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RESEARCH COLORADO

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Northern Colorado BUSINESS REPORT

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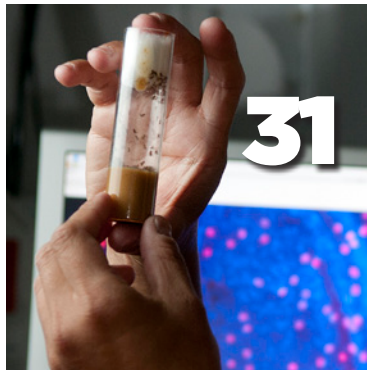

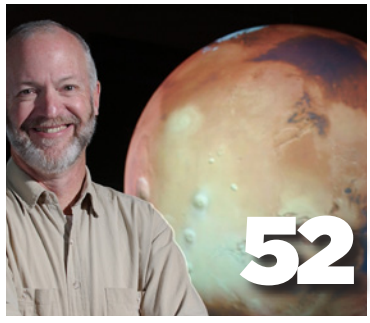

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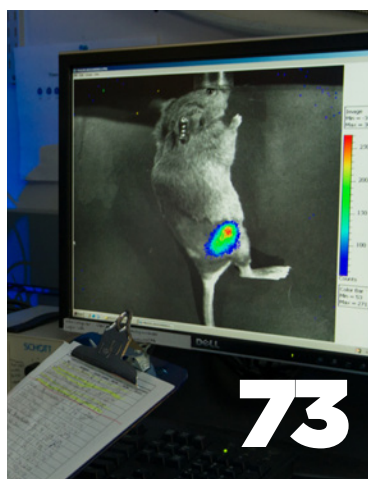

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KEEP OUR **RESEARCH ECONOMY STRONG**

CHRISTOPHER WOOD

JEFF NUTTALL

It often gets overlooked: Colorado's research economy seemingly sits behind the scenes, with professors and researchers in laboratories at one of the state's research universities or federal laboratories.

But, eventually, many discoveries made by those researchers and scientists find their way to the marketplace, as technologies are commercialized, either through licensing agreements or creation of spinoff companies.

All along the Front Range, bioscience, clean-tech, energy, software, Internet and other high-tech companies have located in Colorado in large part because of the presence of science-driven institutions.

But does the public at large truly appreciate how important our universities and laboratories are to the state's economy?

We think not. One can explore huge reductions in state funding to see that these institutions are somewhat taken for granted. That's one reason that our company, BizWest Media LLC, has teamed with Colorado State University in Fort Collins, the University of Colorado Boulder and the University of Colorado Denver | Anschutz Medical Campus to produce Research Colorado, an annual magazine designed to tell the stories of the state's research community.

Along with the Colorado School of Mines and 25 federal laboratories, as well as other research generated at other universities and private companies, these institutions generate billions of dollars in payroll and capital investment in Colorado produce billions of dollars in economic impact in Colorado, spurring job in the private sector at the same time.

Consider these numbers:

- CU's four campuses — CU-Boulder, CU Denver, Anschutz Medical Campus and University of Colorado-Colorado Springs — employ more than 26,000 people and contribute more than $6 billion a year to the state economy through spending on goods and services. The university system received $790 million in research funding in 2011 and has spawned 114 companies since the mid-1990s, the vast majority of which still have operations in Colorado.
- Colorado State University in Fort Collins brings in more than $330 million per year for research and employs 7,000 people. In addition, CSU alumni produce $5.2 billion in house hold income in Colorado.
- Collectively, CU and CSU churn out more than 320 new patent filings annually, each one representing even more economic potential.

Bioscience, clean technologies, environmental engineering, aerospace and atmospheric sciences are just examples of the major industry sectors that benefit from Colorado's research universities and federal laboratories.

Think about these institutions' direct employment and purchases, as well as the spinoff companies, contract research, patent work and other economic benefits.

Relating that story is a priority for our company, BizWest Media LLC, which publishes several regional business publications, including the Boulder County Business Report and the Northern Colorado Business Report, as well as numerous magazines and industry directories. Covering the research core of Colorado's universities and laboratories has become one of our major areas of focus, not only with Research Colorado, but also with our recurring Discoveries section in each of our newspapers.

Research Colorado features articles highlighting the economic impact of the universities and federal laboratories, key areas of scientific excellence and profiles of new initiatives and researchers.

In addition, each of our sponsoring universities is featured in eight-page sections highlighting key areas of strength at their particular institutions.

This publication is being distributed through the sponsoring universities, economic-development agencies along the Front Range, through direct mail and as inserts in our two Colorado business publications.

Visit ww.researchcolorado.com for all of the content, with new features added throughout the year.

We're grateful for the help and support of officials at CSU, CU-Boulder and the CU Anschutz Medical Campus. Please contact us with ideas for the next edition in 2014!

Christopher Wood is publisher of the Boulder County Business Report. Jeff Nuttall is publisher of the Northern Colorado Business Report. Both are managers of BizWest Media LLC. They can be reached at cwood@bcbr.com and jnuttall@ncbr.com, respectively.

[ON THE COVER] **Rachael Collins, a CU-Boulder aerospace engineering undergraduate student, pilots satellites at the Laboratory for Atmospheric and Space Physics on the CU-Boulder campus.** GLENN J. ASAKAWA

Engineering Professor Bryan Willson, director of the EECL

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Developing smart-grid technology to light up the night at the Engines and Energy Conversion Lab, one of “30 Awesome College Labs” listed by *Popular Science* magazine.

Colorado State University

CASEY A. CASS

Peter Ramig and his anti-stuttering earpiece at the University of Colorado Boulder.

OUTSIDE THE LAB

Colorado's world-class research is changing lives here at home

BY LISA MARSHALL

Five years after being diagnosed with Stage III lung cancer, Ellen Smith, 63, of Centennial, is newly married and traveling the world again.

Durango third-grader Annelise Heinicke, who has cystic fibrosis, is looking forward to a long, healthy life.

Haxtun farmer Dan Anderson has seen his wheat seed business thrive, thanks to researchers who have helped boost the yields of wheat and reduce its susceptibility to disease and drought.

Jessica Sabo, a 26-year-old graduate student who lives in Boulder, is able to confidently speak her mind after a lifetime of paralyzing stuttering.

Ellen Smith, of Centennial, was one of the first people in the world to use a groundbreaking lung cancer drug, Crizotinib,developed at the CU Cancer Center on the Anschutz Medical Campus.

JONATHAN CASTNER

"I feel so fortunate to have ended up in a place where so much research on stuttering has been done," said Sabo, whose therapist at the University of Colorado Boulder is renowned in the field.

Smith, Heinicke, Anderson and Sabo are among thousands of Coloradans who benefit each year, on a deeply personal level, from living in a state rich with academic research across the sciences. The economic impact on the state alone is noteworthy:

- CU's four campuses — CU-Boulder, CU Denver | Anschutz Medical Campus and UCCS — employ more than 26,000 people and contribute more than $6 billion a year to the state economy through spending on goods and services. The university system received $790 million in research funding in 2011 and has spawned 114 companies since the mid-1990s, the vast majority of which still have operations in Colorado.
- Colorado State University in Fort Collins brings in more than $330 million per year for research and employs 7,000 people. In addition, CSU alumni produce $5.2 billion in house hold income in Colorado.
- Collectively, CU and CSU churn out more than 320 new patent filings annually, each one representing even more economic potential.

But dollars aside, those who hunker down in labs for years to unravel scientific puzzles say that the end game is what keeps them motivated: the potential to change lives.

Here's a look at some of the ways they are doing so.

Riding a wave of cancer discovery

It was June 2009 when Smith, a retired teacher and mother of three, heard the words she had been bracing for since she had been diagnosed with lung cancer 14 months earlier.

"My doctor said, 'I'm sorry. There's nothing else we can do for you,'" said Smith, whose left lung already had been removed, and had endured chemotherapy only to see the cancer spread. "The question was: 'Where do we go now?'"

Smith went to the University of Colorado Cancer Center on the Anschutz Medical Campus.

There she learned of a clinical trial of an experimental drug called Crizotinib, which aims to kill cancer in a way that few other drugs do. It works by inhibiting a molecular mutation or "oncogenic driver" called anaplastic lymphoma kinase (ALK), believed to somehow play a role in turning healthy cells into cancer cells. Only about 4 percent of lung cancer patients (often non-smokers like Smith) possess the ALK mutation, and only they are eligible for the drug. CU researchers helped develop screening tests for ALK and have led the clinical trials on Crizotinib. It earned FDA approval in 2011 and now several other personalized cancer drugs are in the works.

"The paradigm is shifting," said Dr. Ross Camidge, director of the Thoracic Oncology program at the CU Cancer Center. "If we can screen people for these oncogenic drivers and give them the right drug to interfere with the one they have, we can have a real impact."

After tests confirmed Smith was ALK-positive, she became one of the first in the world to take Crizotinib.

"By the time I had my next scan, it

Continued on next page

Continued from previous page

had reduced the cancer to the point you couldn't see it any more," she recalled.

But Smith's story doesn't end there.

When the cancer began to crop up again cell by cell, Camidge used targeted radiotherapy to successfully beat it back, a technique he refers to as "weeding the garden." When the cancer became too aggressive for that, he pulled Smith off Crizotinib and put her on a chemotherapy shown to be particularly effective in ALK-positive patients. Eighteen more months went by. When the cancer reared its head again, Camidge suspected it might have forgotten how to resist Crizotinib, so he put her back on the drug.

Today, Smith is planning a fall trip to Paris with her new husband.

"She illustrates the fact that if you are in a cutting-edge academic center which is involved in new breakthroughs, you can surf a wave of discovery," said Camidge. "She is still surfing."

Getting at the root of cystic fibrosis

As a physician who has taken care of plenty of adults with cystic fibrosis, Dr. Jennifer Heinicke knew what lay ahead for her daughter with the disease. When Annelise was born in 2004, median life expectancy for someone with CF was 38; by the time most reached adulthood, they required supplemental oxygen and were probably awaiting lung transplants.

So when Jennifer first got word in February 2012 that the Food and Drug Administration had approved Kalydeco, the first drug ever to treat the underlying cause of the progressive genetic disease, she burst into tears.

"I have seen what a devastating disease this can be," she said. "To have that not be her future … there are just not words for the kind of gratitude I feel."

Key to the development of Kalydeco was physician-scientist Frank Accurso, director of the Mike McMorris Cystic Fibrosis Research and Care Center, based at Children's Hospital in Aurora.

Intrigued by "the puzzle" of a hard-to-understand disease with no cure, Accurso first started studying CF during his residency in the 1970s at the CU School of Medicine. He has since built the CF center into the largest in the country and has played an instrumental role in advancing understanding of CF's genetic underpinnings.

By the late 1980s, he and his colleagues had zeroed in on a gene called cystic fibrosis transmembrane conductance regulator (CFTR), which when flawed can make it hard for CF sufferers to clear airways of mucus and to digest food.

Annelise must use a special vest 40 minutes per day to help her breathe and takes 25 pills daily to aid digestion.

In 1998, Accurso and the Cystic Fibrosis Foundation partnered with Vertex Pharmaceuticals to use gene sequencing to look for mutations of CFTR. By the mid-2000s they had found one known as the "G551D mutation," which makes it difficult for sodium chloride (salt) and water to escape cells. Soon they had developed Kalydeco, which essentially "opens the gate" in cells, allowing salt and water to flow as they are supposed to, clearing the lungs.

Accurso led the clinical trials of Kalydeco.

When asked how they went, he still chokes up: "It worked beyond our wildest dreams."

Today, only about 5 percent of CF patients are eligible for the drug. But researchers continue to work to find other mutations and the drugs to target them.

Meanwhile, Annelise, who started taking Kalydeco on Valentine's Day 2012, says she can already run further without getting tired.

"She doesn't necessarily realize what a big deal it is," Jennifer said. "It could be curative. It could mean that she could have a normal life expectancy and not need a transplant some day. It's phenomenal."

Helping farmers flourish

Like farmers everywhere, wheat growers in Colorado have had their share of disasters, from insects to drought. But thanks to an innovative partnership with Colorado State University, the wheat seeds they use each year have improved dramatically, as cutting-edge agricultural research has led to new varieties of seeds that produce more wheat per acre, allow it to flourish in times of drought and make it more resistant to certain diseases.

Dan Anderson is a third-generation farmer in Haxtun about 30 miles east of Sterling, Colo. Anderson sells wheat seed to other growers in the region and his business has flourished because of the high quality of seed stock CSU has developed.

"My brother and I have both been involved in the wheat industry for 20 years," he said. "We've seen these programs grow over time. "

The first varieties that CSU's Colorado Wheat Research Foundation produced for sale were created in 1996.

"We now have ownership of 15 varieties," Anderson said. "And these varieties have better yield characteristics, better disease characteristics, and better drought characteristics."

But Anderson said it's not just about developing new varieties of seed. CSU is also at work on technologies that may allow

CSU PHOTOGRAPHY, COMMUNICATIONS & CREATIVE SERVICES

Dan Anderson is a third-generation farmer in Haxtun about 30 miles east of Sterling, Colo.

them to be developed much faster. Currently it takes seven to 10 years to bring a new variety to market, but that time could be reduced to four years if promising new research at CSU proves to be successful.

"This is a wonderful collaboration between public and private entities," Anderson said.

Setting the standards for stuttering therapy

Roughly 1 percent of the American population stutters. Yet just what causes stuttering remains a mystery.

"We are convinced that it is neurologically based and it does have a genetic component, but we are not close to fully understanding it," said Peter Ramig, a professor in the department of speech, language and hearing sciences at CU-Boulder and a renowned researcher in the field. "At this point, you can't take away the cause, but you can definitely work around it."

For 33 years, Ramig has studied the best ways to do that, sharing his findings on therapies not only with patients in his own clinic, but also with speech language pathologists around the globe via textbooks, DVDs and research papers.

He has used computer analysis of stutterers' vocal cords to better understand why the stutter fades when they change their pitch, as in singing or speaking to a child. He has picked apart the biomechanics of speech — what the tongue and vocal cords do and how air flows when one makes a T or K sound, for instance — and has developed strategies to avoid getting stuck on such sounds. He has also studied the efficacy of hearing-aid type devices for stutterers and was one of the first to explore the impact that self-help groups and desensitization therapies can have on improving speech.

"People understand much better now the importance of dealing with the emotional side of stuttering," said Ramig, who had stuttered since childhood, but now speaks almost fluently. He stressed that, contrary to popular belief, emotional trauma does not cause stuttering but can exacerbate it.

"When you anticipate that something, like saying certain sounds, is going to be unpleasant, you start to tense and it can make things worse," he said. "The more you try not to stutter, the worse you get."

That was the case for Jessica Sabo.

GLENN J. ASAKAWA

CU-Boulder's Peter Ramig has helped Jessica Sabo, who barely talked in high school due to her stuttering, excel in her master's program in counseling and art therapy at Naropa Institute in Boulder.

> **"We are convinced that it is neurologically based and it does have a genetic component, but we are not close to fully understanding it."**
>
> **— Peter Ramig, professor in the Department of Speech, Language and Hearing Sciences at CU-Boulder**

Sabo said she seldom talked at all in high school.

"I didn't want to hear my stuttering so I would hold it in, and if I did talk, I didn't want to see people's reactions so I kept my head down," she said. "It just created a lot of shame in my life."

In a brief video that was shot in Ramig's office 14 months ago, Sabo keeps her head down and eyes on the floor as she struggles quietly for nearly two minutes to form one word.

In subsequent months Ramig urged her to keep her head up and, as she put it, "sweat out the stuttering" rather than hold it in — essentially to desensitize her to the sound of her own words.

"Listening to it changed how I thought about it and how I physiologically reacted to it," she said.

Sabo does not expect her stutter to disappear entirely, but today she says she has learned to "stutter functionally."

She is now excelling in her master's degree program at Naropa University in Boulder, studying counseling and art therapy.

"It has made such a difference to work with someone who stutters," she said of Ramig. "He knows what it's like and that has driven his research. He is one of us."

GLENN J. ASAKAWA

Wind turbine at the NREL turbine research area south of Boulder.

Federal labs mean extra experts and funding for Colorado research

BY PAULA MOORE

Federally funded research laboratories in Colorado — with alphabet-soup acronyms such as JILA, NOAA, NEON, NIST — partnering with the state's research universities and local companies, constitute the backbone of the state's high-tech economy. They are leaders in developing new technologies and finding ways to launch them in the commercial world.

The state's 25 federal labs — from the National Renewable Energy Laboratory (NREL) in Golden to the National Center for Atmospheric Research (NCAR) in Boulder to the Centers for Disease Control, in Fort Collins — form one of the largest concentrations of such labs in the United States. The facilities are involved in fields as disparate as managing natural resources and renewable energy to weather prediction and space physics.

Their partnerships with Colorado's research universities, including Colorado State University, the University of Colorado Boulder and the Colorado School of Mines, translate into jobs and industries pumping more than $1 billion a year into the Colorado economy, according to Boulder-based CO-LABS, a nonprofit group started in 2007 to promote the state's federal labs as well as connect them with businesses, educational institutions and other government entities.

"They turn out amazing research and technology that does commercialize into the economy; they convert ideas into jobs, … and they are a competitive advantage for Colorado nationally and globally," said Ken Lund, executive director of the Colorado Office of Economic Development and International Trade.

"You can point to the density of our federal labs and our three research universities as a real center for innovation," said Bill Farland, chairman of CO-LABS.

"Our ability to translate research into solutions to problems, products and spinoff businesses is pretty evident," said Farland, who also serves as vice president of research at Colorado State University.

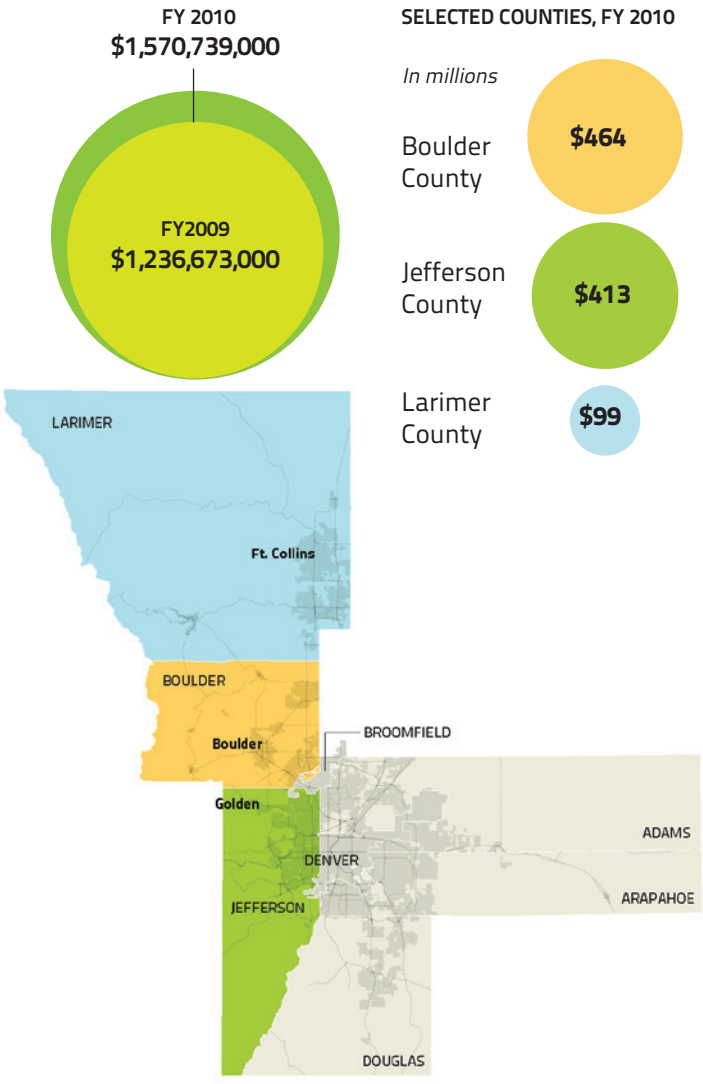
The labs account for more than 16,000 direct and indirect jobs in Colorado, according to the 2013 Colorado Business

"You can point to the density of our federal labs and our three research universities as a real center for innovation"

— Bill Farland, VP for Research at CSU, chairman of CO-LABS

CO-LABS IMPACT ON COLORADO

ECONOMIC BENEFITS



CO LABS FOOTPRINT

The facilities occupy 4.7 million square feet of leased and owned real estate in Colorado.

The Colorado portion of construction at Colorado's federal research facilities totaled approximately $84.1 million in FY 2009 and $201.0 million in FY 2010.

In millions	FY 2009	FY 2010
Boulder County	$27.7	$89.6
Jefferson County	$49.5	$108.3
Larimer County	$6.7	$2.4

LAB WORKERS RESIDENCES

	FY 2010
Boulder County	2,880
Jefferson County	2,171
Larimer County	803
Denver MSA includes Adams, Arapahoe, Broomfield, Denver, Douglas and Jefferson counties	7,725

Sources: CO-Labs Impact Study March 2011

Economic Outlook compiled by CU-Boulder's Leeds School of Business. They occupy roughly 5 million square feet of leased and owned real estate, principally in Boulder, Jefferson and Larimer counties.

The labs and their university affiliates contributed $1.5 billion to the state economy in fiscal 2010, up from $1.2 billion the previous year, CU-Boulder research shows. Data from 2010 is the most recent available.

In this time of trillion-dollar federal deficits, local labs face the same budget constraints as other federal agencies, but many believe looming budget cuts will be minimal due to the significance of the labs' work.

"The good news is, clean energy and the environmental impact of energy are still important to the administration," said Bill Farris, NREL's associate laboratory director in charge of innovation, partnering and outreach.

The genesis of Colorado's federal laboratories dates to the 1940s, when military research was conducted here. The Central Radio Propagation Laboratory, which studied radio waves, was established in 1946 and evolved into the National Oceanic and Atmospheric Administration with a major lab in Boulder. NOAA is involved in predicting weather on Earth and in space, as well as in environmental research, with other offices in Denver, Niwot, Fort Collins, Longmont, Grand Junction and Pueblo.

"Research here at NOAA in Boulder has consistently focused on areas of critical national need, whether it's understanding the layers of the atmosphere or … predicting the best frequencies for radio transmission," said Katy Human, NOAA spokesperson.

U.S. Census Bureau data for 2010 show Colorado has the second-most highly educated population in the country behind Massachusetts; 36 percent of the state's adults have a bachelor's degree or higher. The state has the eighth-highest concen-

Continued on next page

DOWN TO THE Nth

NIST sets measures for everything from scales to atomic clocks

BY PAULA MOORE

If a business needs to know whether a butcher's scale is accurate or what time a NASDAQ stock was traded, the National Institute of Standards and Technology and its Boulder Laboratories probably had a hand in those measurements.

Gaithersburg, Md.-based NIST, founded in 1901, standardizes all types of measurements — from length and weight to time. NIST's Boulder facility, part of the U.S. Department of Commerce, is 50 years old, and the institute also jointly runs JILA (formerly the Joint Institute for Laboratory Astrophysics) with the University of Colorado Boulder. NIST employs roughly 700 people in Boulder and a total of about 2,900 scientists, engineers, technicians and other personnel nationwide, according to the institute.

Michael Kelley

"We serve as the ultimate source of what we call traceability for measurements. … To make something, you have to be able to measure it," said Michael Kelley, acting director of NIST's Boulder Laboratories. "That underlies all trade."

Especially with foreign trade, NIST helps give U.S. companies confidence that measurements in other countries can be relied on, and vice versa.

"Measurement confidence is one way we facilitate fair trade," Kelley said.

Some of NIST's hottest projects involve measuring the performance of cybersecurity systems, which keep technology such as computers, the Internet and cell phones secure, and the energy efficiency of buildings nationwide, according to Kelley.

"If you can't measure something, you can't control it or modify it," he said.

Continued from previous page

tration of science and engineering doctoral degree holders, according to the National Science Foundation.

One of the state's best-known federal laboratories, the U.S. Department of Energy's NREL, was established in 1974 after a national energy crisis. NREL, the only government lab in the country devoted to renewable energy, has a 327-acre main campus in Golden and a 305-acre National Wind Technology Center just south of Boulder. NREL employs some 1,700 people and had a 2011 budget of $389 million. Each of Colorado's research universities has a representative on the board of NREL's manager/operator, the Alliance for Sustainable Energy LLC.

"We reduce the risk for the technologies that are important to renewable energy and energy efficiency, and push to the point where the commercial world will pick them up," said NREL's Farris.

Arvada-based PrimeStar Solar Inc., for example, uses NREL's photovoltaic technology. PrimeStar was acquired in 2011 by technology giant General Electric Co., and GE hopes to build the nation's largest solar-panel plant at a PrimeStar facility in Aurora. The plant, delayed for now due to the economy, is expected to cost $300 million and employ 355 people.

To make sure NREL's mission remains cutting edge, the lab's main campus has undergone a $450 million expansion since 2009, adding some of the world's most technologically advanced, sustainable buildings and creating hundreds of construction jobs. Its newest structure, the LEED Platinum, 182,500-square-foot Energy Systems Integration Facility (ESIF), is nearly finished and will house one of the world's most powerful supercomputers. Not only will the computer help update the U.S. electrical power grid to accommodate renewable energy, but heat it generates also will warm the ESIF building. The ESIF will be one of the most energy-efficient data centers in the world, operating at an ultra-efficient power usage effectiveness (PUE) rating of 1.06 or lower, according to NREL. The average PUE rating for U.S. data centers was 1.8 in 2011, according to The Uptime Institute, which tracks data center operations.

Noteworthy research at Colorado labs includes:

- The Deepwater Horizon Atmospheric Science Team, a partnership between NOAA and CU-Boulder that was honored by Gov. John Hickenlooper in 2012 for its work in assessing air-quality risks posed by the disastrous 2010 BP oil spill in the Gulf of Mexico. The team estimated the oil-leak rate and analyzed the impact of that oil on the environment.
- The governor also recognized the Centers for Disease Control and Prevention Lab in Fort Collins for discovering a gene that, when activated, prevents the bacteria that cause Lyme disease from causing infection after a tick bite.
- The Cooperative Institute for Research in the Atmosphere, an institute within CSU via an agreement with NOAA, is at the forefront of climate-change research.
- NCAR, sponsored by the National Science Foundation, and Columbia University scientists recently teamed up to use weather prediction technology to forecast influenza outbreaks by region. The 2012-2013 flu strain is one of the worst and most widespread in recent history, according to the CDC.
- David J. Wineland, a physicist at the Commerce Department's National Institute of Standards and Technology in Boulder, shared the 2012 Nobel Prize in physics for developing groundbreaking experimental methods that enabled "the very first steps toward building a new type of superfast computer based on quantum physics," according to the Royal Swedish Academy of Sciences. Wineland shared the award with French researcher Serge Haroche. Wineland's research also led to the creation of extremely precise clocks that could be the basis for a new standard of time.

The State of Colorado has identified seven advanced industries it considers economic accelerators, including aerospace, advanced manufacturing, bioscience, electronics, energy and natural resources, technology/information and infrastructure/engineering, according to Lund of the economic development office. The state's federal labs are key to further developing those industries, which already make up 20 percent of Colorado's economy and have a global impact as well.

"We feel like if we can grow the capacity of those seven sectors, we will be able to create jobs faster than other states," Lund said.

Federally funded research entities in Colorado

Akron

USDA CENTRAL GREAT PLAINS RESEARCH STATION
40335 County Road GG
Akron, CO 80720
970-345-2259
Person in Charge: Merle F. Vigil (research leader, soil scientist)
Year Founded: 1907
www.ars.usda.gov

Boulder

COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES (CIRES)
CU Campus Box 216
Boulder, CO 80309
303-492-1143
Person in Charge: Dr. Bill Lewis, Ph.D. (interim director)
Year Founded: 1967
www.cires.colorado.edu

JILA
CU Campus Box 440
Boulder, CO 80309-0440
303-492-7789
Person in Charge: Murray Holland (director)
Year Founded: 1962
jila.colorado.edu

LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS (LASP)
1234 Innovation Drive
Boulder, CO 80303-7814
303-492-6412
Person in Charge: Daniel Baker (director)
Year Founded: 1948
lasp.colorado.edu

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH (NCAR)
1850 Table Mesa Drive
Boulder, CO 80305
303-497-1000
Person in Charge: Roger Wakimoto (director)
Year Founded: 1960
www.ucar.edu

NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON)
1685 38th St., Suite 100
Boulder, CO 80301
720-746-4844
Person in Charge: Russ Lea (CEO)
Year Founded: 2007
www.neoninc.org

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)
325 Broadway
Boulder, CO 80305-3337
303-497-3000
Person in Charge: Michael Kelley (acting Boulder labs director)
Year Founded: 1901
www.nist.gov

NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION (NOAA)
325 Broadway
Boulder, CO 80305
303-497-6000
Person in Charge: Don Mock (executive director)
Year Founded: 1954
www.boulder.noaa.gov

NATIONAL SNOW AND ICE DATA CENTER (NSIDC)
1540 30th St.
Boulder, CO 80303
303-492-8028
Person in Charge: Mark Serreze (director, senior research scientist)
Year Founded: 1976
www.nsidc.org

NOAA EARTH SYSTEM RESEARCH LABORATORY (ESRL)
325 Broadway
Boulder, CO 80305-3328
303-497-6643
Person in Charge: Don Mock (executive director)
Year Founded: 2005
www.esrl.noaa.gov

NOAA NATIONAL GEOPHYSICAL DATA CENTER (NGDC)
325 Broadway
Boulder, CO 80305
303-497-6826
Person in Charge: Don Mock (executive director)
www.ngdc.noaa.gov

NOAA NATIONAL WEATHER SERVICES - WEATHER FORECAST OFFICES (WFO)
325 Broadway
Boulder, CO 80305
303-497-6000
Person in Charge: Don Mock (executive director)
www.crh.noaa.gov/bou

NOAA SPACE WEATHER PREDICTION CENTER (SWPC)
325 Broadway
Boulder, CO 80305
303-497-6000
Person in Charge: Don Mock (executive director)
www.swpc.noaa.gov

NTIA INSTITUTE FOR TELECOMMUNICATION SCIENCES
325 Broadway
Boulder, CO 80305
303-497-5216
Person in Charge: Alan W. Vincent (associate administrator and director)
Year Founded: 1943
www.its.bldrdoc.gov

RENEWABLE AND SUSTAINABLE ENERGY INSTITUTE (RASEI)
2445 Kittredge Loop Drive, Fleming Building Suite 208
Boulder, CO 80309
303-492-0284
Person in Charge: Michael Knotek (director)
Year Founded: 2006
rasei.colorado.edu

UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH (UCAR)
1850 Table Mesa Drive
Boulder, CO 80305
303-497-1000
Person in Charge: Thomas J. Bogdan (president)
Year Founded: 1960
www.ucar.edu

Colorado Springs

US AIR FORCE ACADEMY RESEARCH CENTERS AND INSTITUTES (USAFA)
2354 Fairchild Drive, Suite 4K25
USAF Academy, CO 80840-6200
719-333-7731
Person in Charge: Col Robert Kraus (chief scientist)
Year Founded: 1954
www.usafa.af.mil

Denver

U.S. GEOLOGICAL SURVEY (USGS)
Denver Federal Center, Building 810
Denver, CO 80025
303-236-5900
Person in Charge: Randall Updike (regional executive)
Year Founded: 1879
www.usgs.gov

USGS CENTRAL ENERGY RESOURCES SCIENCE CENTER
Denver Federal Center, MS 939
Denver, CO 80225
303-236-5900
Person in Charge: Chris Potter (director)
energy.usgs.gov

USGS COLORADO WATER SCIENCE CENTER
Denver Federal Center, MS-415, Building 53
Denver, CO 80225
303-236-6900
Person in Charge: James E. Kircher (director)
co.water.usgs.gov

Federally funded research entities in Colorado

USGS GEOSCIENCES AND ENVIRONMENTAL CHANGE SCIENCE CENTER
Denver Federal Center, Building 25
Denver, CO 80225
303-236-5345
Person in Charge: Buddy Schweig (director)
gec.cr.usgs.gov/index.html

USGS MINERAL RESOURCES SCIENCE CENTER
Denver Federal Center, Building 20
Denver, CO 80225
303-236-1800
Person in Charge: Ian Ridley (director)
minerals.cr.usgs.gov/index.html

USGS WATER QUALITY TESTING LABORATORY
Denver Federal Center, Building 95
Denver, CO 80225
303-236-2000
Person in Charge: Randy Updike (regional director)
nwql.usgs.gov

Fort Collins

CENTERS FOR DISEASE CONTROL AND PREVENTION LAB (CDC/DVBD)
3150 Rampart Road
Fort Collins, CO 80521
800-232-4636
Person in Charge: Lyle Petersen (director of Division of Vector-Borne Diseases)
Year Founded: 1940
www.cdc.gov/ncezid/dvbd/index.html

COOPERATIVE INSTITUTE FOR RESEARCH IN THE ATMOSPHERE (CIRA)
Colorado State University
Fort Collins, CO 80523
970-491-8448
Person in Charge: Christopher Kummerow (director)
Year Founded: 1983
www.cira.colostate.edu

US DEPARTMENT OF THE INTERIOR, NORTH CENTRAL CLIMATE SCIENCE CENTER
Colorado State University
Fort Collins, CO 80523
303-968-8986
Person in Charge: Jeff Morisette (director)
Year Founded: 2012
www.doi.gov/csc/northcentral/index.cfm

NORTH CENTRAL CLIMATE SCIENCE CENTER
Colorado State University
1476 Campus Delivery
Fort Collins, CO 80523
Person in Charge: NC CSC Director Jeffrey Morisette
Year Founded: 2012
970.226.9144
http://revampclimate.colostate.edu

USDA AGRICULTURAL SYSTEMS RESEARCH UNIT (ASRU)
2150 Centre Ave., Building D, Suite 200
Fort Collins, CO 80526
970-492-7300
Person in Charge: Dr. Laj Ahuja (research leader)
Year Founded: 1985
www.ars.usda.gov

USDA FOREST SERVICE, ROCKY MOUNTAIN RESEARCH STATION
240 W. Prospect Road
Fort Collins, CO 80526
970-498-1100
George S. Sam Foster (station director)
Year Founded: 1909
www.fs.fed.us/rmrs

USDA NATIONAL WILDLIFE RESEARCH CENTER
4101 LaPorte Ave.
Fort Collins, CO 80521
970-266-6000
Person in Charge: Larry Clark (director)
Year Founded: 1886
www.aphis.usda.gov/wildlife_damage/nwrc/

USDA-ARS CROPS RESEARCH LABORATORY
1701 Centre Ave., Sugarbeet Research Unit
Fort Collins, CO 80526
970-492-7149
Person in Charge: Dr. Leonard Panella (supervisory research geneticist)
Year Founded: 1969
www.ars.usda.gov

USGS FORT COLLINS BIOLOGICAL SCIENCE CENTER
2150 Centre Ave., Building C
Fort Collins, CO 80526
970-226-9100
Person in Charge: David Hamilton (director)
Year Founded: 1996
www.fort.usgs.gov/default.asp

Golden

NATIONAL RENEWABLE ENERGY LABORATORY (NREL)
15013 Denver West Parkway
Golden, CO 80401
303-275-3000
Person in Charge: Dan Arvizu (director)
Year Founded: 1977
www.nrel.gov

USGS GEOLOGIC HAZARDS SCIENCE CENTER
1711 Illinois St.
Golden, CO 80401
303-478-5041
Person in Charge: Jill McCarthy (chief scientist)
geohazards.usgs.gov

Lakewood

U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION
Sixth Ave. and Kipling St., Building 67
Lakewood, CO 80025
303-445-2720
Person in Charge: Lowell Pimley (director)
Year Founded: 1902
www.usbr.gov/pmts/tech_services

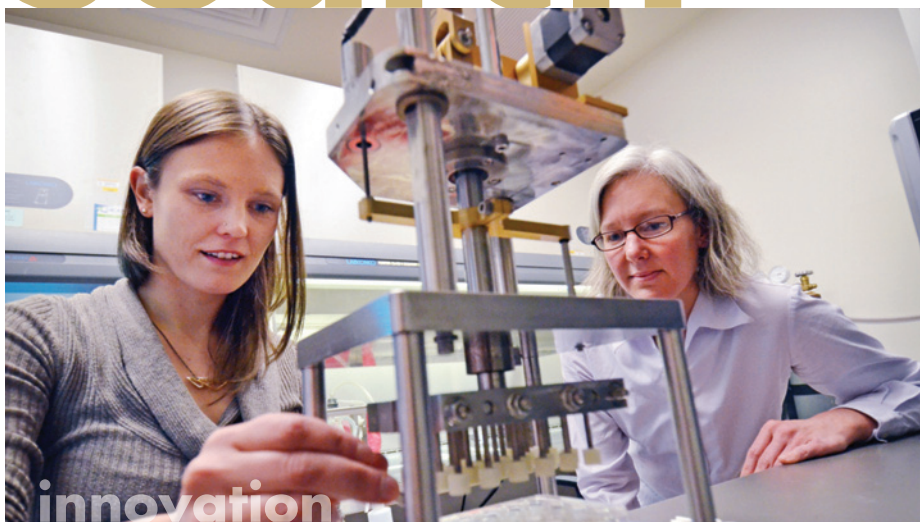
Pueblo

U.S. DEPARTMENT OF TRANSPORTATION, FRA-TRANSPORTATION TECHNOLOGY CENTER
55500 DOT Road
Pueblo, CO 81001
719-584-0750
Person in Charge: Lisa Stabler (president)
Year Founded: 1967
www.aar.com/index.php

Wyoming

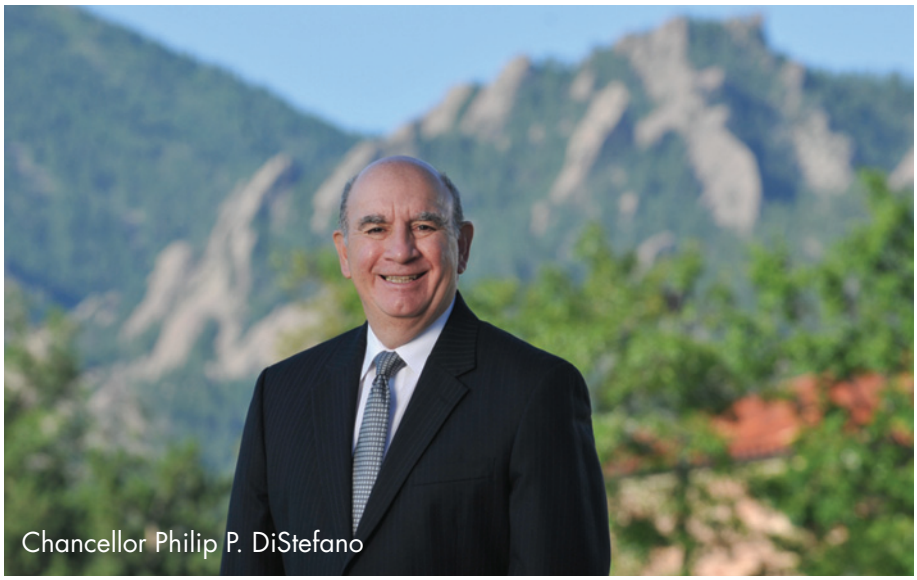
NCAR-WYOMING SUPERCOMPUTING CENTER (NWSC)
8120 Veta Drive
Cheyenne, WY 82009
307-996-4321
Year Founded: 2012
nwsc.ucar.edu

Research



University of Colorado **Boulder**

CU-Boulder research: Innovation that changes lives


Chancellor Philip P. DiStefano

It's no surprise that Boulder is among the top five cities nationwide in patent production, according to a recent Brookings Institution report. The reason? Brookings' report links the presence of research universities, a highly educated and scientifically trained workforce, and an environment of collaboration to a community's innovation quotient.

By this and a good many other measures, Boulder is a center of innovation, and CU's presence is central to that growing reputation. CU-Boulder, which earned $380.7 million from sponsored research in 2012, is among a vanguard of elite American universities that have led in innovation and discovery. According to a 2010 study in the prestigious journal *Science*, 19 American universities generate about half of U.S. research citations—and CU-Boulder is eighth on that list.

CU-Boulder's strong national and local research position is a result of a few basic factors that have come together marvelously over time. Our faculty are among the most competitive nationally for federal research grants. We have a basic belief in interdisciplinary work that informs all aspects of our research and teaching. We combine people, programs and disciplines. We mix graduates and undergraduates within the research environment. We collaborate with our fellow universities in Colorado, with our peer universities around the nation and the world, and with our partners in the private sector in Colorado.

The BioFrontiers Institute at CU-Boulder, directed by CU Nobel laureate Tom Cech, is a perfect example of these factors in action. BioFrontiers brings together world-class researchers in the life sciences, physical sciences, mathematics, computational sciences and engineering, with the mission to collaborate, combine visions, experiment and advance in revolutionary ways. Cartilage and tissue regeneration, new treatments for cardiovascular disease and cancer, and new ways to administer vaccines are just a few recent results of these dynamic collaborations, along with 27 startup companies in the last five years that have resulted from CU biotech research.

Colorado ranks third in the nation for the size of its aerospace workforce, due in large part to CU-Boulder—the top-funded public university in the world by NASA—working in partnership with local aerospace contractors. In November the newest Mars explorer, CU's MAVEN spacecraft, is scheduled for launch, representing the largest research contract in our history at $485 million. Meanwhile, our partners at Louisville's Sierra Nevada Corporation are working to put Americans back into space with the Dream Chaser spacecraft. CU graduate and undergraduate students are working on both of these projects, preparing them to become the next generation's scientists, engineers, teachers and industry leaders, and ensuring Colorado's position in the nation's aerospace economy for decades to come.

Similarly, the work of David Wineland, our fifth Nobel Prize winner since 1989, could create the next generation of superfast quantum computers. Dr. Wineland, of CU-Boulder's physics department and the National Institute of Standards and Technology, is not only transforming the digital future but also adding to the strong and vibrant history of strategic partnerships among CU-Boulder and the 11 major federal laboratories that call Boulder and its environs home.

We start our research from the expected launch pads—asking tough questions, confronting complicated problems, wondering about both the big issues and the tiny riddles of life on earth and beyond. But the answers we provide and the solutions we pioneer end up back with you. They enrich our economy. They save lives, improve lives, and alter the landscape of communities here and around the world. I invite you to partner with us in this exciting journey of discovery at **www.colorado.edu/research.**

> "CU-Boulder research in bioscience, clean energy, technology and aerospace has spawned 76 companies since 1994 and has been an engine of innovation advancing Colorado's economy and quality of life."

Companies formed based on CU-Boulder technology, 2010–12

Clean Urban Energy—Energy storage solutions to optimize performance of buildings, utilities and grid operators

Mosaic Biosciences—New class of synthetic materials to support tissue regeneration

OnKure Inc.—Biotechnology

RedWave Energy Inc.—Infrared thermography, visual inspection and industrial photography

SuviCa Inc.—Early-stage cancer drug discovery and development

Clarimedix Inc.—Light-based medical device to treat Alzheimer's disease

BioSIPs Inc.—Turning fiber residues into petroleum-alternative, high-performance building materials

Shape Ophthalmics—Developing shape memory polymer devices for treating ophthalmic conditions

Double Helix—Optical-digital technologies used in range estimation, super-resolution and 3-D imaging

Xeris Pharmaceuticals—Ready-to-use glucagon rescue pen for diabetic seizures

ClarVista Medical—Novel method for the in situ attachment of a secondary intraocular lens onto an implanted lens

Mobile Assay Inc.—Smartphone-based, app-enabled mobile real-time diagnostic technology

Advanced Conductor Technologies—High-performance superconducting cables for power transmission and energy storage

ASTRA LiTe—LIDAR device for remotely and accurately determining depths of semitransparent media

Gogy—Interactive e-learning software

Source: www.cu.edu/techtransfer

Sponsored research awards, FY 2006–12

in millions of dollars

Sponsored research includes awards from federal agencies, private industry, nonfederal labs, and the state of Colorado that funded more than 2,000 research projects in 2012. The top funding agencies for CU-Boulder traditionally include the National Science Foundation, NASA, the Department of Health and Human Services, and the Department of Commerce.

Source: www.colorado.edu/VCResearch/reports

*Included one-time stimulus funding of $86.6 million from the American Recovery and Reinvestment Act of 2009

National Research Council's most recent rankings

20 CU-Boulder graduate programs in the top 20 or top 20%

PROGRAMS RANKED AS HIGH AS THE TOP 5 OR TOP 5%	BEST RANK	BEST PERCENT
Geography	2	4%
Aerospace Engineering Sciences	2	6%
Integrative Physiology	4	6%
Astrophysical and Planetary Sciences	4	12%
Psychology	6	3%
Mechanical Engineering	6	5%
Civil Engineering	7	5%
Physics	8	5%
PROGRAMS RANKED AS HIGH AS THE TOP 10 OR TOP 10%		
Applied Mathematics	6	18%
Atmospheric and Oceanic Sciences	7	14%
Chemical Engineering	8	8%
Spanish	8	13%
Chemistry and Biochemistry	12	7%
Geology	13	9%

Source: sites.nationalacademies.org/PGA/Resdoc

RESEARCH HIGHLIGHTS

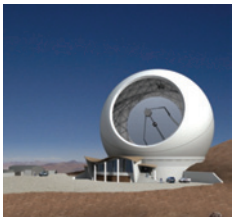
1
of only 34 public research universities in the Association of American Universities

800+
Undergraduates involved in research across CU-Boulder

$1B+
Follow-on funding for companies formed based on CU-Boulder technologies

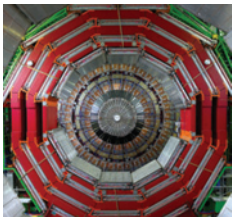
Global Reach for Research

CU-Boulder researchers work around the globe on cutting-edge projects, often collaborating with colleagues in other countries. Here's a snapshot of just a few of the many areas where scientists are engaged in research.



Astronomy in Chile

• CU-Boulder is a partner in a project to build a 25-meter ground-based telescope at 5,500 meters in the Atacama Desert that will probe distant galaxies for stellar nurseries.



Physics in Switzerland

• CU-Boulder physicists were part of an international research team that used the world's largest atom smasher to find the first direct evidence of the sought-after Higgs boson particle.

Hydrology in Nepal

• CU-Boulder has partnered with the U.S. Agency for International Development to assess glacier contributions to water resources originating in the mountains of High Asia.

Ecology in Antarctica

• CU-Boulder scientists have been traveling to the Dry Valleys on the shore of McMurdo Sound for almost two decades to study the area's largely ice-free aquatic and terrestrial ecosystems.

Seismology in New Zealand

• CU-Boulder researchers deployed seismometers to the bottom of the ocean off the shores of New Zealand that will allow them to better understand how tectonic plates form.

Sociology in South Africa

• CU-Boulder researchers have worked to estimate the prevalence of HIV/AIDS in South Africa and to understand how communities, families and individuals cope with the disease.

RESEARCH HIGHLIGHTS

76
New companies based on CU faculty research discoveries since 1994

4
National Medal of Science winners

ranked 1st
in atomic/molecular/optical physics every year since 2006 in *U.S. News & World Report*

CU Discoveries

CU-Boulder researchers develop innovative solutions for some of the world's most daunting challenges, going inside the atom, around the world, up the highest peaks and even into space, seeking new ways to improve the quality of life.

The wide range of CU-Boulder research and creative work has long resulted in high quality and broad impact as measured via citations of faculty by subsequent research efforts, important national and international collaborations, and discoveries that lead to viable commercial business development.

From creating a new form of matter, to devising tomorrow's large-scale energy sources, to improving the delivery of vaccines, CU-Boulder's research has a history of delivering tangible benefits that often lead to profitable business opportunities.

World-class physics breakthroughs

- Chilled a gas of molecules to just above absolute zero, a feat once considered nearly impossible and which may allow for the development of **novel ways to control chemical reactions**
- Generated **the first laser-like beams of X-rays from a table-top device**, paving the way for major advances in medicine, biology and nanotechnology development
- **Boosted the performance of atomic clocks** by packing the atoms closer together and eliminating atomic collisions

CU-Boulder has five Nobel Prize winners

- David Wineland, physics 2012: Developed techniques for measuring and manipulating individual quantum systems
- John Hall, physics, 2005: Contributed to the development of laser-based spectroscopy, including the optical frequency comb technique
- Carl Wieman and Eric Cornell, physics, 2001: Created a new form of matter called Bose-Einstein Condensate
- Tom Cech, chemistry, 1989: Discovered that RNA in living cells is not only a molecule of heredity but also can function as a catalyst

Museum of Natural History

CU-Boulder's Museum of Natural History houses the largest natural history collection in the Rocky Mountain Region. More than 4 million objects are categorized into five disciplines: anthropology, botany, entomology, paleontology, and zoology. The collections include the world's oldest documented Navajo textile, the Aiken bird collection, and Colorado's largest collection of bees. Faculty and staff at the museum conduct world-class research using the extensive collections. Some of the current research at the museum includes algal ecology of lakes and streams, the first colonization of the Americas, and coprolites and dinosaur diets.

To plan your visit or for more information go to:
cumuseum.colorado.edu

Revolutionary biotechnology research

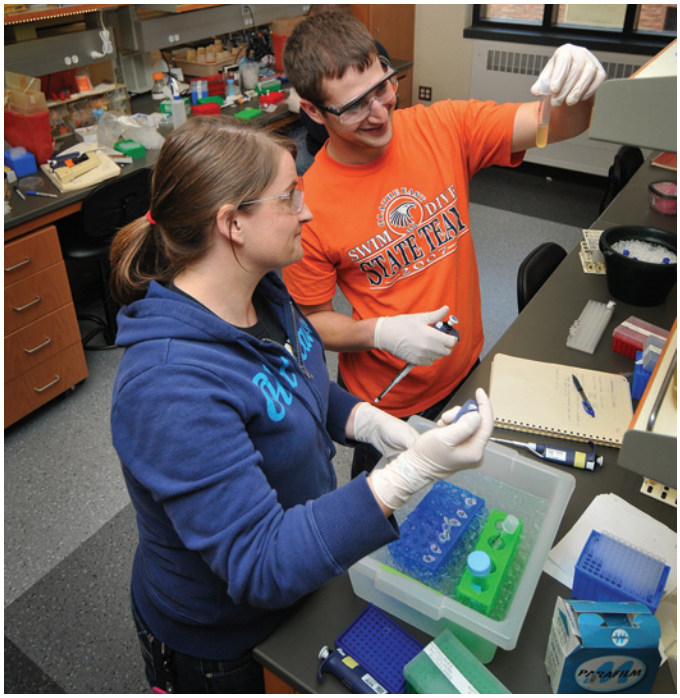
- Isolated the fatty acids in Burmese python blood that promote heart health, a discovery that has implications for **treating human heart disease**
- Created a degradable gel-like scaffolding that can stimulate the **growth of new human tissues** to replace those lost by injuries and disease
- Developed techniques for the **chemical synthesis of DNA and RNA**, forming the foundation for so-called "gene machines"
- Uncovered the role glial cells play in enhancing pain, opening new doors for the **treatment of chronic pain** and for blocking addiction to some painkillers
- Produced an **inhalable measles vaccine**, eliminating the need for needles and syringes and laying the groundwork for developing other inexpensive vaccines

RESEARCH HIGHLIGHTS

146
License and option agreements granted to businesses in the past five years from CU-Boulder discoveries

$50M
Revenue generated by licensed technology in the past five years

103
Research centers, laboratories and institutes in eight colleges and schools that span virtually every academic discipline on CU-Boulder campus



Pioneers in aerospace engineering and space exploration

- Launched science experiments built by CU-Boulder's BioServe Space Technologies on more than **40 space shuttle flights** since 1991
- Produced **18 CU-affiliated astronauts**, who flew on a combined 40 NASA space shuttle missions
- Leading **NASA's next mission to Mars**, the $485 million MAVEN mission, which is scheduled to launch in November
- Designed or built an instrument that has visited or is en route to **every planet in the solar system**, including the dwarf planet Pluto

Unearthing mysteries of the past

- Discovered the **best-preserved prehistoric farming village in Latin America**, which was buried under 12 feet of volcanic ash and which is still under excavation by faculty and students
- Used high-tech tools to study the teeth of early hominids, **challenging long-held assumptions about how our early relatives lived** and what they ate

Pursuing tomorrow's renewable energy sources

- **Manipulating the microbe E. coli to produce biofuels** and create an efficient and inexpensive process for manufacturing gasoline
- Improved localized wind forecasts, in collaboration with NOAA, for use by electric utilities to **increase the efficiency of wind energy production**
- Studying the **integration of plug-in electric hybrid vehicles with smart grid technologies** in collaboration with NREL

A global leader in environmental sciences

- Uncovered evidence that **the Greenland Ice Sheet may be sliding faster into the ocean** due to massive releases of meltwater from surface lakes
- Discovered that a **warmer climate is allowing pine beetles to breed twice a year**, increasing their ability to devastate forests
- Determined **that two-thirds of the Earth's permafrost will likely melt by 2200**, unleashing vast amounts of greenhouse gases into the atmosphere and accelerating warming
- Showed that Earth's glaciers and icecaps outside of the regions of Greenland and Antarctica are **shedding billions of tons of mass** annually
- Showed that **dust settling on snow in the Upper Colorado River Basin causes the snow to melt early** and robs the Colorado River of 5 percent of its flow each year

Outreach to Colorado and beyond

- **Touches 335,000 Coloradans in 37 counties** with programs ranging from K–12 education, to water quality studies, to presentations on the potential impacts of climate change
- **Reaches 56,000 Colorado K–12 students and 2,400 teachers** with programs like CU Wizards, Science Discovery and Shakespeare Summer Partnerships

Ongoing investments in discovery

- **Dedicated the Jennie Smoly Caruthers Biotechnology Building** in spring 2012, which is designed to encourage interdisciplinary research collaborations that fuel innovation
- **Added the new "X-wing" to the JILA physics facility**, where CU and NIST researchers can explore the quantum world, design precision lasers and break new ground in ultracold physics
- Bought a **state-of-the-art 3T Trio Magnetic Resonance Imaging System** that is used to investigate how the brain works and influences our behavior

RESEARCH HIGHLIGHTS

TOP 10
Ranking among the top research universities in funding for environmental science research

5
Nobel laureates
(four in physics, one in chemistry)

$381M
Sponsored research funding in fiscal year 2012


Payson Sheets


Brian Argrow

Federal Laboratories Located Near Boulder, Colorado


Lucy Pao

Bureau of Reclamation, U.S. Department of the Interior (BuRec)—Denver

National Ecological Observatory Network (NEON)—Boulder

National Institute of Standards and Technology (NIST)—Boulder

National Renewable Energy Laboratory (NREL)—Golden

National Telecommunications and Information Administration (NTIA)—Boulder

National Center for Atmospheric Research (NCAR)—Boulder

National Oceanic and Atmospheric Administration (NOAA)—Boulder

U.S. Geologic Survey (USGS)—Lakewood

Source: co-labs.org/labs

CU-Boulder Research Institutes

- Alliance for Technology, Learning, & Society (ATLAS)
- BioFrontiers Institute
- Cooperative Institute for Research in Environmental Sciences (CIRES)*
- Institute for Behavioral Genetics (IBG)
- Institute of Arctic & Alpine Research (INSTAAR)
- Institute of Behavioral Science (IBS)
- Institute of Cognitive Science (ICS)
- JILA*
- Laboratory for Atmospheric & Space Physics (LASP)
- Renewable & Sustainable Energy Institute (RASEI)*
- University of Colorado Museum of Natural History

*Joint institute with federal labs

See the full list of CU-Boulder institutes and centers at www.colorado.edu/research.

Pictured above from left to right: Peter T. May-Ostendorp, William A. Surles and Gregor Henze.

University of Colorado **Boulder**

In Colorado and beyond, CU-Boulder research changes lives.

Connected to dynamic research partners in Colorado, across the nation and around the world, CU-Boulder occupies a unique position in the research landscape—with an ongoing mission to advance the economy, culture and health of Colorado, the nation and the world.

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CLOSE TO THE FLAME

CSU, CU scientists unraveling mysteries of wildfires

BY JANE HOBACK

New research on Colorado forests challenges many of the old assumptions about the risks, severity and causes of the devastating wildfires of the past decade.

Work being done by scientists at Colorado State University and the University of Colorado Boulder could lead to important changes in how and when to prevent and fight severe fires in the future.

The effects of drought, warmer temperatures, pine beetle outbreaks, restoration and fire management practices all play a part in the current and future health of the state's forests.

"All of the discussions have focused on the same old solutions: fire suppression, thin the forests, reduce some fuels," said Thomas Veblen, professor of geography at CU-Boulder and head of the biogeography lab. "But most people who work in this field say we can't thin our way out of this. The big challenge is, how do we adapt to or mitigate the effects of global warming? We are just beginning to have realistic discussions about that."

While it's relatively safe to predict warmer temperatures these days, it's harder to predict drought, according to Nolan Doesken, state climatologist with the Colorado Climate Center at Colorado State University's department of atmospheric science.

"Over the last 20 years, predicting warmer than average temperatures

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A smoke plume rises on the southwestern flank of the High Park Fire on the ridge west of West White Pine Mountain, June 23, 2012.

GLENN J. ASAKAWA

A view of a wildfire burning in the Four Mile Canyon area west of Boulder from an overlook in Louisville, Colo., on September 6, 2010.

has been a good bet because they have been warmer than average seven out of 10 years," Doesken said. "We have seen a lot of warm springs and a lot of hot summers. We have had long periods of many consecutive days warmer than historically average. And that is a stressor to a natural ecosystem."

But Doesken said there is no reliable method of predicting the amount of precipitation each year, or even the areas where it will occur. In 2011, for example, there was abundant water in northern Colorado, but extreme drought in the southern part of the state. But 2012 saw drought statewide and nearly all year long, similar to 2002, which had seen Colorado's worst extreme drought in several decades.

Climate has been a contributing factor in wildfires such as those last summer, High Park near Fort Collins and Waldo Canyon in Colorado Springs, Doesken said. "But it's certainly not the only factor. Are we warmer more often than we have been? Most likely. But did we also have drought in the past? Absolutely, probably every bit as bad as we've had the past few years."

Fire behavior models that are used to predict the spread and severity of fires have used as a basis what the climate has been, not what it is likely to be in the future, Veblen said. "When we input, as an experiment, future parameters, we get incredibly high severity fires."

Warmer, drier weather, particularly the 2001-02 drought, accelerated the pine beetle epidemic in the southern Rocky Mountains, which is estimated to have hit nearly 3,000 square miles of forests, according to a recent study by CU-Boulder doctoral student Teresa Chapman.

"Once the beetle populations are sufficiently high, there are so many millions of beetles attacking the tree that even if climate conditions return to normal precipitation, normal temperatures, there are just too many beetles for the weakened tree to defend itself."

— Teresa Chapman, CU-Boulder doctoral student

But her research showed that the outbreak is affected not only by warmer temperatures, but also by the fact that weather affects a tree's ability to produce resin, the hydrocarbon that helps it ward off insects.

"Once the beetle populations are sufficiently high, there are so many millions of beetles attacking the tree that even if climate conditions return to normal precipitation, normal temperatures, there are just too many beetles for the weakened tree to defend itself," Chapman said.

The study also revealed that the beetle outbreak originated in several locations and spread, rather than starting in one location, as some researchers had previously believed.

Fire management officials and others have assumed that all the trees killed by pine beetles must make forest fires worse and as a result have cleared and thinned the dead trees as a preventive measure.

But researchers such as Chapman and CU-Boulder's Veblen are taking a second look at those assumptions.

A new study by Veblen will look at whether a beetle outbreak increases fire severity.

"That question has not been resolved yet," Veblen said.

For example, a recent study conducted by Veblen and other researchers, using data from past fires in lodgepole pine forests in west-central Colorado, found that under extreme fire conditions there was no difference between stands infested by beetle kill and those that had not been affected.

Restoring forests in a way that enables them to withstand fires as well as prevent high-severity fires is the focus of new projects led by Tony Cheng. Cheng is director

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CHANGING LANDSCAPES

Charred ecosystems altering the face of Colorado's forests

CSU PHOTOGRAPHY, COMMUNICATIONS & CREATIVE SERVICES

Wildfires and pine beetle outbreaks are changing the landscape of Colorado forests, and the shift will likely result in fewer lodgepole pines and more aspen trees and subalpine fir.

But whether the shift will bring in more fire-resistant, drought-tolerant forests isn't clear.

"We're not seeing the forest replenishing itself with the same species, especially of lodgepole pine," which has been hit hard by the beetle epidemic, said Teresa Chapman, a University of Colorado Boulder doctoral student who is doing research on forest regeneration and future forest predictions. "We are not seeing a lot of regeneration, either in the high elevations or in the low elevations where there have been fires."

The seedlings are in competition with abundant woody shrubs, grass and ground cover.

So Chapman predicts a shift from lodgepole pine to aspen, as well as subalpine fir, depending on the location.

But while aspen is fire-resilient, it's not particularly drought-tolerant. And while the subalpine fir is shade-tolerant, it's neither drought-tolerant nor fire-resilient, Chapman said.

"We see a new forest," Chapman said. "Pine is pretty drought-tolerant. It loves the sun. So when we replace that forest with an alpine fir forest, we might have a more drought-susceptible and less fire-resilient forest. And those are the two major disturbances we can expect in the next 50 years."

Colorado State University researchers observe as National Park Service Alpine Hot Shots firefighters torch a tree killed by bark beetles in Horseshoe Park, Rocky Mountain National Park, April 22, 2009, as a part of collaborative research between the National Park Service and Colorado State University on fire fuels and bark beetle management.

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of the Colorado Forest Restoration Institute and an associate professor in the department of forest and rangeland stewardship, both at Colorado State University.

Studies show that historically, forests in Colorado have burned frequently, every five to 30 years, keeping down tree and plant growth. The result was low intensity surface fires that creep primarily along the ground.

But logging as well as management practices that dictated aggressive fire suppression have "altered that fire regime," Cheng said.

The result is denser forests, particularly ponderosa pine forests, that generate super-intense fires when they burn.

Cheng's project aims to remap and reconstruct what historic forest conditions might have looked like before the era of actively putting out fires. That might lead to reducing the number of trees and conducting prescribed burns that would return forests to historic conditions. The projects are on the Front Range and the Uncompahgre Plateau west of Montrose.

But as Cheng acknowledged, "Tree cutting in particular and prescribed fire burns are very socially controversial."

So another aspect of the project is to get community members involved so they develop a better understanding of those historic forest conditions.

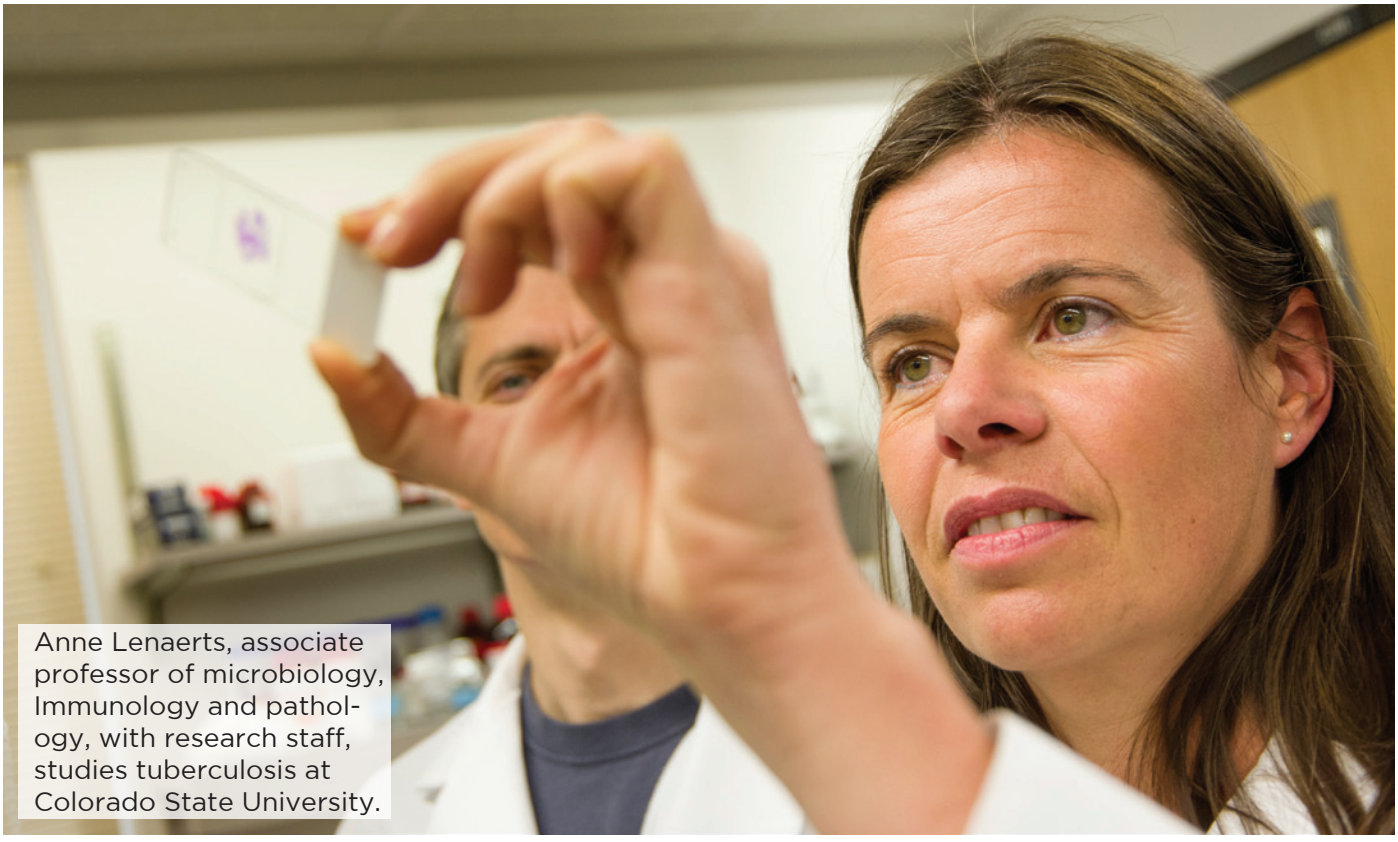
That's not an easy proposition.

"There's a value in living in Colorado forests," Cheng said. "We have acculturated that; more trees are better. And that's a problem because one part of restoration is actually having more frequent fires so that the forest functions normally. That's a hard public safety issue to overcome."

But current forest conditions, coupled with warmer and perhaps drier climates in the future, dictate that changes in fire management as well as land-use policies are necessary, the researchers agree.

"It's not just about the fires today," Cheng said. "It's about the kinds of forests we are going to have for future generations."

BIOSCIENCE WONDERS



Anne Lenaerts, associate professor of microbiology, Immunology and pathology, with research staff, studies tuberculosis at Colorado State University.

CSU PHOTOGRAPHY, COMMUNICATIONS & CREATIVE SERVICES

Scientists lead in new international fight against TB; thyroid cancer diagnostics and using DNA sequencing to help hungry children

BY LISA MARSHALL

Inside a 25,000-square-foot laboratory on the Colorado State University campus, an army of tuberculosis researchers clad in respirators and white biosafety suits wages war on what some are calling the return of the "White Plague." Sixty-five miles to the south, at the University of Colorado Cancer Center, 248 scientists are collaborating to turn the historic one-size-fits-all paradigm for treating that disease on its head. Meanwhile, in the glistening new $160 million home of CU-Boulder's BioFrontiers Institute, biologists and computer scientists are joining forces to map the inside of the human gut.

Infectious disease, cancer, and the human microbiome are just a few areas of research helping to put Colorado on the map as a hub of bioscience at a time when the industry has been waning nationwide.

According to the nonprofit Colorado Bioscience Association, the state's bioscience industry grew 4.6 percent in employment between 2007 and 2010, while nationally bioscience declined 1.4 percent. More than 600 bioscience companies are now located here, and each year, Colorado's research institutions spin out 20 more. With the advent of the new BioFrontiers Institute, the near completion of the 578-acre Fitzsimons Life Science District and adjacent CU Anschutz Med-

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Of **BIOLOGISTS, PHYSICISTS** and **COMPUTERS**

BioFrontiers Institute takes down the walls between them

BY LISA MARSHALL

With the goal of creating what its Nobel Prize-winning director Tom Cech calls "productive collisions," the new BioFrontiers Institute on the CU-Boulder campus hopes to model what can happen when walls — both physical and institutional — come down.

"The problems we face in medicine are getting too complicated to address within a single discipline," said associate director Jana Watson-Capps. "We are trying to find people who do not fit into a single research box, and bring them together."

Conceived in 2002, the BioFrontiers Institute officially opened its doors last spring, moving into a new 336,800-square-foot facility thoughtfully designed to bring together physicists, biologists, computer scientists, and state-of-the art technologies to tackle tough biotech puzzles.

The Institute has CU-Boulder funding to hire a dream team of 20 new faculty members whose research interests lie between or across disciplines. So far nine have been hired; they include an evolutionary biologist using high-throughput gene sequencing to better understand human gut bacteria and a physicist/biologist using state-of-the-art imaging to understand the role disordered proteins in cells play in Alzheimer's disease.

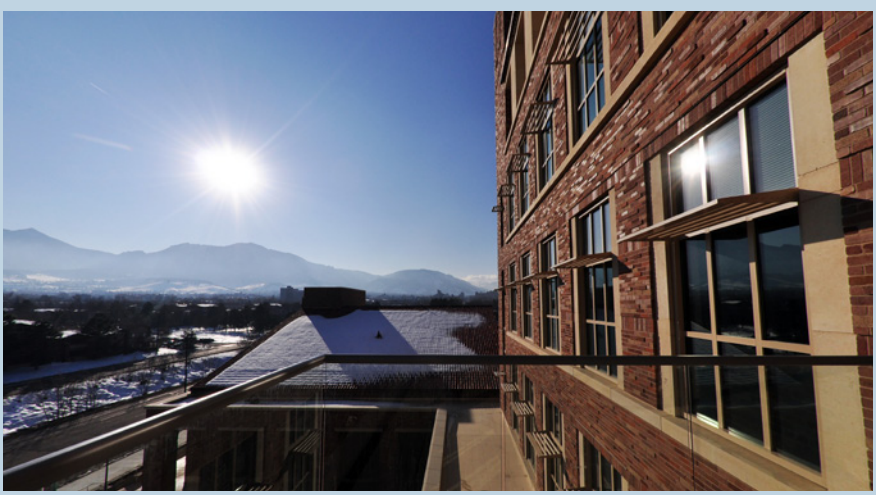
The institute is also reaching out to industry, inviting private companies not only to use its sequencing and imaging facilities, but also to collaborate with its scientists on risky, out-of-the-box projects.

"Sequencing projects often go overseas because of cost considerations, but I think companies are finding that the choices are limited, and their offerings are not really flexible enough to support novel ideas," said Jim Huntley, director of the Institute's sequencing facility. "Here, we have expertise to develop risky applications that the biotech industry relies on."

With shared lab space, restaurants, and a Main Street that passes through numerous "research neighborhoods," the building is designed to force scientists to step out of their silos and individual research goals, and to interact on bigger-picture projects.

The plan appears to be working, according to Watson-Capps.

"To see the new research projects that have sprung up from people meeting over cookie hour or at barbecues or coffee is amazing," she said.



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ical Campus in Aurora, and the continued expansion of CSU's veterinary and infectious disease programs, the future looks bright.

"Strategy was laid 10 years ago by our research institutions, the Governor's office and industry to build Colorado into one of the top bioscience clusters in the country," said CBA president April Giles. "We have created the ideal ecosystem to foster innovation and grow great companies here."

Keeping the White Plague at bay

When CSU first established a five-person tuberculosis research program in a corner office on campus in the early 1980s, TB was not a high priority among global researchers.

"There was an assumption in the late '60s and '70s that TB was done, that we had beaten it," said Dean Crick, one of 163 researchers who now make up CSU's Mycobacteria Research Laboratories.

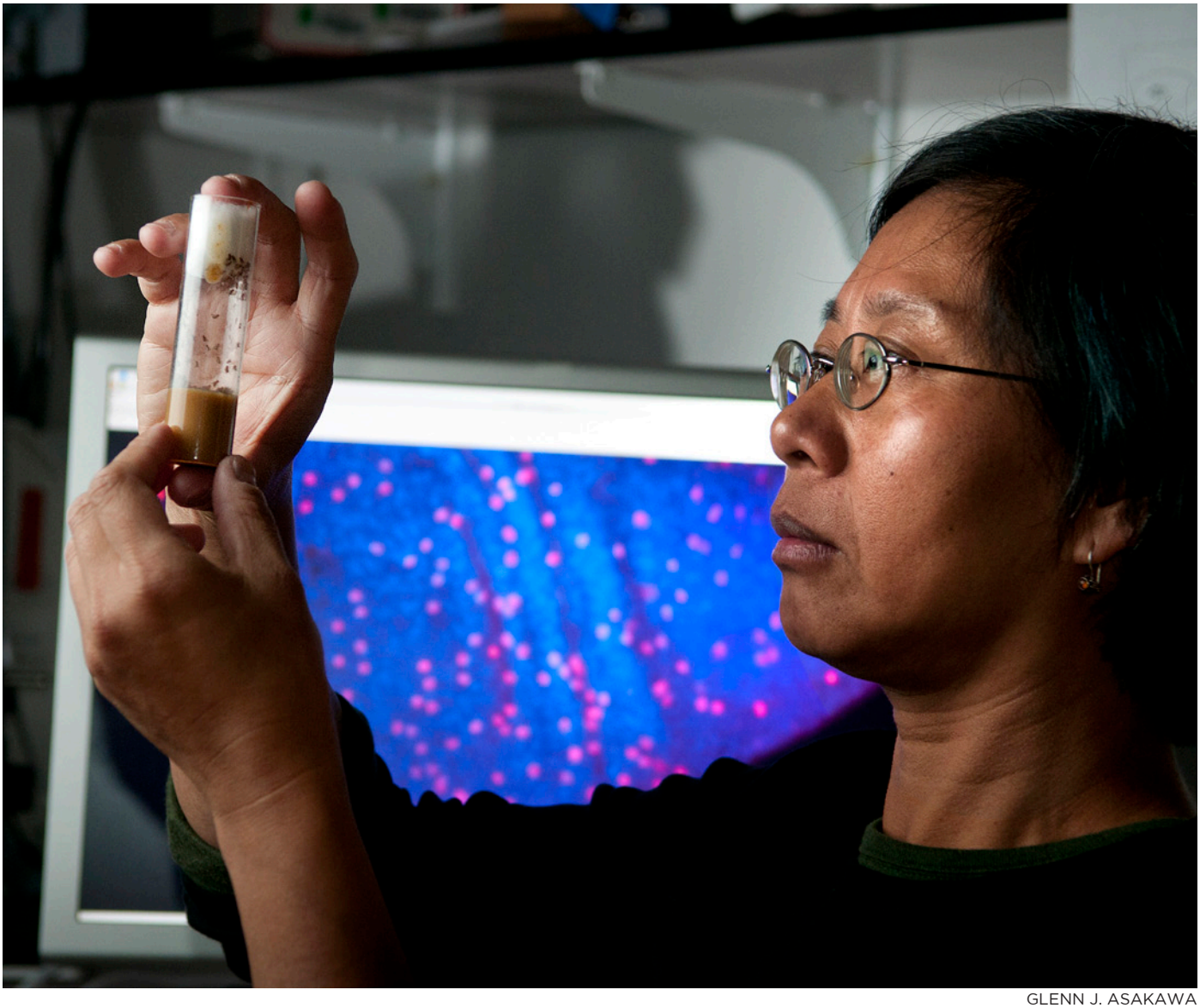
The highly contagious, airborne disease swept through Europe in the 17th and 18th centuries, earning the moniker of White Plague. By the early 20th century, TB was a leading cause of death in the United States. But by the mid-20th century, thanks to the availability of a vaccine called BCG and the advent of several new drugs, the epidemic seemed to lie down.

Later in the 20th century came the HIV epidemic, which compromised immune systems and made people more vulnerable to TB. Soon multidrug-resistant strains began to proliferate. By 1993, the World Health Organization had declared TB a global health emergency.

Today, 8.7 million are infected annually and 1.4 million die. An estimated 9 percent of cases worldwide are completely resistant to all the drugs available. These kinds of cases have now been reported in 84 countries.

"It is the revisiting of the White Plague," said Diane Joyce Ordway, an assistant professor in the department of microbiology, immunology, and pathology at CSU. "It is a big problem."

To address it, CSU has developed one of the largest academic TB research programs in the world, drawing roughly



GLENN J. ASAKAWA

University of Colorado Boulder Associate Professor Tin Tin Su of the molecular, cellular and developmental biology department holds a vial of fruit flies that she uses for her research into a CU drug screening technology to identify novel therapies for cancer.

$12 million annually to study everything from cheaper, faster diagnostics to better vaccines and new drug targets.

In 2009, Ordway and her colleagues rocked the TB research world when they discovered that strains grown in a lab and long used in animal models did not realistically model the way new drug-resistant strains behave in humans. That meant that while therapies might have worked when tested on animals, they might not work in the real world.

"We have been setting ourselves up for failure," she said.

Her group now uses only more realistic "clinical strains," derived from human TB patients, for testing new treatments. "That's why people come to us. They want to work with real strains that affect real people."

The MRL has also become the go-to source for labs wishing to acquire TB reagents so they, too, can study the disease. Between 2006 and 2009 it served more than 600 international labs in 44 countries.

As a result, progress is being made. On Dec. 31, 2012, the Food and Drug administration approved the first new TB drug in the past 40 years — bedaquiline, which Johnson & Johnson has been testing at CSU for several years.

"This is a huge breakthrough," said Ian Orme, who helped found the MRL in the 1980s.

Filling a gap in cancer research

If you looked at the map of National Cancer Center Network members across the country, historically you would have found a gaping hole across the middle of the United States, with the most prestigious cancer research and treatment facilities located on the East and West coasts. That is no longer the case.

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This year, NCCN is expected to add the University of Colorado Cancer Center to its list.

"This is a very big coup, to become a part of this exclusive group, and something the state can be really proud of," said Dr. Dan Theodorescu, Cancer Center director.

While it is housed on CU Anschutz Medical Campus, the Cancer Center consortium includes all National Cancer Institute-funded researchers in the state, including those from CU-Boulder and CSU. Collectively, its 248 members draw about $160 million in annual cancer research funding, pumping out more than 3,000 cancer-related publications since 2005. In 2008 alone, 22 patents were filed out of UCCC-member research, and between 2006 and 2009, 11 startup companies were formed.

Since its founding in 1987, the Cancer Center has developed a reputation as a pioneer in unraveling the molecular mechanisms behind bladder, lung, thyroid and other cancers, and several new tests and drugs have resulted.

In 2012, doctors began using a new thyroid cancer diagnostic test called Affirma, which grew out of a multiyear collaboration between CU professor Dr. Bryan Haugen and the San Francisco-based biotech company Veracyte Inc.

Typically, the 15 to 30 percent of patients with suspicious thyroid nodules that cannot be definitively diagnosed via a mild procedure called a needle aspiration must have surgery to find out whether they have cancer. Seventy percent turn out to be benign.

"It is expensive," Haugen said. "They have to go through the risks and apprehension of having surgery, and then they have to live the rest of their lives with the potential side effects of having some of their thyroid removed."

Haugen estimates 75,000 to 100,000 people undergo unnecessary surgery annually.

"I thought, 'There has got to be a better way,'" he said.

In the 1990s, he started looking for a molecular marker of the disease and over time, he and colleagues found 142 associated genes. In 2007, Veracyte came to him with the idea of collaborating on a test, and ultimately they were able to develop what they call "a genomic fingerprint" of what a benign tumor looks like.

The Breastmilk, Gut Microbiome, and Immunity Project is the latest in a series of research endeavors that have propelled Knight, 35, to star status in the nascent field of human microbiome research.

Rob Knight, researcher specializing in bioinformatics

Instead of going under the knife if their first test is inconclusive, patients can now submit a second sample of thyroid fluid and have it genetically scoured for that fingerprint.

"It will improve quality of life and save money," Haugen said.

Meanwhile at the Center, other gene sequencing technologies are being put to use to better classify human cancers into subgroups. Several kinds of lung cancer or bladder cancer may be identified, for example, and molecularly targeted drugs or existing chemotherapy agents may be identified that are best suited to treat them.

Theodorescu hopes to work more closely with CSU's College of Veterinary Medicine and Biomedical Sciences to increasingly test such drugs on companion animals that have no other options.

"We like to break down barriers," he said. "We want to do things together that we could not do alone."

Gene sequencing to end hunger?

When a colleague first approached CU-Boulder BioFrontiers Institute researcher Rob Knight about a Gates Foundation grant to study childhood malnutrition in the developing world, Knight thought his friend had the wrong guy.

"I was extremely skeptical," said Knight, who specializes in bioinformatics, the merging of computer science and biology. "I said, 'Shouldn't the Gates Foundation be spending its money on food, rather than DNA sequencing?' Fascinatingly, the answer is no. It's not that simple."

In reality, mounting research shows that microorganisms in the human gut play a critical role in helping the body break down carbohydrates, fats and proteins efficiently. If that microbial community is damaged by malnutrition or other factors, an array of problems can ensue, including malnutrition.

"You can feed these kids as much corn or vegetable porridge as you like and it won't reverse," Knight said.

Armed with an $8.3 million Gates Foundation grant, along with lightning-fast computational tools developed in his own lab, Knight is collaborating with an international team of researchers over the next two years to answer two essential questions: What prompts one child's gut bacteria to develop in a healthy way while another's do not? And what can be given to a malnourished child, along with food, to restore nutritional health?

The Breastmilk, Gut Microbiome, and Immunity Project is the latest in a series of research endeavors that have propelled Knight, 35, to star status in the nascent field of human microbiome research, the study of the hundred trillion or so bacteria inhabiting our bodies.

Until recently, scientists interested in better understanding those microorganisms were stifled by high costs and long waits for gene sequencing. But Knight and his colleagues at CU-Boulder have helped to develop new rapid-fire "error-

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SENSITIZING PROSTHETICS

Sensors injected into live muscles send wireless signals to artificial limbs

BY LISA MARSHALL

Look at the typical prosthetic arm and it looks remarkably similar to one from the end of World War II. It straps across the back and uses a cable system to allow the user to control a metal hook by shrugging his or her other shoulder. Newer electric powered versions use external electrodes instead of a cable system to control them, look more life-like and allow for lifting heavier loads. But even they are limited to grasping and picking things up.

"The human hand can do a lot more than grasp and pick things up," said Richard Weir, an associate professor in the University of Colorado Denver's new bioengineering department.

Weir has spent more than a decade working to build a better prosthesis — one that more closely resembles the complex system that allows the human hand to, for instance, play a Brahms concerto or spell out the alphabet in sign language. This spring, he will move one step closer to that goal, when below-elbow amputees at the Walter Reed Army Medical Center in Bethesda, Md. begin testing a next-generation implantable prosthesis control interface he helped design with partners Alfred E. Mann Foundation, Illinois Institute of Technology and Sigenics Inc.

"It could someday mean that rather than just open and close, a person with a forearm amputation will be able to have individual finger and thumb control and wrist control," said Weir.

While the typical prosthetic hand has 1 or 2 degrees of freedom, the human hand has 22. Some systems use surface electrodes that sit on the upper forearm to tap into the brain-to-muscle signals that remain even when the appendage is gone. But they only tap into two muscles. There are 18 muscles in the forearm involved in the control of the human hand and wrist.

The new system relies on rice-sized capsules called Implantable MyoElectric Sensors (IMES) that are injected into the residual muscles of the upper forearm and wirelessly telemeter signals from these muscles to an external prosthesis controller.

"It could someday mean that rather than just open and close, a person with a forearm amputation will be able to have individual finger and thumb control and wrist control."

— Richard Weir, associate professor in the University of Colorado Denver's Bioengineering Department

"It could totally blow the socks off what people with upper-limb amputations can currently do," said Weir.

Previously, Weir helped to design a hand prototype with 18 degrees of freedom that could spell out the alphabet in sign language if the signals were available to control it. Now, he's working on research that could someday enable this hand to do one more thing it can't do now: Feel touch.

"We have a ways to go on that one," he said.

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correcting bar-coded sequencing" techniques and software. Where it once cost $8 to analyze one gene sequence, it now costs $30,000 to analyze one billion, enabling the research to move forward at a much swifter pace.

"Knight's work has propelled the field forward tremendously," said microbiome research pioneer Jeffrey Gordon of Washington University in St. Louis.

Over the years, Knight has co-authored pivotal papers showing that lean and obese mice differ in their gut microbiota.

"Somehow, the altered microbial community made them want to eat more," Knight said. Now he's exploring the flip side of the equation — the malnutrition-microbiota link.

In June the Human Microbiome Project Consortium, a federally funded group of 200 scientists including Knight, also mapped the entire microbial makeup of a healthy human for the first time, using 4,788 specimens from 242 healthy adults.

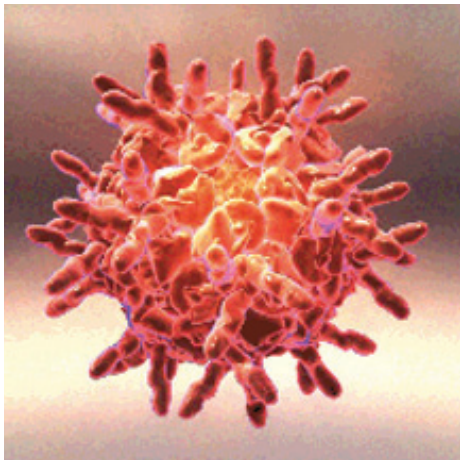
And in November, Knight teamed up with researchers around the world to launch "American Gut," an effort to use crowd funding and open-access data sharing to help academics and individuals learn even more about what lives within them.

People can submit a sample and a donation and get their gut microbe partially sequenced, while contributing to a larger data set for study.

Ultimately such research could lead to oral probiotics to address malnutrition and other ailments, new ways to diagnose health problems, and clues as to how people can improve their overall health by altering their guts.

"If you look at our host genome, we are all 99.9 percent the same," Knight says. "But if you look at our gut microbiota, it can be 80 to 90 percent different between two people."

And as he noted, it's a lot easier to change what's growing in your gut than it is to change your genes.



10 LIFE-CHANGING IDEAS

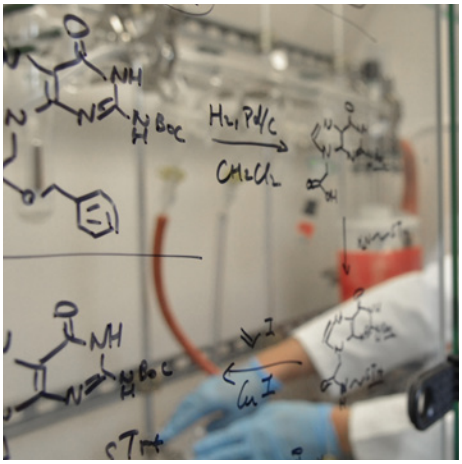
Plant detectives, predicting the unpredictable fire and helping rare earth metals become less rare

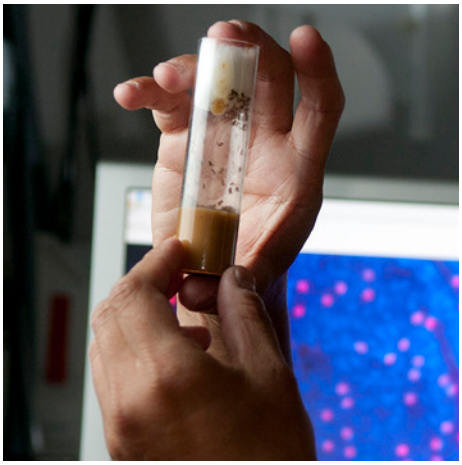
BY PAULA MOORE

Research under way at Colorado's research universities might unlock a cure for cancer, make natural gas production safer, better predict the movement of devastating wildfires and otherwise improve the lives of people worldwide.

These are 10 life-changing ideas being investigated at the schools.

1 Fat Gene: Researchers have discovered that deleting a specific gene in mice prevents them from becoming obese even on a high fat diet, a finding they believe may be replicated in humans. "When fed a diet that induces obesity these mice don't get fat," said Prof. James McManaman, lead author of the study and vice-chairman of research for Obstetrics and Gynecology at the University of Colorado School of Medicine. "It may be possible to duplicate this in humans using existing technology that targets this specific gene." In the two-year study, the research team created a strain of mice without the Plin2 gene, which produces a protein that regulates fat storage and metabolism. Usually, mice fed a high fat diet will eat voraciously, yet these showed an unusual restraint. Not only did they eat less, they were more active.



2 Plant Detectives: Colorado State University biologist June Medford and her team have dug deep into the natural world and have come up with a way for plants to detect environmental pollutants and explosives. Using a computer-designed detection trait, the researchers can rewire a plant's natural signaling process so it turns from green to white when certain chemicals are detected in air and soil. That key step is part of a long process that could be used in a wide range of applications — from airport security to monitoring pollutants such as radon in a home. Medford said, "We've 'taught' plants how … to tell us there is something nasty around."

3 Stopping Viruses Cold: Billions of people worldwide are at risk for getting mosquito-borne diseases from yellow fever to West Nile virus, and few treatments are available. Susan Keenan, UNC biological sciences professor, and her team are investigating and developing compounds to prevent the growth of such diseases, including one that prevents viruses from reproducing. The team's long-term goal is to develop its compounds into virus-preventing drugs.

4 Diet Soda or Water: Many dieters choose zero-calorie drinks over the recommended water during their efforts to lose weight. CU Anschutz Health and Wellness Center Executive Director James O. Hill is trying to determine if zero cal drinks offer the same benefits as water for weight loss. He is principal investigator on a study, half of which will be conducted at the Anschutz Health and Wellness Center and half at Temple University in Philadelphia. "There have been a lot of studies showing that non-caloric soft drinks are a better choice during weight loss than caloric drinks, but there's never been a study comparing zero-calorie beverages with water," said John C. Peters, chief strategy officer at the CU Anschutz Health and Wellness Center. "This will be the first one."

5 It's a Gas: University of Colorado Boulder mechanical engineering professors Scott Bunch and John Pellegrino lead a team experimenting with the use of graphene membranes, one of the world's thinnest and strongest materials, to separate molecules through sieving. That process is a "significant step," according to CU, toward more energy-efficient gas production and reducing carbon dioxide emissions from power plant exhaust pipes.

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Colorado State University biologists June Medford and A.S.N. Reddy have been awarded a Defense Advanced Research Projects Agency grant to examine the possibility of genetically engineering plants to rapidly lose their green color in response to biological or chemical weapons.

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6 Joint Venture: A new, longer-lasting joint implant material, developed at CSU over the past 17 years, was implanted in the knee of an English patient in 2012 and is being sold in Europe. The material was created by Susan James, head of CSU's mechanical engineering department, and BioPoly LLC of Fort Wayne, Ind. It allows people to have joints repaired at a younger age and alleviates their pain faster. The new material is made from hyaluronic acid and ultra-high molecular weight polyethylene. It is now being evaluated for approval and use in the U.S.

7 Reducing Rarity of Rare Earth Metals: Colorado School of Mines has joined several institutions and industry partners to address critical shortages of rare earth metals. Such metals are widely used in technology and defense industries, among others. This year the group received a $120 million federal grant to address four problems related to the metals: creating substitutes, diversifying existing supply sources at risk of disruption, improving reuse and recycling, and strengthening energy security.

8 Cancer-Fighting Fruit Flies: CU-Boulder, along with the University of Colorado Anschutz Medical Campus, CSU and SuviCa Inc. of Boulder, is finding compounds that may lead to development of cancer-fighting therapies. Professor Tin Tin Su of CU-Boulder and co-founder of SuviCa, uses a genetically modified fruit fly model to screen for such compounds. The compounds may be used alone or with existing therapies.

9 Wildfires On The Move: As geographic areas grow drier with climate change and the threat of wildfires increases, the University of Colorado Denver is investigating how to better predict the fires' movement. Jan Mandel, chief of the university's mathematics & statistical sciences department, heads a group working on a National Science Foundation-funded project to use real-time data to analyze and track fires. Such improved tracking could give residents in a fire's path more time to get out of harm's way and guide firefighters more quickly to contain and put out fires.

10 Stabilizing Vaccines: Researchers have developed a new technology that produces stable vaccines, which can withstand long temperature variations and thereby save millions of lives. In effect, the thermostabilization technology developed by CU Skaggs School of Pharmacy and Pharmaceutical Sciences faculty member John Carpenter in collaboration with CU-Boulder faculty Ted Randolph and Amber Clausi could potentially revolutionize the vaccine industry. Most vaccines require refrigeration, which adds considerable cost to the production and storage of current conventional vaccines. Long-term stability is a significant problem in vaccines for use in emergency situations and especially for vaccines used in the developing world. The savings realized from the elimination of cold chain costs and related product losses would significantly increase the profitability of vaccine products and save millions of lives.


CU research partnerships
with national laboratories
deliver new knowledge
and learning opportunities,
a surging entrepreneurial
environment, and
a positive impact on
our economy and
quality of life.
University of Colorado
Boulder
www.colorado.edu

UNIVERSITIES REACH OUT

Tech transfer initiatives take on new urgency to help restart Colorado economy

BY PAULA MOORE

Colorado universities, intent on seeing their tech breakthroughs live on in the real world, are reaching out to businesses in new ways to help the state create jobs and ensure a more resilient economy.

The state's major research universities have long hosted technology transfer offices, whose staff members help bridge the gaps between academic research and the commercial world.

Now, thanks in part to the recent brutal recession and the need to ensure the health of vital industries, even more focus is being placed on critical technology transfer initiatives.

"We're very much a key player in the ecosystem of entrepreneurship," said Todd Headley, president of CSU Ventures, a nonprofit group that helps Colorado State University in Fort Collins with its technology transfer. "We definitely have an impact on Colorado's economy through jobs created and money raised."

Tech transfer in Colorado doesn't yet match the volume taking place in Massachusetts and California, but it's getting there, according to experts in the field.

"We're nowhere in the realm of the

Continued on next page

COLORADO INNOVATION INDEX
Four Key Findings:

Talent: Colorado has the most workers with a bachelor's degree or higher in the country, lagging only one state, Massachusetts. But Colorado has slipped in educating its own residents.

Ideas: Colorado issued more than 450 patents per million residents, one of the leading rates in the nation.

Capital: Colorado gets a healthy dose of public funding from Small Business Innovative Research and Small Business Technology Transfer Grants, though it is below other states in terms of National Institutes of Health funding.

Entrepreneurship: Colorado ranks well here, especially in its high concentration of self-employed workers, but the returns these entrepreneurs generate are only average.

SOURCE:COLORADO INNOVATION NETWORK

COURTESY OF THE FITZSIMONS REDEVELOPMENT AUTHORITY

Fitzsimons BioBusiness Incubator in Aurora

Continued from previous page

MITs and Stanfords of the world, which really have tech transfer nailed down," said Stephen Miller, Rocky Mountain Incubation Collaborative board member and former president/CEO of the CleanLaunch Technology Incubator in Golden. "But we're improving. It takes that combination of talent, capital and ideas."

University tech transfer offices work with faculty and staff to help stimulate innovation, preserve ownership of their intellectual property and stimulate the Colorado economy, according to the schools.

For example, the Office of Technology Transfer at the Colorado School of Mines in Golden manages the patenting and licensing of intellectual property developed at the school. CU's Technology Transfer Office — which serves the university's Boulder, Colorado Springs, Denver and Anschutz campuses — analyzes the commercial feasibility of intellectual property and helps develop strategies for its commercialization.

Mike Freeman

Incubators such as the Rocky Mountain Innosphere in Fort Collins, which works with CSU and CSU Ventures, help young companies with little or no revenue receive the mentoring and other resources they need to get on a solid footing. They help companies develop business plans, protect their intellectual property with trademarks or copyrights, and decide what corporate form — LLC, C corporation, etc. — to adopt.

In 2012, the RMI had 35 client companies in industries such as cleantech and bioscience, with roughly 200 employees total. Those companies raised nearly $20 million last year.

"That's the biggest challenge — raising capital," said Mike Freeman, CEO of the Innosphere.

Toward that end, the RMI is helping to reinvigorate Colorado's angel network with the creation early this year of the Colorado Angel Investors Inc. investment club. The Innosphere also recently partnered with the Colorado Enterprise Fund and Loveland-based Home State Bank to establish a $500,000 early-stage debt pool for its startup companies.

In Aurora, the Fitzsimons BioScience

Continued on next page

NEW FUNDING PROGRAM?

Lawmakers consider expanding cash fund for startups

BY PAULA MOORE

If the Advanced Industries Acceleration Act, HB 13-1001, being considered in the Colorado Legislature this year, is approved by Colorado lawmakers, it will create a program that provides cash grants for startup companies in industries such as aerospace, bioscience, cleantech and information technology. The bill would replace two existing state measures — the Bioscience Discovery Evaluation Grant Program and the Clean Technology Discovery Evaluation Grant Program.

"If HB 1001 goes through, it would essentially pull the bioscience program into the larger program and could make changes to our program," said Sonya Guram, manager of the bioscience grant program.

HB 13-1001 would create a cash fund administered by the Colorado Office of Economic Development and International Trade to provide proof-of-concept, retention and infrastructure funding grants as well as early-stage capital. Funds for the new program would come from sources including income tax, gifts, donations and General Assembly appropriations. Starting in fiscal 2014-2015, the Advanced Industries fund would get $5.5 million a year from the state, the bill specifies.

Ken Lund, executive director of the economic development office, has high hopes for the measure, saying, "I'm optimistic about its passing."

Its predecessors, such as the bioscience grant program, created in 2006, have helped launch more than 35 companies and created 300 jobs; the program has awarded $24 million in grants, including $5.2 million to 33 projects in 2012. The program is funded by state gaming revenues.

Ken Lund

Continued from previous page

Incubator has helped launch 50 companies since it opened in 2000.

"Incubators are catalysts for growing businesses," said Vicki Jenings, director of business relations at the Fitzsimons Redevelopment Authority in Aurora, which runs the bioscience incubator. "We're taking advantage of the fact that the University of Colorado Anschutz Medical Campus is next door; it's a catalyst for a lot of spinoff activity."

Vicki Jenings

The incubator currently has 37 companies "growing here," according to Jenings.

Among companies the Fitzsimons incubator has helped launch is Myogen Inc., a biopharmaceutical company acquired by Gilead Sciences Inc. for $2.5 billion in 2006. Myogen develops and commercializes small molecule therapies for cardiovascular disease, including Flolan, which is used to treat pulmonary hypertension.

"The incubation model has a 25-year track record," said Jasper Welch, a board member of the Rocky Mountain Incubation Collaborative board, and a former Durango mayor. "It's probably the most proven of the various business-growth models."

Other models are also cropping up, including a sort of tough love, fast-track approach known as an accelerator. Boulder-based TechStars, which calls itself the No. 1 accelerator in the world, helps strengthen young, relatively solid companies through mentorship and investment. TechStars invests $118,000 in each client, but also works to help these startups get funding from angel investors and venture capitalists. Clients each raise an average of $1.4 million in outside capital after leaving TechStars, according to the accelerator.

Where incubators generally have an open-ended time frame for businesses, accelerators have finite start and stop dates; TechStars' clients get three months.

"An accelerator is more like a boot camp," said the RMIC's Miller. "There's a competitive process to get in, and a set time frame."

Colorado State University in Fort Collins uses three "superclusters" to turn its research into real-world businesses as fast as possible. The superclusters are alliances of faculty members focused on research in infectious diseases, cancer prevention and clean energy, who collaborate with economists and business experts "to bridge the vastly different worlds of business and academia," according to the university.

"CSU has really made a concerted effort to blossom in the area of technology transfer — to see a return on investment, so to speak," said Bill Farland, CSU vice president of research. "If we look at the way the superclusters have affected technology transfer, they really have been the flood that raises all boats."

A new report, the Colorado Innovation Index, gives the state high marks for its research and development activity, its well-educated populace, and its entrepreneurial activity, particularly in technology sectors. But Colorado's educational attainment is slipping and its small businesses are able to generate only average returns. The report was produced by the Colorado Innovation Network, a new group formed to help the state track and improve new business creation.

Still, the state generates high marks for patents and the interest of venture capitalists.

In 2011, for instance, Colorado ranked third, behind California and Massachusetts, for patents, generating more than 450 patents per million residents that year. And in 2012, MoneyTree ranked Colorado the fourth-leading destination for early stage venture capital.

The Rocky Mountains rise above Denver and the Anschutz Medical Campus.

BRINGING RESEARCH HOME

It doesn't require a genius to know it's important to get research from the laboratory to where it can directly help patients.

But maybe it helps if you are a genius.

Eric Coleman, MD, a geriatrician at the University of Colorado School of Medicine, won a $500,000 MacArthur Foundation "genius" fellowship in 2012 for his work on how to help patients transition from hospital to home.

Too often, patients leave the hospital only to be readmitted within a month. That's costly and usually preventable. Coleman demonstrated that getting patients more involved in self-care and giving them more information about their illnesses and signs of recurrence cut readmission rates. That cuts costs and keeps people healthy.

That's research at its best.

The University of Colorado Denver | Anschutz Medical Campus is a powerful engine of research in Colorado and makes an impact nationally. The two campuses generate more than $400 million in research funding annually, the bulk of that through the Anschutz campus.

Research, education, health care and community involvement are what the University of Colorado Denver | Anschutz Medical Campus is all about.

Across the two CU campuses, scientists are unveiling the workings of the most minute components of life, seeking breakthrough discoveries for a better future. Other researchers are taking on diseases and teaching people how to live healthier. The university focused on bringing breakthroughs more quickly to the people who need them.

That saves money and makes lives better. You might call it a stroke of genius.

Read more in the following seven pages.

"The education and research taking place at the University of Colorado Denver | Anschutz Medical Campus are vital to Colorado. We're shaping the next generation of leaders in health care, business, architecture, liberal arts and more. While some of our faculty and students peer into the human genome, others create music and art that nurture society in different ways. We also add more than $4 billion to the state economy annually.

Between our two campuses we offer more than 130 degree programs in 13 schools and colleges. At the Denver Campus, the city is the classroom for our diverse student body, which earns more graduate degrees each year than any other institution in Colorado. The Anschutz Medical Campus is a health care complex in Aurora, where research is improving lives and education occurs in classrooms and in two of the best hospitals in the country.

We're proud to be making an impact."

- Chancellor Don Elliman

Serving the state, by the numbers

Anschutz Medical Campus

Nearly **16,000 jobs**
on the Anschutz Medical Campus

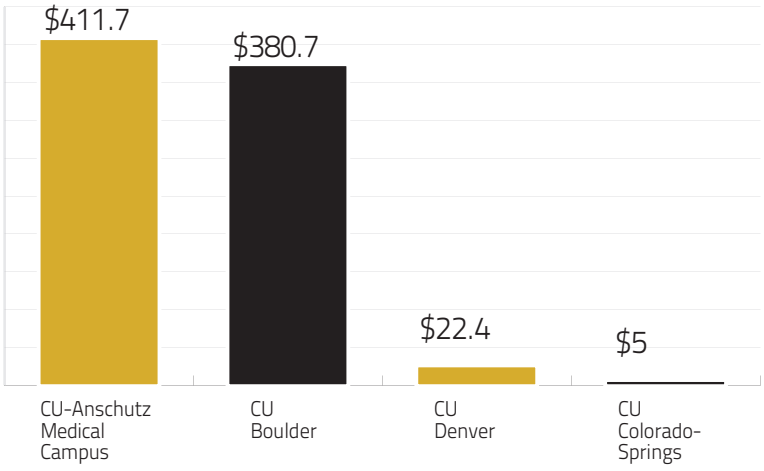
$2.4 billion
income and spending, campus and two affiliated hospitals

$3.8-$4.6 billion
income and spending, campus and two affiliated hospitals

$1.1 billion
payroll and operating expenses

Research awards by campus, 2012

(unaudited figures, in millions)



$400 Million

In fiscal year 2012 the University of Colorado Denver | Anschutz Medical Campus sponsored project research was valued at more than **$400 million**, the highest among Colorado's research Universities. Much of that funding went to the Anschutz campus for health care research. The federal National Institutes of Health provided the largest proportion of the dollars.

A doctor explains to a young patient the workings of a device that researchers believe will help him manage diabetes.

Brains can develop better with the nutrient choline

Could we some day prevent diseases such as schizophrenia? Research at the University of Colorado School of Medicine is exploring that question, a topic that could have huge implications for health.

Choline, an essential nutrient similar to the B vitamin, appears to reduce schizophrenic risk factors in infants, CU researchers found. Choline, which plays a big role in fetal brain development, also is being studied for potential benefits in liver disease, including chronic hepatitis and cirrhosis, depression, memory loss, Alzheimer's disease and dementia, and certain seizures.

Here's how the researchers went about their work. Normally, the brain responds fully when it first hears a clicking sound but inhibits its response to a second click that follows immediately. In schizophrenia patients, that second response often is not screened out.

So in infants, a full response to a second click could indicate risk of developing schizophrenia later in life.

In the CU study, some healthy pregnant women took 3,600 milligrams of phosphatidylcholine each morning and 2,700 milligrams each evening; others took a placebo. After delivery, their infants received either choline or a placebo. Eighty-six percent of the infants who got the choline inhibited the response to repeated sounds. In the placebo group, the figure was 43 percent.

Choline affected brain function. Now, says Robert Freedman, MD, professor and chairman of the Department of Psychiatry, more work needs to be done to explore the implications of this finding.

"The Anschutz Medical Campus is buzzing with research. More than $400 million in research funding fuels our investigations into fighting cancer and diabetes, improving health and much more. Research can take years of trial and error. But the eventual payoff is so powerful. We're creating more targeted treatments, improved diagnostics, less invasive and safer procedures, and biotechnology businesses. And we're working to speed up how quickly we get those breakthroughs out of the lab and into the world. Where CU's research really hits home for me, however, is in the individual stories -- when a child with cystic fibrosis can breathe more easily, when a patient hugs her doctor because a genomic test tells her she doesn't have thyroid cancer. Then we see how our work truly changes lives."

- Lilly Marks

CU vice president for health affairs and executive vice chancellor for the Anschutz Medical Campus.

Finding and turning off the "fat switch"

A team of CU researchers may have figured out what happens in the body to make so many people obese.

The "fat switch" is what Dr. Richard Johnson calls it. And the main culprit is fructose.

His findings, published in a book "The Fat Switch," could lead to reduced obesity, and so lower health care costs.

Johnson, a CU School of Medicine professor and chief of the Division of Renal Diseases and Hypertension, said there has been a tendency to blame obesity on poor habits – eating too much, for example.

He and his team found, however, that fructose and other foods common in the American diet trigger a switch in our metabolism that makes us want to eat more and want to exercise less. Here are questions and answers with Johnson.

Q: You looked at fat in people and other animals. What did that tell you?

A: Weight is normally tightly regulated among animals. They tend to gain weight to help survive during periods of food shortage or famine. When they do this, they develop fatty liver, they'll increase the fat in their blood and their abdomen, and they even become insulin resistant. So they develop all the features of metabolic syndrome. Humans continue to store and accumulate fat, whereas an animal gains fat and loses it in a regulated way.

Q: In your book, you discuss the evolution of humans and of sugar in our diet.

A: As we looked for what could activate this switch in animals and we realized that fructose was a big way to activate it, we then started looking at humans and saw that this mechanism we had discovered could actually account for a lot of the obesity in humans. We further linked the susceptibility of humans to fructose to a mutation that occurred 15 million years ago during a period of famine. The mutation resulted in a greater increase in uric acid in response to fruit, and thereby allowed us to increase our fat stores more easily in the setting where fruit availability was decreasing. This mutation likely acted to protect us during periods of famine in our past. Then we found that there are other foods that can activate the switch, though not as much as fructose.

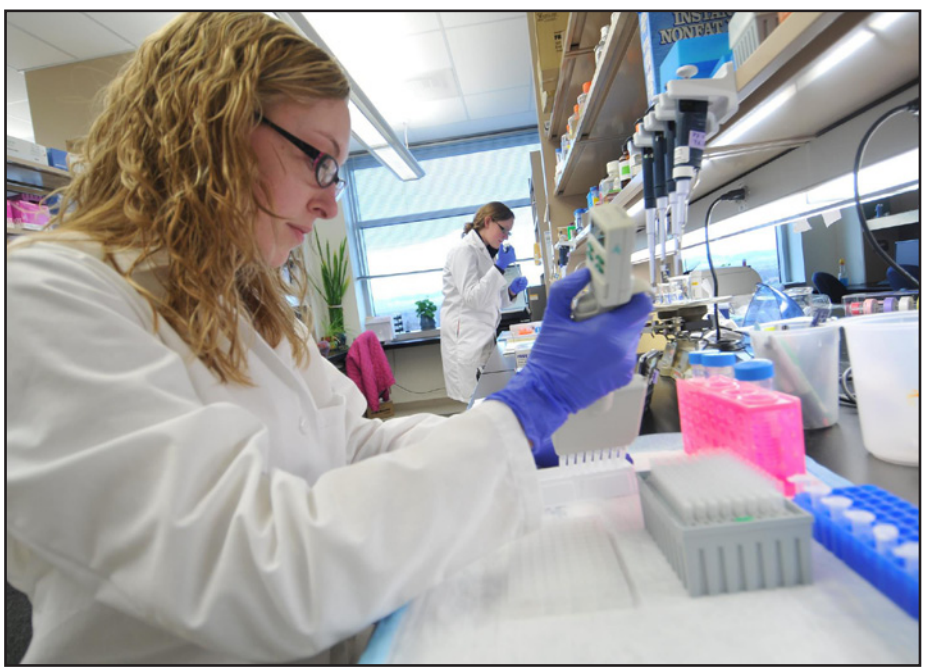
Q: Such as?

A: Umami foods, the type of food that's called savory, such as gravies and shellfish. However, beer is the greatest culprit after sugar. We realized that you can activate the switch a number of ways. Then we looked at what happens when the switch gets activated and how it might play a role not just in diabetes and obesity, but a lot of other diseases, including celiac disease, food allergy and attention deficit. The book makes the case that the fructose/uric acid switch is probably the underlying major mechanism for the obesity epidemic. It's very controversial. But the data is the data. I use everything, from anthropology and evolution and comparative physiology to biology and molecular biology and history, to put together the total argument.

Richard Johnson, MD

Q: Do you believe this could be the breakthrough to end this health crisis?

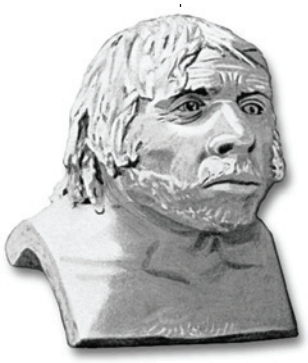
A: I believe the book provides major insights that could lead to how to prevent and treat obesity, but also one day how to cure obesity.



Sometimes, research peers into our past

Where did those Neanderthals go?

It's long been thought they disappeared some 30,000 years ago because they were outpaced by modern humans. But a researcher at the University of Colorado Denver has cast new light on their story – and ours.



"We are changing the main narrative," said Julien Riel-Salvatore, assistant professor of anthropology. "Neanderthals were not inferior to modern humans. They were just as adaptable and in many ways simply victims of their own success."

The CU Denver anthropologist has discovered that Neanderthals made tools, weapons and ornaments on their own without contact with humans. He also found that Neanderthal burials and those of early humans sometimes were nearly identical.

In another study, Riel-Salvatore, working with C. Michael Barton, professor of anthropology at Arizona State University, used computer modeling to determine how early hominids adapted to climate change during the last Ice Age.

Turns out the Neanderthals adapted perfectly well, ranging farther for food. Their problem was that the far more numerous humans did the same thing. The two groups interacted more often. And they interbred more often. Ultimately, Neanderthals were not wiped out by humans or outcompeted. They were simply genetically swamped by their close cousins until they eventually vanished.

Well, mostly. Neanderthal genes make up between 1 and 4 percent of today's human genome, especially in those of European descent.

Unfriendly Facebook – studying how technology changes relationships

Unfriending someone on Facebook may be as easy as clicking a button, but a new study from the University of Colorado Denver shows the repercussions often reach far beyond cyberspace.

"People think social networks are just for fun," said study author Christopher Sibona, a doctoral student in the Computer Science and Information Systems program at the University of Colorado Denver Business School. "But in fact what you do on those sites can have real world consequences."

Sibona found that 40 percent of people surveyed said they would avoid in real life anyone who unfriended them on Facebook. Some 50 percent said they would not avoid the person and the remaining 10 percent were unsure. Women said they would avoid contact more than men.

The study highlights how relationships are changing as the world becomes increasingly connected by the Internet.

Speaking of connecting, friend us at facebook.com/CUAnschutzMed and facebook.com/UCDenver.

Probing racial disparities

In the first study of its kind, researchers have found that those who suffer cardiac arrests in upper income, white neighborhoods are nearly twice as likely to get cardiopulmonary resuscitation (CPR) than people who collapse in low-income, black neighborhoods.

'If you drop in a neighborhood that is 80 percent white with a median income over $40,000 a year, you have a 55 percent chance of getting CPR," said study author Comilla Sasson, MD, an assistant professor in the Department of Emergency Medicine.'If you drop in a poor, black neighborhood you have a 35 percent chance. Life or death can literally be determined by what side of the street you drop on."

Sasson, an emergency room physician at University of Colorado Hospital, analyzed data from 14,225 patients who suffered cardiac arrests in 29 cities from 2005-2009. She and her colleagues used census data to determine in which neighborhood the event took place, its racial make-up and median household income. Low-income was considered at or below $40,000 a year.

Colorado School of Public Health explores timely issue of fracking

Air pollution caused by hydraulic fracturing or fracking may contribute to acute and chronic health problems for those living near natural gas drilling sites, researchers from the Colorado School of Public Health say.

"Our data show that it is important to include air pollution in the national dialogue on natural gas development that has focused largely on water exposures to hydraulic fracturing," said Lisa McKenzie, lead author of the study and research associate at the Colorado School of Public Health.

The researchers' report, based on three years of monitoring, found a number of potentially toxic petroleum hydrocarbons in the air near the wells including benzene, ethylbenzene, toluene and xylene. Benzene has been identified by the Environmental Protection Agency as a known carcinogen. Other chemicals included heptane, octane and diethylbenzene but information on their toxicity is limited.

"Our results show that the non-cancer health impacts from air emissions due to natural gas development is greater for residents living closer to wells," the report said. "The greatest health impact corresponds to the relatively short-term, but high emission, well completion period."

That's due to exposure to trimethylbenzenes, aliaphatic hydrocarbons, and xylenes, all of which have neurological and/or respiratory effects, the study said. Those effects could include eye irritation, headaches, sore throat and difficulty breathing.

"We also calculated higher cancer risks for residents living nearer to the wells as compared to those residing further [away]," the report said. "Benzene is the major contributor to lifetime excess cancer risk from both scenarios."

The report, which looked at those living about a half-mile from the wells, comes in response to the rapid expansion

of natural gas development in rural Garfield County, in western Colorado.

Typically, wells are developed in stages that include drilling followed by hydraulic fracturing, the high powered injection of water and chemicals into the drilled area to release the gas. After that, fracking and geologic fluids, hydrocarbons and natural gas return to the surface. The gas is then collected and sold.

Garfield County asked the Colorado School of Public Health to assess the potential health impacts of these wells on the community of Battlement Mesa, which has a population of about 5,000.

McKenzie used standard EPA methodology to estimate non-cancer health impacts and excess lifetime cancer risks for hydrocarbon exposure. She noted that EPA standards are designed to be public health proactive and may overestimate risks.

"However, there wasn't data available on all the chemicals emitted during the well development process," she said. "If there had been, then it is entirely possible the risks would have been underestimated."

The report concludes that health risks are greater for people living closest to wells and urges a reduction in those air emissions.

School of Medicine rankings

The University of Colorado School of Medicine, located on CU's Anschutz Medical Campus, was highly ranked in the 2012 US News & World Report ratings of medical schools. CU was:

NO. 5
in broad category of primary care.

NO. 3
in family medicine

NO. 5
in pediatrics

NO. 7
in rural medicine

The school's hospital affiliates are among the best in the country:

For the second consecutive year:

- University of Colorado Hospital (UCH) was designated as highest-performing academic hospital in the United States by University HealthSystem Consortium.
- UCH was No. 1 in Colorado and Denver area,
- Children's Hospital Colorado: No. 5 in the U.S.
- University of Colorado Hospital and National Jewish Health: No. 1 respiratory hospital in U.S.

Olfactory research leads in many directions

For the past 25 years, Diego Restrepo, a professor of cell and developmental biology at the CU School of Medicine, has been nosing around for information about the sense of smell. He's examined olfactory tissue from catfish to rodents to humans in hopes of revealing the complex mechanism behind this oft-under-appreciated sense.

That work serves as a foundation for an array of potential applications: developing new treatments for anosmia (lack of a sense of smell) and spinal cord injuries; using easily accessible olfactory sensory neurons as a window into other neurological problems; even developing better systems for sniffing out bombs or detecting cancer.

As co-director of the CU medical school's new Center for NeuroScience, Restrepo says his mission is to bring scientists and physicians together, bridging the gap between basic research and clinical applications in hopes of improving the lives of those suffering neurological problems. In a sense, he's been doing that his whole career.

"I was drawn to [the olfactory] field because it is one where, first, you have to look deep into the mechanism to see how things actually work—and it is not a trivial mechanism," said Restrepo, who spent a decade at the Monell Chemical Sense Center in Philadelphia before coming to CU in 1997. "It's interesting from the basic science and the clinical side, and I love both."

Staring at a digital image of a mouse brain processing an odor, Restrepo still marvels at the complex system. Rodents, which identify their mates and family members by the smell of their urine, use about 5 percent of their genes to process scents. In humans, Restrepo said, that number is 1 percent to 3 percent.

Mammals perceive smell when a molecule binds to one of 10 million to 20 million highly specialized olfactory receptors in the upper nasal passage, each encoded to perceive a certain subset of odors. The signal is then sent to the brain via one of many fragile axons nestled in a thin, bony plate called the cribriform. When those axons reach the olfactory bulb in the brain, they converge on one of 2,000 distinct relay stations called glomeruli, each also believed to encode for a subset of odors. Ultimately, the complex pattern enables us to distinguish between the sweet aroma of grandma's cookies and, say, poisonous gas.

School of Medicine researcher Diego Restrepo helps lead the Center for NeuroScience.

This device allows Diego Restrepo to analyze antibodies more precisely.

Scientists also have discovered that human tumors cause a change in body odor, detectable by either trained animal sensors or chemical techniques. Unlike other sensory neurons, buried deep inside the eye or ear, olfactory sensory neurons are easily accessible for research.

As the only primary neurons in direct contact with the environment, olfactory neurons are constantly being damaged and regenerating themselves.

Studies show that loss of a sense of smell can be an early, cardinal sign for numerous neurological problems, from Alzheimer's to Parkinson's to multiple sclerosis to depression. By examining the olfactory cells of patients with those diseases, and comparing them with healthy controls, Restrepo hopes to better understand the physiological underpinnings of those diseases and how to treat them.

Boots to Suits

Thousands of servicemen and women from all branches of the military are now coming home, returning to school and to the workplace, eager to start new lives and become leaders in our community. With the newly created program, CU Denver Boots to Suits, we are teaming up with the Denver Metro Chamber of Commerce to assist highly trained and well-educated veterans as they move from the classroom to a new career.

Contact information

Website	ucdenver.edu
Facebook	facebook.com/UCDenver
	facebook.com/CUAnschutzMed
Twitter	@cudenver
	@cuanschutz

School facts

Total Enrollment (Fall 2012):

17,965 students

- 57% undergraduate
- 43% graduate/professional
- 75% full time
- 15% out-of-state residents
- 7% international students

Programs

More than **130** study programs in 13 schools and colleges

Degrees Awarded

More graduate degrees than any other Colorado institution-one third of all graduate degrees in the state. (FY2010-11)

Alumni

114,857 (as of FY2012)

- ~ 67% live in Colorado
- ~ More likely than their peers to have an off-campus job

Schools and Colleges

College of Architecture and Planning | Denver Campus
College of Arts & Media | Denver Campus
Business School | Denver Campus
School of Dental Medicine | Anschutz Medical Campus
School of Education & Human Development | Denver Campus
College of Engineering and Applied Science | Denver Campus
Graduate School | Both Campuses
College of Liberal Arts and Sciences | Denver Campus
School of Medicine | Anschutz Medical Campus
College of Nursing | Anschutz Medical Campus
Skaggs School of Pharmacy and Pharmaceutical Sciences | Anschutz Medical Campus
School of Public Affairs | Denver Campus
Colorado School of Public Health | Anschutz Medical Campus

MAVEN'S DEBUT IN SIGHT

GLENN J. ASAKAWA

Mars mission seeks more clues to climate, water mysteries

BY PAULA AVEN GLADYCH

Until the rovers Spirit and Opportunity first landed on Mars nearly a decade ago, Earth's neighboring planet seemed mysterious and elusive. Today, discoveries on Mars continue to elicit wonder and awe, but many mysteries are being explained, thanks in no small part to University of Colorado Boulder researchers.

An ambitious new $485 million mission, MAVEN, is scheduled to head to the red planet Nov. 18. MAVEN (Mars Atmosphere and Volatile EvolutioN) was designed by LASP, the University of Colorado Boulder's Laboratory for Atmospheric and Space Physics.

MAVEN's mission is to determine how Mars' atmosphere has changed over time, where the atmosphere has

Bruce Jakosky

gone, whether the planet's carbon dioxide and water were lost to space, and if so, how much disappeared that way. The mission also will determine how sunlight and solar winds control those processes of change and how they have evolved over time.

LASP became involved with MAVEN after winning a NASA design competition in 2006. Bruce Jakosky, principal investigator in charge of the MAVEN mission and a professor in LASP and the department of geological sciences at CU-Boulder, helped design the project, which has been in the works for nine years.

"We started our thinking on it in 2003, Jakosky said. "We were one of 20 teams that put in full mission proposals. They selected two for a study and to develop our ideas in more detail."

NASA gave the two finalists money and nine months to flesh out their proposals. CU-Boulder was selected for the flight in 2008.

"We had a year of getting our act together and that put us on a natural flow to launch in 2013," Jakosky said.

MAVEN will take 10 months to get to Mars. Once it reaches orbit around the planet, the project's primary science mission will begin. It is slated to take a year, but Jakosky hopes the instruments will last much longer than that, maybe even a decade.

The satellite also will have on board a device that will relay communications with the rovers that are now exploring Mars' surface.

Researchers at the university have designed and tested eight different scientific instruments that will go up with the MAVEN mission in November.

Final phases of environmental testing are going on now to make sure all instruments are operational and can withstand the rigors of launch and the mission. Once everything is ready to go, MAVEN will be attached to the spacecraft, which is being provided by Lockheed Martin.

In August, the university will ship the

Continued on next page

WHAT'S UP

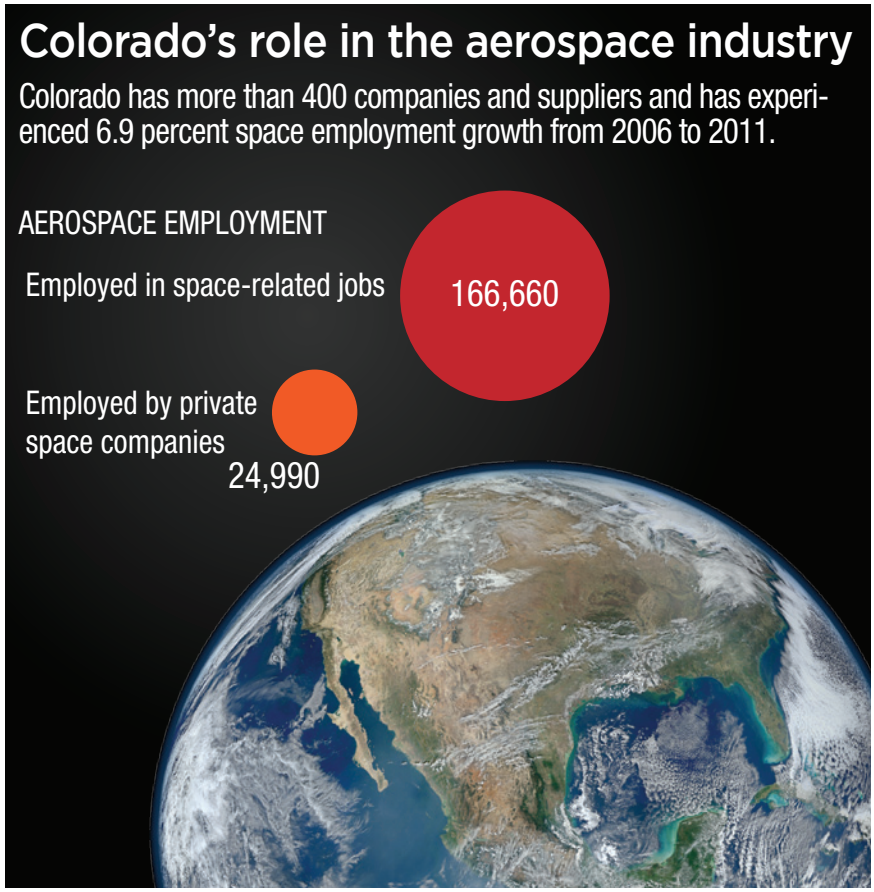
A sampling of projects around the state:

CSU prof leads international Big Bang experiment — Robert Wilson, a Colorado State University professor of physics, has been chosen to help lead an international collaboration of 340 scientists and engineers from 62 institutions in five countries. The group will focus on subatomic research to discover "universal" answers about the Big Bang and black holes.

Colorado Space Grant Consortium — Consisting of 12 Colorado colleges, universities and one foundation, COSGC is a NASA-selected program through which, since 1989, more than 2,000 students have been involved in a hands-on satellite development program. It has launched three sounding rockets, three Space Shuttle payloads, two orbiting satellites and more than 200 BalloonSats.

Colorado's role in the aerospace industry

Colorado has more than 400 companies and suppliers and has experienced 6.9 percent space employment growth from 2006 to 2011.



SOURCE: COLORADO SPACE COALITION

Opposite page: CU's Laboratory for Atmospheric and Space Physics (LASP) operates several NASA satellites.

YOUNG SPACE COMMANDERS

At LASP, students help run the show

BY PAULA AVEN GLADYCH

Many students dream of becoming astronauts, operating spacecraft, conducting research, discovering new frontiers. But students at the University of Colorado Boulder have a chance to live that dream while they're still in school. As part of the Laboratory for Atmospheric and Space Physics' mission control center, students help professionals guide four NASA spacecraft.

The most famous mission LASP controls is Keppler, a NASA mission that looks for planets going around other stars. To date, Keppler has found 2,740 potential planets orbiting 2,036 stars, many of those Earth-size planets. Twenty professionals and 20 students support operations at mission control.

Working at the control center is a real job for real pay, said Bill Possel, director of mission operations and data systems at LASP. The organization selects between five and ten students a year to spend 10 weeks of their summer learning everything from orbital mechanics to the specifics of each mission the lab manages. Written and practical exams ensure that only the best students end up working for mission control. Students must commit to working 20 hours a week and being on call whenever there is a problem with one of the satellites.

"Students get firsthand experience of what it is like to operate a very large and very expensive satellite."

— Bill Possel, director of mission operations and data systems at LASP

"Students get firsthand experience of what it is like to operate a very large and very expensive satellite," Possel said.

Mission control has been in operation since 1981 and has flown up to five spacecraft at one time.

The satellites have scientific instruments on board. It is mission control's job to change the settings on the instruments to get the most science they can out of each satellite. Mission control also maintains the satellites themselves, making sure they are positioned correctly and that all parts are functioning as they should.

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spacecraft and instruments to Cape Canaveral, Fla., to get ready for launch.

The Mars mission is an important one and is a testament to the successful, long-lasting partnership between CU-Boulder and NASA.

The University of Colorado Boulder founded LASP 60 years ago when the U.S. government captured German V2 rockets at the end of World War II and engaged universities around the country to put scientific instruments on them to send into space.

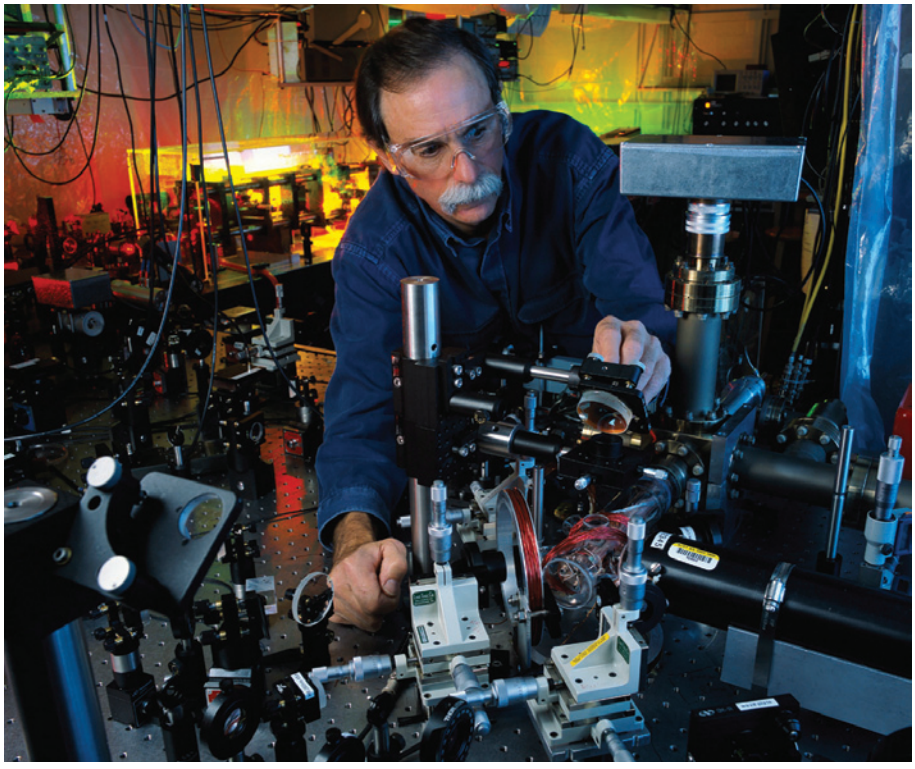
Since then, the program has evolved, with more than a dozen instruments currently operating in space. LASP is the only organization, other than NASA iself, that has sent instruments to every planet in the solar system. And even though Pluto is no longer technically considered a planet, LASP also has instruments en route to Pluto.

"It is exciting to see what goes on around here," said Jakosky. "The quality of the work; the sophistication of the instruments; the ability of the scientists. It is a wonderful group. I'm thrilled to be part of it."

GLENN J. ASAKAWA

Colin Stewart, CU-Boulder mechanical engineering graduate student, gets hands on experience with controlling missions at CU's Laboratory for Atmospheric and Space Physics.

CU-BOULDER'S **NOBEL LAUREATE** LIST GROWS



Prize to Wineland has CU-Boulder pushing close to the Ivy Leagues

BY DEBRA MELANI

Boulder's newest Nobel laureate, largely responsible for propelling the field of quantum physics forward to more unimaginable advancements, is more than brilliant — he is also an unassuming nice guy. Almost anyone who knows David Wineland would say so. Wineland recently expanded the University of Colorado Boulder's list of Nobel Prize winners to five.

Coaxing the soft-spoken, mild-mannered Wineland to accept praise for the honor he shared with French colleague and good friend Serge Haroche is about as easy as isolating and observing a particle without disrupting its quantum-mechanical nature. Of course, Wineland and Haroche did manage the latter feat — once deemed impossible — through what the Royal Swedish Academy of Sciences called "ingenious laboratory methods."

Wineland, 69, attributes the achievement to the work of many.

"I think the prize tends to focus on a couple of individuals, but I think it may distort a little bit how science is done," said Wineland, a CU-Boulder physics lecturer who leads graduate students in his lab at the National Institute of Standards and Technology. "The things I worked on, a lot of people worked on. I think it's more a recognition of the field," said Wineland, who joined NIST 37 years ago and just bumped its Nobel physics count to four.

Modesty aside, Wineland's discovery — the ability to trap electrically charged atoms, or ions, and control and measure them with light, or photons, without destroying

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CU-BOULDER AND NIST NOBEL LAUREATES

1989

CU-Boulder's Distinguished Professor Thomas Cech shared the chemistry prize for his discovery that RNA in living cells is not only a molecule of heredity, but also can function as a biocatalyst, initiating or increasing the rate of a chemical reaction.

1997

NIST's William Phillips shared the physics prize for developing methods to cool and trap atoms with laser lights.

2001

CU-Boulder's Distinguished Professor Carl Wieman and CU-Boulder and NIST's Eric Cornell won the physics prize for creating a new form of matter called Bose-Einstein condensate, which could lead to the creation of precise measuring devices and lasers that could dispense beams of atoms for micro-assembly purposes.

2005

CU-Boulder and NIST's John (Jan) Hall won the physics prize for his contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique.

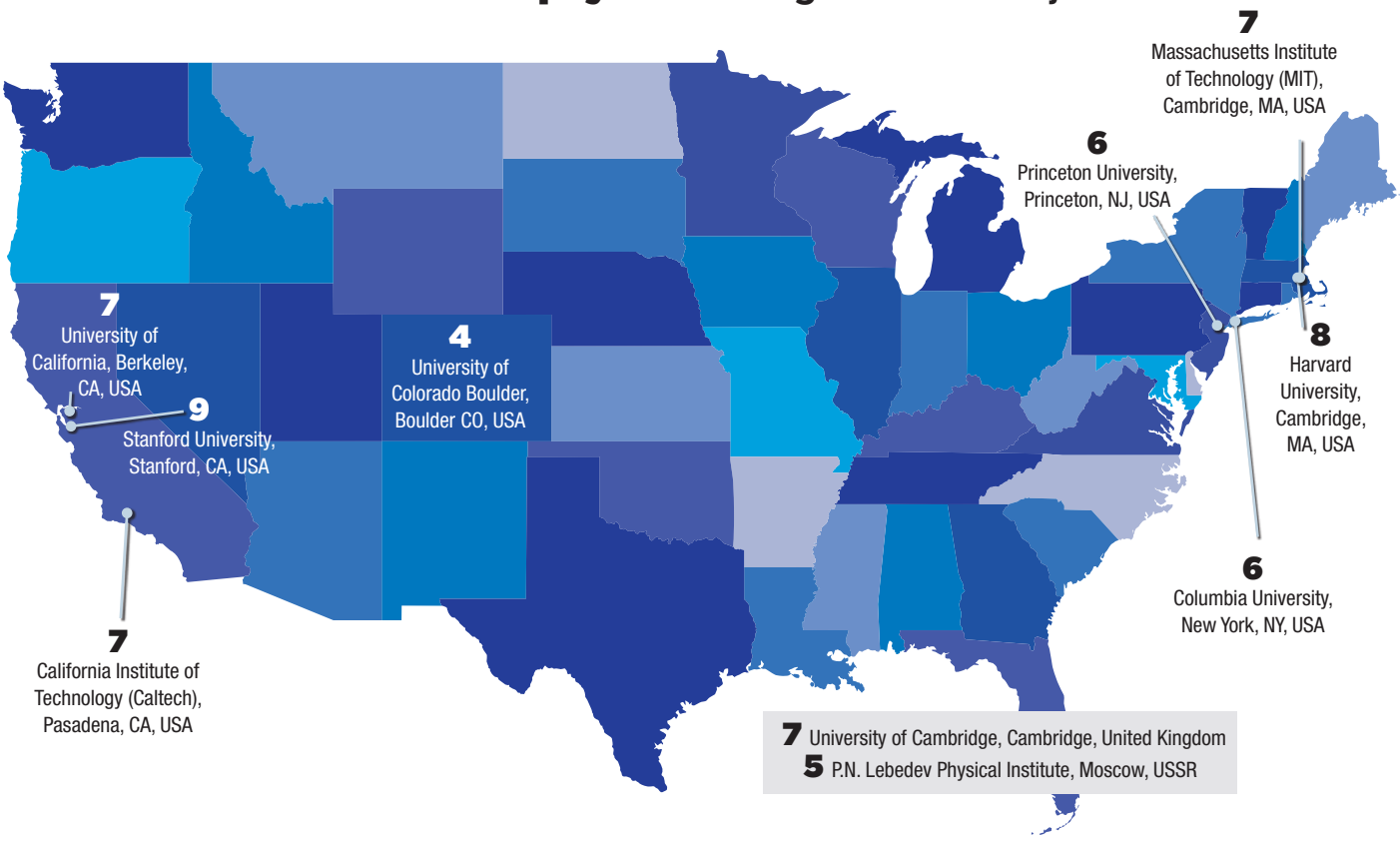
2012

CU-Boulder and NIST physicist David Wineland won the Nobel for his discovery of the ability to trap electrically charged atoms, or ions, and control and measure them with light, or photons, without destroying them. Wineland shared the prize with French researcher Serge Haroche.

** Several CU-Boulder research faculty members shared the 2007 Nobel Peace Prize with former Vice President Al Gore for their contributions to the international report of the Intergovernmental Panel on Climate Change.*

(CU and NIST)

How **CU-Boulder's Nobels for physics** rank against the "Majors"



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them — has opened the door to the field of quantum physics as never before, said Paul Beale, professor and chair of CU-Boulder's department of physics.

"We now have the potential in the future of producing computers that are thousands or millions of times faster than what we have now," Beale said.

Such a computer could "change our everyday lives in this century in the same radical way as the classical computer did in the last century," Wineland's Nobel citation stated.

In addition to quantum computers, Wineland focuses on the development of atomic clocks, an area where his pioneering efforts are leading to the next generation of the world's most-precise timekeepers.

"He's an exquisitely good scientist," Beale said. "He basically invented several fields in order to do his work. This is not the first Nobel Prize he could have won."

Wineland's work could help create atomic clocks that are thousands of times more stable and sensitive, which could lead to advancements in GPS technology, among other things.

Wineland's 2012 Nobel Prize in physics brings to four the number of laureates associated with CU-Boulder's physics department.

"There are only a few universities in the world that have as many or more, and they are the very best places in the world," said Beale, attributing the success to a strong commitment between NIST and CU-Boulder.

CU-Boulder's highly ranked graduate program attracts top students. One of them is Brad Blakestad, who worked with Wineland for seven years, graduating in 2010, and is now a physics consultant in Washington, D.C.

"He's a pretty laid-back guy and incredibly intelligent," Blakestad said of the lanky, horseshoe-mustached Wineland, who can sometimes be seen on the bike paths of Boulder to get, he says, "some exercise and away from physics for a while."

Blakestad recalled how Wineland, who is married with two sons and two grandchildren, gave graduate students freedom to explore but was always available to provide direction. "He doesn't attract a lot of attention to himself on purpose, but everyone is familiar with his work and respects him because of how good he is."

Many great minds inspired and helped Wineland on his Nobel Prize path, from childhood math teachers to college mentors to the group of scientists he works with today. In fact, asked about his greatest pride, Wineland singled out his current colleagues' collective success, a choice unlikely to come as a surprise to those who know him.

Wineland, born in Wauwatosa, Wis., grew up in Sacramento, Calif. He earned a bachelor of arts degree in physics from the University of California at Berkeley and master's and doctoral degrees in physics from Harvard University, where he worked with Nobel laureate Norman Foster Ramsey Jr. Wineland then performed postdoctoral research with Nobel laureate Hans Dehmelt at the University of Washington before joining NIST.

"Despite being extremely good and at the very top of the field, he's very humble," Beale said. "When he gave his Nobel lecture, he spent most of the time thanking all of the people he's worked with. He's just the nicest guy you can imagine."

Blakestad said Wineland's love of science is evident. Exploring the unexplored and doing the "detective work" are the best aspects of the job, Wineland said, and he does not plan to hang up his lab coat any time soon.

"Science never ends," he said. "You reach some plateaus, maybe, but the work never ends. We can always look forward to making better things."

A STEP BEYOND BIOFUELS

Biorefining the next big thing in clean fuel production

BY PAULA AVEN GLADYCH

As in the movie *Back to the Future*, biofuels are the stuff movie legends are made of, and the new age gasoline substitutes made from plants are getting plenty of limelight here in Colorado.

The University of Colorado Boulder, the Colorado School of Mines, Colorado State University and the National Renewable Energy Laboratory work together on what is called C2B2 or the Colorado Center for Biorefining and Biofuels. Scientists, researchers, students and professors are developing new technologies to convert entire plant species into fuels for cars and homes.

It hasn't yet gotten to the point where they can throw trash and banana peels into the back of a car and take off, but the reality is just as awe-inspiring.

C2B2's research budget varies from year to year, ranging from $1 million to $1.5 million annually. The center has two full-time staff members. The number of researchers funded by the center varies based on the number of open projects. All researchers are full-time employees of the three universities and NREL, according to Frannie Ray-Earle, managing director of C2B2.

The majority of C2B2's resources come from corporate sponsors such as Chevron Technology Ventures, General Motors and Kimberly-Clark.

"They see it as a real value. …They get more resources for their dollar than if they went to one institution at a time," said Ken Reardon, Colorado State University site director for C2B2 and associate department head for Chemical and Biological Engineering at the university.

CSU PHOTOGRAPHY, COMMUNICATIONS & CREATIVE SERVICES

Biofuels research on extraction processes is conducted at the National Renewable Energy Laboratory.

C2B2 is working on ways to convert algae into fuels. Algae are prime candidates because they grow quickly and don't require prime agricultural land to cultivate, said Reardon. "Algae sidesteps the issue of land. You can grow algae in a parking lot or a desert. It can grow on land you would never use for traditional agriculture."

Growing algae also can use up waste materials. Wastewater can provide nutrients for the algae and carbon dioxide could be piped into algae facilities for faster growth.

"As a country we use a lot of liquid fuels, so finding a renewable and clean resource for those is important," he said.

Most media attention has focused on biofuels because the subject seems sexier than biorefining, but biorefining will be the most important development for years to come, he said. That's because researchers will develop ways to take biomass and use it to make many of the same chemicals that come from fossil fuels.

Turning ears of corn into ethanol is "old school," Reardon said. "We want to take the whole plant and turn it into fuel so we get

Continued on next page

CLEANTECH INDUSTRY TRAINING NEW LEADERS

Fellows institute seeks execs who can bring clean technologies to market

BY PAULA AVEN GLADYCH

As the cleantech industry picks up steam in Colorado, the Colorado Cleantech Industry Association (CCIA) wants to make sure there are enough talented individuals able to bring these new technologies to market.

CCIA has teamed up with the Colorado School of Mines, Colorado State University and the University of Colorado Boulder to offer the Cleantech Fellows Institute, a training ground for seasoned executives from other industries who are interested in starting cleantech businesses but don't know where to begin.

Cleantech covers many different sectors, including renewables such as wind, solar, biofuels, geothermal and advanced transportation technologies.

The program helps entrepreneurs understand the opportunities and challenges of starting and growing companies in the cleantech industry. In 2012, CCIA received grant money to seed the effort. The organization hired a director and put together a 14-week curriculum to help executives understand the different sectors involved in cleantech and where the opportunities were, said Christine Shapard, executive director of CCIA.

The institute graduated its first five fellows in January 2013, and three of those five are starting companies based on what they learned, she said.

"They came in not having connections with the cleantech investment or technology community or thought leader community," Shapard said. "We built that ecosystem around them. A couple came in with their own ideas of what they were interested in and we gave them mentors and handholds in the industry that would accelerate their ability to grow a company."

The fellows also were introduced to researchers at Colorado's major research universities and federal research labs, such as the National Renewable Energy Laboratory (NREL).

The program has $100,000 in grant money for 2013 and 2014 and, according to Shapard, CCIA would like to take the program national or even international in the next five years.

"Right now it is a model program for the U.S. and something we would like to expand," she said. "We don't know what it will look like yet, but we have high hopes for it."

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more for the effort and resources we used to grow the plant. We want to turn it into fuels, but also adhesives, plastics and even synthetic fibers."

Colorado's cleantech industry is one of the most extensive in the world, in part because of the close collaboration among scientists and researchers at the state's three major research universities and NREL.

Until recently scientists had not spent much time investigating biofuels, in part because fossil fuels were so cheap and readily available. Only in the past five or six years have researchers stepped back into the discipline to take another look.

CSU's expertise lies in plant sciences and ecology, as well as its renowned Engines and Energy Conversion Laboratory. Sustainability is very important to the university. Colorado School of Mines is focused on the fundamentals of thermal processing and gasification, the production of diesel fuels from algae and bio-based plastics and chemicals.

The University of Colorado Boulder is a leader in the areas of biochemical processing, membrane separations, and environmental sciences.

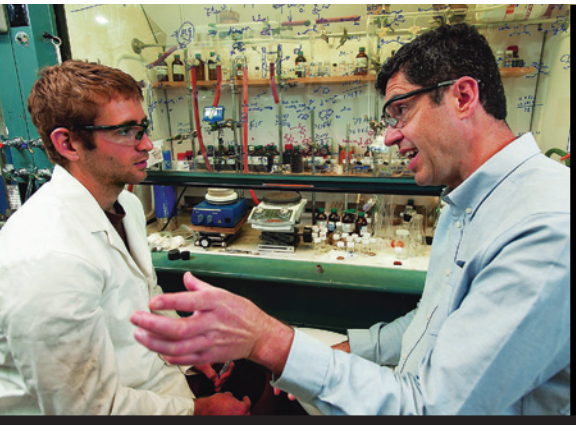
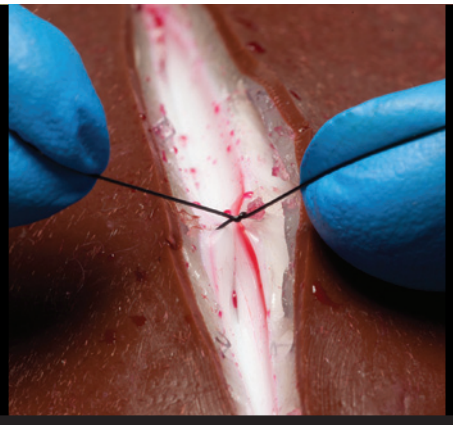
"We want to take the whole plant and turn it into fuel so we get more for the effort and resources we used to grow the plant. We want to turn it into fuels, but also adhesives, plastics and even synthetic fibers."

— Ken Reardon, Colorado State University site director for C2B2

CU-Boulder also is a leader in the area of solar-thermal chemical processing. The university received a three-year grant in 2008 to study the use of concentrated sunlight to heat biomass, such as grass, sorghum, corn stalks and leaves, wood waste and algae to more than 2,000 degrees Fahrenheit for just fractions of a second. The process produces an intermediate syngas, a mixture of carbon oxides and hydrogen, that can easily be converted into hydrogen or liquid fuels, according to Professor Alan Weimer of CU-Boulder's chemical and biological engineering department and executive director of C2B2.

The National Renewable Energy Laboratory conducts research on biomass characterization, biochemical and thermochemical conversion, chemical and catalyst science, integrated biorefinery processes, microalgal biofuels and biomass process and sustainability analyses. It also heads up the virtual National Bioenergy Center, which supports and coordinates the nation's biomass research activities.

"Part of the reason C2B2 is so great is that even if someone is the only one in their area at the university, they can partner with someone at another university that has complementary skills," said Reardon. "It facilitates the collaboration. It makes it very strong."


CSU a national leader
in cutting-edge research making a difference

BY BILL FARLAND
Vice President for Research

Colorado State University is proud to be one of the top research universities in the nation. According to the National Science Foundation, CSU ranks in the top 7 percent of all U.S. institutions in overall research and second in the nation among public universities without medical schools in terms of research funding on a per faculty basis.

Despite this stellar record of research support and accomplishments, with the economic downturn affecting federal funding, that status is at risk. Private partnerships are becoming increasingly important for expanding the research excellence at the state's only land-grant university, and for meeting the economic needs of the region, the state, and the world at large.

So how does a major research university solve critical problems and impact business in Colorado?

By providing a wealth of information, cutting-edge data and innovation to the public and private sectors - data and information that can be used to address today's issues as well as tomorrow's challenges. At CSU, administrators and faculty work closely with state leaders, economic development organizations and industry associations to leverage the vast assets of the university for economic development.

In addition to providing a skilled workforce, the university creates new technologies that are licensed in Colorado. These technologies often lead to new startup companies and job creation.

To that end, through CSU Ventures, the commercialization arm of the university, CSU expedites technology transfer and the commercialization of intellectual properties created by Colorado State researchers and provides useful information and skills to industry and local/state decision-

SEE NATIONAL LEADER > PAEG 66

BILL FARLAND
Vice President for Research

CSU collaborating with Coke **to create water-neutral bottling plant**

Imagine making a factory water-neutral when the primary ingredient used in making the product – soft drinks and other beverages – is water. Impossible? Not to the Coca-Cola Company, which hopes to make its Denver bottling plant water-neutral by 2020.

As part of the initiative, Coca-Cola has made this commitment: For every liter of product that goes out of the plant, the company will replenish that liter somewhere along the watershed where it derives its supplies, in this case the South Platte River. In addition Coca-Cola plans to re-works its operations to off-set some of its water use with water-saving plumbing devices and landscaping.

Colorado State University will play a significant role in helping Coca-Cola achieve its ambitious goal. Students from CSU's College of Business have been working with plant officials for the past several months, looking for better ways to utilize the state's limited water resources.

"We are proud to partner with CSU and its students to help solve the water challenges that we face in our business and our local community," said Matt Wilson, vice president of Market Unit Sales Operations in Denver said.

Wilson is based at the Coca-Cola Refreshments York Street facility in Denver, where the company produces and bottles Coca-Cola, Dasani Water and other beverages. Coca-Cola Chairman and CEO Muhtar Kent announced in 2011 that he wanted the Denver facility to be the first in the company to attempt water neutrality.

"Coca-Cola Refreshments has recognized this as a stretch goal, and they are doing an incredible job of getting closer and closer to reality," said Jim Francis, a professor in CSU's College of Business and Director of the Business Beverage Institute. "They are very serious about this project and their corporate social responsibility."

CSU and Coca-Cola have been working together on numerous water initiatives since signing a strategic partnership in 2011. In addition to serving as CSU's official beverage provider, Coca-Cola has provided scholarship money and internship opportunities for students. Coca-Cola also has helped fund the Business Beverage Institute, which opened in 2012.

CAM the Ram and Coca-Cola's signature polar bear mascot met for the first time in 2011 when CSU signed a strategic partnership. CSU and Coca-Cola are working together on numerous projects, including a plan to make the Denver bottling plant water-neutral by 2020.

In return, CSU is providing access to its more than 100 years of experience in water research. CSU has long been a world leader in water storage and conservation, spearheading projects throughout the United States, China and Africa.

CSU students evaluated every example of water use at the Denver facility, with recommendations to upgrade restroom and kitchen fixtures , several production systems, and to implement Xeriscaping on the facility's grounds.

Francis said the partnership has both immediate and far-reaching benefits for CSU and Coca-Cola.

"Coca-Cola is one of the largest corporations in the world, and we have direct access to their expertise and to what they are doing," he said. "They have been a very active partner for us, particularly on water issues and sustainability. They have promoted the whole green initiative in a much more active way than the public is aware. For Coca-Cola, sustainability is one of their most important internal goals."

While CSU is helping Coca-Cola reach its water-neutrality goals, Coca-Cola is providing CSU students opportunities to work and learn in a corporate setting. CSU has 18 students enrolled in the not-for-credit Beverage Business Institute curriculum, focused upon business operations in the beverage-related industries and all are getting hands-on experience through the relationship with Coca-Cola.

CSU and Coca-Cola have been working together on numerous water initiatives since signing a strategic partnership in 2011.

Professor **greening up builder**

When Campus Crest, a student housing company headquartered in North Carolina, initiated development of The Grove at Fort Collins, the idea of sustainable building wasn't a consideration. But during a Fort Collins community meeting on the proposed development, the company's founders, Ted Rollins and Mike Hartnett, were encouraged to contact Colorado State University's Institute for the Built Environment (IBE).

IBE is committed to fostering sustainable building construction and operations through education and research. A conversation between the founders and IBE began a partnership that continues to impact the sustainability of Campus Crest's student housing projects nationwide.

The Institute for the Built Environment is in the College of Applied Human Sciences

Initially IBE was cautious about working with Campus Crest because the project was hotly debated in the community. But, when Brian Dunbar, IBE executive director, asked Campus Crest to meet four conditions, Campus Crest agreed to all of them – and then some.

The conditions were to seek LEED certification on the Ft. Collins project, engage IBE early in the development of at least one new project, provide sustainability education to its employees and to make its prototype building sustainable.

"I'm proud that, due to our research and directives, the Fort Collins Grove project went from one that the city council turned back before our involvement, to a project that they approved. Many community members thanked us for our involvement," Dunbar said. "Working with Campus Crest on their green initiatives has given CSU students excellent opportunities for hands-on learning."

Today, all of the buildings at The Grove at Fort Collins are being built to meet standards for LEED certification, which means the buildings are built for energy efficiency, resource conservation and indoor environmental quality. The Grove at Fort Collins is the first green development in Campus Crest's 39-site portfolio.

But the impact of the IBE's involvement doesn't stop at The Grove. IBE staff Josie Plaut and Tara Steckly are members of Campus Crest's NEXT Team, which oversees the company's sustainability initiatives.

Brian Dunbar, a Construction Management professor and director of CSU's Institute for the Built Environment, who helped change the way Campus Crest does business.

In addition to meeting IBE's four conditions, Campus Crest has developed programs for the students on green living. The programs encourage sustainability through activities and competitions and provide green living tips.

"They are genuinely on the path toward corporate sustainability," Dunbar said. "This synergistic relationship has resulted in great learning and research opportunities for both our institute and for Campus Crest, and is positively impacting their student residents across the country."

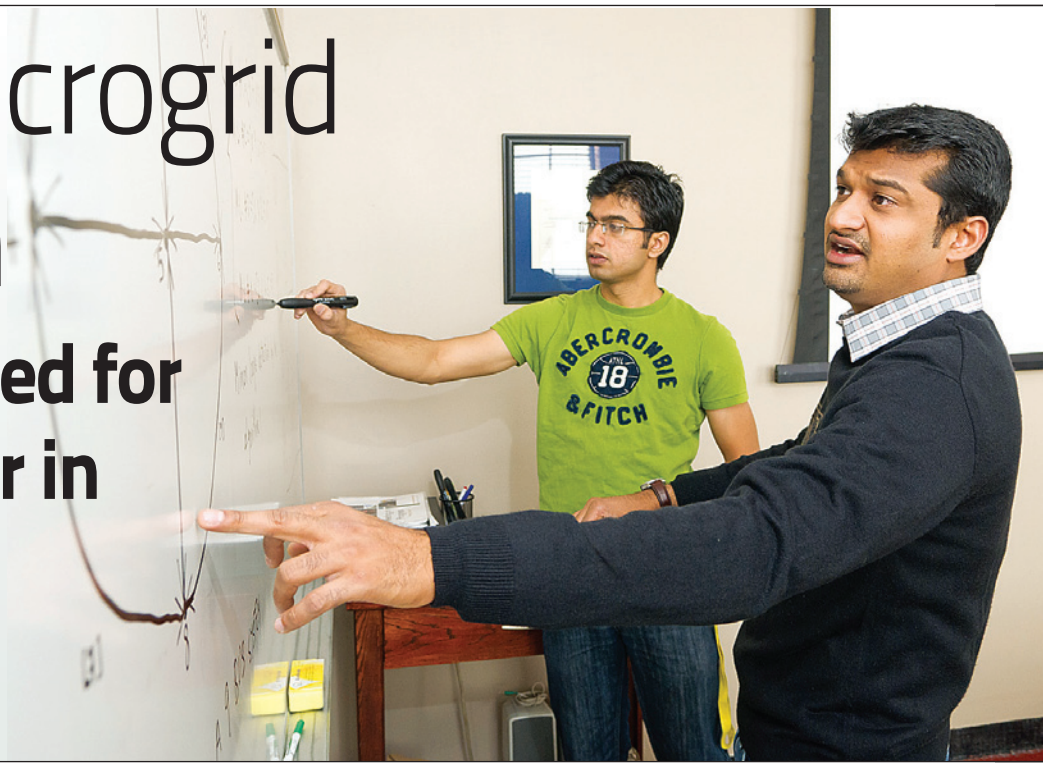
"We helped Campus Crest redesign their prototype building, so all projects starting construction in 2013 will be built to align with Energy Star and LEED standards," Plaut said. "In addition, they are looking at ways to improve their existing portfolio of buildings through greener operations, maintenance and retrofits. "

In January 2012, Campus Crest recognized the IBE's role in transforming the company with the Catalyst Award, which is given to an outside organization that has had a profound impact on the company.

Campus Crest also has been recognized. Last year it was awarded the 2012 Emerald Asset Management "Green Company Executive Award," which recognizes corporate leaders committed to innovation and sustainability. The IBE is now assisting with Campus Crest developments near the University of Pennsylvania, Carnegie Mellon University and Oregon State University.

The Institute for the Built Environment is in the College of Applied Human Sciences

CSU's microgrid research addresses need for reliable power in emergencies



Sid Suryanarayanan, an assistant professor of electrical engineering at Colorado State University, works with a student. Suryanarayanan is an expert in microgrid development, a technology is designed to help stabilize power grids during disasters.

When Superstorm Sandy hit the U.S. East Coast in October, Sid Suryanarayanan, an assistant professor of electrical engineering at Colorado State University, knew how to solve some of the problems it caused: Use microgrids.

SID SURYANARAYANAN
Assistant Professor, Electrical Engineering

Suryanarayanan and his colleague at the University of Cyprus had recently published a paper in the journal IEEE SmartGrid about microgrids and how they can make power systems less vulnerable to expensive disruptions.

A microgrid is "a fully functional and self-contained subset of the electric power grid, with access to local generation sources, power delivery assets such as cables and protection switchgear, and end user loads," Suryanarayanan said. "The unique nature of the microgrid paradigm is that it can function in connection with the rest of the grid, or can isolate/island itself when the need may arise. The need may be due to economics – highly inflated price of electricity in the deregulated spot market - or reliability – when the rest of the grid is going dark due to a cascading blackout."

CSU has been exploring how to improve the electrical grid for nearly a decade. Since 2005, Denmark - the world's most advanced wind-powered nation – CSU's Engines and Energy Conversion Laboratory and a company called Spirae in Fort Collins have collaborated to address the challenge of transforming intermittent renewable energy such as wind power into a stable and reliable resource.

CSU and Spirae jointly developed the InteGrid Laboratory, one of the largest facilities of its type in the world, to provide innovative solutions for renewable and distributed power integration. These "smart grid" systems are critical for consistent grid management with the ever increasing use of renewable energy in the world.

Suryanarayanan's expertise is in creating highly reliable microgrid units that can be isolated and used to provide local power to people during disasters such as Superstorm Sandy. He takes a comprehensive view of power grids that includes design, operation, and economics and works on integrating renewable energy technologies in the grid, and providing new control options to the end user.

"When it comes to losing a critical infrastructure like the power grid to a disaster, we must bear in mind that its absence will only prolong the path to a full recovery," Suryanarayanan said.

The existing electric grid, he said, "is one of the 'smartest' engineering systems in existence. What has been lacking in the grid is the end-user side distribution systems, where electricity is delivered at lower and usable voltages," Suryanarayanan said.

"Now, electricity demand is projected to increase steadily in the next three decades, with little to no increase in the aging delivery system to bring the electricity to the end user," Suryanarayanan said.

"So, employing local resources with smaller electrical ratings in a coordinated manner, i.e., the microgrid, seems viable as the next step for increasing the smartness of the electric grid. The tremendous advances we have made in the areas of computers, communication, information exchange, and controls will enable this transformation," he said.

Simulated skin developed at CSU

making waves across national surgical circles

The skin is made out of silicone but it looks, feels and behaves just like the real thing – it even bleeds.

Developed at Colorado State University, simulated skin is a new technological innovation that is being used by schools across the country to teach surgical techniques.

"It is a significant, stressful leap for medical and veterinary students to go from the classroom to the surgery suite," said Dr. Dean Hendrickson, a veterinarian, and associate dean for Professional Veterinary Medicine at CSU and one of the inventors. "Industry standards for training sometimes actually encourage incorrect techniques, or skills that don't translate into real-world situations. These artificial simulations help students master their technique, dexterity and confidence before they operate for the first time on a person or someone's pet."

The university has partnered with the startup company SurgiReal, which was created by CSU veterinarians with the help of CSU Ventures and an angel investor.

Sales of three sizes of artificial skin products started in November. Two of the products can be ordered with or without vessels to mimic bleeding. SurgiReal also offers a model that allows teaching of intravenous injections and blood draws that it will build on request. The company, which is based in Fort Collins, employs a chief operating officer and a chief research-and-development officer.

DR. DEAN HENDRICKSON
Associate Dean for Professional Veterinary Medicine

Next up they'll build a prototype abdominal cavity complete with organs such as the kidney, bladder, spleen, pancreas, stomach and liver.

In the last 50 years, modern medicine has made astounding advances in surgery, yet many of today's veterinary and human medical students still hone basic surgical and suturing skills on carpet pads and pig's feet before transitioning to a live patient. Hendrickson's breakthrough provides students with artificial body parts that look, feel and bleed just like real skin, muscles and vessels.

The artificial replicas of sections of human and animal bodies - such as an abdominal wall - give students a realistic learning environment that bridge the gap between classroom lectures and procedures such as surgical cuts and sutures on real human or animal patients.

The artificial tissues consist of layers of silicone that closely simulate skin, connective tissue and muscle. Built into the silicone are realistically placed and sized "blood vessels" that are connected to an artificial blood source that supplies the tissue with realistic bleeding.

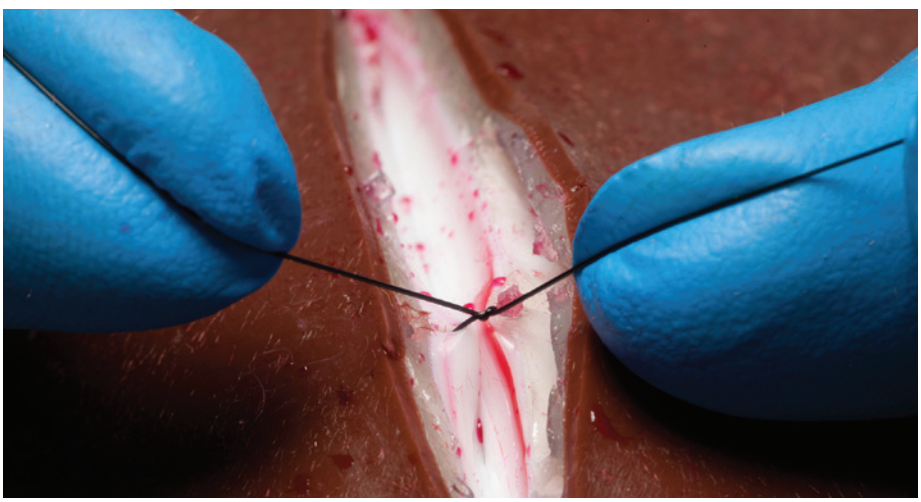
Some models are colored realistically, such as a brown-skinned abdominal wall of a horse, with white layers and red layers representing muscles and tissues. However, students also may use simulated tissue in translucent material so they can better view and understand, for example, suture patterns from a three-dimensional perspective while learning correct stitches.

"Our hope is that, with this model, we can begin to help students build better skills that will make for better outcomes," said Dr. Fausto Bellezzo, a co-creator of the technology with Hendrickson. Bellezzo is also a veterinarian and researcher at CSU's Veterinary Teaching Hospital.

CSU Ventures is a subsidiary corporation of the Colorado State University Research Foundation, a private, non-profit foundation that helps the university move technologies from the lab into the market place.

Colorado State University's Animal Teaching Hospital is part of the College of Veterinary Medicine and Biomedical Sciences.

A video illustrating the model is available on CSU's YouTube channel at http://www.youtube.com/watch?v=ILV-tI1hdA8 and at the SurgiReal web site: www.SurgiReal.com.



An image of the simulated skin created by CSU veterinarians for students – either in veterinary or human medicine – to practice surgical techniques.

CSU leads the field in natural gas research

Natural gas increasingly is seen as the fuel that will help the U.S. transition from oil to alternative energy solutions.

Colorado State University has spent decades conducting cutting-edge natural gas research – from reducing emissions at the wellhead to training next-generation geologists.

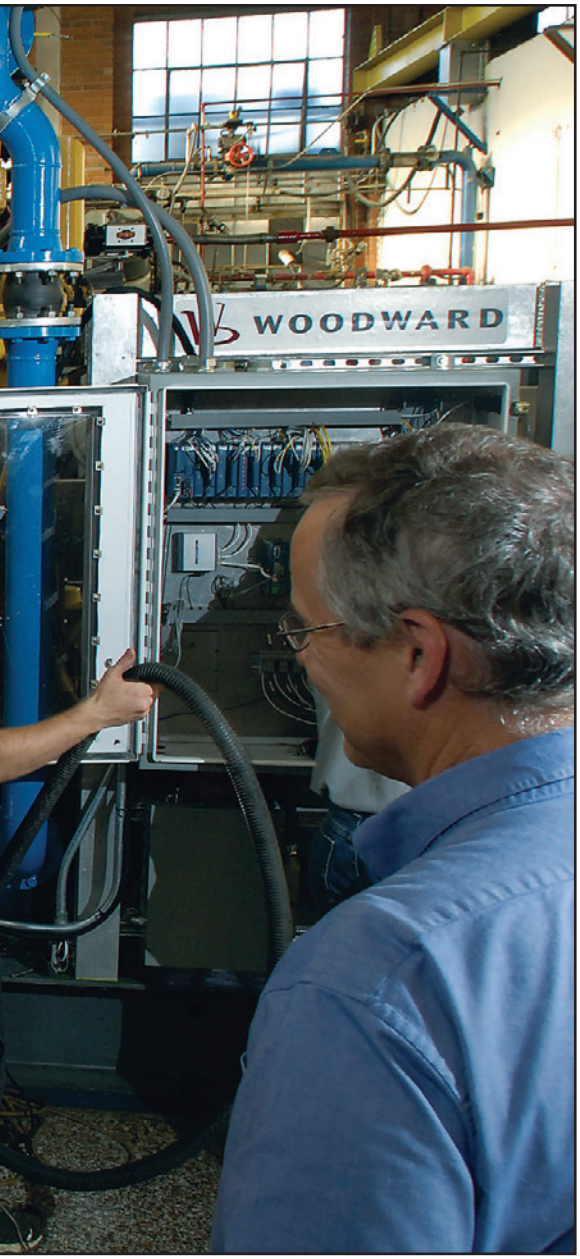
CSU's work with natural gas begins with the earliest elements of the exploration process – from training geologists and controlling emissions to land reclamation.

The Department of Geosciences in the Warner College of Natural Resources has a long history of working with partners in the petroleum industry. The college is named for Colorado State alumnus Ed Warner, who discovered the Jonah natural gas field in eastern Wyoming.

Among the ongoing research projects in the college:

- **Geosciences exploration:** The Department of Geosciences works on fundamental geology of oil- and gas-bearing strata, including significant work with shale deposits that are at the center of today's expanding horizon for natural gas.

- **Land reclamation:** Scientists in the Restoration Ecology Lab study the ecology of plant communities and use this knowledge to aid in the reclamation of land disturbances associated with energy development. Shell Oil Co. has endowed a $2 million chair in the Warner College



Undergraduate students get valuable experience in CSU's Engines and Energy Conversion Laboratory working with natural gas engines and other projects sponsored by corporate donors.

Colorado State University has spent decades conducting cutting-edge natural gas research – from reducing emissions at the wellhead to training next-generation geologists.

to fund Mark Paschke, a professor doing research identifying and reducing ecological impacts associated with energy development in the Rocky Mountain region.

• **Production and Transmission:** In the College of Engineering, the Engines and Energy Conversion Laboratory – the only independent large industrial engine test laboratory in the nation - has been a crucial research organization for the Compressor and Pump Station Technical Committee of the Pipeline Research Council International. Led by laboratory founder and Professor Bryan Willson, CSU has done more than any group in the world to address impacts of natural gas production, helping industry partners reduce environmental effects of natural gas compression as well as improve efficiency.

• **Oil and Gas Separation and NOx reduction**: Colorado State researchers work with companies, such as Encana and Anadarko, to test new technologies for these companies before they decide to commit the required investment to implement them in the field. Recently, CSU engineers have performed field evaluation of new spark plugs for a spark-plug manufacturer, assessed new NOx reduction technology, measured efficiencies of new catalyst formulations, and evaluated advanced air/fuel ratio controllers.

• **Projects with industrial engine manufacturers**: Caterpillar, Cummins, Waukesha, Dresser-Rand Guascor are large industrial engine manufacturers that have worked with the Engines and Energy Conversion Laboratory to reduce emissions, increase efficiency, and improve operability of their products.

Sally Sutton, chair of the Geosciences department and associate professor at CSU teaches 'Natural Gas 101."

Serving the state, by the numbers

$330 million – Amount of annual research funding CSU faculty attract

21 – Startup companies CSU has created in the past five years, creating hundreds of private sector jobs

710 – CSU patent applications over the past five years

182 – Technologies CSU has licensed to private enterprise since 2007

2 - Two CSU spinoffs, VetDC and KromaTiD were selected as finalists in the prestigious Biowest Venture Showcase. VetDC won the competition.

650 - More than 650 CSU researchers disclosed inventions between 2007 and 2011 – about twice the faculty from the previous five-year period.

$7.6 million – Amount CSU Ventures startups contributed to CSU's research expenditures between 2007 and 2011 – a 450% increase from the previous five years total.

CSU impact on Colorado economy

13,140 – Jobs CSU supports through direct employment and related spending

$403 million – Yearly household income generated in Colorado by CSU's direct and indirect employment impacts

$61 million – State and local sales taxes generated by people whose livings depend on CSU

80 percent – Portion of CSU students who are Colorado residents

99,000-plus – CSU alumni who live and work in Colorado

$5.2 billion – Household income created annually in Colorado by CSU alumni, equivalent to 3.7 percent of the state's household income.

$365 million – Personal income taxes and state sales taxes generated by CSU alumni in Colorado

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makers for optimal business and economic development strategies.

CSU Ventures startups contributed more than $7.5 million to CSU's research expenditures between 2007 and 2011 – a 450 percent increase from the previous five years' total.

Just a few recent emerging technologies at CSU:

• **Chemistry Professor Eugene Chen** and his researchers have developed several patent-pending chemical processes that could create second generation biofuels, specialty chemicals, and sustainable bioplastics from non-edible biomass for use in everything from optical fibers and contact lenses to furniture and automobile parts.

• **John Volckens** and his research team in the Department of Environmental and Radiological Health Sciences, in collaboration with a commercial engineering company, have developed a personal aerosol sampler that captures nanoparticles for use in a new measurement device. The establishment of exposure guidelines based on measurements by this device could contribute greatly to the safety of manufacturers and consumers of products containing engineered nanoparticles.

• **Elizabeth Ryan,** also in the Department of Environmental and Radiological Health Sciences, and her colleagues at Texas A&M are developing novel dog food formulations, utilizing dry bean powder as a major protein source. Early clinical studies have shown that canine diets using beans as the primary protein source resulted in greater regulation of metabolic status during weight loss compared to control diet fed dogs.

While the recent economic downturn has presented challenges, CSU has continued to make progress in understanding the needs of the private sector and in introducing novel mechanisms to help address those needs. CSU continues promoting the quality of life and economic development prospects throughout Colorado, the state and world through its expertise and innovation.

How to sum up research at Colorado State? Local discovery,

How to sum up research at Colorado State?

Local discovery, global impact.

ENERGY RESEARCH "COLLABORATORY" EXPANDS

Study of fracking, carbon management added to mission

BY PAULA AVEN GLADYCH

The Colorado Renewable Energy Collaboratory, a groundbreaking partnership between Colorado's research universities and the National Renewable Energy Laboratory, has changed its name to Colorado Energy Research Collaboratory (CERC) to reflect two new research missions — carbon management and fracking technology.

The partnership's original mission when launched more than five years ago was to explore and develop renewable energy technologies that would harness the power of wind, sun and biofuels.

Stein Sture, the University of Colorado Boulder's vice chancellor for research, said that both carbon management and fracking are important for the development of cleaner energy technologies, even though neither fits into the renewable research arena. Fracking, for instance, has allowed the United States to tap into a supply of natural gas it did not have the technology to reach economically in the past.

"Natural gas is probably among the cleanest of the traditional fossil fuels," Sture said. "It's a big issue to Colorado, so the Colorado Renewable Energy Collaboratory has been discussing this for a couple of years."

And while shale gas, derived from oil shale, is a fossil fuel, it is "relatively clean in many ways," he said. "It does not have as many bad byproducts as traditional petroleum resources, and given the industry drive in Colorado across the political spectrum, we recognized that looking into and taking seriously this shale gas was something we should do."

He added that shale gas will not last forever. Some people predict that formations could last 20 to 50 years, "but right now, in a transition to a full-fledged renewables arena, shale gas might save us in pollution and costs. Shale gases are better than coal."

The University of Colorado Boulder received a $12 million National Science Foundation grant in October 2012 to study fracking; much of the research is aimed at finding ways to dramatically reduce the groundwater and air pollution associated with the process.

The Collaboratory also has embraced the science, economics and business aspects of carbon management.

Global climate change has made it imperative that countries find ways to reduce their carbon footprints and learn to sequester and harvest carbon dioxide from the atmosphere. The CERC will look at ways to sequester CO_2 emissions, either in deep geology, agriculture or other techniques, Sture said. Many manufacturing processes require CO_2, so the center will look for ways to take any CO_2 produced in the extraction of fossil fuels to use in the manufacture of other products.

"We are still primarily dependent on fossil fuels; as much as we want to move our energy system toward renewable energy, that's a process likely to take decades," said David Hiller, executive director of the Collaboratory. "In the meantime, we will do what we can do to make existing sources of energy and energy technologies cleaner, especially cleaner in reducing carbon emissions."

Maintaining a Colorado partnership to study clean energy technologies makes perfect sense, since the state produces coal, oil, natural gas, sun and wind, he said. And while the state doesn't have sufficient cropland to be a big biofuels producer, it does have energy experts who can help develop the fledgling industry.

Each of the Collaboratory's centers works closely with industry partners to make sure that any key developments have an opportunity to be tested in the marketplace and eventually adopted.

"We're excited to have the Carbon Management Center rolling out," Hiller said. "We are in the midst of speaking with several dozen companies in the U.S. and around the world who have an interest in these issues. That includes oil and gas companies, coal companies, and technology companies working on solutions to the technological challenges in reducing carbon emissions."

STUDYING ATMOSPHERE'S SECRETS

Federal labs, university centers make Colorado a major international hub for climate and air pollution research

BY PAULA MOORE

From leading the investigation of global warming to determining the facts of fracking's impact on the environment, Colorado universities and federal labs rank among the world's top atmospheric researchers.

The National Research Council rates the department of atmospheric science at Colorado State University in Fort Collins as one of the best such departments in the country. The Boulder area is one of the world's centers for atmospheric chemistry and air-quality research through the University of Colorado Boulder, as well as labs such as the National Center for Atmospheric Research (NCAR) and National Oceanic and Atmospheric Administration (NOAA). NCAR is a global leader in using supercomputers to study fields such as climate science and the environment.

Atmospheric research has to do with the Earth's air, and the emissions, particles and weather that can affect it.

"It's about the air we breathe, air quality," said Jessica Gilman, research chemist with the Cooperative Institute for Research in Environmental Sciences in Boulder (CIRES). "We all live downwind of something, and we need to know where it's coming from and where it's going."

CIRES is a joint venture between CU-Boulder and NOAA that looks for better ways to understand how natural and man-made disturbances impact the planet.

A big reason that Colorado attracts atmospheric research is its own dramatic climate, caused by a complex topography of mountains, valleys and plains, experts say.

A researcher at the South Pole releases a balloon bearing instruments that measure ozone and more. NOAA tracks the ozone hole that still forms every year high in the atmosphere above the South Pole, and less severe ozone depletion that occurs elsewhere around the globe.

PHOTO COURTESY NOAA

PHOTO COURTESY CIRES

Natural gas well.

Major research at CU-Boulder and CSU includes work related to the controversial oil and gas industry practice called hydraulic fracturing, or fracking, and its effect on ecosystems and communities near drilling sites. Fracking involves pumping pressurized water, chemicals and sand into well bores to crack rock and release petroleum and natural gas for extraction. The technology has been blamed for problems from water contamination to earthquakes.

In late 2012, CU-Boulder won a $12 million, five-year grant from the National Science Foundation to create the Sustainability Research Network for fracking research, including separating fact from fiction related to the practice.

"Judgments are being made about fracking without all the research being in," said Joseph Ryan, director of the Sustainability Research Network and CU-Boulder's Environmental Engineering Program.

"The big goal of our project is to put together a framework, a tool kit of methods, that all the different stakeholders can use to assess the environmental, economic and social tradeoffs of developing oil and gas resources."

The Sustainability Research Network — which involves nine research institutions, including CSU, NOAA and Colorado School of Mines — is gathering data for analysis, which then will be used to make recommendations about policies, regulations and better practices for the oil and gas industry.

"We're trying to come up with a list of what we know, what we don't know and what we hope to learn," Ryan said.

CIRES' Jessica Gilman recently finished a study that shows oil and gas wells may contribute to lung-damaging ozone pollution through producing volatile organic compounds such as propane. At its Weld County test site, Gilman's team found that oil and gas operations are the major wintertime source of VOCs, which are the "starting ingredients" for ozone pollution.

CSU's top-flight atmospheric department, headed by Jeffrey Collett, is known for its work in areas such as radiation, atmospheric chemistry and cloud microphysics, but it is also getting involved in oil and gas research. CSU is home to the Center for Multiscale Modeling of Atmospheric Processes, one of only 17 National Science Foundation science and technology centers nationwide, and is developing a revolutionary approach to understanding the role of clouds in climate change.

Jessica Gilman

"The big goal of our project is to put together a framework, a tool kit of methods, that all the different stakeholders can use to assess the environmental, economic and social tradeoffs of developing oil and gas resources."

— Joseph Ryan, director of the Sustainability Research Network and CU-Boulder's Environmental Engineering Program

University of Colorado Boulder researcher Beverly Kingston is director of CU-Boulder's Center for the Study and Prevention of Violence.

JONATHAN CASTNER

SOCIAL RESEARCH TAKES ON SOCIETAL ILLS

Colorado scientists lead nation on preventing school violence, using genetics to redefine 'hows' and 'whys' of substance abuse

BY BRITTANY RAUCH

Across Colorado's academic research world, social scientists are helping to understand and find solutions to some of the most troubling issues of our times, among them violence in schools and substance abuse.

Researchers at the University of Colorado Boulder have been at the forefront in studying youth violence and how to prevent it. As a result, they have been able to craft school safety programs that have been used as models nationwide.

At Colorado State University, researchers have developed healthy building initiatives that may improve the health of those who use them every day and save energy at the same time.

And a groundbreaking, long-running study of twins at CU-Boulder, is providing important insight into substance abuse and learning disabilities.

Blueprints for Healthy Youth Development

Does violence prevention start in the womb? Could the tragic mass killings in Aurora or in Newtown, Conn., have been prevented by early use of programs to prevent violence, delinquency and drug abuse?

CU-Boulder researcher Beverly Kingston and others are working to find answers to those questions. Kingston is director of the Center for the Study and Prevention of Violence at CU.

The Center is currently involved in a collaborative effort called Steps to Success, aiming to reduce youth violence in the Montbello neighborhood of Denver. Steps to Success is funded by a five-year, $6.2 million agreement with the Academic Centers of Excellence in Youth Violence Prevention at the national Centers for Disease Control and Prevention.

The project includes community surveys and implementation of several programs; one is a nurse-family partnership where nurses are assigned to pregnant mothers in high-risk neighborhoods before their children are born, and another provides intensive family therapy for older students who are already having difficulty in the school and community.

"If you really did this with fidelity, we could reduce violence in this country by probably 30 percent," Kingston said.

The center at CU-Boulder provides resources for effective programs in bullying prevention, school climate surveys and additional initiatives on its website, http://www.colorado.edu/cspv.

Pro-Environmental Behavior

At Colorado State University, researcher Jeni Cross, a sociologist, is involved in a multiphase study of a new correctional facility in Fort Collins, assessing the impact of integrated design.

Along with her colleague Tara O'Connor Shelley, Cross will be working with the building's occupants, both offenders and employees, and with operators of the building to assess energy use as well as the building's impacts on occupants' well-being and job performance.

The research team hopes that the new LEED-certified building, owned and operated by Larimer County, will positively impact the overall health of the occupants. Known as the Alternative Sentencing Building, the facility houses work-release prisoners. LEED certification (Leadership in Energy and Environmental Design) provides a rating system to evaluate the environmental characteristics of buildings.

Cross said data from the previous building used to house these inmates showed the people sentenced to short-term time there, on work-release programs, had negative general health trends.

"Their sleep patterns are very disturbed, it is difficult for them to get to sleep, they get disturbed easily while they are there," she said. "It looks as if the old building was not very conducive to health."

Cross also has conducted a number of studies in schools.

In 2007 she compared the electricity use of two Fort Collins high schools, Rocky Mountain High School, built in 1973, and LEED-certified Fossil Ridge High School, built in 2004. Her goal was to understand how the 34-year-old school was able to outperform the LEED building and achieve a 50 percent reduction in electricity use.

The study revealed that charismatic teachers at Rocky Mountain were energizing students about conservation as a cultural value of the school.

"They were setting behavioral expectations in the school," Cross said. "There were a number of people, mainly the leaders, who were communicating with people on a regular basis and encouraging them to change their routines and behaviors."

Rocky Mountain generated $40,370 in total operations savings between 2006 and 2007. The results of this study encouraged another school, Poudre High School, a non-LEED school, to reduce its electricity consumption by 50 percent by adopting similar behavior and leadership strategies.

Colorado Twin Registry Studies at CU

CU-Boulder's Institute for Behavioral Genetics has developed one of the largest registries of twins in the United States, enabling study of substance abuse and other topics.

The Center for Antisocial Drug Dependence, funded by the National Institute on Drug Abuse, is focusing on genetic influences on antisocial drug dependence and on its treatment.

John K. Hewitt, director of the Institute for Behavioral Genetics, along with the Center for Antisocial Drug Dependence, has been using the twins to help research genetic influences on vulnerability and subsequent drug use, primarily in adolescence.

Since 1997, the center has been following a group of individuals who were recruited as adolescents from the Longitudinal Twin Study and Community Twin Study.

Hewitt said some genetic research indicates there is a general vulnerability to "behavioral disinhibition." This hallmark is defined as a combination of poor control with impulsive behavior, a response to immediate reward, and a tendency to be less concerned about adverse consequences.

This tendency seems to predispose teenagers to a wide range of risky behaviors, Hewitt said. Previous research indicated that certain genes predisposed some people to addictions to certain drugs, such as alcohol. Newer research indicates a specific gene is not at fault, but blames a broader genetic predisposition to behaviors that cause poor impulse control, among other things.

"It's not an earth-shattering conclusion, but it is a different way of approaching the role of genetic risks in substance abuse," Hewitt said. "So we see it now as a more general vulnerability to poor behavioral control, which includes among its manifestations the use of not one but many different substances."

The center is in its third wave and last year of data collection for the twins — young adolescents, older adolescents and young adults. Hewitt is hoping to have data analysis results within the next two years.

The twin registry has been collecting data on twins since 1967 and at last count 17,136 individuals were registered in its database. Approximately 9,000 of them had participated in one or more research study. The center recruits identical and fraternal twins — the difference between the similarity of the two reveals how much genes are influencing behavior.

Additional research and resources surrounding the Colorado Twin Registry and the Institute for Behavioral Genetics can be found at http://www.colorado.edu/ibg.

LEARNING FROM MASTERS

Student researchers join scientists in labs, achieve award-winning results

BY BRITTANY RAUCH

Prior work with stroke victims led University of Colorado medical student Marissa Hudak to seek a spot on a multidisciplinary team at the University of Colorado Hospital, looking at how to reduce stroke treatment time.

Hudak is one of thousands of students who learn world-class research techniques on the frontlines of Colorado's academic research world — in the lab.

At Colorado State University, for instance, the Center for Undergraduate Research offers more than 20 programs directed at undergraduate research.

The number of undergraduate researchers in formal programs at CSU has grown from fewer than 1,300 in 2008-2009 to more than 4,250 in 2011-12. Last fall the university had about 818 graduate research assistants and graduate fellows working in its labs in paid positions.

Similar scenarios play out at Colorado's other research universities.

"The great thing about students is they're enthusiastic," said Eric Cornell, a Nobel-Prize-winning researcher at JILA, NIST, and the department of physics at CU-Boulder. "They don't know what's impossible yet, which means they are willing to try anything.

"Time and again it is the students who come up with the really good ideas that make it work and I'm just sort of around to make sure it all fits together."

JILA, a joint institute of CU-Boulder and the National Institute of Standards and Technology, has approximately 150 students working in the lab on a regular basis.

Students' participation in research has a huge impact on the classroom, schools and the public.

JONATHAN CASTNER

Marissa Hudak is one of thousands of students who learn world-class research techniques on the frontlines of Colorado's academic research world — in the lab.

Hudak began medical school at the University of Colorado School of Medicine, on the CU Anschutz Medical Campus, in 2010.

Dr. Ethan Cumbler, an associate professor, had already begun work on reducing stroke treatment time at UCH and found Hudak a perfect fit for the multidisciplinary team that aimed to improve the time it took to administer a clot buster medication, tissue plasminogen activator. The stroke work was part of a Quality Improvement project at the University of Colorado Hospital, on the CU Anschutz Medical Campus.

"When I came out here I knew I wanted to get more patients this medicine, and I didn't really know how I could do that as a student, but that was my mission coming into school," Hudak said.

The sooner tPA is administered to the patient, the fewer disabling effects from the stroke. The team sought to reduce the time it took to administer the medication to under an hour; the hospital's average at the time was about 77 minutes, Hudak said. The American Stroke Association recognizes hospitals that have a low treatment time as part of a Target Stroke Honor Roll.

Hudak interviewed other hospitals that were on the honor roll to identify their processes and compare the results to UCH's current practices.

"Our goal was to create a standard protocol that would happen every time and everyone would recognize this protocol," she said.

Hudak's real-world research allowed her to respond immediately to feedback from hospital personnel and to implement new strategies that accommodated the staff's concerns. Once the team gained participation from every person involved in caring for the stroke patient, the response time for administering the medication improved from 77 minutes to approximately 43 minutes.

Hudak has gone on to present the team's findings nationally, including at the International Stroke Conference. The University of Colorado In-Hospital Stroke Quality Improvement Team also received an Award for Excellence in teamwork from the Society of Hospital Medicine.

Nicole Ehrhart, professor of clinical sciences, images stem cells implanted in the femur of a mouse under anesthesia in the Animal Cancer Center.

CSU PHOTOGRAPHY, COMMUNICATIONS & CREATIVE SERVICES

CSU'S ANIMAL SCIENCE BREAKS NEW GROUND

Vaccines and vet medicine improve the lives of mice and men

BY JOSHUA ZAFFOS

In 2011 Steven Dow and researchers in his laboratory at Colorado State University were studying drugs expected to block vaccine responses in mice.

But the results surprised them.

Instead of suppressing vaccines' effectiveness, the drugs actually enhanced vaccine immunity, providing new insights into the way vaccine responses actually were being regulated.

That "chance discovery," Dow said, has stimulated a new line of research for his lab at CSU's College of Veterinary Medicine and Biomedical Science, testing how drugs that target a class of white blood cells known as monocytes can be used to boost cancer and vaccine treatments.

After early studies using mice, Dow and his team are starting clinical trials in dogs. They also have launched a startup company to develop the research commercially in conjunction with CSU Ventures, the university's technology transfer office.

"We're excited about this because it has applications both for cancer patients and healthy individuals," Dow said, adding that applications of the technology may benefit both human and animal medicine.

Dow and other CSU veterinary scientists have made a habit of producing groundbreaking discoveries, building on Colorado State's worldwide reputation as a leading animal-sciences research institution.

Just as CSU at large has successfully grown its research budget in recent years, the College of Veterinary Medicine and Biomedical Sciences has maintained top-tier funding. College research expenditures totaled more than $56 million in 2011, marking the sixth straight year that school funds have exceeded $50 million.

The money has supported faculty and researchers in important investigations into causes and treatments of animal cancers, infectious diseases, reproductive health issues, and other pressing concerns. Findings and innovations have made CSU a destination for pet owners, ranchers, and

Continued on next page

Stacy Sawyer has her schipperke "Rosie" checked following neurology surgery by Dr. Stephanie Engel at the Veterinary Teaching Hospital.

CSU PHOTOGRAPHY, COMMUNICATIONS & CREATIVE SERVICES

TREATMENT FOR CHRONIC PAIN — IN PETS AND PEOPLE

BY JOSHUA ZAFFOS

Fortunately, what happens in Las Vegas doesn't always stay in Vegas, especially for animals and people with chronic pain.

Linda Watkins, a neuroscience and psychology professor at the University of Colorado Boulder, was speaking at an international conference in the Nevada city in 2010; her presentation on groundbreaking chronic pain management research for people got the attention of Robert Landry, a Lafayette, Colo.-based veterinarian who was attending the meeting.

After hearing about Watkins' innovative research into glial cells — cells that surround neurons in humans' and animals' brains and spinal cords — Landry approached her, and they began discussing how to apply her research to dogs. The two are now working with a startup company, Xalud Therapeutics Inc., based in San Francisco, to bring forward the therapies for canines in pain — and eventually for people.

Glial cells have often been overlooked in neuroscience, Watkins said, with most studies focusing strictly on how neurons send pain messages throughout the body. But the "pesky, little" glial cells are ten times more numerous than neurons, and her research indicates they can play a moderating — or aggravating — function that eases or intensifies pain perceptions.

Watkins' studies suggest that injecting subjects (initially rats) with a glial-calming gene therapy increases the release of Interleukin 10, a natural anti-inflammatory protein, and eliminates neuropathic pain for up to 90 days after a single injection, which can then be repeated. The treatments could provide unprecedented relief to people suffering chronic pain from a variety of causes, as well as potentially providing a novel treatment for multiple sclerosis, amyotrophic lateral sclerosis (Lou Gehrig's disease), and other debilitating conditions, and to animals with similar ailments.

"There are no drugs on the market that target these cells," Watkins said. "It's a major shift in how we look at chronic pain and medicine."

Watkins and Landry, who is based at Mountain Ridge Animal Hospital in Lafayette, have started clinical studies and screening on dogs. Xalud Therapeutics has received funds from the National Institutes of Health and is also waiting on an American Kennel Club grant to continue testing and to study how to translate the results to humans within the next year.

Continued from previous page

zoo managers who seek animal cancer treatment, among other services, while supporting research that aids people as well as critters of all sizes.

"We've got a tradition of doing cutting-edge research on both large and companion animals," said Sue VandeWoude, associate dean for research at the veterinary medicine college, who studies the biology, occurrence and treatment of feline leukemia and feline immunodeficiency virus in house cats, mountain lions, and bobcats.

With roots as an agricultural college, Colorado State and its veterinary science program initially became more oriented toward livestock and equine health to serve the state and nation's ranchers. A new emphasis toward companion animals developed in the 1950s, as postwar America became more suburban and families' relationships with animals and pets changed.

In addition, CSU veterinary scientists now work across a range of research and applied fields to explore how animal treatments can be translated to benefit humans.

The Musculoskeletal Research Program promotes studies and treatments that prevent and treat muscular and skeletal injuries and diseases and other orthopedic maladies, including osteoporosis in horses. The Animal Reproduction and Biotechnology Laboratory focuses on reproductive biology and technologies for horses and livestock, with many lab techniques now used commercially around the world for both animals and people. VandeWoude said the reproduction lab's reputation, resources and successes are so significant that just about every animal fertility clinic in the United States is likely to have a technician trained in Fort Collins.

The school's advanced technology also provides an indispensable leg up for scientists and physicians, and for the university's veterinary teaching hospital and its students. The college's radiology department specializes in veterinary diagnostic imaging, VandeWoude noted, saying, "It's not that easy to anesthetize a horse."

Services for companion animals, horses and livestock, and zoo creatures include digital X-rays, CT and PET scans, ultrasound technology for evaluating organ health, and MRI equipment for analyzing brain, spinal cord and joint health. The state-of-the-art operations serve research and applied medical purposes.

Dow and others are also leading pioneering studies of regenerative medicine, using stem cells taken from fat tissue to suppress inflammation in such diseases as asthma and chronic infections. CSU scientists are evaluating the use of stem cell therapy to treat chronic kidney disease in cats and chronic liver disease in dogs. The use of stem cells for suppressing inflammation could also help treat arthritis, inflammatory bowel disease, and immune disorders in horses, dogs, cats, and in humans.

Outside the labs, CSU veterinarians help to inform and treat challenges in wildlife and livestock health. In 2012, university technicians and scientists worked with wildlife and ranch managers to diagnose and prevent the spread of rabies outbreaks among local skunks and an anthrax outbreak at a Logan County cattle ranch.

Such public health and community work remains an essential part of CSU's mission as a public education institution.

University of Colorado Boulder
Directory of Research Centers And Institutes

UNIVERSITY OF COLORADO RESEARCH CENTERS

AMERICAN MUSIC RESEARCH CENTER
Campus Box: 288 UCB
303-492-7540
http://ucblibraries.colorado.edu/amrc/
Director: Thomas Riis

ASSESSMENT & RESEARCH CENTER (ARC)
303-735-4388
http://www.colorado.edu/atlas/research/arc/
Director: Kimberly O'Neal Kalahar

BIOSERVE SPACE TECHNOLOGIES CENTER (BST)
Campus Box: 429 UCB
303-492-1005
http://www.colorado.edu/engineering/BioServe/
Director: Louis Stodieck

BUENO CENTER FOR MULTICULTURAL EDUCATION
Campus Box: 247 UCB EDUC 247
303-492-7371
http://www.colorado.edu/education/BUENO/
Director: Leonard Baca

BUSINESS RESEARCH DIVISION
Campus Box: 420 UCB
303-492-8227
http://leeds.colorado.edu/brd#overview
Director: Cindy Dipersio

BYRON R. WHITE CENTER FOR THE STUDY OF AMERICAN CONSTITUTIONAL LAW
Campus Box: 401 UCB
303-735-6344
http://www.colorado.edu/law/centers/byronwhite/
Director: Melissa Hart

CARL MCGUIRE CENTER FOR INTERNATIONAL STUDIES
Campus Box: 256 UCB
303-735-5500
http://www.colorado.edu/Economics/mcguire/
Director: Wolfgang, Keller

CENTER FOR ADVANCED ENGINEERING & TECHNOLOGY EDUCATION (CAETE)
Campus Box: 435 UCB, ECOT 126
303-492-6331
http://cuengineeringonline.colorado.edu/
Director: Mario Vidalon

CENTER FOR AEROSPACE STRUCTURES
Campus Box: 429 UCB, ECAE 197
303-492-6838
http://www.colorado.edu/engineering/CAS/
Director: Carlos Felippa

CENTER FOR ASIAN STUDIES
Campus Box: 366 UCB, 1424 Broadway St., Boulder, CO
303-735-5122
http://cas.colorado.edu
Director: Timothy Oakes

CENTER FOR ASTROBIOLOGY
Campus Box: 600 UCB
303-735-3800
http://lasp.colorado.edu/life/
Director: Kathleen Cirbo

CENTER FOR ASTROPHYSICS & SPACE ASTRONOMY (CASA)
Campus Box: 389 UCB, DUAN C333
303-492-4050
http://casa.colorado.edu/
Director: James Green

CENTER FOR BRITISH & IRISH STUDIES
Campus Box: 184 UCB
303-492-2723
http://www.colorado.edu/ArtsSciences/british/
Director: John Culshaw

CENTER FOR COMPUTATIONAL LANGUAGE & EDUCATION RESEARCH (CLEAR)
Campus Box: 594 UCB, CINC, 1777 Exposition Drive, Boulder, CO 80309-0594
303-735-5150
http://clear.colorado.edu/start/index.php
Director: James Martin, Martha Palmer

CENTER FOR ENERGY & ENVIRONMENTAL SECURITY (CEES)
303-735-0181
http://www.colorado.edu/law/eesi/
Director: Lakshman Guruswamy

CENTER FOR ENVIRONMENTAL JOURNALISM
ARMR 112A
303-492-4114
http://www.colorado.edu/journalism/cej/
Director: Len Ackland, Tom Yulsman

CENTER FOR ENVIRONMENTAL TECHNOLOGY (CET)
Campus Box: 425 UCB
303-492-6908
http://cet.colorado.edu/
Director: Albin Gasiewski

CENTER FOR HUMANITIES & THE ARTS
Campus Box: 280 UCB, MCKY 201
303-735-0237
http://www.colorado.edu/ArtsSciences/CHA/
Director: Helmut Muller-Sievers

CENTER FOR IMAGING THE EARTH'S INTERIOR
Campus Box: 390 UCB
303-492-5243
http://tagg.colorado.edu/geophysics/html/ccita.html
Director: Michael Ritzwoller

CENTER FOR INTEGRATED PLASMA STUDIES
Campus Box: 390A UCB, DUAN F837, 2000 Colorado Ave., Boulder, CO
303-492-8760
http://cips.colorado.edu/
Director: Tobin Leo Munsat

CENTER FOR LABOR EDUCATION & RESEARCH (CLEAR)
Campus Box: 3443 Wolverine Loop, Broomfield, CO 80023
Director:

CENTER FOR LIFELONG LEARNING & DESIGN (L3D)
Campus Box. 430 UCB
303-492-1502
http://l3d.cs.colorado.edu/
Director: Gerhard Fischer

CENTER FOR LIMB ATMOSPHERIC SOUNDING (CLAS)
3300 Mitchell Lane, Room 2404, Boulder, CO 80301
303-497-8062
http://www.eos.ucar.edu/hirdls
Director: John Gille

CENTER FOR LIMNOLOGY
Campus Box: 216 UCB, CIRES 266
303-492-5191
http://cires.colorado.edu/limnology/
Director: William Lewis Jr.

CENTER FOR MEDIA, ARTS & PERFORMANCE (CMAP)
Campus Box: 301 UCB, 1125 18th St., Boulder, CO
303-735-1336
http://www.colorado.edu/atlas/camp/index.html
Director: Michael Theodore

CENTER FOR MEDIA, RELIGION & CULTURE
ARMR 112A
303-492-1357
http://cmrc.colorado.edu/
Director: Stewart Hoover

CENTER FOR NEUROSCIENCE
Campus Box: 345 UCB
303-492-6275
http://www.colorado.edu/neuroscienceprogram/center.html
Director: Dr. Steven Maier

CENTER FOR PHARMACEUTICAL BIOTECHNOLOGY (CPB)
Campus Box: 424 UCB
303-315-6075
http://www.colorado.edu/che/research/pharm_biotech_training.html
Director: John Carpenter, Theodore Randolph

CENTER FOR RESEARCH ON TRAINING (CRT)
Campus Box: UCB 345, MUEN E228
303-492-5032
http://psych.colorado.edu/~ahealy/CRT-Frame3.htm
Director: Alice Healy

CENTER FOR SCIENCE & TECHNOLOGY POLICY RESEARCH
Campus Box: 488 UCB, 1333 Grandview Ave., Boulder, CO
303-735-0451
http://sciencepolicy.colorado.edu/
Director: William Travis

CENTER FOR THE INTEGRATIVE STUDY OF WORK
Campus Box: 457 UCB
303-735-8484
http://www.colorado.edu/research/CISW
Director: Robert Levin

CENTER FOR THE STUDY & PREVENTION OF VIOLENCE (CSPV)
Campus Box: 483 UCB, 1440 15th St., Boulder, CO
303-492-1032
http://www.colorado.edu/cspv
Director: Delbert Elliott

CENTER FOR THE STUDY OF INDIGENOUS LANGUAGES OF THE WEST (CSILW)
Campus Box: 295 UCB
303-492-8456
http://www.colorado.edu/linguistics/csilw/
Director: James Andrew Cowell, Research Associate

CENTER FOR WESTERN CIVILIZATION
Campus Box: 232 UCB, HLMS 169
303-492-6132
http://www.colorado.edu/cwc/
Director: Robert Pasnau

CENTER OF THE AMERICAN WEST
Campus Box: 282 UCB, MCKY 229
303-492-4879
http://www.centerwest.org/
Director: Patricia Limerick

CENTER TO ADVANCE RESEARCH & TEACHING IN THE SOCIAL SCIENCES (CARTSS)
Campus Box: 481 UCB, IBS 1B75
303-735-3721
http://cartss.colorado.edu/
Director: David Brown

CHILDREN, YOUTH & ENVIRONMENTS CENTER FOR RESEARCH & DESIGN (CYE)
Campus Box: 314 UCB
303-735-5199
http://www.ucdenver.edu/cye
Director: Willem van Vliet

CLINICAL TRANSLATIONAL RESEARCH CENTER
Campus Box: 119 UCB, 1900 Wardenburg Drive, Boulder, CO
303-735-3056
http://www.colorado.edu/research/gcrc/
Director: Elizabeth Connick,

University of Colorado Boulder
Directory of Research Centers And Institutes

COLORADO ASSOCIATION FOR MANUFACTURING & TECHNOLOGY (CAMT)
Campus Box: 23 UCA, 216 16th St., Suite 850, Denver, CO
970-222-9134
http://www.camt.com
Director: Cynthia Christie

COLORADO CENTER FOR ASTRODYNAMICS RESEARCH (CCAR)
Campus Box: 431 UCB, ECNT 323
303-492-6677
http://ccar.colorado.edu/
Director: George Born

COLORADO CENTER FOR COMMUNITY DEVELOPMENT (CCCD)
Campus Box: 128 UCD
303-556-6660
http://www.cudenver.edu/cccd
Director: Lois Brink

COLORADO CENTER FOR PRESERVATION RESEARCH (CCPR) & COLORADO CENTER FOR SUSTAINABLE URBANISM (CCSU)
Campus Box: B126 UCD
303-556-3688
http://thunder1.cudenver.edu/preservation/index.html
Director: Jeremy Nemeth

COLORADO POWER ELECTRONICS CENTER (COPEC)
Campus Box: 425 UCB
303-492-7003
http://ece-www.colorado.edu/~pwrelect/index.html
Director: Robert Erickson, Dragan Maksimovic

COLORADO SPACE GRANT CONSORTIUM (COSGC)
Campus Box: 520 UCB
303-492-3141
http://spacegrant.colorado.edu/
Director: Christopher Koehler

COMPUTER & COMMUNICATIONS SECURITY CENTER (CCSC)
Campus Box: 430 UCB
303-492-4398
Director: John Bennett

CONFLICT INFORMATION CONSORTIUM
Campus Box: 580 UCB
303-492-1635
http://conflict.colorado.edu/
Director: Guy Burgess, Heidi Burgess

CU REAL ESTATE CENTER
Campus Box: 419, KOBL S210
303-492-3258
http://leeds.colorado.edu/realestate#description
Director: Sherman Miller

DARPA CENTER ON NANOSCALE-SCIENCE & TECHNOLOGY FOR INTEGRATED MICRO/NANO-ELECTRO-MECHANICAL TRANSDUCERS (IMINT)
Campus Box: 427 UCB
303-492-0734
http://www.imintcenter.org/
Director: YC Lee

EARTH SCIENCE & OBSERVATION CENTER (ESOC)
Campus Box: 216 UCB, Ekeley W245
303-492-5086
http://cires.colorado.edu/cses/
Director: Waleed Abdalati

ETHNOGRAPHY & EVALUATION RESEARCH
Campus Box: 580 UCB, ARCE A234
303-735-0887
Director: Anne-Barrie Hunter, Sandra Laursen

IBSC CENTER FOR DETERMINANTS OF EXECUTIVE FUNCTION & DYSFUNCTION
Campus Box: UCB 344, MUEN D414
303-492-6655
http://defd.colorado.edu
Director: Marie Banich

INDUSTRY/UNIVERSITY COOPERATIVE PROJECTS CENTER (I/UCPC)
Campus Box: 427 UCB
303-492-3410
Director: Jack Louis Zable

INDUSTRY/UNIVERSITY COOPERATIVE RESEARCH CENTER FOR FUNDAMENTALS & APPLICATION OF PHOTOPOLYMERIZATION (IUCRC)
Campus Box: 424 UCB
303-492-3247
http://css.engineering.uiowa.edu/~cfap/
Director: Christopher Bowman

INTERNATIONAL RESEARCH CENTER FOR ENERGY & ECONOMIC DEVELOPMENT (ICEED)
Campus Box: 263 UCB, 850 Willowbrook Road, Boulder, CO 80302
303-442-4014
http://www.iceed.org/
Director: Dorothea El Mallakh

KELLER CENTER FOR STUDY OF THE FIRST AMENDMENT
Campus Box: 333 UCB
303-492-2662
Director: David Reed Mapel

LIQUID CRYSTAL MATERIALS RESEARCH CENTER
Campus Box: 390 UCB
303-492-1515
http://lcmrc.colorado.edu/
Director: Noel Clark

MARION DOWNS NATIONAL CENTER FOR INFANT HEARING (MDNC)
Campus Box: 409 UCB
303-492-6283
http://www.mariondowns.com
Director: Janet Leah Desgeorges

NATIONAL CENTER FOR HIGHER EDUCATION MANAGEMENT SYSTEMS (NCHEMS)
3035 Center Green Drive, No. 150 Boulder, CO 80301-2251
303-497-0301
http://www.nchems.org/
Director: Dennis Jones

NATIONAL EDUCATION POLICY CENTER (NEPC)
Campus Box: 249 UCB
303-492-8370
http://www.epicpolicy.org/
Director: Kevin Welner

NATIONAL SNOW & ICE DATA CENTER
Campus Box: 449 UCB, 1540 30th St., Boulder, CO
303-492-8028
http://nsidc.org/index.html
Director: Mark Serreze

RESEARCH & ENGINEERING CENTER FOR UNMANNED VEHICLES (RECUV)
Campus Box: 429 UCB
303-735-1285
http://recuv.colorado.edu/
Director: Eric Frew

RICHARD M. BURRIDGE CENTER FOR SECURITIES ANALYSIS & EVALUATION
Campus Box: 419 UCB
303-492-4664
http://leeds.colorado.edu/burridge#mission
Director: Gregory Seals

ROBERT H. & BEVERLY A. DEMING CENTER FOR ENTREPRENEURSHIP
Leeds School of Business
303-735-5415
http://deming.colorado.edu/
Director: Paul Jerde

ROCKY MOUNTAIN TRADE ADJUSTMENT ASSISTANCE CENTER (RMTAAC)
2595 Canyon, Suite 440, Boulder, CO 80302
303-499-8222
http://www.rmtaac.org/
Director: Joni Waddell

SILICON FLATIRONS: A CENTER FOR LAW, TECHNOLOGY, & ENTREPRENEURSHIP
Campus Box: 401 UCB, Wolf Law Building, 2450 Kittredge Loop Road, Boulder, CO 80309
303-492-5442
http://www.silicon-flatirons.org/index.php
Director: Phil Weiser

UNIVERSITY OF COLORADO RESEARCH INSTITUTES

ALLIANCE FOR TECHNOLOGY, LEARNING, & SOCIETY (ATLAS)
Campus Box: 320 UCB, ATLS 223
303-735-4577
http://www.colorado.edu/atlas/
Director: John Bennett

BIOFRONTIERS INSTITUTE
Campus Box: 596 UCB, 3415 Colorado Ave., Boulder, CO
303-492-3544
http://biofrontiers.colorado.edu

COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES (CIRES)
Campus Box: 216 UCB
303-492-1143
http://cires.colorado.edu/
Director: William Lewis

INSTITUTE FOR BEHAVIORAL GENETICS (IBG)
Campus Box: 447 UCB, IBG 101, 1480 30th St., Boulder, CO
303-492-7362
http://ibgwww.colorado.edu/
Director: John Hewitt

INSTITUTE OF ARCTIC & ALPINE RESEARCH (INSTAAR)
Campus Box: 450 UCB, 1560 30th St., Boulder, CO
303-492-6387
http://instaar.colorado.edu/
Director: James White

INSTITUTE OF BEHAVIORAL SCIENCE (IBS)
Campus Box: 483 UCB, 1440 15th St., Boulder, CO 80302
303-492-8147
http://www.colorado.edu/ibs/
Director: Jane Menken

INSTITUTE OF COGNITIVE SCIENCE (ICS)
Campus Box: 344 UCB
303-735-3602
http://www.colorado.edu/ics/
Director: Donna Caccamise

JILA
Campus Box: 440 UCB
303-492-7789
http://jilawww.colorado.edu/
Director: Julia Jennings Bachinski

LABORATORY FOR ATMOSPHERIC & SPACE PHYSICS (LASP)
Campus Box: 590 UCB
303-492-6412
http://lasp.colorado.edu/
Director: Daniel Baker

RENEWABLE & SUSTAINABLE ENERGY INSTITUTE (RASEI)
Campus Box: 027 UCB, 2445 Kittredge Loop Road, Boulder, CO
303-492-0284
http://rasei.colorado.edu/
Director: Michael Knotek

UNIVERSITY OF COLORADO MUSEUM OF NATURAL HISTORY
Campus Box: 218 UCB
303-492-6892
http://cumuseum.colorado.edu/
Director: Patrick Kociolek

University of Colorado Anschutz Medical campus Directory of Research Centers And Institutes

RESEARCH CENTERS

ALTITUDE RESEARCH CENTER
12469 E. 17th Place, Aurora, CO 80045-0508
303-724-1670
www.altituderesearch.org/

ANSCHUTZ HEALTH & WELLNESS CENTER
Building 500, 13001 E. 17th Place, Aurora, CO 80045
303-724-9975
www.ucdenver.edu/academics/colleges/medicalschool/centers/HumanNutrition/AHWC/Pages/Wellness
Director: James Hill

BARBARA DAVIS CENTER FOR DIABETES (BDC)
1775 Aurora Court, Aurora, CO 80045
303-724-6836
www.ucdenver.edu/academics/colleges/medicalschool/centers/BarbaraDavis/Pages/barbaradaviscenter
Director: Marian Rewers

BIOMOLECULAR NMR CORE FACILITY
Room L18-1300, RC-1 South, CU Anschutz Medical campus
303-724-3600
www.ucdenver.edu/academics/colleges/medicalschool/programs/biomol/strucbiocores/nmr/Pages/NMRCoreFacility
Director: David Jones

BONFILS BLOOD CENTER
717 Yosemite St., Denver, CO 80230
303-341-4000
www.bonfils.org/
Director: Bryan Krueger

CENTER FOR ADVANCING PROFESSIONAL EXCELLENCE
13070 E. 19th Ave., Mail Stop F495, Aurora, CO 80045
303-724-1215
www.ucdenver.edu/academics/colleges/medicalschool/education/cape/Pages/default
Director: Jennifer Hummer Fisher

CENTER FOR GAIT & MOVEMENT ANALYSIS (CGMA)
Children's Hospital
720-777-6600
www.ucdenver.edu/academics/colleges/medicalschool/departments/Orthopaedics/research/bioengineering/Pages/CGMA
Director: James Carollo

CENTER FOR GENES, ENVIRONMENT & HEALTH
1400 Jackson St., Denver, CO 80206
303-270-2769
www.nationaljewish.org/professionals/research/programs-depts/genetics-therapeutics/
Director: David Schwartz

CENTER FOR HUMAN NUTRITION
13001 E. 17th Place, Aurora, CO 80045
303-724-9975
www.ucdenver.edu/academics/colleges/medicalschool/centers/HumanNutrition/Pages/HumanNutrition
Director: James Hill

CENTER FOR HUMAN SIMULATION
Campus Box F435, Building 500, Room N5201
303-724-0500
www.ucdenver.edu/academics/colleges/medicalschool/centers/HumanSimulation/Pages/Home
Director: NA

CENTER FOR INSTRUCTIONAL SUPPORT
Campus Box F496
303-900-2414
www.ucdenver.edu/academics/colleges/medicalschool/centers/CIS/Pages/CIS
Director: Hilliard Jason

CENTER FOR NEUROSCIENCE
12801 E. 17th Ave., Campus Box 8105, Aurora, CO 80045
303-724-6193
www.ucdenver.edu/academics/colleges/medicalschool/departments/neurology/research/NeuroScience/Pages/neuroscience
Kenneth Tyler, Diego Restrepo

CENTER FOR RESEARCH IN IMPLEMENTATION SCIENCE AND PREVENTION (CRISP)
13199 E. Montview Blvd., Suite 300, Aurora, CO 80045
303-724-1240
www.ucdenver.edu/academics/colleges/medicalschool/programs/crisp/Pages/default
Director: Allison Kempe

CENTER FOR SURGICAL INNOVATION
12631 E. 17th Ave., Room 6203, Aurora, CO 80045
303-724-2756
www.ucdenver.edu/academics/colleges/medicalschool/centers/SurgicalInnovation/Pages/CSI
Director: Sarah Massena

CENTER FOR SURGICAL TREATMENT OF LUNG INFECTIONS
12631 E. 17th Ave., C310, Aurora, CO 80045
303-724-2799
www.ucdenver.edu/academics/colleges/medicalschool/departments/surgery/divisions/CardiothoracicSurgery/Pages/CenterfortheSurgicalTreatmentofLungInfections
Director: Marvin Pomerantz

CENTER FOR WOMEN'S HEALTH RESEARCH
12348 E. Montview Blvd., Denver, CO 80045
303-724-0305
www.ucdenver.edu/academics/colleges/medicalschool/centers/WomensHealth/Pages/WomensHealth
Director: Judith Regensteiner

CHARLES C. GATES REGENERATIVE MEDICINE AND STEM CELL BIOLOGY CENTER
Campus Box 8320
303-724-3050
www.ucdenver.edu/academics/colleges/medicalschool/centers/StemCell/Pages/StemCell
Director: Dennis Roop

COLORADO INTELLECTUAL & DEVELOPMENTAL DISABILITIES RESEARCH CENTER (IDDRC)
12800 E. 19th Ave., Aurora, CO 80045-0511
303-724-3839
www.ucdenver.edu/academics/colleges/medicine/Centers/IDDRC/Pages/index
Director: Karl Pfenninger

COLORADO NUTRITION OBESITY RESEARCH CENTER
University of Colorado Medical Campus
www.ucdenver.edu/academics/colleges/medicalschool/centers/HumanNutrition/NORC/Pages/ColoradoNORC
Director: James Hill

COLORADO PREVENTION CENTER (CPC)
13199 E. Montview Blvd., Suite 200, Aurora, CO 80045
303-860-9900
www.cpcmed.org/
Director: William Hiatt

COLORADO SICKLE CELL TREATMENT AND RESEARCH CENTER
13121 East 17th Avenue, C-222, Education 2 South, Room 3211, Aurora, Colorado 80045
303-724-9070
www.ucdenver.edu/academics/colleges/medicalschool/centers/sicklecell/Pages/Home
Director: Kathryn Hassell

COLORADO TRANSLATIONAL RESEARCH IMAGING CENTER (CTRIC)
12401 E. 17th Ave., Aurora, CO 80045
720-848-6611
www.ucdenver.edu/academics/colleges/medicalschool/departments/Radiology/ctric/Pages/CTRIC
Director: Gerald Dodd

CU CANCER CENTER
Anschutz Cancer Pavilion, 1665 Aurora Court, Aurora, CO 80045
720-848-0300
www.uch.edu/colorado-cancer-center/
Director: John Harney

DENVER INSTITUTE OF PSYCHOANALYSIS
12469 E. 17th Place (F478), Aurora, CO 80045
303-724-2666
www.denverpsychoanalytic.org/
Director: Stacey Keller

HEMOPHILIA AND THROMBOSIS CENTER
13199 E. Montview Blvd., Suite 100, Aurora, CO 80045
303-724-0724
www.ucdenver.edu/academics/colleges/medicalschool/centers/HemophiliaThrombosis/Pages/home
Director: Marilyn Manco-Johnson

HUMAN MEDICAL GENETICS PROGRAM
12800 E. 19th Ave., Aurora, CO 80045
303-724-3102
www.ucdenver.edu/academics/colleges/medicalschool/programs/HumanMedicalGenetics/Pages/Genetics
Director: Richard Spritz

KEMPE CHILDREN'S CENTER
13123 E. 16th Ave., B390, Aurora, CO 80045
303-864-5250
www.ucdenver.edu/academics/colleges/medicalschool/departments/pediatrics/subs/can/Pages/ChildAbuseNeglect
Director: Desmond Runyan

LINDA CRNIC INSTITUTE FOR DOWN SYNDROME
12700 E. 19th Ave., Aurora, CO 80045
303-724-6599
www.ucdenver.edu/academics/colleges/medicalschool/institutes/lindacrnic/Pages/lindacrnic
Director: Tom Blumenthal

MARION DOWNS HEARING CENTER
1793 Quentin St., Unit 2, Aurora, CO 80045
720-848-3042
www.mariondowns.com/
Director: Susan Mirabito

University of Colorado Anschutz Medical campus Directory of Research Centers And Institutes

PERINATAL RESEARCH CENTER
13243 E. 23rd Ave., MS F441, Aurora, CO 80045
303-724-0543
www.ucdenver.edu/academics/colleges/medicalschool/departments/pediatrics/research/programs/perinatal/Pages/PerinatalResearchCenter
Director: Georgina Garza

ROCKY MOUNTAIN TASTE AND SMELL CENTER
12800 E. 19th Ave., Aurora, CO 80045
303-724-3436
www.ucdenver.edu/academics/colleges/medicalschool/centers/tastesmell/Pages/tastesmell
Director: Tom Finger, Diego Restrepo

TRAUMA RESEARCH CENTER
12700 E. 19th Ave., Aurora, CO 80045
303-724-6308
www.ucdenver.edu/academics/colleges/medicalschool/departments/surgery/Research/TraumaCenter/Pages/Welcome
Director: Anirban Banerjee

WEBB-WARING CENTER
12850 E. Montview, Aurora, CO 80045
303-724-4783
www.ucdenver.edu/academics/colleges/medicalschool/centers/WebbWaring/Pages/WebbWaringHome
Director: John Repine

VICE CHANCELLOR FOR HEALTH AFFAIRS CENTERS

CENTER FOR BIOETHICS AND HUMANITIES
13080 E. 19th Ave., Aurora, CO 80045
303-724-3994
www.ucdenver.edu/academics/colleges/bioethics/Pages/bioethicshumanities
Director: Therese Jones

COLORADO AREA HEALTH EDUCATION SYSTEMS (AHEC)
13120 E. 19th Ave., MS-F433, Aurora, CO 80045
303-724-0348
www.ucdenver.edu/life/services/AHEC/Pages/index
Director: Jack Westfall

COLORADO CLINICAL & TRANSLATIONAL SCIENCES INSTITUTE (CCTSI)
12401 E. 17th Ave., Aurora, CO 80045
720-848-7100
cctsi.ucdenver.edu/Pages/index
Director: Ronald Sokol

AFFILIATE CENTERS

ROCKY MOUNTAIN MULTIPLE SCLEROSIS CENTER
12631 E. 17th Ave., Aurora, CO 80045
720-848-2080
www.mscenter.org/
Director: Karen Wenzel

SCHOOL OF MEDICINE INSTITUTES

INSTITUTE FOR CHILDREN'S MENTAL DISORDERS
13001 E. 17th Place, Building 500, Room C2000B, Aurora, CO 80045
303-724-4955
www.childrensmentaldisorders.org/research.html
Director: Stephen Edmonds

VICE CHANCELLOR FOR HEALTH AFFAIRS INSTITUTE

CARDIOVASCULAR INSTITUTE
12700 E. 19th Ave., AMC, Box B-139, Aurora, CO 80045
303-724-2086
www.ucdenver.edu/academics/colleges/medicalschool/institutes/CardiovascularInstitute/Pages/CardiovascularInstitute
Director: Rachel Rosenberg

COLORADO STATE UNIVERSITY RESEARCH
DIRECTORY OF RESEARCH CENTERS AND INSTITUTES

CSU CENTERS AND INSTITUTES

COLLEGE OF AGRICULTURAL SCIENCES

THE CENTER FOR MEAT SAFETY AND QUALITY
1171 Campus Delivery, Fort Collins, CO 80523-1171
970-491-7703
www.ansci.colostate.edu/programs/meat_safety.html
Director: John Sofos

CENTER FOR SUSTAINABLE INTEGRATED PEST MANAGEMENT IN COLORADO
1177 Campus Delivery, Fort Collins, CO 80523
970-491-1377
www.coloradoipmcenter.agsci.colostate.edu/
Director: Deborah Young

INSTITUTE FOR LIVESTOCK AND THE ENVIRONMENT
C003 Plant Sciences Building, Fort Collins, CO 80523
970-491-2326
www.livestockandenvironment.org/
Director: Jessica Davis

PROGRAM IN MOLECULAR PLANT BIOLOGY
(970) 491-4991
www.plantbiology.colostate.edu
Chair, Elizabeth A.H. Pilon-Smits

ROCKY MOUNTAIN CENTER FOR CROP BIOSECURITY
108 Johnson Hall, Fort Collins, CO 80523-1036
970-491-6987
www.sustainability.colostate.edu/centers/crop-biosecurity
Director: Howard Schwartz, William Brown Jr.

SHORTGRASS STEPPE LONG-TERM ECOLOGICAL RESEARCH
970-491-1796
www.sgslter.colostate.edu/
Director: John Moore

WESTERN CENTER FOR INTEGRATED RESOURCE MANAGEMENT
3001 Campus Delivery, Fort Collins, CO 80523-3001
970-491-8373
www.wcirm.colostate.edu/
Director: Gordon Niswender

WHEAT RESEARCH, OUTREACH, AND EDUCATION PROGRAM
(970) 491-5261
Thomas O. Holtzer, Co-Director
(970) 491-6501
Eugene Kelly, Co-Director

COLLEGE OF APPLIED HUMAN SCIENCES

CENTER FOR COMMUNITY PARTNERSHIPS
320 Occupational Therapy Building, Fort Collins, CO 80523-1573
970-491-5930
www.ccp.colostate.edu/
Director: Cathy Schelly

CENTER FOR FAMILY & COUPLE THERAPY
Gifford Building on Lake Street
970-491-4947
www.hdfs.cahs.colostate.edu/centers_outreach/cfct/Default
Director: Jenn Matheson

INSTITUTE FOR THE BUILT ENVIRONMENT
1501 Campus Delivery, Fort Collins, CO 80523-1501
970-491-5041
www.ibe.colostate.edu/
Director: Brian Dunbar

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