

# 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 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, and 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. Federal support initiated UC's research mission and provides nearly 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 (9.2.4). Three National Energy Laboratories are affiliated with the University of California, conducting research that is vital to the nation's security and energy future.

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 with 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 (9.2.3, 9.2.4).

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

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 2018–19, direct expenditures for research at UC totaled over \$4.9 billion, with federal funds providing nearly half. Private sources account for about 21 percent — 14 percent from nonprofit organizations and seven percent from corporate sponsors. About one-quarter represented the University’s own funds derived from gifts, endowments, general funds, and other sources. Over 60 percent of research expenditures in 2018–19 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.

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 2018–19, UC’s indirect cost recovery for research was over \$1.1 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 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.

### The research community

Research funds principally pay for people’s time. Of the roughly 163,000 full-time equivalent (FTE) employees at the University, about 26,400, or about 16 percent, were paid with research funds.

**UC’s research-funded FTE, 2018–19**

Faculty	Postdoctoral Scholars	Students	Other Academic	Other Staff	Research Total
2,597.9	4,769.5	4,600.3	3,954.4	10,491.2	26,413.2
10%	18%	17%	15%	40%	100%

While faculty serve as principal investigators for research projects, submitting proposals and managing the research, they make up only ten 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 over 4,700 FTE postdoctoral researchers. 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'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. Students make up another one-sixth of the research workforce. In 2018–19, about 24,500 students were employed as paid research assistants. Though most are graduate students, UC undergraduate students also participate in research; the 2018 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 quarter century, UC has secured more licensable patents than any other U.S. research university.<sup>1</sup> 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 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 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. 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 2018, UC celebrated 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 2018–19, UC received grants funding 1,152 new clinical trial research projects in addition to 3,644 projects already underway. These projects represent a crucial stage in the journey from a scientific discovery to an effective

---

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

treatment. Of the research dollars that came to UC from businesses during 2018–19, 13 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 41 Natural Reserve System (NRS) sites around California. Most of UC’s climate science work is funded by federal agencies.

### 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, four percent of the workforce are postdocs, and at LANL, 13 percent are postdocs or student assistants.

### Looking forward — uncertainties in federal research funding

With federal funding supporting about half of UC’s research, the vitality of UC’s research enterprise is dependent on agencies whose funding is reviewed annually. Long-term prospects for federal research 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 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

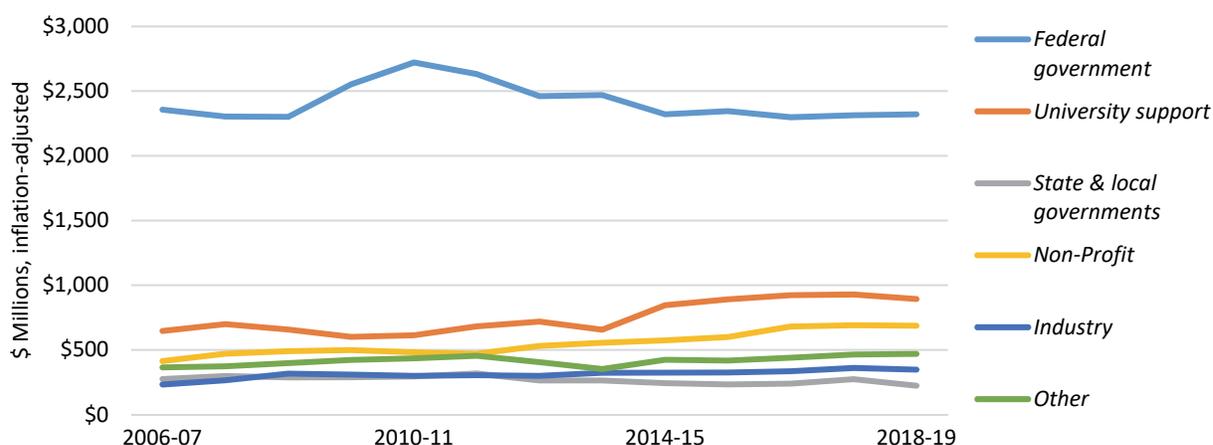
UCOP Research & Innovation: [ucop.edu/research-innovation](https://ucop.edu/research-innovation)

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](https://ucop.edu/institutional-research-academic-planning/files/UC-research-impacts-in-california.pdf)

## 9.1 RESEARCH EXPENDITURES

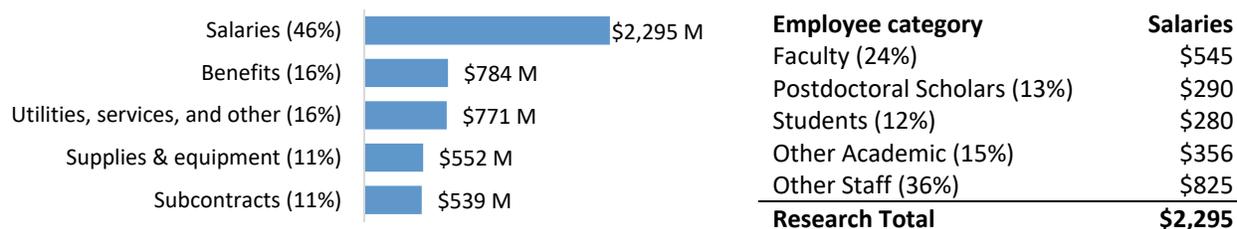
### Federal funds support most of the research conducted at UC. Salaries and benefits represent more than half of all research expenditures.

#### 9.1.1 Direct research expenditures by source Universitywide 2006–07 to 2018–19



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 2018–19



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.

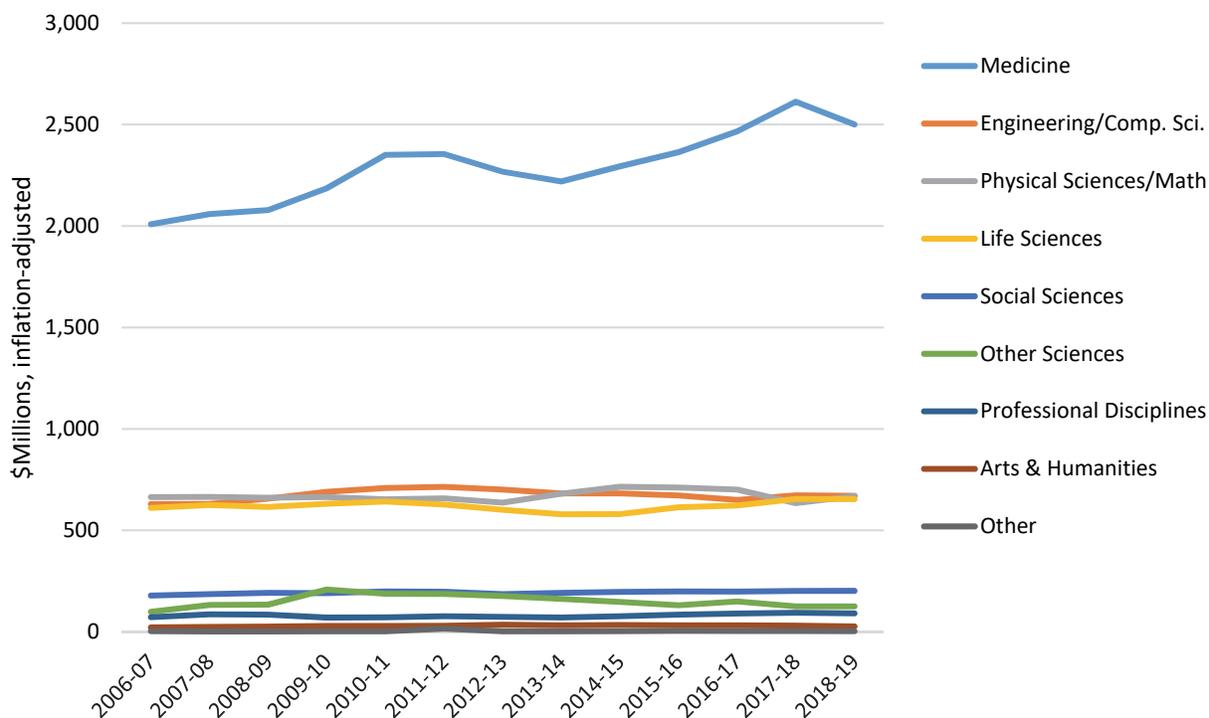
UC's direct research expenditures during 2018–19 were about \$4.9 billion. Of this, 47 percent came directly from federal agencies, one of the lowest shares in the last two decades. A further seven percent represents federal flow-through funds that came to UC from the state, corporations, nonprofits, 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 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. When over \$1 billion in recovered indirect costs are included, UC's 2018–19 research expenditures amounted to nearly \$6 billion, almost one-fifth of UC's total expenditures.

The majority of research expenditures pay the salaries and benefits of UC's research workforce.

## 9.1 RESEARCH EXPENDITURES

### 9.1.3 Direct research expenditures by discipline Universitywide 2006–07 to 2018–19



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 reflects the availability of funding and parallels the nationwide pattern.

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 five to six percent of NIH’s annual appropriations for research and seven to eight percent of NSF’s annual research appropriations.

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.

## 9.1 RESEARCH EXPENDITURES

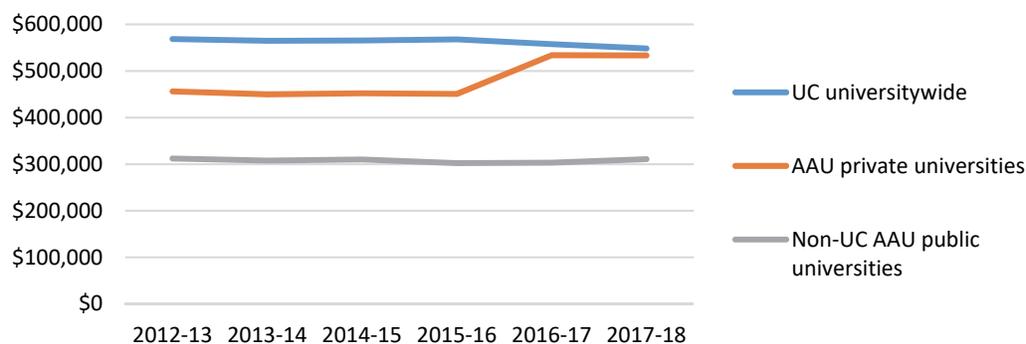
**UC accounts for nearly nine percent of all research expenditures at all US universities. Average research expenditures per ladder-rank faculty are higher at UC than its comparison peers.**

### 9.1.4 Research expenditures US 4-year universities 2017–18

	Research expenditures	Percent of US total
UC universitywide	\$5.6 B	9.2%
Other public universities	\$33.2 B	54.5%
Private universities	\$22.1 B	36.4%

Source: IPEDS. Excludes for-profit institutions, which conduct a negligible share of research.

### 9.1.5 Average inflation-adjusted research expenditures per ladder-rank faculty UC and AAU comparison universities 2012–13 to 2017–18



Source: IPEDS

UC faculty are extremely successful at attracting research support from both government and private sponsors. In the most recent year available, UC on average spent \$549,000 in externally sourced research funding per tenured and tenure-track faculty member, compared to 534,000 per faculty member for Association of American Universities (AAU) private institutions, and \$311,000 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.

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.

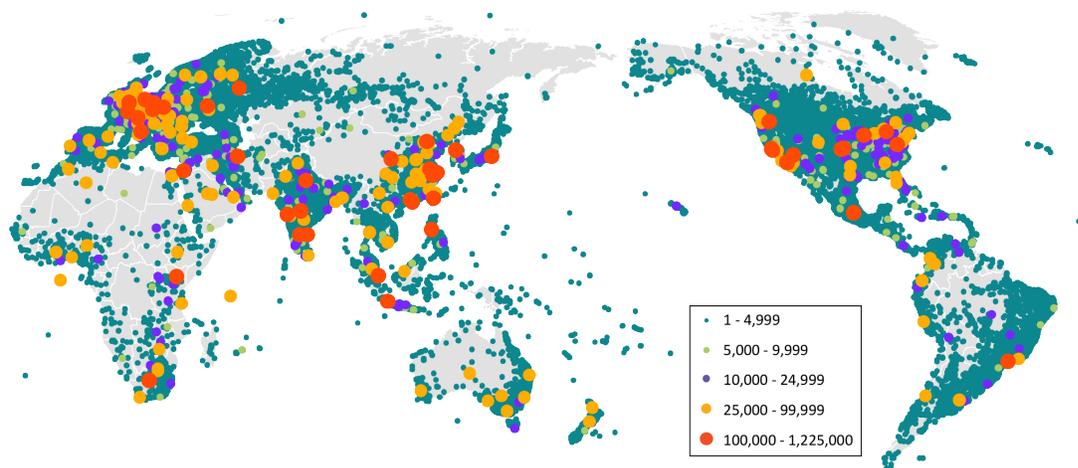
UC Location	Research expenditures per ladder-rank faculty
San Francisco*	\$3,968,000
San Diego	\$687,000
<b>UC AVERAGE</b>	<b>\$549,000</b>
Los Angeles	\$535,000
Berkeley	\$479,000
Davis	\$414,000
Irvine	\$283,000
Santa Barbara	\$239,000
Santa Cruz	\$210,000
Riverside	\$182,000
Merced	\$158,000

\*UC San Francisco is an exclusively health sciences campus, where many non-ladder rank (clinical) faculty also conduct significant research. The average excluding UCSF is \$431,000.

## 9.2 RESEARCH IMPACT

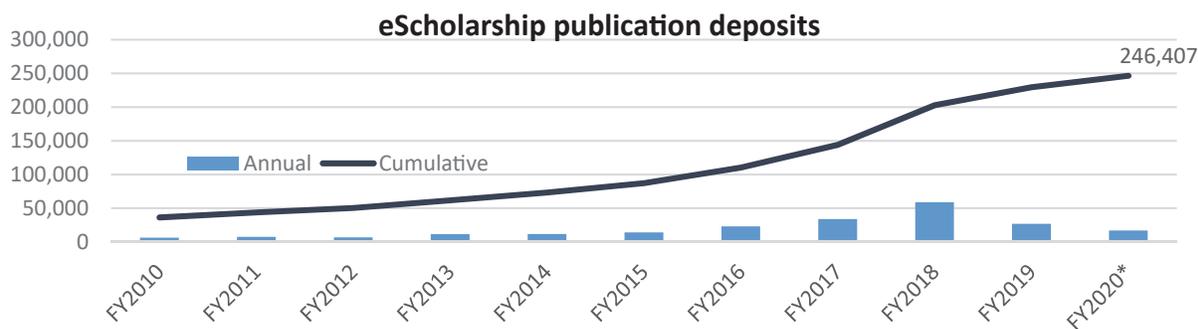
**UC’s Open Access policies continue to add to a growing body of freely available research publications in eScholarship, UC’s open-access repository and publishing platform, expanding the global reach of UC’s research findings.**

### 9.2.1 eScholarship downloads of UC scholarly materials Universitywide Through March 2020



This map shows the geographic distribution and concentration of views for scholarly materials deposited in eScholarship, UC’s 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 over 66 million times by readers around the world. The repository contains nearly 250,000 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 over 11,000 articles under the policy in 2018–19 alone. The success of this policy has also helped encourage the depositing of almost 12,000 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.



\* Partial-year data

## 9.2 RESEARCH IMPACT

The University of California is a major research presence at both the state and national levels, producing nearly ten percent of the nation’s research publications.

### 9.2.2 UC research publication performance, by Field-Weighted Citation Impact (FWCI) and discipline group Universitywide 2014 to 2019



Source: SciVal® database, Elsevier B.V., scival.com (downloaded March 18, 2020)

As a premier research university, UC creates and disseminates new knowledge. The publication of UC’s 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 a metric created by Elsevier’s SciVal® tool called the Field-Weighted Citation Impact (FWCI), which takes into account differences in research publication practices across disciplines and normalizes impact against a global baseline. The FWCI can benchmark the impact of publications regardless of differences in publication

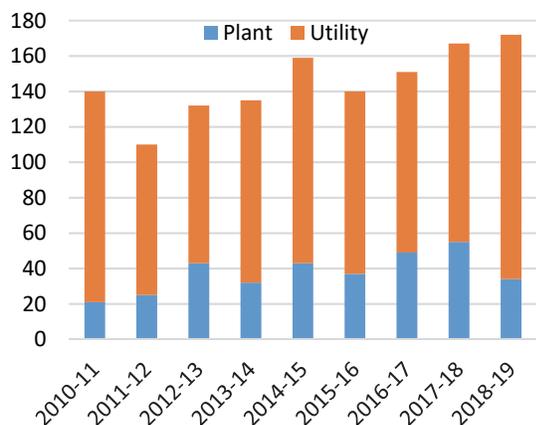
length, discipline, age, and type. In any given disciplinary area, the global average FWCI is arbitrarily taken to be equal to 1.00; publications with FWCI greater than 1.00 have been cited more frequently than would be expected, while publications with FWCI less than 1.00 have been cited less than would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

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

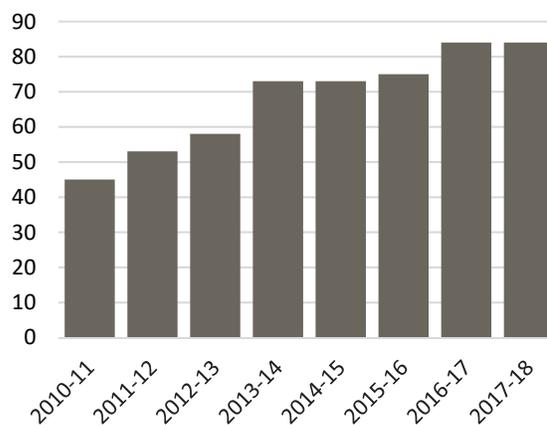
## 9.2 RESEARCH IMPACT

### 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 2018–19



#### 9.2.4 Startups based on UC patents formed in California, Universitywide, 2010–11 to 2017–18



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 UC’s public service mission. UC’s 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. 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

nonexclusively 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, 2019, UC’s license portfolio in California included 1,353 active utility and plant licenses to 655 separate companies.

#### UC patent licenses active in California, June 30<sup>th</sup>, 2019

	Utility	Plant	Total
Active licenses	801	552	1,353
Number of licensees	493	131	624

UC startups are independently operating companies that were formed to develop and commercialize a UC technology. During fiscal year 2018, 84 startups based on UC technology were formed.