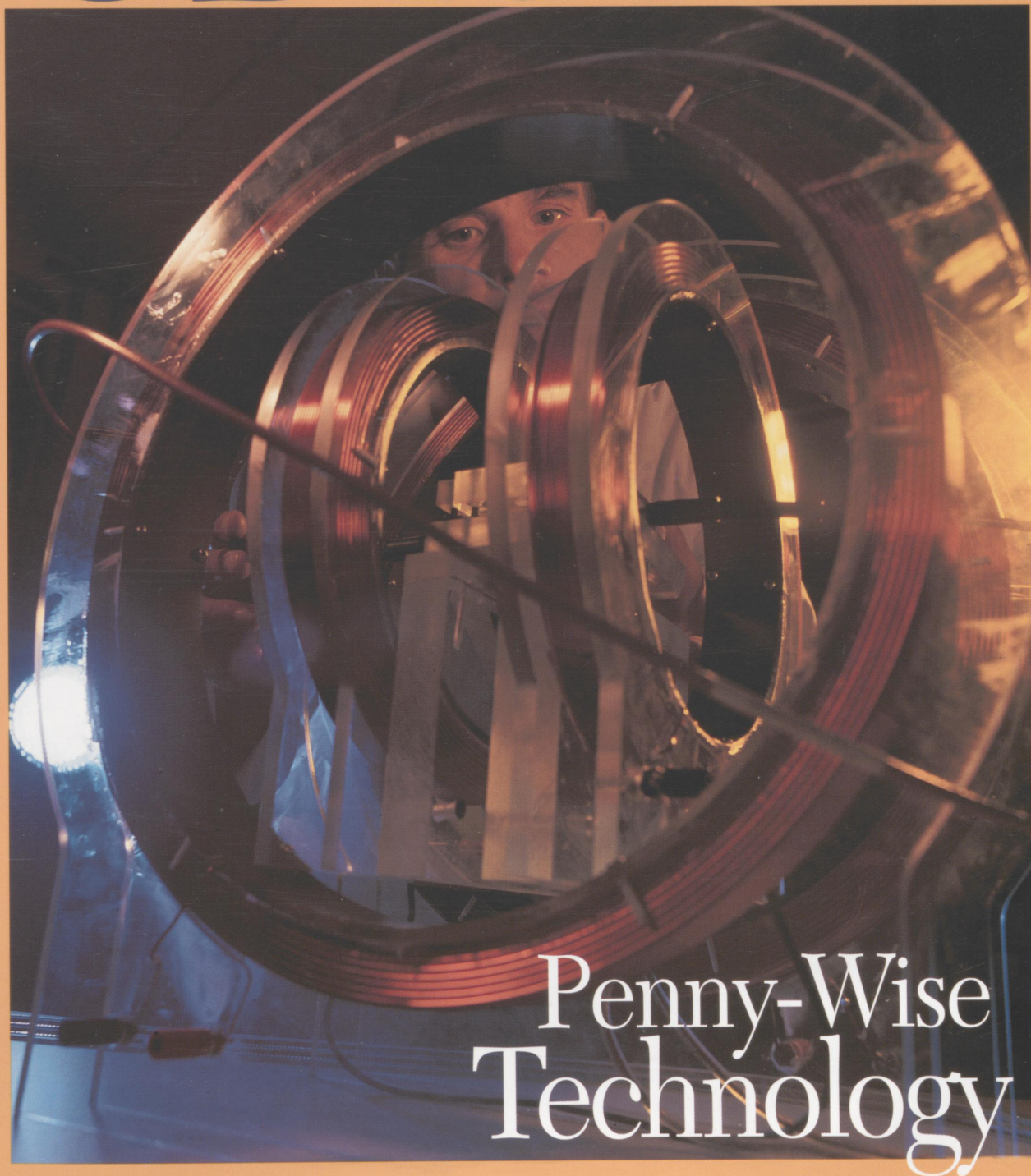


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ODYSSEY



Penny-Wise
Technology

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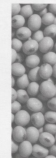


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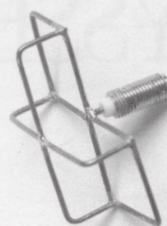
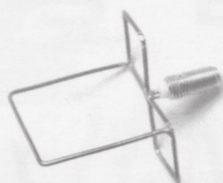
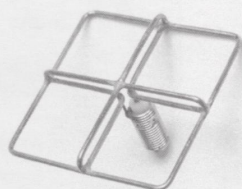
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and more...



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Front cover photo: Craig Grimes uses standard electro-
magnetic coils in his remote-sensor research. See the
"Penny-Wise Technology" feature on page 2.

University of Kentucky



Penny-Wise Technology

Designing sensors and antennas of the future

Shopping one day at Home Depot, Craig Grimes noticed a man who had just pulled a set of drill bits off the rack by the exit door. As the man took a couple of steps toward the door, with the unpaid-for merchandise, Grimes thought about the alarm that would sound if the shopper decided to dash out of the store just then. For Grimes at that moment, a new research interest was born.

"I started thinking about the little white tags attached to store merchandise and how, if they're not deactivated, these markers interact electromagnetically with the 'interrogation coils,' as I call them. It's this interaction that sets off an alarm,"

says Grimes, an associate professor of electrical engineering at the University of Kentucky. These coils, a few meters apart and situated in front of an exit door, are now so commonplace, Grimes adds, that we hardly give them a thought. "I began to consider how these anti-theft markers work and whether or not this technology could be extended to chemical and environmental sensing."

Developing new uses for sensors is only one of Grimes's wide-ranging research interests. He is also breaking new ground in the field of antenna technology, he's working to characterize and control thin-film materials and devices, and he's re-

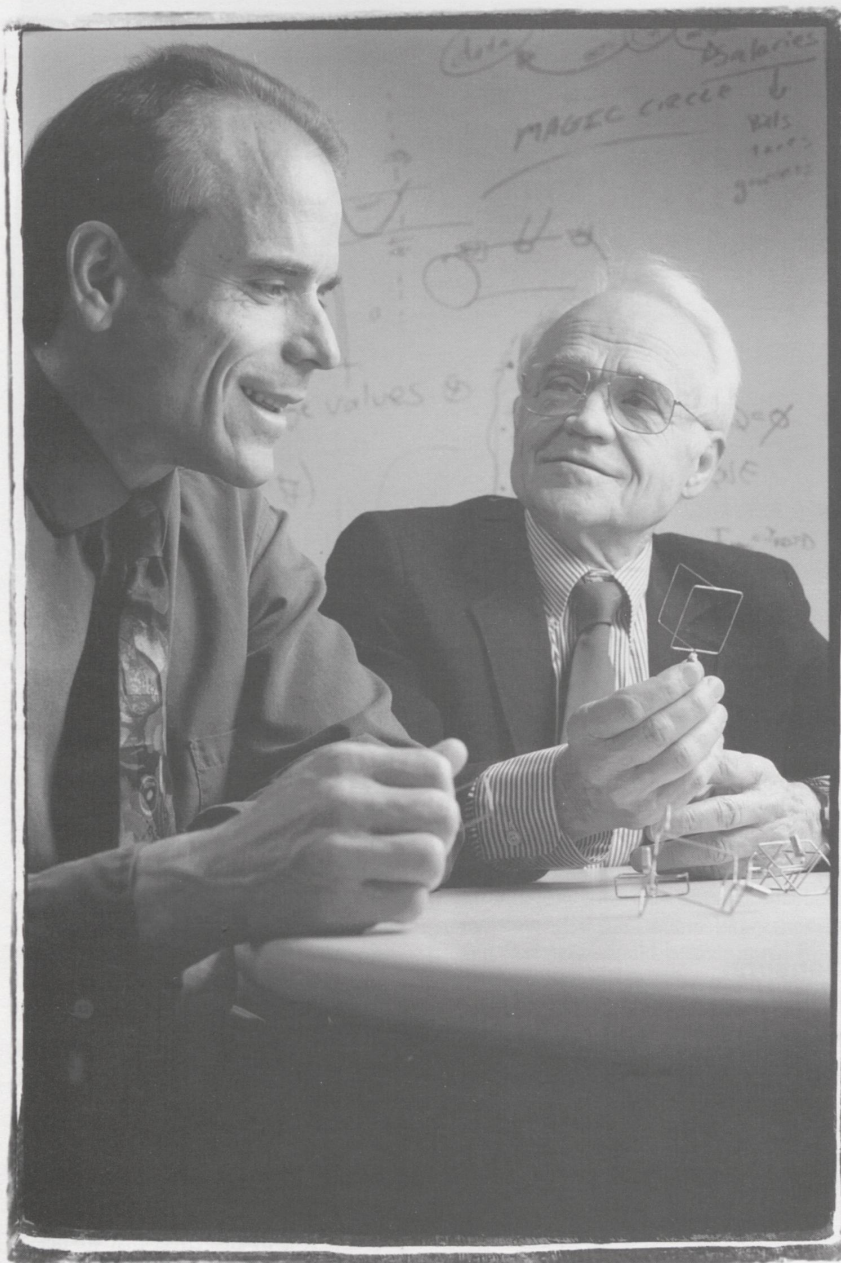
cently ventured into the young science of nanotechnology—working to understand the properties of nanotubes.

Grimes admits he's always had a healthy curiosity, but says his path into science wasn't a clear and direct one.

"As an undergraduate, I was really unfocused. I started out as an accounting major, switched to econ, then industrial engineering, then mechanical engineering," Grimes says. "Then I dropped out and kind of spent a couple of years skiing. I was kicked out of the University of Texas as an undergrad because my GPA was so low."

Grimes ultimately ended up driving a

WRITTEN BY
JEFF WORLEY



CRAIG GRIMES FOLLOWED IN HIS FATHER'S FOOTSTEPS TO BECOME AN ELECTRICAL ENGINEERING PROFESSOR. THE TWO HAVE COLLABORATED ON ANTENNA RESEARCH SINCE 1983 WHEN CRAIG WAS A STUDENT AT PENN STATE. DALE GRIMES IS CURRENTLY A VISITING PROFESSOR IN THE UK DEPARTMENT OF PHYSICS.

schoolbus in Austin, and the reality of the job drove him back to the university classroom. "I got serious about my career while driving a bus for \$4.85 an hour," he says. "That job put things into crystal clarity."

Grimes left Austin in 1983 and headed to Penn State, where his father was a professor of electrical engineering and chairman of the department. "I still couldn't make up my mind what I wanted to focus on, so my dad, in exasperation, told me that if I was incapable of picking something, I might as well go into electrical engineering. And here I am."

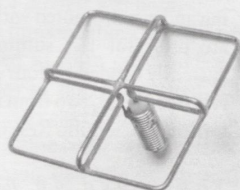
Grimes got serious at Penn State, earning both a B.S. in electrical engineering and a B.S. in physics in 1984. By then, his undergraduate experience at the University of Texas had begun to fade into the past like an image in the rearview mirror of a schoolbus. But Grimes wasn't finished with Austin yet. "I went back to the University of Texas in '84 to do my graduate work," he says. He left Austin again in 1990, this time with both a master's degree and a Ph.D. in electrical engineering.

Grimes came to UK in the fall of 1994 as an assistant professor of electrical engineering and was promoted with tenure to associate professor last summer. His work is currently funded by four grants from NSF, two from NIH, two from the U.S. Air Force Office of Scientific Research, one from the

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KEAT GHEE ONG, AN ELECTRICAL ENGINEERING DOCTORAL STUDENT, TESTS AN ANTENNA INSIDE AN ELECTROMAGNETIC ANECHOIC CHAMBER. THE CHAMBER WALLS ARE DESIGNED TO ABSORB ALL ENERGY, WHICH ALLOWS THE ANTENNA TO BEHAVE AS IF IT WERE IN OUTER SPACE. THE PYRAMID SHAPE OF THE CHAMBER WALLS HELPS TO PREVENT UNWANTED REFLECTIONS OF THE ENERGY BACK OUT INTO THE CHAMBER.



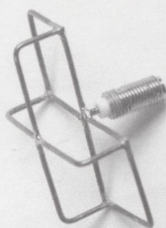
Department of Education, and one from NASA for a combined \$3 million. Grimes supervises a staff of five postdocs and seven graduate students who work with him on his sensor and antenna research.

Sensors: simple and sophisticated

When Grimes talks about the sensors he and his research associates are developing, he does so with unrestrained enthusiasm. "We're just talking about a small piece of mostly iron and nickel," he says, "but it supports a really sophisticated technology. And one of the beauties of this technology is that it's inexpensive—one of these sensors that identifies your package as you leave a store costs about a penny." A kilogram of the basic material, enough to make several thousand sensors, comes in a roll

(imagine a reel of film that would snap into a movie projector) and costs about \$100. Triggered by a standard electromagnetic coil, sensors work without batteries or attachments of any kind.

As any of us who took Physics 101 may recall, electrical current can produce magnetic effects, and vice-versa. If an electrical current runs through a wire, a magnetic compass near that wire will move. A moving compass will generate electricity in a nearby wire. This relationship between electricity and magnetism, discovered by the Danish experimenter Christian Oersted, is generally seen as one of the highlights of 19th-century physics. "It is by this effect that we detect and monitor our sensors," Grimes says. "The sensors we use in our research—we commonly refer to them as 'ribbons'—are composed of iron and nickel, with a little



phosphorous, silicon and boron thrown in," says Grimes.

How do the sensors work? "Our sensors are the magnetic equivalent of a church bell," Grimes explains. "If you hit the bell with a hammer, you've transformed kinetic energy into an elastic wave that deforms the bell, which rings at its resonant frequency." This frequency is inherent in the size of the bell—from the boom of a cathedral bell to the tinkle of a hand-held dinner bell.

"Our sensors 'ring' magnetically," Grimes explains. "Instead of hitting a bell with a hammer, we magnetically pulse a sensor by passing a current through a wire-wound coil to generate a magnetic field." The energy that is in the magnetic field is absorbed by the sensor, which causes it to mechanically deform, like the bell. But instead of sending out acoustic waves, the ribbon generates magnetic waves.

"Using a pick-up coil, we listen to the sensor and determine its resonant frequency. By looking at changes in its resonant frequency, we can gather environmental information," Grimes explains.

"Just as a church bell will change its resonant frequency in response to temperature, pressure, or mass load—consider the effect of a coat of paint on a bell—so does the resonant frequency of our magnetic sensor," he explains.

Sensors in your car and in your Cheerios

For the past four years, Grimes has been developing sensors with an eye toward various practical applications of this technology. He and his team have fine-tuned sensors to measure several different environmental parameters, including pressure, temperature, the viscosity of liquids, the surface tension of liquids, and mass load. "One immediate application that I'd think

would interest the motor industry would be the use of a reliable, inexpensive sensor to monitor oil viscosity in cars," says Grimes. "The sensor, which would cost only pennies, would tell drivers when they needed to change the oil in their car.

"In one application of the technology, we coat the sensors with a thin layer of ceramic aluminum-oxide," Grimes says. "Aluminum-oxide changes mass in response to humidity levels, thereby changing the resonant frequency of the adjoining sensor." The result is a disposable, inexpensive humidity sensor that can be monitored from inside sealed packages.

Grimes and his research team have built a working antenna 100 times more efficient than what anyone thought possible.

The cereal industry could be one of the first customers for Grimes's new technology. If a sensor were placed, for example, in each box of Cheerios as it was hustled down a conveyor belt, temperature, humidity and moisture—the natural enemies of crispness and freshness—could be monitored from inside each sealed box. The sensors could be monitored in the warehouse or in the grocery store. "In this way, product freshness could be assured," Grimes says. "The spoiled food products could be weeded out easily."

As this technology advances, a grocery employee might one day take a hand-held tester down the cereal aisle to "pulse" the boxes on the shelves. Depending upon the response of the sensors, the employee would know whether or not a box of cereal was fresh enough to sell.

Another application of the sensor technology Grimes has developed could be in

the medical field. Grimes and research associates Chaohui Tong and Qingyun Cai developed a glucose-responding polymer to detect sugar levels. A polymer is a plastic-like material designed to capture certain organic molecules, in this case the glucose-sugar molecule. Thin layers of these polymers are applied to the magnetic sensors. Once the sensor is prepared, Grimes tests it by alternately immersing the sensor in high or low solutions of glucose to see how it responds.

"What is very exciting about this technology is that a small magnetic sensor could be placed under the skin of someone with diabetes, under the skin of his hand, for example, and glucose concentration could then be measured by the patient simply passing his hand in front of a pick-up coil," says Grimes. "You would get an immediate reading, thereby providing a quick bloodless and painless method for diabetics to take sugar-level readings." Currently, someone with diabetes has to prick the end of a finger and draw a drop of blood to analyze sugar concentration.

Another medical application would benefit patients diagnosed with an ulcer. For a doctor to measure how acidic a patient's stomach contents are, current practice involves having the patient swallow a tube that remains attached to an external machine. This procedure, to say the least, isn't very user-friendly.

"Instead of having patients swallow this long tube, they could swallow a tiny sensor encased in a pill," Grimes explains. "The sensor inside the pill could immediately and continuously be monitored as it passes through the digestive tract. The pill would cost around a nickel and as it went down it

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would measure pH and pressure." To develop and commercialize this sensor technology, Grimes formed a company in 1998 called SenTech Corporation. The corporation recently received an NIH Small Business Innovative Research award for \$100,000 to support Grimes and Nick Nickls, a professor of internal medicine at the UK medical center, in this sensor research.

Downsizing antennas

A separate research program of Grimes's is focused on developing efficient, electrically small antennas. Antennas are used to transmit and receive electromagnetic energy, such as sunlight and radio waves. "Current antenna technology is stymied," says Grimes, "because for efficient operation antennas have to have a physical dimension roughly equivalent to the wavelength of energy being radiated. This size-wavelength relationship is a tremendous problem if you want to operate at low frequencies or use miniature antennas."

Low-wavelength electromagnetic waves would be of tremendous value for radar mapping of the sea floor, prospecting, or simply locating buried pipes. However, generation of low-frequency, long-wavelength electromagnetic waves that can effectively penetrate earth or sea water would require an antenna several miles long.

A project proposed in the 1980s by the U.S. Navy illustrates the scope of this problem. Some navy engineers contemplated building an antenna across the length of the Upper Peninsula of Michigan to enable communication with submerged submarines. This gargantuan antenna was never built, but the fact that this project (Project Sanguine) was seriously proposed is an acknowledgment of the antenna size problem.

And the limitation of known antenna technology is not so esoteric as deep-sea communications. Today, the largest single item in a cellular telephone is the antenna. Furthermore, some types of tumors have

"A small magnetic sensor could be placed under the skin of someone with diabetes, under the skin of his hand, for example, and glucose concentration could then be measured by the patient simply passing his hand in front of a pick-up coil."

been found to self-destruct when directly exposed to low-frequency radiation. However, because extremely large antennas are needed to generate these waves, destruction of tumors using low-frequency energy has not become a practical reality.

"Interestingly enough, while antenna technology is faced with this severe operational constraint, mother nature is not," Grimes says. "Atoms, for example, efficiently radiate energy at wavelengths several hundred times greater than the physical size of the atom. What does mother nature know that antenna engineers do not?"

This was the question that Dale Grimes, Craig's father, set out to answer in the mid-1960s as a professor at the University of Michigan. (He is now retired and a visiting professor in the Department of Physics here at UK). Craig began working with his father on this problem in 1983 when still a

student at Penn State. After several decades of work, the two came to understand just how an atom emits energy.

"The trick then became transferring our understanding of how an atom operates to a working model on a macroscopic scale of dimensions, something, for example, the size of a breadbox," Grimes says. Many mathematical questions first had to be answered. Then, idealized, spherical mathematical functions had to be transferred into a working antenna.

"The other key obstacle is how you convince a funding agency to give you some of their research dollars to enable the actual doing," Grimes says. "Keep in mind, this is a very controversial path of research. Efficient, electrically small antennas were declared impossible several times over the past 50 years by several very famous scientists. The fact that mother nature was doing it every day, all around us and *in* us, has continually been dismissed as 'quantum effects.'"

Grimes was pleased that his funding proposal to the U.S. Air Force Office of Scientific Research was met with a lot of interest. Arje Nachman, an Air Force physicist with a strong medical background, thought Grimes was on to something. "It was Dr. Nachman's opinion that we were on the right path, and with his support AFOSR provided us the resources to do the work," Grimes says.

The further good news, Grimes happily reports, is that he and his research team have built a working antenna 100 times more efficient than what anyone thought possible. It consists of three cross-pieces of copper wire attached at 90-degree angles, and looks, frankly, like something a child might accidentally build.

Grimes agrees. "Yes, it looks rudimentary, but it supports very precise field symmetries that enable the antenna to behave as if it were more than 100 times larger. Needless to say, we've applied for a patent." He

adds that if all goes well, commercial fabrication and production could happen relatively soon. "The next few years will be an interesting ride."

The funding challenge

Grimes admits that his research, especially his antenna work, is controversial, and he says such leading-edge work can often fail to attract funding support, especially among more "conservative" funding agencies. "For half a century now, very respected scientists in the electromagnetics community have said that building functional, electrically small antennas is impossible, and this has become something of a mantra to the antenna community," Grimes says. "When we would argue theory with some people, things would get a little touchy at times."

But as Grimes and his antenna team continued to develop and refine a convincing mathematical framework for the development of smaller antennas, funding agencies began to pay more and more attention.

"By our best count, Craig has written and submitted 46 grant proposals since coming to UK," says Fitzgerald Bramwell, vice president of Research and Graduate Studies. "Fifteen of these have been funded and eight are pending. That's an extremely impressive success rate, and it reflects the interest his work continues to generate at various funding agencies around the country."

Grimes concedes that grant writing takes a lot of his time but says it's simply part of the "professorial landscape." He says that one reason for his funding success is his writing skills. "You need to have good ideas and be able to convey those ideas effectively to the reviewers of your proposal," Grimes says. "If you don't you don't get far. It's a very competitive environment."

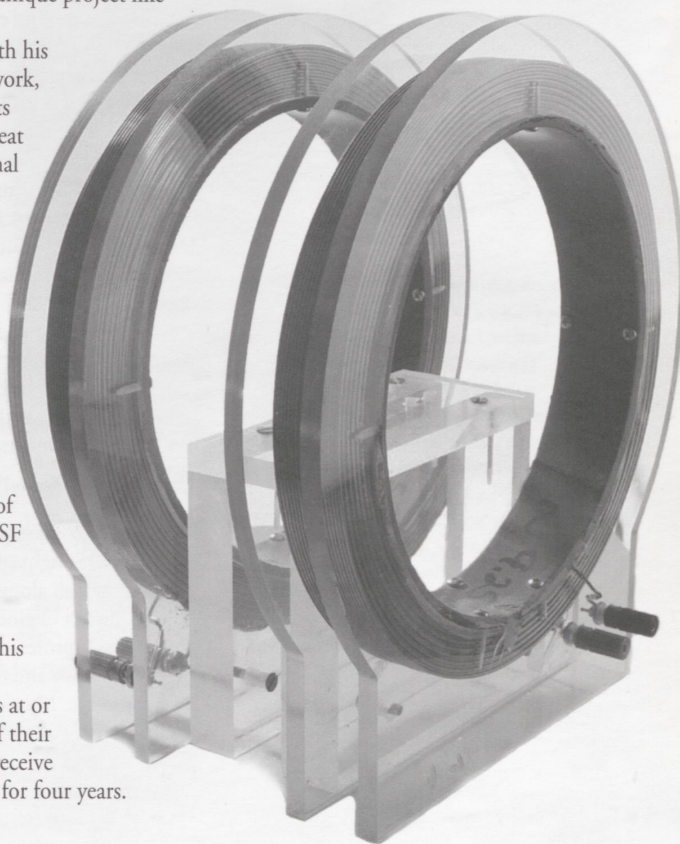
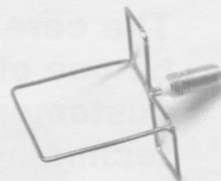
"Craig's willingness to invest an enormous amount of time working with fund-

ing agencies is remarkable," says Joe Fink, UK assistant vice president for Research and Graduate Studies. Fink cites Grimes's Air Force funding as one example of this resolve.

"Craig went to Washington and spent a day sitting down with Air Force officials to go through the theory with them, just sat in one room all day and talked with physicists and mathematicians," says Fink. "At the end of the day, they said, 'Well, you got the math to work and nobody else has been able to do that, so we'll give you some money to see if you can build such an antenna.' This is a feather in the cap of the Air Force scientists, too, I think, who were willing to listen and support a unique project like this."

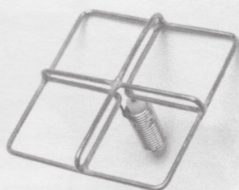
As a result of both his sensor and antenna work, Grimes has six patents pending. "I have a great deal of time, emotional and mental energy involved with all of them, and hope to see the ideas captured in these patents translated to commercial products."

Strong recognition for Grimes's work came recently in the form of a prestigious 1999 NSF CAREER Award. Formerly called the Presidential Young Investigator Award, this support is given to outstanding scientists at or near the beginning of their careers. Grimes will receive from NSF \$210,000 for four years.



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The cereal industry could be one of the first customers for Grimes's new technology. If a sensor were placed, for example, in each box of Cheerios as it was hustled down a conveyor belt, temperature, humidity and moisture—the natural enemies of crispness and freshness—could be monitored from inside each sealed box.

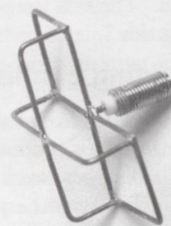
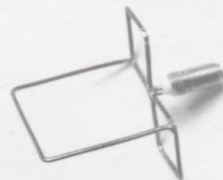


"Craig Grimes is in the vanguard of relatively young and extremely talented faculty who are assuming the leadership of the research enterprise for the College of Engineering and the university," says Thomas Lester, dean of the college. Lester says that in addition to Grimes's innovative research, his approaches to funding have also been novel. "It's unusual for an electrical engineer to attract funding from, for example, the National Institutes of Health, but Craig has been successful in doing this." The engineering dean adds that since medicine is relying more and more upon technical devices to assist in quality of life and in treating diseases, such "crossover" funding will likely become more prevalent.

All in the family

Anyone who takes a backward glance at Grimes's life might conclude that he should have known all along that he was destined to become an engineering professor. "My father was a professor of engineering, and all of our family and friends were professors and scientists. My sister is a professor, my brother-in-law is a professor, my cousin is a professor, and my uncle is a professor."

Grimes adds that although he grew up around "a lot of science," he wasn't indo-

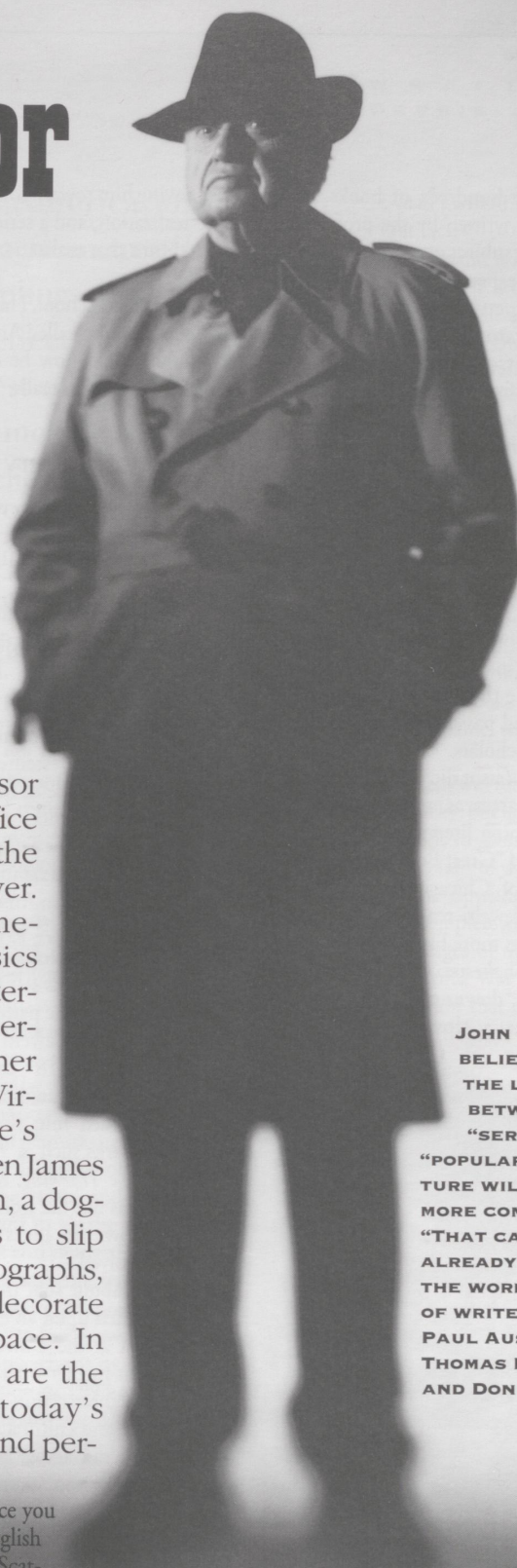


trinated in any formal sense. "It wasn't like my father and I would get together after dinner and he'd teach me quantum physics, but there might well have been an osmosis effect," he says.

And Grimes is happy to mention yet another "very bright scientist" now in his immediate family—his wife Beth Dickey, an assistant professor of materials engineering at UK. "Of course, I chose my wife wisely," Grimes says, laughing. "She certainly is one of the best scientists I have ever met. She is also an excellent writer, so it is a pleasure to collaborate with her on grants." Grimes says the two recently had a DoE grant funded for which they were co-PIs, and they have two grant applications currently under review.

"One of my six patents pending is a joint invention between Beth and me," Grimes says. "She is able to ask very thought-provoking questions. For example, while we were stuck in traffic a few months ago, she asked a couple questions about how one could align carbon nanotubes into useful electronic structures. Once the question emerged, we considered different solutions. By the time we got out of traffic, we had the complete invention worked out. ☐"

Solving the Case of The Professor Who Loved Popular Literature



Books line opposing walls of Professor John Cawelti's office on the 12th floor of the Patterson Office Tower. On the sagging time-warped shelves, classics are crowded in with literary criticism and paperbacks. William Faulkner keeps company with Virginia Woolf, Goethe's *Faust* is wedged between James Joyce and Ralph Ellison, a dog-eared Dante threatens to slip from the top shelf. Photographs, artwork and awards decorate the remaining wall space. In the back of the room are the academic tools of today's scholar—a computer and personal printer.

This is precisely the kind of office you might expect an accomplished English professor and author to inhabit. Scat-

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JOHN CAWELTI BELIEVES THAT THE LINES BETWEEN "SERIOUS" AND "POPULAR" LITERATURE WILL BECOME MORE COMPLEX. "THAT CAN ALREADY BE SEEN IN THE WORKS OF WRITERS LIKE PAUL AUSTER, THOMAS PYNCHON, AND DON DELILLO."

tered among the hundreds of books are more than a few written by the professor himself, and their subject matter is not at all what you would expect.

Cawelti is an expert in what is now known as popular literature. The 70-year-old teacher has spent a lifetime deriving intriguing insights from mysteries, westerns, and horror stories. For years, however, Cawelti's specialty was not an obvious choice. When he began his work, popular literature was considered "sub-literature," of little serious concern, suitable only as entertainment for the masses.

This was particularly true in 1960 when Cawelti received his Ph.D. from the University of Iowa. Forty years ago Cawelti was all set to follow in his predecessors' footsteps, scrutinizing the works of recognized literary greats and passing this knowledge along to future scholars.

The young professor did just that in fact, beginning his career as an instructor in humanities teaching literature, art, music appreciation, and "Great Books" courses at the University of Chicago. In his spare time, though, Cawelti read for relaxation and found he was more likely to pick up a mystery than a Shakespearean play or Victorian novel. His "downtime" reading habits, like a slow burning fuse, seemed to

be moving him toward some quietly explosive realization, and a series of "accidents" would turn that realization into a life-long pursuit.

"In graduate school, I had taken a course in what was then called American Civilization and would now be called American Studies," Cawelti recalls. "The course was

thought it was an oversimplification, but it got me thinking."

Cawelti was slowly realizing the importance of popular literature in modern life, and he admits that the seeds of this interest had been sown years before. "I remember very vividly the hours I spent as a child listening to "The Lone Ranger" show on

"I remember very vividly hours I spent as a child listening to 'The Lone Ranger' show on the radio three times a week from station WXYZ in Detroit. Though I've long since forgotten what happened on any particular program, I have never forgotten the vigorous clarity of the form itself."

a combination of literature and history, so I was already interested in the idea of the cultural significance of literature."

This idea was reflected in Cawelti's first book, *Apostles of the Self-Made Man*, published in 1968. It examined the changing concept of success in America, particularly the ongoing struggle between conflicting benchmarks of success—financial wealth and power versus self-fulfillment.

"I traced the pattern of ideas about success," Cawelti says. "I started in the late 18th century with Benjamin Franklin's ideas and continued into then contemporary works such as *The Power of Positive Thinking*. My main concern was not the works themselves but how the ideas in those works evolved."

About that time, Cawelti happened upon an essay by a sociologist at the University of Chicago that further whetted his interest in the intersection of popular literature and cultural significance.

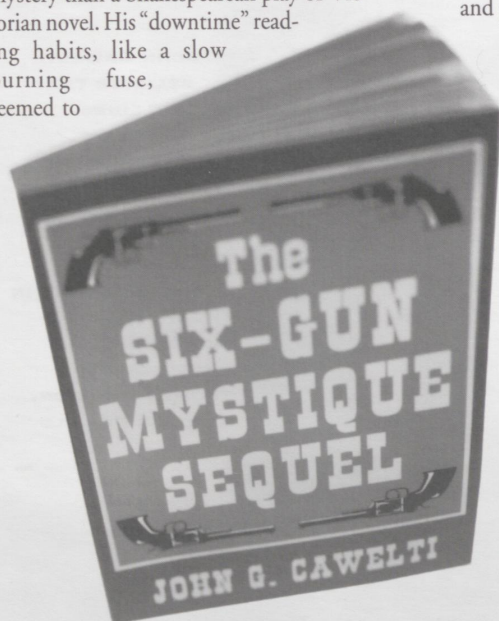
"I ran across an essay by a colleague about westerns," Cawelti recalls. "It was the first work I had seen dealing with westerns and society. I

the radio three times a week from station WXYZ in Detroit," Cawelti says. "Though I've long since forgotten what happened on any particular program, I have never forgotten the vigorous clarity of the form itself."

This genre became the subject of Cawelti's first book, titled *The Six-Gun Mystique*. This book has been in print since it appeared in 1970 and has gone through two major revisions. The most recent version appeared last year as *The Six-Gun Mystique Sequel*.

"To my great surprise at the time, my work was greeted with interest and support by my colleagues at the University of Chicago," he says. "I expected them to look down their noses at me, particularly the older professors, but they didn't." The value of what he was doing was further verified when he was invited to the summer home of his colleague Ronald Crane, one of the founders of the Chicago School of Criticism and a distinguished scholar of 18th-century literature.

"When I walked into Crane's summer home, I saw that he had a wall covered with bookshelves, like in his apartment in Chicago," says Cawelti. "But the bookcases of his summer home were not filled with the



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leather-bound classics found in the Chicago apartment. Instead, they held westerns and detective stories.

"I began to realize then that people were really interested in these forms of literature," Cawelti says. "I began to see them as artistic creations in their own right and wanted to know what makes them good."

Perhaps more importantly, he also found that these forms of literature provide insight into cultural trends. Westerns, for example, deal with the relationship between the characters and the land.

"Our images of America and what it means to be an American are complicated," Cawelti says. "We see these feelings refracted in the western. They reflect our ambivalence about the conquest of the frontier, and, therefore, tend to include a nostalgic look back to what we believe was a simpler era."

Westerns also deal with the clash of cultures, and our discomfort with how this is handled in the western has made it harder for us to see them in their original form, according to Cawelti. The result is two-fold. First, westerns have become much less important than they once were, and, secondly, new westerns are now more likely to be an art form rather than works of popular culture. Cawelti cites the movie *Dances with Wolves* and the Clint Eastwood film *Unforgiven* as examples.

Mysteries, on the other hand, are a replacement for religious myths and can be traced back historically to the Bible. "They deal with transgression and punishment," he says. "These modern stories also offer faith in our power of reason, that there is always a rational explanation and that humans are capable of finding out what it is. They are a dramatization of the scientific method."

Horror stories focus on our attempt to deal with monstrosities, according to Cawelti. "These stories convince us that we are able to overcome even the worst evils

"Our images of America and what it means to be an American are complicated. We see these feelings refracted in the western. They reflect our ambivalence about the conquest of the frontier, and, therefore, tend to include a nostalgic look back to what we believe was a simpler era."

and horrors that we might encounter," he says. "They say that human beings will prevail over evil."

One form of popular literature Cawelti has not tried to deal with is the romance novel, but it is not because he thinks the genre is less important. "My daughter is a great lover of the romance novel," he says. "They are very important. More than 50 percent of the books now published are romances."

Mystery, horror, detective novel or western, through all the years of scholarship, Cawelti says his respect for popular literature has increased.

"I see these works as tremendously important because so many people read them and are influenced by them," he says. "They are not only important as entertainment and relaxation but because they are modern myths. They are reflective of the way in which we see the world and the way in which people want to see the world."

The years have also changed the status of these works in the academic world. Popular culture is now firmly established as a mainstream discipline. In fact, Cawelti was honored as a founding scholar by the Popular Culture Association in 1993 and received an outstanding service award for his contributions to popular culture in 1996.

Young scholars around the world have also taken up the cause, pursuing their particular interests in the cultural implications of modern works. A recent two-page

e-mail Cawelti received attests to that fact.

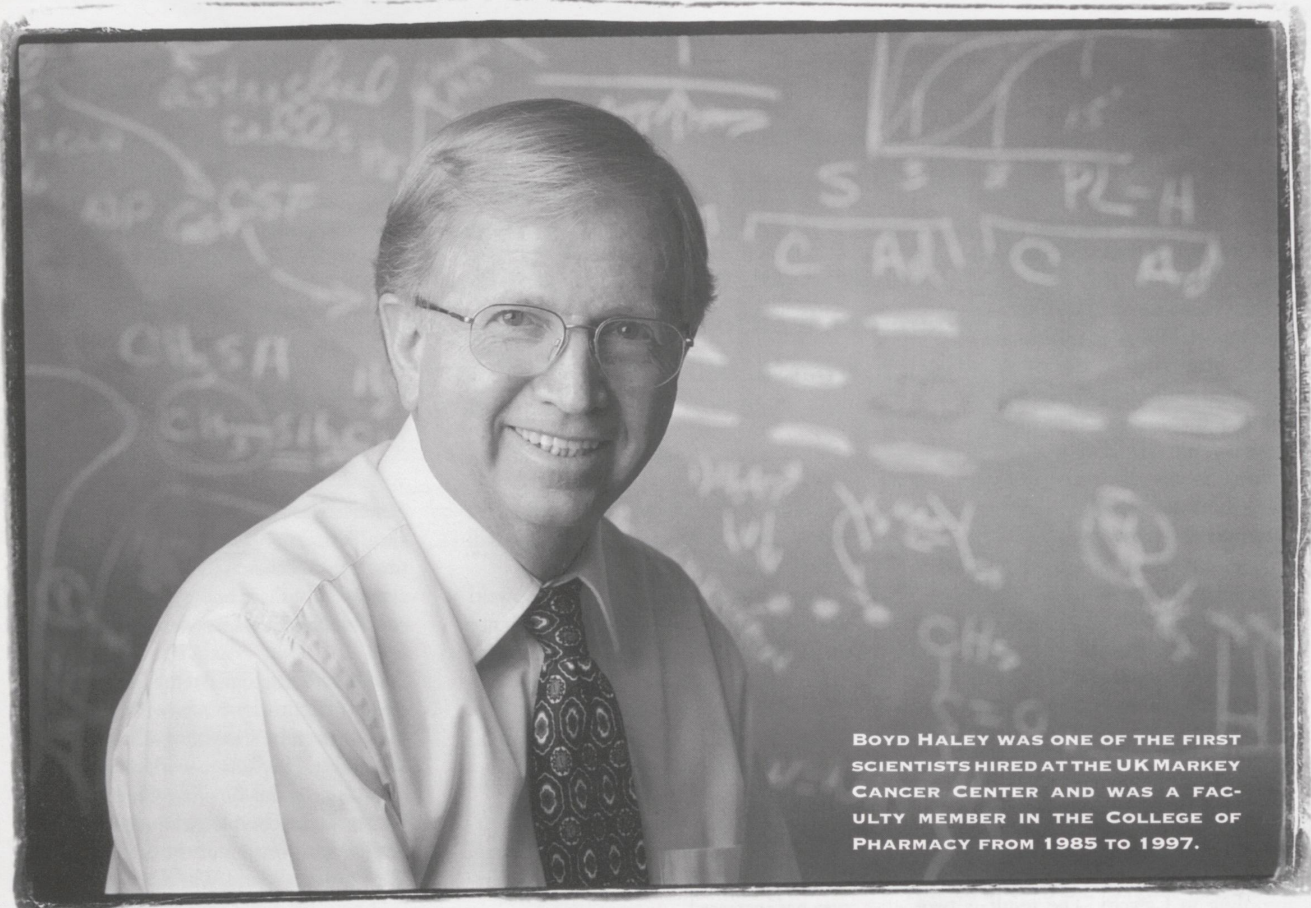
"My name is Martin Weidinger and I am a student of political science and English & American Studies at the University of Vienna/Austria," it begins. "My main reason for writing is to tell you how brilliant I found *The Six-Gun Mystique Sequel*. I just got my university degree by writing my thesis about gender roles in westerns and the relevance of the image of the man as it is created by the frontier myth in 20th-century

American politics and society *The Six-Gun Mystique Sequel* offers new perspectives and is miles away from just summarizing already-published books or retelling the contents of the same westerns over and over."

In May, Cawelti will retire from the University of Kentucky, but he will not leave his life's work entirely to young scholars such as Weidinger. He plans to work on an edition of essays for the Bowling Green Popular Press as well as complete a long-term project dealing with images of the South and the West in post-World War II America.

"I have no doubt that popular literature will continue to flourish and to evolve in reaction to changes in our lives," Cawelti says. "I would predict that the lines between traditional genres like the horror story, detective story, romance, and science fiction will progressively blur and that new genres which consist of mixes of these established forms will arise." He cites the example of the popular series "The X-Files," which clearly crosses the line between science fiction, the detective story and the thriller.

"I also would expect that the lines between 'serious' and 'popular' literature will become more complex. That can already be seen in the works of writers like Paul Auster, Thomas Pynchon, and Don DeLillo. I believe that new versions of the traditional genres will continue to be written. In many ways, traditional popular genres are the mythology of our times." ■



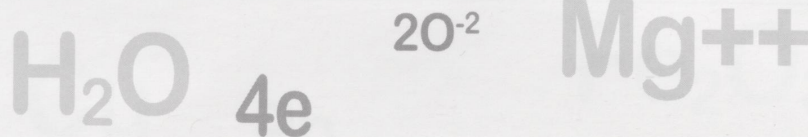
BOYD HALEY WAS ONE OF THE FIRST SCIENTISTS HIRED AT THE UK MARKEY CANCER CENTER AND WAS A FACULTY MEMBER IN THE COLLEGE OF PHARMACY FROM 1985 TO 1997.

W R I T T E N B Y
A L I C I A P . G R E G O R Y

At the Crossroads of Chemistry and Biology

Every living thing can be reduced to chemicals. Carbon, hydrogen, nitrogen—these chemical elements are the foundation for molecules that form the intricate, three-dimensional structures we know as DNA. Scientists at the University of Kentucky are focusing on the chemical roots of life in a new program designed to solve biological problems through chemistry.

While federal funds have dried up for traditional chemistry areas like weapons research, federal agencies and pharmaceu-



"There are people who don't want to touch genetically engineered food in the grocery store, but they'll happily pour Drano into their toilet. It's a completely ill-founded comfort level, and it's a fault of our education system that this kind of misunderstanding persists."

—Anne-Frances Miller

tical firms are eager to fund biological chemistry, says Boyd Haley, chair of the chemistry department at UK. "The Cold War is over. We've lost federal funding to develop better war materials, so the focus of chemical researchers has switched to things like environmental toxins that affect biological systems, and sensors for medical diagnostics.

"What we're setting up right now is an undergraduate degree program—a degree in chemistry with an emphasis in biological chemistry," Haley says. "If you're a smart student, you'll realize that getting an undergraduate degree in biological chemistry will increase your chances of getting into and surviving medical, dental or veterinary school, because it just so happens that in those professional schools the major flunk-out course is biochemistry."

It's clear that this is a hot job market, Haley says. "Take a look at the number of want ads in the back of *Science*, the major magazine where companies advertise for research people. The majority of these jobs require biological chemistry expertise."

Before this program began in the chemistry department, the closest thing on the UK campus was a Ph.D. program in biochemistry through the College of Medicine. "The university needs all of these—undergraduate and graduate programs—to provide a top-notch education," Haley says. "In the Ph.D. program they zero in on medical applications, while we

are doing a wide range of basic research. If you look at top 20 universities, they all have a biochemistry department and a chemistry department with a biological emphasis.

"Biological chemistry varies from biochemistry in that it usually involves application of 'heavy-duty' chemical techniques to biological problems such as using mass spectrometry and nuclear magnetic resonance," says Haley. He adds that an understanding of the various areas of chemistry, such as physical chemistry, and their application to biological problems is more heavily emphasized.

Biological chemistry was one of 11 strong research areas identified by UK as part of the Research Challenge Trust Fund (RCTF) initiative. Established by the 1997 Kentucky Postsecondary Education Act, one phase of RCTF includes \$16 million to support new faculty, graduate students and staff in the selected areas.

The biological chemistry program received \$3 million to renovate lab space and hire four research faculty and eight research assistants. The four new faculty, in addition to "five outstanding UK faculty" who have been conducting research in biological chemistry, are shaping a solid research and education enterprise, Haley says.

"Obviously, when you launch a new program, you hire new faculty to teach the courses," Haley says. In addition to teaching undergraduate courses in biological

chemistry, each new faculty member will be responsible for developing one graduate-level course in his or her area of expertise.

Haley was one of the first scientists hired at the UK Markey Cancer Center and was a faculty member in the College of Pharmacy from 1985 to 1997. He joined the Department of Chemistry the following year as professor and chair. "I came to the chemistry department because I wanted to teach graduate students," Haley says. "The level of work I do requires people who know a lot of chemistry."

Haley says today's booming biological chemistry market is one result of the Bayh-Dole Act of 1980, which enabled small businesses and not-for-profit organizations to retain title to innovations made under federally funded research programs. As a result, there was an explosion in the number of start-up biotech companies. "All of a sudden I can invent something, have the university patent it, and I'm allowed to take it and convert the new intellectual property into a business that will make money, create jobs and serve the public," Haley says.

"A large number of jobs available today are with companies that started out very small and are now large and have actually overtaken the old-fashioned pharmaceutical firms," he says. "It doesn't take a lot of money to start one of these companies—you find a protein that causes a disease, make an antibody to it, develop a simple Western blot test, and start selling your technology to the world."

Haley himself has transformed a technology developed in his lab into a thriving biotech company named Affinity Labeling Technologies Inc. (ALT). He co-founded ALT in 1998 with Curt Pendergrass, who received his Ph.D. in toxicology from UK in 1995 and worked as a postdoctoral fellow in Haley's lab for nearly four years.

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Located on the UK campus in the Advanced Science and Technology Commercialization Center, known as ASTeCC, ALT develops, manufactures and markets nucleotide photoaffinity probes—radioactive compounds used in research and diagnosis of disease. When these photoprobes are exposed to ultraviolet light, they bind to the active site of the protein, allowing it to be permanently tagged for identification. ALT uses photoprobes to diagnose periodontal disease and test toxicity levels before and after tooth extraction, and is selling this technology to a worldwide market.

And just recently, German scientists at the University of Göttingen confirmed findings that Haley published in 1992 in the proceedings of the *National Academy of Sciences* that proposed a diagnostic test for Alzheimer's disease. "UK owns a patent on this, and I hope to be able to make the test available as an aid for early Alzheimer's diagnosis," he says.

"In terms of cutting-edge research, I'd say chemists at UK are very close to the front of the pack in many areas, despite the fact that we just don't have the number of researchers other universities have," says Haley. "There isn't a better biosensor group in the country than the one here led by Leonidas Bachas and Sylvia Daunert. They have organized a major NSF graduate training grant in the biosensor area in addition to their personal grants, which are extensive. We have an excellent materials research center with Robert Haddon, and Allan Butterfield's research in protein oxidation in neurological disease is known around the world," Haley says.

"And add to these great strengths our new biological chemistry faculty. Tae Ji is absolutely the king of his area. Anne-Frances Miller is an outstanding protein NMR researcher—in the front of her field. Edward DeMoll's research is first-rate, and he is collaborating with outstanding researchers across the country. Stephen Testa is just

beginning, but his ideas are outstanding.

"Our new faculty alone brought in over \$1 million this year and a huge amount of free research equipment from their established laboratories. We're well on our way to paying back that \$3 million investment in the program."

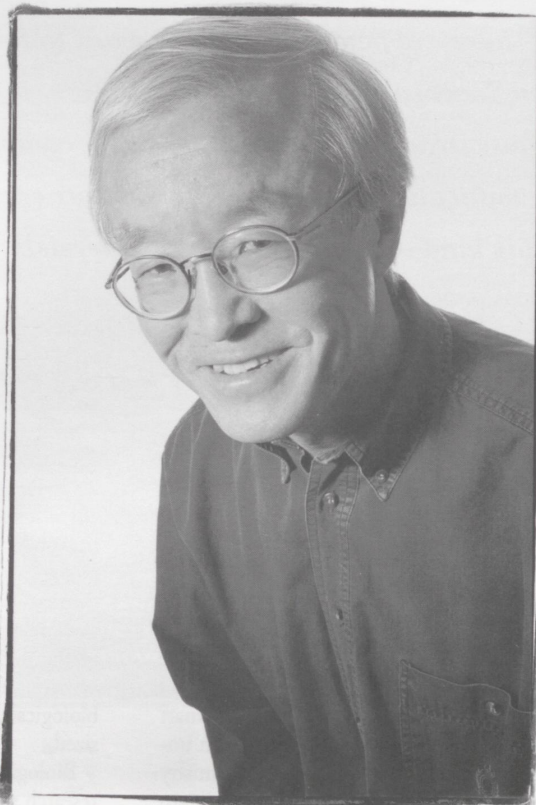
The chemistry of reproduction

Boyd Haley and Tae Ji (pronounced "Gee") are longtime friends. As colleagues at the University of Wyoming for almost a decade, they changed the face of biological chemistry. "Boyd and I were instrumental in drawing international attention to the biological chemistry center at Wyoming in the particular area of research called photoaffinity labeling," says Ji, who spent 30 years as a professor at Wyoming.

"Scientists from all over the world came to that center, and we traveled all around the world giving lectures," says Ji, a native of Korea, who did his doctoral work at the University of California at San Diego. "Boyd and I have been very competitive over the years, but our relationship is built on mutual respect of our science. I was very sorry when he left the University of Wyoming."

Haley played a major role in getting him to come to Kentucky, says Ji. "I had been getting offers from other universities, but I didn't go."

So what convinced Ji to come to the Bluegrass? "I knew I could trust Boyd, but there's more to the story than friendship.



BEFORE THE UK OFFER, TAE JI SAYS HE WAS CONCERNED ABOUT REESTABLISHING HIS REPUTATION AT ANOTHER UNIVERSITY, BUT BECAUSE HE ALREADY KNEW HALEY, HE COULD CONTINUE TO FOCUS ON HIS RESEARCH HERE.

Before the UK offer, I knew that if I moved to a new university, I'd have to reestablish my reputation, starting from ground zero. But at UK I didn't have to do that because the chair of the department knew me. I could continue to concentrate on my research—that was a major factor," says Ji. "Boyd's vision of creating a new group of scientists in the chemistry department emphasizing chemical approaches to biological problems struck me as an approach that would work very, very well."

Ji says the reason chemical approaches are

Cu

Pb

Fe₂O₃

Ca⁺²

so attractive today is the advent of molecular biology. "Chemical approaches were very popular and effective about 30 years ago, but in the meantime molecular biology rose to prominence. Now that the molecular biological approach has been fully utilized and chemical tools have become much more advanced, we are using chemical approaches on top of our mo-

lem for both sexes. We know a lot less about problems with sperm production than we know about infertility in women, but the same hormones are at work," Ji says.

"The contraceptive pills that have been used for the last 40 years or so are steroid hormones, and those hormones go into every cell in the body and affect cell function regardless of what that cell controls.

This hormone may also hold the key to early diagnosis of some cases of ovarian cancer. "Most of the time when we find this cancer, it's too late," Ji says. "Some ovarian cancer cells produce HCG, and there is a group of scientists right now trying to find out why that occurs so that they can work to develop diagnostic tools to detect HCG in these cells."

"Future contraceptive pills will use non-steroid hormones that will target only the ovary and will eliminate side effects."

—Tae Ji

lecular technology, and this combination has become a new, powerful method of solving biological problems," he says.

Ji was the last scientist of the four RCTF faculty Haley was trying to recruit, and Ji says that when Haley showed him the new faculty members' vitas he was very impressed. "I thought I could fit in with the rest and we could really create some powerful teams," he says. "The existing faculty have outstanding backgrounds in chemistry—in particular, analytical, inorganic, organic, physical and radio chemistry. Being able to tap into such expertise is an opportunity you don't get too often."

Ji's research focuses on three hormones, LH (luteinizing hormone), FSH (follicle stimulating hormone), and HCG (human chorionic gonadotropin). LH and FSH are involved in the development of gonads in both sexes and the control of sexual cycles in women. "These are the crucial hormones in regulating ovulation cycles," Ji says. "They have to come in at the right time, in the right sequence for ovulation. Obviously, these hormones are important for succession of the species, but in addition they are keys to solving infertility, making better contraceptives, and treating menopause."

Sixteen percent of families in the world face infertility, Ji says. "Infertility is a prob-

lem for both sexes. We know a lot less about problems with sperm production than we know about infertility in women, but the same hormones are at work," Ji says. "The contraceptive pills that have been used for the last 40 years or so are steroid hormones, and those hormones go into every cell in the body and affect cell function regardless of what that cell controls.

When the pill first came out about 50 years ago, the dose was 50 times higher than the current dose, and we saw tremendous side effects—cancers, gene disruption—and researchers said the maximum time period you could take the pill without major effects was five to 10 years," he says. "Future contraceptive pills will use non-steroid hormones that will target only the ovary and will eliminate side effects."

FSH also plays an important role in the acute phase of prostate cancer. "We recently, in collaboration with other groups, have found that prostate cancer cells start producing FSH and its receptor molecules simultaneously. We think the reason the cancer cells proliferate and the patient dies is because FSH stimulates cell growth and division," Ji says.

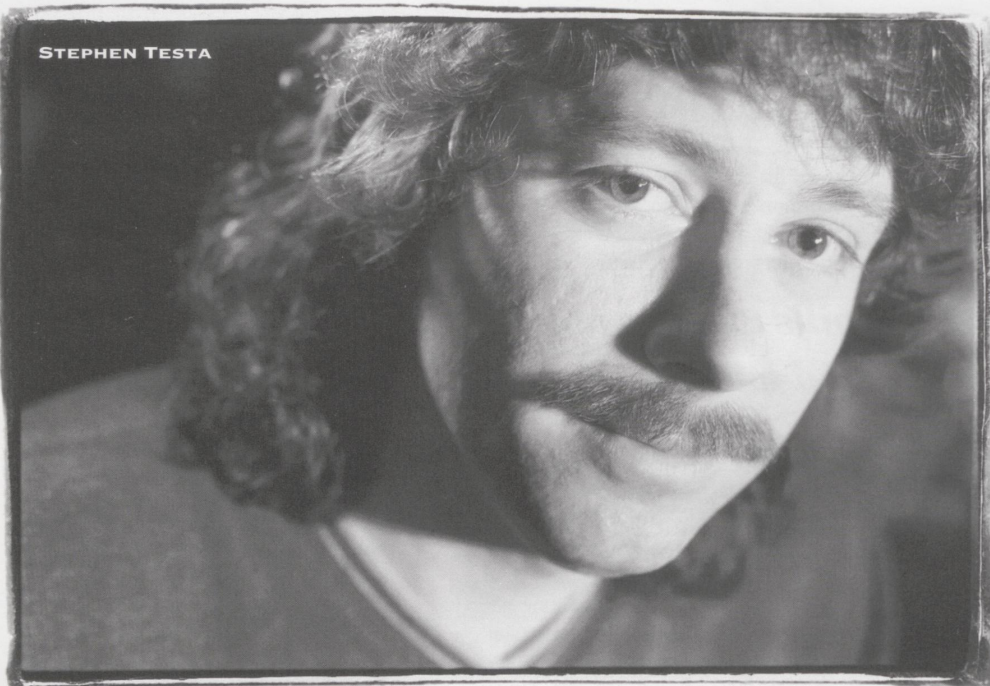
The third hormone, HCG, is key in protecting fertilized eggs. "When an egg is fertilized, the first thing it does is go to the mother's womb. As it starts developing, it produces HCG, which blocks the initiation of menstruation." Without HCG, the egg will be flushed from the womb when the woman menstruates and she will have a miscarriage. This hormone is critical in the first three months of fetal development, Ji says. "All pregnancy tests test for HCG."

HCG, LH and FSH have high specificity, which means they bind only to certain molecules called receptors. Once these hormones bind to the receptor, it generates a signal. "The focus of my research has been to learn how the hormone and receptor interact and how occupied receptors generate hormonal signals," says Ji. "If we can identify the precise mechanisms, we will be able to generate the hormonal signals without having the particular hormone present." So instead of taking hormonal pills, Ji says, you could spray something into your nose with a chemical that simulates a specific hormone to fool the receptor into generating the desired signal.

In addition to the array of medical applications in humans, Ji says his research may also impact animal breeding. "Veterinary science labs and biotech companies are using these hormones to regulate cycles in cattle, and that's a huge market. These hormones will impact horse breeding and in-vitro fertilization in all kinds of animals and in humans," says Ji. "For in-vitro fertilization you need lots of eggs and the way to make them is to use these hormones."

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STEPHEN TESTA



Changing the shape of chemistry

You could say Stephen Testa has gone "where no man has gone before" in the chemical world. Armed with a Ph.D. in biochemistry and molecular biology from Purdue in 1994, Testa went to the University of Rochester in New York to "start something new." A half year later he had generated enough preliminary data to apply for an NIH postdoctoral fellowship, which he was awarded.

"The essence of this new area is creating a better way to develop therapeutics from small portions of DNA," Testa says. "We know that certain regions of DNA are important for certain diseases, and we know we can target them by simply making DNA that will bind to these targets. The buzzword for the way this is currently done is 'antisense.'"

"Antisense simply means you target the linear sequence of a gene. All genes are made up of adenine (A), thymine (T), guanine (G), and cytosine (C). Because we know that A pairs with T, and G pairs with C, we can easily design a complementary molecule that will bind tightly to the region we're targeting, shutting it off and potentially stopping the disease."

The problem is that these molecules are relatively long, resulting in non-specific binding to the DNA, Testa says. Essentially, this long strand sticks to other regions in the DNA that have a sequence similar to the target site. "So the idea that Doug Turner—my postdoctoral advisor at Rochester—and I came up with was to find a way to make these molecules shorter. And the way we do that is to exploit the fact that RNA can fold into three-dimensional, bio-

logically active structures. Up until now it has been widely appreciated that only proteins can be exploited for drug design in this manner," he says. "What we did was show that RNA does form these structures, and that you can target them with small molecules and potentially affect biological activity."

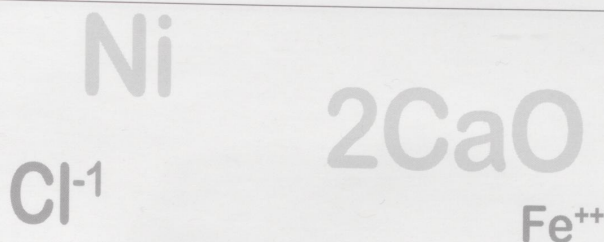
In addition to this method of creating DNA that fits like a puzzle piece into a specific spot on the RNA chain, Testa is working on an experimental tool to test potential therapeutics. This new and powerful "combinatorial method," as he calls it, will allow him to test billions of these small molecules simultaneously and single out the ones that work best.

"For example, if you want a therapeutic that is 16 bases long, there are billions of possible different sequences. If I were able to test even a thousand a day with current methods, it would take over 10,000 years to test them all. I'm developing a method where we can test all of them in about a week.

"There are certainly important advantages to using such technology for drug development, not just to save time but also to reduce cost. This technology will give us the ability to learn about disease targets we currently know nothing about," Testa says.

As scientists identify more and more genes responsible for disease, the opportunity to develop specific therapeutic molecules grows. "There's no better time than now to start thinking about how we can use biological chemistry principles to design therapeutics against specific diseases," he says.

"In the project where I'm developing the



combinatorial method, the model target is a potentially lethal fungus that causes pneumonia in AIDS and cancer patients. I'm also working with DNA that causes a type of muscular dystrophy called myotonic dystrophy," he says. "We've known for nearly 10 years what happens to your DNA and RNA when you have this disease—certain regions grow longer, or expand. What I'm working on is a novel method to cut the expansion out, which will essentially fix the RNA and/or DNA. Because we know an essential step in this disease, there's absolutely no reason why we can't start developing therapeutics that will make a big difference in people's lives."

If he succeeds in cutting out that expansion, Testa says the method will be applicable to a wide range of diseases, including AIDS and cancer.

While the reasons why this expansion occurs are still a mystery, Testa says in the past year alone scientists have made breakthrough discoveries about why this expanded region causes the effects you see in myotonic dystrophy patients. "I'm certainly not the first person to think about developing a therapeutic for this," says Testa, "but very few scientists have tried to target this disease at its fundamental source."

"There's an important reason I'm in the chemistry department despite the fact that most of my training has been in biochemistry and biophysics. All biomolecules are simply chemicals. There are no magical properties at work here; these biomolecules follow all the rules we learn in basic chemistry, and it's precisely this kind of information that we want to exploit for designing new therapeutics."

"Here at UK there is a lot of opportunity to form interdisciplinary collaborations, not just within the chemistry department but throughout the entire campus. It's exciting to get in on the ground floor of something like this, especially as a junior faculty member."

An anaerobic way of life

Edward DeMoll was right under Boyd Haley's nose, but it took a phone call to NSF to find him. "Dr. DeMoll, who we got from the UK medical center, I found by talking to a program administrator at the National Science Foundation," says Haley. "I asked for leads on good, young faculty in biological chemistry that I might attract to UK, and he said, 'Well, you've got one right in your back yard. You should go after Eddie DeMoll.' So I met him at an American Society for Biochemistry and Molecular Biology conference in San Francisco. I just walked up to him during his poster presentation and introduced myself."

DeMoll now has dual appointments, a primary appointment as an associate professor in chemistry and another in microbiology and immunology in the College of

Stephen Testa: "It's exciting to get in on the ground floor of something like this, especially as a junior faculty member."

Medicine. "In mixing disciplines you find you're doing research a lot of people don't think about doing because you've got two different viewpoints on things," he says.

Methanogens, organisms that produce methane gas, have been DeMoll's research focus since he was a postdoc. "All forms of life are either bacteria, archaea or eucaryotes," he says.

He explains that archaea are of three different types: methanogens, extreme halophiles (they live in very high-salt environments), and extreme thermophiles (they live at very high temperatures). Extreme thermophiles include organisms that live on the ocean floor near hot thermal vents and

in the hot springs in Yellowstone National Park. DeMoll says there is some overlap between these three groups of archaea. "Some of the methanogens are also extreme thermophiles. I work with one that we grow at 75 degrees Celsius. Also, extreme thermophiles and methanogens are all anaerobic (they live in the absence of oxygen)."

Scientists didn't really establish that archaea was a separate group until the mid-'80s, with the advent of molecular biology, he says. "Originally, I think the guy used the term 'archaea' because he was thinking these were ancient-type bacteria, but actually the ones we see today are pretty modern organisms. They have their own niche—the ability to live in extreme environments. Molecularly and genetically they are unique and because a lot of archaea haven't been isolated until recently, there's a whole big area, a whole brand-new biochemistry, out there to be studied."

DeMoll says one application for extreme thermophiles is in polymerase chain reaction (PCR), a common laboratory technique for reproducing specific DNA sequences. PCR can produce millions or billions of copies of a piece of DNA in a few hours. "There's one step in PCR where you need to heat up the sample, so it's convenient to have an enzyme that's not killed by the heat," he says.

"Methanogens live in swamps, in your gut, in digestive systems of different species—but in all of these environments methanogens are anaerobic and produce methane to get their energy," DeMoll says. "The main reason I started looking at methanogens was my postdoc mentor at NIH, Thressa Stadtman. She was one of the first people to actually study these in the late 1940s."

DeMoll recalls that when he began his research in the early '80s, not much time had passed since the OPEC boycott caused

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fuel prices to skyrocket. "The Department of Energy was created, and one of their focus areas was basic energy sciences. It included a little group called energy biosciences, which was interested in funding research on energy production through biological means," he says. "Since methane is natural gas, I thought, 'Heavens, I've been looking at the biochemistry of methanogens for four-and-a-half years.' The energy biosciences group funded that work."

Many methanogens grow on a single carbon source like carbon dioxide, DeMoll says, and his goal is to explore the enzyme that facilitates the synthesis of one-carbon compounds into a two-carbon compound. "They need a source of electrons, too, so a lot of methanogens take carbon dioxide and hydrogen and make methane out of it. The enzyme complex involved here fixes carbon dioxide through a unique mechanism that doesn't evolve oxygen, and this is something we haven't found in the rest of the world."

This enzyme complex is also involved in the reverse reaction—breaking down two-carbon compounds into single-carbon compounds to produce methane. DeMoll says of the five proteins in this enzyme complex, three have novel catalytic activities. His current research is focused on revealing the structure and mechanisms by which these proteins work.

"To do this research we use 'glove bags' because we have to work in the absence of air," DeMoll says. "Before these tools were developed, we had to work in a room filled with nitrogen. We had to wear breathing equipment and work in pairs because of the danger. It was pretty eerie, because all you could hear was your own breathing."

DeMoll has been collaborating for the past three years with a number of other researchers, including fellow UK scientist Robert Perry in microbiology and immunology and Christopher Walsh, a biologi-

cal chemistry and molecular pharmacology researcher at Harvard Medical School. Walsh's work is focused in the same area as Perry's and DeMoll's, so he wanted to come to Lexington to meet up with them. "Just coincidentally, Chris's sister lives in Lexington, too—in the same neighborhood where Bob and I live—so Chris has both professional and personal reasons to come to town," DeMoll says. The three researchers are currently involved in a project based on Perry's findings about the organism that causes bubonic plague.

"Iron is not very widely available in the environment, so many of the bacteria that cause disease have to scavenge for iron once they get into the body. They make these little compounds that go out and steal iron from various parts of our body and bring it back to the bug. Bob found out that by the natural route of infection the organism that causes bubonic plague wasn't virulent—when he mutated the genes responsible for a certain kind of iron uptake, it did not cause disease. The National Institutes of Health was very interested in this," says DeMoll.

"Though we don't have a bubonic plague problem in the United States, it's a good model of disease so that's why we study it. The Army is interested in it because a lot of places they go, they have to worry about plague."

DeMoll says his role in this project is to explore the fundamental catalytic mechanisms—the way enzymes stimulate reactions—when the bubonic plague organism enters the body.

He sums up his research with these three goals: 1) learn about new types of catalysis and uncover new chemistry to create and break down carbon compounds, 2) improve methane for heating applications (manure ferments and produces methane that farmers can use for small-scale heating), and 3) reveal the mechanics of each step in enzyme reactions.

DeMoll points to the research project he did in his senior year at the University of

Texas at Austin as the experience which led him to his current career. "One of the most important things a student can do is undergraduate research," DeMoll says. "My research project was really the first exposure I got, and it proved to me that science was a lot of fun."

Problem-solving through enzyme engineering

She came to the University of Kentucky to solve a "two-body problem," says Anne-Frances Miller, an associate professor who spent almost seven years at Johns Hopkins University.

"My husband had been promoted at Boston University, and I'd been promoted at Hopkins, but I couldn't get a job in Boston and he couldn't get a job near Baltimore. So the University of Kentucky was able to come up with two tenured positions and the apparatus I needed," Miller says. "This is a really smart thing for a place like UK to do—exploit the fact that they have more than one position open to get two people at once. You'll get people you might not otherwise get, and moreover once you've got them, you're less likely to lose them because neither one will leave without the other. More institutions should clue into this." Miller and her husband Ganpathy Murthy, an associate professor of physics, came to UK last summer.

"UK is very attractive in terms of colleagues, and the equipment and research support was crucial. It's suicide to go somewhere that won't give you support," she says.

Miller praises Boyd Haley for what she calls energetic and forward-thinking leadership. "His willingness to shake the system into trying something new is very important because institutions that aren't prepared to toss out the old as soon as it is outdated, if not before, will go the way of the dinosaurs. They may persist as teaching institutions, but they will not succeed as research institutions. You need gutsy people in the higher offices, people who are willing to evaluate risk after risk instead of retreating to the comfort of what

has been done before," says Miller, who earned her Ph.D. in biophysical chemistry from Yale and conducted postdoctoral research at MIT.

Through grants from the American Cancer Society, NSF, NIH, and the Petroleum Research Foundation totaling more than \$1 million since 1993, Miller has been utilizing nuclear magnetic resonance (NMR) to study enzymes.

"NMR reveals chemical functionality," she explains. "We take advantage of the fact that the nuclei of naturally occurring atoms emit very weak but extremely informative signals. In the example of my own research, the

enzyme superoxide dismutase has 2,000 hydrogen atoms in it, with 2,000 separate protons—each with its own signal, each one giving you information about what a corner of the molecule is doing. It's very rich information and, moreover, it's site specific. You can map what each individual proton is experiencing."

In the simplest terms, Miller's work focuses on the movement of electrons. "Electrons are minute, fundamental particles. Enzymes, which are great big proteins by comparison, are able to manipulate exactly where electrons go, and how much energy is involved in these transactions.

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TO DO HIS RESEARCH, EDWARD DEMOLL USES 'GLOVE BAGS' BECAUSE HE HAS TO WORK IN THE ABSENCE OF AIR. "BEFORE THESE TOOLS WERE DEVELOPED, WE HAD TO WORK IN A ROOM FILLED WITH NITROGEN. WE HAD TO WEAR BREATHING EQUIPMENT AND WORK IN PAIRS BECAUSE OF THE DANGER. IT WAS PRETTY EERIE, BECAUSE ALL YOU COULD HEAR WAS YOUR OWN BREATHING."



"I don't need to be the world's expert on some itty bitty corner of something virtually irrelevant. I want my work to be of interest and of use to as big a community as possible."

—Anne-Frances Miller

"The amount of energy the protein itself can leverage on these electron movements is something, as chemists, we call the 'redox potential,'" she says. "Superoxide dismutase gives and takes electrons onto the metal ions in the enzyme. The higher the redox potential of that ion, the more avid an electron receptor that ion will be." In a lot of cases, says Miller, she wants to reverse this process so that instead of accepting electrons a metal ion will act as a donor.

"We can go in and modify the protein slightly and dramatically alter the chemistry that the enzyme will execute." The goal, she says, is to engineer enzymes to do novel chemical reactions through very minor changes to the original proteins.

"We've been able to take an enzyme that normally activates manganese, make a single change, and now it activates iron. The reverse change," she says, "is perhaps the more clinically useful one. Iron is a little bit toxic, and manganese isn't, so you would take an enzyme that uses iron and have it use manganese instead."

"The enzyme's job is to focus the metal ion on one particular reaction—and this is really the hallmark of enzymes as catalysts, they are very specific," Miller says. "There are a lot of catalysts that do a perfectly decent job accelerating a reaction; frankly

iron alone without the whole protein accelerates the reaction very, very well. But most metal ions catalyze many reactions.

"A cell has a thousand reactions going at once, and they need to occur in synchrony and harmony—you can never afford to build up one compound and not have enough of another, so reactions have to be tightly controlled and highly specific. You can't have iron running around doing a dozen reactions willy nilly. Control is what the protein brings to you," Miller says. "Because protein enzymes like superoxide dismutase are exquisitely specific, it's safe to administer a fair amount of this stuff to a patient. You don't need to worry about by-products, side reactions, or other unintended activity."

Miller says she is focusing on superoxide dismutase because it is the little cousin of a number of other more complex enzymes that catalyze clinically, environmentally and industrially important chemical reactions. "What we'd really like is the option to choose the metal that is most useful and adapt the protein to do whatever chemistry we desire. Superoxide dismutase is a great model for learning exactly how we can go about doing that."

This research has sweeping applications. "Pain relief, inflammation, arthritis, auto-

immune disorders, spinal cord damage—the possibilities go on and on," Miller says. "A lot of people are already looking at oxygen free-radical damage. The loss of function after spinal cord injury is largely related to damage after the injury, not during the injury itself, and often that damage is the result of uncontrolled oxidative reactions." Oxidation simply refers to any chemical process that removes electrons from a molecule.

"Many, many diseases have an oxidative damage component," she says. "Superoxide dismutase can prevent all that. UK has a lot of strength in this area."

Miller's research also reaches into the area of waste detoxification, breaking down toxic pesticides, herbicides and PCBs. "We work very hard in my lab to not get pigeonholed into something too specific," she says. "I don't need to be the world's expert on some itty bitty corner of something virtually irrelevant. I want my work to be of interest and of use to as big a community as possible."

Miller says the public needs to be well educated about biological chemistry and biotechnology. "We're seeing the fruits of these technologies on a day-to-day basis," she says. "Genetically engineered crops and animals, genetic therapies for congenital diseases, genetic production of drugs—decisions we make every day should be based on a good education in these areas."

"The rampant fear of genetic engineering is dangerous. It produces inappropriate action, knee-jerk responses, to a technology that has enormously powerful possibilities. This sort of blind fear is completely unnecessary—biotechnology is extremely exciting, and it's not inaccessible to the public. We all stand to benefit a lot as long as we inform ourselves to make wise decisions," says Miller. "There are people who don't want to touch genetically engineered food in the grocery store, but they'll happily pour

Drano into their toilet. It's a completely ill-founded comfort level, and it's a fault of our education system that this kind of misunderstanding persists."

Miller says UK students in the new biological chemistry program will be well prepared for the new world of biotechnology. "We've given some serious thought to trying to put together a group of courses that will give an advanced undergraduate or entering graduate student a solid foundation. Our students should come out with a working knowledge, a working comfort, and an aggressive excitement, because biological chemistry will be a real part of their future," Miller says.

"If they're ready to step in with confidence and a good understanding, they'll have a lot more options available to them and they'll be more sought-after. My own students are getting into law firms, the patent-trademark office and industry at a number of levels because of the comfort and familiarity they have with this new area." ■



(LEFT TO RIGHT) GRADUATE STUDENTS JOSEPH WALSH, RONALD KEDER AND EMINE YIKILMAZ FOLLOWED THEIR PROFESSOR ANNE-FRANCES MILLER (FOREGROUND) TO THE UNIVERSITY OF KENTUCKY FROM JOHNS HOPKINS. IN THE BACKGROUND IS ONE OF SEVERAL STATE-OF-THE ART NUCLEAR MAGNETIC RESONANCE INSTRUMENTS IN THE CHEMISTRY DEPARTMENT'S NMR LAB.

A BAD, BAD BUG

Supported in her work by two prestigious fellowships from UK's Graduate School, Lisa Pedersen is studying a bacterium called *Legionella*. If you recall the TV ad where a kid at King's Island is water-rushed down the last turn of the giant slide and jetted out into the air, you have an image that may help you understand this bacterium.

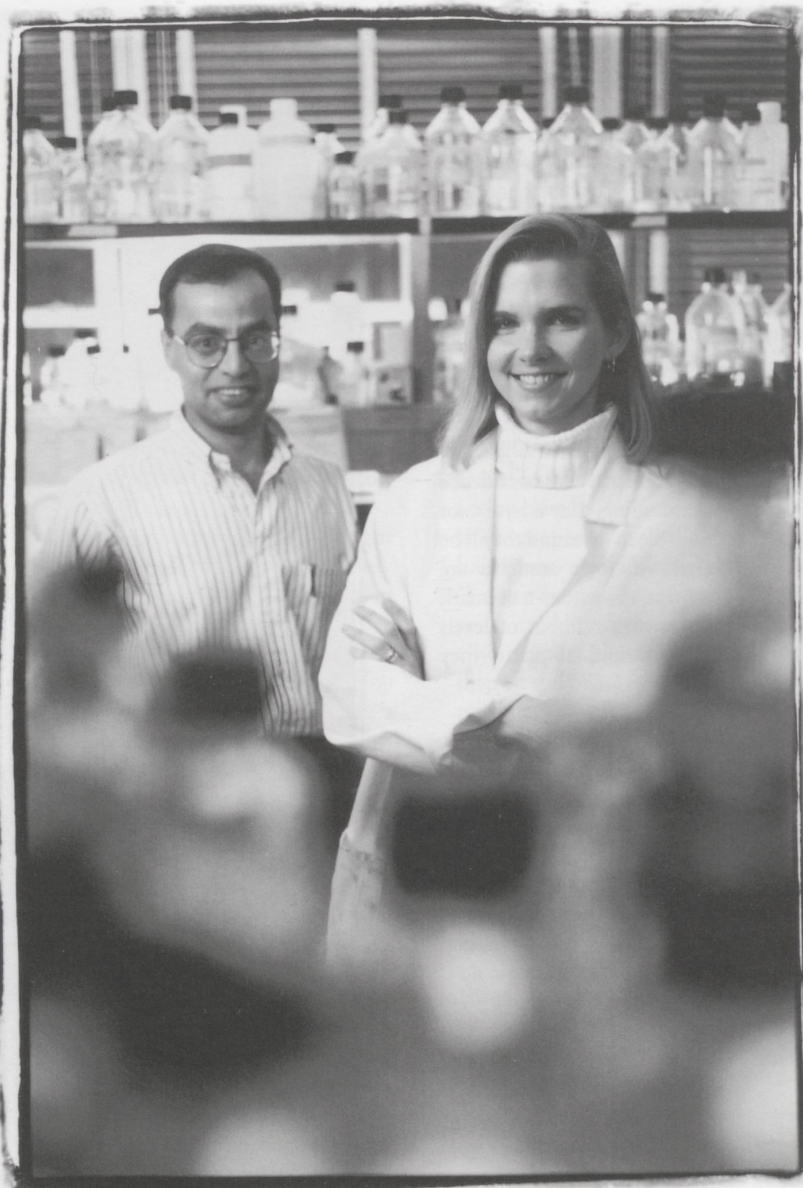
Pedersen is studying one species of *Legionella*, called *Legionella pneumophila*. When the water that moves these bugs is contaminated and changes into aerosol form (water droplets small enough to be inhaled) the bacteria, if breathed in by humans, can cause flu-like symptoms, muscle aches, headaches, loss of appetite, and dry cough.

"I was interested in *Legionella pneumophila* and its system from the start," she says. "As soon as I met with Dr. Abu Kwaik and he told me about how *L. pneumophila* works to hijack the host cell, I was hooked. I found it fascinating, and jumped at the opportunity to work on it." Yousef Abu Kwaik is an associate professor in UK's Department of Microbiology.

"*L. pneumophila* causes two distinct illnesses," says Pedersen, who plans to graduate in May with a doctorate in microbial biology. "One of these, with symptoms lasting up to 48 hours, is usually taken care of pretty easily by the immune system." This brand of the disease is commonly referred to as Pontiac fever.

Potentially much more serious is the second illness, which can lead to pneumonia and, possibly, death. An outbreak of this cousin of Pontiac fever among persons attending a state convention of the American Legion in Philadelphia in 1976 led to the disease's name. In this outbreak, 180 people came down with pneumonia and 29 died.

Legionnaire's disease is transmitted through inhalation of contaminated aro-



GRADUATE STUDENT LISA PEDERSEN, WITH YOUSEF ABU KWAIK, IS STUDYING A BACTERIUM CALLED *LEGIONELLA*, WHICH, IF BREATHED IN BY HUMANS, CAN CAUSE FLU-LIKE SYMPTOMS, MUSCLE ACHES, HEADACHES, LOSS OF APPETITE, AND DRY COUGH. ABU KWAIK IS AN ASSOCIATE PROFESSOR IN UK'S DEPARTMENT OF MICROBIOLOGY.

WRITTEN BY
TARA ANDERSON

sols generated by air-conditioning cooling towers (not window air-conditioner units), shower heads, drinking fountains, and jacuzzis. *L. pneumophila* is carried by amoeba that live in the water; no person-to-person transmission has ever been documented.

"When the bacteria-containing water droplets are inhaled, they enter the cells lining the air exchange regions of the lungs, the alveoli," Pedersen says. "If the immune system doesn't kill them, the bacteria can rapidly multiply and destroy the alveolar cells. Up to 50 percent of cases occurring in some hospital outbreaks have resulted in deaths."

The key to preventing the onset of pneumonia is finding a way to target the bacteria's ability to multiply unchecked within macrophages, the body's seek-and-destroy militia, and other cells in the alveoli. Pedersen has already singled out some genes that allow the bug to thrive inside macrophages, and she is currently working on identifying other genes which are vital to the way *L. pneumophila* escapes its host cell and spreads to other cells in the lungs. "This work is important because if the bacteria can't break out of the host cell to infect other cells, they just eventually die inside the macrophages and the infection is stopped," Pedersen explains.

Anyone can be infected by *L. pneumophila*, but only about five percent of infections result in Legionnaire's pneumonia, with about 25,000 cases diagnosed in the United States each year. Those who catch this bug are most frequently the elderly, people with suppressed immune systems, and smokers. Legionnaire's pneumonia kills 15 to 50 percent of patients.

One reason to focus on *L. pneumophila* is that it is an excellent model for studying other bacteria, Pedersen says. "What we

learn from *L. pneumophila* may be applicable to other intracellular bacteria, including those that cause more common diseases."

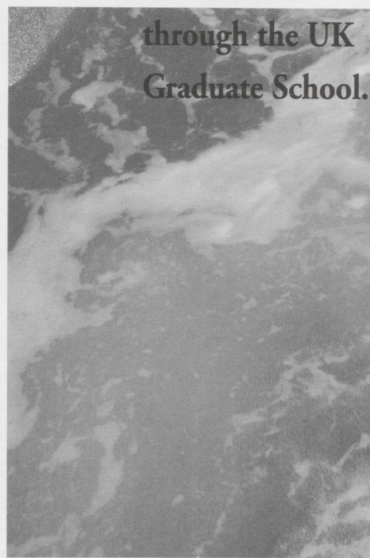
She says she has enjoyed her years in graduate school at UK. "I've learned how to solve problems, to design and develop experimental plans, and to draw sound conclusions from experimental data," she says. "I've also learned that not everything works the first time around."

Pedersen adds that *not* finding the expected answer is also an important research result. "That's not a bad thing, because sometimes a 'mistake' leads to new discoveries. It's a fantastic and exciting time to be in research," she says. "I have made good friends here, some of whom have graduated and now hold post-doc positions. Others have gone on to pursue other dreams, like med school."

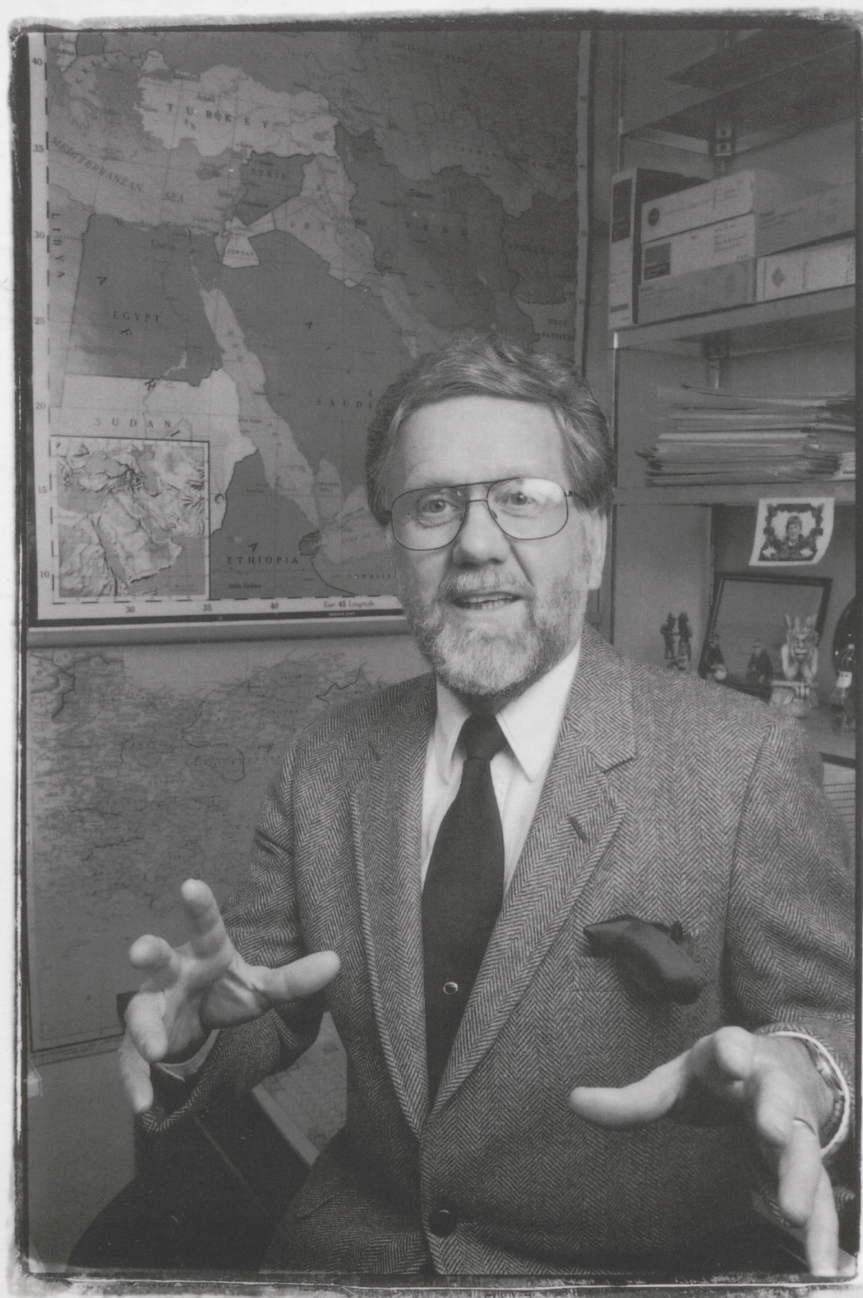
"Lisa has been a very good graduate student," says Abu Kwaik. "She came to us not having done any research in her life, and has developed into a very good scientist within a short period of time. Over the past couple of years, she has developed her skills tremendously, and has become a great asset for our research program. It's always very rewarding to see a graduate student developing scientific skills. These are the future scientists who will make a difference."

Pedersen has been well supported in her work at UK. She received a Kentucky Opportunity Fellowship for 1998-1999 and a Dissertation Year Fellowship for 1999-2000 through the UK Graduate School. The \$15,000 Kentucky Opportunity Fellowship is part of the Research Challenge initiative established in 1997; the Graduate School awarded 35 Kentucky Opportunity Fellowships in 1998-99 and another 35 for the current academic year. Dissertation Year Fellowships carry a stipend of \$12,000 and cover full tuition. ■

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KIRWAN AWARD WINNER WIDELY RECOGNIZED FOR KURDISH STUDIES



Having grown up on a northern Minnesota farm with no running water, Robert Olson was surprised to enjoy that luxury his first year in the Peace Corps in 1963. "I like you because you never complain," he recalls the Corps director telling him.

"That's because I'm the only volunteer whose standard of living has gone up since I've come to Turkey," Olson joked.

Today Olson is a University of Kentucky history professor and the recipient of the Graduate School's 1999 Albert D. and Elizabeth H. Kirwan Memorial Prize for his work in Kurdish studies, a field in which he is ranked among the top three

ROBERT OLSON WAS THE FIRST SCHOLAR TO PUBLISH A BOOK RECOGNIZING THAT THE KURDS PLAYED A MAJOR ROLE IN THE SETTLEMENT OF WORLD WAR I, AND ALSO THE FIRST TO ARGUE, IN HIS *THE SHEIKH SAID REBELLION AND THE EMERGENCE OF KURDISH NATIONALISM: 1880-1925*, THAT THE KURDISH NATIONALIST MOVEMENT IS JUST AS IMPORTANT AS THE CONTROL OF OIL IN THE MIDDLE EAST.

WRITTEN BY
DAVID WHEELER

scholars in the world. The Kurds are a people who primarily inhabit a plateau region in adjoining parts of Turkey, Iran, Iraq and Syria, and now comprise 25 million people living all over the Middle East.

"Bob should be noted for his broad and thorough familiarity with both the history and the contemporary circumstances of the region," says Cemal Kafadar, professor of Turkish studies at Harvard University. "He's a rare person, who can do both really well."

The significance of Olson's work is two-tiered. Not only was he the first scholar to publish a book recognizing that the Kurds played a major role in the settlement of World War I, he was also the first to argue, in his *The Sheikh Said Rebellion and the Emergence of Kurdish Nationalism: 1880-1925* (1989), that the Kurdish nationalist movement is just as important as the control of oil in the Middle East.

Olson's overall term for the Kurdish nationalist movement and its effect on the Middle East is what he calls the Kurdish question. "If the Kurds were to be given their own sovereign state in northern Iraq, the United States would have easier access to oil reserves. But if that happens, the Kurds in Turkey might demand their own autonomous zone to be carved out of the southeastern section of that country, causing conflicts of interest between the United States and its ally," Olson says.

"A further consideration is that Turkey might, then, demand that Europe and the United States help them control the Kurdish movement if they are going to let water flow down to Israel and its Arab dependencies," he says.

The United States' concern over the Kurdish question makes the subject relevant and as real to Olson's students at UK as it is to students in Turkey, where the highest percentage of Kurds live. His book *The Siege of Mosul and Ottoman-*

Persian Relations has been used at Istanbul University in graduate studies courses.

"It's clearly pleasing when the people with whom you're dealing translate your books into their own language," he says. In fact, four books that Olson has authored or edited have been translated into either Turkish or Arabic. He works in several languages, though primarily in Turkish, French, Ottoman (a combination of Turkish, Arabic and Farsi, which was the official language of the Ottoman Empire until 1918) and English.

Olson's accomplishments fit the criteria of the Kirwan prize well. His five books, 75 articles, and approximately 60 scholarly essays and reference works, combined with 70 presentations at colleges and conferences, are, indeed, "outstanding contributions to original research or creative scholarship," as the prize requirements stipulate.

Last December his expertise led him to address the Kurdish question as one of two main speakers at a closed seminar conducted by the Institute for National Strategic Studies for high-ranking State Department intelligence and military officials, policy analysts of the Middle East, and political analysts who advise the president of the United States.

In an earlier life, the university history professor taught high school English in Hibbing, Minnesota. After his first year of teaching, he joined the Peace Corps and spent two years living and working in Turkey. Sometime during his second year there, he decided he wanted to be a professor of Middle Eastern history. "It was an exhilarating, eye-opening experience to be in another culture, especially an Islamic culture, and to be actively learning another language," he says.

Olson's fluency in Turkish came with practice, but not without an occasional blunder—like the one that occurred soon after his arrival in the new country. "When

The \$5,000 Kirwan prize, presented through the UK Graduate School, recognizes outstanding scholarship over the period of four academic years. It is one of the top honors given by UK to a faculty member.

you visit someone in their home, you typically say, 'Your house is very nice and very comfortable.'" But in Turkish the word "house" is very similar to the word "wife," and Olson mixed up the words on his first try at the compliment. "I said, 'Your wife is very nice and very comfortable.'" The mistake did not lead to a fistfight, only to a funny look from the hosts.

After returning from the Peace Corps, Olson attended Indiana University, where he received a Ph.D. in 18th-century Ottoman history. His mentor at Indiana, Wadie Jwaideh, was the most recognized scholar of Kurdish studies in the world at the time. Olson taught at Clemson University for one year and joined the UK faculty in 1973.

Because the Gulf War in the mid-1990s created an upsurge of Kurdish nationalism, Olson had several opportunities to write for *Middle Eastern International*, the premier political journal on the Middle East.

Just as Olson bridged the gap between America and the Middle East firsthand as

continued on page 26

"The greatest richness in my intellectual and personal life has been my acquaintance with Middle Eastern peoples, cultures and civilizations."

—Robert Olson

a Peace Corps volunteer, he offers his students a similar connection through his passion for teaching about the region and its history. "The greatest richness in my intellectual and personal life has been my acquaintance with Middle Eastern peoples, cultures, and civilizations," Olson says.

Unfortunately, he often finds that before he can teach his students anything about the region, he must spend time breaking down misconceptions—about Muslim fundamentalists, for example—that Olson says are perpetuated by the media. "The pejorative stereotype is quite distant from the truth," he says.

The field of Kurdish studies has grown considerably since Olson's first trips to the Middle East in the 1960s. And more young scholars are expressing an interest in the Kurds, a trend which pleases Olson.

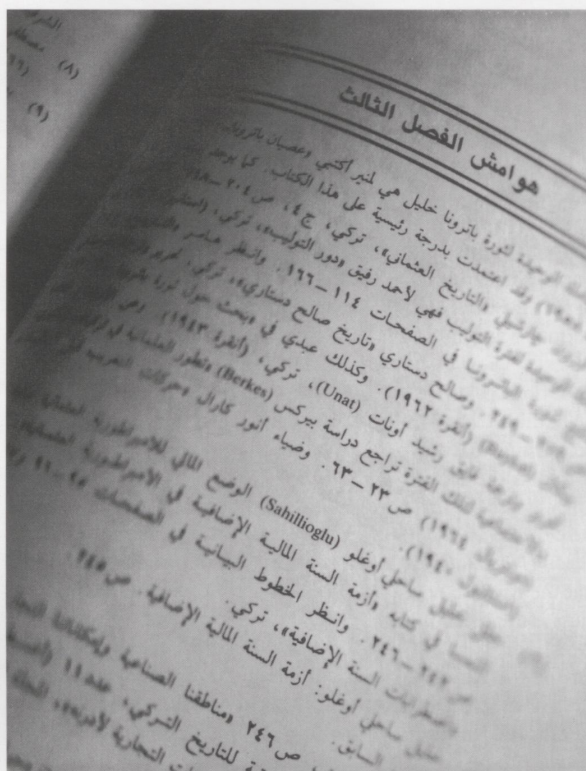
He says there may come a time when he can no longer keep up with the younger scholars in his field. But until that time, interpretation of the Kurdish question is still in his hands: "I hope within the next two or three years I can finish a book on the Kurdish question in Turkish-Iranian-Syrian-Israeli relations."

Of all his accomplishments, Olson says that the Kirwan prize is the highlight of his career. "I was very pleased that the selection committee recognized my work. That was very gratifying."

"He has in his own scholarship increased the visibility of UK in what might be called the Middle Eastern studies community. No question about that," says Doug Boyd, acting director of UK's Office of International Affairs.

When Boyd traveled recently to the University of Texas-Austin to present a paper, he experienced firsthand Olson's scholarly renown. "The Middle Eastern experts there said, 'You're from the University of Kentucky? You must know Bob Olson!'"

While attending the Third World Stud-



FOUR BOOKS THAT OLSON HAS AUTHORED OR EDITED HAVE BEEN TRANSLATED INTO EITHER TURKISH OR ARABIC.

ies Association Meeting in Costa Rica in November 1999, Olson says he was surprised when it was announced that his *The Kurdish Question and Turkish-Iranian Relations: From World War I to 1998* was selected as the Outstanding Book for 1999-2000 published by a member of the association. Olson received his award immediately after the keynote speaker Oskar Arias (Costa Rican president from 1986-1991 and Nobel Peace Prize winner in 1987) had delivered his address.

"I was so inspired by his plea that the United States should stop all arms and weapons systems sales to Third World

countries that I immediately announced that I would donate my award to President Arias and his Foundation for Peace and Progress on behalf of the Third World Studies Association and the University of Kentucky," says Olson.

The \$5,000 Kirwan prize, presented through the UK Graduate School and named in honor of the university's head football coach from 1938 to 1944 and president from 1968 to 1970, recognizes outstanding scholarship over the period of four academic years. It is one of the top honors given by UK to a faculty member. ■

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INSURING THE HEALTH OF UK GRADUATE STUDENTS

More than 1,600 graduate students now have health-care coverage under a new student insurance funding plan offered by the University of Kentucky. The plan, which began in the 1999 fall semester, offers "no cost" coverage for degree-seeking graduate students who are full-time teaching assistants, research assistants, graduate assistants, or fellowship recipients, or a combination of any of these appointments.*

"At major research universities health insurance is becoming an important part of support packages offered to graduate students," says Mike Nietzel, dean of the UK Graduate School. "To achieve our goal of becoming a top-20 public research institution, we needed to take this step to be able to compete for the outstanding graduate students who play such a key role in increasing the quality of UK research and teaching."

But beyond recruitment concerns, this health-care plan was a tangible way to demonstrate to current graduate students that UK values their contributions, Nietzel says. "The faculty and administration deserve credit for supporting this investment, and the graduate students who advocated for and consulted with us on this plan are to be commended."

The student who focused university attention on this issue in 1998 was Susan Mains, a doctoral student in geography who served as the Graduate School's representative in the UK Faculty Senate. "One of the first things I did was send out an e-mail survey to graduate students to get a sense of what health issues they faced, and the response was amazing. Hundreds of e-mails came in," she says.

Graduate students who are fully funded as assistants or fellows fall under UK guidelines that limit additional employment. Mains says with an average annual stipend of \$9,000 and without the option to get

insurance from another employer, many students could not afford to buy health insurance. "I learned that one family had to stand in line at the public health department because they couldn't afford the premiums for regular health care, and other grad students were dropping out of school because of medical bills they couldn't pay after accidents, illnesses and pregnancies."

"I've watched my colleagues struggle to stay healthy while teaching undergraduate courses, taking seminars, attending conferences, and undertaking their own research. At some point something has to give and, unfortunately, it's usually the graduate student's well being," Mains says.

She incorporated her survey results and information she collected on health plans offered by universities across the country into her proposal to the senate. While several parts of the proposal are not reflected in the health-care plan approved by the UK Board of Trustees last March, Mains says she has received positive feedback from fellow graduate students.

"A graduate student who recently had to have triple bypass surgery didn't have health coverage last year. He said to me, 'Without this plan, I'd probably be bankrupt now.' Just his words alone made the year I spent on this proposal worthwhile."

Under the insurance plan, graduate students have a \$450,000 major medical benefit. They pay a percentage of their medical costs, including a \$5 co-pay on generic drugs and \$15 co-pay on brand-name drugs.

Nietzel says that although details of graduate student health insurance coverage for 2000-2001 aren't available yet, he was hopeful that some improvements in benefits could be realized without too large an increase in the cost of the premium.■

**Full-time assistantships are defined as 20 hours of service per week; full institutional fellowships carry a stipend of \$8,000 or more.*

—ALICIA P. GREGORY

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KIOSK

BINGED-OUT BEETLES

Another round of geranium petals seems to be the order of the day for thrill-seeking Japanese beetles. It seems that after feeding on these petals, Japanese beetles get so intoxicated that they pass out for 12 to 18 hours. In the wild, this can be a lethal binge.

Drawing on research done in the 1920s, UK entomologists Daniel Potter and David Held have been studying this phenomenon, trying to figure out what exactly in the geranium causes such a powerful reaction.

Since the Japanese beetle feeds on 300 plants and 79 plant families, including many plants grown for profit or pleasure, researchers are always looking for new, earth-friendly methods of controlling them. The geranium's knockout punch offers an intriguing possibility.

"We found that when Japanese beetles fed upon the petals of geranium, generally in less than an hour the bugs enter a kind of narcotic state," says Potter. "They curl up on their back and pull their legs close to their underside. They'll twitch if you disturb them, but they're clearly in dreamland."

Funded by the U.S. Department of Agriculture, Potter and Held have found that plants grown in full sunlight pack more of a culinary wal-

lop for Japanese beetles.

And the bugs seem unable to resist temptation. When researchers gave beetles who had never encountered a geranium a choice between the nutritious linden plant and the mind-blowing geranium, the beetles overwhelmingly chose geranium and ended up staring up at the sky. Each time the beetles recovered, they chomped down another helping of petals and all but ignored the healthy choice.

Potter's team reared pairs of beetles in boxes with soil so that they could lay their eggs. One group received the healthy linden leaves, one group received the geranium petals, and one group received an equal amount of both.

"As one would expect, the group that got the linden leaves lived long and happy lives and laid a large number of eggs," says Potter. "Both groups with access to geranium spent the better part of this two-week experiment on their backs in a narcotic state, had a much higher mortality rate, and laid very few eggs."

Unlike certain caterpillars, Japanese beetles seemed unable to learn. In fact, each time they recovered from a geranium-trip, they would consume al-



most 10 times the previous amount before becoming intoxicated.

In theory, an insect that views nature as its personal buffet, like the Japanese beetle, should be able to learn from this type of bad experience.

"Of course, we're presuming this is an unpleasant experience for the Japanese beetle," says Potter. "Clearly their nervous system is being affected and perhaps that's compromising their ability to learn. It certainly has some parallels to human addiction, although I don't think it's quite the same phenomenon."

With the help of plant chemists at Boyce Thompson Institute at Cornell University, UK researchers are testing various geranium chemicals on the beetle-favorite Virginia creeper, and they've been able to duplicate the geranium's narcotic effects. Potter says that by this coming summer they'll have identified the exact extract.

This knowledge should prove useful in further Japanese beetle control research.

"One of my goals is to understand the insect better," says Potter. "I think if you understand the biology of a pest insect, it opens up new avenues for management that are environmentally more responsible."

Japanese beetle management is serious stuff—almost all of the states east of the Mississippi River except Florida suffer tremendous financial damage from the rav- enous insects. This research is part of the USDA's effort to prevent the Japanese beetle from spreading to the western United States, where it could devastate such economic mainstays as the California vineyards.

The Japanese beetle's behavior makes it an interesting insect to study, Potter says.

"I really like the Japanese beetle. It's my bread and butter insect. It's a great bug, sort of *The Terminator* of the insect world."

—JONATHAN RIGGS

AIMING FOR THE STARS

One muggy Memphis night in the summer of '69, John Main sat in his parents' den watching crackling black and white images of Neil Armstrong and Buzz Aldrin on the moon. Ever since that historic evening, he's been a "space geek," says the UK professor of mechanical engineering and recent recipient of a prestigious National Science Foundation Faculty Early Career Development Award.

The four-year, \$163,000 award provides Main support to shoot for the stars with his work on a novel space telescope. By reflecting images of distant stars with a colossal mirror, the telescope may allow astronomers to see galaxies as far removed in time as the Big Bang, the cataclysmic explosion that scientists believe was the dawn of our universe.

"Because light takes time to travel from one place to another, the farther you can see in space, the farther you can see back in time," Main says. "If you want to see farther back, you've got to gather more light. With a bigger mirror, you can catch more photons."

The concept sounds simple—the new telescope, known as the Next Generation Space Telescope, reflects light into sensitive

optics and transports images back to earth. The catch, however, is size—at a kilometer in diameter, the mirror's girth would stretch across 11 football fields.

"To build one that large, we'll have to get over the constraint of structures we can carry in the cargo bay of the shuttle or similar launch vehicle," Main says. That's where his project, designing the mirror apparatus, comes in.

A mirror constructed out of a flexible film could be rolled up and stashed on board a launch vehicle. Once the vehicle is in orbit, the mirror would robotically deploy and unroll in space.

"The mirror we're designing has pretty much the consistency of Saran Wrap," Main says. "We're working to change it from a big piece of thin plastic into a precision primary mirror that can be used for world-class science."

The transformation may sound like something from a science-fiction novel, but it's based on sound mechanical principles. The thin plastic, a weave of electrically polarized molecules known as piezoelectric material, changes shape in the presence of an electrical field. Main envisions that an electron gun, connected to the material with a lightweight framework, would spatter the plastic film with electrons. The

plastic would then mold itself into a parabolic shape that would reflect a celestial view far deeper into space than even the Hubble space telescope has delivered.

Main's project, like the Hubble project which culminated after 20 years of research by NASA and other scientists, will require time and intensive collaboration. He is now creating small composite mirrors as stepping stones to the ultimate project. A mylar mockup in his lab resembles a miniature satellite dish made out of shiny metallic film.

"It's kind of fun—students look at it and they get excited—it's not something that's divorced from the things they dream of," he says.

Main's enthusiasm is intensified by the award's

long-term funding. "This is the kind of thing that faculty members need to be doing or at least trying. We don't necessarily have to win every proposal we write, but we've got to get in the game to bring more national recognition to the university. It also sets an example for the undergraduates whom we're teaching—there's no reason they can't set their sights on anything they want to accomplish."

Main, who earned his Ph.D. in mechanical engineering at Vanderbilt University, came to UK in 1997. His list of credentials includes a Summer Faculty Fellowship at the NASA Marshall Space Flight Center in Huntsville, Alabama, in 1995 and a NASA Advanced Concepts Research Program Fellowship for 1997-98.

—KIM CUMBIE



A MYLAR MOCKUP OF THE MIRROR JOHN MAIN IS BUILDING RESEMBLES A MINIATURE SATELLITE DISH MADE OUT OF SHINY METALLIC FILM.

RX: A SIMPLE COMMON BEAN

If someone told you that a simple bean grown in Kentucky primarily for animal feed could reduce the risk of heart disease, help prevent cancer, and protect against osteoporosis, you might well be skeptical.

Well, set your skepticism aside. The bean in question is the soybean, and recent news of its powers have now been substantiated by the FDA, which recently approved the claim that soy protein, taken with a low-fat diet, may reduce the risk of heart disease. That claim is based on work published by James Anderson, a College of Medicine professor and endocrinologist at UK, and other researchers in the *New England Journal of Medicine* in 1995.

Anderson has been researching and promoting the beneficial effects of soy protein for the last five years, and evidence of health benefits keeps piling up. "I think soy foods bring more health benefits to the table than anything we can eat," he says.

Anderson notes that there are six major health benefits of soy foods. For starters, soy reduces the risk of heart attack. LDL cholesterol (the so-called "bad" cholesterol) is a strong predictor for heart attack, and Anderson says that soy protein lowers LDL

by 13 percent, which translates to a 20 percent estimated reduction in risk. As Anderson sees it, this is due mainly to a key part of the soy protein: the isoflavones. These plant estrogens act like aspirin in their role as anticoagulants, decreasing clotting in the blood. "I assign about 70 percent of soy health benefits to isoflavones," he says.

The impact of soy protein in reducing the risk of cancer is strongest for prostate cancer, according to Anderson.

There is also some optimistic data for breast cancer, but the jury is still out.

"I recently attended the International Soy Symposium in Washington, D.C. All the experts were there. The data is just not firm enough for us to make public health statements about soy protein and breast cancer," Anderson says.

But there is mounting evidence that soy foods protect us from osteoporosis. "It makes more dense bones," he says, which is good news for women approaching menopause. Another health benefit for these women is that soy protein reduces menopausal symptoms.

Anderson says that only 15 percent of the women whose doctors prescribe hormone replacement therapy actually follow the recommended treatment. And concerns

about the side effects from hormones, like breast cancer or blood clotting, prevent many women from choosing this therapy. Anderson believes soy protein may be a good alternative. "I feel comfortable recommending to my patients who can't take estrogens that they take soy isoflavones."

Anderson has conducted research on soy's effect on diabetes since the mid-'70s and is excited by what soy protein does for the kidneys. Anderson says about one-third of all diabetics develop kidney problems, such as "protein leakage."

"This problem is the first definite sign of kidney disease in diabetes," Anderson says. He explains that in diabetics "the blood flow through the kidneys increases to 30 to 50 percent above normal." This increased blood flow damages blood vessels, and protein leaks into the urine. "Our data support the fact that the use of soy protein decreases protein leakage," Anderson says.

For his patients who can benefit from soy protein, Anderson advocates 25 grams a day. He believes soy products won't be hard to find, pointing out that each year since 1995 soy food sales have climbed 20 to 25 percent.

—KATHLEEN WILLS-ELLISON

HURTFUL WORDS

"Sticks and stones may break my bones, but words will never hurt me."

Sound familiar? Many of us used this singsong chant as children to respond to playground teasing. And if we remember correctly, such a passive response rarely, if ever, stopped the verbal provocation.

When it comes to teasing, "Kids often go right for the jugular," says Richard Milich, a UK professor of psychology. "And it's unfortunate that the kids who are teased the most handle it the worst."

Milich and his colleague Monica Harris Kern, associate professor of psychology, are involved in an ongoing research program that focuses on helping kids deal with teasing. This research was inspired in part by Milich's experiences gained by running a social skills program at the UK Psychological Services Center for kids with peer difficulties. The children in the program reported a lot of problems related to teasing, prompting Milich and Kern to start researching what kids regard as the best responses to being teased.

In the initial studies, children between the ages of eight and 12 were shown videos of someone being teased and were asked to

judge the effectiveness of different responses to the teasing, for example, ignoring the teasing, becoming hostile, or deflecting it with humor. Milich was able to use the results of the studies as a basis to help children decide on the best way to cope with being teased; then they practice their reactions.

That's right: practice.

"It's like any other skill.

It's like baseball—you have to work at it," Milich says.

Five years and many studies later, the research program has grown to include a study on college students' personality types and how personality affected their response to teasing and to seeing others being teased.

"We were surprised by how strongly some people recalled their teasing and how strongly they felt about teasing others," says John Georgesen, a doctoral student in social psychology who worked on the project.

Two hundred Introductory Psychology students completed personality questionnaires, answered questions about teasing history, viewed tapes of teasing situations, and wrote narratives about teasing experiences.

The study showed that personality does influence teasing behavior and also affects responses to teasing, Georgesen says. The re-

SEVERAL UK JOURNALISM STUDENTS FROM MARIA BRADEN'S MAGAZINE WRITING CLASS CONTRIBUTED ARTICLES TO THIS SEC-

TION. LEFT TO RIGHT ARE JONATHAN RIGGS, JENNIFER SPRING TAYLOR, ANN MULLINS, AND JENNIFER CALDWELL. NOT PICTURED ARE KATHLEEN WILLS-ELLISON, SARAH OKRYNSKI AND GREGG CASILLO.



searchers found that individuals who are emotionally overreactive tend to think hostile responses are more appropriate; of even greater significance, they are also less forgiving of teasers, even years later.

Highly extroverted individuals tend to be more assertive and talkative, and tease others more often. They have less empathy toward those they tease.

"They don't think teasing is that big of a deal," Georgesen says.

People who aren't very confrontational tend to feel more remorse for teasing and tease others less, Georgesen says. "They find hostile responses inappropriate."

Milich says that children who are repeatedly teased feel there is no way to stop it and that they have no recourse. In fact, being teased relentlessly was a common factor in many of the recent school shootings, such as those at Paducah, Kentucky, and Littleton, Colorado, he says.

The results of another recent study may help explain why victimized children feel helpless in response to repeated teasing. This study examined how teachers thought children would respond to teasing. "It was clear that teachers just were not aware of how upset kids get," says Kern.

Children have no escape at school, Milich says. "The results of this study raise the whole issue of school officials being sensitized to how upsetting teasing is," he says.

And these psychic bruises may not heal for years, if ever.

"Just because there are no punches thrown doesn't mean it's not serious," Kern says.

—JENNIFER SPRING TAYLOR

CULTIVATING INTERNATIONAL INTEREST IN MOLECULAR FARMING

Last fall, Quinn Li received what he calls "the invitation of a lifetime."

"I was invited by the People's Republic of China to join 99 other Chinese Ph.D.s from around the world for a two-week conference focused on agriculture and environmental sciences," says Li, a staff scientist at UK's Tobacco and Health Research Institute (THRI). Li was the only tobacco researcher invited from the United States.

"It was clearly an honor for me to represent the University of Kentucky in China, and this was my first time back in my native country in an official capacity," Li

says. About half of the conference participants were from the United States.

Among other universities represented were Yale, MIT, the University of Wisconsin-Madison, and UC Davis.

Li explains that this was a "moveable conference": the seven scientists in his group visited 18 different provinces and cities. They started in Henan Province in east central China, then spent six days in Yunnan in southwest China. These provinces are the major tobacco production bases in China. Yunnan Province contributes approximately 40 percent of the national tobacco taxes and profits, and 65 percent of its

income is derived from the tobacco industry.

"During the visit, I went to two tobacco research institutes, one tobacco college, and three tobacco corporations," says Li. "And I gave six seminars to research professionals and students, and two reports to the governor of the Yunnan Province and the Overseas Chinese Office of the State Council."

In his talks and reports, Li says he focused mainly on the work he and other THRI researchers are doing in the field of "molecular farming"—research which utilizes the tobacco plant as a factory to make a variety of useful substances—and disease resistance in the tobacco plant. "The concept of molecular farming was new to them, and they showed a lot of interest in it," says Li.

He says the trip was exhausting but exhilarating. "One high point was meeting so many top people in agriculture around the world as well as dozens of political leaders and policymakers in China," he says.

This conference coincided with the nation's 50th anniversary celebration, and the invited guests were treated as dignitaries during the parade in Tian An Men Square. While millions of Chinese watched the live extravaganza on TV, Li's group watched it

from the square itself. "Only a few thousand people were allowed to watch the parade in person, so it was clearly prestigious to be among this group," Li says.

Li came to UK from Xiamen University in southeastern China in 1991 to work toward a doctorate in plant physiology. He received his degree in 1995 and, with his newfound interest in novel uses for tobacco, he then found a home at THRI.

"THRI was highly honored by Dr. Li's invitation, and we were especially pleased that he had the unique opportunity to communicate the institute's biotechnology program to tobacco research institutes in China," says Maelor Davies, director of THRI. "We anticipate that China will become very interested in using plants like tobacco as economical, environmentally compatible production systems to help meet its ever-increasing need for a wide variety of consumer products and medicines."

Li plans to keep in touch with several of the scientists he met on this trip, especially those Chinese scientists interested in the possibility of future collaborations on the molecular farming of tobacco. "Right now, the interest there is focused on disease resis-



tance of plants, but there is also a lot of enthusiasm for future, novel uses of tobacco," he says.

Li was also pleased to dispel an image held by some in China about the University of Kentucky. "A lot of people there have only one image of Kentucky, and that's Kentucky Fried Chicken—KFC has invaded almost all major cities in China," Li says. "So when people hear 'University of Kentucky,' some of them think 'the University of Kentucky Fried Chicken.' I was pleased to let them know that we are very separate organizations."

—JEFF WORLEY

LIVING BY CHANCE

Sex. Drugs. Alcohol.

These topics make their way into the morning paper on, seemingly, a daily basis. And often, the focus is on young people. Rick Zimmerman, an associate professor in the UK Department of Communication, has spent most of his career trying to figure out why adolescents and college students take these various risks, and to find ways to prevent these choices.

In a random sample survey of 918 University of Kentucky undergraduates during fall 1998, Zimmerman found that students are involved in

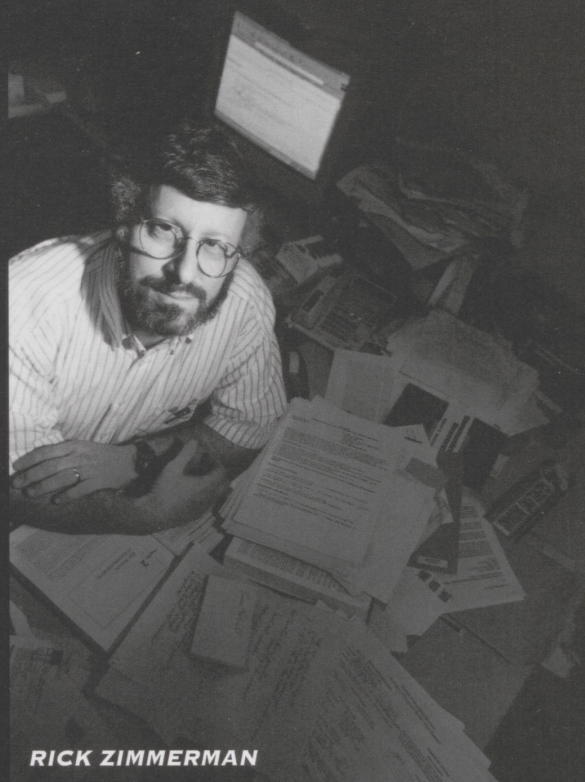
a number of risk-taking behaviors. And although he's not surprised at the students' responses, he suspects many Kentuckians would be.

Of those who had engaged in sexual intercourse, 35 percent had five or more lifetime partners, and 46 percent drank alcohol in the context of a sexual experience. Only 30 percent reported using a condom the last time they had sex. And 10 percent said they had either been pregnant or had gotten a partner pregnant.

As for alcohol, tobacco and drugs, 39 percent said that they drank in order to become intoxicated "often or always," and 45 percent smoked cigarettes in the past month. About one fourth of the sample smoked marijuana during the past month.

The UK study provides strong data to suggest that binge drinking is a significant issue among students, regular marijuana use is a problem for a significant minority of them, and unprotected sex is prevalent among those who are sexually active. "All of this is fairly consistent with other published data about college students," Zimmerman says.

For the past several years, the Kentucky Department of Health Services has chosen Zimmerman to head up



RICK ZIMMERMAN

an evaluation of the state's HIV prevention programs. He is also involved with four other studies that focus on HIV prevention and interventions on risk-taking, marijuana and sexual decisions among young people. Three of these studies are funded by the National Institutes of Health.

In a project Zimmerman just finished for the National Institute on Alcohol Abuse and Alcoholism, he found that a well-targeted school-based curriculum could delay the initiation of sexual activity among adolescents. "This curriculum is focused on building assertiveness, and refusal and negotiation skills," Zimmerman says. Now, he's building on that

research to see how similar results could be achieved among other groups, including youth in Appalachia.

"There is an exciting and oftentimes frightening period of three to five years in young people's lives when they can go cruising along to disaster," Zimmerman says. "We're trying to understand both the issues that are related to their risk-taking and what kinds of interventions can be successfully implemented to reduce their behaviors."

In addition to school curricula, other intervention methods he'll test could include mass media campaigns and "small media," such as videotapes or comic books.

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UK RESEARCH MEANS BUSINESS

Zimmerman says there are many reasons why young people take various health risks. "Some teenagers, for example, are sensation seekers—they love to take risks. And peer pressure is clearly at work, especially the pressure for young men to become sexually active," he says. The growing body of research in this area also shows that a lack of attachment to the immediate family or to the school community is a predictor for risk-taking.

As his work has progressed, Zimmerman says he has become more passionate about finding ways to keep young people from becoming involved in unsafe behaviors. He is a member of the Fayette County Teen Pregnancy Task Force and has served on the board of directors for the Lexington Chapter of Planned Parenthood.

Zimmerman came to UK in 1994, after spending the first 11 years of his career in the Department of Sociology at the University of Miami. He says he felt it was time to move his two children, now 15 and 11 years old, "out of the crime and drug capital of the world."

"A worry I had in coming to Kentucky," he says half-seriously, "was that there wouldn't be enough risky behavior here to study. It turns out that, unfortunately, there's plenty of risk-taking going on everywhere."

—KARLA DOOLEY

Five start-up technology businesses based on University of Kentucky research have recently "graduated" from the university environment to business locations in the Lexington area. Three of the new businesses have moved into the Kentucky Technology Center, which officially opened last December at UK's Coldstream Research Campus.

Reflectronics Inc., Equine Biodiagnostics Inc., and The Lexington Carbon Company LLC are among the first tenants of the two buildings that currently comprise the Kentucky Technology Center. The \$1.5 million privately funded development contains specialized laboratory and office space and is managed by Kentucky Technology Inc., UK's for-profit corporation to assist in new business start-ups. Five additional buildings are planned for the center.

Reflectronics, based on the research of UK's Fred Payne in agricultural engineering, manufactures fiber optic sensors for the food, pharmaceutical, and chemical process industries.

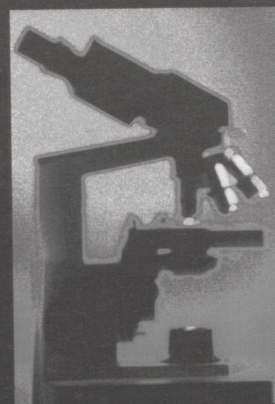
Equine Biodiagnostics provides specialized diagnostic lab testing for the equine industry worldwide. EBI's primary focus is Equine Protozoal Myeloencephalitis, a neurologic disease that

causes muscle deterioration and can be fatal. The company is based on the work of David Granstrom, formerly with UK's Gluck Equine Research Center.

The Lexington Carbon Company develops and manufactures specialty activated carbon materials. Commercial applications for these materials include gas and liquid separation, energy conversion systems, water treatment, environmental processing of gas and liquid streams, removal of pollutants, military and industrial protective filters, and medicine, food and beverage processing. LexCarb is based on the research of the late Frank Derbyshire, and Marit Jagtoyen and Geoff Kimber of UK's Center for Applied Energy Research.

Both EBI and LexCarb had their start on campus at UK's Advanced Science and Technology Commercialization Center, better known as ASTeCC. "Their graduation from the facility fulfills one of ASTeCC's primary objectives — the commercial development of UK research leading to the creation of new businesses and economic development for the commonwealth," says Fitzgerald Bramwell, UK vice president for Research and Graduate Studies.

Two additional high-tech



start-ups have also moved recently from their on-campus location in ASTeCC.

GenApps, a company that develops techniques to prevent disease in plants such as tobacco, is now located in Winchester, Kentucky. The company's work is based on the research of Mark Nielsen, formerly with UK's agronomy department. And Tigen Pharmaceuticals, which works on selective delivery of drugs to target tissues, has moved its operation to Bolivar Street in Lexington. Tigen is based on the research of Thomas Burke, pharmacy.

"ASTeCC has graduated seven new technology-based businesses since the building opened in 1994," says Joe Fink, ASTeCC director and Research and Graduate Studies vice president. "In all, more than 30 new businesses have been started by UK faculty, or have been based on technology developed at UK."

There are currently six businesses, both with and without ties to the university, at UK's Coldstream Research Campus.

—DEB WEIS

ENLISTING A NATURAL ENZYME IN THE FIGHT AGAINST CANCER

Radiation and chemotherapy can be effective tools to combat the growth of cancerous cells, but unfortunately the side effects from these treatments make some people sick. Recent research conducted by a UK toxicologist, however, suggests that by incorporating a natural body enzyme into existing treatments, the result might be much less toxic for patients.

Daret St. Clair, a professor in the UK Chandler Medical Center, is studying the antioxidant enzyme manganese superoxide dismutase (MnSOD) that may suppress the growth and even eventually help eradicate the existence of cancer in humans.

"We're still far away from a non-toxic drug that can stop cancer, but the good news is that this enzyme we've been working with is a natural body enzyme," St. Clair says. "It is non-toxic, which makes it much better than any drug or chemical prevention ever known."

In 1998 St. Clair received a three-year grant for approximately \$600,000 from the National Cancer Institute to study the effectiveness of this enzyme in suppressing cancerous tumors. Her previous research has shown that this enzyme, which is located in the mitochondria (the energy producers) of the cell, slows the growth of cancer. Antioxidants like MnSOD are believed to offer protection against free-radicals, molecules

with unpaired electrons that move through the human body and destroy proteins, carbohydrates, lipids, and nucleic acids.

Primarily because of its antioxidant value, MnSOD has been studied since its discovery in 1979, but St. Clair's research is distinctive in that she is researching the enzyme's potential to regulate cancer cells. "Our lab is one of the two leading groups in the country with this particular focus on cancer research," says St. Clair, whose investigative team consists of nearly a dozen junior faculty, postdocs, graduate students and research associates.

She discovered the value of MnSOD while researching its protective role against an anticancer drug called adriamycin (ADR). Adriamycin causes severe cardiac toxicity in lab animals, especially in the mitochondria of their cells. During the study, St. Clair inserted genes that code for MnSOD into cancer cells found in mice. Unexpectedly, the metastasis of the tumors was blocked.

"We then had critical evidence that showed mitochondria might be important in regulating cancer," St. Clair says. With Kelly Kiningham, a research assistant professor, St. Clair



DARET ST. CLAIR

began examining the ability of MnSOD to regulate cancer proteins. While studying an aggressive form of cancer called fibrosarcoma in mice, Kiningham inserted a gene that encodes the MnSOD enzyme. The enzyme regulated the activity of protein produced by a family of genes called the jun and BCL genes, which St. Clair says her team thinks is responsible for cancerous fibrosarcoma growth and death respectively.

Based on these studies, St. Clair, Kiningham, research associate Judy Hines, and postdoctoral fellow Yunfeng Zhao are studying the mechanisms by which MnSOD suppresses cancer development and at what point in the genetic process cancer can be stopped from spreading. "What we're try-

ing to find out is at what point the normal cell first becomes cancerous, and what role MnSOD might play at this stage," says St. Clair.

While St. Clair is "cautiously optimistic" about the direction of this research, she says that much more research will need to be done in the years ahead.

—GREGG CASILLO

UK PROFESSOR NAMED KENTUCKY STATE GEOLOGIST

Jim Cobb has come a long way from working in the mail room at the Illinois State Geological Survey; he's recently been named the new state geologist and director of the Kentucky Geological Survey.

"I feel very fortunate and blessed," Cobb says. "Kentucky has a diverse and interesting natural geology that makes my job very exciting."

Cobb, a native of Illinois, earned his bachelor's degree in geology at the University of Illinois. He received his master's from Eastern Kentucky University and then went to Illinois for his doctorate. In 1980, he returned to Kentucky, where he saw great opportunities. He was right.

For the past 10 years, Cobb has been the assistant state geologist. In his new position he follows Donald Haney, who served as state geologist for 21 years before retiring. Cobb is only the 12th director in the 145-year history of the Kentucky Geological Survey.

The Kentucky Geological Survey, a UK institute, investigates Kentucky's mineral, energy, and water resources by studying geological samples gathered by field researchers. The survey also advises federal, state, regional and local governments, and responds to over 13,000 requests annually for information related to coal, water, oil, natural gas, minerals and geological hazards such as landslides, sinkholes and seismic activity.

Under Cobb the survey will concentrate on keeping current information available on the Internet at <www.uky.edu/kgs>. KGS will expand its Web database of maps and information on Kentucky's natural resources as well as the Web-based Earth science education network designed to aid teachers and attract students to the study of geology. The network explains Earth science concepts to students from kindergarten age to 12th grade.

"The survey stores millions of bits of information on geology, maps, and resources," Cobb says. "Making it available on the Internet will make it easier to distribute that information."

As the state geologist, Cobb will not only manage the survey but will also spend time in Frankfort briefing legislators on Kentucky's ground-water availability, water supply, minable coal and mineral availability, and oil and gas resources. Legislators use this information to make decisions on issues such as water usage, waste management, flooding and natural hazards, and mining.

Cobb also says he loves teaching at UK and does not want to cut back on that, he says. "There's something about being with students that keeps me charged up," he says.

—SARAH OKRZYNSKI



JIM COBB

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PARTING SHOTS

"Minds are like parachutes; they work best when open."

-Lord Thomas Dewar (1864-1930)

"We should take care not to make the intellect our god; it has, of course, powerful muscles, but no personality."

-Albert Einstein (1879-1955)

"The mind is not a vessel to be filled but a fire to be kindled."

-Plutarch
(45-125 A.D.)

"The only reason some people get lost in thought is because it's unfamiliar territory."

-Paul Fix (1901-1983)

"The brain is a wonderful organ; it starts working the moment you get up in the morning and does not stop until you get into the office."

-Robert Frost (1874-1963)

"Nothing is more conducive to peace of mind than not having any opinions at all."

-Georg Christoph Lichtenberg (1742-1799)

"To the man who only has a hammer in the toolkit, every problem looks like a nail."

-Abraham Maslow, psychologist (1908-1970)

"One's mind, once stretched by a new idea, never regains its original dimensions."

-Oliver Wendell Holmes
(1841-1935)

"Only the mediocre are always at their best."

-Jean Giraudoux (1882-1944)

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