outcomes; the global distribution of downloads from the UC eScholarship repository (9.2.1) indicates how eagerly this knowledge is sought. The frequency with which UC research is cited is another indicator of its quality and importance (9.2.2). UC research advances the economy and global technical leadership through licenses resulting from UC-generated patents (9.2.3).

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 graduate and undergraduate students; or how thoughtful work in the arts and humanities furthers the understanding of ourselves as one species among many on this planet.

UC's research expenditures

While research expenditures track only some of this activity, they can indicate how research changes in scope and focus over time. They also can provide some relative sense of how research institutions compare to one another.

During 2019–20, direct expenditures for research at UC totaled over \$5.1 billion, with nearly half sourced from federal funds. Private sources account for about 22 percent — 14 percent from nonprofit organizations and eight percent from corporate sponsors. University funds derived from gifts, endowments, general funds, and other sources provided 18 percent. Over 60 percent of direct research expenditures in 2019–20 went to salaries and benefits. Of this, about one-quarter went to faculty; the majority supported staff researchers; and about one-quarter went to students and postdoctoral scholars. Faculty annual contracts are for only nine months, and their salaries and benefits are supported for the three remaining months on these grants.

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

In 2019–20, UC's indirect cost recovery for research was over \$1.2 billion. The true indirect costs of research, however, are typically higher than the rate research sponsors are willing to pay. Rates negotiated with federal agencies are below 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.

The research community

Research funds principally pay for people's time. Of the roughly 166,000 full-time equivalent (FTE) employees at the University, about 23,500, or 14 percent, were paid with research funds.

UC's research-funded FTE, 2019–20

Faculty	Postdoctoral scholars	Student employees	Other academic employees	Other staff employees	Research Total
2,185	3,925	3,978	3,446	9,961	23,494
9%	17%	17%	15%	42%	100%

While faculty serve as principal investigators for research projects, submitting proposals and managing the research, they make up only nine percent of the research community 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 4,454 postdoctoral researchers (roughly equivalent to 3,925 FTE). As shown in Indicator 5.1.4 of this report, postdoctoral scholars are most prominent in medical research and life science fields.

Research results — enhancing instruction

UC research enhances student preparation and 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. Students make up another one-sixth of the research workforce. In October 2020, about 9,500 students were employed as paid research assistants. Though most are graduate students, UC undergraduate students also participate in research; the 2020 UC Undergraduate Experience Survey found that about 36 percent of UC students had been involved in faculty-directed activity other than coursework.

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 quarter century, UC has secured more licensable patents than any other U.S. research university.¹ Since 1980, over 1,400 startup companies have been founded around UC inventions, with about 85 percent based in California. UC researchers submit nearly five new inventions per day in such diverse areas as 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 another way to demonstrate the results of research. This chapter compares the impact of UC research publications to global averages and to 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. 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. CDL is 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 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 nearly 200 books and over four dozen multi-issue journals annually. Of the nation's top

¹ <https://developer.uspto.gov/visualization/university-patent-count-expenditures>

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 2019–20, UC received grants funding 1,191 new clinical trial research projects in addition to 4,241 projects already underway. These projects represent a crucial stage in the journey from a scientific discovery to an effective treatment. The percentage of research awards devoted to clinical trials has grown over the past ten years, from about four percent in 2010–11 to 15 percent in 2019–20.

UC National Laboratories — science in the national interest

The three University of California-affiliated Department of Energy (DOE) 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. The Laboratories also support UC's educational mission.

Looking forward — uncertainties in federal research funding

With federal funding supporting about half of UC research, the vitality of the UC research enterprise is dependent on agencies whose funding is reviewed annually. Hence, long-term prospects for federal research sponsorship are always uncertain. However, UC is proactive in developing strong relationships with these agencies to advise them on funding priorities. The near-term future is promising for funding to support climate and environmental science, artificial intelligence, civil and cyber infrastructure, and medicine.

Whatever changes in priorities are embodied in the federal budget, one certainty is that 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 effort 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

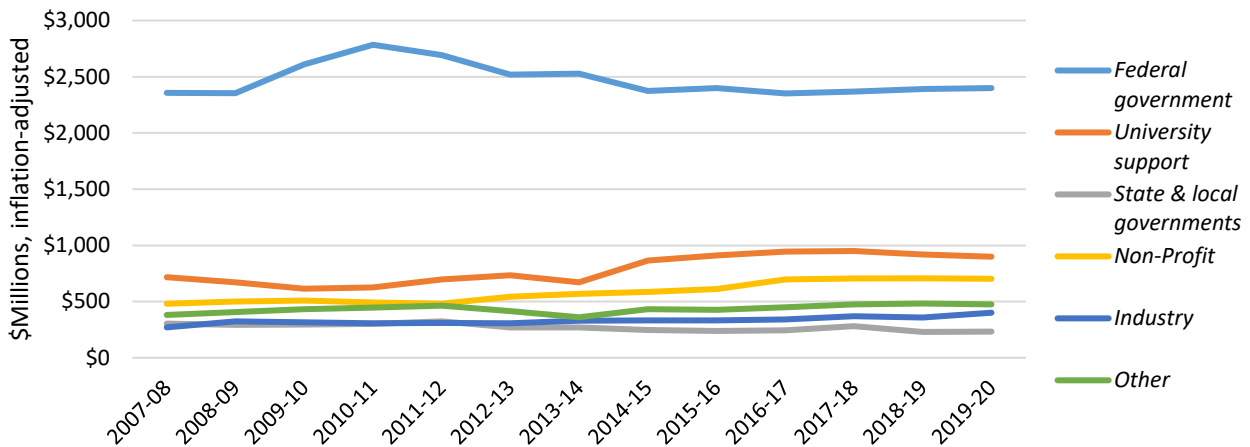
UCOP Research & Innovation: ucop.edu/research-innovation

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

9.1 RESEARCH EXPENDITURES

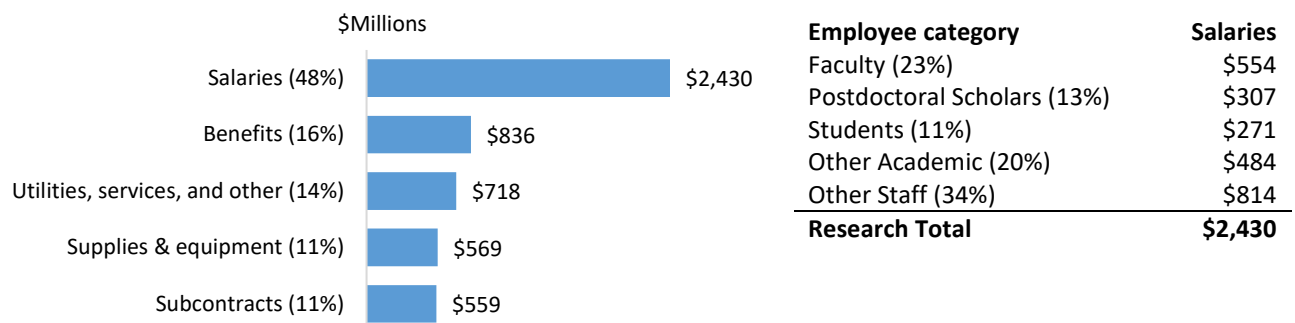
Federal funds support most of the research conducted at UC. Salaries and benefits represent more than half of all research expenditures.

9.1.1 Direct research expenditures by source, Universitywide, 2007–08 to 2019–20



Source: UC Corporate Financial System. Direct amounts have been adjusted for inflation and do not include accrual funds for postemployment retirement benefits or indirect cost recovery funds.

9.1.2 Direct research expenditures by cost type, Universitywide, 2019–20



Source: UC Corporate Financial System and Corporate Personnel System. Direct amounts do not include accrual funds for postemployment retirement benefits or indirect cost recovery funds.

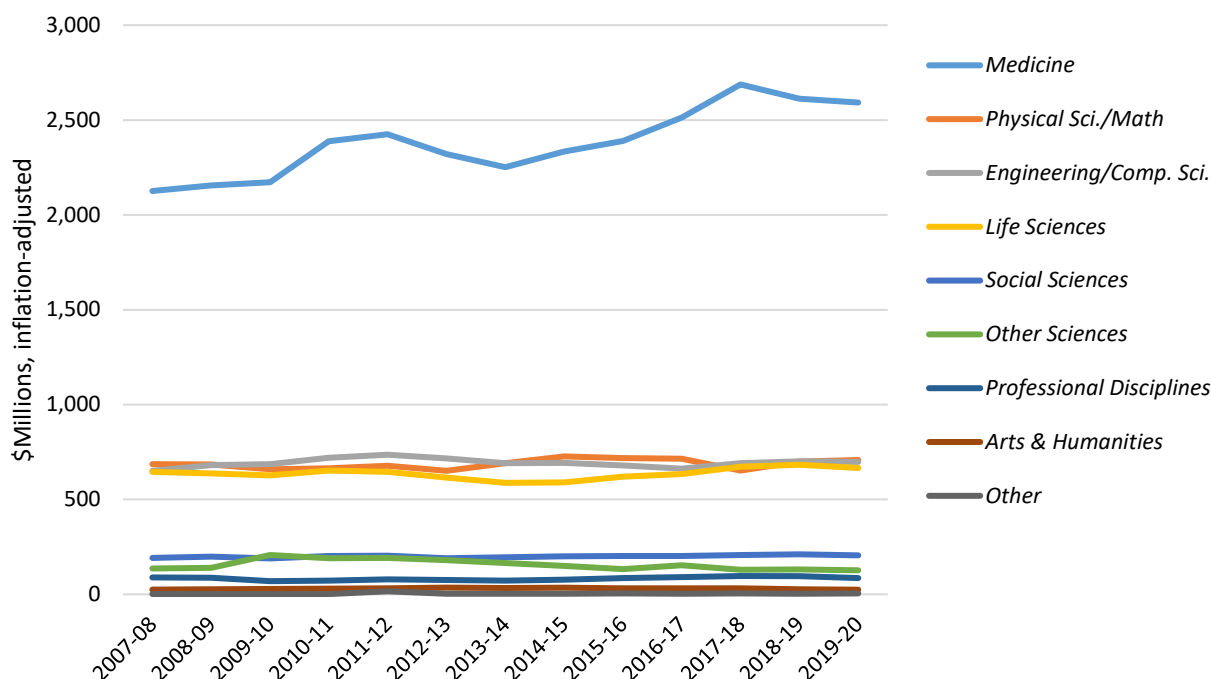
UC direct research expenditures for 2019–20 were about \$5.1 billion. Of this total, 47 percent came directly from federal agencies, one of the lowest shares in the last two decades. A further seven percent represents federal flow-through funds that came to UC from the State, corporations, nonprofits, or other universities. About three-quarters of UC's federal research support was provided by the National Institutes of Health and the National

Science Foundation. Federal cutbacks starting in 2006 ended a long period of growth. This trend was temporarily reversed during 2009–10 by the American Recovery and Reinvestment Act, which provided over \$1 billion in research funds to UC. After peaking in 2010–11, federal funds declined until 2014–15 and have remained essentially flat since then.

9.1 RESEARCH EXPENDITURES

Science, technology, engineering, and mathematics (STEM) and medical fields represent the majority of all research expenditures.

9.1.3 Direct research expenditures by discipline Universitywide 2007–08 to 2019–20



Source: UC Corporate Financial System. Direct amounts have been adjusted for inflation and do not include accrual funds for postemployment retirement benefits or indirect cost recovery funds.

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 figure 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.

These data reflect UC's continuing competitiveness in securing federal awards and its 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 five to six percent of the NIH annual appropriations for research and seven to eight percent of the NSF annual research appropriations.

9.1 RESEARCH EXPENDITURES

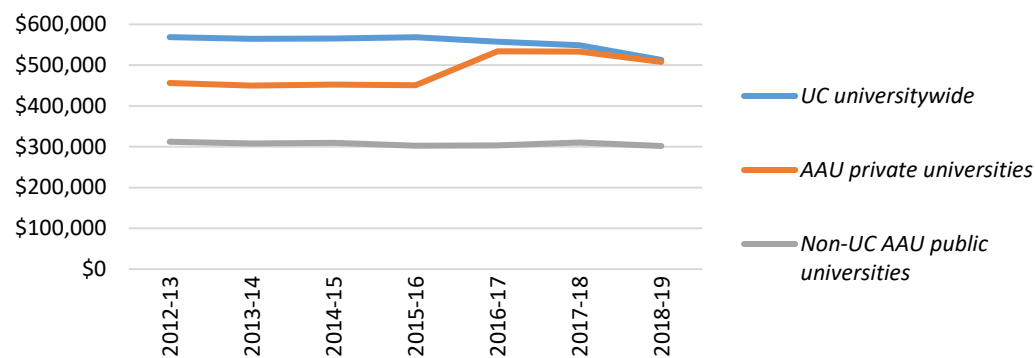
UC accounts for well over eight percent of all research expenditures at all US universities. Average research expenditures per ladder-rank faculty are higher at UC than its comparison peers.

9.1.4 Research expenditures US 4-year universities 2018–19

	Research expenditures	Percent of US total
UC Universitywide	\$5.4 B	8.6%
Other public universities	\$34.7 B	55.4%
Private universities	\$22.6 B	36.0%

Source: IPEDS. Excludes for-profit institutions, which conduct a negligible share of research. This figure is slightly different from UC's own figures due to differences in how IPEDS treats non-functional expenses.

9.1.5 Average inflation-adjusted research expenditures per ladder-rank faculty UC and AAU comparison universities 2012–13 to 2018–19



Source: IPEDS

In the most recent year available, UC spent an average of \$512,000 in externally sourced research funding per tenured and tenure-track faculty member, compared to \$508,000 per faculty member for Association of American Universities (AAU) private institutions, and \$302,000 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. The second-largest source of research support is the National Science Foundation.

With the exception of UC Berkeley, all of the top-ranked UC campuses for research expenditures per ladder-rank faculty have medical schools. Twenty-one out of the 27 AAU Private institutions and 22 out

of the 36 non-UC AAU Public institutions have an accredited medical school.

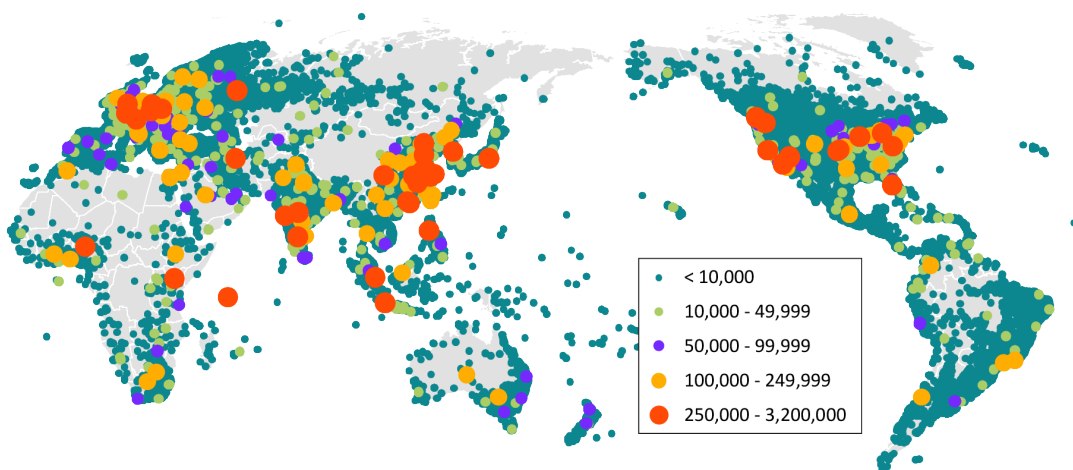
UC Location	Research expenditures per ladder-rank faculty
San Francisco*	\$3,581K
San Diego	\$653K
UC AVERAGE	\$512K
Los Angeles	\$516K
Berkeley	\$471K
Davis	\$383K
Irvine	\$258K
Santa Barbara	\$242K
Santa Cruz	\$215K
Riverside	\$183K
Merced	\$170K

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

9.2 RESEARCH IMPACT

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 views and downloads of UC scholarly materials Universitywide Through April 2021

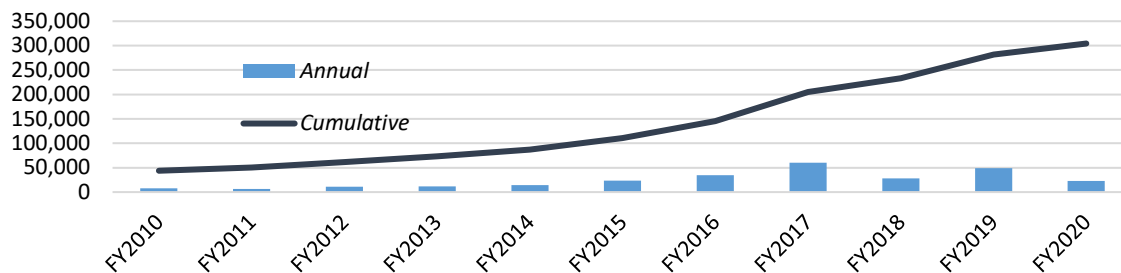


Source: California Digital Library

This map shows the geographic distribution and concentration of views for scholarly materials deposited in eScholarship, the UC open access (OA) publishing platform and repository managed by the California Digital Library. Since 2002, UC-sponsored research in eScholarship has been viewed and/or downloaded almost 90 million times by readers around the world. The repository contains over 300,000 individual items, including many articles, research reports, working papers, and the 80-plus OA journals that are published on the platform.

Deposits to eScholarship have increased substantially since the adoption of the UC Academic Senate's Open Access Policy in 2013, with faculty submitting almost 30,000 articles under the policy in 2020 alone. The success of this policy has also helped encourage the depositing of nearly 20,000 additional scholarly materials (pre-policy publications, electronic theses and dissertations, working papers, etc.) in that same period, making even more UC scholarship publicly accessible to the world.

eScholarship publication deposits



9.2 RESEARCH IMPACT

The University of California is a major research presence at both the state and national levels, with impacts above both global averages and AAU peers.

9.2.2 UC research publication performance, by Field-Weighted Citation Impact (FWCI) and discipline group Universitywide 2015 to 2020



Source: SciVal® database, Elsevier B.V., scival.com (downloaded March 31, 2021)

As a premier research university, UC creates and disseminates new knowledge. The publication of UC research findings creates an ever-growing foundation for scientific discovery and social impact.

The quality and impact of UC research publications can be characterized by the Field-Weighted Citation Impact (FWCI) SciVal® tool, which was created by Elsevier. The FWCI tool takes into account differences in research publication practices across disciplines and normalizes impact against a global baseline. The FWCI tool can benchmark the impact of publications regardless of differences in

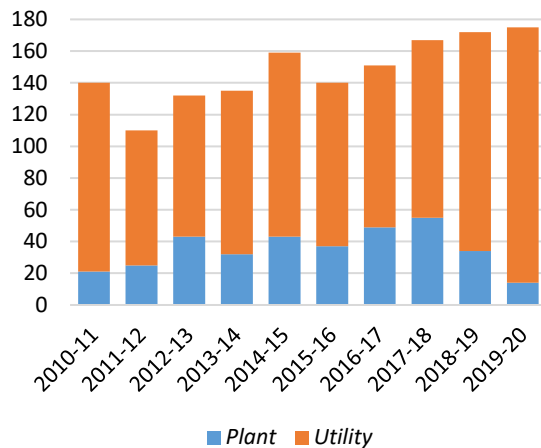
publication length, discipline, age, and type. In any given disciplinary area, the global average FWCI is equal to 1.00; publications with FWCI greater than 1.00 have been cited more frequently than would be expected, while publications with FWCI less than 1.00 have been cited less than would be expected. The UC average FWCI is 1.96, or nearly twice the global average.

UC's publication impact is particularly high in the fields of arts and humanities, economics, computer science, engineering, and medicine.

9.2 RESEARCH IMPACT

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 patents issued to California businesses, Universitywide, 2010–11 to 2019–20



UC patent licenses active in California, June 30, 2020			
	Utility	Plant	Total
Active licenses	921	553	1,474
Number of licensees	580	134	714

Source: UC Knowledge Transfer Office

UC research often leads directly to new patentable inventions and other innovations; bringing them to the marketplace is part of the UC public service mission. UC inventions take two paths to the marketplace: they may be licensed to an existing company or they may become the cornerstone of a new startup company.

Invention commercialization promotes technological advances, generates economic benefits and helps support UC’s research enterprise. UC’s patents are commercialized under utility licenses and plant licenses.

Utility licenses cover inventions protected by utility patents, such as processes, machines, manufactured items, or compositions of matter, and are often issued exclusively to a single licensee. Plant licenses cover plant cultivars and are often licensed non-exclusively to nurseries and distribution centers.

From the high-tech centers of San Diego and Silicon Valley to the agriculture of the Central Valley, UC licenses its technologies throughout California. As of June 30, 2020, UC’s license portfolio in California included 1,474 active utility and plant licenses to 714 separate companies.