Dear Alumni and Friends,

Colorado State University’s College of Engineering is proud of the important work that is done by our faculty, staff, and students. This publication provides just a few examples of current projects to improve human health, to save lives, and to understand and protect our environment.

This is work with “purpose” – work that is done to solve an important problem and to meet a need. These projects have a global impact, resulting in new technologies or new knowledge that is carried into the classroom, impacting thousands more CSU students.

The College of Engineering is “on the move.” We are growing our enrollments, our research programs, and our faculty. More importantly, we are creating new opportunities for our students. One such opportunity is our new cooperative education program (page 18). This program provides our industry and corporate partners with access to great talent and provides our students with practical work experience, making CSU graduates among the most well-prepared for work upon graduation.

It is an honor to serve as dean of CSU’s College of Engineering. I hope you will enjoy reading this publication and will visit CSU often!

Warm Regards,

Sandra Woods

Mission

The College of Engineering’s mission is to do purposeful work that impacts our global society. This important work includes:

• Providing an excellent education for students,
• Generating new knowledge,
• Applying that knowledge to develop and implement solutions for global problems,
• Working with internal and external partners to conduct meaningful engagement, and
• Stimulating local, regional and global economic development.
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This publication was funded by generous gifts from our alumni and friends. We are deeply grateful for your support! Printing of this publication represents less than 0.01% of the College’s annual expenditures.
Researchers Tackle a Disease
Once Thought Defeated

In the year 2012, it’s difficult to imagine that one-third of the world’s population is infected with the bacterium that causes tuberculosis. This seemingly Old World disease continues its stranglehold on humankind despite advances in vaccine technology, diagnostics, and treatment. In fact, *Mycobacterium tuberculosis* drug-resistant strains began to emerge in the 1980s, dashing hopes that the disease could be eradicated.

Against this backdrop, researchers at Colorado State University and in tuberculosis laboratories around the world are in a race against time to find, test, and bring viable drugs to market — if not to rid the world of tuberculosis forever, at least to bring better treatment to the millions of people worldwide who suffer from the disease’s wrath. The task is not easy. Drug companies have many thousands of compounds in their library. Determining which of these compounds has potential as a tuberculosis drug requires testing on a massive scale. And then, even when drug candidates have been identified, researchers must look for toxic effects that would prevent the drug from ever getting to the marketplace. Dr. Brad Reisfeld, an Associate Professor in the Department of Chemical and Biological Engineering, is deeply involved in these efforts, using engineering and mathematical modeling to better understand and predict the effectiveness and toxicity of drugs and other compounds in the body.

“Our aim is to reduce animal testing and failed clinical trials, both of which are costly in terms of time, money, and animal life,” said Dr. Reisfeld. “Using biologically based modeling, computer simulation, and targeted experimentation, we hope we can improve on both these counts while dealing with a huge number of possible drug candidate and drug candidate combinations. Ultimately, my dream is to develop ways to improve therapies to treat not only one of the world’s most intractable infectious diseases, but all infectious diseases.”

Treatment for tuberculosis today largely depends on the physician treating the patient, and where in the world the patient resides. Tuberculosis treatment is particularly challenging in the developing world because treatment plans, which can last six months to 24 months, are difficult for patients to maintain. Part of the body’s reaction to the bacterial infection is to encase the bacteria within masses of immune cells known as granulomas. These cellular structures hinder the entry of drugs and are thought to enable the disease to re-emerge as patients age or immune systems are compromised by other factors.

“We are doing work on understanding granulomas as well as trying to develop better ways to get drugs into the granulomas to kill the bacteria harboring there,” said Dr. Reisfeld. “We work cooperatively with our colleagues in the Department of Microbiology, Immunology and Pathology who have been at the front lines of tuberculosis research for several decades.”

After completion of his doctoral degree at Northwestern, Dr. Reisfeld completed a postdoctoral fellowship at Johns Hopkins Medical School.
in biomedical engineering where he was investigating controlled drug release for the treatment of brain tumors. He entered industry for eight years before applying to the National Institutes of Health for a career development award. That award took him to Colorado State University and the Department of Environmental and Radiological Health Sciences. In 2006, he joined the Department of Chemical and Biological Engineering, where he maintained an interest in the effects of foreign chemicals (e.g., environmental pollutants and drugs) on human health, particularly as related to using quantitative models that could be used to replace animal experiments.

In his laboratory today, Dr. Reisfeld works with a team of undergraduate and graduate students in achieving two main goals: exploring the fate and disposition of environmental pollutants in the body to improve the risk and safety assessment for these chemicals; and quantifying the transport, biodistribution, interactions, and effects of drugs/antibiotics in the body to optimize therapies for the treatment of infectious diseases. Each of his students has their own research project that fits into the lab’s larger themes, providing undergraduate students a chance to hit the ground running when they apply to graduate programs or are ready to enter the workforce. The Reisfeld laboratory is home to a diverse group of students, with majors ranging from chemistry and biological engineering, to biology and computer science. Also in the group are two senior colleagues who are involved in research and student mentoring: Dr. Arthur Mayeno, an expert in organic, analytical, and computational chemistry; and Dr. Mike Lyons, an expert in physics, mathematics, and computational modeling. In a lab that is interdisciplinary, ready access to multiple fields of expertise is a great benefit and provides a way for the group to undertake challenging and relevant problems in the biosciences.

“We are trying to develop ways of optimizing drug therapy by understanding where the drug goes in the body, what it does there, and how we can balance the efficacy of the drug versus toxicity,” said Dr. Reisfeld. “In addition, we want to better understand how the immune system interacts not only with the drug, but with the pathogen, and also be able to prioritize chemicals that might make it into clinical trials. We use chemistry, biology, mathematics, computer modeling, engineering, and targeted experiments, all in a team framework to work efficiently toward our goals. It’s the only way we’ll be able to tackle the challenges of tuberculosis and other infectious diseases successfully.”

Dr. Reisfeld received his bachelor’s degree from the University of California, Davis, in chemical engineering, then went on to Penn State for his master’s in chemical engineering, and Northwestern for his Ph.D.

Brad Reisfeld
“Ultimately, my dream is to develop ways to improve therapies to treat not only one of the world’s most intractable infectious diseases, but all infectious diseases.”
From Workstation to Island Oasis, Researcher Works to Improve Climate Models

Growing up in northern Illinois, Eric Maloney experienced firsthand booming thunderclaps, billowing clouds, and downpours that seemed to be the essential experience of “raining cats and dogs.” As a pre-teen, he once videotaped a tornado from his front door, punctuated by the sounds of his mother yelling at him in the background. Since then, Dr. Maloney has traveled from his colloquial roots in weather observation to a global research program at Colorado State University and aims to build a better understanding of tropical meteorology, particularly as related to tropical precipitation.

This fall, Dr. Maloney will be heading to the Maldives as part of an international field program called DYNAMO (Dynamics of the Madden-Julian Oscillation), occurring in the Indian Ocean. Researchers will deploy weather analysis equipment on land, sea, and in the air, generating data to help better describe the Madden-Julian oscillation, a weather phenomenon in the Indian and Pacific oceans that enhances precipitation every several weeks. Students from the College of Engineering also will be participating in the project, mostly assisting in the launch of weather balloons from Diego Garcia and Malé. Though he usually can be found in front of a computer screen, Dr. Maloney notes the opportunity to participate in field work will enhance his ability to translate weather data into more refined climate models.

“Computer models don’t simulate tropical precipitation very well, and part of what we would like to do is improve representation of large-scale precipitation in climate models,” said Dr. Maloney, who joined Colorado State University in 2008.

“Tropical precipitation is fundamentally important for...
understanding the climate system and how it works. If we want to simulate that system correctly, we better get tropical precipitation in our models right. As we look to the future, it’s critical that we be able to make reliable projections of climate, and to do that we have to understand what controls tropical precipitation.”

The Madden-Julian oscillation (detected in 1971 by Roland Madden, an alumnus of Colorado State University, and Paul Julian) is a 40-50 day oscillation, occurring three or four times a year, that involves variations in wind, sea surface temperatures, cloudiness, and rainfall. The oscillation not only affects tropical weather, but also has a profound impact on global wind patterns.

Now, Dr. Maloney is working to understand what controls tropical precipitation and what influences its variability, including ocean-centric patterns such as the Madden-Julian oscillation, and the El Niño and La Niña southern oscillation, a climate pattern that occurs across the tropical Pacific Ocean roughly every five years. The MJO starts in the Indian Ocean near the equator and slowly moves east over Indonesia, and then into the tropical Pacific Ocean. It dies out as it gets to the central Pacific Ocean. The MJO pulls in air at lower levels, and then ejects air outward high in the atmosphere. It can create large-scale winds that extend over the Atlantic Ocean, and can cause variations in hurricane activity.

“In our work, we are trying to better understand the Madden-Julian oscillation and determine how to better characterize it in climate models,” said Dr. Maloney. “Our research work in the Maldives will give us on-the-ground data that should help us better determine conditions leading to creation of the oscillation as well as improve forecasted impacts of the oscillation on hurricanes and other phenomena as it travels eastward. With better data, we will be able to improve our climate models. With better models, we will be able to improve our predictions for the impact of climate change on these patterns, and more reliably project how global warming will affect global weather systems.”

Despite Dr. Maloney’s long interest in weather and climate, he started out as a physics major. He considered atmospheric sciences as an undergraduate student at the University of Illinois, Urbana-Champaign, but decided on physics as a strong foundation from which to build. While at Illinois, he worked with faculty members in atmospheric science and his interest was rekindled. He decided to continue on to graduate school, heading to the University of Washington, Seattle, where he met his mentor, Dr. Dennis Hartmann, who introduced him to the field of tropical precipitation variability.

“He laid out a series of options – and that meeting with him set the course for my professional career,” said Dr. Maloney. “It’s amazing how one person can determine the direction your life will take. I keep that in mind when I’m advising my students.”

Dr. Maloney finished his Ph.D. in 2000, and then received a Climate and Global Change Postdoctoral Fellowship from the National Oceanic and Atmospheric Administration. He went to work at the National Center for Atmospheric Research in Boulder (with which he still partners on research projects), where he worked for two years before moving on to Oregon State University where he was an assistant professor in the College of Oceanic and Atmospheric Sciences. The NSF Science and Technology Center for Multi-scale Modeling of Atmospheric Processes brought him to Colorado State University, where he found a home to further pursue his climate modeling ambitions as well as provide mentorship to future atmospheric scientists.

Currently, Dr. Maloney has five graduate students and a postdoctoral fellow in his laboratory, four of whom will be going to the Indian Ocean to assist on the MJO project. His current students and projects are:

- **Walter Hannah**: developing new ways of representing precipitation in climate models to improve aspects of tropical variability.
- **Gus Alaka**: studying why atmospheric wave disturbances in West Africa show intermittent strengthening and weakening and the implications for Atlantic hurricanes.
- **Adam Rydbeck**: studying to what extent climate variability in the western Pacific controls climate in the eastern Pacific.
- **Stephanie Slade**: developing a statistical prediction model for Atlantic hurricanes with a two-to-three week lead time.
- **Brandon Wolding**: a new student who will most likely focus on high resolution or regional climate models studying tropical precipitation.
- **James Benedict**: a CSU graduate and postdoctoral fellow, who is working to improve the representation of tropical precipitation in climate models.

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**Participants in the Indian Ocean studies** include the National Center for Atmospheric Research, the University of Miami, Oregon State University, the University of Washington, and Texas A&M, as well as participants from 10 countries, including meteorologists from the Maldives.
The course of world history often is thought to be determined by dynamic leaders, fortuitous discoveries, catastrophic events, or errors in navigation. But soil moisture?

The French invasion of Russia in 1812 marked a turning point in Napoleon Bonaparte’s fortunes. Bogged down in the Russian “rasputita,” or quagmire season of mud, his army was badly damaged and never recovered. Hitler’s invasion of the Soviet Union during World War II also was strategically hindered by the season of mud, slowing down the German advance and helping to save the Soviet capital, Moscow.

Understanding factors affecting soil moisture conditions and advancing geomorphic mapping are all part of the work Dr. Jeff Niemann conducts with his research team in the Hydrologic and Water Resources Computing Laboratory. Like the Russian rasputita, soil conditions are not only critical to military campaigns, but also to agriculture, infrastructure development, environmental quality, and even the prevalence of infectious diseases.

“When I was a faculty member at Penn State, I received a Presidential Early Career Award for Scientists and Engineers to look at the interaction of topography and soil moisture, and that launched me in this direction,” said Dr. Niemann, an associate professor in the Department of Civil and Environmental Engineering. “The grant gave me a 10-kilometer grid. That type of resolution is nearly useless to military planners. We want to use weather-related models to get that resolution down to one kilometer, then use the topography and other information to get useable grid cells around 10 or 30 meters. High resolution of soil moisture mapping is critical to successful planning.”

Using measurements in the field, numerical models and fine resolution software tools, Dr. Niemann and his research team are developing software that can be deployed to help field officers plan for conditions they can’t see. Field locations in the Poudre Canyon and Piñon Canyon Maneuver Site in southeastern Colorado provide real testing sites to determine what occurs naturally in the soil. Data including topographic curvature, upslope land area, and slope angles, as well as soil and vegetation characteristics help determine soil moisture. The challenge, noted Dr. Niemann, is to distill and make assessments with as little data as possible.

Dr. Niemann noted that his research would not be possible without the hard work of his undergraduate and graduate students.

Above, graduate student Greg Steed, Professors Tim Gates and Jeff Niemann and undergraduate student Justin Kattnig, collect data at a well on a ranch along the Arkansas River north of Buena Vista, Colorado. On the next page, graduate students Mike Coleman and Shaina Sabatine are members of Niemann’s research team measuring soil moisture.
They do all this while I just guide them,” said Dr. Niemann, who also teaches Water Engineering for International Development. “Mike Coleman, a Ph.D. student, is developing the methodology and has done a lot of the field work with the involvement of other graduate and undergraduate students who get a great research experience. Without them, we would not be able to take on the scope of work that we have in the group.”

As the software evolves, two pathways to deployment are under investigation. In the first, the software will be embedded in the Weather Impact Decision Aid, software that will be on the laptops of commanders in the field. This is a tactical decision aid to gauge how weather will affect activity, taking weather variables to make stoplight maps of green, yellow, and red for routing, bivouac, and operations planning. Soil moisture would be added to this software for use in decision making. The other pathway is software for the Engineer Research and Development Center, located stateside, for “reach backs,” where questions come in from the field and are answered by a central staff.

Military applications are just one aspect of soil moisture research, said Dr. Niemann, with civilian and humanitarian needs in soil moisture mapping another area of interest. One area of particular interest to Dr. Niemann is the use of soil moisture mapping to predict ponding and outbreaks of infectious disease, such as malaria and Dengue fever, associated with increases in mosquito populations.

“This is an area of interest and certainly something I’m very passionate about,” said Dr. Niemann, who recently returned from Gabon where he was helping to develop water and sanitation systems for medical clinics, orphanages, and homes for widows. “If we can use this technology to not only help keep our soldiers safe, but also to help save lives in the developing world, that would be a very good thing.”
From the Power Grid of 1890s to the Smart Grid of the Future, Researcher’s Work in Signal Processing Helps Take Power to the Next Generation

Originally built in the 1890s, and improved and expanded as technology advanced and the population grew, the power grid in the United States is now straining under the weight of demands that are increasing almost exponentially. Researchers across the country, including at Colorado State University, are collaborating on ways to transform the current power grid to a Smart Grid that allows for two-way communication between utilities and their customers, and is able to respond quickly to changing electric demand.

Dr. Liuqing Yang, an associate professor in the Department of Electrical and Computer Engineering, understands intimately the challenges this transformation presents. Trained as a power engineer, her early career focused on traditional aspects of power generation and she worked as an instructor at China’s Power Institute. When she came to the United States from China for graduate work, she focused her master’s and Ph.D. studies on digital signal processing and its applications in various fields including wireless communications, technologies to complement GPS systems, and, eventually, power systems. Signal processing deals with operations on or analysis of signals, including those generated in the creation, distribution, and use of power.

“What with my power background and my graduate work in signal processing, I was constantly looking for projects that would bind the two fields together,”
said Dr. Yang, who joined CSU in 2010. “At CSU, I now have several areas of research, including projects rooted in the development of the Smart Grid, which I am very excited about.”

The main difference between the Smart Grid and a “dumb” grid, notes Dr. Yang, lies in the neurosystems that allow for two-way communication and networking. Her research focuses on improving communication through facilitating both wireless and wired communication and networking. An improved Smart Grid will allow for the more efficient transmission of electricity, quicker restoration of electricity after power disturbances, reduced peak demand, better integration of customer-owned power generation systems (e.g., rooftop solar panels and backyard wind turbines), moving from one-directional (power plant to customer) to multi-directional systems (power plant to customer, customer to power plant, customer to customer, etc.), and the increased integration of large-scale renewable energy systems (e.g., wind and photovoltaic “farms”).

“For example, if we have a homeowner with solar panels, we would design communication systems that would get household appliances like stoves and refrigerators to use that energy first, turning to the power grid second, for optimum resource allocation,” said Dr. Yang. “In order to do that, we have to improve the processing of signals for the grid, increase integration of renewable energy resources, and understand that we are moving from big central power plants to decentralized power generation. Another factor is the high variability endemic to renewables – the sun isn’t shining and the wind isn’t blowing 24 hours a day – so we have to build that power variability into our Smart Grid as well.”

Patterns of usage also present challenges, particularly as electric cars become more popular and draw huge loads during typically low-usage times; and patterns become unpredictable as drivers try to power up wherever they happen to be. Charging and travel patterns are a particular challenge to the power structure, said Dr. Yang, confounding planning efforts. Advanced signal processing becomes a key tool in helping utility companies tackle these new realities.

“Most of the work in my research lab focuses on advanced tools in processing signals in the power grid,” said Dr. Yang. “In the past, we didn’t have many signals to work with; but nowadays PMUs (phasor measurement units) are widely deployed to assess the health of the power system. We are in the process of developing new tools that will allow us to make advances in enhancing the stability of the power grid, transform into a Smart Grid, and begin the design and development of intelligent transportation systems.”

Tied closely to the power grid, the development of intelligent transportation systems (ITS) involves improving transportation safety and mobility through the integration of advanced communication technologies into the transportation infrastructure and in vehicles. ITS encompasses a broad range of wireless and wired communications-based information and electronics technologies. Dr. Yang serves on one of the technical committees with the Intelligent Transportation Systems Society and an IEEE Smart Grid Vision Project group, and said being able to participate in the creation of the next generation of intelligent power and transportation systems (built on the scaffolding of the old), is both challenging and rewarding.

“The Smart Grid is the main reason I came to Colorado State University, because of all the groundbreaking work underway here,” said Dr. Yang. “Colorado is well known for its Smart Grid industries. Without my colleagues here, without colleagues in the bigger society, and without our graduate students who do so much of the hard work, it wouldn’t be possible to make the Smart Grid a reality.”

Dr. Yang’s research is supported with funding from the National Science Foundation, Office of Naval Research, Air Force Research Laboratory, Army Research Office, Air Force Office of Scientific Research, and DOCOMO USA Labs. She also collaborates with Western Electricity Coordinate Council, and NEC Laboratories.

Dr. Liuqing Yang received her master’s degree and Ph.D. from the University of Minnesota, focusing on digital signal processing. She joined CSU’s Department of Electrical and Computer Engineering in 2010.
Electric Cars on the Move
Linking Transportation Infrastructure with Power Infrastructure

Quietly, almost imperceptibly, a revolution is underway. Electric cars, once the toys of hobbyists and darlings of environmentalists, are going mainstream. Given current purchasing patterns, the Nissan Co. estimates that by the year 2020, one in 10 cars worldwide will run on battery power alone. Tesla Motors’ market research estimates that by the year 2020, 30 percent of vehicles will be battery electric or plug-in hybrid. As the author Malcolm Gladwell would put it, electric cars have almost reached the tipping point.

But how to power all these millions of cars is the question that is on Dr. Siddharth (Sid) Suryanarayanan’s mind.

“The expansion of the electric fleet can only happen if we are able to build a viable Smart Grid on top of the existing legacy power grid,” said Dr. Suryanarayanan, an assistant professor in the Department of Electrical and Computer Engineering. “We have to build the infrastructure that will support the transformation of our transportation system, but we have to build that infrastructure on foundations created more than a century ago. Starting over really isn’t an option.”

Dr. Suryanarayanan works in the area of modern electric power systems, particularly on the design, operation, and economics of finite-inertia power systems and integration of renewable energy to electric grids. Finite-inertia power systems differ from utility power systems in that the capacity and the inertia of generators are small and the distance between various electrical components is short. A shipboard power system is an example of finite-inertia power, as is an off-grid home powered by solar, wind, or other alternative energy sources. His research includes the development of microgrids, where customers can become “utility company partners;” how to transform the legacy power grid into the Smart Grid; developing efficient interconnections and transmission between energy producers (including wind and solar) and end users (including plug-ins and hybrids); and the development of energy-efficient buildings.

“The United States is showing leadership in this area, thanks in large part to funding made available through the Energy Independence and Security Act, and the Stimulus Act,” said Dr. Suryanarayanan. “There are a lot of things happening in the background, of which end users are not aware. To work, this transformation needs to be seamless as we try to efficiently link the transportation infrastructure with the power infrastructure.”

A challenge with plug-in vehicles, said Dr. Suryanarayanan, is the potential for everyone to plug in when they get home from work, which would create massive electricity draws on power systems. He is looking to develop an intelligent cycling scheme with diverse charging areas. By taking the problem apart and turning it into a mathematical problem, he can develop algorithms, put the variables into a computer, and “start crunching.” The concern is to create a system of high reliability when there is a diversity of energy sources, multiple peak demands and generation cycles, and the need for intelligence in the delivery, resource selection, and use of power. In his laboratory, Dr. Suryanarayanan’s undergraduate and graduate students provide the bulk of the research groundwork, gaining valuable experience to help direct their career and academic decisions.

His research is getting noticed at the national level. Dr. Suryanarayanan was selected to attend the National Academy of Engineering symposium in September 2011. To attend the symposium, approximately 315 participants – aged 30 to 45 years, who are performing exceptional engineering research and technical work in industry, academia, and government – were nominated by fellow engineers or organizations. From these nominations, 85 participants were chosen by a selection committee. The symposium, held at Google’s headquarters in California, examined developments in additive manufacturing, engineering, sustainable buildings, neuroprosthetics, and semantic processing. Closer to home, the School of Global Environmental

Siddharth Suryanarayanan

“The expansion of the electric fleet can only happen if we are able to build a viable Smart Grid on top of the existing legacy power grid.”
Sustainability at Colorado State University named Dr. Suryanarayanan as one of its Resident Faculty Fellows and awarded funds to further his research in the advanced electric power systems of the Smart Grid initiative. In the last year, Dr. Suryanarayanan co-authored an article on futuristic energy management of buildings that won best prize in the Institute of Electrical and Electronics Engineers (IEEE) Industry Applications Society’s flagship conference. Another article he co-authored in 2010 on the evolution of the Smart Grid on electric distribution systems is listed among the top 25 hottest articles of 2010 by Elsevier’s The Electricity Journal.

Dr. Suryanarayanan completed his undergraduate work at the University of Madras, and then attended Arizona State University, where he could explore his interest in power energy, completing his master’s degree and Ph.D. in electrical engineering. He joined Florida State as a research faculty member before taking a tenure-track position at the Colorado School of Mines. While at CSM, Dr. Suryanarayanan became aware of what was going on at Colorado State University, where faculty members in the College of Engineering were taking the lead in energy research and education, particularly in the Engines and Energy Conversion Laboratory. He joined CSU in 2010.

Dr. Suryanarayanan works in the area of modern electric power systems, particularly on the design, operation, and economics of finite-inertia power systems and integration of renewable to electric grids.
Development of New Heart Valves Blends Fields of Fluid Mechanics and Medicine

If you step into Dr. Prasad Dasi’s cardiovascular and biofluids laboratory, you may feel yourself having an Edgar Allen Poe moment, a la “The Tell-Tale Heart.” To refresh your high school English, the protagonist is driven to insanity by what he thinks is the sound of his murder victim’s heartbeat emanating from beneath the floorboards. But Dr. Dasi’s lab is not designed for ghoulish purposes. Rather, its intention is to assist in the development of new cardiac devices such as heart valves that may one day improve and even save the lives of individuals with structural heart disease.

The human heart is a marvel of engineering. An intricate “device” comprised of valves and pumps, made out of muscle, connective tissue, and vessels, its sole purpose is to pump blood throughout the body’s blood vessels with rhythm and repetition. A healthy human heart, beating at 72 beats per minute, will beat approximately 2.5 billion times during the average human lifespan. The challenge when something goes wrong, like a defective valve, is replacing it with something that will work as well and for as long as the real thing.

Cardiovascular biomechanics may not seem an obvious area of choice for an engineer whose expertise is in the physics of fluid mechanics but, said Dr. Dasi, fluid mechanics is basic to the heart’s design, and to the designs of cardiac devices that try to replicate nature.

“I looked at my area of expertise, the physics of fluid mechanics, and wanted to apply that to something that could make a difference,” said Dr. Dasi, who completed his bachelor’s degree at the Indian Institute of Technology Bombay in India, and his master’s and Ph.D. in civil and environmental engineering at Georgia Institute of Technology. “For a number of years, my focus was understanding turbulence, particularly with regard to turbulence and the way it mixes pollutants in the air and water.”

After six years working in turbulence and fluid dynamics as a graduate student at Georgia Tech, Dr. Dasi took up a postdoctoral position in the Joint Department of Biomedical Engineering at Georgia Tech and the...
School of Medicine at Emory University. In 2004, he began postdoctoral work on improving the design and function of prosthetic heart valves, and understanding the biomechanics of single ventricle heart defects before and after surgical correction. Dr. Dasi joined Colorado State University as an assistant professor in the Department of Mechanical Engineering in August 2009.

“I was interested in what happens from a fluid dynamics perspective, as to what happens in children with congenital heart defects when a surgeon tries a mechanical fix,” said Dr. Dasi, who now specializes in cardiovascular fluid mechanics. “What we want to do is engineer surgeries to minimize the incidence of turbulence and energy loss to ease the work load on the weak hearts and improve flow of blood so that children can be children — so that they can run and play, and enjoy activities that require higher blood flow throughout the body.”

Replacement valves used in heart surgeries are either mechanical or biological. Mechanical valves are made of synthetic materials and are designed to outlast the patients. However, blood can stick to the valves and create blood clots so patients need to take blood-thinning medicines for life. Biological valves are made from animal tissue or from human tissues of a donated heart or the patient’s own tissues. Biological valves don’t require blood-thinning medications, but aren’t as durable as mechanical valves and eventually need to be replaced. Because of this, mechanical valves are usually used and biological valves are used for older patients.

“One focus area of research in my lab is to improve the design of mechanical valves with a particular emphasis on delivering these valves via minimally invasive surgery, with valves that are made to squish into arthroscopic equipment, then snake down to the spot where they will be deployed,” said Dr. Dasi. “Minimally invasive surgery is better for the patient and can reduce surgical costs substantially. Of course, fluid dynamics and materials will govern the success of any heart valve.”

To take on the design of a better heart valve that would mitigate turbulence and improve flow, Dr. Dasi needed a heart with which he could test his designs. An undergraduate student helped develop a cadaver beating-heart model. A Senior Design Team in mechanical engineering also developed a beating heart simulator to assist Dr. Dasi in his other heart studies.

In addition to research into replacement valves, Dr. Dasi is exploring the formation of congenital heart defects using the zebra fish as a model in collaboration with Dr. Deborah Garrity, an associate professor in the Department of Biology. In January, 2011, he received a grant from the American Heart Association to develop a unified method to develop and validate a new index to capture the severity of heart valve disease in patients who have single or multiple valve diseases and/or hypertension.

“The work of my students has been critical into getting the lab up and running, and creating the tools we needed to conduct our studies,” said Dr. Dasi. “Collaboration with other faculty members in the School of Biomedical Engineering also is an important part of our ability to move forward on all these projects so that we can begin to make a positive impact on the lives of heart patients around the world.”

Graduate students Susan Mazalan, food science and nutrition, and Brennan Johnson, bioengineering, work with Prasad Dasi and Deborah Garrity, associate professor of biology, to explore the formation of congenital heart defects using zebra fish as a model.
The ancient Egyptians considered the brain to be a waste product not worth preserving for the afterlife. Aristotle thought the function of the brain was merely to cool the blood. Hippocrates, the father of medicine, hit the nail on the head.

Men ought to know that from nothing else but the brain come joys, delights, laughter, and sports, and sorrows, griefs, despondency, and lamentations.

Today, at Colorado State University, Dr. Randy Bartels, an associate professor in the Department of Electrical Engineering, has partnered with researchers in the College of Veterinary Medicine and Biomedical Sciences in a project that may help to elucidate the most inner workings of the brain. Through the development of new microscopy techniques and tools, Dr. Bartels and his research team hope to eavesdrop on communication in the brain at the molecular level.

“When I came to CSU in 2003, I spent some time trying to figure out what projects I thought were important enough that they were worth spending my time on,” said Dr. Bartels, who heads Colorado State’s Laboratory for Ultrafast and Nonlinear Optics. “I really wanted to pick problems I could see would have a really strong, direct impact on people in everyday life. Eventually, I settled on working on improving biological imaging and diagnostics in an effort to find ways to better understand biology and disease, and maybe help improve the quality of peoples’ lives.

“The problem was that I didn’t have much credibility for working with biological specimens and problems, as I spent my graduate years blowing things apart. But I was motivated to find a way to switch my research direction.” (As a graduate student, Dr. Bartels investigated what happens when you have a light intense enough, such as a high-power short pulse laser, to rip things apart, e.g., what new things would be created.)

Long fascinated by all things scientific, Dr. Bartels had his first “nerdy optics moment” as a young boy flying over Alaska, when he looked out the cockpit window (his father was a bush pilot) and saw a rainbow. And, while rainbows are a fairly common meteorological optical phenomenon, this one was
completely round. A phenomenon known mainly to pilots, atmospheric scientists, and optical engineers, circular rainbows can be seen when the bottom of the rainbow isn’t cut off by the horizon, as happens when observing a rainbow from the ground. It helps to have a seat in the cockpit of an airplane.

Dr. Bartels completed his undergraduate degree in electrical engineering at Oklahoma State University, worked at Lawrence Livermore National Laboratory, and then attended the University of Michigan where he completed his master’s degree and Ph.D. in electrical engineering focused on optics. He is the recipient of numerous awards and honors, including the Beckman Young Investigator Award, Monfort Professor Award, Presidential Early Career Award for Science and Engineering, a Sloan Research Fellowship in Physics, IEEE-LEOS Young Investigator Award, an Office of Naval Research Young Investigator Award, and he was recently elected to the level of Fellow of the Optical Society of America.

The Beckman Young Investigator Award allowed him to build up research experience in developing new types of microscopy, letting him indulge his interest in the biological sciences. Later funding from a CSU Monfort Professor award helped him to extend his efforts in developing new biological microscopy techniques. A grant from the Keck Foundation earlier this year is giving Dr. Bartels the opportunity to create a microscope that could, for the first time, see characteristics of molecules, exchanged between cells, tell cells what to do and how to behave. The new microscope will be constructed in the Keck Laboratory for Ultrasensitive Raman Microscopy that will be housed in the new Engineering II Building. Dr. Bartels, along with his co-principle investigator on the Keck grant, Dr. Stuart Tobet, will eventually test the new Keck Microscope using live tissue samples. Dr. Tobet is Director of the School of Biomedical Engineering in the College of Engineering and a Professor in the Department of Biomedical Sciences, College of Veterinary Medicine and Biomedical Sciences.

“We hope that this will be a transformative technology that we will be able to use to look at small molecules involved with signaling – basically peek in on communication between cells,” said Dr. Bartels. “Using high-speed, 3-D imaging, we want to be able to study the processing in the brain and learn how neurons communicate at the cellular and sub-cellular level. This new technology should enable us to image fast enough to capture dynamics, like action potentials in neural spikes.”

Randy Bartels

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Signaling molecules control biological behaviors spanning from basic human development to attack from toxins. The molecules are so tiny that not even dye techniques – known as fluorescence – used to light up tiny particles can reveal their properties. New imaging techniques could potentially have an impact on understanding the molecular biology of normal cells as well as abnormal cells, like cancer cells, suggesting new treatment pathways for a host of diseases.

Dr. Bartels joined Colorado State University as an assistant professor in 2003. In addition to his collaborative work in microscopy, his current 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, which includes seven graduate students, is interested in the dynamics of molecules excited by femtosecond (one quadrillionth) laser pulses, particularly in the limits of control over a specific degree of freedom when laser pulses drive the creation of molecular wave packets. The development of this work may help to understand the function of many biological markers in real time and in the living cell.

“We are a very interdisciplinary group with students coming from physics, chemistry, and engineering; and we are helping to bring new technology to help solve very intricate problems involving molecular machinery,” said Dr. Bartels. “Working with our partners in the biomedical sciences, we are trying to solve problems that are at the interface of two or more disciplines – it opens up whole new fields of studies, with new ideas fueled by transformative technologies.”
Clouds Still a Mystery to Atmospheric Scientists; Numerical Cloud Models Increase Our Understanding

The beauty and simplicity of clouds floating in the summer sky belies the mystery that lies within these visible masses of moisture. Whether a thing of beauty, like cirrus clouds painting the early dawn, or a thing of terror, like a descending funnel threatening to unleash havoc, clouds stimulate the imagination and provide atmospheric scientists with a wealth of complex questions that need to be answered as the science of climate moves forward.

“In terms of the sciences, atmospheric science is a relatively young science and offers a world waiting to be discovered,” said Dr. Susan van den Heever, an assistant professor in the Department of Atmospheric Science. “Our group is particularly interested in mesoscale processes (weather systems that generally range from several kilometers to several thousand kilometers horizontally), storm dynamics, and cloud physics, which we investigate through the use of numerical modeling.”

Originally from South Africa, Dr. van den Heever completed her undergraduate degree in mathematics, but took a few atmospheric science classes out of personal interest. After spending two years as a high school teacher, she decided to return the University of Witwatersrand, where she completed her master’s degree in physical geography, and joined a climatology research group that was studying the impact of El Niño and Southern Oscillation on South African drought. Her computer modeling skills took her in the direction of Colorado State University, where she...
of moderate to deep convective clouds in the tropics, including those clouds that form during the genesis phase of hurricanes.

• Exploring how natural aerosols such as dust are ingested into severe mid-latitude storms such as squall lines and supercells, and what impacts this has on the organization and intensity of these storms, on the size and depth of storm anvils, and on the graupel (soft hail) and hail produced by these storms. The impacts of urban areas on downwind precipitation also are being investigated through the aerosols they produce.

• Understanding the vertical and horizontal structure of liquid and ice phase clouds in warm and cold frontal zones. This study uses model output, as well as observational data from NASA’s CloudSat and CALIPSO satellites, and is designed to study the role that clouds and aerosols play in regulating Earth’s weather and climate.

• Exploring the transition from cloud droplets to rain through the use of satellite data such as TRMM and CloudSat, and evaluating how these transitions are represented in cloud models.

• Investigating tropical convective processes using data from CloudSat. The goal of this project is to better understand how efficiently different tropical storm types transport mass, heat, and moisture to the upper troposphere, what levels cloud anvils detrain at (release to the surrounding atmosphere), what kinds of ice crystals make up the anvils, and what impacts this all has on the radiation budget.

• Investigating the relationships between clouds, radiation, land surface processes, and the production of carbon dioxide through the development of an integrated modeling system to represent such processes.

“We have so much to learn about storm microphysics; right now we have more questions than solutions,” said Dr. van den Heever. “When we look at the big picture as it concerns climate change, we really don’t know how cloud processes will change and, in turn, how these processes will impact climate. How will the transport of water vapor and energy change? How will this feedback to the climate? How will storms change? Will we have more tornadoes, drought, hurricanes, snowfall? How will water distribution and availability change? If things dry up, there will be less vegetation and more dust, and that, too, has an impact on climate.

“Understanding key microphysical and convective processes now is important to our understanding of the impacts of future climate change.”
Real-World Experience, Blended with Education, Gives Co-Op Student a Unique Opportunity

In today’s world of quick returns and fast-paced work environments, the challenge for university graduates is how to hit the ground running and quickly become a valuable, producing member of their organization’s team. Combining the need for education with the need for experience can create a push-me-pull-me conundrum. Devote yourself completely to your education, and you may lack valuable experience to build your skills (and your résumé). Devote yourself to extracurricular work and activities, and your grades may suffer, or your time to your degree may stretch beyond your financial ability (or your parents).

For students in the College of Engineering, co-ops offer one viable solution that incorporates education and experience in balance. Julia Taussig, a third-year student majoring in Chemical and Biological Engineering with a certificate program equivalent to a minor in Biomedical Engineering, is currently working for the Dow Chemical Company through its co-op program, allowing her to gain valuable experience early in her academic career that is helping to shape her future.

Dow’s alternating-term co-op program allows students to alternate between periods of study and paid on-the-job training (three terms) while working toward a degree. Students work at different Dow locations across the United States as they move from one assignment to the next. The Dow Co-op Program provides university students the first-hand experience of working for a global company as well as the opportunity to evaluate Dow as a potential full-time employer.

“I completed my first co-op term and was really surprised by how much responsibility I had right away,” said Taussig, who learned about the Dow Co-Op Program while attending the Society of Women Engineers national conference in 2010. “I worked at the Dow Chemical site (I did not work in a plant within the site because I was in the building with people mostly from Environmental, Health, and Safety) in Deer Park, Texas, and focused on environmental projects, including waste, water, and air. “Much of my work involved compliance issues and reports to the Texas Commission on Environmental Quality.”

Taussig’s projects included the development of a checklist for self-audits to make it easier for company employees to comply with pertinent regulations. She worked with her supervisor to develop a spreadsheet to keep track of compliance data surrounding air, recordkeeping requirements, and reporting that data to the state.

Julia Taussig

“I completed my first co-op term and was really surprised by how much responsibility I had right away. It was a great experience, and I also got a better understanding of the importance of what I am learning at CSU.”
Taussig said she was nervous about a temporary move to Texas and being isolated from family and friends, but she soon found a supportive community of Co-ops and new-hires in Deer Park. She also joined the Houston Hillel and a running club (Runner’s High Club), and participated in the BP MS 150 bike race to help raise funds for the National Multiple Sclerosis Society.

“It was a great experience, and I also got a better understanding of the importance of what I am learning at CSU,” said Taussig. “My supervisor had two kids, so air quality was a personal concern for her and her family. As part of my work, I want to make sure companies are responsible to future generations so that they can live happy and healthy lives.”

For Taussig, the day-to-day experiences were only surpassed by two larger lessons.

“Probably the biggest thing I learned is that work is perpetual,” laughed Taussig. “In school, you have a midterm coming up, you study, and it’s done. But at work, I really came to understand the effort and work it takes to move from words to action – how efficiency is important, people come together, tasks are assigned, projects taken on – and how much has to happen to get things done.”

This fall, Taussig will complete her second co-op term at Dow’s international headquarters in Midland, Michigan, where her work will focus on manufacturing engineering.

Cooperative Education Takes Students from Classroom to Workplace

Work experience is invaluable in making career choices, but for many university students those experiences typically occur at the end of their academic career or after graduation. The Cooperative Education Program in the College of Engineering offers students a different option – work full time for a company as early as your sophomore year, then rotate back to school.

The Cooperative Education Program is an academic program in which students work at least three semesters, two of which are fall or spring, in a position related to their major. The work semesters rotate with academic semesters (students often do two work rotations in a row, combining spring and summer semesters, or summer and fall). Co-op students gain at least a year’s worth of experience with the same employer and earn a competitive salary to help support their academic expenses.

“For students, one of the biggest benefits is career exploration,” said Terry Comerford, Cooperative Education Program Coordinator for the College of Engineering. “Co-oping is one of the best ways to study engineering. When students are working, they can apply what they have learned in school. They also get to see where engineers are at five or ten years post-graduation. It gives them the motivation they need to come back and chug through calculus or organic chemistry.”

The Cooperative Education Program in the College of Engineering began in Spring 2010 as a pilot program with Ball Corporation. After the program’s first year, the college administration decided to open the program to more students and more companies, including Wolf Robotics, Delta Airlines, the Federal Highway Administration, and Dow Chemical.

To qualify for the co-op program, applicants must be full-time students at the College of Engineering and be in good academic standing. Students also are required to have completed a minimum of 45 credits toward an engineering degree. Comerford works closely with both the co-op students and the co-op employers to ensure program requirements are met, including submitting an application, a semester planning worksheet, orientations, evaluations, and details with Student Financial Services regarding scholarships, grants, and loan requirements.

“We closely coordinate with the students and the companies to make this the best possible experience for both our students and their co-op employers,” said Comerford. “For students, co-oping provides them a paid opportunity to work in their chosen field. An added bonus is that a substantial portion of their earnings can help them cover the cost of college.

“Students also get to learn more about a company’s culture, build a powerful resume, and develop a network of professional contacts. For the employers, participating in our co-op program lets them get to know our students and invest in someone who may become a valuable permanent employee in the near future.”
From Chef to Hydraulics Engineer: An Unlikely Career Path for ERC Director

If you happened to be driving through Evergreen, Colorado, in the 1980s, you might have stopped for a bite at the Wolfhouse or Tyler’s Tavern. And if you happened to meet the proprietor, Chris Thornton, you might be a little surprised by where he’s at today. As director of the Engineering Research Center, Dr. Thornton manages a complex set of engineering research projects for clients that have included the U.S. Army Corps of Engineers, Colorado Department of Transportation, Federal Highway Administration, U.S. Bureau of Reclamation, and consulting companies.

It’s certainly not the life he would have imagined 20 years ago.

“In early 1990, I realized I needed to do something else,” said Dr. Thornton, who worked as a chef for nine years after completing a chef apprenticeship program. “The hours were incredibly long, and the stress of operating restaurants was starting to take a toll. I was a resident of Colorado, and I enjoyed the outdoors, so I thought I would go back to school and study wildlife biology – and soon realized that was not the best career choice for me. Not knowing what to

Chris Thornton

“This project gives the Army Corps of Engineers a better idea of their options as the reconstruction of New Orleans’ levees continues, and helps them determine what will be the best design to avoid a repeat of the catastrophic breaches we saw during Hurricane Katrina.”
do, I took a statics class and loved it; it was like solving puzzles. I decided then and there that I would get into structural engineering and design wood homes and that was it."

Looking for a job to make ends meet, Dr. Thornton headed over to the office of Dr. Steve Abt, who was at that time director of the Hydraulics Laboratory.

“Steve had a work study position, so I showed up at his office with a ponytail long enough to stick in my pants and a pierced ear,” said Dr. Thornton. “Steve, then Lt. Colonel and now Major General Abt, took one look at me and threw me out of his office. The third time I went back, he told me to clean out one of the large flumes, which took about a week. After getting it all cleaned out, he sent me down the hall to talk to Scott Hogan to sign up for a paying job, and I’ve been here ever since. Now I run the place.”

Dr. Thornton completed his bachelor’s degree in civil engineering, and focused on hydraulics for his master’s and Ph.D. (“I never in a million years thought I would have a Ph.D.,” notes Dr. Thornton). In 1999, he was appointed director of the Hydraulics Laboratory and, in 2005, of the ERC. He also is an assistant professor in the Department of Civil Engineering.

“I really think my job has been to build on the legacy of great engineers like Steve Abt, Jim Ruff, and Daryl Simons, just to name a few,” said Dr. Thornton. “They made a reputation for the water program here at CSU.”

And Dr. Thornton has been busy building on that legacy. In 2009, the U.S. Army Corps of Engineers awarded $1.7 million to Dr. Thornton and his research team to design and build the world’s largest wave overtopping simulator at the university’s Foothills Campus in Fort Collins. The project consists of a specially designed tower and control mechanism, about 28-foot-tall by 7-foot-wide, operated by a computer system that simulates waves larger than the waves that hit New Orleans during Hurricane Katrina. The waves “overtop” the crest of the “levee” and are sent crashing down the 40-foot-long, six-foot-wide “trays,” which represent the levee’s protected side slope.

Researchers at the Army Corps of Engineers Coastal Engineering Laboratory at the Engineering Research and Development Center in Vicksburg Miss., created the trays to simulate different options for levee armoring that can better resist erosion. Levees and their supporting infrastructure are susceptible to erosion and, as a result, can potentially have catastrophic breaches, if overtopped by greater-than-the-design hurricanes and associated storm surges.

“Our studies showed that the use of armored turf significantly enhanced the strength of vegetation and stopped erosion,” said Dr. Thornton, who worked with experts from the Netherlands during the construction of the overtopping simulator. “This project gives the Army Corps of Engineers a better idea of their options as the reconstruction of New Orleans’ levees continues, and helps them determine what will be the best design to avoid a repeat of the catastrophic breaches we saw during Hurricane Katrina.”

For Dr. Thornton, while engineering discoveries, like the efficacy of armored turf, are important, equally important to him is the training of new engineers. The Engineering Research Center is an applied laboratory where teams including undergraduate and graduate students work to solve real-world problems. It’s an opportunity Dr. Thornton was able to take advantage of as a young undergraduate, and it’s an experience he enjoys sharing with today’s students.

“This is a business, and we provide a service to our clients, but we also provide a facility to train engineers,” said Dr. Thornton. “The projects give us the resources that allow us to train world-class engineers. They learn how to work in a group, they have to present at seminars where they can show their strengths and work to strengthen their weaknesses, and they have to get their hands dirty. I teach our Senior Design course and I always start off by telling the students that they’re done being students, they now need to be engineers. Once they’re done here, we know we can send them out in good faith – these are great people to work with.”

Dr. Thornton with Research Associates Bryan Scholl and Jason Berg at the wave overtopping simulator at the Engineering Research Center.