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KANSAS engineer

BIO

New laboratories and degree programs to breathe life into regional economy

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< from the dean >

No Boundaries

KU pursues unlimited opportunities in bioengineering and more

A fabled science fiction TV show of the late 1960s boldly claimed that space was the final frontier. It's a fairly finite statement that observes frontiers through a purely colonial or scouting perspective.

As engineers and researchers we, too, are concerned with exploring new territories, but we aren't so rigid as to think they are only be defined by a geographical context.

The opportunities to investigate new frontiers — whether found at the molecular level of a living cell or under a sheet of ice 3 kilometers thick — are as limitless as the human imagination.

At the University of Kansas School of Engineering new frontiers constantly are being identified and examined. Faculty and researchers here recently completed new laboratory space for use in the new Bioengineering Research Center, or BERC. KU's BERC formalizes the collaborative relationships that have developed in recent years among engineering faculty and investigators at the KU Medical Center and elsewhere on campus.

Led by Dr. Paulette Spencer, D.D.S., Ph.D., BERC's structure will allow it to take a holistic approach to addressing health challenges facing people and the medical community that serves them. With expertise in bioimaging; bioinformatics; biomaterials and tissue engineering; biomechanics and neural engineering; biomedical product design and development; and biomolecular engineering; the center's researchers will join forces with each other and with health care practitioners and industry to develop new tools, techniques and knowledge that have the power to transform.

Learn more about BERC on page 2.

The center's focus extends beyond the health care industry and looks to create a new benchmark for bio-inspired research that addresses the proper care and handling of Planet Earth. Pioneering research in biofuels and biodiesel, efforts in biocatalysis, studies in bioremediation — all these build upon the expertise found within our walls and expand the generally held concepts of new frontiers.

Interdisciplinary efforts such as these are hardly new to the university.

KU centers, such as the NSF Center for Remote Sensing of Ice Sheets, featured on page 8, The Center for Environmentally Beneficial Catalysis and KU's Information and Telecommunication Technology Center all work to integrate and harness the multiple talents of our faculty and their colleagues abroad. Truly trailblazers in their respective fields, our people are pursuing unlimited opportunities in these newly defined frontiers.

Stuart R. Bell

Over the past six months several of our faculty have been identified for their outstanding work. Instructor Ed McBride Jr. was selected for KU's H.O.P.E. Award for his commitment to students. Associate Professor Susan Williams received the university's inaugural award for sustainability for her campus biodiesel program. Distinguished Professor Don Green earned Honorary Membership status in the Society of Petroleum Engineers.

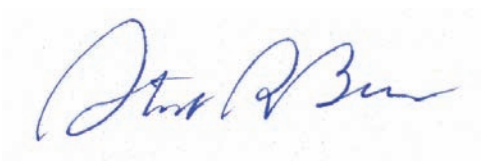
The drive to excel and explore extends to our students as well.

Our Jayhawk Motorsports team, which designs, builds and races a formula-style car, earned second place at the Formula SAE West competition in June. Aerospace engineering students also were recently honored with awards from the American Institute of Aeronautics and Astronautics.

Engineering and computer science alumni are breaking new ground in their endeavors, too. ITC CEO and President Joe Welch was selected by Ernst & Young to be one of the Entrepreneurs of the Year. Petroleum engineering alumna and Royal Dutch Shell executive Linda Zarda Cook was named to Forbes Magazine's 100 most powerful women list.

We know there are many other alumni who are pioneers in their sphere of influence. If you've chosen a path that's taking you into new territory all of us at the KU School of Engineering want to hear about your good news.

Please send us information about your job, your family, or special activities and frontiers you're exploring. You can use the form on the back page or send us an email (jhummels@ku.edu). Your classmates will be interested in what you're doing, and we always like to hear from you.



The Kansas Engineer is published semi-annually by the University of Kansas School of Engineering and is distributed to more than 16,000 engineering and computer science alumni and friends. The Kansas Engineer is not published at state expense.

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The mission of the University of Kansas School of Engineering is to provide its students with the highest quality educational experience possible, to generate and apply knowledge through research, development, and scholarly activity, and to serve society, the state, and the engineering profession.

Photo illustration by Jill Hummels/Kevin Lafferty

Paulette Spencer, DDS, Ph.D., stands in one of the newly renovated laboratory spaces that greatly expand bioengineering research efforts at the University of Kansas. Spencer, a Deane E. Ackers distinguished professor of mechanical engineering, is director of the Bioengineering Research Center at KU.

Time to Get Growing

KU's new Bioengineering Research Center has designs to make the best better

Merriam-Webster's definition of "interface" provides a good view of the expansive development that's been under way at the Bioengineering Research Center at the University of Kansas School of Engineering. In case you haven't cracked the tome lately, here's what M-W has to say.

Interface: *1: a surface forming a common boundary of two bodies, spaces, or phases <an oil-water interface>2: the place at which independent and often unrelated systems meet and act on or communicate with each other <the man-machine interface>*

Many, though by no means all, of the research ideas germinating at the center focus on the interface of native biological materials and manmade devices. Moreover, the center's collaborative approach to its discovery method is all about interface — the blending of seemingly disparate disciplines, each with its own dialect, to produce effective and lasting results.

Dr. Paulette Spencer, D.D.S., Ph.D. and Deane E. Ackers distinguished professor of mechanical engineering, has spent a career analyzing the interface and synthesizing new biomaterials that can repair or replace damaged or diseased native tissues.

"If you know that a material fails at the interface with biological tissues, then you must focus your attention on the interface if you want to develop superior biomaterials," she said. "If I really wanted to be about developing the next generation of biomaterials then in my opinion I had to start at the

Photo by Jill Hummels

A graduate student works on a project in the research lab of Assistant Professor of Chemical and Petroleum Engineering Michael Detamore.

Photo by Jill Hummels

Congressional staff, left, listen as Lisa Friis, right, associate professor of mechanical engineering, explains how a device provides valuable information about her research. Friis has developed a spine analog that can be used in a variety of research applications.

interface. I had to understand what was occurring at the interface that would cause — that would initiate — the failure."

In her role as director of KU's Bioengineering Research Center — BERC for short — Spencer is clear about the prospects and obligations before researchers. They must identify opportunities, investigate trouble spots and then synthesize better or more durable alternatives for the populace. Moreover, the timing for such discovery could hardly be more opportune.

Spencer points to figures from the American Academy of Orthopaedic Surgeons, that physicians in the United States perform nearly 200,000 total hip replacements and 300,000 total knee replacements every year. In addition, replacement materials are used in millions of dental-oral-craniofacial procedures — Spencer's specialty — ranging from tooth restorations to major reconstruction of facial hard and soft tissues. Synthetic replacement materials used in these various procedures often last less than one-tenth as long as the original material, she said. The materials' short clinical lifespans can mean repeated treatment to maintain or even return the patient to a satisfactory level of performance.

> "What the center is about is bringing together what appear to be diverse disciplines, putting that effort toward some common, integrated problems all related to materials and devices and technology development for the biomedical community."

"Our ideal model is the native healthy tissue," Spencer said. "That native healthy tissue is the model we use for all of the chemistry (and) all of the mechanics that our constructs — our synthetic or tissue-engineered constructs — have to realize." BERC researchers also will conduct fundamental studies of healthy biological tissues to better understand their structural properties and features, Spencer said. For example, bone has the ability to repair itself. Researchers need to scrutinize the tissue's ability to undergo self-repair in order to recreate those features and incorporate them into a fatigue-resistant design. "What occurs naturally in healthy human beings are all the same principals we'd like to be able to capture in a material."

Foci for the Future

Over the past several years, the School of Engineering has been quietly assembling a squadron of faculty members and researchers with expertise in bio-related engineering. These core faculty members — anchored in several different departments within the school — have been engaged in building ties and collaborating with counterparts at the KU Medical Center, the School of Pharmacy, the School of Allied Health and the College of Liberal Arts and Sciences. To be sure, their disciplines are diverse, yet when deftly integrated prove to be complementary.

"The research teams working within the center will be able to bridge the gap between clinical, basic and applied sciences," said Stuart Bell, dean of the KU School of Engineering. "I'm confident they will tackle some of the great issues facing patients humankind today and turn theories and discoveries into ideas and products that change people's lives for the better."

Six main areas of activity have been identified for BERC and the corresponding graduate level bioengineering degree programs:

- bioimaging,
- bioinformatics,
- biomaterials and tissue engineering,
- biomechanics and neural engineering,
- biomedical product design and development and
- biomolecular engineering.

Faculty and students will take on a vari-

ety of challenges facing the medical community that range from early diagnosis of disease, especially for various types of cancer; to device development for management of orthopedic injuries; to tissue repair and replacement for both soft and mineralized tissues.

These interdisciplinary research teams have created an environment that promotes collaboration among investigators, Spencer said.

"What the center is about is bringing together what appear to be diverse disciplines, putting that effort toward some common, integrated problems all related to materials and devices and technology development for the biomedical community," Spencer said. By rallying material scientists, engineers, clinical scientists and pharmaceutical scientists to look at related problems, the teams will explore new directions and approaches and identify the next generation of technologies. Working independently, it's unlikely these researchers would ever realize that potential, she said.

Discovery Process

KU BERC's structure may be its key to success.

"What's different about us is the modeling component of the group works side by side with the analytical component," Spencer said.

Plucking an example from the realm of biomaterials, Spencer described a process of discovery that quickly and effectively incorporates newly gleaned data.

"We have a complete feedback loop," she said. "We may start with the analytical characterization, … we'll move then to one of our computational models." Current models allow the researcher to examine the synthesized material at the molecular level as well as manipulate the molecules to see how that action affects the material's properties. "Once we go back to the synthesis lab, we synthesize the material as close to that computational molecular design as possible, then we do further characterization. Now we take that back to the molecular model and see if indeed it performs in the molecular model the way it was originally proscribed. Now if it does, then our next step is to interface this material with biological tissue and look at the behavior, understand the mechanical and chemical properties of the material at the interface with the biological tissue. We strive to understand these features at the nano-, micro- and macro-levels. … We take that information into another virtual environment, into a mathematical modeling environment, where we look at the behavior in a dynamic fashion, but in a fashion that simulates the clinical behavior, or the clinical challenges that this material will be placed under, and we determine how the material behaves under that scenario. Now, if at that stage everything looks very positive, then we are ready to go to the cellular level.

"In a very cost-effective manner, we have optimized the material before we ever get to the level of involving cells and certainly long before we ever get to the level of involving animals," Spencer said.

Another KU distinction is the depth of its endeavors.

"There are a lot of groups that have capability at the macro scale. There are very few groups that would have the range from the nano to the micro," she said.

BERC's structure relies heavily on the abilities of clinical imaging devices and researchers in bioimaging.

"Obviously, some of these biological imaging devices that we're working on ultimately we look forward to them having application in a variety of areas, including some of the areas associated with very early diagnosis of disease. We also look forward to working with the industrial community to translate our laboratory discoveries into real-world applications that will benefit society."

Engineering a Stronger Economy

"Time to Get it Right," a report prepared by the Greater Kansas City Community Foundation, pointed to research efforts in life sciences as having the greatest potential for economic and humanitarian returns for the region. Bioengineering research and KU were noted as key elements in the prosperity equation.

"BERC represents a partnership between higher education, the community and industry," Dean Bell said. "The center will provide the mechanisms that facilitate and promote the introduction of new technologies into patient care and at the same time make strong contributions to the economic development of the region through technology transfer and entrepreneurship."

The center has a clear road map that goes from the lab all the way to the patient, Spencer said.

"We're not to the point where this roadway is a superhighway, but at least the support is there, the commitment is there," she said. Partnerships forged as part of the Kansas City Area Life Sciences Initiative provide an opportunity to increase biomedical research productivity in the region and take advantage of educational and industrial ties that bring findings and solutions to patients.

"Sometimes that cutting-edge research, if it stays in that academic environment, it just dies on the vine. It doesn't ever get to the stage of translating to materials or products that benefit the biomedical community, or patients (and) society at large," Spencer said. "Translating that knowledge into real-world benefits is an arduous process." Both the National Science Foundation and the National Institutes of Health are focused on supporting basic science research. However, once the end result approaches the level of commercialization, funding agencies adopt the stance that industry should step in to support the actual transition. "It may still be five to 10 years before you're ever into the level of a real-world application."

The state of Kansas, specifically through the Kansas Biosciences Authority, is making a commitment to fill the gap and support academic-industrial partnerships that can fuel potential economic development, she said.

"The state is not just giving lip service." It is investing in translational research.

investigations

Research at the KU Bioengineering Research Center will focus on several types of work, including:

- **the design, synthesis and characterization of new biomaterials, both synthetic and tissue engineered,**
- **development of clinical imaging devices and technologies; biosensor development and application,**
- **medical biophysics and multi-scale bioimaging with various forms of energy, such as light and sound,**
- **multi-scale computational modeling,**
- **biomechanics of motion and neural engineering, and**
- **the manipulation of molecules to facilitate the next generation of nanotechnologies.**

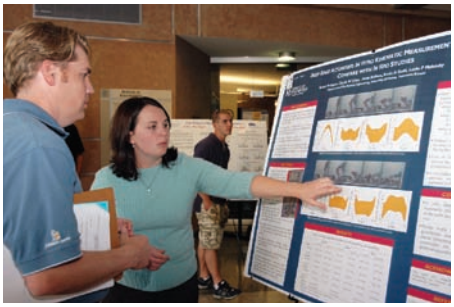

Photo by Jill Hummels

Graduate student Amber Reeve discusses her bioengineering research with a judge during the Graduate Engineering Association's annual research poster contest in October.

In addition, the focus on entrepreneurial activity, product development and student internships in KU's bioengineering graduate degree programs will help develop the next generation of leaders in the biomedical industry.

"By integrating these entrepreneurship activities into our classroom we're building the road map to facilitate the translation of our laboratory discoveries into these real-world applications," Spencer said. Students will expand their leadership potential and abilities with the expectation that they will be able to take these cutting-edge technologies and translate them into real-world benefits.

Spencer is excited about what she's witnessing at KU, specifically the enthusiasm and the we-can-do-better attitude in others she sees around her. The mind-set permeates strata including not only faculty and students, but also leadership in the school and the university, she said.

"There's genuine passion about giving back to the state." If that passion is channeled in the proper ways and with the proper support and interaction — including the support of the Kansas Biosciences Authority — that's really a good example of how to build academic-industrial relationships that will lead to economic development, she said. "And I think the commitment here to accomplish that is so genuine that it will happen.

"You have people on board that are looking 20 and 30 years down the road. … There are very few people here who are not talking in that continuum: five, 10, 15, 20, 30, 40 years down the road."

Story by Jill Hummels

Bioengineering Degrees at KU Reflect Boom in Kansas Biosciences

In conjunction with the expansion of the biosciences industry near Lawrence and Kansas City, the University of Kansas School of Engineering this fall offered students the chance to pursue graduate degrees in the cutting-edge field of bioengineering.

"These degree programs are something we've been working toward for some time," said Stuart R. Bell, dean of the KU School of Engineering. "We've been assembling a strong team of faculty with expertise in a variety of bioengineering disciplines and developing solid ties with researchers at the KU Medical Center, as well as elsewhere on the Lawrence campus."

Bioengineering at KU is a collaborative approach to engineering, biology and medicine, encompassing research fields such as neural engineering, nanotechnology, biosensor development and product design. Applications include diagnosis of cancer, tissue repair and development of devices to help people with spinal cord injuries and more.

The launch of the doctoral and master of science degree programs in bioengineering, which the Kansas Board of Regents approved in March, will cement the status of the university as a leader in the study of life sciences. In all, nearly 50 faculty members from KU's Lawrence campus and the medical center in Kansas City, Kan., will contribute to bioengineering instruction and investigation.

"This is a great move forward for the entire university, our students and the people of this state," said Bell.

Paulette Spencer joined KU as a distinguished professor this fall to direct bioengineering research. She is renowned for developing biomaterials to replace lost skeletal or oral tissue. Spencer, the first woman to hold a distinguished professorship at the School of Engineering, will lead the new Bioengineering Research Center at KU.

"It will open the door to the fastest-growing field in engineering and to the discipline that is attracting the best and brightest young engineers," said Spencer. "The fundamental goal is to enable researchers to deliver advances more quickly to patients."

Carl Luchies, associate professor of mechanical engineering and a 10-year veteran of KU, was selected to serve as academic director of the bioengineering graduate program. Luchies — who conducts research in biomechanics, balance, gait and motor control — also serves as director of one of the six bioengineering degree tracks.

The bioengineering degree tracks and their faculty directors are:

- bioimaging, Larry Cook, professor of radiology
- bioinformatics, Terry Clark, assistant professor of electrical engineering and computer science
- biomaterials and tissue engineering, Michael Detamore, assistant professor of chemical and petroleum engineering
- biomechanics and neural engineering, Carl Luchies, associate professor of mechanical engineering
- biomedical product design and development, Lisa Friis, associate professor of mechanical engineering; and Sara Wilson, associate professor of mechanical engineering; and
- biomolecular engineering, Marylee Southard, associate professor of chemical and petroleum engineering.

Innovations from bioengineering work at the university will accelerate the rise of the biosciences industry along the Interstate-70 corridor via technology transfer and entrepreneurship. A 2006 survey by the Kansas City Area Life Sciences Initiative showed that 199 life sciences firms in the region employed between 17,500 and 20,000 people (up from 15,000 in October 2003). Of these companies, 58 percent increased employment in 2006. In all, the local life sciences sector last year accounted for approximately $638 million in expenditures.

To learn more about bioengineering degree programs at KU, go to www.bio.engr.ku.edu

Story by Brendan Lynch, University Relations