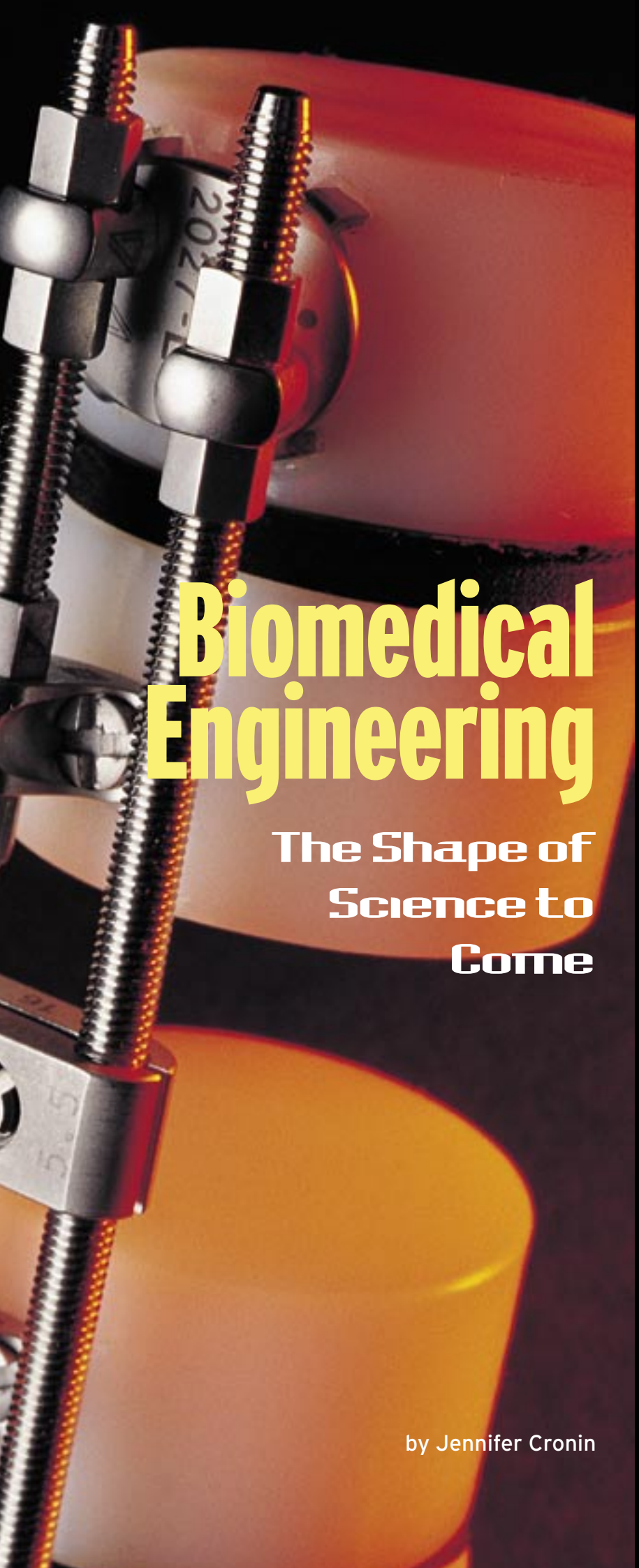


Biomedical Engineering

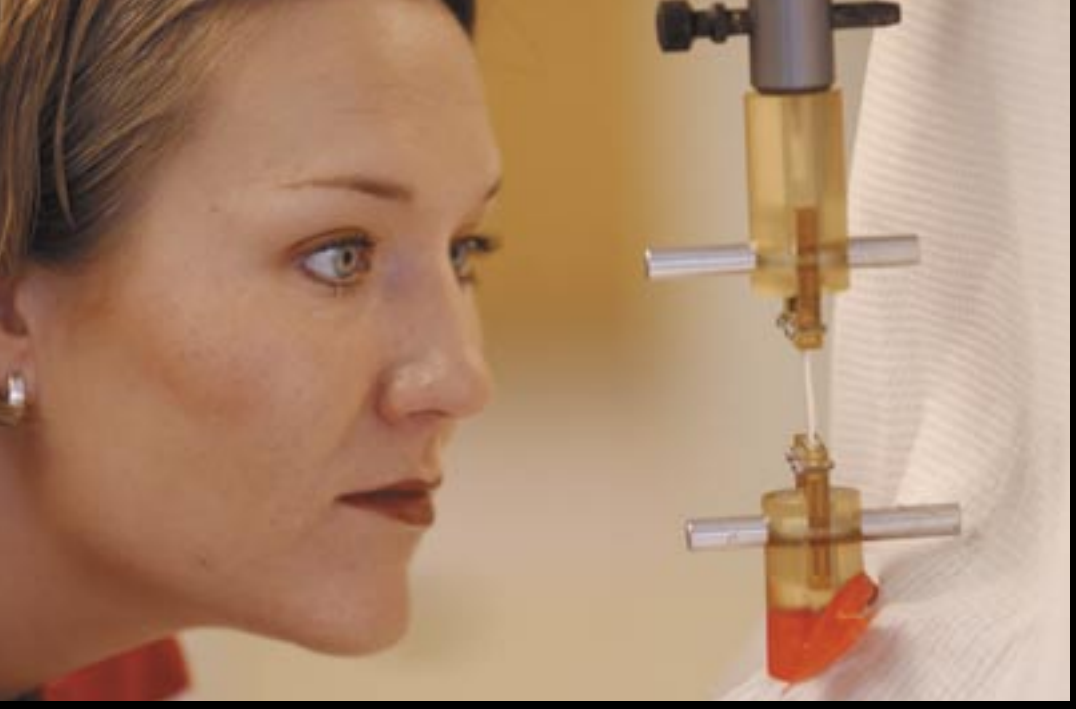
The Shape of Science to Come

by Jennifer Cronin

When players from The University of Iowa's women's basketball team went to work on improving their win-loss totals a few seasons back, they turned to people outside the coaching staff for a little extra help.

Along with gymnasts and soccer players under the direction of the University's athletic department, the basketball team tried to reduce sports injury by participating in a University of Iowa College of Engineering Iowa Spine Research Center study of the relationship between muscle agility and knee injury in female athletes. Coming in response to an alarm signaled by coaches that female athletes seem to suffer a high occurrence of knee injuries, the study is a prime example of the applied research pursued jointly within the engineering college's Department of Biomedical Engineering and the University's health science disciplines.

Using a Nintendo-like device to measure muscle contractions, the team of biomedical and health care scientists learned that leg responses can improve through regular balance training sessions of no more than a few minutes a day. The project's lead investigators were Malcom H. Pope, former chair of biomedical engineering and past director of the Iowa Spine Research Center; David Wilder, associate professor of biomedical engineering; and John P. Albright, orthopaedic surgeon and director of sports medicine services at University of Iowa Hospitals and Clinics. Together, they showed a few Iowa athletes something that couldn't have been taught on the court, and they advanced the prevention of muscular and skeletal injury among female athletes worldwide.



Totally Tubular
The pig vein (technically, porcine aortic tissue) is the artery of choice for recent graduate Tricia Walker and other researchers working with Professor M. L. Raghaven, who wants to learn more about how abdominal aortic aneurysms develop in the human body. K. B. Chandran (right), chair of biomedical engineering, believes Walker and other graduates will solve medical mysteries.

Their findings join medical advances that might once have seemed unbelievable. Doctors long have sought to help pregnant women overcome the problem of Type I diabetes, a leading cause of birth defects; new techniques involving an artificial pancreas may provide the solution and even eliminate the need for multiple doses of insulin and repeated blood-sugar tests. Likewise, Alzheimer's has kept physicians guessing about the mystery of a progressive, degenerative disease that dismantles the memory, spawns behavioral disorders, and always proves fatal; an implant now may help doctors take a potential step toward detecting and warding off consequences of the disease's impairment of cognitive reasoning—something people need to accomplish the simplest of daily tasks.

Behind these innovations has been the work of University of Iowa biomedical engineers, scientists melding the disciplines of medicine and engineering. As the technology they negotiate changes rapidly, and research elicits new insights almost daily, schools across the country are introducing dramatic changes to their engineering programs.

"Biomedical engineering has expanded tremendously over the past 10 to 12 years," says K. B. Chandran, chair of biomedical engineering in the University of Iowa College of Engineering. "This is now the place to go for answers to medical puzzles. Many people think this field is the science of the future, because of ongoing awareness of the biological building blocks of the human body."

The University of Iowa initiated its biomedical engineering program in 1974. The department hired Chandran and three other professors in 1978, and received accreditation for the undergraduate program in 1985. The department also established a master's degree and a doctoral program in 1985. The first student enrolled in June 1977; the program now has 260 undergraduates.

Yasar Dahab is an engineering undergraduate committed to research in the University of Iowa Roy J. and Lucille A. Carver College of Medicine. For the past two years, Dahab, a math and science enthusiast when he was in high school, has worked in unison with Iowa medical researchers on the design of a portable pulmonary artery pressure monitor. He chose Iowa's program after looking at six others around the country. Lured by faculty reputation and research opportunities, he's since become interested in the field's creative aspects, and feels confident his blend of engineering and biological training augurs a sensible future for his medical school plans this year.

"It's not so much about numbers as about problem solving," says the Lincoln, Neb., native.

His first two years included math courses such as matrix algebra, engineering calculus, and differential equations (all designed to help him catch up with students who had previous engineering training). Courses later in his undergraduate career included chemistry, physics, and advanced classes like biomechanical and bio-

electrical design, which focus on how technology can monitor and affect physiological systems.

"You have to have a certain fascination with the human body, the machinery of it, how it repairs itself," he says. "It's challenging; it means looking at the world in a whole new way. The research projects stretch your cognitive abilities and expand your outlook."

Iowa's program focuses on several main areas of research: biomaterials, which involves the modification of both living and manmade materials for implantation, such as the development of an artificial pancreas; biomechanics, which would lead to treatment of impaired musculoskeletal and cardiovascular systems, including replacement parts for hips and knees and detection of warning signs of aneurysms; medical imaging, which seeks ways to improve the noninvasive visualization of body parts and functions; and tissue engineering, which concentrates on developing replacements for diseased tissues such as blood vessels and heart valves.

The program is interdisciplinary and includes courses from the biological, chemical, and physical sciences; biomedical engineering; and computer software development. Students also may enroll in entrepreneurship training through the University of Iowa Henry B. Tippie College of Business. Students and faculty work together on many projects of common interest with their colleagues in the Colleges of Medicine, Dentistry, and Liberal Arts and Sciences.

Biomedical engineering graduate programs have existed in the United States since 1961. But the history of biomedical engineering research reaches back to World War II, when medical scientist Willem J. Kolff invented the artificial kidney dialysis machine; he later headed the team that developed and tested an artificial human heart. In 1974, when The University of Iowa entered the field, there were 19 master's degree programs and 26 doctoral programs; today there are 72 master's and 76 doctoral programs around the country.

"Medicine is becoming increasingly technologically oriented," Chandran says. "Thirty years ago, doctors were limited to images on a chest X ray, for example. They'd take a photograph and develop the film. It was crude, inaccurate. But now the health care profession has magnetic resonance imaging and computed tomography (CT), thanks to engineers. Implants also were developed with the help of engineers. So, having that engineering background is extremely helpful in medicine today."

Stephen Hunter, who holds a primary appointment in obstetrics and gynecology as well as appointments in chemical and biochemical engineering and biomedical engineering, has been testing and refining an artificial pancreas first developed by biomedical specialists in the 1970s. He credits engineering principles and strategies as key to the development of technology that may improve the welfare of pregnant women and prevent birth defects.

"There's so much crossover anymore that you need to have both medical and engineering expertise to solve the

Things That Go Bump

David Wilder, associate professor of biomedical engineering, wants to make sure that farmers have their bodies cushioned in the best possible way to avoid back injury when their tractors take an unforeseen bump. With the help of an impact platform (right) and other investigative devices on the Oakdale Research Campus, Wilder is interested in seeing his work lead to safer designs in trucks, tractors, and construction vehicles. He recently spent time at the Iowa State Fair talking with farmers and other fairgoers about the importance of protection for the spine.

mysteries of the human body," he says, "whether that means one person working from backgrounds in both areas or experts from various areas putting their heads together."

Matthew Rizzo, professor of neurology, also has an appointment in the College of Engineering; he investigates Alzheimer's disease, strokes, and cognitive aging with a simulator that allows him to experiment with human subjects without putting anyone in harm's way. He's learned, among other things, that the likelihood of car crashes caused by drivers afflicted with the early stages of Alzheimer's is linked to specific cognitive impairments measured by neuropsychological tests of attention and decision making. Including Hunter and Rizzo, 27 University faculty members hold joint appointments in a health science college and in the engineering college.

The biggest challenge to overcome with biomedical engineering, Chandran notes, is to establish effective communication and collaboration between the engineering sciences and medical sciences.

"Trying to merge these two areas is difficult. There is no doubt about it," Rizzo says. "But the relationships forged at Iowa have taken off. The collaborative spirit here is strong."

That strength is based upon a historical foundation of partnership with the University's medical college. Engineering and orthopaedic researchers from the beginning have joined forces in the development of joint replacements (new hips, knees, and ankles), and last year industrial engineering professor Geb Thomas and biomedical engineering professor Edwin Dove helped Alicia Weissman, assistant professor of family medicine, create a synthetic breast the researchers hope will improve the ability of women and their doctors to detect tumors during breast exams.

The University's Medical Image Processing Laboratories also ranks as a significant partner. The lab's researchers work side by side with Iowa's engineers on hardware and software for multidimensional image analysis and microsecond multiple-splice spiral scanning technology. Using computers and software built in the lab and collaborating with Iowa professor of radiology Eric Hoffman, assistant professor of biomedical engineering Joseph Reinhardt constructs three-dimensional pulmonary images for use in characterizing what a normal lung looks like. Such analysis may aid in the early detection and tracking of chronic obstructive pulmonary disease, lung cancer, emphysema, and other diseases.

Reinhardt teaches biomedical engineering students in the areas of his expertise, including the fields of one- and two-dimensional systems, signal processing, and medical imaging, as well as analysis of structures within the human lung. His pedagogy reflects the increasingly complex nature of the program.

"Biomedical engineering has changed from a curriculum that was composed of traditional engineering, mechanical

One for the Road

In the basement of University of Iowa Hospitals and Clinics, professor of neurology Matt Rizzo is the driving force behind research into a better understanding of Alzheimer's disease and other cognitive problems that come with old age. A main vehicle in his line of inquiry is a late-model sedan featuring elaborate custom packaging—computer banks under the hood and an interior rigged with monitors record biological and behavioral responses of volunteers who take the wheel and negotiate wide-screen driving scenarios.

A Lung with a View

An unprecedented look at the airways and lungs of the human body is possible because of collaboration between experts at Iowa. Eric Hoffman, professor of radiology, and Joseph Reinhardt, assistant professor of biomedical engineering, have developed revolutionary equipment that makes patient diagnosis and monitoring much quicker and therefore less expensive, as well as more detailed and accurate.

engineering, electrical engineering, and biology to new courses developed by biomedical engineers who have integrated biology and engineering into one curriculum," Chandran says. "Our courses now must combine biology and engineering in an integral and intimate way."

Iowa's biomedical engineering program is one of 21 accredited programs in the United States and one of only 10 at public universities. It joins the ranks of schools like Johns Hopkins, Carnegie Mellon, Case Western, Northwestern University, Georgia Tech, and the University of California at San Diego.

"In Iowa, we have two excellent engineering colleges at The University of Iowa and Iowa State University," Chandran says. "One of the major unique characteristics that absolutely distinguishes us from ISU is our biomedical engineering department."

Like Dahab, one-third of Iowa's biomedical engineering undergraduates go on to medical school. Those who do not enter the department's new fast-track program, which combines a bachelor's degree curriculum with master's program study, may choose to continue their education in the department's graduate degree programs, pursue graduate studies in other institutions, or choose a career in biomedical or traditional engineering industries.

"The number of biomedical engineers in the workforce is relatively small," Chandran says. "Of course, it's in the early stages yet, as an academic exercise, but biomedical engineering is a valuable field because graduates have unusual skills."

Some people with doctorates in biomedical engineering continue in academics, but others take jobs as consultants to small medical device companies and work in product development at pharmaceutical companies. Companies recognize the value of biomedical engineers, who are accepting appointments as executive officers and vice presidents, says Doug Kurschinski, a 1985 Iowa biomedical engineering alumnus who's had no trouble keeping busy since he left Iowa City. After obtaining an M.B.A. from the University of Chicago in 1990, he helped his company, Saint Louis-based Stereotaxis Inc., introduce into American health care the magnetic navigation technology that, only a few years ago, might have been regarded as fodder for science fiction. Now, the tool enhances the clinician's ability to manipulate cardiovascular and neurological imaging equipment.

"The only boundary is the limit of our imaginations," Kurschinski says. "Biomedical engineers now have breadth and cross boundaries, just as other engineers have done. With increasing ability to synthesize their theories and help in product development, biomedical engineers will foster the growth of a major engineering field in this century, much as the traditional engineer did in the last."