2002-2003 University Research Professors

Thomas Leinbach: Bolstering Indonesia's Rural Economy

"Each year 2.5 million people in Indonesia are coming into the labor force, looking for work," says Thomas Leinbach. "About 80 percent of Indonesia's population is rural. So the government is faced with the question: 'How do we create employment?'"

Leinbach, a professor of geography at UK for 25 years, has studied economic development in Indonesia since 1978. His current research explores what he calls an "understudied" aspect of rural non-agricultural employment—how the development of small businesses fits into family aspirations.

"Many rural families in Indonesia, and in the developing world around the globe, need to do more than farm their own land. Some must take off-farm work for survival. Others do it to achieve some upward mobility or to gain income to put their children through school. Many Indonesian children still do not get beyond elementary school."

Leinbach says the government's compulsory education program has been derailed by the economic crisis in Indonesia. "Attendance rates of children in poor families have been especially affected. While over 90 percent of eligible students are enrolled in elementary school, this figure drops to 53 percent for junior high school."

The kinds of enterprises Leinbach is studying include informal transportation and repair businesses, furniture making, garment manufacturing, batik cloth and other handicraft operations. "I'm looking at small businesses that are not associated with agricultural production or processing—things that provide services or produce and manufacture goods, and have an element of entrepreneurship." His research includes analysis of labor participation and census data, as well as face-to-face interviews conducted in Indonesia with successful entrepreneurs and their families to "find out what drives these enterprises."

Women and children play a crucial role in the rural nonfarm economy, Leinbach says. "In many cases both the head of the house and the spouse have businesses. Many women operate and manage 'warungs,' a kind of general store that sells everything from cooking oil to rice to tobacco to soap. There's profit even in such simple and small-scale operations, and these enterprises can be managed while the spouse raises children and carries out other household duties." It's also common for families to send children off to the city to work. "Young girls go into the city as maids or textile factory workers; young boys do apprenticeships in service occupations or factory work."

Leinbach's research in Indonesia has been supported by the University Research Professorship, Fulbright-Hays awards, the National Science Foundation, and the National Geographic Society.

This work has spawned two book projects. The first is *The Indonesian Rural Economy: Mobility, Work and Gender*, a soon-to-be-published collection of original essays to which Leinbach contributed three chapters. He is also working on *The Rural Labor Process in Indonesia*, which, as Leinbach says, "examines family livelihoods through the lenses of mobility, employment activities and the process of entrepreneurship." This book is based on analysis of census data and his own case studies.

—Alicia P. Gregory

Gary Ferland: Configuring Quasars

UK's Gary Ferland, a professor of physics and astronomy, spends a lot of his time in Outer Space—way out in Outer Space.

His research focus for the past 22 years has been the study of quasars—small, intense celestial sources of radiation characterized by large changes in wavelength. The astronomer begins this study by analyzing data downlinked from the Hubble Space Telescope, our eye on the universe that can see billions of light years away with amazing clarity. The Hubble "observes" quasars through spectroscopy, a way of separating electromagnetic radiation according to wavelengths.

Ferland admits the fundamental challenge of such work is numerically simulating what goes on in a quasar. "In astronomy we can't do an experiment as you can in physics. All we can do is observe what comes to us," he says. "There's an old saying in the field: 'Those who can do, do; those who can't, simulate.'"

Ferland's ongoing project involves the development of a large computer program used to simulate astronomical objects like quasars and supernovae. His primary goal is to achieve the formidable task of tracing the birth of the very first stars in the universe. "This happened about 12 billion years ago, and these were near the centers of very massive clouds of gas that were forming quasars," he explains.

He adds that in the past couple of years he's been recasting much of his work to be in step with the next generation of NASA's space observatories. These will, for the first time, obtain very high-quality images and data in types of infrared light that cannot reach the ground. "This is an exciting opportunity to take advantage of observations that were never before possible. I've developed the code's infrastructure specifically for the types of observations that will become possible."

Ferland says he is thankful for the University Research Professorship because it has allowed him the unique opportunity to focus all his efforts into making major improvements to the physics, and improving the code itself. "It's seldom possible to put a great deal of work into basic infrastructure of a project like this, due to the need to get new results and meet deadlines, on top of the other demands on time."

—Jeff Worley

The University Research Professorships, established in 1976 to recognize outstanding research achievement, carry an award of $35,000 to enable professors to devote full time to their research or continue to teach and use the award to support research activities. Since the inception of the award, there have been 93 University Research Professors at UK. Funds for this award are provided by the Office of the Vice President for Research.

Andrew Klapper: Finding Structure in Randomness

"It's really an operation that's very much like addition and subtraction. It's very, very simple."

That's how Andrew Klapper, a computer science professor entering his 10th year at UK, describes the process of utilizing the "key" (think encoder/decoder) in private key cryptosystems.

These types of encryption systems, faster but not as secure as those that keep credit card numbers safe on the Internet, help ensure that interlopers can't eavesdrop on large-volume communications like mobile-to-mobile phone conversations or video on demand.

In cryptography, unpredictability is crucial. The idea is that if the coded sequence in which a message is embedded appears to be irregular, intruders cannot easily predict the rest of the sequence and get access to the message itself.

To create this safeguard of unpredictability, cryptologists like Klapper utilize sequences that seem to be random in nature.

"We look for random-appearing sequences and hope that they are also unpredictable," Klapper explains. "These random-looking sequences are then used to scramble messages in unpredictable ways. My interests are in understanding and generating such sequences using algebraic methods."

Yet the full story of Klapper's research in encryption belies the complexity behind the "simple" mathematical concept. Its highlight is his invention of a new class of pseudorandom sequence generators called Feedback with Carry Shift Registers (FCSRs), which he developed with colleague Mark Goresky in the early 1990s.

Klapper's work on FCSRs evolved as a result of successfully attacking a weakness in an earlier cryptosystem that had been used to secure information transfer in the European banking industry.

This is mathematical work that can never sleep, Klapper says.

"There's a constant give and take," he says. "People invent new systems, and then a few years later others come up with ways of attacking them. Then we have to come up with new systems to resist the new attacks."

Klapper will use the 12 months' dedicated research time funded by the University Research Professorship to finalize his first book about FCSRs, tentatively titled *Algebraically Generated Sequences*.

Beyond cryptography, Klapper says FCSRs will eventually have many other applications, most immediately in the field of Quasi-Monte Carlo simulations. This is a widely used approach to modeling physical phenomena with somewhat random behavior, such as the flow of air over a proposed airplane wing design.

The application, though, is not what excites Klapper most. It's the math.

"Finding a proof is the most exciting thing about my work," he says. "I think of myself as a theorist. My goal is finding the theoretical foundations of FCSRs so that people who do the applications can take them and use them."

—Robin Roenker

Timothy McClintock: Making Sense of Smell

UK physiology professor Timothy McClintock's career in olfactory research started when he decided to accompany some hermit crabs who were house-hunting.

"Hermit crabs live in snail shells," McClintock explains. "And there's no better snail shell than one that was just a snail a few minutes ago. Evolutionally, crabs have learned to detect places where snails are being eaten. When they smell it, they come running."

Working with this smell-mediated behavior as a second-year graduate student, McClintock was hooked. His research—now primarily with mice and lobsters—has been in olfactory reception ever since.

It's a field wide open for discovery.

"You have about 35,000 genes in your genome, and 1,000 of those genes, almost 3 percent, are devoted to olfactory reception," says McClintock, who began his work at UK nine years ago. Moreover, the olfactory system is one of only three parts of the nervous system known to be capable of regenerating.

"The sensory neurons in your nose die and are replaced normally throughout life. They live only 60 to 90 days," McClintock explains. "You have a couple of million of them, so you're talking about replacing 20,000 or so per day. There are also two nerve cell types that are replaced continuously in the brain's olfactory bulb."

Ultimately, insights into how olfactory neurons regenerate may lead to therapeutic applications for neurodegenerative disorders and neurotrauma, McClintock says.

Another key question in olfactory research is exactly how the system takes something as intangible as a scent—which has no definite spatial origin like vision or sound—and converts it into a neural code the brain understands.

"Odor information is more like thoughts and ideas than other sensory information. It's free from a spatial dimension," McClintock explains.

The support of the University Research Professorship has allowed McClintock to do certain costly experiments he wouldn't have been able to do otherwise, he says.

While olfactory biology is a "hot area of neuroscience" right now, McClintock says his UK team's work—focusing on analyzing olfactory receptor proteins and the molecular physiology of isolated olfactory cells that share specific characteristics—is unique in the field.

"One of the fascinating things about smell is that some of its effects on our behavior are unconscious," McClintock says. "That's what the whole perfume industry is based on. I think it behooves us to understand how the sense of smell works. There are plenty of questions still to be answered."

—Robin Roenker