California Council on Science & Technology

20 Years

1988
2008

A Voice for the Future
The First Two Decades of the California Council on Science and Technology

Preface

In 1996, eight years after the California Council on Science and Technology was created, CCST adopted its first strategic plan. At the center of that plan was the following goal:

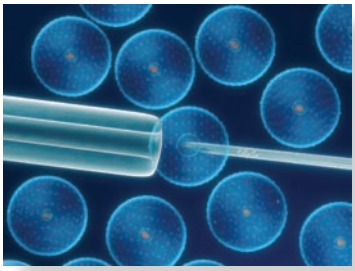
By 2010 the California Council on Science and Technology should be fully established as an essential element of public policy, molder of public opinion, and independent council to all that relates to science and technology policy in California.

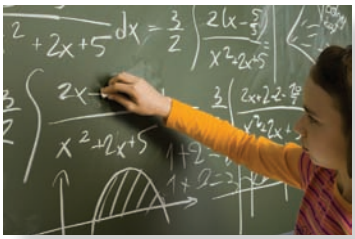
For a young organization, that was an ambitious objective. CCST had done important work in its first years, but relatively few state legislators or business leaders knew of it. The gap between science and technology, on the one hand, and the actions of government and many companies, on the other, remained large.

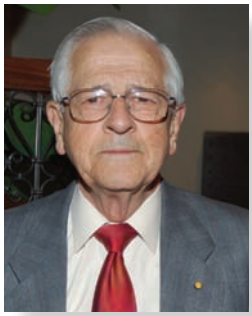
Today, as CCST begins its third decade, the goal it established back then is within reach. The number of studies undertaken by CCST has grown dramatically. Legislators trust and respect CCST and look to it for independent, objective, and nonpartisan advice. The gap between science, technology, and society in California has been reduced.

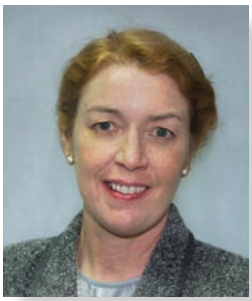
Much of CCST's success can be attributed to the strong foundation on which it was built. Led by several young and far-sighted state legislators–including Sam Farr, who later became a U.S. Congressman, and John Garamendi, who later became the state's Lieutenant Governor–the 1988 resolution that created CCST addressed both current and future needs. CCST was to consist of "distinguished scholars and experts, including scientists and engineers from California's academic and industrial community," according to the founding legislation. It was to analyze and report on "public policy issues involving science and technology" and "identify long-range research needs for sustaining the state's economic development and competitiveness and provide direction for new scientific and technological activities."

CCST has risen to this challenge. During its first 20 years, it has issued important reports on transportation, energy research, science and mathematics education, nanotechnology, economic development, and many other topics. Council members and staff meet with legislators, state agency officials, members of the Governor's and Lieutenant Governor's offices, and leaders of federal laboratories and the private sector to consult on issues that have scientific or technological components. CCST organizes briefings, convenes meetings, and









reviews the more than 100 bills introduced in the California legislature each year that involve science and technology. It has become a valued resource within California and a model of involvement for scientists, engineers, and policymakers in other states.

CCST remains a small organization with just a handful of staff based in Riverside, Sacramento, and Santa Cruz. It amplifies this expertise by drawing on the volunteer efforts of more than 150 accomplished scientists, engineers, physicians, and business leaders from throughout the state and beyond. CCST is overseen by a 16-member Board of Directors who set CCST's overall agenda. The Council itself consists of 30 members, many of whom have been elected to the National Academies of Sciences and Engineering and the Institute of Medicine. In addition, CCST has more than 100 Fellows who are available to conduct specific projects and advise on public policy issues.

The history of CCST recounted in these pages illustrates both how much has already been done and how much more could be done. Even with this extensive network of volunteers, CCST must be selective in what it undertakes. While science and technology are pervasive in today's world, CCST must carefully balance its initiatives against available resources.

This anniversary is an opportunity to look ahead as well as behind. CCST will continue to call on leaders in higher and K–12 education, industry and federal laboratories to advise policymakers on critical science and technology issues facing the state–energy use and production, environmental protection, education, sustainable development, water supplies, transportation infrastructure, and healthcare, to name just a few. We will continue to address these complex issues independently and objectively, with the goal of providing essential inputs to increasingly challenging policy discussions.

For two decades, the California Council on Science and Technology has acted as a voice for science and technology in California. As the significance and importance of science and technology in society and on the economy grows, it remains vitally important for that voice to be heard.

Creating a Stronger California

The California Council on Science and Technology has become the leading state-level science and technology advisory body in the country.

Policies that involve science and technology–long a focus of attention at the federal level–have become a major concern in the states as well. State governments spend increasing sums on research and development (R&D) to spur economic growth and address the needs of their citizens. Many of the most important problems facing state government and business leaders cannot be solved without drawing on scientific and technological expertise.

In 1988 the California legislature created a way for public and private sector organizations to access that expertise. Drawing on models operating at the federal level–including the National Research Council, the National Science Board, and the White House Office of Science and Technology Policy–an Assembly Concurrent Resolution approved by unanimous vote in both the Assembly and the Senate created the California Council on Science and Technology. As CCST's founding legislation observed, more than "25 percent of the members of the National Academy of Sciences live and work in California as do more than 25 percent of the engineers working in the United States." CCST was designed to create a resource on which government,

academic, and business leaders could call when they faced problems requiring scientific or technological input.

During its first two decades, CCST has had great success in meeting its founders' ambitions. It has issued formal reports on a wide variety of policy issues. Behind the scenes, Council members and staff have interacted with policymakers, consulted on issues, and built a web of personal and professional connections that can catalyze progress. In many cases, discussions of ideas within CCST and between CCST and policymakers have taken place for years before a decision has been made to move forward with a formal initiative.

We didn't want to be just a think tank. We wanted to be a think and do tank.

Susan Hackwood
CCST Executive Director
1995–present

Success breeds success. The more CCST has been successful, the more our advice has been sought.

Larry Papay
CCST Council Chair
2005–07

1988 Assembly Concurrent Resolution 162 calls for the formation of the California Council on Science and Technology.

1989 The first meetings of the Board and Council are held.

1990 CCST begins assisting State Department of Education on proposals for the State Systemic Initiative in Science and Mathematics Education.

Formation and Early History

CCST was established to provide a resource on which leaders in the public and private sector could draw when they faced problems involving science and technology.

Why did CCST work so well? We got the right mix of minds and personalities together at the very beginning. They were highly committed, and they understood what it takes for a seed to be planted and nurtured.

Theodore Hullar
CCST Council Chair
1989–92

CCST was established during a period of heightened concern about California's future. In the 1980s, competition from abroad was threatening California's traditional leadership in such areas as aerospace and energy production. The state had recently lost national competitions for several important national research facilities, including the Earthquake Engineering Research Center and Sematech, an industrial consortium to conduct research and development in semiconductor manufacturing technology. Economic, demographic, and environmental changes that continue to this day were assuming increased prominence.

Assembly Concurrent Resolution 162, which was filed with the Secretary of State on September 15, 1988, called for "the establishment, within one year of the effective date of this resolution, of the California Council on Science and Technology, to report to the presidents of the University of California, the University of Southern California, the California Institute of Technology, Stanford University, and the Chancellor of the California State University, and to respond to the Governor, the Legislature, and other entities on public policy issues related to science and technology."

The founding legislation incorporated two key ideas that would prove critical to CCST's success. First, it called for the Council to consist of experts from business as well as from the educational sector. The inclusion of leaders from the private sector on CCST has greatly broadened the range of perspectives on which CCST can draw. The private sector members of CCST can access legislators and the Governor's office in ways that Council members from academia typically cannot.

Second, CCST was funded in a way that was both sustainable and independent of government. Core support for CCST has come from the five institutions of higher education specified in the legislation, with the addition of the California Community Colleges in 1994. By not relying on government or industry for funding, CCST has been able to tell government and business leaders what they need to hear, not just what they want to hear. Most recently, the six largest federal laboratories in California supported by the Department of Energy and the National Aeronautics and Space Administration have become affiliate members of CCST, which has further broadened CCST's resources.

1992 Project California Select Panel is created to establish California as an international leader in advanced transportation and telecommunications systems.

1992 Interim report from CCST panel defines R&D program and priorities for the California Integrated Waste Management Board.

1995 The Legacy of Project California report describes achievements of collaboration between the state, industry, labor, and academia.

Following the approval of the founding legislation, a working group consisting of representatives from the five founding universities developed CCST's Articles of Incorporation and Bylaws. The Board of Directors met for the first time on March 27, 1989, and the first meeting of the Council took place on November 2, 1989. A press conference following the first Council meeting drew considerable attention, with the San Jose Mercury News describing CCST as "a high-powered effort to preserve and expand the state's economic base by combining the resources of academia and industry."

CCST has had two executive directors during its first 20 years. The first was Donald Shields, former president of Southern Methodist University. Shields oversaw many of CCST's initial policy analyses. He also launched CCST's first major initiative–Project California, a collaborative effort among government, industry, and academia to develop clusters of companies working on advanced transportation and telecommunications technologies.

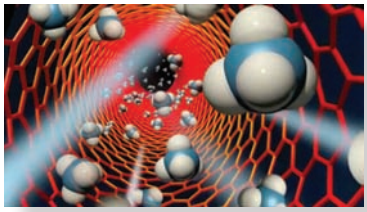
Since 1995 CCST's Executive Director has been Susan Hackwood, founding dean of the Bourns College of Engineering at the University of California, Riverside. Hackwood oversaw an expansion of the board to include more representatives from industry. She also spearheaded the creation of the CCST Fellows program. As specified in the Bylaws, the Fellows are a "distinguished group of researchers, scientists, analysts, and technical experts who–through affiliation and coordination with CCST–are willing and able to participate on projects that research and advise California state government, local government, the education sector, the public sector, and select private sector initiatives on science and technology matters and issues."

The most recent structural change to CCST has been the establishment of the California Teacher Advisory Council, which is modeled after a similar group at the National Academies. Cal TAC is a group of 12 outstanding K-14 science and mathematics teachers who provide a connection between the teaching community and the educational experts and policymakers who are shaping California's educational system.

CCST's robust structure has served it well as it has taken on an increasing number and variety of projects.

CCST is truly independent, which allows us to give recommendations to the state independently and without worrying about the fallout.

Robert Byer
CCST Council Chair
1995–98



At the Lawrence Berkeley National Laboratory's Molecular Foundry, researchers are working to unlock the potential of nanoscience to battle such problems as global warming and disease.

1996 CCST advisory panel recommends reforms in how the state invests in information technology.

1998 New Connections report lays out ways to improve the adoption of electronic materials in California schools.

1999 The California Report on the Environment for Science and Technology (CREST) analyzes the state's science and technology infrastructure.

Advanced Science and Technology

CCST has provided policy advice on a wide variety of advanced science and technology projects.

The best way to teach is to learn. Over 100 high-school-age students a year work as the floor staff of the Exploratorium in San Francisco.
© Exploratorium www.exploratorium.edu

Building integrity and authority is something you can't do overnight. It is a credit to the staff and the volunteers who have done an extraordinary job, carefully balancing points of view and bringing the best judgment possible to problems.

Karl Pister
CCST Board Chair
1992–present

Because CCST was created in part to respond to the loss of national facilities to other states, it quickly became involved in discussions involving other major facilities. Council members and staff played roles in decisions to site a combustion dynamics research facility at Lawrence Berkeley National Laboratory and Sandia National Laboratories/California at Livermore, an engineering education coalition at California State University, Northridge, and a particle physics facility known as the B factory at the Stanford Linear Accelerator Center in Palo Alto. The success of these efforts was an early demonstration of CCST's ability to help strengthen California's science and technology infrastructure.

One of the first formal requests for CCST's assistance came from the California Integrated Waste Management Board. In 1992 the Board asked CCST to create an independent panel of experts that could identify research priorities and develop a ranking system to evaluate research initiatives. The panel held six meetings, conducted two public forums, and gathered information from federal, state, and local officials, industry, public interest groups, and researchers. In its November 1992 report the panel recommended establishing a process to review research programs and a system to access information in both open and company publications. It evaluated 12 research programs and described how to arrive at a prioritized research agenda. It also suggested that 20 to 25 percent of the Board's research budget be set aside for innovative research "modeled after similar programs that have been operated successfully by other mission-oriented research agencies." This kind of practical advice for state agencies would become a hallmark of CCST's work.

Another early request came from the California Department of Transportation, which asked CCST to help it develop a plan for a California transpor-

2000 Interim review of the Public Interest Energy Research (PIER) program leads to substantial changes in the program.

2002 Benefits and Risks of Food Biotechnology examines science of agricultural biotechnology.

2002 Critical Path Analysis of California's Science and Technology Education System shows how schools can better prepare future scientists, engineers, and skilled technical workers.

tation research and development center. In March 1994 the panel issued a report that laid out goals, programs, facilities requirements, intellectual property rights provisions, funding, and an implementation plan for the center.

In 1996, the Department of Information Technology asked CCST to help it develop protocols that it could use to review requests for information technology received from other state agencies. Within six months, a panel created by CCST issued a report that described how the Department could substantially reduce the amount of time–then two or more years–needed to process an information technology request.

These early projects, though tightly focused on specific issues, had important implications for CCST's future. They demonstrated that CCST could respond expeditiously to help state agencies solve problems. They also began to build the linkages between CCST and state officials that would lead to much more broadly targeted initiatives.

The first such initiative was a comprehensive review of a new energy research program in the state. When legislation to deregulate the electric power industry in California was enacted in 1996 and 1997, the state also created a $62-million Public Interest Energy Research (PIER) program to ensure that energy research, development, and demonstration projects would continue. In 1998 the California Energy Commission asked CCST to form a panel to conduct a thorough evaluation of the PIER program. The PIER Independent Review Panel evaluated the program from February 1999 through March 2001, releasing an interim report in March 2000. That report strongly endorsed the need for a PIER program in California. However, it also highlighted a number of problems with the program, including the lack of a program director, unclear responsibilities and authorities for program managers, limited coordination between PIER programs and other R&D activities, and an overly complex and time-consuming contracting process. The California Energy Commission moved quickly to address these problems, so that by the time the panel's final report was released, many of the panel's recommendations had already been implemented.

A second panel reviewed the PIER program from June 2003 through May

2004 Nanoscience and Nanotechnology report used to develop state nanotechnology strategy.

2004 The National Academies and CCST enter into a memorandum of understanding agreeing to cooperate to their mutual benefit.

2005 Interim report on intellectual property derived from stem cell research provides framework for discussion of intellectual property issues.

A passenger riding in an electric smart car views a GPS map of San Francisco over WiMAX technology on an Echo Peak-enabled Santa Rosa laptop. The demonstration was part of a keynote address by Anand Chandrasekher, Intel ™ senior vice president and general manager of the Ultra Mobility Group, at the Intel Developer Forum in San Francisco. Echo Peak will be the industry's first integrated Wi-Fi/WiMAX module to be offered as an option for notebooks based on Montevina processor technology in 2008.

2005, with a preliminary report issued in March 2004. This panel again found that the program was "essential" and had "demonstrated its importance to the state." However, it also recommended that the program develop a strategic plan, set up an independent advisory board, increase its workforce, and consider whether the program should be moved outside the California Energy Commission or have increased operational independence within it. Once again, the interim report generated policy responses even before the final report was released.

CCST completed two other major projects on advanced science and technology issues during its first two decades. The first, requested by the Department of Agriculture, was on the risks and benefits of food biotechnology when used to improve the characteristics of crops grown in the state of California. A July 2002 report pointed out that agricultural biotechnology has the potential to increase food supplies, reduce the application of pesticides, improve the quality of food, and provide new pharmaceuticals and biofuels for the future. It also observed that any new technology can pose risks, both real and imagined. However, assessments of risks should be based on the actual characteristics of products, not on the processes used to develop those products. According to that rationale, the report said, there is no scientific justification for imposing additional regulatory requirements on the products of agricultural biotechnology, since traditional agricultural methods yield crop varieties comparable to those produced through the new biotechnology. The report contributed to a policy environment in California where severe restrictions on agricultural biotechnology have not been imposed.

A January 2004 report examined another high-technology area of potentially great importance to California: nanotechnology. The ability to manipulate materials on the molecular level could transform microelectronics, medicine, agriculture, and many other industries. As a traditional leader of high-technology industries, California is well-positioned to take advantage of the nanotechnology revolution. But factors critical to the success of high-technology industries will determine the state's prospects, including the support of researchers, the economic climate for entrepreneurs, technology transfer programs, tax and regulatory policies, intellectual property protections, and the existence of a skilled

2006 Report on California's federal laboratories describes opportunities for collaboration.

2006 Response to the National Academies report Rising Above the Gathering Storm lays out actions needed to ensure California's economic competitiveness.

2007 Critical Path Analysis of California's Science and Mathematics Teacher Preparation System shows how to boost quantity and quality of fully prepared and effective teachers.

workforce. The report pointed out that keeping the public well informed about nanotechnology is particularly important, both to build support for needed policies and to allay unwarranted concerns about possible risks of nanotechnology products. It recommended that risk-benefit analyses be built into nanotechnology research and development from the beginning, to anticipate and deal with potential hazards or societal issues before they arise. And it presented recommendations to the California congressional delegation, the California legislature, the Governor's office, state agencies and departments, and the state's colleges and universities to take steps to ensure the state's leadership in nanotechnology.

Finally, an important ongoing initiative is CCST's review of healthcare information technology. High-technology treatments are common in medicine, but some of the simplest and most straightforward aspects of the healthcare system are plagued by inefficiencies. In particular, accessing and exchanging information within the healthcare system remain great challenges. According to a study conducted by the California Regional Health Information Organization, physicians could not find information previously recorded in paper charts 30 percent of the time and were not aware of 25 percent of the prescriptions given to patients.

One CCST initiative has been to work with state officials to increase the efficiency of healthcare through the creation of a statewide data exchange system. As a result of these discussions, legislation has been introduced to implement electronic healthcare records for every resident of the state, and the Governor has responded by issuing executive orders that anticipate many of the provisions in proposed legislation.

All of CCST's reports on advanced science and technology issues demonstrate a critical feature of its operations: a rigorous review process. Draft reports are reviewed by Board members, Council members, and Fellows, as well as by outside experts. Reviewers ask whether the issues are addressed, whether the response is targeted, and whether the results are clear and sound, with the review process being overseen by standing CCST committees focused on particular subjects. This careful review process works to ensure that CCST's reports are fair and accurate syntheses that draw on a wide variety of perspectives.

CCST SUSTAINING INSTITUTIONS

- University of California
- California State University
- California Community Colleges
- California Institute of Technology
- Stanford University
- University of Southern California

2007 Series of reports highlights research being done at federal laboratories that benefits California's economy and citizens.

2007 Comments on the West Coast Governors' Agreement on Ocean Health Action Plan submitted offering CCST's assistance with program development.

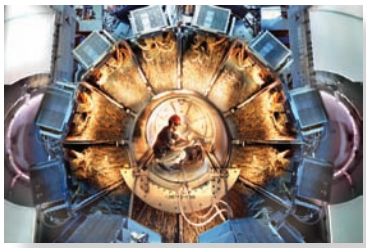
2008 Workforce investment board toolkit released; a website based resource for the Workforce Innovation in Regional Economic Development project.

Measures of Scientific Technological Strength

A comprehensive evaluation of California's science and technology infrastructure created many new opportunities for CCST and for the state.

The day our report on the federal laboratories in California was released, legislation was introduced in the State Senate to deal with major problems we had identified.

Miriam John
CCST Council Vice-Chair
2008–10



A worker crouches within the detector of the BaBar experiment at the Stanford Linear Accelerator Center.

The Silicon Vertex Tracker was at the heart of the BaBar experiment.

photos by Peter Ginter

The success of CCST's advanced science and technology projects boosted its confidence and ambitions. Since it was founded, CCST had been discussing the prospect of conducting a broad analysis of the science and technology system within the state of California. By the late 1990s, it was ready to proceed.

It began by dividing the overall task into more manageable subtopics–an approach it had successfully taken on other projects. In the case of the California Report on the Environment for Science and Technology (CREST), individual researchers or research teams investigated eight topics: California science and technology indicators, state-supported research and development, the R&D tax credit in California, venture capital funding, private foundation support, the education of a skilled workforce, research at academic institutions, and the work of federal laboratories in California. With support from the W.M. Keck Foundation, reports from these separate investigations were synthesized into an overall report, which was released in November 1999.

CREST acknowledged California's traditional strengths in high-technology industries, including aerospace, defense, electronics, computers, software, motion picture production, multimedia entertainment, medical devices, agriculture, environmental technologies, and telecommunications. Approximately one in every five U.S. employees in a high-technology industry works in California. Almost 10 percent of jobs in California are in high-technology industries, and the average pay in these jobs is roughly twice the average for other jobs in private, non-farm industries.

However, CREST also found troubling signs of an erosion in California's scientific and technological preeminence. Industry's support of academic R&D is relatively low in the state. The state's university science and engineering departments have been losing ground to departments in other states. Primary and secondary schools in California are not preparing enough students for high-technology jobs, which increases economic inequality among workers and raises the prospect that high-technology jobs and industries eventually will move to other states.

The report made a series of recommendations designed to counter these trends. It called on state government to take a leadership role in sustaining

California's high-technology industries by coordinating research policies and setting R&D priorities. In particular, it encouraged the state to explore options that would promote industrial support of university-based R&D. It called for K-12 instruction and teacher training programs to emphasize science and mathematics education. It also urged that science and technology education programs be strengthened in California's colleges and universities, including its community colleges.

The CREST project had a substantial impact on public policy in the state. It contributed to several legislative proposals and to the eventual reorganization of the committee structure in the California legislature. For example, one consequence of the report was a new joint committee on Preparing California for the 21st Century to engage in long-term strategic planning for science and technology in the state. The creation of three California Institutes for Science and Innovation reflected recommendations in the report. The project cemented CCST's reputation for taking on ambitious and difficult projects, with input from many sources and rigorous review.

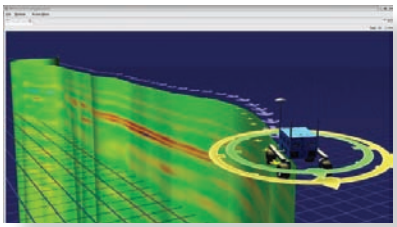
CREST also led CCST in important new directions. For example, a direct outcome of the CREST project was an analysis of the major federal laboratories in the state. A February 2006 report noted that the six largest laboratories in California accounted for more than $5 billion in annual spending and 23,000 jobs, many in high-paying, high-technology occupations. The laboratories collaborate with businesses and research universities in the state, provide research opportunities for young university graduates, and provide enrichment activities in science for thousands of K-12 students.

The CREST project was the first major effort to analyze the state's science and technology infrastructure to determine if the state has the people, the capital investment, and the necessary governmental policies to maintain state leadership. As such, it filled a gap in the policy-making process and created an opportunity to engage the state government in long-term planning. California's status as a high-tech leader is dependent upon the vitality of its schools, universities, federal laboratories, technology-based companies, and venture capital firms, as well as the commitment of its elected and appointed officials. The goals of CREST were to provide information,

CCST FEDERAL LABORATORY AFFILIATES

- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Sandia National Laboratories *(California Division)*
- Stanford Linear Accelerator Center
- NASA Ames Research Center
- NASA Jet Propulsion Laboratory

The K10 rover is being developed at NASA's Ames Research Center to explore the moon and other planets.



The K10 rover can carry ground-penetrating radar to characterize subsurface structure.

Following CREST, we started to receive requests for more projects than we could do. We had to become much more selective.

C. Judson King
Council Chair
2002-04

The Sacramento Area Science Project (SASP) is an education partnership between the University of California, Davis, and California State University, Sacramento. SASP is a regional site of the California Science Project one of the California Subject Matter projects.

guidelines, and recommendations for policies involving science and technology and to demonstrate the usefulness of in-depth analysis of the state's science and technology indicators.

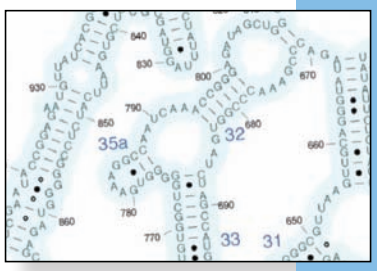
However, the report went on to say that the laboratories remained "a largely untapped resource for California." It concluded that high-technology industries are responsible for a widely envied "California technology miracle." If used appropriately, they could provide expertise in areas such as homeland security, water management, energy efficiency, and planning for natural disasters; they could provide state leaders with high-quality, evidence-based advice; and they could cooperate with the private sector in such areas as information technology, robotics, biotechnology, and nanotechnology.

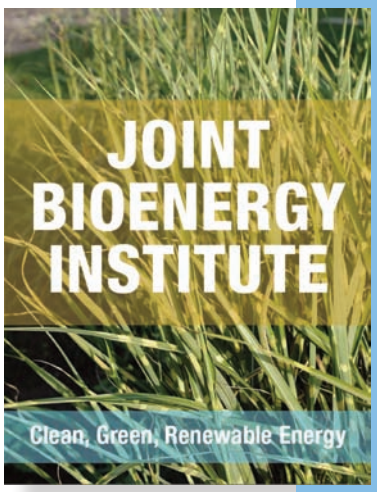
The report described key obstacles blocking greater cooperation between the laboratories and the state. For example, the state's contracting rules generally prohibit agencies from paying in advance for research services, whereas federal law requires advance payments. Different ways of managing indemnification, audits, and intellectual property also hinder cooperation. Small companies are not likely to know about the technical opportunities the laboratories offer. Agreements must be created one by one, which impedes and delays progress. The report particularly called attention to the fact that the technology miracle is not benefiting all Californians, with many graduates of high school and community college not adequately prepared to enter the high-technology workforce.

The report made four major recommendations: streamline the contracting process with the state, create bridges between laboratory and state officials, use the labs to enhance state research on key issues such as homeland security, and assess the state's competitive edge.

Soon after the report was issued, legislation was introduced to address many of the report's recommendations. In addition, the six laboratories became affiliate members of CCST, creating stronger links between the laboratories and the rest of California's science and technology community. For example, it encouraged the development of incentives for K-12 students to pursue elementary and high school teaching careers, and it urged expansion of teacher education programs in the California State University and University of California systems.
An important follow-up project was a

series of Focal Point reports on each of the six laboratories. The reports described innovative scientific and technological research conducted at the laboratories that has benefited California's economy and the well-being of its citizens.





Jay D. Keasling is Chief Executive Officer and Vice President of Fuels Synthesis at the Joint BioEnergy Institute. JBEI is a partnership of Lawrence Berkeley National Laboratory and the Sandia National Laboratories, the Lawrence Livermore National Laboratory, the University of California campuses in Berkeley and Davis, and the Carnegie Institution for Science at Stanford University. JBEI researchers tackle the key scientific problems that currently block the cost-effective conversion of lignocellulose, the main component of plant cell walls, into biofuels and other important chemicals.

Economic Vitality

Economic development and competitiveness have been central concerns of CCST throughout its first two decades.

Though CCST is focused on science and technology policy, its founding legislation also called on the organization to "identify long-range research needs for sustaining the state's economic development and competitiveness." Strengthening California's economy has therefore been an important part of its mission.

The largest project undertaken by CCST in its first decade was aimed squarely at economic development and competitiveness. In the summer of 1992 CCST launched a collaborative project between the state, business, labor, and the academic community to develop globally competitive, high-technology clusters of businesses centered on transportation and telecommunications technologies. Known as Project California, the initiative was directed by a Select Panel consisting of 26 senior business, government, and academic leaders. Special Advisors provided institutional breadth and expertise throughout the project, and funding came from a diverse group of 50 organizations across the state.

The project's overall goal is as relevant now as it was then: to create high-value-added jobs for Californians while enhancing the state's commitment to reduce environmental pollution and urban congestion. The project pursued this goal in three phases. In the first phase the project examined six advanced transportation technologies that offered the best potential to achieve the goal: alternative-fueled vehicles, electric vehicles, fast rail systems, intelligent vehicle highway systems, mass transit, and advanced telecommunications. In the second phase, 70 private and public sector organizations developed action agendas for specific technologies in each of these categories. In the third phase, Project California supported nine industry-driven alliances to implement the action agendas. Today, as transportation issues continue to loom ever higher on the state's agenda, Project California serves as an early demonstration of the need to reach across sectors to make progress on complex problems.

Another area where CCST has a long record of involvement involves intellectual property rights. Traditionally, each state agency in California has negotiated its own contracts with the organizations that perform state-funded R&D. As a result, California's approach to managing intellectual property was splintered and uncoordinated, sharply reducing incentives

to develop state-funded research into marketable products.

A September 2004 bill asked CCST to conduct an analysis of intellectual property policies for state-generated research or state-funded research done by third parties. In a report released in January 2006, a study group convened by CCST urged the state to streamline contracting processes and preserve the state's rights to develop intellectual property or use intellectual property for research or non-commercial purposes. It noted that federal policies had been successful in fostering an environment for innovation and bringing innovations to market, and it recommended that California adopt policies consistent with federal policies. The study group also acknowledged that considerable further discussion would be needed for the state to design and implement a comprehensive set of intellectual property policies.

In the middle of this broad study of intellectual property, an event with important implications for California's intellectual property policies occurred. The passage of Proposition 71, the Stem Cell Research and Cures Initiative, in the November 2004 election raised key questions about the commercialization of ideas generated through state-funded research. The initiative called for the creation of the California Institute for Regenerative Medicine and for funding of approximately $300 million annually for ten years to be made available for stem cell research.

Since CCST was already studying the state's intellectual property policies, it agreed to expand the scope of its study to include contracts, grants, and agreements developed under Proposition 71. An interim report released in August 2005 noted that expectations for immediate financial returns from state-sponsored stem cell research were unrealistic. The development of effective therapies from such research would take at least 10 to 20 years, the report pointed out. The most valuable initial outcomes of the research will be research tools, scientific data, research publications, and incremental steps forward in understanding the science. The group recommended that these products be made readily available to other researchers to speed stem cell research. It also urged that state policies be made consistent with federal policies to avoid hindering the advance of research. This would imply

Eight colleges and universities from across America have won national recognition in the National Wildlife Federation's Chill Out: Campus Solutions to Global Warming nationwide competition. This award program honors the U.S. schools that are ahead of their time in addressing global warming and being highly creative in doing so. The Grand Prize Winner, Butte College in Oroville, California, a two-year community college, is on the track to be carbon neutral by 2015, by employing energy efficiency measures in all campus facilities.

CCST has to be able to resist political pressures. It has to be prepared to say no to people who may want to hear something else.

Paul Jennings
Council Chair
1999-2001

Biology Professor Steven Oppenheimer, California State University, Northridge, works with one of his students on cell surface and cell adhesion in cancer and development research using sea urchins.

photo by Phil Schermeister

Stanford University professor Roger D. Kornberg, was awarded the Nobel Prize in Chemistry, 2006, for resolving the machinery that decodes the information in DNA.

that ownership of intellectual property should reside with the grantee, rather than with the state. At the same time, the California Institute for Regenerative Medicine should retain rights to use the research, which would enable it to focus on its ultimate goal: discovering and developing new ways of treating degenerative diseases.

CCST's most recent involvement in economic development also had a national context. In October 2005 the National Academies released the report *Rising Above the Gathering Storm,* which immediately drew widespread attention from the media, from businesses, and from governments at all levels. Written by a committee of distinguished scientists, engineers, and business leaders, the report documented the challenges to the nation's continued economic leadership and laid out a series of essential recommendations to preserve the nation's economic competitiveness.

In 2006, at the request of California's Governor, CCST convened four task forces chaired by corporate leaders to translate the major recommendations of *Rising Above the Gathering Storm* to the state level. The task forces recommended that the Governor:

- Initiate an aggressive "California Campaign for Talent" by creating a highly competitive environment that attracts and retains top talent in science, technology, engineering, and mathematics, both from the United States and around the world.

- Champion science and technology in California by positioning California as the national leader in science and technology, raising the stature of science and technology careers to make them more attractive, and recognizing and honoring California's leadership in science and technology.

- Create an advisory function to the Governor, similar to the White House Office of Science and Technology Policy, and a complementary joint legislative standing committee on science and technology.

- Invest in science and technology research and innovation in California by identifying "grand challenges in science and technology," creating a state innovation fund, supporting existing science and technology assets, fostering public-private partnerships, and making use of R&D tax incentives.

As the leadership of CCST noted in a December 7, 2006, letter to the Governor, "California is at a crossroads, and executive decisions made in the near term will shape the future and determine whether or not we stay at the vanguard of research and development while maintaining an economy that thrives on California-based creativity, informed risk taking, and investment in innovation."

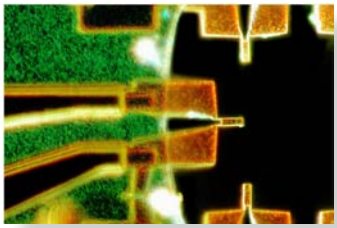
The reports from the task forces have had a dramatic influence on state policy. The Governor's 2007 State of the State address named innovation, education, and the environment as key issues that must be addressed to prepare California for the future. New initiatives on teacher training and credentialing, innovation, research and development, and greenhouse gas reductions took shape both in the legislature and in the Governor's office. Today, action continues on a variety of fronts to implement the task force's recommendations.

The California Institute for Telecommunications and Information Technology at the University of California, San Diego, is conducting research on the future of telecommunications and information technology. In the photograph at top are Experimental Game Lab staff researcher Alex Dragulescu, graduate fellows Joey Hammer and Erik Hill, graduate student Mike Cloud, and the director of the UCSD Center for Research in Computing and the Arts, Sheldon Brown.

The Center for Information Technology Research in the Interest of Society (CITRIS) creates information technology solutions for pressing social, environmental, and health care problems. CITRIS facilitates partnerships and collaborations among faculty members and students at the Berkeley, Davis, Merced, and Santa Cruz campuses of the University of California with industrial researchers from more than 60 corporations. Pictured here is a CITRIS project built with Gallery Builder for a croquet 3D virtual environment.

Science, Technology, Engineering, and Mathematics Education

Improving education and preparing a workforce for the future have been major components of CCST's work.



Nanoscale electromechanical devices (NEMS) for analyzing biomolecules. NEMS have offered unprecidented sensitivity for experiments in low temperature physics and electronics. A collaboration between two of the founders of the Kavli Nanoscience Institute at Caltech (Scott Fraser and Michael Roukes) created these nano-cantilevers to bring the use of NEMS devices to chemical sensing of water-borne molecules at room temperature. The motions of the small "diving board" devices is read out electronically to sense the presence of defined biomolecules.

photo from the Califronia Institute of Technology

Throughout its history, CCST has devoted considerable attention to science, technology, engineering, and mathematics (STEM) education. California traditionally has prospered from its position as a technological leader, innovator, and generator of new industries. But technological leadership requires highly trained scientists and engineers and a skilled workforce, and in these vital areas California is falling behind.

CCST's involvement in STEM education began early in its history. Shortly after it was created, CCST helped the State Department of Education submit a proposal to the National Science Foundation for a State Systemic Initiative in Science and Mathematics Education, which resulted in a $10 million award in 1992. The success of that effort led a few years later to a more formal request from the Education Department, the Governor's office, and the Education Council for Technology in Learning. The textbook adoption and procurement process in California had been designed for paper textbooks. With the advent of interactive software, the process was too slow and cumbersome to accommodate electronic learning tools. To improve the process, CCST convened an Electronic Media Teaching Task Force. In its April 1998 report, the task force recommended establishing a new selection process specifically for electronic learning resources so that high-quality technology-based instructional materials can be selected and purchased by local school districts on a continuing basis. It also recommended establishing an Electronic Learning Resources Fund that could support the use of electronic learning resources in grades K-12. While no legislation was passed, the report of the task force contributed substantially to legislative discussions around improving the adoption process for electronic learning resources.

The CREST project also had a major educational component. Most important, it concluded that California's schools, colleges, and universities were not graduating enough technologically literate students to meet the needs of the state. This conclusion led directly to one of the most important projects undertaken by CCST. With funding from the William and Flora Hewlett Foundation, the Semiconductor Industry Association, and Hitachi Ltd., investigators and research groups investigated six broad issues related to STEM education: the demand for skilled workers, pipelines issues in K-12 education, the roles of colleges and universities, factors affecting bachelor's degrees in science and

engineering, continuing education, and the digital divide. These inputs then were synthesized into a final report.

The report presented a first-of-its-kind analysis of the pathways students take to reach employment requiring STEM training. It applied the principles of a critical path analysis, which analyzes workflows and problem points in complex projects, to education. The Critical Path Analysis of California's Science and Technology Education System report found that many jobs requiring STEM training in California are either going unfilled or are being filled by people from other states or countries. The K-12 educational system is not producing enough students who are ready to study STEM subjects in college, a problem that is intensifying due to demographic changes in the state. The community college system in California is not producing enough two-year graduates ready to move immediately into high-technology jobs or into a four-year program. Four-year colleges and universities in California are not producing enough graduates with degrees in science and engineering, partly because relatively large number of students who enter college planning to major in those subjects switch to other degree areas. More than 35 percent of masters degrees, which are in significant demand by California industry, are awarded to students from other states or countries, and comparable number of doctorate degrees go to non-resident aliens.

The report made a wide-ranging set of recommendations to address California's skills gap. It laid out a set of initiatives to increase student participation and success in STEM subjects at all levels, from kindergarten through graduate school. It asked colleges and universities to set targeted increases in enrollment, degrees, and quality indicators at all levels. It focused attention on the importance of two-year colleges in preparing future scientists and engineers for the California workforce. And it particularly emphasized improving the quality of California's teachers at the K-12 level, to increase the numbers of students who graduate from high school with an interest and skills in science and technology.

The importance of this last point led within a few years to another major project in STEM education. In partnership with the Center on the Future of Teaching and Learning, CCST applied a similar critical path analysis to the system that prepares K-12 science and mathematics teachers in California. The study found that, despite considerable

Our Achilles heel in California is our educational system. We create new ideas, but not enough new people.

Susan Hackwood
CCST Executive Director

The UCLA Science Project is one of 18 statewide sites funded by State Legislation and NCLB funds. The UCLA Science Project brings together teachers and the expertise of UCLA's Science professors to create programs for K-12 educators.

Cal TAC member Janet English, science teacher from Serrano Intermediate School, at the Northrop Grumman Zero Gravity event.

The future of California and the economic well-being of the nation depend on always staying ahead of the curve, and the head of the curve is creativity. If we don't use our voices to maintain an investment in creativity, we're going to fail.

Sam Farr, U.S. Congressman and coauthor of the legislation that created the California Council on Science and Technology

A boy enjoys the High Wire Bicycle in the California Science Center. Additional attractions include a seven-story IMAX theater with 3D capabilities, a special exhibits gallery, food and retail services, a conference center, and more.

efforts to boost the quantity and quality of fully prepared and effective science and mathematics teachers in California, a shortage of such teachers persists, especially in low-performing schools. The critical path analysis revealed the full scope and scale of the problem. For example, too many science and math teachers are underprepared. Of the new teacher hires in 2004-05, 54 percent of new science teachers and 66 percent of new math teachers did not hold even a preliminary credential. And the problem of underprepared teachers is especially severe in disadvantaged schools. The report also found that California would need 33,000 new science and mathematics teachers over the next decade, far above the current rate of teacher production in the state.

The Critical Path Analysis of California's Science and Mathematics Teacher Preparation System report called for a large and sustained effort by the state government, California's institutions of higher education, and schools and districts throughout the state to produce enough well-prepared teachers in science and mathematics. It supported the development of programs to encourage retirees to enter teaching, recruit and prepare new teachers, create streamlined pathways for aspiring teachers, and distribute qualified teachers to low-performing schools. It recommended ways to support teachers in their early years and to ensure their continued professional development throughout their careers. The result has been a blueprint for institutions to follow in addressing one of the most serious problems facing the state.

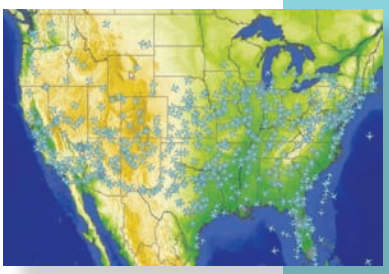
CCST also has undertaken a number of smaller initiatives involving STEM education. It analyzed the industry demand for professional science masters degrees in the California State University system and found widespread interest among employers for such graduates. It has worked with California State University San Luis Obispo to explore a program that puts science and mathematics teachers to work with scientists and engineers in the summer to experience cutting-edge research and gain ideas that they can take back to their classrooms.

Since 2005 CCST also has been able to call on its California Teacher Advisory Council for input on educational policies and initiatives. This 12-member group of science and mathematics teachers from a diverse set of K-14 schools has become involved in a variety of policy discussions,

both with CCST and with outside groups. The group cosponsored a February 2007 workshop on online professional development with the National Academies Teacher Advisory Council. They currently are organizing a meeting of influential leaders in government, industry, and higher education organized around key issues in K-12 science education as seen from the perspective of practicing teachers.

Most recently, CCST is planning an important new component of its educational efforts. The Science and Technology Fellows Program will place ten Ph.D. recipients in the legislature for each of five years. CCST will recruit, screen, prepare, and place fellows in positions where they can work directly for legislators on legislation that has a science and technology component. CCST views the program as becoming a model for other states and hopes to extend it eventually to mid-career scientists and engineers.

Since 9/11, radiation detection has taken on a new immediacy as a means of preventing a nuclear attack within the United States. In an effort to find an answer to the problem of identifying smuggled nuclear material, physicist Nick Mascarenhas at Sandia National Laboratories in California says a neutron scatter camera they are developing may be able to detect radiation from much greater distances and through more shielding than current detection instruments.



The Future Air Traffic Management Concepts Evaluation Tool (FACET), developed at Ames Research Center, was selected as NASA's 2006 "Software of the Year." FACET is a flexible software tool that provides powerful simulation capabilities and can rapidly generate thousands of aircraft trajectories to enable efficient planning of national traffic flows.

Ben Hindson is part of a team at the Lawrence Livermore Laboratory's Chemical and Biological National Security Program that develops methods of detecting bioterrorism agents.

The Next Two Decades

The need for informed advice on issues involving science and technology is even greater today than it was 20 years ago.

During its first 20 years, CCST achieved many of the goals envisioned by its founders. Yet the need for scientific and technological advice in both the public and private sectors is greater today than it has ever been. The state of California continues to face critical issues in such areas as climate change, education, high-technology economic development, transportation, and healthcare. Scientific and technological input will be essential if the state is to address these issues successfully.

A major focus of CCST's next two decades will likely be energy and the environment. California is leading the nation in reducing greenhouse gas emissions. Yet responding adequately to climate change will be one of the greatest challenges California has ever faced. Reducing emissions and preparing for climate change will require analysis of the state's water supply, flood protection, land use planning, preservation of wild areas, agriculture, biodiversity, transportation, and energy production. Progress on all of these fronts will require careful consideration of the knowledge generated through scientific and engineering research.

The most recent revision of CCST's strategic plan laid out seven objectives for CCST:

1. Plan a bilateral collaboration with the National Academies with the purpose of assisting policymakers within California and making known to the National Academies science and technology issues of state concern.
2. Develop a proactive process to identify science and technology issues requiring attention in addition to responding to specific state government requests.
3. Gain recognition throughout California and especially in California's science and technology community.
4. Maintain and enhance CCST access to the executive and legislative branches of state government.
5. Increase and diversify CCST core sustaining support while expanding its project funding.
6. Remain independent and avoid and/or manage both the realities and the perceptions of conflicts of interest.
7. Develop a human resource plan to include smooth leadership transition and staff expansion to provide back-up for key positions and to increase the science and technology skill base while providing staff resources to increase core sustaining support.

The challenges facing CCST will be even greater in the future. Our best years are ahead of us.

Charles Kennel
Council Chair
2008-10

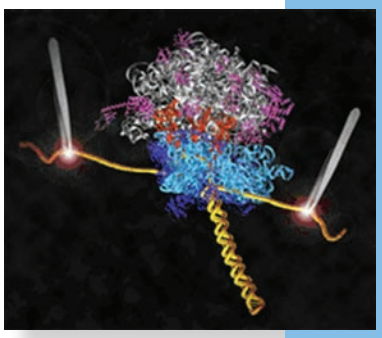
These objectives will guide CCST's planning and development. They also serve as a model for other states. At a convocation co-organized by the National Research Council and CCST in 2007, representatives from many other states studied the structure and functions of CCST, seeking to emulate its success. At the same time, CCST has been exploring partnerships with other states to explore issues that transcend state boundaries.

The path ahead for CCST is clear. Science and technology will become ever more important at the state level. The public and private sectors both will need guidance to confront challenges and take advantage of new opportunities. For 20 years the California Council on Science and Technology has offered objective, informed, nonpartisan advice on a broad range of issues. Its input will become increasingly valuable as science and technology come to have an ever greater influence on our lives.

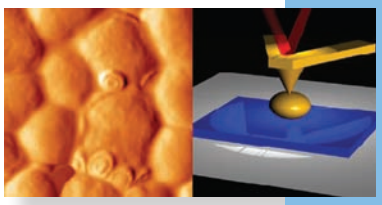
We haven't succeeded yet. We have work to do. We have extraordinary challenges out there that can and must be met.

John Garamendi, California Lieutenant Governor and coauthor of the legislation that created the California Council on Science and Technology

The California Institute for Quantitative Biomedical Research (QB3) hosts much of its computational biology work on the new Mission Bay campus of the University of California, San Francisco, shown left, as well as on the Berkeley and Santa Cruz campuses. QB3 has entered into a new data management partnership with Lawrence Berkeley Laboratory's Biological Data Management and Technology Center.



Schematic diagram shows a ribosome moving along a strand of messenger RNA (in yellow) held by optical tweezers. For the first time, QB3 researchers have glimpsed the physical steps of the ribosomal machinery as it translates mRNA into a protein.



At the California NanoSystems Institute (CNSI) at the University of California, Los Angeles, Professor James Gimzewski focuses on how the techniques used in the study of nanotechnology can be applied to a broad range of applications, from surface engineering to medical treatments to art. Shown at left is an image from an atomic force microscope (AFM) of yeast cells. At right is a graphic representation of an AFM tip touching a cell.

The California Council on Science and Technology

Science and Technology in the State's Interest

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