Within this “Research Angle,” you’ll find information about just a few of the extraordinary projects and people within Colorado State University’s College of Engineering. Through our research program, our students, faculty and staff make discoveries that contribute to human health, the environment, quality of life, and economic development in Colorado, the U.S., and around the world. Our goal is to “Engineer Global Solutions” through research and the generation of new knowledge with world-wide impact. The projects described in this publication exemplify this goal, affecting billions of people.

The College of Engineering’s research enterprise generates more than $50,000,000 in expenditures annually, and that number is increasing. Over the five year period from fiscal year 2001 through fiscal year 2006, research expenditures in the College of Engineering increased by more than 50%. Certainly, these expenditures benefit the State of Colorado’s economy. More importantly, however, these research projects employ undergraduate and graduate students, helping them to fund their education as they develop new knowledge and create new discoveries.

Faculty Competitiveness

Universities with significant research programs have the opportunity to enrich their students’ education as they interact with top faculty and gain experience in research laboratories or in the field. Research provides graduate and undergraduate students with resources to fund their education, generates new knowledge, contributes to economic development, and allows faculty to bring new discoveries and cutting-edge research into the classroom.

Colorado State University’s research expenditures exceeded $267 million in the 2005/2006 fiscal year. To put this in perspective, CSU’s research funding, as a whole, ranks among the top few institutions in the U.S. for universities without a medical school.

Engineering Global Solutions

Two projects that exemplify the global impact of CSU’s College of Engineering are being conducted within our Engines and Energy Conversion Laboratory. Together, these projects will affect the health of billions of people around the world.

Launching Satellite and Center

Colorado State University’s Department of Atmospheric Science is one of the leading atmospheric science programs in the U.S. and in the world, due to its excellent faculty and global partnerships. Recent launches of the CloudSat satellite and our newest NSF Science and Technology Center are described on pages 4 and 5.

Centering on Research

In addition to our new STC, CSU is the lead institution on an NSF Engineering Research Center (ERC) and a partner in a second ERC.

Investing in the Future

The College of Engineering has a great faculty. Read about three assistant professors, recent recipients of NSF CAREER Awards and the Presidential Early Career Award.

Making Energy Efficient

CSU has a long history of renewable energy research. For information about a new technology that will make solar energy more efficient and cost-effective, see page 11.

www. engr . co l o s t a t e . edu

Dean of Engineering
Developing Technology Solutions to Save Energy and Reduce Pollution

What began as a student design project for the 2002 Clean Snowmobile Competition is now a promising new technology that is restoring clean air in the Philippine cities of Manila, Cebu and Vigan. About 84% of this country’s population is dependent on tricycles powered by two-stroke engines for their transportation. There are over 1.3 million tricycles in use in the Philippines, and the pollution from just one of these two-stroke engines is equivalent to 30-50 modern catalyst-equipped, fuel-injected automobiles.

When faculty adviser Bryan Willson and members of the 2002 snowmobile team learned that the technologies resulting from their research could help underdeveloped countries with pollution problems, they jumped at the opportunity. Envirofit International Ltd. was established jointly as a private, nonprofit corporation by the Colleges of Engineering and Business to develop and disseminate the technologies around the world. Willson, director of the Engines & Energy Conversion Laboratory (EECL), and Paul Hudnut, director of Venture Development, worked with former students Tim Bauer and Nathan Lorenz to develop the Envirofit business plan.

As a result of the research conducted in the EECL on a new type of direct-injection system, fuel and oil consumption in two-strokes are reduced by 35% and 50% respectively, carbon monoxide emissions are reduced by up to 85% and hydrocarbon emissions by 90%. Envirofit licenses the core of the direct injection system from Orbital Corporation, adapting the existing technology for retrofit application to address the largest transport sector in the world: hyper-polluting vehicles with two-stroke engines. Orbital has been developing the patented “OCP” (Orbital Combustion Process) for over 20 years, and their system is used by a variety of commercial and recreational market products. The end result is that Envirofit has developed a production-proven, reliable and purpose-built product.

Envirofit has retrofitted and successfully tested engines in the Philippines, where particulate emissions in the four largest cities result in more than 2,000 premature deaths, 9,000 cases of severe respiratory illness and more than $430 million of economic losses every year, according to World Bank estimates. The company was honored as one of 25 Tech Museum Award Laureates from around the world in 2005, and in 2006 was named in the Stanford Social Innovation Review as one of 10 innovative technology companies that create global social change.

Extensive field testing has been done, and now the first real-world direct-injection retrofit test on a fleet of vehicles is scheduled for fall 2006, with production in Vigan expected to increase from 35 to 100-200 vehicles per month.

www.envirofit.org and www.engr.colostate.edu/eecl

Cook Stoves with Global Impact

Colorado State’s Engines & Energy Conversion Laboratory (EECL) is a world leader in engine research and development of new products and technologies to reduce emissions and fuel consumption. With $20M in funded research since 1991, the EECL has formed strong partnerships with government agencies and companies in the U.S. and around the world to bring new solutions to a variety of environmental challenges. Over 50 undergraduate and graduate students work with faculty in the lab each semester on a wide range of research projects that have national and international impact.

The Global Innovation Center for Energy, Health and the Environment (GIC) is a partnership of the Colleges of Engineering and Business to develop and disseminate technology solutions to human needs in the developing world. An exciting new EECL/GIC collaboration is the Advanced Stoves Laboratory where they are creating clean-burning cook stoves that will have a positive impact on health, the environment, and local economies.

One-half of the world’s population cooks their food and heats their homes on stoves that burn biomass such as wood and agricultural wastes; there is a need for 500 million of these cook stoves. Smoke from stoves using biomass is the #1 cause of death in children under five years of age worldwide, and the #2 cause of respiratory illnesses in women. And people in developing countries making $1-2 a day cannot afford the “improved” stoves that are beginning to be offered for sale.

Student researchers at the GIC are working on basic combustion science related to stoves. They are working to develop stoves that are cleaner and more efficient, and are also applying modern manufacturing methods to get the cook stoves into widespread use at a lower cost to the consumer. The GIC is collaborating with partners to apply their work to meet needs in Latin America, Asia, and Africa.

Students and faculty

www.engr.colostate.edu/eecl
CloudSat’s Unique Data Excites Scientists Around the World

Scientists worldwide are clamoring for the first-of-its-kind information about clouds from CloudSat, the world’s first cloud-profiling radar in orbit, said Graeme Stephens, CSU atmospheric science professor.

CloudSat blasted into space above Vandenberg Air Force Base north of Santa Barbara, California, on April 28 with CALIPSO, another NASA Earth Observation Satellite, aboard a Boeing Delta II rocket.

The radar launched Stephens and Colorado State's College of Engineering into history.

“The international attention has been intense and is only going to grow,” said Stephens, CloudSat’s inventor. “The data are already flowing to the European operational forecast center in the U.K., to research groups in Europe, Canada, and Australia. The University of Tokyo is sending a post-doctoral researcher to learn about CloudSat data — and we in turn about their models that run on the massive Earth simulator computer — and China is becoming interested in CloudSat and the possibility of launching their own version.”

CloudSat is the first space-borne millimeter-wavelength radar to look vertically at the characteristics of clouds and precipitation, particularly water and ice content that could help scientists improve predictions of climate changes and weather patterns. In addition to improving weather forecasting, the data will help investigate how clouds determine Earth’s energy balance, increase the accuracy of severe storm warnings, improve water resource management and develop even more advanced radar technology.

The Cooperative Institute for Research in the Atmosphere or CIRA, which is based at Colorado State, collects CloudSat data and distributes it to scientists around the globe.

CloudSat’s first images, released in early June, captured as much media attention as the launch itself because the world witnessed unprecedented views of clouds and storms such as Tropical Storm Alberto. In July, CloudSat recorded images of the increasing intensity of Hurricane Daniel in the central Pacific Ocean east of Hawaii.

Stephens, a University Distinguished Professor in the college’s Department of Atmospheric Science, has spent more than a decade of his career on CloudSat. Cooperating on the project were NASA’s Jet Propulsion Laboratory, Ball Aerospace and Technologies Corp., the Canadian Space Agency, the U.S. Department of Defense, and the U.S. Air Force. 

www.cira.colostate.edu

The Cooperative Institute for Research in the Atmosphere

CIRA was established in 1980 through an agreement between NOAA and Colorado State University.

For over 25 years, CIRA has actively engaged in multidisciplinary environmental science and engineering research on a global level. Hundreds of graduate students and scientists have worked on projects ranging from local area severe storm prediction to global climate. CIRA’s focus on multidisciplinary research is demonstrated by the strong research partnerships formed between the Colleges of Engineering, Natural Resources, and Natural Sciences at Colorado State, as well as multiple partnerships with federal agencies (such as NOAA, The National Park Service, DoD and NASA).

These partnerships have created numerous opportunities for faculty to engage in cutting-edge research outside the boundaries of their traditional fields of expertise. CIRA has indeed offered a unique opportunity for scientists and engineers to address issues of a larger magnitude and on a more global scale. For instance,

- electrical engineers work with atmospheric scientists and hydrologists on new methods to forecast streamflow and floods
- physicists, mathematicians and atmospheric scientists are involved in innovative methods to analyze environmental data
- water resource faculty work with sociologists to communicate hydrological data to users
- faculty from atmospheric chemistry, statistics, and electrical and computer engineering are solving problems centered around air quality and visibility

Outreach and service to the national and international communities are of paramount importance to the CIRA mission. One example is its 10-year participation in the Global Learning and Observations to Benefit the Environment (GLOBE) Program, an international hands-on, primary and secondary school-based science education program.

With research funding totaling $150M over the last 25 years and now averaging $12-14M a year, CIRA is well positioned to continue to lead the nation in producing highly-skilled and qualified faculty and student teams to address the complex global and regional environmental issues facing society today and in the future.
Scientists have struggled for decades to improve the way the clouds are represented in global atmospheric models. Since the 1960s, scientists have used such models to understand and predict future systematic changes in weather that affect the planet and particularly farmers, utilities, insurance companies and government agencies. A major, long-standing problem has been modeling the effects of clouds in a realistic way.

In July 2006, the National Science Foundation awarded Colorado State University and its partners a $19 million Science and Technology Center to build a radically new kind of global atmospheric model that will more realistically depict cloud processes.

The NSF Science and Technology Center for Multi-Scale Modeling of Atmospheric Processes will be based at Colorado State in the College of Engineering’s renowned Department of Atmospheric Science.

Even with very large, complex computers, scientists working on climate modeling struggle to represent the physical and chemical processes of clouds, including precipitation, strong cloud-scale motions and radiation. It has been especially difficult to realistically simulate the interactions between cloud systems and the global-scale circulation of the atmosphere.

The prototype model developed at Colorado State uses a high-resolution model to simulate the populations of clouds in each of the thousands of “grid columns” of a global atmospheric model. The cloud model represents a sample of the clouds in each grid column. This new approach has only recently become possible because of the increasing speed of computers.

The new model will make it possible to produce more robust simulations of both next week’s weather and future climate change. The work of the modeling center will have a wide range of impacts on both science and society because it will increase our understanding of climate processes and our ability to make reliable simulations of cloud processes as they relate to both climate change and weather prediction.

David Randall (center), Scott Denning (left) and Wayne Schubert head Colorado State’s research team for the new science and technology center.

cmmmap.colostate.edu

NSF Science and Technology Center Details

About one-third of the $19 million budget is dedicated to education, outreach and diversity, including training for K-12 science teachers and support for Colorado State’s popular Little Shop of Physics program. The program involves professors and students using everyday objects to show young people that science can be fun.

Colorado State plans to start construction next year on a building at the Foothills Campus to house the new Science and Technology Center, including three faculty members, 17 researchers, 18 students, and nine support staffers.

“Our College of Engineering continues to be a world leader in critical research related to environmental sustainability and climate,” said Colorado State President Larry Penley. “This new center, which will advance the complicated science of climate forecasting, is a significant recognition of the important work conducted by our atmospheric science faculty. This project is particularly special because it will also enable Colorado State to expand its outreach to K-12 teachers and help encourage young people to explore their interests in math and science.”

“We’ll look at questions like ‘Why are clouds white?’ and ‘Why do clouds stay up?’ – questions that have to do with the basic science of air, water, energy, and light,” said Brian Jones, director of the Little Shop of Physics. “We’ll develop materials for schools related to the program that complement existing materials and relate to state standards. Our goal will be to help ensure that, when the kids who go through the school get to college, they have strong training in basic sciences and an interest in studying science, including climate science.”

Center Leadership

David Randall, professor of atmospheric science since 1988, will serve as principal investigator and director of the center. Co-principal investigators include John Helly of the San Diego Supercomputer Center at the University of California, San Diego; Chin-Hoh Moeng of the National Center for Atmospheric Research in Boulder; and Scott Denning and Wayne Schubert of Colorado State’s atmospheric science department. The project involves the participation of many other investigators and educators around the country and in Canada, Japan, England and Australia.
EUV Center’s Research Accomplishments

- Compact EUV lasers with record average power (CSU)
- High harmonic generation into the water window (CU)
- High harmonic generation from ions in a capillary discharge plasma waveguide (CU and CSU)
- New EUV spectroscopies of nanoclusters and surfaces (CSU and CU)
- Table-top EUV microscopy with record sub-38 nm resolution (CSU/Berkeley)
- Sub-15 nm resolution soft x-ray microscopy at synchrotrons (Berkeley)
- First demonstration of nanoablation with a focused EUV laser beam (CSU)

Education and Scholarship Highlights

- Research opportunities for 56 Ph.D. and M.S. students
- 11 workshops at elementary, middle and high schools in Colorado and California
- 71 students involved in Research Experiences for Undergraduates (REU)
- 53% of EUV REU students are now pursuing graduate careers in engineering and science
- Multiple multidisciplinary projects involving two or more institutions
- Four visiting graduate students hosted in 2006 from France, Spain, and Argentina
- 24 competitive awards to undergraduate and graduate students from professional societies, federal agencies, or university and industry associations since 2003
- 59 journal articles, 44 conference proceedings and 107 conference abstracts

Industry Connections

- The Center currently has 15 industrial members. This list is comprised of 13 U.S. companies and two foreign companies, from small businesses to large corporations.
- $3.1 million of industry funds directed toward research of the Center, which approaches the NSF base budget and shows the quality of interaction with industrial members.

Center Leadership

Co-Principal investigators are Jorge Rocca (CSU, Center Director); Margaret Murnane (University of Colorado-Boulder, Center Deputy Director), David Attwood (University of California-Berkeley), Henry Kapteyn (UC-Boulder), and Carmen Menoni (CSU). Center Administrative Director is Sheila Davis and the Education Director is Michael Celaya.

euverc.colostate.edu
NSF ERC for Collaborative Adaptive Sensing of the Atmosphere Tests the Next Generation of Radars

The nation’s ability to monitor, anticipate and respond to dangerous weather events is becoming increasingly important as tornadoes and floods destroy more property and jeopardize more lives. However, the portion of the atmosphere that contains critical information on the bulk of these hazards, the lower troposphere, cannot be fully observed because the Earth’s curvature blocks standard high-power, long-range radars.

Oklahoma’s “tornado alley” is serving as a test bed for a new weather-detection system that overcomes the effects of the Earth’s curvature and will lead to earlier detection of hazardous atmospheric phenomena. Colorado State University and its research partners in the National Science Foundation Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere (CASA) are designing low-power solid-state radars that are highly reliable, inexpensive and adaptive, and operate collaboratively. Scientists will have an unprecedented ability to observe the lower troposphere using an advanced system of Distributed Collaborative Adaptive Sensing (DCAS) networks designed to overcome Doppler radar limitations. This networked system enables end users to determine needs and allocate resources – such as power, frequency, and bandwidth – to the regions where threats exist.

The prototype, CASA Radar 1, was designed by researchers, faculty, and students from Colorado State, the University of Massachusetts at Amherst, the University of Oklahoma, and the University of Puerto Rico at Mayaguez. It was tested at the CSU-CHILL radar facility east of Greeley before being deployed to Oklahoma. A second test bed in Houston will monitor and predict floods more accurately and a third in Puerto Rico will improve monitoring of floods produced by thunderstorms and hurricanes over the island.

Through this partnership of universities, corporations, and government agencies, CASA is demonstrating the potential for DCAS networks to revolutionize our understanding, detection and prediction of atmospheric phenomena, saving lives and property through better and earlier hazardous weather warnings.

CASA Center Leadership

Electrical & computer engineering Professor V. Chandrasekar is the Colorado State University principal investigator for CASA; other CASU investigators are Professors V.N. Bringi, Anura Jayasumana, and Steve Rutledge. Omnia E. Hakim, director of the Colorado Alliance for Minority Participation, participates in the Center’s goal to expand the number of underrepresented students involved in science, mathematics and engineering. The University of Massachusetts-Amherst is leading the Center.

CSU-CHILL Radar Facility

• In 1990, NSF moved the CHILL facility to Colorado State University after reviewing competing proposals from a number of universities with educational programs in atmospheric science and electrical engineering. Steve Rutledge, atmospheric science department head, is principal investigator of CSU-CHILL.
• The CSU-CHILL radar is at the forefront of ground-based meteorological radar research at Colorado State University. It is an advanced polarimetric and Doppler radar at S band capable of measuring full scattering matrix of weather targets, and has a unique dual-transmitter, dual-receiver configuration to enable multiple polarization states.
• The recent acquisition of an offset fed antenna allows for improved sidelobe and cross-polarization performance and, when coupled with capabilities to transmit various polarization states, will substantially advance the remote sensing of clouds and precipitation.
• The CHILL radar system also serves as a developmental testbed for the nation’s NEXRAD radars.
• The dual-Doppler capability of CSU-CHILL and the Pawnee radars enables the study of a wide range of precipitation systems, from flood events to supercell storms.
• Real-time dissemination of CHILL data is made possible via the Internet, allowing users of V-CHILL to rapidly interrogate the datastream, make real-time decisions and control the scanning of the antenna to study evolving storm structures.
• The radar provides data for graduate research at the M.S. and Ph.D. levels, as well as Research Experiences for Undergraduates and a broad range of outreach programs for middle and high school students.

www.radar.colostate.edu/casa
Bledsoe and Pruden Receive NSF CAREER Awards

How Streambeds Process Pollutants
The shape of riverbeds may affect how streams combat excess nitrogen that depletes oxygen levels and chokes aquatic life, hurting water bodies, drinking water supplies and potentially tourism around the world.

Most scientists studying how streams process excess nitrogen have studied the biology, not the physical form and hydraulics of the streambed. Brian Bledsoe, civil engineering assistant professor, argues that channel form could be just as important in determining stream health. Knowing how the forms of small streams help manage pollutants could help increase the cost effectiveness of stream and watershed restoration.

Bledsoe received a $450,000 NSF CAREER Award over the next five years to further these studies.

Bledsoe’s research will include creating new outdoor laboratories for graduate and undergraduate students in and around Fort Collins to study Spring Creek, Sheep Creek, the Little Snake River and the North St. Vrain River. Bledsoe and his team will inject tiny amounts of nitrogen isotopes into the streams and track them to monitor how the profiles of the riverbeds and flow conditions affect nutrient retention.

Tracing the Path of Antibiotics
The rapid spread of disease-causing bacteria that are resistant to high doses of antibiotics represents a global health threat. Environmental engineers and scientists have been measuring the effects of antibiotic drugs that make their way from farms and cities into our rivers and streams, and their findings are disturbing. Widespread exposure to antibiotics promotes the spread of antibiotic resistant genes (ARG), which cause bacteria to become resistant to antibiotics. This makes it challenging to find effective medicines when people are ill.

Amy Pruden, assistant professor of civil and environmental engineering, recently received the NSF CAREER award to characterize the occurrence of ARG along the Front Range of Colorado and investigate the role of on-farm management, wastewater treatment, and drinking water treatment in reducing the spread of ARG. Pruden’s research will help to open new approaches to mitigation and treatment of these unique contaminants.

www.engr.colostate.edu/dean/facultystaff/profiles

Bartels Receives Presidential Early Career Award
Randy Bartels has an impressive track record since joining the Department of Electrical and Computer Engineering as an assistant professor in 2003. Bartels has been honored with numerous awards in his young career from many disciplines.

His honors since 2004 include the Sloan Research Fellowship in physics, the Beckman Young Investigator Award in chemistry, the Gold Medal Human-Competitive Award for advancing evolutionary computation, the Optical Society of America’s Adolph Lomb Medal for his contributions to optics, and the National Science Foundation CAREER Award recognizing his early potential for scientific leadership.

On July 27 of this year, Bartels received a Presidential Early Career Award, the U.S. government’s highest honor granted to outstanding up-and-coming scientists and engineers. He was one of 56 scientists from around the country to be honored at the White House, and one of two scientists nominated by the U.S. Department of Defense, Office of Naval Research. Last year, ONR presented Bartels with the Young Investigator Award in recognition of his advances in physics and engineering.

Bartels heads Colorado State’s Laboratory for Ultrafast and Nonlinear Optics, where his research concentrates on the generation and control of short laser pulses and their use for the control of quantum dynamics – to precisely control the positions of atoms in molecules, for example. His research group is using this control to develop more precise and portable atomic clocks.

With support from the Monfort family and the Beckman Foundation, Bartels’ team is developing new molecular-specific in-vivo imaging techniques that could be harnessed to study molecular function in cells in new ways. As part of the NSF ERC for Extreme Ultraviolet Science and Technology, he is developing new coherent imaging techniques to form images of ultrasmall objects on ultrafast timescales.

www.engr.colostate.edu/ultrafast
CSU Leads Five-University Seismic Project to Raise the Height of Wood Construction

The National Science Foundation estimates that more than 75 million U.S. citizens in 39 states live in areas at risk for earthquake devastation. Single-family homes in North America are primarily constructed of wood because of its energy-absorbing properties and demonstrated ability to withstand the effects of wind, major storms and seismic disturbances.

In recent years, however, low-rise woodframe buildings have sustained significant structural and non-structural damage from earthquakes. The January 1994 Northridge Earthquake near Los Angeles was the most damaging in the U.S. since the San Francisco Earthquake in 1906.

Past research on load paths in woodframe construction during earthquake shaking is limited. Colorado State is heading a new study that is the first step in moving toward performance-based design for woodframe structures of all sizes. The four-year project is funded by the National Science Foundation as part of the Network for Earthquake Engineering Simulation (NEES).

NEESWood is a consortium of researchers led by John van de Lindt, associate professor of civil engineering at Colorado State. Co-principal investigators are Rachel Davidson (Cornell University), Andre Filiatrault (State University of New York at Buffalo), David Rosowsky (Texas A&M University) and Michael Symans (Rensselaer Polytechnic Institute).

The NEESWood project team is developing a new design philosophy for mid-rise woodframe construction in regions of moderate to high seismicity. Full-scale testing of a two-story woodframe structure is ongoing at SUNY-Buffalo. Testing on a one-story woodframe model was completed at Colorado State University’s structures laboratory last summer. The NEESWood two-story test is the largest full-scale three-dimensional shake table test ever performed in the U.S. and the largest wood structure test ever performed in the world. The results will serve as a benchmark for both woodframe performance and nonlinear numerical models for seismic analysis of woodframe structures.

Initially simulating the effects of a major earthquake on a 160-square-foot, one-story building on a “shake table” at Colorado State, van de Lindt and his five-university team will progress to seismic analysis and testing of taller buildings at participating institutions before concluding their tests on a mid-rise (six to seven story) multi-family residential woodframe apartment building in Miki City, Japan. Collaborations between NEES and Japan’s National Institute for Earth Science and Disaster Prevention E-Defense Project will serve as a basis for a globally seamless network for earthquake engineering.

www.engr.colostate.edu/NEESWood/

The Impact of Packing

In 1611, Johannes Kepler made a cryptic and loosely-explained assertion that “fruitstand” packing of equal spheres, such as that seen in a stack of oranges, was the tightest possible packing for these solids. Utilizing some of the same mathematical principles, civil engineering Professor Paul Heyliger is studying assemblies of spheres and other curvilinear particles to expand our knowledge of how the structure and properties of collections of individual particles influence the number that can be packed into a particular volume and how they respond to external load.

Components such as stress and elastic stiffness are being investigated in a variety of two- and three-dimensional shapes including circular discs, ellipses, chips, spheres, spheroids and combined octants of ellipsoids known as potatoes. Problems involving particle compaction can be extremely complex and include particle rearrangement, stick and slip of the contact regions, and changes in the number of contact points. The numerical analysis of points of contact is another aspect of this research that will be of interest to industry due to the resulting stress on the particles.

Heyliger’s work may impact the future design of products and packaging in the materials, food processing, and drug industries. For example, the understanding of mechanical behavior of tablets is important to the pharmaceutical industry because of the influence of pill shape on packing properties and the subsequent stresses that can lead to defects in the tablets. Materials formed by powder compaction can yield similar features. Heyliger’s research could be an important step in developing the next generation of materials whose manufacturing and processing involves these novel structural systems.
Proteomics May Be the Key to Successful Cardiac Surgery

Cardiovascular disease is the single leading cause of death in America and results in more than 16 million deaths worldwide. Heart valve replacement is an important treatment for people with heart disease; however, the ideal prosthetic heart valve has not yet been developed. Currently available prostheses include bioprostheses (artificial heart valves fashioned from animal tissues such as pig valves) that sometimes undergo immune rejection by the patient. One solution to the development of a better heart valve prosthesis would be a "living" tissue-engineered heart valve made from the combination of animal tissues and the patient's own cells. Improving currently available bioprostheses as well as the development of a living tissue-engineered heart valve depends on gaining a better understanding of the immune rejection process.

Ken Reardon, professor of chemical and biological engineering, has formed a new collaboration with Professor Chris Orton, head of the cardiac surgery team at the Veterinary Teaching Hospital, to understand why donor tissue is sometimes rejected. They are developing methods for screening a large number of proteins for the critically important property of antigenicity, or the degree to which a substance induces an immune response, across species. To accomplish this, Reardon and Orton are using proteomics to look at all of the proteins in the tissues used for bioprosthetic heart valves.

Proteomics is a new focus in the field of biotechnology that enables a system-wide analysis of proteins produced by cells. With proteomics, researchers can detect proteins that elicit an immune response, and subsequently identify the protein antigen, categorize the antigens into broad groups according to their origin, and then place them into smaller categories according to structure, type, physical and chemical properties.

By exposing separated proteins to naturally-occurring and acquired antibodies, Orton and Reardon will determine which proteins are responsible for the antigenicity of biomaterials, and this knowledge can be used to develop strategies to selectively remove those proteins. This study will provide important insights about the bioprostheses and about tissue transplantation in general.

www.engr.colostate.edu/bep/faculty.html
Breakthrough Technology Will Make Solar Electricity Mainstream

The world’s six billion inhabitants currently use the energy equivalent of 400 trillion megawatt-hours of electricity per year – the output of 300,000 typical power plants. If all the world’s inhabitants could afford the cost and had access to electric power lines, this figure would be far greater.

With the world’s population expected to reach over eight billion by the year 2025, an increase of 80 percent in annual global energy production will be required, or almost 12 trillion barrels of oil per year. At this rate, scientists are predicting that fossil fuel use will peak by the year 2030. As oil, coal, nuclear and natural gas reserves decrease and environmental problems escalate, the use of renewable energy is expected to increase significantly from the current levels.

Clean renewable energy sources include wind energy, solar energy including photovoltaics, geothermal energy and hydroelectric power. To be effective, these technologies must be reliable and inexpensive to produce. However, wind and geothermal energy sources are suitable only in some regions.

Efforts are underway at Colorado State to make renewable energy more cost-effective and efficient for widespread use. By using byproducts of the copper and zinc mining industry and turning ordinary window glass into solar panels, a team of investigators has developed a manufacturing technology that can turn photovoltaics into the most cost-effective, clean and efficient energy source on the market.

The team first demonstrated this technology on a machine that produces 3”x3” solar cells; they will be producing 16”x16” modules that have 25 times more output. The innovations they have made in the areas of production process, production hardware and design of PV modules have the potential to reduce the cost of manufacturing PV modules to less than $1/watt. At these costs, solar electricity will be competitive with current methods of electricity generation in most areas of the U.S. and the world.

www.engr.colostate.edu/me/facil/mel/index.html

Energy Facts

- Today more than two billion people—one-third of the world’s population—live without electricity, using kerosene and other polluting fuels to light their homes.
- It takes 1500-3000 watts to power a U.S. home, not including heating and cooling loads.
- Crystalline silicon accounts for approximately 95% of the PV market.
- Silicon of very high purity is needed by the microelectronics industry, and the feedstock for crystalline silicon is limited.
- It takes three to four months to recoup the energy using this new method, versus five to six years with traditional Silicon-based PV modules.

Comparison of Production Methods with Current PV Technology:

- 100 times less purity required for feedstocks
- 100 times less semiconductor material required than with silicon solar cells
- Lower manufacturing costs due to simple hardware
- Lower cost raw materials and window glass substrates
- Fully automated, fast processing, resulting in excellent reliability and high efficiency
- Production at the rate of one cell every two minutes; five to ten hours of production will produce enough PV modules to power a home.

Benefits of Photovoltaics

- Distributed energy generation: Electricity produced where it is needed
- Energy security: Domestic energy resource
- Energy independence: Reduction in dependence on foreign energy
- Lower cost: Not affected by fluctuating fuel costs
- Production of high tech industry jobs: 40% annual growth in the last four years in the PV industry
- Reduction in environmental pollution and greenhouse gases

The Research Team

Since 1991, mechanical engineering Professor W.S. Sampath and research associates Kurt Barth and Robert “Al” Enzenroth have been developing innovative thin-film technologies for the mass production of PV modules.
It is an exciting time in the College of Engineering at Colorado State University!

As this issue illustrates, we are truly meeting the challenge of “engineering global solutions.” Outstanding faculty, students, and staff make it happen every day. Curiosity and discovery are at the heart of our research. Innovation and its application in meeting societal or market needs are the drivers for economic development having global impact. We strive for developing two-way, interdependent relationships with our public and private partners as we, together, engineer these global solutions. Learn more about our economic development initiative at www.engr.colostate.edu/research/econ_dev.

We hope you enjoy this year’s Research Angle. Please let me know how we can work together.

Wade O. Troxell, Associate Dean for Research and Economic Development
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Join us for Engineering Innovation Breakfasts featuring updates on technological trends and innovative research projects and academic programs. If you or a colleague would like to learn more about engineering at Colorado State, call (970) 491-7028 for program details.