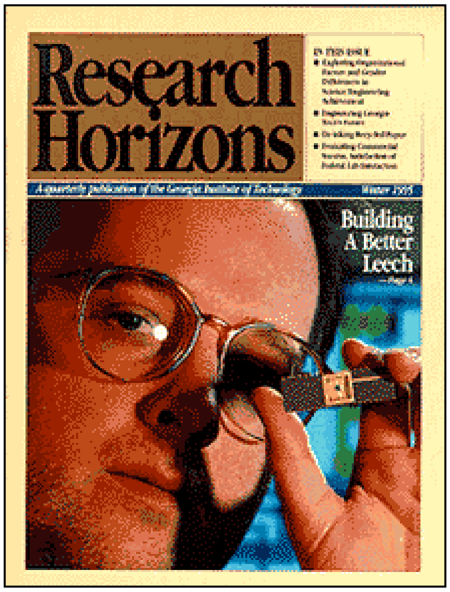
Georgia Tech Research Horizons



Research Horizons

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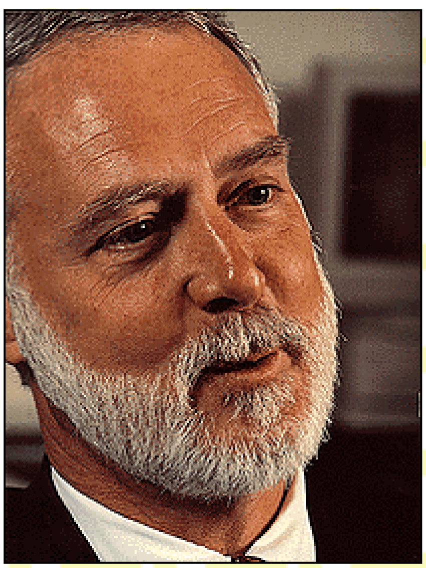
Engineering Georgia Tech's Future:

Wayne Clough

By Lea McLees

ON ANY GIVEN DAY, Georgia Institute of Technology academic and research faculty are preparing 13,000 students for their future roles in society, pursuing cutting-edge research on approximately 2,000 active grants and contracts, or working with any of the 1,300 industries and communities Georgia Tech helps yearly with technical assistance and economic development. Meanwhile, the world is changing at a rapid pace -- becoming more interdisciplinary, globally competitive, and reassessment-oriented.



Tending to the multi-dimensional fundamentals of a growing research university in a quickly evolving world poses an enjoyable challenge for Georgia Tech's new president, Dr. Wayne Clough.

"We must balance the needs of first-year students through doctoral candidates, while maintaining vigor in our continuing education programs, research, and service roles, and do so in a time of rapid change," he explains. "The complexity of this multifaceted university is what makes my work interesting."

Clough's decisions on how to approach this challenge are regularly influenced by his experience as a teacher, researcher, administrator and civil engineer. He has taught students, conducted research, and served as a consultant to a range of companies and agencies for the past 26 years.

"So many things we do in developing Georgia Tech's many dimensions affect faculty, or affect our approach to gaining or distributing resources," he says. "My years as a teacher, researcher and administrator come into play almost every day."

A Teaching and Research Foundation

Clough, who began work as president on September 1, 1994, is the first Georgia Tech graduate to take the helm of his alma mater. He earned bachelor's and master's degrees in civil engineering at Georgia Tech in 1964 and 1965, and completed his doctorate at the University of California-Berkeley in 1969. Most recently he served as provost at the University of Washington, where he directed that school's teaching and research missions and helped develop the university budget. He taught civil engineering at Virginia Tech, led that school's Department of Civil Engineering for seven years and then served as dean of engineering there from 1990 to 1993. He also taught civil engineering at Stanford and Duke universities and worked with the U.S. Corps of Engineers and Woodward-Clyde Consultants.

Clough has published 120 papers and reports, authored six book chapters and advised 34 doctoral and 25 master's students through completion of their graduate degrees.

He was recognized for his contributions as a teacher with the 1986 George Westinghouse Award presented by the American Society of Engineering Education. In addition, he has received seven national awards related to his research from the American Society of Civil Engineers, including the Norman Medal, the society's oldest and highest recognition. Clough was elected to the National Academy for Engineering in 1991.

Clough continued his research and thus his instruction of graduate students even as he took on administrative and managerial responsibilities at Virginia Tech. "I was still very much a faculty member as a dean," he recalls. "I felt it was very important, and very possible that I would be returning to the faculty any day."

Clough's research interests lie in geotechnical engineering and include earthquake studies, numerical analysis, soil structure interaction, in-situ testing, and underground openings. He is the author of several widely used computer codes for geotechnical engineering. The codes allow for simulation of interactions between soil, groundwater and structures such as buildings and dams.

"They were designed to provide maximum flexibility," he says. "Analytically, they simulate the way an engineer thinks about doing a job."

Clough continued his research on a smaller scale after being named provost at the University of Washington. Preparing for the 1994 Terzaghi Lecture sponsored by the American Society of Engineers, which recognizes and honors a civil engineering career, required two years of work involving literature review, compilation of materials, and developing the information into a design format. "Once I settle in at Georgia Tech, I hope I'll have time to do some research and maybe team teach a seminar," he says.

Preparing Future Generations

Clough recalls one of his most challenging and exciting teaching experiences: leading a freshman honors English seminar at Virginia Tech, during which works of literature were dissected and discussed. A mix of engineering and English majors read the works of Maya Angelou, William Faulkner and others.

"We threw in Head to Head, a book by Lester Thurow on economic competition, to keep the engineers fully engaged," Clough notes. "The engineers marveled at how fast the English majors could read and understand the nuances in literature, while the English majors appreciated the engineers' analytical skills as they studied Thurow's work."

A similar combination of strengths will prepare Georgia Tech graduates for the future, he notes. Team-building, problem-solving and communication skills are valued more and more by business and engineering employers. "We are graduating some of the best technologically educated citizens of this country, and they need to know how it fits into our culture," Clough says.

Just as Clough believes literature and engineering should go hand-in-hand, so do research and teaching. Research is teaching, he maintains - researchers share their latest findings with students in the classroom. Graduate assistants working with advisers on research projects are learning from that process.

Clough argues that the issue research universities need to address is not research versus teaching, but the proper distribution of teaching effort to ensure students at all levels of the educational spectrum - from freshman to doctoral - get the instruction they need. Maintaining the integrity of teaching, and rewarding good teaching tangibly, is important.

"Research universities must ask, 'What do you provide as clear evidence of the value of teaching to the schools, departments, and individual professors?'" Clough says.

Serving the State and the Nation

Georgia Tech will be an integral part of helping Georgia continue its move toward a more technologically based economy. The Georgia Research Alliance has already identified advanced telecommunications, environmental technology and biotechnology as areas holding potential benefits to Georgia-and the state's traditional industries, such as textiles, agriculture and pulp/paper, are becoming highly technical. Georgia Tech is helping to maintain that traditional base while contributing expertise to new industry.

The institute can help in the continuing education arena, as well, by delivering engineering education in innovative ways -- like distance learning.

"Technological advances are so rapid that knowledge becomes obsolete quickly," Clough says. "Tech can use new methods of educational delivery to help citizens in Georgia stay up-to-date on the latest technology and its applications."

Students in Georgia Tech's present distance learning programs can earn master's degrees in electrical, industrial, nuclear, environmental, mechanical and health physics/radiological engineering via videotape, contacting the instructor by phone, fax or e-mail as needed. Georgia Tech is part of a statewide system offering refreshers for the Fundamentals of Engineering and Professional Engineering exams with sites set up around the state, and receives faculty and staff development programs from the National Technological University via satellite.

Changing Funding Environments

As a civil engineer, Clough knows that structures with built-in elasticity are less likely to collapse or develop structural defects. Flexibility in finance also is vital to building a research university budget that can adapt to changing times.

"Some proposals in Congress may eliminate or significantly reduce traditional research and student loan programs," Clough says. "Added to this is an increasing demand for accountability, and a focus on what research universities do with the funding they receive. The changing emphases in research require us to create a model that allows us to be responsive to new initiatives. That flexibility has to be reflected in our resource base."

Clough sees flexibility as being gained by using resources carefully and avoiding locking funds into uses that can be quickly outdated by changes in the research agenda.

"We're a $370 million business at Georgia Tech," he explained. "We have to manage those resources very carefully. Raising money and getting money is not the answer, if it becomes locked up through an 'entitlements' process. The key is to build a resource base, so that in ten years you have more flexibility."

Also important are enhancing the resource base, staying informed about changes in the state and federal environment, and making sure policymakers and lawmakers are apprised of Georgia Tech's contributions and needs.

Addressing Administrative Issues

Georgia Tech is an evolving research university with much potential. While many of its units are near the top in national stature, others have yet to reach this level. Clough feels Georgia Tech will only fulfill its aspirations when it can point to nationally recognized programs in all its colleges. In addition, Tech has to work on its management systems. Research universities need good human resources and training that support employees and enhance their work abilities and environment. Businesses are ahead of universities in addressing many of these issues, Clough notes.

"At the same time, the very nature of universities creates an environment that is different from a traditional business. Universities place high value on individual initiative, and diversity of opinion is valued," he notes. "The history of independence in the university means we need to work harder to mobilize institutional commitment. Even if the administrative commitment is there, we often depend on a voluntary response."

Clough has begun to make administrative changes that reduce the number of layers between himself and employees and students, so communication is as direct as is possible. He also has a direct e-mail account so anyone can share ideas with him: president@carnegie.gatech.edu.

In addition, he emphasizes the power of thoughtful, informed strategic planning. "This is not just a brainstorming project," Clough says of Georgia Tech's strategic planning process. "Everyone has to understand the context in which to make decisions, because there are not infinite amounts of money, facilities or resources."

Continuous quality improvement is also a part of Georgia Tech's future - it helps define the other end of the human dimension, the responsibility of the employee to the research university. "People work hard, share their responses with the team, think of ways to improve what they are doing, and accept the fact that you cannot do only what you want to do. You have to accept evaluation of your work. It develops a clear understanding of each person's responsibility to the institute."

Today and Tomorrow

People around the state, nation and world see the results produced via Georgia Tech's many dimensions, both through graduates sent into the work force and campus research, Clough notes.

"The research university is charged with the noble task of educating young people and helping them grow as productive citizens in a democratic society, as well as having a research and development side that in today's environment has to be business-oriented," he concludes.

"The challenge is to not lose sight of any of our responsibilities. I know Georgia Tech can meet that challenge."

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Women in Science and Engineering:

Viewing gender differences from an organizational context

By Lea McLees

WHEN SONIA KOVALEVSKY was appointed math professor at the University of Stockholm during the 19th century, she did not receive the warm and hearty welcome that a new faculty member might expect. "As decidedly as two and two makes four, what a monstrosity is a woman who is a professor of mathematics, and how unnecessary, injurious, and out of place she is," was one of the comments heralding Kovalevsky's appointment, according to H.J. Mozans' Women in Science.

Dr. Mary Frank Fox (right) and her students Kathryn Michaelis (left) and Mahtab Mahmoodzadeb review surveys that, along with site visits, provide information on inclusion and exclusion, job assignments and training, and evaluation schemes and systems from faculty members and doctoral students in five science and engineering fields nationwide.

Female colleagues in science and engineering are hardly considered "monstrosities" in the 1990s. Women do, however, remain under-represented in academia, particularly at higher ranks -- despite increasing numbers of women earning doctoral degrees from prestigious universities, says Dr. Mary Frank Fox of the Georgia Institute of Technology's School of History, Technology, and Society. She has studied women and men in scientific and academic organizations for 20 years.

"Despite growing pools of women with doctoral degrees in the 1970s and 1980s and the passage of 15 to 25 years during which those pools have matured in professional time, the proportion of women who are full professors has changed little over the past two decades," says Fox.

Organizational factors play a role in these discrepancies, Fox maintains. She is exploring those factors, and how they may be linked to gender differences in science and engineering achievement, with a $459,539 grant (1991-95, with H. Etzkowitz, State University of New York at Purchase), from the National Science Foundation. With a national survey of 5,400 science and engineering faculty and students, and site visits to more than 30 different science and engineering departments and programs for women in science and engineering, Fox is collecting data on inclusion and exclusion, job assignments and training, and evaluation schemes and systems.

Respondents to the survey are faculty members or doctoral students in chemistry, computer science, electrical engineering, microbiology and physics nationwide.

Among the topics Fox explores is the role of the faculty adviser: How does the adviser help students, and does the type of guidance or amount of time spent with students vary? Fox also seeks information about interactions among smaller research groups within departments, and how graduate student performance is evaluated. Experimental data indicates that when criteria for evaluation are loosely specified, minorities and women are affected.

"When there is a known standard, they do better," Fox explains. "I want to go further and assess that in science and engineering fields."

She also wants to determine whether men and women have different experiences in and perceptions of their organizations or departments. The basic question is -- which types of departmental and research group conditions tend to foster higher participation and performance of women in doctoral education in science and engineering?

Why Look at Organizational Factors?

Organizational factors are particularly important to science and engineering because these fields are social by nature -- more so than the humanities.

"Compared to the humanities, the sciences are more likely to be performed in teamwork rather than solo, to be carried out with costly equipment, to require funding, and to be more interdependent enterprises," says Fox. "From an organizational perspective, achievements of women and men are a consequence also of the characteristics and practices of educational and work settings."

An organizational approach is even more compelling in light of other differentiating factors that can be ruled out. Past research by Fox and others shows that in most science and engineering fields, men and women are as likely to have graduated from universities rated as "strong" or "distinguished." The few exceptions include mathematics, where 45 percent of men, compared to 37 percent of women, earned doctoral degrees in top departments. In physics, women also were somewhat less likely to have attended a top university -- but women were more likely than men to have graduated from top universities if they studied psychology or microbiology.

Gender differences also are small in the percentage of women compared to men who held research or teaching assistantships during graduate school. In addition, research shows that marriage and motherhood do not govern women's performance in science -- at least among those who have remained in scientific careers. Despite these similarities, women publish less than men in science and engineering fields and are often under-represented as organizers and prestigious invited speakers at professional meetings. However, their abilities as measured by IQ are higher as a group than their male colleagues'.

"The attainments of women in science and engineering are not a simple function of their individual characteristics," Fox explains. "Rather, they are a consequence also of the characteristics and practices of the environments in which they are educated, and in which they work. Personal factors may play a role, but one does not exist in a social vacuum. People connect with and reflect the elements of their settings."

Compelling Statistics

As of 1991, 95 percent of women in science and engineering with doctoral degrees worked in academia. However, across science and engineering fields, the higher the rank, the lower the proportion of women at that rank. In 1991, women were 29 percent of the assistant professors, 21 percent of the associate professors, and 9 percent of the full professors in science and engineering within four-year colleges and universities.

"In every field but psychology, the number of women at the rank of full professor is meager," Fox explains. "In half the categories -- physics, math, environmental science and engineering -- women are 6 percent or fewer of full professors."

Chemistry provides a good example of the dissonance between the number of women in full professorships and the growing percentage of women with doctoral degrees. Among doctoral granting institutions, women were 3 percent of full professors in 1985 and 4 percent in 1990, according to American Chemical Society (ACS) figures. However, 7.7 percent of chemistry doctoral graduates were female in 1970; 11 percent in 1975; 17 percent in 1980; 20 percent in 1985; and 25 percent in 1990, according to ACS and National Center for Educational Statistics.

"Even allowing for up to 15 years between the doctorate and rank of full professor, women's educational attainments are not translating into expected rank over time," Fox concludes.

Fox's Approach

Fox uses a combination of research methods -- survey and site visits. She spent a year developing her survey questionnaire in two forms, one for faculty members and one for students. She pre-tested them among students and faculty in each of the fields surveyed. Male and female respondents were selected using true systematic sampling, such that each individual had a known probability of being selected. The respondents come from a range of departments, from those with relatively low proportions of women earning doctoral degrees over time, to those with relatively high proportions and those showing marked increases in proportion of female doctoral recipients.

Preparing the survey distribution roster such that she and her student research team will be able to consider differences among respondents by field was quite important, Fox notes. Generally, more female scientists and engineers at four-year colleges and universities work in life sciences, psychology, and social science. Women made up 41, 20 and 26 percent of doctoral employees in those areas, respectively, during 1991. In contrast, men were twice as likely as women to work in physical, mathematical and environmental sciences. Understanding why these differences exist, and whether they are due to organizational factors, is vital.

Fox explicitly followed guidelines of survey research developed at the Survey Research Center at the University of Michigan in Ann Arbor, where she worked earlier. That, along with questionnaire design, resulted in a 67 percent faculty response rate and a 60 percent student response rate. The expected response rates for such groups are under 50 percent for faculty and no better than 30 for students.

"We use administrative controls on everything we do, and used every variable established in survey research as producing both quality and quantity in response rate," Fox explains. The only aspect of the survey research not being done by Fox and her student research team is the keypunching of the results.

The site visits have been conducted among 20 science and engineering departments that are also in the survey sample, and at 11 program sites designed to increase the participation and performance of women in science and engineering. In these visits, Fox interviews administrators, faculty and students, with an aim to answering the question: What constitutes a favorable organizational environment for women in doctoral education in science and engineering?

The Importance of Understanding

Women are making inroads and are becoming represented in fields across science and engineering, albeit slowly. So why explore gender differences in science and engineering?

"Training in science and engineering is an investment the public makes. Science and engineering are funded through tax subsidies or profits of corporations," Fox notes. "It is a public investment. We can't afford to squander that type of investment. We need a collective response to deal with these issues. We need informed policy for making experiences and outcomes optimal."

When she completes analysis of her survey data, Fox will report her findings in a series of journal articles, because of the scope and range of methods employed. Fox also is developing a curriculum minor at Georgia Tech in the study of women, science and technology with colleagues Carol Colatrella and Anne Balsamo of Georgia Tech's School of Literature, Communication, and Culture, and Steve Vallas of the School of History, Technology, and Society. The curriculum will integrate research, research training programs, curriculum and teaching. Ultimately, Fox hopes her research helps provide insight into removing gender-related barriers that may exist in graduate education and work in academia.

"Until we know what works and does not work, solutions will be ill informed, ad hoc, and frequently misplaced and wasteful, even though people are of good intent," Fox noted. " I see this research leading to recommendations for ways departments and research groups can better organize for positive and productive outcomes."

Further information is available from Dr. Mary Frank Fox, School of History, Technology, and Society, Georgia Institute of Technology, Atlanta, GA 30332-0345. (Telephone: 404/894-1818) (Email: mary.fox@hts.gatech.edu)

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From Promise to Product:

The application of technology from federal lab/company partnerships

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By John Toon

COMPANIES PARTICIPATING WITH federal laboratories in research and technology development efforts report that more than 22 percent of their projects have resulted in new products, processes or services, according to a National Science Foundation-sponsored report done by researchers at Georgia Tech.

The survey also found that most industrial participants are satisfied with their company's partnership with the federal laboratory; 89 percent of respondents report that the project was a good use of their company's resources.

However, the interactions were less successful when measured by another criterion -- the creation of new jobs. "Our limited evidence suggests that laboratory-industry commercial technology interactions can be quite successful, but there are no guarantees," says Dr. Barry Bozeman, director of Tech's School of Public Policy and the lead author of the study. Variance in quality and benefit of the interactions mean that "sometimes the commercial technology lives up to the promise; often it does not."

The Georgia Tech study surveyed 219 companies who worked with federal laboratories in joint technology development projects. In addition to providing data on levels of commercial product development and industry satisfaction, the study reports information about the economic costs and benefits of federal laboratory-industry technical interactions and assesses the role of partnerships in creating new jobs.

During the past decade, federal legislation has provided mandates and incentives for federal laboratories to work with industry in producing and developing new technology. This attempt to use federal laboratories to enhance U.S. "competitiveness" has been controversial but, according to Bozeman, "the early results show that industry-federal lab technology partnerships have a good deal of promise."

Despite the fact that most of the projects examined have not yet ended and that most began after 1990, 22 percent have already led to the marketing of a new product. In another 38 percent of the cases, product development is underway.

"This is certainly a reasonable rate of product development from R&D," Bozeman says.

Most participants were satisfied, including even some who did not receive an economic return on investment. Bozeman says, "Any time 89 percent go away as satisfied customers you have to be doing something right. However, the economic cost and benefit data, though generally favorable, is much more equivocal."

Companies' economic returns are positive overall but vary a great deal. While a handful of companies reported economic benefit in excess of $10 million, in nearly one-third of the projects, costs exceeded benefits.

According to Bozeman, "one of the more useful figures is net benefit, the difference between costs and benefits. After subtracting costs, the average benefit is $1,087,000. This figure is inflated by a few projects with enormous benefits, but still indicates that many of the projects are quite successful." In return on investment, the average for all projects is nearly $3 returned for each dollar invested.

The researchers were interested in determining not only the level of success of industry-federal laboratory commercial interactions, but also the reasons for success. According to Bozeman, the more successful projects tended to involve smaller companies with a high percentage of scientific and technical employees and companies that had experience working with the federal lab on more than one project.

Bozeman suggests research partnerships with broad goals offer greater opportunity than narrowly-focused programs. "The company needs to be relatively flexible rather than looking for one specific technology or technological need," he says. "The company needs to understand that success is most likely with a research partnership, rather than simply taking the research results of the lab and expecting these results to turn into a product."

This research was sponsored by the National Science Foundation's Research on Science and Technology Program under contract 9220125. The results are reported in "Industry Perspectives on Commercial Interactions With Federal R&D Laboratories: Does the Cooperative Technology Paradigm Really Work?"

Further information is available from Dr. Barry Bozeman, School of Public Policy, Georgia Institute of Technology, Atlanta, GA 30332- 0345. (Telephone: 404/894-0093) (E-mail: barry.bozeman@pubpolicy.gatech.edu)

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Research Horizons
Georgia Institute of Technology

Building a Better Leech

By Lea McLees

ASK THE AVERAGE PERSON on the street how leeches have been useful to humans, and you will probably hear about the long-lived physician's practice of bleeding patients with the slippery, segmented worms.

But times have changed, and leeches are making new contributions via a collaboration between Dr. Steve DeWeerth of the Georgia Institute of Technology and Dr. Ron Calabrese of Emory University. DeWeerth and his students are building circuit models of portions of the leech's nervous system that control swimming and circulation.

Steve De Weerth (left) and doctoral candidate Girish Patel examine a VLSI chip that contains one segment of the leech system they are modeling. The biggest challenge DeWeerth and students face is modeling complexity of the leech in swimming and circulatory systems on both the cell and system levels.

"If we can learn how to model these biological systems, we may be able to utilize that knowledge to build better pumps, better motor control systems for robots -- and further down the road, to build better prosthetics for humans," says DeWeerth, an assistant professor in the School of Electrical and Computer Engineering.

But why the leech? Two reasons, DeWeerth says. First, its swimming and circulatory systems contain a fairly large but manageable number of neurons, compared to other systems one might model -- the human retina, for example, contains millions of neurons. Having a manageable number of neurons is important if the researchers are to depict behavior on both the cell and system levels in real time.

The neurons are also part of fairly regular, repetitive structures. "The segmented nature of the animals allows us to design one basic element which models a segment and then use that element over and over again with only neighboring connections between the elements," DeWeerth explains. "That type of regularity is not typical of most motor systems."

Second, the motor systems of the leech are intricately mapped because biologists like Calabrese have observed them for years. Calabrese studies the leech circulatory system and is knowledgeable about biological research into leech locomotion. The two researchers' collaborative work -- which also includes modeling the neurosystems for swimming in the eel-like lamprey, a jawless fish -- is funded with seed money from the Emory/Georgia Tech Biomedical Technology Center.

DeWeerth and his students use neuromorphic analog VLSI circuits to model the circulatory and swimming neurosystems. Neuromorphic means the analog circuits are modeled after biology; VLSI stands for very large scale integration, meaning the researchers pack lots of transistors and functional elements onto a small area of silicon.

DeWeerth's work is unlike much current analog VLSI modeling of biological systems. "Most of the work done so far with analog VLSI in modeling neurosystems has been for sensory systems -- for example, researchers have developed VLSI models of early visual processing in the retina, which is in the back of the human eye, and early auditory processing in the cochlea, which is in the inner ear," DeWeerth explains. "However, very little has been done with VLSI in modeling motor systems."

The leech's movement is in itself quite interesting, DeWeerth notes. Each of 20 segments in the animal houses motor controllers for swimming, and the controllers work together to cause the leech body to move. The kind of oscillation they induce is called phase lag.

"If you think of the position of the body as a big sine wave, each stage is a little bit out of phase of the one behind it. It's just like a wave moving down the body," DeWeerth says. "When leeches move faster, they keep the same phase, they just increase the frequency."

THE RESEARCHERS DESIGN the computer chips they need based on their knowledge of the two neurological systems, have the chips fabricated, and then assemble and test them. They have successfully modeled several individual segments thus far.

The research involves experimentation at both the circuit and system levels, DeWeerth says.

"There is a lot of standard circuitry people know about, but there is always new circuitry involved," he explains. "A lot of what we do here is motivated by what new circuits we can come up with to perform certain functions. We take these elementary building blocks we are given and put them together in new and unique ways to build functioning systems."

The biggest challenge the researchers are finding is emulating biological functioning at both the cell and system levels. It is a difficult task. Although many mathematicians and biologists are studying biological motor systems, few research groups are modeling them with circuits. The circuit models of the leech circulatory and swimming neurosystems that have been produced link together simple oscillators that are not accurate replicas of the corresponding neural building blocks involved. Modeling biological motor systems on both the cell and system levels, as DeWeerth is doing, facilitates accurate modeling of the biological behavior. The use of analog VLSI also allows for this behavior to be replicated in real time, which is very important if these systems are ever to be used in real-world applications.

"You can't do this detailed modeling mathematically because the equations would be horrendous," DeWeerth says. "You can't do a computer simulation because there's not enough computing power to actually simulate the entire system. The challenge is to build the entire system and get it to work, and better yet, get it working in real time."

The researchers' future goals include incorporating the electrical systems they build into a larger one including sensor feedback and adaptability. They also want to learn more about motor systems and eventually apply their knowledge to other projects.

"We're learning how the systems work and we are giving feedback to biologists, but the other side of the goal is to apply what we learned to engineering systemsin areas such as signal processing, robotics, and biomedical prosthetics," DeWeerth says.

Further information is available from Dr. Steve DeWeerth, School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0250. (Telephone: 404-894-4738) (E-mail: steve.deweerth@ece.gatech.edu)

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Research Horizons
Georgia Institute of Technology

De-inking Recycled Paper:

A brighter future thanks to Georgia Tech de-inking research

By Lea McLees

THAT COMPLETED TO-DO LIST, newspaper, catalog or telephone book you just tossed into the appropriate recycling bin has a brighter future with the development of a patented technology for removing ink from recycled fibers.

Researchers at the Georgia Institute of Technology are applying a direct current electric field to recycled fiber slurry, thus removing more ink, saving chemicals and making the resulting fibers brighter than other de-inking processes do. The Georgia Tech process is especially effective for dirts (dark specks) reduction on laser-printed waste paper like that produced in most offices, says Dr. Jeffery Hsieh, director of Pulp and Paper Engineering.

Dr. Jeffrey Hsieh (left) shows pulp and paper student assistant Dana Beck a continuous de-inking tube reactor used to remove ink from recycled fibers.

"The process can be applied to all kinds of paper -- lightweight coated paper, newsprint and other kinds of fibers,"says Hsieh, professor of chemical engineering. "However, the most significant aspect of the process is that it gets ink out of office waste by almost reversing the activity of a laser printer."

In 1993, 8.4 million tons of printing and writing paper were recovered for recycling, according to the American Forest and Paper Association. The uniformity, availability and higher profits associated with this waste stream put it in high demand for tissue paper, new printing and writing paper, and exports. De-inking is one of the key operations performed in recycling such paper.

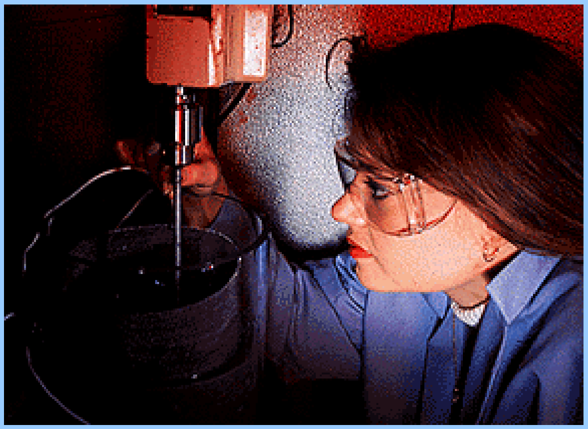
However, much office paper has been laser printed. The heat used in laser processing makes ink particularly hard to remove because it electronically deposits ink particles on the fibers.

Traditional recycling processes rely on chemical and mechanical actions to remove ink from such fibers and include several dispersion, flotation and washing steps. They thus reduce fiber strength, which must be compensated for with the addition of fortifying chemicals.

"These operations add to the cost of recycling and make it less economical, compared to virgin paper-making,"Hsieh explained. "There is a need for technology that de-inks fibers in fewer stages, to reduce fiber destruction and cost."

The de-inking process developed at Georgia Tech is based on a reactor comprising a central anode and a perimetal cathode, which can be retrofitted to existing recycled paper processing equipment. Ink particles carry charges ranging from high positive to weak negative; paper fibers usually carry a weak negative charge. Applying the direct current field to a reactor full of fiber slurry attracts the ink particles away from the fibers and causes the ink to coagulate. The massed particles float to the surface of the slurry with some help from gas bubbles generated by the electric field. The coagulated ink is then skimmed off the top of the slurry using rotation scoops, continuous conveyors, or other means.

This process removes twice as many of the ink specks from office paper, compared to traditional de-inking without the electric field. Paper made from the treated fibers has a significantly lower number of ink specks per recycled handsheet, when compared to a control sheet.



The current also helps remove dust particles from the fiber and creates oxygen in the reactor -- both actions improve fiber brightness and whiteness. Brightness evaluations showed an increase of two to six points on samples of paper ranging from newsprint to offset printing paper.

Finally, test results of tear, tensile and burst show that the strength of paper made from the Georgia Tech de-inked fibers is at least equal to those of control sheets. This results from the use of fewer mechanical steps and chemical additions that are known to weaken fibers.

If a reactor operator chose to use chemicals in the de-inking process, smaller amounts could be used because the electric current dissociates them through the reactor, increasing their efficiency, Hsieh says. The operator also could turn off the de-inking cell if he did not want to use the current on a particular batch of paper.

This process specifically addresses de-inking, while other patented electric processes focus on different objectives.

The patent was issued on Aug. 24, 1993 and a presentation on the work appears in the 1992 AIChE Forest Products Symposium Proceedings. Future research could address how the charge affects the metallurgy of reactor shafts, Hsieh says, as well as pilot plant trials and mill scale ups.

Hsieh is director of the Center for Excellence for High Yield Pulp Science at Georgia Tech, and is an adjunct professor at the Institute of Paper Science and Technology. He recently was named a Fellow of the Technical Association of the Pulp and Paper Industry for his service the association and the pulp and paper industry.

Further information is available from Dr. Jeffrey Hsieh, School of Chemical Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0100. (Telephone: 404/894-3556) (FAX: 404/894-2866)

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RESEARCH NOTES

Zeolite Research Benefits Petroleum Industry

One of the nation's leading research and development programs in molecular sieve zeolites and clays is based at the Georgia Tech Research Institute. The program is primarily sponsored by industry and is active in catalysis and adsoption. Researchers are trying to understand the microscopic function and development of microporous solids for the petroleum industry. Significant studies are focusing on environmentally benign methodologies for catalyst preparation.

Hsieh Named TAPPI Fellow

A chemical engineering professor was recently named a Fellow of the Technical Association of the Pulp and Paper Industry (TAPPI).

Dr. Jeffery S. Hsieh was recognized for his service to the association and to the pulp and paper industry. TAPPI is the world's largest technical association for the paper and related industries, and only one percent of its membership holds the Fellow title.

Hsieh is recognized as a tireless worker, a superb teacher, a prolific writer and an expert in pulping and bleaching. He serves as director of Pulp and Paper Engineering and director of the Center of Excellence for High Yield Pulp Science at Georgia Tech, and is an adjunct professor at the Institute of Paper Science and Technology.

Since joining Georgia Tech's Pulp and Paper Engineering Program in 1983, he has influenced significant growth in student enrollment, number of research projects, and technical articles produced. Hsieh has been well received by students who like his enthusiastic, hands-on teaching style and clear explanations of fundamental knowledge applied to practical situations.

Prior to coming to Georgia Tech, Hsieh spent 10 years in the paper industry. He wrote "Mixing Processes in the Flocculation of Microcrystalline Cellulose Sols with Cationic Polymers in Polymer Colloids II," edited by Robert M. Fitch and published by Plenum Press. His recent patent for de-inking recycled fiber by applying a direct current electric field provides a new method for the emerging technology of de-inking recycled fibers. His recent study on pulping kudzu indicated that the use of anthraquinone will improve its tensile and burst.

A TAPPI member since 1976, Hsieh was a member of the Nomination Committee and Academic Relations Committee for Human Resource Development and has been an active member of the Pulp Bleaching and Secondary Fibers Committees of TAPPI's Pulp Manufacture Division. He is also a member of the American Institute of Chemical Engineers (AIChE) and is committed to promoting interaction between AIChE and TAPPI.

EPA Hazardous Substance Research Center Provides Leadership, Service

The Georgia Tech Research Institute (GTRI) is providing national leadership and service in handling technology transfer and training programs for the U.S. Environmental Protection Agency's Hazardous Substance Research Center (HSRC).

The HSRC is a five-center program comprised of 26 major research universities nationwide.

GTRI is part of the South and Southwest Center, headquartered at Louisiana State University and including Rice University. The South and Southwest Center addresses understanding and cleanup of contaminated sediments in the nations waterways, lakes and estuaries with emphasis in EPA's regions 4 and 6, which include Kentucky, North Carolina, New Mexico and states to their south and east.

In addition to other technology transfer and training (T3) activities for the South and Southwestern United States, GTRI produces two national publications: Centerpoint, a news journal, and Newspoint, a series of news releases on environmental information. Both publications provide timely updates on activity by all five centers, says Dr. John C. Nemeth, director of the HSRC South and Southwest technology transfer and training program at GTRI.

In addition, the staff has provided significant leadership across other national center programs including:

- re-education and retraining of displaced Department of Defense personnel;
- special research programs for minority academic institutions;
- technical outreach services for communities that could have hazardous waste Superfund sites, with a major emphasis on environmental equity and justice issues;
- hosting a major national technology transfer conference in November 1994.

Several staff members have provided the U.S. EPA center director in Washington with meeting support on many issues, as well.

For further information on "Research Notes," contact Lea McLees, Research Communications Office, Georgia Institute of Technology, Atlanta, GA 30332-0828. (Telephone: 404/894-4259) (FAX: 404/894-6983)

(E-mail: lea.mclees@gtri.gatech.edu)

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Research Horizons
Georgia Institute of Technology

RESEARCH NOTES: Closeup

Four at Georgia Tech Named IEEE Fellows

Four Georgia Tech faculty are among 248 people elected to the highest membership rank of the Institute of Electrical and Electronics Engineers (IEEE). Hugh W. Denny, Daniel C. Fielder, William E. Sayle and Mark J.T. Smith were named IEEE Fellows by the organization's board of directors. They were selected from a pool of 542 candidates and join a growing number of IEEE Fellows working at Georgia Tech.

Hugh W. Denny

Until his retirement this spring, Denny was chief of the Environmental Electromagnetic Effects Division of the Georgia Tech Research Institute's (GTRI) Sensors and Electromagnetic Applications Lab. He was elected as an IEEE Fellow for "the advancement of technology to minimize electromagnetic interference (EMI) through improved electrical and architectural design practice."

A principal research engineer, Denny's career at Tech spans almost 35 years. He and his colleagues realized in the early 1970s that the design and construction of a building can be an important contributor to EMI problems between elements of complex systems. Denny integrated all aspects of a building's structure with electrical needs to develop construction guidelines that meet electrical performance requirements.

Theory and applications manuals on grounding, bonding and shielding in construction resulted from Denny's EMI work for the Federal Aviation Administration and the Air Force. These manuals have been adapted and used worldwide in the military and commercial worlds since they were initially published. In addition, Denny organized national workshops and short courses to start a dialogue on EMI problems between builders and electronics users in the late 1970s--this led to important changes in the National Electrical Code and the Lightning Protection Code, all based on Denny's work.

Denny also developed guidelines for grounding and lightning protection systems used on rapid transit systems such as those in Atlanta, Miami and Pittsburgh. He wrote Grounding for the Control of EMI, which has sold more than 9,000 copies since 1983, and he is an industrial consultant on EMI issues. In 1992, he visited India for three weeks as a United Nations Industrial Development Organization consultant. There he gave lectures on grounding, bonding and shielding and advised Indian engineers on testing and design issues. In addition, Denny has worked on lossy transmission line filters, radio frequency bonding, and interference cancellation.

Denny serves on IEEE's Electromagnetic Compatibility (EMC) Standards Committee, is the IEEE Press liaison for the EMC Society, and will serve as treasurer of the EMC Society International Symposium in August.

Daniel C. Fielder

Dr. Fielder, professor emeritus in the School of Electrical and Computer Engineering, was elected as an IEEE Fellow "for contributions to the study and use of integer and discrete mathematics in electrical engineering." Although he officially retired in 1988, Fielder still teaches and pursues research in engineering applications of integers and combinatorics. Results of his conversation counting formulas continue to be presented at international conferences.

In his 46 years in academia, Fielder has taught a wide range of electrical engineering courses, bringing a sense of enthusiasm and intellectual stimulation to his students. Much of his research, which is devoted to the simplification of complex conventional solutions to circuits and systems problems, has grown out of the inspiration of the classroom and has resulted in improved techniques for classroom presentation of complex material. One of Fielder's most significant contributions in that area is the use of integers as control devices in computational procedures.

His early research on ladder network design led to a pedagogically sound procedure to generate tables of integers for direct design of ladder networks. An improved technique to generate subscripts to produce quotient coefficients for Euclid's algorithm, applicable to the design of linear sequential networks, resulted from Fielder's research into continued partial fraction expansions. He also developed a procedure to generate subscripts that obtain A,B,C,D parameters of admittance matrices. His research on integers resulted in extension of the technique of Cederbaum and Weinberg for symbolic matrix inversion and to a procedure for the direct generation of residues and partial fraction expansion coefficients. Fielder also extended and simplified the Quine-McCluskey boolean reduction procedure and developed new techniques for generating state tables for sequential machines. Several special purpose integer sequences have been collectively classified as "Fielder Sequences."

William E. Sayle

Dr. Sayle is professor and associate director for undergraduate affairs in the School of Electrical and Computer Engineering (ECE). He was elected as an IEEE Fellow "for [his] contributions to engineering education."

As an associate director since 1988, Sayle has directed ECE's undergraduate programs and served as the primary academic advisor to more than 1,600 students, supervised 60 graduate teaching assistants, and scheduled more than 110 lecture and 75 laboratory sections each academic quarter. He is a founder of the ECE's power electronics educational program, one of the first in the United States, and is an active participant in the IEEE Power Electronics Society and the Power Electronics Specialists Conference.

Sayle has been tireless in recruiting young people to the engineering profession. For more than 14 years, he served as the Georgia Tech Engineering Faculty Consultant for the Southeastern Consortium for Minorities in Engineering (SECME). In this position, Sayle presented engineering-oriented demonstrations to students all over Georgia, and he involved local industries and made Georgia Tech resources available on a regular basis. Sayle also developed seminars and in-service training sessions so that SECME teachers are more aware and involved in aspects of the engineering profession.

For his efforts, he earned the SECME Outstanding Service Award in 1988. Sayle also received the 1993 Engineer of the Year for Greater Atlanta from the Georgia Society of Professional Engineers. He remains active in a number of IEEE activities, including chairing the IEEE Committee on Engineering Accreditation Activities and serving on the IEEE Education Society Administrative Committee. Sayle has also served as an IEEE program evaluator for the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) since 1983.

Mark J.T. Smith

Dr. Smith, an associate professor in the School of Electrical and Computer Engineering, was elected to the grade of IEEE Fellow "for [his] fundamental contributions to the theory and design of multirate digital filter banks."

Smith has played a major role in this area. His early contributions introduced conjugate quadrature filters (a.k.a., the Smith/Barnwell filters) and the aliasing component matrix approach to analysis and design of digital filter banks. Smith's work introduced the concept of exact reconstruction and provided the first design method for obtaining optimal and near optimal two-band filter banks of this type.

Smith has also received international award recognition in the IEEE Signal Processing Society for his co-authored publications: on efficient recursive filter banks and implementation methods for 2-D subband coding; on directional image decompositions; and on time-domain design methodologies which allow for the optimal construction of low-delay systems, wavelet transforms, time-varying wavelet transforms, and a host of other analysis-synthesis systems. This work has important implications in image and video compression for data transmission and storage.

Additionally, Smith has been active, with his students, in research that has contributed many new innovations in vector quantization, subband coding, speech and music synthesis and modification, and object detection and classification, some of which is being marketed commercially through Georgia Tech. Smith, an award-winning teacher at Georgia Tech, is the co-author of two introductory textbooks, and co-author of two advanced-level books that are expected to be in print by the end of the year.

-- Notes contributed by: Mark Hodges, Jackie Nemeth, Lea McLees

For further information on "Research Notes," contact Lea McLees, Research Communications Office, Georgia Institute of Technology, Atlanta, GA 30332-0828. (Telephone: 404/894-4259) (FAX: 404/894-6983) (E-mail: lea.mclees@gtri.gatech.edu)

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