INNOVATE 2 INNOVATION

An Assessment of California's Innovation Ecosystem

Phase I Report

Prepared for the California Legislature
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Prepared by
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Executive Summary

In 2010, a bi-partisan group of California Legislators asked the California Council on Science and Technology (CCST) to assess California's Science and Technology (S&T) Innovation Ecosystem. CCST designed a two-phase approach: first, this preliminary report to coincide with the opening of the 2011 Legislature and the gubernatorial transition; and, second, submission of a detailed set of recommendations in May 2011.

In the face of a statewide fiscal crisis and a rapidly changing global landscape, California needs once again to do what it does best: "innovate its way to innovation." This report offers a specific list of actions that legislators can take to catalyze California's innovation ecosystem. The initial steps to explore these actions can be accomplished without a commitment of new state funding rather through reallocation of existing resources, philanthropic funding, and contributions of time. Establishing California's priority to "innovate its way to innovation" is timely in light of recent passage of the federal America COMPETES Authorization Act of 2010, which is designed to increase federal support for research, science and innovation.

Recommendations

The challenge facing California is not that it has too few technology initiatives, research assets or even special R&D funds on the supply side. The problem over the past several decades is that California does not have an innovation strategy that effectively supports interaction between our research assets (world-class universities and federal laboratories) and industries that connects the demand side more effectively to California's wealth of R&D resources. CCST's recommendations aim to bridge this gap.

Innovation Action Team: The primary recommendation is to bring together public and private leaders who are given a specific charge to focus on California's innovation and competitiveness infrastructure. An Innovation Action Team (IAT), comprised of leaders from universities, industry, and government, should be tasked to develop an Innovation Roadmap that will include specific recommendations for Improving Critical Innovation Infrastructure in California. This Innovation Action Team would be convened for this specific purpose over a defined period of approximately 12 months. Facilitated and staffed by CCST, this team would provide their recommendations to the Legislature. The focus of the Innovation Action Team would be to develop the following:

Innovation Roadmap

CALIFORNIA INNOVATION INITIATIVE: Identify and build support for specific actions to promote the effective and timely translation of research into use (design to delivery). These actions could include institutional and policy innovations, multi-sectoral financing, legislation, and public and stakeholder communication. The Initiative will begin with extensive collaboration among the Legislature, administration, and networks of industry, entrepreneurs, universities, federal research laboratories and nonprofits.

COMMUNITIES OF INNOVATION: Strategic planning and investment will support the development of communities of innovation through the co-location of federal, state and private science and technology assets (e.g., Federal Research Laboratories and Public and Private Universities) to address state challenges and to promote innovation, entrepreneurship, knowledge transfer, and job creation.

Improve Critical Innovation Infrastructure

CALIFORNIA EDUCATION INNOVATION CONSORTIUM: An educator-driven alliance to fund, develop and deploy effective practices for K-16 digitally enhanced education. This would engage the broader use of technology to support the learning of students of varying levels and backgrounds, and to train the workforce needed to surpass global competition.

SCIENCE AND TECHNOLOGY-BASED WATER ROAD MAP: Engagement of a broad segment of California's S&T community to innovate across the water system end-to-end, linking water and energy technology, agriculture and biotechnology, and climate and conservation strategies. This would entail using best practices and new approaches to utilizing information systems, biotechnology, and advanced water technologies.

Background

California's innovation ecosystem achieved world leadership in the last century because of its system of higher education, high-talent workforce, advanced technical infrastructure, and enlightened policies. These perishable assets must be continually renewed. Today this renewal is more critical than ever because of the unprecedented international competition for both California's markets and its innovation workforce.

Noting the changing global landscape, in 2010, a bi-partisan group of California Legislators asked the California Council on Science and Technology (CCST) to assess California's Science and Technology (S&T) Innovation Ecosystem. CCST designed a two-phase approach, with this preliminary report to coincide with the opening of the 2011 Legislature and the gubernatorial transition followed by delivery of a detailed set of recommendations in May 2011.

In late 2010, CCST convened a series of regional roundtables with industry and research leaders across the state to seek their input on the challenges faced by California and possible solutions that could be achieved building from California's S&T capacity. From these meetings, CCST identified two key strategies essential to achieve this task:

- Developing and leveraging public-private partnerships linking California's assets in education, research, technology, finance, and philanthropy to create social and technical innovations that competitors with less complete infrastructure cannot match.

- Enlisting California's S&T community in finding solutions to two of the state's major challenges, education and water, and, in so doing, enhancing California's international competitiveness.

Building on these two key strategies, the recommendations above emerged in the regional roundtable meetings. Each of the recommendations received broad support in these discussions and the participants believed they merited further development, in support of CCST's goal for the final report to legislators in May 2011.

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Introduction

On May 17, 2010, thirteen members of the California Legislature requested that the California Council on Science and Technology (CCST) conduct a comprehensive assessment of California's science and technology (S&T) innovation ecosystem. Specifically examining human capital, investment, and infrastructure; this assessment is to analyze and report on current global innovation systems, and recommend to the Legislature actions that should be taken to sustain the state's role as a global leader in science and technology. A purpose of this assessment is to identify ways that California's businesses, universities, research institutions and governments can work together to accelerate the application of our R&D capacity to help address the state's challenges and promote commercialization, entrepreneurship and job creation.

Innovation is the key driving force of economic growth, especially in developed economies. In encouraging innovation we need to remember that innovation is more than technology, and that it is not confined only to certain sectors, such as computing or biotechnology. Perhaps it would be clearer if we called it "ingenuity" – the creation of additional economic value through the recombination of knowledge in any sector, in any place.[1]

The challenge facing California is not that it has too few technology initiatives, research assets or even special R&D funds on the supply side. The problem over the past several decades is that California does not have an innovation strategy that effectively supports interaction between our research assets and industries that connects the demand side more effectively to California's wealth of R&D resources.

CCST's examination and recommendations take into consideration the necessary talent, critical components of the entrepreneurial environment (especially investment and public policy), and effective catalyzing of partnerships. The final report will include a summary of the exceptional attributes of the state's federal laboratories, universities, and other unique facilities and networks while discerning what game-changing possibilities are on the horizon for California by maximizing the value and competencies of these organizations.

Specifically, CCST has undertaken a comprehensive examination and analysis to:

- Assess the condition of California's S&T economy, describing the overall S&T innovation ecosystem in the current global economy.
- Recommend actions for maintaining S&T leadership and competitiveness in an increasingly globalized economy, and facilitating new job opportunities through entrepreneurship and education.
- Focus on two over-arching issues for California: 1. digitally designed education, and 2. water.

The purpose of this Phase 1 Report of CCST's Innovation Ecosystem Assessment is to help inform the Legislature in preparing potential legislative initiatives and transition plans of the new governor. This initial report presents the findings from the CCST convened regional roundtables, initial points of analysis of the state's innovation ecosystem, and a framework for the full i2i Innovation Ecosystem Assessment that will be delivered to the Legislature, along with a more detailed set of recommendations in May 2011. The regional roundtables took place between October 26 and 29, 2010 and were hosted by UC Merced, Stanford, CSU San Marcos, CSU Los Angeles, and NASA Ames. Additional education-focused roundtables were held at CSU East Bay and also in Orange County and San Diego.

In the sections that follow, an initial assessment of California's global competitiveness is outlined. The innovation ecosystem, communities of innovation and the two areas of strategic focus – education and water – are presented, and the core results of the regional roundtables are described. In addition, recommendations for Phase 2 of the assessment are laid out. This report includes as well, detailed appendices for the framework for the comprehensive assessment, current federal lab partnerships, and academic R&D funding.

Competitive Assessment

In 1999, the California Council on Science and Technology prepared the California Report on the Environment for Science and Technology (CREST) which provided, for the first time, a comprehensive assessment of the present status and long term trends affecting the science and technology infrastructure in California.

It is now time to update the findings of the CREST report given increasing global and domestic competition, rapidly changing technology, and dramatic shifts in finance in the past decade; and Phase 2 of this effort will accomplish this. Phase 2 of CCST's Innovation Ecosystem Assessment will provide a comprehensive assessment of California's innovation system. The framework for this comprehensive assessment creates an Innovation Index allowing for ongoing measurement of the state's innovation "ecosystem" of assets (R&D and talent), innovation process (patents, licenses), and outcomes (employment, wages). See Appendix A for this framework and the analysis of selected indicators presented in this section.

SOME KEY FINDINGS OF THE 1999 CREST REPORT

- California reported high rates of technology industry leadership and strong research and development (R&D) activity, but there was a need for more partnership between industry and academia to expand the state's research base and promote commercialization
- While the state's academic research was excellent quality, California was losing ground to other high-tech states in commercially crucial technology fields
- Federal labs are a major asset, but better use could be made by state government and industry
- California is the world leader in venture capital investment with the opportunity to consider other early-stage market-driven funding methods for small business startups
- It is essential to improve K-12 education, expand teacher education programs at CSUs and UCs, and focus on community colleges and the expansion of lifelong learning and skills development

California is a global leader in innovation. The state is home to world-class companies and R&D facilities which are designing the next technological breakthroughs. However, the world is changing rapidly. (See Appendix B for global comparisons.) Through technological advance, the political opening of vast new markets, and human ambition, new and formidable economic players have entered the arena. Instead of viewing our new context as a zero-sum game in which one region's gain is another region's loss, it is important to recognize the opportunities that emerge through the new access to creative resources and untapped markets.

In order for California to maintain its leadership role in the global innovation system, the state must maintain its capacity for attracting global talent and investment and better leverage the innovation assets it currently possesses. Central to achieving these two points is sustaining a world-class comprehensive educational system that will produce talent competitive in the global market, attract talent from around the world, and fuel the innovation processes in the state.

How is California's Innovation System faring in terms of generating new ideas, attracting global talent, and generating new talent locally?

California is a global innovation leader by multiple measures such as R&D activities and patent generation. However, a better understanding of the talent resources underlying the state's success sheds light on the sustainability of the state's innovation system.

California remains the nation's leading technology state, ranking 1st overall in R&D expenditures.

The majority of this funding comes from industry and the federal government, including federal labs supported by Department of Energy, Department of Defense and NASA as well as grants and contracts from the National Institutes of Health. According to the National Science Foundation, R&D spending in California totaled $71 billion in 2006 across all funding sources.[2]

Federal obligations to public and private facilities equaled $21 billion in 2006. Much of this funding supports the operations at federal labs located in the state, which are important to the state's innovation system. Some of these labs are exploring new ways of working with the private sector. A discussion of how the state's federal assets can be leveraged with academic and industry resources to promote entrepreneurship and commercialization within "communities of innovation" is provided in Appendix C.

CALIFORNIA R&D PERFORMANCE		STATE RANKING
TOTAL R&D, 2006	$71 Billion	1
Industry, 2006	$58 Billion	1
Federal Obligations, 2006	$21 Billion	1
Academic, 2007	$6.7 Billion	1

California is the top state in patent registrations.

Over the last two decades, the number of patents registered by primary inventors located in the state has increased in number and as a percentage of the U.S. total. In 2009, the state accounted for 25 percent of total U.S. patents, up from 15 percent in 1990. From 2008 to 2009, the number of registrations in the state increased eight percent while total U.S. registrations increased six percent.

California attracts 50 percent of all U.S. venture capital (VC) investment.

In 2000, California accounted for only 41 percent of total U.S. investment. After declining from the peak in 2000, in 2010, investment in the state increased 17 percent over the previous year reaching nearly $11 billion. This marks the first improvement in VC investment since 2007. Over time, investment patterns have shifted across industries and reveal new areas of opportunity. While Software attracts the largest sums of VC investment, its percentage of total investment continues to diminish as other industries attract more funding. Investment in Industrial/Energy has grown robustly since 2002 and has continued strongly in Biotechnology and Medical Devices. Between 2009 and 2010, VC increased 188 percent in Telecom, 50 percent in Computers, 76 percent in Consumer Products, and 44 percent in IT Services.

One of California's strongest assets is its diverse workforce.

Much of the state's talent comes from outside the state and country. Compared to the U.S., the state depends on larger shares of foreign talent to fill its science and engineering (S&E) jobs. While foreign-born talent is expanding as a percentage of the total workforce across the U.S. and across all occupations, foreign-born talent is growing fastest as a share of S&E occupations in California. Increasing five percent, foreign-born S&E talent made up 38 percent of all S&E talent in the state in 2009, up from 33 percent in 2000. Across all occupations, foreign-born talent in the state increased only one percent. Nationally, foreign-born S&E talent increased three percent from 2000 to 2009.

California's world-class universities serve critical roles in the state's innovation system.

The state's universities perform basic science as well as applied research and development. They develop the state's youth into world-class talent and also attract global talent through their reputation of excellence.[3] In 2006, over half of the state's foreign-born S&E talent was between the ages of 18 and 30 upon entry into the U.S.[4] The number of S&E degrees conferred to nonpermanent residents has been on the rise. Since 1995, S&E degrees conferred to foreign students increased 69 percent in California and 34 percent nationally. A discussion of international student flows is provided in Appendix D.

It is important that California continues to attract talent from abroad in order to grow the state's diverse talent base and to strengthen its global connections; however, it is also essential that the state prepare its own youth for a world-class education and global labor market.

As opportunities grow in other parts of the world, the state's pull of global talent will likely diminish. Today the state has technology leadership to solve its problems but must develop the talent to continue to develop and apply that technology into the future.

UNIVERSITIES HAVE ESSENTIAL ROLE IN INNOVATION

Universities serve a vital function in an innovation system in the creation of new knowledge, and the building of networks as well as the development of talent. An innovation system requires a highly skilled workforce, and higher education institutions train graduates and undergraduates in a wide range of fields relevant to all aspects of innovation including professionals marketing and finance, as well as educators and research scientists. Building our knowledgebase, universities codify useful knowledge in form of publications, patents and prototypes. They advance technological breakthroughs by creating new scientific instrumentation and methodologies.

Universities form networks and stimulate interaction through conferences, entrepreneurship centers, alumni networks, and personnel exchanges. Facilitating interaction between users and suppliers of technology will increase the capacity for scientific and technological problem-solving. Examples of this include contract research, cooperative research with industry, technology licensing, faculty consulting, and access to specialized instrumentation and equipment. Such productive interactions can spawn the creation of new firms, and universities can support this through licensing, incubation, financing and science parks.[5]

How well is the state investing in its future competitiveness and preparing its youth?

California ranks at the bottom of the nation in terms of math and science proficiency for eighth graders. In 2009, the state's eighth graders ranked third to last of all states, the District of Columbia and Department of Defense schools. In science proficiency, the state ranked second to the bottom of 45, tying with Hawaii and scoring above Mississippi.

California students in pursuit of a college degree are faced with multiple challenges.

The first challenge is in the acquisition of the skills required for admission into the UC and CSU systems. The second challenge is in the ability to pay the rising costs of tuition. The per student State of California general fund spending has dropped significantly since 2007. To help fill this funding gap the universities are increasingly turning to higher-paying students from outside the state and abroad.

While California currently remains a leader in technology assets, the state's talent base is increasingly at risk. California must vastly improve the development of local talent while continuing to attract talent from abroad in an increasingly competitive global marketplace.

EIGHTH GRADE MATH AND SCIENCE PROFICIENCY

	MATH 2009		SCIENCE 2005	
TOP FOUR STATES	Massachusetts	1	North Dakota	1
	Minnesota	2	Montana	2
	New Jersey	3	New Hampshire	
	North Dakota		Vermont	
	Vermont		South Dakota	3
			Massachusetts	
CALIFORNIA RANKING	THIRD WORST OF 52 Equal to West Virginia & New Mexico Above Alabama & District of Columbia		SECOND WORST OF 45 Equal to Hawaii Above Mississippi	

Note: Data includes District of Columbia. 2005 Science proficiency data does not include six states.
Source: National Assessment of Math & Science Proficiency by Grade

The Innovation Ecosystem & Strategic Areas of Education & Water

California can "innovate to innovation" or "i2i" by using the special resources and talent resident in the state, especially through partnerships, to foster the emergence of new ideas that will contribute to the economic vitality of the state. Through regional leadership roundtables CCST identified three critical issues of our state that receive a targeted focus in this analysis. These critical issues are:

1. California's innovation ecosystem benefits from many existing assets, but greater value could be generated through the development of linkages throughout the system.
2. The creation of digitally designed education, i.e., the integration of technology in education to more effectively educate and train students of varying abilities, provide high-quality education to all of California's children, and to develop a workforce that meets the needs of an innovation economy.
3. The critically important issue of water and particularly the intersection between water resources, climate change, energy, healthcare, food production and environmental stewardship.

Both education and water are critical underpinnings of California's economy and areas where the innovation ecosystem and state public policy and investment intersect. They are also areas where social innovation is as important as technological innovation to achieve meaningful impact.

RECOMMENDATIONS

Bring together public and private leaders charged to focus on California's innovation and competitiveness infrastructure. An Innovation Action Team (IAT), comprised of leaders from universities, industry, and government, should be charged to develop an Innovation Roadmap that will include specific recommendations for Improving Critical Innovation Infrastructure in California.

California's Innovation Ecosystem: Assets & Opportunities

California benefits from a host of world-class assets in terms of its research and development, talent and innovative companies. Even with these existing strengths, there is growing evidence that maintaining the state's position as a global economic leader is under threat given the state's fiscal crisis, slipping educational performance, and growing global competition. The CCST led regional leadership roundtable discussions attended by industry and research leaders identified issues that California needs to address to effectively compete in the global economy and create high-paying jobs.

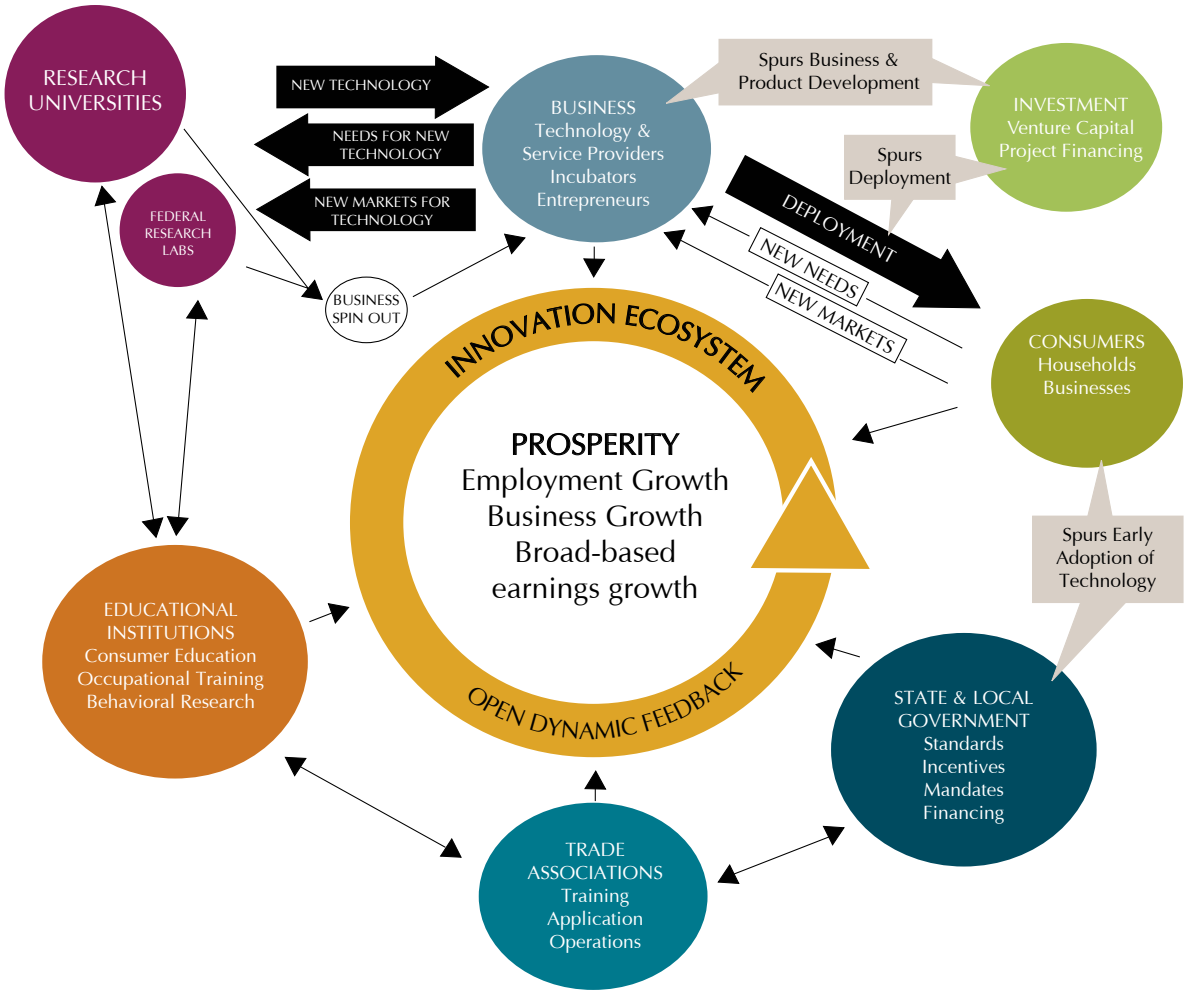
Innovation is considered key to prosperity as a means for increasing productivity. Productivity growth is the basis for rising real wages for workers, increasing returns to shareholders, and increasing per-capita income for the state and the nation. The only way to compete globally and raise our standard of living is through innovation -- finding new and better ways to use natural, human, and capital resources to increase productivity.

Science and technology-based innovation is globally becoming a key to economic and community success. While each state and economic region has a different set of industries and must compete globally in its own way, there is potential for boosting innovation across all industries including agriculture, education and healthcare as well as expected high-value industries such as information technology, clean energy and biotechnology. In order for California to achieve lasting, broad-based economic success, California must find new ways of generating greater value from its existing world-class innovation assets.

INNOVATION ECOSYSTEM: Assets And Processes

An innovation ecosystem consists of creative elements and processes that together form and drive the innovation economy. While advances in science and technology are key ingredients, innovation encompasses the process of turning these breakthroughs into new market opportunities and new business models. Innovation is about ideas as ingredients and creative recipes. Stanford economist Paul Romer proposed a "new growth theory" that explains the central role of innovation in advanced economies.[6] In new growth theory, ideas are the primary catalyst for economic growth. New ideas generate growth by reorganizing physical goods in more efficient and productive ways. For Romer, the ingredients (natural, human, capital resources) are not as important as the recipes (the ideas about how to put the ingredients together). The recipes are the product of the innovation process.

ASSETS AND DYNAMICS OF AN INNOVATION ECOSYSTEM



A vital innovation ecosystem is driven by a diverse mix of economic actors in an environment which supports the flow of information between universities, businesses, researchers, consumers, investors, educators and policymakers. It is this interaction that creates the vital feedback loops that speed adaptation and creation in the commercialization process which results in economic growth and prosperity.

The image above illustrates the actors in an innovation ecosystem and the dynamics which generate added value beyond the sum of the individual elements. Creating new and stronger linkages in California's innovation system will stimulate the dynamics already in place, speed the broad deployment of technology already under development and result in gains in employment and prosperity in the state.

- California's world-class universities play a key role in knowledge creation as valuable technology originates in universities, labs and other research centers, the flow of information from new market demands helps to drive research and development.

- Venture capital investment of cash and business development assistance serves to accelerate the commercialization of viable technology.

- Innovative public policy can support the growth of new markets and the early adoption of new technology. Standards, incentives, public procurement mandates, opportunities for demonstration projects and creative financing options help stimulate the development and adoption of new technology.

- California's educational institutions including universities, community colleges and other workforce training centers contribute meaningfully to the region's highly skilled talent pool.

While California's innovation ecosystem benefits from high-value ingredients in talent, R&D capacity and venture capital, the state could generate greater value from them by spurring the innovation process, the use of new recipes. One way this can be achieved is through the facilitation of access into and linkages between different state assets such as the numerous world-class research facilities resident in California.

In addition to California's 27 public and private research universities[7], 24 federal labs[8] and numerous private research facilities (see Appendix C), the state has launched many efforts over the years with the purpose of supporting science and technology in the state. Among the State's three public postsecondary education segments, UC is designated the state's primary academic research institution (as stipulated in the Master Plan for Higher Education). Therefore, most State funded research programs involve a UC campus. Examples of efforts that are still underway include the following:

UC DISCOVERY GRANTS: The Industry-University Research Cooperative Program (IURCP) was established by University of California President Richard Atkinson (former Director of National Science Foundation and Chancellor at UC San Diego) in 1996, building on the success of the MICRO program established in 1981. The purpose of MICRO was to support innovative research in microelectronics technology and its applications in computer sciences by maintaining leadership through expanding cooperative research with industry and graduate education at the University of California. IURCP expanded the university's focus to include bioscience with an initial base of funding of $3 million for UC and $5 million contribution for the state of California.

In 2002 IURCP reorganized as UC Discovery Grants focused on biotechnology, communications and networking, digital media, electronics manufacturing and new materials, information technology for life science, as well as microelectronics (the initial MICRO program). By 2006, UC Discovery Grants provided up to $60 million per year in state, industry and university funds for new research partnerships. Between 1996 and 2006, UC Discovery Grants have provided a total of $281 million in state, industry and UC investments.

CALIFORNIA INSTITUTES OF SCIENCE AND INNOVATION: In 2000, California authorized $75 million annually for three years for four California Institutes for Science and Innovation at University of California campuses to promote multidisciplinary research in collaboration with industry on strategic technology challenges. The Institutes represent an unprecedented partnership between the state, industry, and the University of California. Each Institute focuses on a research field key to the future of California's economy, bringing together UC's world-class scientists and students with industry researchers in a cooperative research and education effort that will produce both new knowledge and the next generation of scientists and technological innovators. The Institutes undertake basic, multidisciplinary research on complex problems requiring the kind of scope, scale, duration, equipment, and facilities that they uniquely provide. The cooperative UC-industry effort will expedite the delivery of public benefits through new products, technologies, services, and jobs.

The Institutes announced in December 2000:

California Institute for Quantitative Biomedical Research (QB3) - University of California San Francisco, UC Berkeley and UC Santa Cruz

California Institute for Telecommunication and Information Technology (Calit2) - UC San Diego, UC Irvine

Center for Information Technology and Research in the Interest of Society (CITRIS) - UC Berkeley, UC Davis, UC Merced and UC Santa Cruz

CNSI California Nanosystems Institute (CNSI) - UCLA, UCSB

INSTITUTE FOR REGENERATIVE MEDICINE (STEM CELL FUND): In November 2004, the voters of California approved Proposition 71, the California Stem Cell Research and Cures Initiative establishing the California Institute for Regenerative Medicine with the purpose of providing grants and loans to support stem cell research, research facilities and other research opportunities to realize therapies, protocols and medical procedures that will result in the cure for and/or substantial mitigation of, major diseases and injuries.

ENERGY BIOSCIENCES INSTITUTE (EBI): An important addition to California's research centers is the Energy Bioscience Institute established in January 2007. BP, the University of California at Berkeley, in partnership with the University of Illinois Urbana-Champaign (UIUC) and Lawrence Berkeley National Laboratory, was granted a total of $500 million to host a research center dedicated to developing biofuel technologies. The EBI conducts both basic and applied biological research relevant to energy. BP and UC Berkeley plan to launch research programs in summer 2011.

The challenge facing California is not that it has too few technology initiatives, research assets or even special R&D funds on the supply side. The problem over the past several decades is that California does not have an innovation strategy that effectively supports interaction between our research assets (universities and federal laboratories described in Appendix C) and industries and connects the demand side more effectively to California's wealth of R&D resources.

Over the years, many solutions have been proposed, and all rely at least in part on public investment. In response to the National Academy of Sciences *Rising above the Gathering Storm Report* [9] outlining the threats to U.S. competitiveness, CCST was asked by Governor Schwartzenegger to prepare a response[10] which recommended a cabinet-level post, state innovation fund, campaign for S&T talent, and innovation awards. At the same time, a group of private technology leadership organizations – TechNet, California Health Institute, Joint Venture: Silicon Valley and Silicon Valley Leadership Group formed the "California Competes" Coalition to call on the governor to make science and technology a priority for the state. The coalition called for increased funding for the California Institutes for Science and Innovation, increased funding for math and science teacher education, and a more strategic focus on science and technology within state government.

Using Paul Romer's terms, California's innovation ecosystem is a cornucopia of rich ingredients and recipes which have made the state the innovation engine it has historically been. However, there is great potential for generating even greater value from the state's assets, and given growing global competition, it is imperative for the state to do so. In the face of the state's current fiscal crisis, it is also imperative to find ways of leveraging more value without creating new costs for the state government. This can be achieved through the formation of an innovation intermediary which would build productive linkages across the state's assets, support public-private collaborative research, development and demonstration, and speed up the commercialization process for viable new ideas and technology.[11]

RECOMMENDATIONS

1. Create an intermediary for California's innovation ecosystem which would spur the innovation process by better leveraging the state's many research, development and business assets.
2. Produce a comprehensive California Science and Technology Index (see Appendix A) that will provide a tool for tracking the state's progress in growing its innovation assets, improving its processes of innovation, and producing better outcomes for its communities.

Communities Of Innovation

The 21st century world is a social networking world in which innovation is highly prized. The networking of today and tomorrow is uniquely open and collaborative consisting of both tangible communities and virtual structures. California's innovation ecosystem in the 20th century benefited from many of these emerging characteristics. However, with other nations and states investing heavily to compete in this new economy, California cannot be complacent.

In other regions of this nation and in other fast evolving countries across the world, communities of innovation are being catalyzed by competitive state and national governments. These emerging and established communities are the result of strategies that embrace the value of networking, co-location of talent, and the opportunity for innovation at the convergence of interests and sectors. California has long benefited from the organic growth of the Silicon Valley innovation community; an effort that has emerged over more than half a century. California now needs an action plan to strategically identify and accelerate the emergence of additional robust Communities of Innovation. For such an approach to be successful, it will need to be adopted and implemented by key stakeholder leaders (industry, government, and academia).

California is uniquely positioned to seed communities of innovation by leveraging existing assets resident in the state – namely federal research laboratories (specifically NASA, Dept. of Energy, and Dept. of Defense), research universities (particularly UC given its land grant heritage and charter), and industry (especially high tech, cutting edge areas such as energy, biotechnology, information technology). Appendix C discusses these issues in more detail.

RECOMMENDATION

Support the development of communities of innovation through the co-location of federal, state and private science and technology assets (e.g., Federal Research Laboratories and public and private universities) to address state challenges and to promote innovation, entrepreneurship, knowledge transfer, and job creation.

Digitally Designed Education: Innovation for Our Ultimate Resource - People

As a component of the overall i2i assessment and recommendations requested by the Legislature, CCST facilitated several discussions around the state, explored the opportunities in new technologies created for education, and will produce recommendations offering more radically effective approaches to educate California's workforce. This work will be a significant component of the i2i final report, resulting in a set of ideas and recommendations that could be implemented by newly identified partnerships.

Several excellent programs targeted at improving education in general and science, technology, engineering and math (STEM) education in particular, with an emphasis on partnerships and human networks, are currently underway. At the K-12 level for example, the California STEM Learning Network, supported by the Bechtel and Gates Foundations, has developed a blueprint for improving STEM education. The university systems in California likewise have numerous programs with demonstrated track records designed to improve education. Investments have been made to catalyze these programs.

However, there still is a need and a real opportunity to look at different models to inspire excellence in education. Utilizing public/private partnerships, a new, innovative approach could leverage the technology base in California to create educational opportunity; a new, transformative approach targeted at worker training and advanced education with access for all Californians. Investing in digitally designed education is,in effect, using the technological supremacy of the state to "reboot" the state's education delivery system and would be designed for the digital native generation –the state's future workforce.

This proposed digitally designed education initiative will focus on looking beyond the traditional educational model to an innovative model designed to answer game changing questions such as:

1. What would education in K-12, two-year colleges and degree granting institutions look like if they were to be digitally designed from the ground up?
2. How can the rapidly emerging technologies of immersive learning, 3D-Internet based learning, e.g. *Serious Games Initiative*, coupled to high-speed communications be used as the core enabler?
3. How can the integration of technology in education more effectively, and measurably, educate, and train students and a workforce of varying needs?
4. How can the emotional and social aspects of education be addressed?
5. What efficiency and effectiveness improvements could be gained in a time of constrained budgets to ensure the highest-quality education at all levels and reaching the most students?

There are seeds of this type of partnership and change agents emerging in California and elsewhere, such as the Virtual Campus at CSU East Bay, and the nascent plans for distance learning in the UC system. California is also home to state-of-the-art research in digital technology, the visual arts and information technology at numerous other public and private institutions, including the University of Southern California, Apple, Cisco and Lucas Film, to name just a few.

It is important to not be constrained by the current barriers to implementation, but instead to identify these roadblocks and develop innovative approaches to overcome them.

Building on new national and state initiatives[12], there are ten Elements of High Quality Digital Learning:

- Student Eligibility: All students are digital learners.
- Student Access: All students have access to high quality digital content and on-line courses.
- Personalized Learning: All students can customize their education using digital content through an approved provider.
- Advancement: Students progress based on demonstrated competency.
- Content: Digital content, instructional materials are on-line and blended learning courses are high quality.
- Instruction: Digital instruction and teachers are high quality.
- Providers: All students have access to multiple high quality providers.
- Assessment and Accountability: Student learning is the metric for evaluating the quality and content of instruction.
- Funding: Funding creates incentives for performance, options and innovation.
- Delivery: Infrastructure supports digital learning.

RECOMMENDATIONS

1. Identify a new kind of digitally designed education process and associated products that will be incorporated as a fundamental component of the i2i project.
2. Catalyze the creation of new public-private partnerships able and willing to go to the next stage of implementation.

WATER: Innovation for California's Fundamental Natural Resource Challenge

Water continues to be the most fundamental resource challenge facing California. Water issues have shaped California's politics and economy since its founding. While the North has the water and the South needs water, the Central Valley must have water to grow its crops. Historically, these water resource challenges were solved by engineering solutions including building massive water systems based on canals and dams.

While these investments remain urgent today, California faces a more complex range of resource challenges including inter-related issues of water, energy, agriculture, climate change, and environmental stewardship that can be addressed through the state's significant science and technology community, represented by its universities, research institutions, and innovative companies.

Why water instead of clean energy? While clean energy is a critical issue facing the state, significantly more progress has been made in the commercialization and adoption of clean energy technology and in related business growth than in the area of water and all of its inter-related issues.[13]

California is home to companies developing breakthroughs across multiple technologies including developing biotechnology, drought-resistant plants, new sustainable approaches to wastewater treatment and water recycling and re-use and sensors and smart systems for precision irrigation in agriculture. Water use in California is particularly energy intensive because much of the state's water demand is located far away from available sources or pumped from deep aquifers, and the process of moving the water results in high-energy costs. According to the California Energy Commission (CEC), "Nearly, 70 percent of the state's stream runoff is north of Sacramento, but 80 percent of water demand is south of Sacramento." The CEC also estimated that the conveyance of water across the state accounted for 11 percent of the state's total electricity use in 2001. Reducing consumption and improving efficiency of California's water-use system would not only conserve water resources but also yield energy savings and reduce greenhouse gas emissions.

California's water system continues to face growing demands and uncertainty as a result of a growing population, a growing economy, environmental protections, aging infrastructure, and the impacts of climate change. Formidable efficiency improvements will need to be achieved in order to compensate for continued growing demand and irregular precipitation. Given the fact that irrigated agricultural water use makes up 77 percent of California's total annual human water use, improvements will need to be system-wide and extend beyond urban consumption. While state government has adopted a policy that water supply reliability and environmental health, particularly in the California Delta are co-equal goals, there is no consensus on how to increase water supply and protect the environment.

The Legislature passed an historic water package in 2009 but a key component of it, an $11 billion water bond, was removed from the 2010 ballot, slowing progress to fix the Bay Delta and

California's aging levee system.

As with energy policy, California is on the cutting edge of water resource policy. Innovative public policy seeks out opportunities to align interests of consumers and the private sector with public goals in order to allow for mutually beneficial outcomes. Examples include:

- The Water Conservation Act of 2009 (SB 7), although not directly including agriculture, requires all water suppliers to improve efficiencies by setting the goal of reducing per-capita urban water use by 20 percent by December 31, 2020. Beginning 2016, any urban retail water suppliers not achieving at least 10 percent reductions by 2015 will not be eligible for state water grants or loans. Under this act, agricultural suppliers are not required to meet the same targets, but they are required to measure agricultural water deliveries for the purpose of reporting and volumetric pricing, and to prepare and adopt agricultural water management plans by 2012, update those plans by 2015, and again every five years thereafter.
- A ballot initiative has been postponed until 2012 that would have raised more than $11 billion through a water bond with $3 billion set aside for improving surface and groundwater storage. Environmental restoration, water quality, conservation programs, and integrated regional water management also would be eligible for funding. In addition to the bond, the package is likely to include plans for new Delta conveyance to deliver water north-to-south more reliably and set policy for statewide conservation by cities and farms. Also, the plan has created the Delta Stewardship Council that would enforce a Delta Plan for how the state plans to restore the troubled Sacramento Bay Delta, the hub of California's drinking water and irrigation water supply.

Public policy can play an important role in aligning incentives related to natural resources, the inter-related challenges of water, energy, agriculture and climate change. What is the right balance between increasing supply and reducing demand for water resources? CCST addresses these issues from the perspective of leveraging our technological and research assets to find solutions. This question and others will be explored, such as:

1. How can California's significant science and technology assets be applied to help promote innovation related to integrated water resources management, particularly at a regional scale?

2. What water-efficiency technologies can be adopted to reduce urban and agricultural water demands and to increase water recycling and re-use?

3. What resource management strategies exist for improving the efficient use, management and quality of the state's limited water resources?

4. Is it technologically feasible to increase the state's water supply, improve water quality, and reduce flood risk while protecting our environment?

5. What irrigation and water measurement methods and devices could be employed to increase agricultural water use efficiency?

6. What water technologies developed in California is exportable to other states and countries and what actions are required to achieve this goal?

7. What planning, information technology, and analytical innovations could be implemented to better align the state's land use, growth and consumption patterns with its finite water resources, while increasing regional self-sufficiency?

California has a rich heritage of pioneering innovative public policy as well as technological advance. The state also is home to early adopters of new technology and practices. California benefits from extensive research and business activity related to water management products and services, and regional concentrations have emerged in the Central Valley, San Diego and Los Angeles. Current collaborative, public-private efforts underway include San Diego's expansion of desalination projects, which includes the largest proposed plant in the U.S.

RECOMMENDATIONS

1. Improve water-use efficiency across the economy to ensure the state's continued prosperity in the 21st century.
2. Identify opportunities for expanding markets, in and outside the state, for innovative California products that will help the state and others improve water efficiency.
3. Catalyze the creation of new public-private partnerships able and willing to go to the next stage of implementation.

Roundtable Results

The roundtable discussions attended by industry and research leaders identified three major issues.

- ECONOMIC INNOVATION: How California will compete in the global economy and create high-paying jobs
- EDUCATION: How California will create an education system that prepares students for the workforce particularly with science, technology, engineering and math skills for the 21st century
- WATER: How California will meet its water challenges in terms of availability, efficiency and quality

ECONOMIC INNOVATION	
CHALLENGES	Unemployment and lack of high-paying jobs
	A world innovating faster than California
	Short-range R&D focus
	Barriers to innovation in biotech/health care
	Venture capital model is broken
	Lack of access to capital by small business
	Poor business environment (tax and regulations)
	Lack of a statewide plan to improve California competitiveness globally
	No big goal to drive California's efforts (like the space race)
SOLUTIONS	California Innovation Initiative: focused on the translation of knowledge, backing high-risk/high-return ventures
	Innovation support at the micro level - including local networks, business, universities, nonprofits
	Regional innovation cluster strategies tailored to the unique strengths of California's regions
	Support for incubators and collaboration to decrease costs and risks
	Microfinance clusters with university collaborations
	Funding for high-risk start-ups/tech grants $50,000-$150,000
	Innovation tax credits and incentives for companies to spin off from universities and locate in California
	Identify constraints to innovation (bureaucratic procedures, regulations, disincentives) and stop them
	Create a State Science Advisor or Office of Science and Technology Policy (OSTP) - perhaps CCST helps craft a state competitiveness plan that would support California's entrepreneurial strengths.

EDUCATION	
CHALLENGES	Teachers need to lead the design of new models of IT to enrich schools
	Use technology to assist individualized learning customized to the learner
	Web 2.0: wiki's tablets, internet, video conferencing provide new resources
	Opening schools/school district firewalls to allow classrooms to connect to scientists/engineers, other schools, other countries
	Funding formulas have not caught up with available education technology and training – access
	Technology infrastructure at schools; aversion by school districts to support new technology
	Children unable to use handheld computers (smartphones, etc.) in classrooms for education use (they are usually forbidden); unable to "block" texting and phone calls to use other features
	Maximizing use of on-line technologies
SOLUTIONS	California Education Innovation Consortium
	State-chartered 501 (c)(3); university research units, technology companies, state officials, early-adopting schools
	A public/private consortium to develop best practices, incentives, tools, tests and evaluations, system architecture options
	Based on a model of distributed, unconnected, voluntary constituents
	Scale best practices, CCST inventory and dissemination
	Use technology to share best teaching practices. Open source professional development.
	Promote technology adoption: best practices scale up
	Create a database of: best practices, video lessons, lesson plans, interactive websites and teach faculty/ students/administration to use it
	Create a statewide assessment that measures creative problem solving

CCST RECOMMENDATIONS TO BRING TECHNOLOGY INTO THE CLASSROOM AT ALL LEVELS:

Shift The Emphasis From Teaching In A Classroom Setting To Student Learning

- Through technology, bring a rich learning environment to the student
- Use peer instruction methods to change lecture time into interactive time
- Leverage ubiquitous and emerging technology for reaching the largest number of people – a real education equalizer

Connect Education Systems Together

- Through CSL Net and other best practices, build on regional hubs connecting K-12 with colleges and universities
- Develop, learn, build, test and grow successful practices
- Build in metrics and benchmarks
- Build funding models that prove efficacy
- Create competitions for funding
- Form a distributed network of laboratories

Connect Education With The Private Sector

- Encourage development of educational tools and processes as a business opportunity; the private sector will fund development if they know the market is there.
- Build on new knowledge of cognitive neuroscience to exploit

  Social networking
  Cognitive intelligent search capabilities
  Cognitive apprenticeship approaches

- Identify new markets for education technology
- Build a strong labor force that is technology savvy
- Strengthen K-12 schools, universities and colleges under stress
- Establish learning as a cradle through career initiative

WATER	
WATER CHALLENGES	Lack of a comprehensive water plan that has broad agreement
	Agricultural issues need to be addressed
	Water, energy and air quality are connected
	Climate and population pressures impact water
	Sustainable energy, water and agriculture issues should be addressed
	Innovative ecosystems: water and energy are related
SCIENCE & TECHNOLOGY SOLUTIONS	Water Road Map 2010-2020-2050 based on science to drive policy and investment
	Launch X Prize for water technology
	Develop good water resource database for informed management and targeted pricing strategies
	New water information system including satellites and sensors for decision support from the Sierras to the Central Valley
	Wireless linked smart sensors – cost information display
	Development large-scale and micro systems (i.e. residence, small business) for grey water capture, treatment and local application for landscaping and other irrigation uses
	Implement agricultural water policies to balance demand and state plan needs
	Implement energy and water efficiency micro-irrigation and subterranean irrigation
	Develop drought-tolerant crops through biotech
	Smart meters for water: residential, industrial and agriculture
	Support market development for new technologies
	Create a water-energy-agriculture research initiative like the California Institute for Regenerative Medicine (Stem Cell Institute)
	Form collaborative efforts with other countries with similar water conditions
	Support development of low-energy desalination methods possibly linked with solar
	Support behavior change in addition to technological advance
	Implement broad based rain capture strategies in urban areas

WATER TECHNOLOGY IN CALIFORNIA

California is a leader in water technology and the challenges we face create an opportunity to develop further technologies in this area. For a description of the investment and business activity currently in the state related to water technology, see Appendix E.

CCST proposes the following Phase II activities for preparing a Science and Technology-Based Water Roadmap:

1. Convene an expert roundtable to identify innovative water technology opportunities
2. Host a meeting with UC and CSU leaders to develop a blueprint for effective water information systems
3. Meet with business leaders to discuss how to promote water technology/industry clusters
4. Include a framework for a science and technology-based Water Roadmap in each 5-year update of the California Water Plan

Recommendations for Phase II

Innovation Action Team: The primary recommendation is to bring together public and private leaders charged to focus on California's innovation and competitiveness infrastructure. An Innovation Action Team (IAT), comprised of leaders from universities, industry, and government, should be tasked to develop an Innovation Roadmap that will include specific recommendations for Improving Critical Innovation Infrastructure in California. This Innovation Action Team would be convened for this specific purpose over a defined period of approximately 12 months. Facilitated and staffed by an entity, such as CCST, this team would provide their recommendations to the Legislature. The focus of the Innovation Action Team would be to develop the following:

INNOVATION ROADMAP

- California Innovation Initiative: Identify and build support for specific actions to promote the effective and timely translation of research into use (design to delivery). These actions could include institutional and policy innovations, multi-sectoral financing, legislation, and public and stakeholder communication. The Initiative will begin with extensive collaboration among the Legislature, administration, and networks of industry, entrepreneurs, universities, federal research laboratories and nonprofits.
- Communities of Innovation: Through strategic planning and investment, support the development of communities of innovation through the co-location of federal, state and private science and technology assets (e.g., Federal Research Laboratories and public and private universities) to address state challenges and to promote innovation, entrepreneurship, knowledge transfer, and job creation.

IMPROVE CRITICAL INNOVATION INFRASTRUCTURE

- California Education Innovation Consortium: An educator-driven alliance to fund, develop and deploy effective practices for K-16 digitally enhanced education. This would engage the broader use of technology to support the learning of students of varying levels and backgrounds, and to train the workforce needed to surpass global competition.
- Science and Technology-Based Water Road Map: Engagement of a broad segment of California's S&T community to innovate across the water system end-to-end, linking water and energy technology.

APPENDIX A: Framework for the California Innovation Index

CALIFORNIA BENEFITS FROM A HOST OF WORLD-CLASS ASSETS IN TERMS OF ITS RESEARCH AND DEVELOPMENT, TALENT AND INNOVATIVE COMPANIES

Even with these existing strengths, there is growing evidence that maintaining the state's position as a global economic leader is under threat given the state's fiscal crisis, slipping educational attainment, and growing competition from abroad.

INNOVATION IS A KEY TO PROSPERITY BY INCREASING PRODUCTIVITY

Productivity growth is the basis for improving real wages for workers, increasing returns to shareholders, and increasing per-capita income for the state and the nation. The basis for improving productivity is innovation. The only way to compete and raise our standard of living is to find new and better ways to use natural, human, and capital resources to increase productivity.

SCIENCE AND TECHNOLOGY-BASED INNOVATION HAS BECOME A KEY TO ECONOMIC AND COMMUNITY SUCCESS

While each state and region has a different set of industries and must compete globally in its own way, every industry needs to become more innovative, based on increasing productivity. This is true for agriculture, education and healthcare as well as high-value industries such as information technology, clean energy and biotechnology. To achieve economic and community success, regions must understand the evolving nature of innovation.

WHILE ADVANCES IN SCIENCE AND TECHNOLOGY ARE KEY INGREDIENTS, INNOVATION ENCOMPASSES THE PROCESS OF TURNING THESE BREAKTHROUGHS INTO NEW MARKET OPPORTUNITIES AND NEW BUSINESS MODES

Innovation is about ideas and recipes. Stanford economist Paul Romer has proposed a "new growth theory" that provides a way to understand the central role of innovation in advanced economies. In new growth theory, ideas are the primary catalyst for economic growth. New ideas generate growth by reorganizing physical goods in more efficient and productive ways. For Romer, the ingredients (natural, human, capital resources) are not as important as the recipes (the ideas about how to put the ingredients together). The recipes are the product of the innovation process.

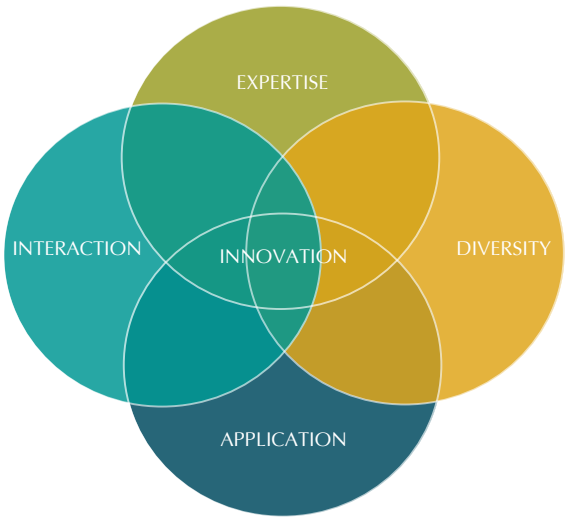
After assessing the field of research and experience with innovation, the Pew Center on the States and the National Governors' Association identified a framework, including both the recipe and the ingredients. Innovation is a recipe composed of four major ingredients[14]:

EXPERTISE: New discoveries, new knowledge, and new insights come from all people who are given the resources necessary for success.

INTERACTION: Face-to-Face is still very important for the exchange of ideas and synergy that creates new business models, marketing plans, or products.

DIVERSITY: Ideas will only get better when they are openly discussed and considered by a mix of people with a variety of research fields, backgrounds, approaches, and mindsets.

APPLICATION: Ideas are useless unless used. The true proof of their value is in commercialization.



THE PURPOSE OF THE CALIFORNIA SCIENCE AND TECHNOLOGY INDEX IS TO PROVIDE AN ASSESSMENT AND TOOL FOR TRACKING THE STATE'S PROGRESS IN GROWING ITS ASSETS, IMPROVING ITS PROCESSES OF INNOVATION, AND PRODUCING BETTER OUTCOMES FOR ITS COMMUNITIES

The Index examines California's science and technology infrastructure and base for innovation. This framework provides important information required for the development of an innovation-based economic strategy. In addition, it offers valuable information to policy makers, administrators and the business community for making informed decisions regarding investment, training and program development. Further, the Index provides residents with accessible information about California's strengths and areas for development as well as how the state's economy is evolving.

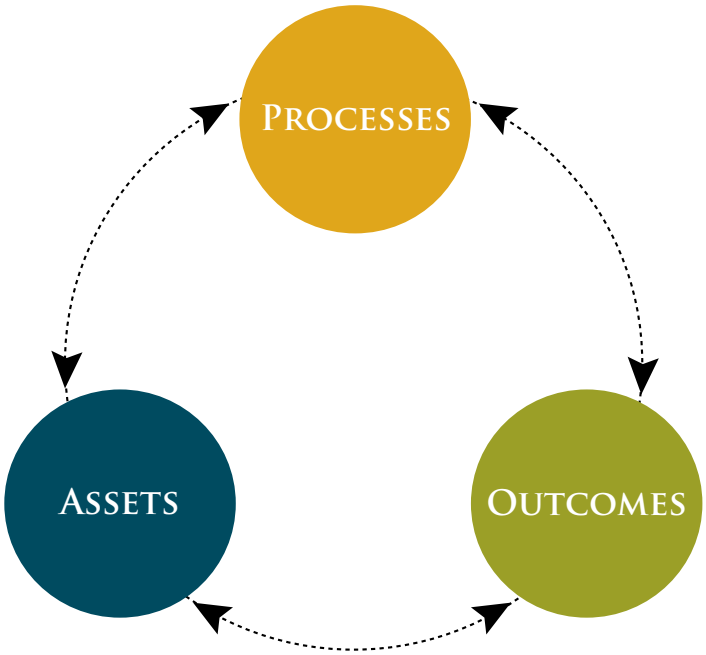
THE INDEX IS ORGANIZED INTO THREE PARTS: INNOVATION ASSETS, INNOVATION PROCESSES, AND INNOVATION OUTCOMES

Each part includes multiple facets, and each part includes a global element which reflects the great importance of California's global connections in the state's innovation system.

ASSETS: California has many strengths and assets. Assets, however, are a necessary but insufficient condition for success. Assets, such as a talented workforce, research and development (R&D) capacity, and investment capital, contribute to a fundamental foundation for innovation. These assets fuel the innovation process and create economic opportunities in the global economy.

PROCESSES: While examining California's assets provides a measure of its innovation capacity, observing the state's innovation processes provides a measure of how well assets are translating into innovations and economic benefit. Processes include the generation of new products and ideas, the commercialization of these, and the propensity of both entrepreneurship and business innovation.

OUTCOMES: Valuing and investing in California's science and technology assets and facilitating the innovation processes in the state will yield positive results for California's economy and the prosperity of its communities. Measuring outcomes from innovation, such as competitiveness, business performance, and economic opportunity, captures California's economic benefits that result from translating assets into innovations.



	FRAMEWORK		INDICATORS	DATA SOURCES
ASSETS	TECHNOLOGY R&D	1	Federal R&D Funding: CA, US, top states?	NSF 03-303, 303-303 and Science Indicators
		2	Private Sector R&D Funding: CA, US, top states?	NSF 03-303, 303-303 and Science Indicators
		3	Academic R&D Funding: CA, US, top states?	NSF 03-303, 303-303 and Science Indicators
	INVESTMENT CAPITAL	4	Venture Capital by Industry	PWC MoneyTree
		5	Cleantech Venture Capital by Industry	Cleantech Group
	TALENT BASE	6	Educational Attainment	Census ACS
		7	Science & Engineering Workforce: CA, US, Top States	Census PUMS
		8	Science & Engineering Workforce by Discipline	Census PUMS
		9	Science & Engineering Workforce by Industry	Census PUMS
	TALENT DEVELOPMENT	10	Science & Engineering Degrees Conferred	NSF, NCES
		11	Academic Rankings of CA Universities	NRC, NSF 03-303
		12	SAT scores: CA, US, Top states	National Center for Education Statistics
		13	High School Graduation Rates	CA Depart of Education
		14	"K-12 achievement levels in STEM fields: CA, US, Top States CST Math & Science Achievement by Grade & Proficiency (CA, 2002-2010) National Assessment of Educational Progress in Math & Science by Grade (4, 8, 12), by state and US (1992, 1996, 2000, 2003, 2005, 2007, 2009)"	CA Depart of Education
	TALENT ATTRACTION	15	Science & Engineering Degrees Conferred to Foreign Students	NSF, NCES
		16	S&E Talent by Place of Birth	Census PUMS
		17	S&E Talent Flows to and from CA	Census PUMS
PROCESSES	IDEA GENERATION	18	Patent Registrations: CA, US, Top States	USPTO
		19	Patents by Technology Area	USPTO
		20	Patents by Entity: University, Lab, Private Company	USPTO
		21	Global Co-Patenting	USPTO
	COMMERCIALIZATION Technology Licensing Activity	22	University Technology Licensing	AUTM
		23	Pre-market approvals and pre-market notifications	US Food and Drug Adminstration
		24	FDA Approvals of biotechnology drugs, Biotechnology Industry Organization	Biotechnology Industry Organization
	ENTREPRENEURSHIP	25	Business Churn: annual in and out-migration, openings and closings: S&E, Non-S&E	NETS
		26	Entrepreneurial Activity	Kauffman
	BUSINESS INNOVATION	27	Small Business Innovation Research (SBIR) Awards	SBA, NSF
		28	SBIR Funding per $1 million GDP	SBA or NSF; Economy.com
OUTCOMES	COMPETITIVENESS	29	State Value Added	2007 Economic Census or Economy.com
		30	Value Added by Industry	2008 Economic Census or Economy.com
		31	Energy Productivity	EIA, BEA, Economy.com
	BUSINESS PERFORMANCE	32	Employment Growth by Industry	BLS QCEW or NETS
		33	Business Growth by Industry	BLS QCEW or NETS
		34	Revenue Trends per Employee, by Industry	NETS
		35	"Foreign Direct Investment Percentage of Employment in Foreign-Owned Companies"	BEA
		36	Total Foreign Exports as Percentage of State GDP	International Trade Administration, BEA
	OPPORTUNITY	37	Earnings Trends by Industry: S&E, Non-S&E	BLS QCEW
		38	California Tax Revenues, Firms and Employees	California Franchise Tax Board

SELECTED INDICATORS

While California remains the nation's leading technology state, ranking 1st overall in R&D expenditures, the majority of that funding comes from industry and the federal government, including federal labs supported by Department of Energy, Department of Defense and NASA as well as grants and contracts from National Institutes of Health. According to the National Science Foundation, R&D spending in California totaled $71 billion in 2006 across all funding sources.[15]

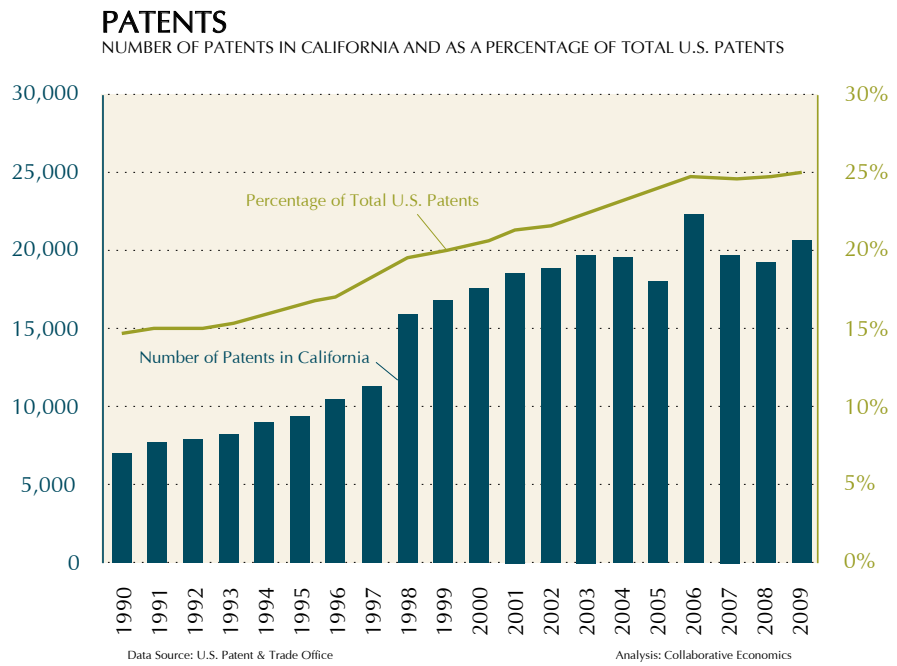
Federal obligations to public and private facilities equaled $21 billion in 2006. Much of this funding supports the operations at federal labs located in the state, which are important to the state's innovation system. Some of these labs are exploring new ways of working with the private sector. A discussion of how the state's federal assets can be leveraged with academic and industry resources to promote entrepreneurship and commercialization within "innovation communities" is provided in Appendix C.

CALIFORNIA R&D PERFORMANCE[2]		STATE RANKING
TOTAL R&D, 2006	$71 Billion	1
Industry, 2006	$58 Billion	1
Federal Obligations, 2006	$21 Billion	1
Academic, 2007	$6.7 Billion	1

Compared to other states, California ranks sixth in total R&D performance per capita. Per capita, the state ranks sixth in federal R&D obligations, seventh in industrial R&D and seventeenth in academic R&D.

R&D FUNDING PER CAPITA: TOP STATES								
REGION	Total R&D Performance		Industry R&D		Federal R&D Obligations		Academic R&D	
	Total	Rank	Total	Rank	Total	Rank	Total	Rank
	2006						2007	
United States	$1,123		$817		$360		$164	
Massachusetts	$3,182	1	$2,407	1	$944	4	$334	2
New Mexico	$2,980	2	$348	31	$1,596	2	$208	8
Connecticut	$2,596	3	$2,374	2	$457	9	$198	12
Maryland	$2,582	4	$610	19	$2,227	1	$451	1
Washington	$2,132	5	$1,776	3	$634	5	$152	25
California	$1,983	6	$1,624	7	$588	6	$186	17

Data Source: Science and Engineering Profiles, by State: 2006-08 (NSF 10-302) November 2009; U.S. Census Bureau, Population Estimates
Analysis: Collaborative Economics



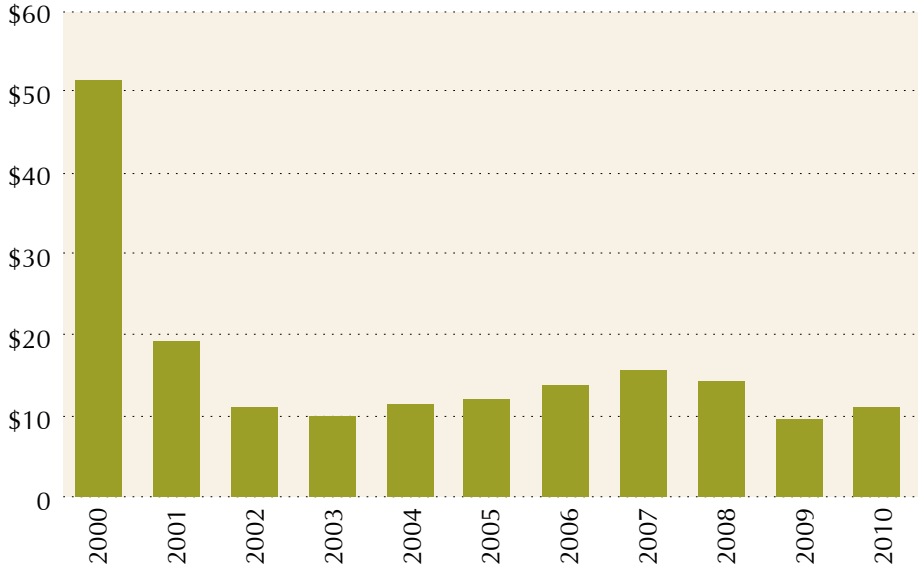
Top States for Patents in 2009	Registered Patents per 1,000,000
Vermont	727
Washington	647
Idaho	609
Massachusetts	561
California	559

California is the top state in patent registrations. Over the last two decades, the number of patents registered by primary inventors located in the state has increased in number and as a percentage of the U.S. total. In 2009, the state accounted for 25 percent of total U.S. patents, up from 15 percent in 1990. From 2008 to 2009, the number of registrations in the state increased eight percent while total U.S. registrations increased six percent. Compared to other states, in 2009, California ranked fifth in patent registrations per capita, following Vermont, Washington, Idaho and Massachusetts.

California attracts 50 percent of all U.S. venture capital (VC) investment. The state's share of U.S. investment has expanded consistently from 41 percent in 2000. In 2010, investment in the state increased 17 percent over the previous year reaching nearly $11 billion, marking the first improvement in VC investment since 2007. Over time, investment patterns shift across industries and reveal new areas of opportunity. While Software attracts the largest sums of VC, its percentage of total investment continues to diminish as other industries attract more funding. Investment in Industrial/Energy has grown robustly since 2002 and has continued strongly in Biotechnology and Medical Devices. Between 2009 and 2010, VC increased 188 percent in Telecom, 50 percent in Computers, 76 percent in Consumer Products, and 44 percent in IT Services.

VENTURE CAPITAL INVESTMENT

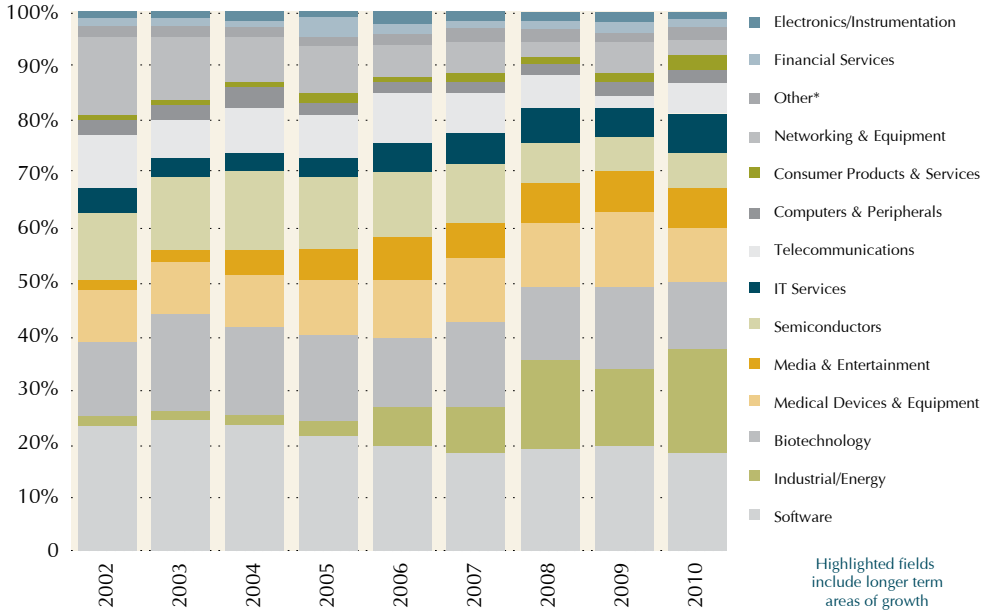
Billions of Dollars Invested
California



Data Source: PricewaterhouseCoopers/National Venture Capital Association MoneyTree™ Report Data: Thomson Reuters
Analysis: Collaborative Economics

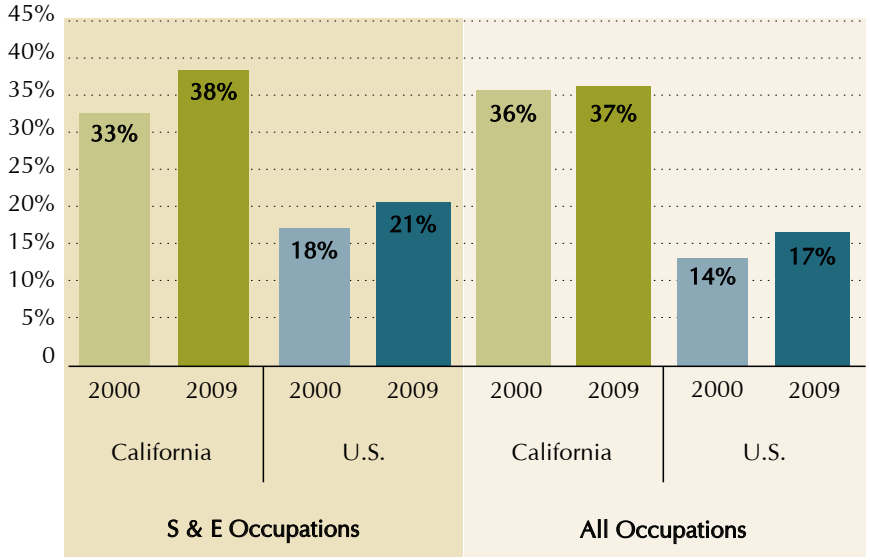
VENTURE CAPITAL BY INDUSTRY

California



* Other includes: Retailing/Distribution, Business Products & Services, Healthcare Services, and other unclassified deals
Data Source: PricewaterhouseCoopers/National Venture Capital Association MoneyTree™ Report Data: Thomson Reuters
Analysis: Collaborative Economics

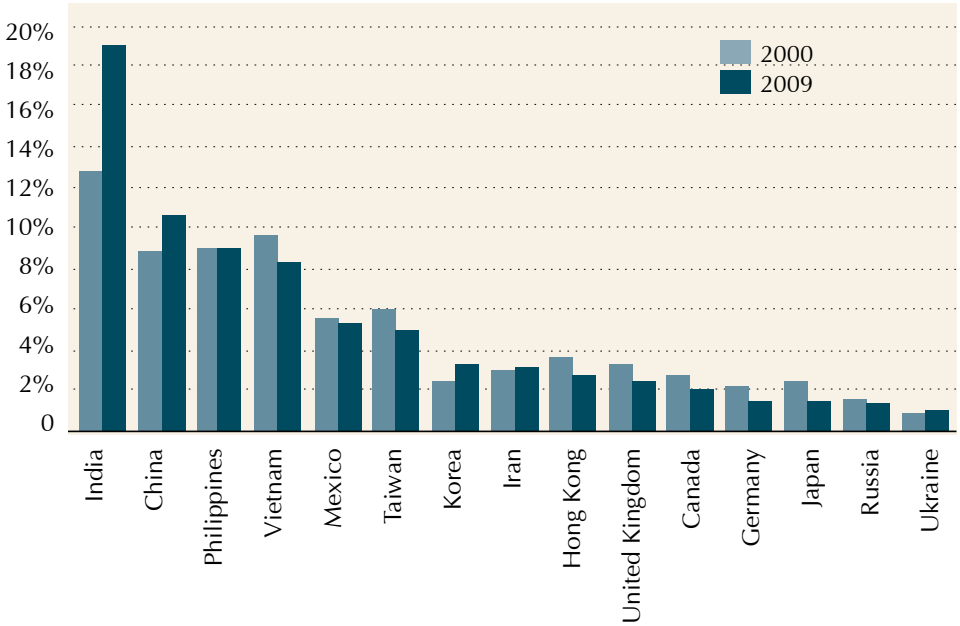
PERCENTAGE OF EMPLOYED TALENT WHO ARE FOREIGN BORN
California and the United States, 2000 and 2009



Note: Foreign born includes people born in U.S. territories/island areas
Data Source: U.S. Census Bureau, 2000 Decennial PUMS, 2009 American Community Survey PUMS
Analysis: Collaborative Economics

One of California's strongest assets is its diverse workforce. Much of this talent comes from outside the state and country. Compared to the U.S., the state depends on larger shares of foreign talent to fill its science and engineering (S&E) jobs. While foreign-born talent is expanding as a percentage of the total workforce across the U.S. and across all occupations, foreign-born talent is growing fastest as a share of S&E occupations in California. Increasing five percent, foreign-born S&E talent made up 38 percent of all S&E talent in the state in 2009, up from 33 percent in 2000. Across all occupations, foreign-born talent in the state increased only one percent. Nationally, foreign-born S&E talent increased three percent from 2000 to 2009.

FOREIGN-BORN SCIENCE & ENGINEERING TALENT BY PLACE OF ORIGIN
California



Note: Foreign born includes people born in U.S. territories/island areas
Data Source: U.S. Census Bureau, 2000 Decennial PUMS, 2009 American Community Survey PUMS
Analysis: Collaborative Economics

Increasingly, S&E talent flows into the state originate in India and China. In 2000, talent from India accounted for 13 percent of the state's S&E talent, and in 2009, Indians represented 19 percent. S&E talent from China increased from nine to eleven percent from 2000 to 2009.

California's world-class universities serve multiple roles in the state's innovation system. They undertake basic science as well as applied research and development. The state's universities develop the state's youth into world-class talent, and also serve to attract global talent through their reputation of excellence.[16] In 2006, over half of the state's foreign-born S&E talent was between the ages of 18 and 30 upon entry into the U.S.[17]

The number of S&E degrees conferred to nonpermanent residents has been on the rise since 2007, after dropping from the peak in 2005. Since 1995, S&E degrees conferred to foreign students increased 69 percent in California and 34 percent nationally. A discussion of international student flows is provided in Appendix D.

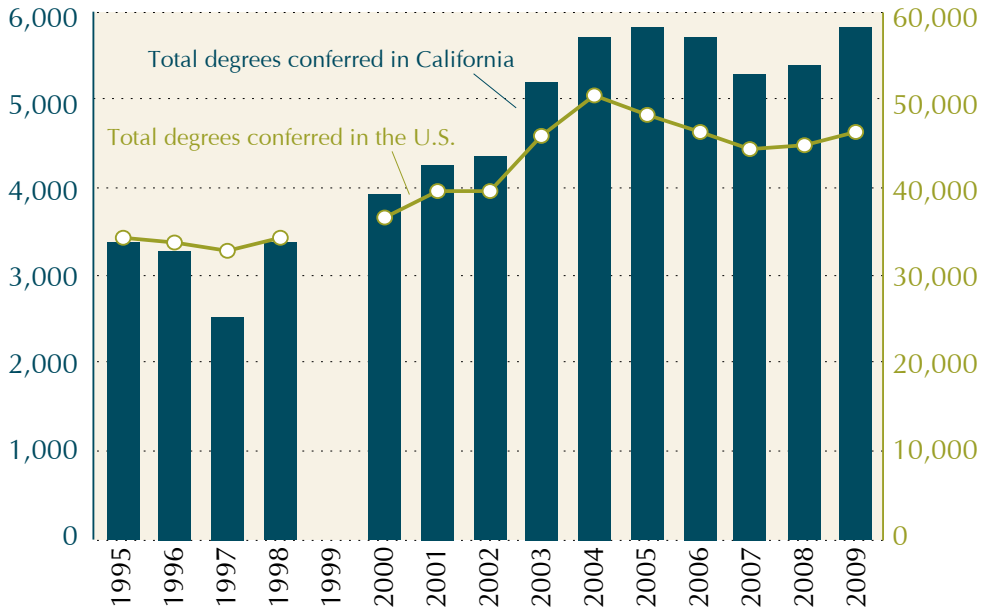
It is important that California continues to attract talent from abroad in order to grow the state's diverse talent base and to strengthen its global connections; however, it is essential that the state prepare its own youth for a world-class education and global labor market. As opportunities grow in other parts of the world, the state's pull of global talent may diminish. The state has technology leadership to solve its problems but must develop the talent to apply that technology. Talent is at risk.

EIGHTH GRADE MATH AND SCIENCE PROFICIENCY

	MATH 2009		SCIENCE 2005	
TOP FOUR STATES	Massachusetts	1	North Dakota	1
	Minnesota	2	Montana	
	New Jersey		New Hampshire	2
	North Dakota	3	Vermont	
	Vermont		South Dakota	3
			Massachusetts	
CALIFORNIA RANKING	THIRD WORST OF 52 Equal to West Virginia & New Mexico Above Alabama & District of Columbia		SECOND WORST OF 45 Equal to Hawaii Above Mississippi	

Note: Data includes District of Columbia. 2005 Science proficiency data does not include six states.
Source: National Assessment of Math & Science Proficiency by Grade

TOTAL SCIENCE & ENGINEERING DEGREES
Conferred to Temporary Non-Permanent Residents
Universities in California and the United States

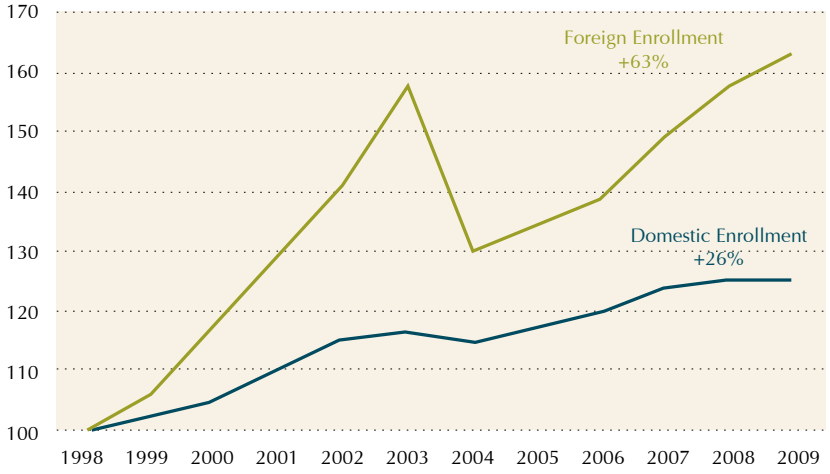


Note: Data are based on first major and includes bachelors, masters and doctorate degrees Data for 1999 is not available.
Data Source: National Center for Educational Statistics, IPEDS Analysis: Collaborative Economics

How well is the state investing in its future competitiveness and preparing its youth? California ranks at the bottom of the nation in terms of math and science proficiency for eighth graders. In 2009, the state's eighth graders ranked third to last of all states plus the District of Columbia and Department of Defense schools. In science proficiency, the state ranked second to the bottom of 45, tying with Hawaii and scoring above Mississippi.

ENROLLMENT GROWTH RELATIVE TO 1998

University of California and California State Universities



Data Source: RAND California Education Statistics

Analysis: Collaborative Economics

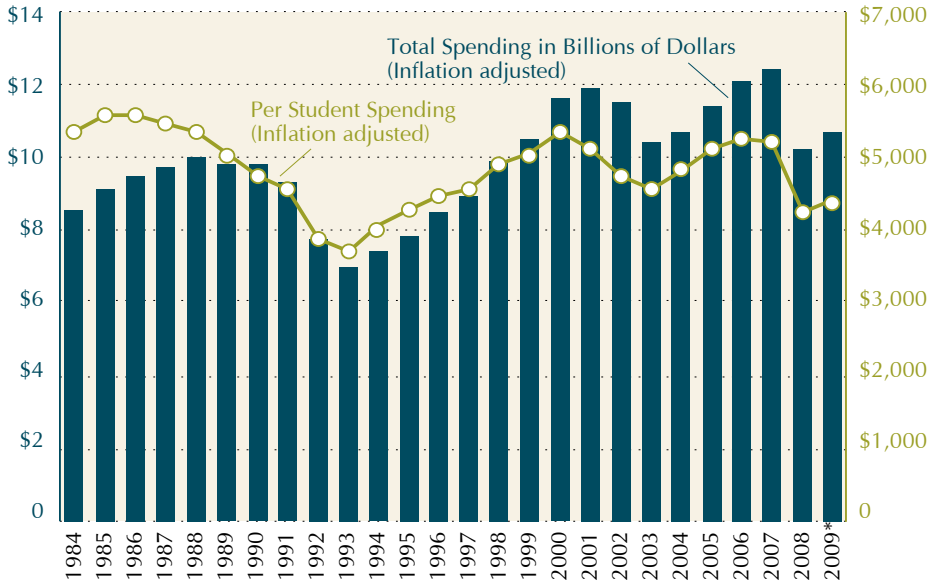
California students in pursuit of a college degree are faced with multiple challenges. The first challenge is in the acquisition of the skills required for admission into the UC and CSU systems. The second challenge is in the ability to pay the rising costs of tuition. Per student general fund spending has dropped significantly since 2007. In part, the funding gap is being filled by higher-paying students from abroad. Since 1998, foreign enrollment in California universities has increased at a faster rate than domestic enrollment. Over this period, domestic enrollment in the UC/CSU systems has increased 26 percent while foreign enrollment has expanded by 63 percent.

TOTAL ENROLLMENT		
University of California & California State University		
	1998	2009
Foreign	20,887	34,020
Domestic	502,560	630,887

HIGHER EDUCATION FUNDING OF PUBLIC INSTITUTIONS

Total and per Student General Fund Spending

California

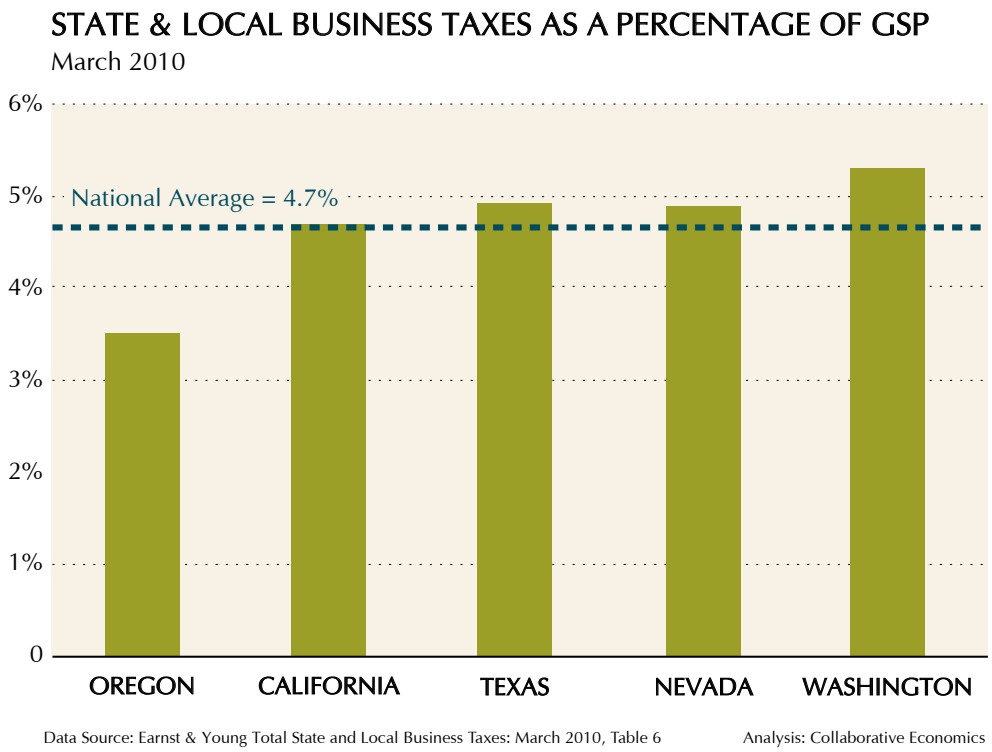


* Data for enrollment is based upon projections.

Note: Data in California fiscal years.

Data Source: California Legislative Analyst's Office and the California Postsecondary Education Commission

Analysis: Collaborative Economics



California's tax revenues play a role in meeting the state's innovation challenges. When reported as a share of gross state product (i.e. the total value produced from all goods and services), California's combined state and local business taxes are similar to the national average.

Broken down by different types of taxes, California's individual income taxes and sales taxes are higher and property taxes are lower when compared to other states. For example, while Washington State, Nevada and Texas have relatively low individual income taxes, they have relatively high corporate and property taxes. The rankings in the table are based on the indexing of taxes by category reported in the Tax Foundation's 2011 State Business Tax Climate Index.[18] When considering the impact of taxes on the state's economy, it is critical to take into consideration the overall tax structure and not simply the rates for specific taxes.

RELATIVE RANKINGS FOR STATE & LOCAL TAXES 2011

	Corporate Tax Index	Individual Income Tax Index	Sales Tax Index	Property Tax Index
California	33	48	49	16
Texas	46	7	37	29
Nevada	4	3	43	17
Oregon	45	46	4	5
Washington	32	1	13	46

Source: Tax Foundation 2011 State Business Climate Index October 2010, Table 2

APPENDIX B: International Comparisons

Competitive Strategies among Global Innovation Leaders:
A snapshot of current innovation indicators and a sampling of leading economies in 2011 will help identify other useful indicators in highly innovative economies. The following is a brief snapshot of innovation indicators and strategies in four foreign nations:

Singapore • European Union • China • India

SINGAPORE	Population 5.08 million

Singapore, an emerging biotech cluster, is "aiming to move up the value chain and position itself as a world class center for R&D through significant government investment."[19] For the period 2006 to 2010 the government committed 13.5 billion in Singapore dollars (SGD) to R & D, more than double the spending of the previous five-year period. 25.3% of this investment was committed to the biomedical sector. Singapore's strengths are its educated and skilled workforce, supportive government, business and regulatory environment and government-supported research institutes.

Biomedical Science

In the late 1990's, Singapore identified biomedical sciences as an area with tremendous growth potential. Between 2000 and 2005, core scientific biomedical research capabilities were created by building human, intellectual and industrial capital. The second phase of the country's biomedical sciences initiative (between 2006 -2010), focused on "strengthening its capacities in translational and clinical research designed to bring scientific discoveries from the bench to the bedside, to improve human health and health care delivery, and ultimately to contribute to the economy and bring benefits to society."[20]

R&D Resource Indicators

- Singapore University of Technology and Design, under construction as of November 2010, is a $700 million venture (partners include MIT and China's Zhejiang University) designed to "road-test" the latest in teaching theory, curriculum and academic features as a model for the future of education in engineering and design. They intend to take on real-world problems and quickly move research from the lab to the marketplace.[21]
- Singapore's R&D initiatives are set by the nation's Research, Innovation and Enterprise Council, chaired by the prime minister, and key work is done by public-sector research institutes.
- The lead public-sector R&D agency, the Agency for Science, Technology and Research (A*STAR), receives 40% of the total public sector R&D funds to carry out various activities with its partners including institutes of higher learning, hospitals, other public-sector agencies, and industry.
- A*STAR has two councils: the Biomedical Research Council (BMRC) and the Science and Engineering Research Council (SERC), supporting R&D in biomedical sciences as well as the physical sciences and engineering.

High Tech Workforce Indicators

Singapore's autonomous universities, the National University of Singapore (NUS) and Nanyang Technological University (NTU), have been ranked among the world's top universities. In the Times Higher Education Supplement's (THES's) World Universities Ranking 2009, the Singapore schools ranked 30th and 73rd respectively, among the top 200 universities in the world.

EUROPEAN UNION	Population: Approximately 500 million

The latest European Innovation Scoreboard (EIS) 2009 ranks the following countries under each of the four categories:

Innovation Leaders

Denmark, Finland, Germany, Sweden, Switzerland and the UK

Innovation Followers (performance below Innovation leaders but above the EU average)

Austria, Ireland, Luxembourg, Belgium, Cyprus, Estoria, Iceland, France and the Netherlands

Moderate Innovators (innovation performance below the EU average)

Czech Republic, Greece, Hungary, Italy, Lithuania, Malta, Norway, Poland, Portugal, Slovakia and Spain

Catching up Countries (innovation performance well below the EU average)

Bulgaria, Croatia, Latvia, Romania, Serbia and Turkey

Leading industries: The 27 nations of the EU comprise multiple industry sectors, some major industries include:

- Automotive: The EU is the world's largest producer of motor vehicles
- Biotechnology: This makes a significant contribution to core European policy goals.
- Chemicals, plastics and rubber industries: Are among the largest and most dynamic industry sectors in the EU.
- Construction: Strategically important for Europe, providing buildings and infrastructure, and is a major contributor to Gross Capital Formation in the region.

R&D Resource Indicators

Because of the nature of the EU as a union of 27 independent countries, most of the investment takes place at the level of individual states. While 94% of public R&D funds in the US are federal, just 7% of public funds flow through central EU programs.

CHINA	Population: 1.3 billion. China is the world's most populous country

With 1,423 million researchers, China is a "hair's breadth away" from claiming more researchers than either the US or the EU who both possess 20% of the world's researchers, compared to Japan (10%) and Russia (7%).[22] China's high rate of growth in GDP enables its priority investments in R&D.

China's government desires to establish internationally competitive technology standards to increase technology transfer from foreign investors and to establish a more indigenous innovation society. China's S&T priority areas are many, but significant impacts are expected in information technology, energy and biotechnology.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) produced its first major survey of research and development in five years.[23] The UNESCO report finds that both China and India are using their economic might to invest in high technology companies in Europe and elsewhere to acquire technological expertise overnight. UNESCO predicts "if current trends persist, by 2025 China will have the world's second largest economy and will be a leading military power."

Major innovation priorities in China include:

- Major investments in education
- An emphasis on exporting, making China the world's largest exporter
- A focus on phased-in economic development and modernization across China's vast and disparate territory in accordance with China's "Go West Strategy."

Scientific and technological pursuits are valued in China; scientists, engineers, academics and increasingly entrepreneurs are recognized as essential to China's society and economy.

In 2006, China developed a Medium-and Long-Term Plan (MLTP) to chart a pathway to prioritize future Science & Technology development. China's MLTP designates energy and the environment as priority fields for development through science and technology utilizing a two-fold approach: [24]

- Acquire, adopt, absorb and ultimately own (through indigenous IP) foreign technologies in renewable energy and pollution control.
- Independently develop renewable energy and pollution control technologies in the key national research programs.

China's economic trajectory is dependent on its capacity to address challenges including:

- Currency inflation
- Outsized global trade surpluses
- Corruption
- High unemployment
- Income disparities
- Projected resource constraints

INDIA — Population: 1,155,347,678

A decade of economic progress has jettisoned this second most populous nation in the world into becoming the fourth largest economy in terms of purchasing power. GDP has increased by an average of 9% annually in fiscal years 2004 – 2009.

India's global competitiveness is based on the country's large market size and on positive results in several key economic indicators. As an example, the World Economic Forum, in its Global Competitiveness Report, 2010-11[25] ranks India as 39th worldwide in innovation, 17th in financial markets and 44th in business sophistication.

In spite of impressive economic progress in recent years, India faces challenges that threaten to derail the nation's science and technology goals.

According to "Science and Technology Strategies for Six Countries," US Committee on Global Science and Technology[26] India lags behind China and Brazil in many common science and technology indicators including:

- Numbers of R&D researchers per million inhabitants
- Numbers of patents granted
- R&D spending as a percentage of Gross Domestic Product
- High technology exports as a percentage of manufacturing exports (World Bank 2009)

In the education arena, India's gross enrollment in higher education is half the world's average. India's large English-speaking population has limited access to first tier S&T higher education. Data suggests that some of the best of India's students go abroad for higher education and never return resulting in a reduction of the quality of India's talent pool of qualified S&T researchers and educators.[27]

In December 2010, India's Vice President Shri M. Hamid Ansari noted that one of the major themes of India's "Eleventh Five Year Plan" is the enhancement of access to higher education. Two additional themes are inclusion and access, recognizing the fact that expansion of higher education does not ensure automatic access to marginalized sections of society.[28]

According to a 2007 publication, "India's Changing Innovation System: Achievements, Challenges and Opportunities for Cooperation, Report of a Symposium (2007),"[29] India is receiving help in regards to their environmental and energy needs through partnering with the United States in programs such as FutureGen. Opportunities for additional US and India partnerships were highlighted with a goal of bringing high level technologies to bear on the larger problems of the world, such as in the field of energy, i.e. atomic power generation, photovoltaics, hydrogen cells, or next generation zero-based coal technologies.

APPENDIX C: Communities of Innovation

The 21st century world is a social networking world in which innovation is highly prized. The networking of today and tomorrow is uniquely open and collaborative consisting of both tangible communities and virtual structures. California's innovation ecosystem in the 20th century benefited from many of these emerging characteristics. However, with other nations and other states investing heavily to compete in this new economy, California cannot be complacent.

For California to remain competitive and further capitalize on our sound innovation ecosystem underpinnings, existing structures and collaborations from the 20th century will require quantum leaps to be a player in the 21st century. At a time when California's financial infrastructure is failing and budgets are being slashed, including that of our major research and teaching universities, California needs to rethink and reengage our creative assets. California must take bold steps to stay competitive by engaging a model that can capture the strengths of the "social networking mindset" and the catalyzing energies of a "space race" impetus. *Many needed quantum leaps will not require new or additional resources; instead they require an inventory, relook and transformation of the existing resources.*

In other regions of this nation and in other fast evolving countries across the world, communities of innovation are being catalyzed by competitive state and national governments. These emerging and established communities are the result of strategies that embrace the value of networking, co-location of talent, and the opportunity for innovation at the convergence of interests and sectors. California has long benefited from the organic growth of the Silicon Valley innovation community; an effort that has emerged over more than half a century. California now needs an action plan to strategically identify and accelerate the emergence of additional robust Communities of Innovation. For such an approach to be successful, it will need to be adopted and implemented by key stakeholder leaders (industry, government, and academia).

California is uniquely positioned to seed communities of innovation by leveraging existing assets resident in the state – namely federal research laboratories (specifically NASA, Dept. of Energy, and Dept. of Defense), research universities (particularly UC given its land grant heritage and charter), and industry (especially high tech, cutting edge areas such as energy, biotechnology, information technology, etc.).

INNOVATION COMMUNITIES

"The landscape for research is changing dramatically as countries across the globe are investing substantial sums in developing large, well-funded research communities, offering expanded incentives to attract corporate research and development, and breaking down public-private barriers to collaboration."[30]

In America, well known traditional Communities of Innovation include the Research Triangle Park in North Carolina and Stanford Research Park. The former was a state strategy and the latter developed organically. In both cases, the development took decades to mature and return value to those investing. Today Communities of Innovation are being seeded around the world through staggering amounts of investment by governments. Around the world the goal is to leverage public and private partnerships to catalyze innovation and competitiveness. These strategies are attracting attention, drawing talent, and helping to escalate the intellectual capital and related economies. In this country, states are developing strategies to seed their own regional communities of innovation; for instance the state of Florida relocated Scripps Medical Institute from San Diego to Jupiter, Florida, and the state of Indiana has expanded the reach of Purdue's intellectual engine by investing in developing satellite communities of innovation across the state.

These Communities of Innovation, whether domestic or international have several consistent components:

- Strategic presence of one or more innovation catalyzing entities such as a major university, state or federal research entity
- Co-location of public and private stakeholders
- Facilitating infrastructure of people and programs devoted to the facilitation of partnerships, interactions and events to support innovation
- Space and technology infrastructure to attract and support the emergence of new ideas and the organizations and companies that will promote them
- A long term, active engagement by stakeholders

California is well positioned to expand the impact of Communities of Innovation across the state. In some cases, it will take a rethinking of approach, a strategic reallocation of existing resources, or a new way of promoting assets. In all cases, it will take the commitment of the state to support the growth of regional excellence and competitiveness.

A key role that the state government can play is encouraging and incentivizing state entities to strategically consider the fundamentals to promote an innovation ecosystem that includes Communities of Innovation namely:

- Human capital (people)
- Capital goods (infrastructure)
- Financial/value capital (resources)

Pillars of Communities of Innovation include:

FEDERAL RESEARCH LABORATORIES

California is home to world-renowned Federal Research Laboratories (labs) with diverse portfolios ranging from aerospace, energy, security, and transportation. Advancements in science and technology, which were mission driven, have often been translated into tangible products, companies, and industries that contribute to the state and the nation's economic competitiveness. In FY 2000, California had approximately $14.6 billion federal R&D expenditures. Most major federal agencies provide funding for California R&D, foremost of which is the Department of Defense (DOD), which accounted for approximately 53% of all federal R&D dollars spent in California in FY 2000. NASA accounted for 25% of federal R&D expenditures in California. Four of the top ten universities in federal R&D spending are in California. Government-owned, privately operated facilities in the state include the Jet Propulsion Laboratory in Pasadena (operated by California Institute of Technology), Lawrence Livermore National Lab and Berkeley National Lab (both operated by the University of California), and the Stanford Linear Accelerator Center (SLAC) at Stanford University. However, the full power and potential of the people (scientists and engineers), facilities (state of the art laboratories and equipment), and content (research) resident in these labs has not been captured or leveraged to the highest potential.

Two of the federal laboratories are currently exploring or working to launch new Communities of Innovation. The potential success of both of these could greatly benefit from the strategic engagement of the state:

- Livermore Valley Open Campus (LVOC): a joint venture between Sandia National Laboratories and Lawrence Livermore National Laboratory that will promote greater collaboration between the world-class scientists at the nuclear security labs and their partners in industry and academia. The LVOC, which would create a shared space between the two adjacent labs for increased scientific interaction and collaboration across the nuclear security enterprise bringing discoveries to the market faster and finding new solutions to energy problems. Open access to the LVOC by the international science community would directly support the advancement of Sandia's Combustion Research Facility, promote key LLNL programs such as the National Ignition Facility (NIF) and its High Density Energy research, increase the profile of NNSA in the region, expand the high-tech "footprint" of the Bay Area and establish the Livermore Valley as the high-tech anchor in the East Bay.

- NASA Research Park (NRP) currently hosts more than 70 on-site industry, university (Carnegie Mellon University, Purdue University, University of California) and non-profit partners. NRP will ultimately comprise 5.7 million square feet of new construction for research and development offices, university classrooms and laboratories, rental housing, museums, and a conference and education center.

Federal Laboratories are a pillar of the innovation communities.

UNIVERSITIES

California has a higher education system that is the envy of the world – ranging from private universities (Stanford and USC) to public (The University of California). It has 3 out of the top 10 and 6 out of the top 20 universities in the world, conducts over $6.5 billion in research and graduates almost 3,000 STEM PhD students per year.

ACADEMIC RANKING OF WORLD UNIVERSITIES FOR 2010	
1.	Harvard University
2.	University of California, Berkeley
3.	Stanford University
4.	Massachusetts Institute of Technology
5.	University of Cambridge (UK)
6.	California Institute of Technology
7.	Princeton University
8.	Columbia University
9.	University of Chicago
10.	University of Oxford
11.	Yale University
12.	Cornell University
13.	University of California, Los Angeles
14.	University of California, San Diego
15.	University of Pennsylvania
16.	University of Washington
17.	University of Wisconsin – Madison
18.	The Johns Hopkins University
19.	University of California, San Francisco
20.	The University of Tokyo

Published by the Center for World-Class Universities and the Institute of Higher Education of Shanghai Jiao Tong University. Rankings are based on quality of education, quality of faculty research output, and per capita performance. California has 3 out of the top 10 and 6 out of the top 20 universities. Source: http://www.arwu.org/ARWU2010.jsp

ACADEMIC R&D EXPENDITURES, 2009					
	Total	Federal	State/local	Industry	Other
California Institute of Technology	$342,455	$305,682	$1,630	$8,756	$26,387
California State University	$265,281	$154,611	$44,545	$7,276	$58,849
Stanford University	$704,183	$477,507	$23,971	$58,491	$144,214
University of California	$4,888,022	$2,449,609	$230,340	$324,441	$1,883,632
University of Southern California	$533,041	$375,024	$9,670	$72,815	$75,532
	$6,722,982				

Source: NSF WebCASPAR (http://www.webcaspar.nsf.gov)

STEM DEGREES AWARDED, 2009				
	Total	Baccalaureates	Master's	Doctorates
California Institute of Technology	499	209	111	177
California State University	12,469	9,297	3,160	12
Stanford University	2,146	603	1,125	410
University of California	17,863	12,680	2,612	2,249
University of Southern California	2,448	614	1,553	264
	35,425			

Source: California Postsecondary Education System (http://www.cpec.ca.gov)

California also has a unique public infrastructure that allows students to begin their education in a community college and progress through the California State University or the University of California system. A first-generation college student, UCR Chancellor White began his higher education at Diablo Valley Community College in Northern California. He achieved his B.A. degree at California State University, Fresno; his M.S. degree at California State University, Hayward; and his Ph.D. at UC Berkeley.

The University of California is a land-grant institution. The mission of these institutions as set forth in the 1862 Morrill Act is to focus on the teaching of agriculture, science and engineering as a response to the industrial revolution and changing social class. Land-grant universities across the country continue to fulfill their mandate for openness, accessibility, and service to people, and many of these institutions including the University of California have joined the ranks of the nation's most distinguished public research universities. When the land grants were established, the focus of public service obligation was on mechanical arts and agriculture. Today the agriculture extension service of land grants continues to serve that important need. However, over time, the mechanical arts portion of the mission has been replaced in our new economy by the need for an innovation and knowledge-based service, an innovation catalyzing function.

Actively catalyzing, participating in, and contributing to innovation communities is one manifestation of this 21st century version of the land grant public service component. The universities serve an important role as catalysts for creativity, job creation, and economic development.

Universities are a second pillar of the innovation communities.

LICENSING INCOME			
Year	Institution	ATUM Reported Licensing Income	
2009	California Institute of Technology		$47,665,535
2009	San Diego State University		$419,873
2009	Stanford University		$65,054,187
2009	University of Southern California		$4,399,006
2009	University of California System		$103,104,667
	Berkeley	$4,885,000	
	Davis	$9,845,000	
	Irvine	$4,490,000	
	Los Angeles	$22,557,000	
	Merced	$ 00	
	Riverside	$1,949,000	
	Santa Barbara	$2,720,000	
	Santa Cruz	$61,000	
	San Diego	$22,235,000	
	San Francisco	$29,252,000	
	Ten Campus TOTAL	$97,994,000	

NOTE: The total for the campuses does not equal the ATUM reported number because of the revenue from Chromosome Painting portfolio is associated with LLNL and which UC manages on their behalf.

INDUSTRY

Silicon Valley is synonymous with innovation; likewise, the biotech industry in San Diego and the San Francisco Bay Area along with other burgeoning industries are centers for creativity. Nations around the world are trying to replicate the environment, thought processes, and innovators who built Apple, Sun Microsystems, etc. Clustering businesses near universities help collaboration. The UCSD Von Liebig Center has seen benefits from being located in an entrepreneurial friendly and investment rich environment.

Industry leaders in California recognize the thin line that separates them from being industry leaders and industry followers. There is a drive, a mind-set that is different in California – not merely thinking outside of the box, but creating a cloud. However, there is a recognition and acknowledgement by industry that the business and economic environment in California may be jeopardizing the health and well-being of innovation and job creation in the state. Industry is ready, willing and able to partner and collaborate with universities and federal labs as evidenced by their active participation in CCST hosted regional roundtables in the past several months.

Industry is a third pillar of the innovation communities.

STATE AND LOCAL GOVERNMENT

State and local governments are uniquely positioned to foster communities of innovation and serve as exemplars for others. However, this requires a new look at current approaches to economic development. Representative examples include enabling land development plans, permitting processes, incentives, and services. *Innovation communities offer a new way of thinking about*

national, state, and local economies requiring new roles for companies, government, and other institutions in enhancing competitiveness.

Government is a fourth pillar of innovation communities.

ALIGNMENT OF STARS

In many ways the stars are aligned to take a bold step to create and lead the nation in modeling these innovation communities:

- Economic Crisis: Creates an environment where people and organizations are more willing to consider new ways of doing business in order to survive; crisis creates chaos and opportunities.
- Policy: America COMPETES Act authorizes both the tools and the resources to thrust R&D, education, innovation and competitiveness to the forefront of the nation's needs in furtherance of economic vitality, global stature and national security.
- Infrastructure: Groups like the Silicon Valley Leadership Group (SVLG) and the Association of University Research Parks (AURP) are positioned and prepared to act. They have offered specific roadmaps such as "The Power of Place 2.0: The Power of Innovation – 10 Steps for Creating Jobs, Improving Technology, Commercialization and Building Communities of Innovation" and the SVLG White Paper "What would it take from Sacramento to foster an environment for private sector employers to grow technology and manufacturing jobs in California again?"

California finds itself at a critical juncture albeit a "tipping point". Its leaders have an opportunity to take big, bold steps to change the overall fiscal crisis by leveraging the resident strengths and capacity within the state in its universities, federal labs, and industry. The fundamental tools are here and available; the challenge is to create a 21st century framework that launches these tools in a new paradigm.

APPENDIX D: International Student Flows in California

Over the span of a single generation, the United States has fallen from first to ninth place globally in the proportion of young people with college degrees. The United States ranks 18th out of 24 industrialized nations in high school graduation rates. In addition, the United States ranks 27th in the proportion of science and engineering degrees conferred. We lag behind other nations in the quality of our math and science education, ranking 25th in a measure of math skills among 15 year-olds and 20th in science skills, according to a 2003 survey of more than 250,000 15year old students in 41 nations.[31]

According to the California STEM Education Coalition 2008 K-12 STEM Education Report Card (http://www.usinnovation.org/state/pdf_stem/STEMEdCalifornia08.pdf) over the past 10 years, the percentage of ACT-tested (ACT Educational Planning and Assessment System) students in California who said they were interested in majoring in engineering dropped steadily from 7.6 percent to 4.9 percent. Over the past five years, the percentage of ACT-tested students who said they were interested in majoring in computer and information science dropped from 4.5 percent to 2.9 percent. However, students who plan early and strategically and have access to high-level and rigorous course work are more likely to be prepared to succeed in STEM fields.

Because of the failure to produce sufficient numbers of science and technology workers, California and the rest of the nation continues to rely on international students to fill science and engineering positions in high technology firms. According to the Institute of International Education's "Open Doors 2010 Report," in 2009-10, the number of international students in the United States increased 2.9 percent over the previous year to 690,923 (up from 671,616).

5 countries account for 52% of all international students in the U.S., and these are in ranking order	
1	CHINA
2	INDIA
3	SOUTH KOREA
4	CANADA
5	TAIWAN

California is the top-ranking state for international students with 94,279 foreign students in California universities in 2009-10 -– a 1.2 percent increase from 2008-09 (up from 93,124). Among the top five states, California is followed by New York (76,146), Texas (58,934), Massachusetts (35,313) and Illinois (31,093). University of Southern California ranks first with 7,987 students in 2009-10.[32] The top five originating nations for California's international students are as follows: 1) China (16.9% of total); India (13.3% of total); South Korea (13.2% of total); Japan (7.3 % of total); and Taiwan (7.0% of total).

California's leading academic institutions housing the largest number of international students (nationally) in 2009-10 are:

CA University	Total Students	National Ranking
University of S. California	7,987	1
University of California, Los Angeles	5,685	7
Stanford University	3,934	25
University of California, Berkeley	3,883	28

The Open Doors 2010 report estimates the total net contribution to California's economy by international students in 2009-10 is $2,834,164,000.[33]

Academic level trends among international students in the United States in 2009-10 are:

- Undergraduate: 274,431 (up 1.7% from 2008-09)
- Graduate: 298,885 (up 3.7% from 2008-09)
- Non-degree: 54,803 (up 5.8% from 2008-09)

THE TOP FIELDS OF STUDY CHOSEN BY INTERNATIONAL STUDENTS IN THE U.S. IN 2008/09 & 2009/10				
Field of Study	2008/09	2009/10	% of Total	% Change
Business and Management	138,565	145,514	21.1%	5.0%
Engineering	118,980	127,441	18.4%	7.1%
Physical & Life Sciences	61,699	61,285	8.9%	-0.7%
Math & Computer Science	56,367	60,780	8.8%	7.8%
Social Sciences	57,348	59,865	8.7%	4.4%
Fine & Applied Arts	34,854	35,802	5.2%	2.7%
Health Professions	35,064	32,111	4.6%	-8.4%
Intensive English Language	28,524	26,075	3.8%	-8.6%
Education	18,120	18,299	2.6%	1.0%
Humanities	19,179	17,985	2.6%	-6.2%
Agriculture	8,961	10,317	1.5%	15.1%
Other Fields of Study	73,011	76,743	11.1%	5.1%
Undeclared	20,944	18,707	2.7%	-10.7%

Source: Open Doors 2010 Fast Facts

Current data on the number of US students who study abroad indicates 260,327 US students studied abroad for academic credit in 2008-09. This figure has more than doubled over the past decade. Here in California, the number of US study abroad students enrolled through California institutions totaled 26,715 in 2008-09 – a 1.5% decrease from the prior year.[34]

DO INTERNATIONAL STUDENTS IN CALIFORNIA REMAIN IN THE STATE FOLLOWING GRADUATION?

Although hard data tracking the numbers of international students graduating with higher degrees who remain in the state following completion of their degrees is very limited, anecdotal information received from California universities, such as Caltech, have observed a shift in the past five years. It has been generally reported that most international students (and postdocs) had previously wanted to remain in the United States because of the scientific infrastructure here. Given the demand and the fact that a large percentage of technical Ph.D.s are conferred to international students, domestic employers in high tech have willingly sponsored work visas.

More recently it has been reported by Caltech (and other universities) that international students are considering jobs at home (i.e. in India, China, Germany, Brazil and Korea) as viable alternatives to staying in the United States. These students are finding that when they combine the new options in their home countries with the disincentives of staying in the United States (e.g. economic recession, difficult immigration laws, international commerce rules such as ITAR or EAR restrictions,[35] stiff competition in grant writing, etc.) returning home increasingly becomes an option.

Another observable trend is that international students are much more connected to their homelands than in the past. No longer do they lose connections to home and their university cohorts there when they come to the United States. The emergence of Skype and Facebook has impacted this trend. (Source: Caltech)

In spite of the above observations, workshops offering green card information continue to draw considerable interest as international students and scholars carefully weigh their options.

The University of Southern California (USC) reports that 2,308 international students graduated from their university between fall 2009 to summer 2010. Of this total, 1,483 students applied for Optional Practical Training (OPT)[36] between August 2009 and August 2010. (Note: OPT is a benefit for F-1 students who are completing an undergraduate or a graduate degree in the United States.) OPT provides an opportunity for students to gain career experience in their field of study. Students can work under this authorization for up to one year. OPT is approved by the United States Citizenship and Immigration Services (USCIS). Once students receive their Employment Authorization Document (EAD card) from USCIS, they can commence their employment.

In addition, international students who major in science, technology, engineering and mathematics (STEM) can apply for a 17-month extension with E-verified companies as they near the one-year end date on their Employment Authorization Document (EAD). USCIS also administers STEM applications. (See http://www.ice.gov/sevis/stemlist.htm for more information.)

POLICY QUESTIONS FOR CONSIDERATION

What is the anticipated impact on California from a potential declining population of international students supplying labor to high technology employers and the need for accelerated development of STEM skills among our local student populations?

According to *Global Trends 2025: A Transformed World*, "China and India are expected in 10 years to achieve near parity with the US in two different areas: scientific and human capital (India) and government receptivity to business innovation (China)."[37]

As foreign nations, such as China and India, continue to match and exceed America's ability to develop its human capital, particularly its science and engineering talent, American employers will be forced to follow the highest degree of workforce excellence wherever they may find it.

Recognizing this dilemma, the National Science Foundation has initiated the Advancing STEM Education Initiative (http://www.nsf.gov/news/news_summ.jsp?cntn_id=116094). This initiative brings together different scientific disciplines and diverse communities of faculty and students, often on the same campus to discuss related matters and options. Seven institutions received funding in FY 2009 through "Innovation through Institutional Integration," a program designed to link institutions' existing National Science Foundation (NSF)-funded projects in science, technology, engineering and math (STEM) education and to leverage their collective strengths. Funded awardees received up to $1.25 million over four years.

1. Should increasing the state's access to data on international student trends in California be a priority public policy goal?

2. What state policy actions are needed to increase the state's capacity to meet the pressing workplace skills needed by California's high technology employers in science, technology, engineering and math (STEM)?

APPENDIX E: Water Technology in California

California is already a leader in water technology and the challenges we face create an opportunity to develop further technologies in this area. The following data suggests what is possible.

Businesses in Water & Wastewater[38] provide products and services that cover the range of high tech and novel technology as well as tried and tested products related to the following:

- Water conservation (control systems, meters & measuring devices)
- Development and manufacturing of pump technology
- Research and testing
- Consulting services (design, build and/or operate)
- Water treatment & purification products/ services

Employment in Water & Wastewater is distributed across the state and growing at a faster rate than overall state growth.

- While statewide employment increased 18 percent between 1995 and 2009, employment in Water & Wastewater expanded 31 percent. After slowing in 2004, jobs picked up nine percent between 2006 and 2009.
- The San Diego Region reported the strongest employment growth of 160 percent from 1995 to 2009.
- Since 2006, the Sacramento Valley posted the strongest job gains in the state of 58 percent from 2006 to 2009.

Businesses in Water & Wastewater increased by 40 percent in number over the 15 years.

- Business growth over the long term was most robust in the Los Angeles Area where establishments increased in number by 75 percent from 1995 to 2009.
- The San Diego Region outpaced all other regions with a jump of 15 percent number of businesses between 2006 and 2009.

Venture capital investment in Water & Wastewater technology is strong in California.

- California accounts for 40 percent of total U.S. venture capital investment in Water & Wastewater technology between 1999 and 2010 (as of November). Investment in the state represents 32 percent of total U.S. investment so far in 2010.
- California investment in Water &Wastewater increased by 143 percent from 1999 to 2010.
- Attracting 57 percent of total investment over the period, Water Treatment reported the strongest growth of all water sub segments, increasing 127 percent from 2006 to 2010.

Endnotes

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- Science Foundation Arizona: a public/private entity that manages an innovation strategy focused on information, communications and biomedical research.
- Oregon Nanoscience and Microtechnologies Institute (ONAMI): a nonprofit that promotes research and commercialization to advance economic benefits of technology innovation.
- Ohio Third Frontier: launched in 2002 as a ten-year $1.68-billion initiative, in 2010 voters approved $700 million to extend funding to 2015 to create an "innovation ecosystem" that supports the transition of great ideas from the laboratory to marketplace, with a focus on fuel cells, photovoltaics, biomedical, sensors and advanced materials.

See, *Governor's Guide on State Research and Development Funds*. 2010. California Profile, Prepared by Collaborative Economics for National Governor's Association and Pew Center on States.

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14 *Investing in Innovation*, 2007. Pew Center on the States and the National Governors' Association. Page 16.

15 *Science and Engineering Profile: California* 2006-08 (NSF 10-302) November 2009. National Science Foundation, Division of Science Resources Statistics, Survey of Industrial Research and Development, 2006; Survey of Research and Development Expenditures at Universities and Colleges, FY 2007; Survey of Federal Funds for Research and Development, FY 2007–08; and Survey of State Research and Development Expenditures, FY 2006.

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18 The Tax Foundation's 2011 State Business Tax Climate Index (SBTCI) is calculated by comparing five separate tax indexes – major business taxes, individual income taxes, sales taxes, unemployment insurance taxes, and property taxes. A state's tax is assigned a score on a scale of zero (worst) to ten (best) based on the Foundation's criteria for business climate. A total of 50 states are ranked for comparison. State rankings for five states are shown in the table for each of the tax indexes, excluding major business taxes. A ranking of 1 reflects the Foundation's best ranking, and a ranking of 50 is the worst for the state business tax climate.

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