THIS PLACE IS A ZOO!

- 2010: Tech's Strategic Plan
- Whitewater!
- Perfecting Poultry
- Corporate Transformation
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there was Rapid Transit
there was Rhodes Hall and the Flat Iron Building
there was Georgia Tech Football
there was Joel Chandler Harris
and beginning on that day, there was a new hospital in town.
Corporate Transformation
It's more than a turnaround; it's thinking—and acting—in new ways.  
Written by Gilbert F. Amelio

This Place Is a Zoo!
A 'scientific spirit' and strong Tech ties have transfigured Atlanta's century-old zoo, rescuing it from near extinction and making it a worldwide model. 
Written by Hoyt Coffee

Whitewater!
Tech engineers have helped create an Olympic-caliber whitewater course on the Ocoee River—and two Tech students are hoping to ride it to Olympic glory. 
Written by David Kennedy  
Photography by Yarin Adir and Gary Meek

Perfecting Poultry
Agribusiness is turning to Georgia Tech for innovative solutions. 
Written by Mark Hodges

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Cover Photo: 
Willie B. is looking a little more contented these days. His cold, sterile cage has been replaced by an environment like an African rain forest. It's the result of Zoo Atlanta's transformation, a remake led by Tech Professor Terry Maple.

GEORGIA TECH ALUMNI MAGAZINE
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Family Ties

Editor:

The Fall 1995 edition of the GEORGIA TECH ALUMNI MAGAZINE drew my attention to several of the many ways that Emory and Georgia Tech are cooperating to enhance the educational environment of Atlanta and the South—including the new MD/PhD program and the cancer research program using Boron-Neutron Capture Therapy.

This interaction of Emory and Tech is encouraging to me because of my heritage with both institutions:

• I attended both schools. In 1939-41, I was at Emory, and in 1942, I entered the Army Air Force as a fighter pilot. When I was released from the service in the fall of 1945, I entered Georgia Tech and graduated in 1948.

• My great-grandfather, Isaac Stiles Hopkins, M.D., Ph.D., had the unique privilege of serving as president of both schools: Emory College 1884-88, and Georgia Tech 1888-1896. This long family association with both schools makes me proud of the work they are doing together.

Walter D. Pittman, AE '48
Buda, Texas

Note from the Net

Dear Alumni Association,

I am the alumni director at George Mason University in Fairfax, Va. Our Alumni home page is now under construction and my staff and I have been “surfing” the Web to get ideas on what to include that would be the most beneficial and interesting to alumni.

Your home page is the most comprehensive that we have come across, and I commend your efforts. I hope you don’t mind if we copy some of your ideas.

Elizabeth S. Littlefield
Fairfax, Va.

The Alumni Magazine welcomes letters. Address correspondence to:
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Georgia Tech Alumni Publications
Alumni/Faculty House
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Students Adopt Honor Code

Honesty is not only the best policy, it's now official policy at Georgia Tech.

Institute faculty approved almost unanimously in a November voice vote the adoption of a new Academic Honor Code, culminating a year-long effort to re-emphasize honesty among Tech students.

"I am proud of the Tech students and faculty, particularly our undergraduate students who led the way, for approving the installation of an honor code," said Tech President Wayne Clough, CE '64, MS CE '65.

"It has been my privilege to teach at two schools with honor codes, and in each case they provided strong reinforcement of issues related to ethics, honesty and character," continued Clough. "These are qualities in short supply in today's world, and the honor code will help us make sure we are regularly reminded of issues at the core of a culture that is a noble experiment in the history of mankind."

The code, initiated by students and approved by campus-wide votes of both graduate and undergraduate students, requires all new students to sign an "honor agreement" not to cheat. In addition to emphasizing academic honesty in general, faculty members say it will clear up some gray areas concerning what is and is not cheating. "Surveys have shown at most schools, including Tech, there's a good deal of cheating," said John Trainor, president of the Student Government Association. "This code will heighten awareness about academic honesty."

Kidd, Long-Time Politician and Tech Grad, Dies

Culver Kidd, GS '36, a fixture in Georgia state politics for almost 50 years, died Dec. 4 after being hospitalized for various health problems.

First elected to the state House of Representatives in 1947, he served in that position until 1952 and again from 1957 to 1963.

In 1962, he was elected to the state Senate, representing Middle Georgia's District 25, and held the job for 30 years before being defeated in a re-election bid in 1992.

"He was an original, and we will not see his like again," Gov. Zell Miller said. "He was savvy and witty. He not only looked after the people in the 25th District—the whole state was his constituency."

In addition to his political duties, Mr. Kidd was president of Middle Georgia Management Services, a small-loan business consisting of six companies.

He also served in World War II, earning a Purple Heart for his actions in Okinawa.
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THE RITZ-CARLTON
ATLANTA
(DOWNTOWN)
Library Advances Online Service

The Georgia Tech Library and Information Center is making advancements in its GTEL® online system to improve delivery of electronic information throughout the state.

The library has created a Web-based version of GTEL® (Georgia Tech Electronic Library) and is connecting to the state-wide library initiative known as GALILEO.

GALILEO (Georgia Library Learning Online) aims to provide electronic resources and improve information access to all University System libraries using a common search engine within a Netscape-based browser. The most popular and visible component of GALILEO is the addition of a set of databases and electronic full-text journals for the Tech community, including alumni, via the GTEL® home page at <http://www.library.gatech.edu>.

Access currently is only available through computer terminals at university system libraries and campuses, but plans call for a dial-in system in the future.

“Eventually we are hoping that every citizen in the state of Georgia will have access to this material. The regional public libraries begin coming online in January.”

Three databases are available from workstations in the Library and throughout most of the campus: ABI Inform, an indexing/abstracting service for business and management research; Periodicals Research Abstracts; and the Encyclopaedia Britannica Online. In addition, the first two sources offer 50 percent of the journals indexed since 1991.

Hispanic Student Awards

Four Georgia Tech students have been awarded the 1995 Alfredo Estrada Academic and Service Awards for Hispanic Graduate Students.

Estrada was in Atlanta Dec. 12 to present the awards to Laureano Hoyos, Jose Luis Vege, Dolores Sala-Batle and Pedro Ardouno.

“In accepting these awards, I ask that when you are able, you pass on to others the hope and help to become the ethical leaders of tomorrow,” Estrada said.

The scholarship is awarded annually to students who demonstrate above-average academic achievement and volunteerism in the Hispanic community.

Estrada graduated from Georgia Tech in 1954 with a bachelor's degree in mechanical engineering. He is chairman and chief executive officer of Vista and Hispanic magazines. He is also a partner in an investment and management enterprise, and recently opened an art gallery in New York.

Student Ann Hoevel checks out the statewide Galileo system at one of the Pentium computers recently installed in the library.
A Noiseless Ride for Olympians

As athletes, coaches and staff make their way around the Olympic Village next summer here on campus, the trams on which they'll ride will be pulled by electric tractors manufactured by an Atlanta company heavy in Georgia Tech connections.

Tug Manufacturing Corp. of Kennesaw, Ga., will work in cooperation with Georgia Power to make 70 M-3 tractors for the Village.

Atlanta company, Tech alums to make Olympic Village tractors

"Georgia Power is committed to a clean-air policy, so that means conventional internal combustion engines are not appropriate," said Tug President Don Chapman, IM '61, who is also a past president of the Alumni Association. "Georgia Power is providing the vehicles for the Village, and it has selected our tractor as the one that will be used exclusively, so we're quite pleased about that."

Two more Tech grads are involved in the project. Alan Clark, ME '82, is Tug's vice president for engineering, and he oversaw the minor modifications to the tractor needed to suit Georgia Power. Jim Johnson, CE '85, is a senior engineer at Tug and also helped head up the project.

The M-3 tractor has been in production for two years and also was chosen as the freight-hauling tractor for Denver's new clean-air airport.

The trams that will be pulled by the tractors will be manufactured by a different company. They are not yet in production.

Tech Training for Quality Standards

Georgia Tech is offering an innovative training program to help small to mid-size companies meet industry standards.

The Center for International Standards & Quality's (CISQ) Implementation Program helps business leaders throughout Georgia meet International Quality Management Standards (ISO 9000 and QS-9000). Thirty participants in industries ranging from carpets to software are currently enrolled in the training program.

The program consists of networks of 10 firms, which form implementation groups. Over roughly a year, the participants go through a series of training, technical-assistance and auditing activities.

"This approach provides a road map to ISO 9000 and QS-9000 registration and is more efficient and less costly than other training programs," CISQ Director David Clifton said.

"In addition, the program allows participants to realize significant benefits from their interactions because it requires them to work together as a group for one year."
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RICOH
Perspective

2010
Tech's Strategic Plan

By John Dunn

Georgia Tech has developed a strategic plan designed to elevate the Institute to a new level of prominence and enhance its standing as an international research university.

"This strategic plan outlines an ambitious program—a blueprint for Georgia Tech's future through 2010," says Dr. Wayne Clough, president of the Institute. "It also presents specific action items, many of which are already being implemented.

"The next 15 years are critical," Clough states, adding that Georgia Tech is "poised on the cusp of greatness."

The plan calls for Georgia Tech to be "a highly focused, pragmatically oriented research university dedicated to excellence in teaching, research and service."

"It recognizes that the trend of the '60s, '70s and '80s towards expansion of enrollments and programs needs to be focused towards development of quality in existing efforts and creation of carefully developed strategic initiatives," Clough explains.

The plan calls for a limit to Tech's on-campus enrollment of 15,000 students, with any increase from the current 13,000 students contingent on strategic goals, demands and resources. The student body, currently made up of 9,000 undergraduate students and 4,000 graduate students, would increase to 10,500 undergraduate students and 4,500 graduate students. Considerable growth is anticipated in

Telecommunications is an aspect of Educational and Information Technology (EIT) that enables interactive communication at Tech. EIT's applications throughout the campus include such areas as administration, resident instruction, research, student services, library and distance learning.
Georgia Tech's primary purpose, the plan says, must be to provide challenging and innovative programs to help students achieve at the highest level.

The plan examines Georgia Tech's strengths and weaknesses as the Institute approaches the millennium. Tech's strategic advantages include:

• A diverse student body drawn primarily from Georgia but with significant national and international representation.
• A faculty led by professors who are nationally and internationally recognized leaders in their fields.
• Tightly focused educational, research and service missions.
• Strong, balanced graduate and undergraduate programs.
• Technological excellence during a time of rapid change and innovation.
• Strong and productive affiliations with business and government agencies.

The plan also recognizes the strategic advantages offered by Georgia's support for the Georgia Research Alliance, a partnership that unites the state, the business community and Georgia's six research universities in the quest for economic prosperity through science and technology; the Hope Scholarship Program, a lottery-financed tuition scholarship for Georgia students who maintain a "B" average and attend state colleges and universities; and the state support given Tech to encourage economic development through the Georgia Tech Research Institute, the Advanced Technology Development Center and the Economic Development Institute.

Georgia Tech expects to capitalize on worldwide exposure and other substantial benefits as the site of the 1996 Olympic Village when Atlanta hosts the Summer Games. The plan proposes to utilize these assets for long-term gain.

Construction of new residence halls associated with the Olympic Games will provide considerably improved living quarters for the student body, but the Institute nevertheless will require significant effort to upgrade its classrooms, laboratories and offices to the same standards.

"Georgia Tech is well positioned among research universities," Clough says. "Even so, the Institute will need to make critical and sometimes difficult choices if it is to maximize the advantages it enjoys and surmount the challenges before it."

The most serious challenges facing Tech include:

• Increased competition for first-rate students and faculty.
• Reduction of federal funding for research.
• Lean state funding relative to its peer institutions.
• The need to improve its organizational structures and administrative processes.

"It is clear that the environment and expectations of higher education are changing, and no one will succeed in the future by simply doing what they did in the past, no matter how well they did it," Clough says.

Goals defined in the plan include:

• Provide superb undergraduate and graduate offerings in technology and related disciplines.
• Lead in the application of advanced teaching methods.
• Maintain strong, nationally and internationally competitive research activities.
• Enhance the campus and help transform surrounding areas to promote a quality residential community.
• Apply technology and expertise to promote economic development, business practices and national public policy.
• Build a strong, effective and efficient administration to support its educational, research and service missions.

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• Build a strong, effective and efficient administration to support its educational, research and service missions.
Dr. William J. Wepfer, associate director for graduate studies in the School of Mechanical Engineering, conducts a class that is also being videotaped for distribution to students worldwide through Georgia Tech's Continuing Education program. Continuing education's goal is to serve 30,000 people by 2010.

purpose, the plan says, must be to provide challenging and innovative programs to help students achieve at the highest level.

The Olympic Village legacy of new and remodeled residence halls will not only provide an attractive living environment for students, but also will provide access to FutureNet, a new campus computer network; the Internet; and closed-circuit cable television.

Tech will also be expected to promote opportunities for students to experience international exposure through study abroad and international cooperative and internship programs.

Both research and community service will be incorporated into the educational experience of students. While service will broaden a student's view of their role in society, research will provide "the excitement of discovery."

"Students must understand that technology is a tool to be used in service of mankind and that their lives are enriched with a lifelong desire for learning," Clough says.

Research is vital to Georgia Tech. In addition to being a central component of the educational experience of undergraduate and graduate students, research exposes faculty members to the latest processes, materials and technologies, enabling them to excel in their disciplines.

While research contributes significantly to Tech's national and international prominence, it also serves to attract technology-oriented businesses to Georgia.

The plan recognizes that Georgia Tech can succeed in a downsized federal research agenda by developing a responsive infrastructure that addresses national needs driven by the new global competition, Clough says.

In an era of interactive, multimedia technology and its transmission, storage and retrieval, one of Tech's primary objectives is to lead in the use and development of "educational and information technology (EIT)." Applications of the technology will be developed and applied throughout the campus, including such areas as administration, resident instruction, research, student services, library, telecommunications and distance learning.

"Through the use of distance-learning technologies, students at remote sites will be provided access to our advanced educational offerings," Clough says. "Telecommunications and EIT will make it possible for Georgia Tech to have an expanded 'virtual' campus."

By 2010, the plan projects that increased undergraduate and graduate courses offered through distance learning will result in an off-campus enrollment of at least 5,000 students. Another objective is to triple the number of people served through Tech's continuing education initiatives, growing from 10,000 to 30,000.

On campus, classrooms will be revamped to become learning studios in which presentations can be enhanced by video, audio, on-line graphics, simulations and direct Internet connections. Faculty will
be encouraged to use the campus cable television system.

A leading center for research and technological development, Georgia Tech seeks opportunities to advance the global economic competitiveness of Georgia and the nation.

For more than three decades, Georgia Tech has helped increase the competitiveness of business and industry in Georgia through its field offices, which now total 18. Tech's Economic Development Institute provides technical assistance to more than 1,300 Georgia companies annually, and the Advanced Technology Development Center offers technical and business-management services to fledgling technology firms through two facilities, one on campus and another in Warner Robins, Ga.

Tech plans to broaden its collaborative efforts with other state, national and international colleges and universities through joint research projects and to expand its “in-residence” program to accommodate visiting business leaders, scientists, public servants, diplomats, military officers, writers, artists and foreign leaders.

“Georgia Tech's founding spirit of entrepreneurship sustains a focus on the application of science and technology to the creation of meaningful new ideas, methods and opportunities," Clough says. "The Institute maintains beneficial partnerships with public and private sectors in education, research and technology to ensure relevance in all that it does and to assure that the benefits of discovery are widely disseminated and utilized.

"Throughout its history, Georgia Tech has accomplished much even in the face of limited resources," Clough says. The strategic plan, he adds, emphasizes that Tech will continue to be a diligent steward of its resources.

"Representatives of every part of the Georgia Tech community worked together to produce this strategic plan," Clough observes. Accomplishing its objectives, he says, will "elevate the Institute to a new level of prominence and enable the Institute to better serve Georgia and the nation."
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Corporate Transformation
It's more than a turnaround

By Gilbert F. Amelio
Chairman, President and Chief Executive Officer
National Semiconductor Corp.

When I took over as president and chief executive officer of National Semiconductor Corp. in mid-1991, the company was on the brink of bankruptcy. National was reeling from years of financial losses, with three days worth of operating capital and questionable market positioning.

Many business experts would have said, "Do a turnaround!"

But I prefer transformation to turnaround. Turnaround follows a ruthless formula of slashing budgets that aren't providing current revenue, cutting R&D spending and selling off selected operations to raise cash—usually accompanied by reductions in staff and layoffs of the general workforce. These actions can create the appearance of health, and the turnaround manager often departs for his next company with pockets full of cash and ready to repeat the performance. But these quick-fix solutions don't address real business disciplines or management problems. The company left behind by the turnaround expert may well lack the means to sustain health, the ability to grow, and it can easily succumb to the next round of financial pressures.

In contrast, transformation management seeks long-term solutions with the intent to regain health, then grow to new heights. Transformation doesn't just happen, nor is it a matter of luck or management theory. It is a process based on well-understood principles and processes that instill new disciplines, structures and systems. The transformation at National Semiconductor used these straight-

Dr. Gilbert F. Amelio (right), Phys '65, MS Phys '67, Ph.D. Phys '68, became president and CEO of National Semiconductor in 1992 and was named chairman in 1995. Before that, he was president of Rockwell Communications Systems. He has accumulated more than 25 years of semiconductor experience. Amelio is co-author with William L. Simon of Profit from Experience, the National Semiconductor Story of Transformation Management, published by Van Nostrand Reinhold, New York, N.Y. Among Amelio's accomplishments are 16 patents that he holds alone or jointly. He was presented the prestigious Masaru Ibuka Consumer Electronics Award in 1991.
forward tools and techniques in specific
down-to-earth approaches that work. Any
chief executive can apply these methods on a
company-wide level, or managers and super­
visors can use the same tools to revitalize
their own work groups or improve their own
management style. Few organizations are so
weak they can’t be saved; few are so healthy
they can’t be improved.

Although the guiding principles are the
same, every situation is different. One of the
first steps is to make a careful assessment of
key problems, strengths, weaknesses and
resources. After my first two-day review meet­
ing with National executives and subsequent
analysis of the financial data, I reached a
number of conclusions. These executives
were bright, committed and hardworking, but
accounting systems were inconsistent and
failed clearly to identify winning and losing
product lines. Gross profit was not being
routinely monitored across all product lines. If
sales were good, everyone was happy, re­
gardless of the impact on the bottom line.

There was evidence of an inadequate under­
standing of the profit equation, strategic plan­
ing or delivering customer value. Even

worse, there was no clear guiding philosophy
of management.

The primary issue was how to go about
transforming. At National, as in other earlier
situations, I introduced a carefully orches­
trated process that falls under the categories
of “People Leadership” and “Business Leader­
ship.”

Two categories fall under people
leadership:

■ Charting the Course—vision, vector,
values.
■ Creating Commitment—the desire to
contribute.

Business leadership also has two
categories:

■ Fixing the Framework
■ Time, Metrics and Money.

In business the definition of success needs
to be clearly charted and understood. Every
dysfunctional organization I have studied has
shown a lack of clear vision and agreed-upon
definitions of success. At National, one of the
first actions was to take the top 40 executives
to an off-site facility for several days of dis­
cussions. The intent was for this to be an

At the Children’s
Museum of Maine,
Dana “DJ” Armstrong
uses an interactive
multimedia computer
lab designed to
improve reading
skills. This program
is sponsored by
National’s plant in
nearby South
Portland.

In initiating the
company’s transfor­
mation, Amelio asked
consumers what they
needed, then
designed products
that met those needs.
Identifying problems is a critical step in setting the course for corrective action, and going into this off-site meeting I recalled an earlier experience at Rockwell where I had been asked to take over a troubled division and either save it or close it down. In my first business review of that Rockwell division, I listened to a full day of business reviews. Then I stood up and told the executive staff that although this division was losing money at a rate that threatened every employee's job, I had yet to hear about a single problem after hours of presentations. That lesson stuck with me, and at the first National off-site meeting I led off by giving my diagnosis of what was wrong in terms of gross profit, return on equity, revenue per employee and other weaknesses. Then we divided the executive staff into teams to draw up lists of specific problems and obstacles to success.

They came up with 75 main problems, which we were able to categorize into six main categories—a list that is easier to deal with. I call these the "Six Ps"—profit, planning, positioning, performance, processes and people.

Next, the working groups were asked to come up with solutions for these problems—the shortest list they could provide. Their list had 40 items, which I again thought was a bit too long. But we set to work to consolidate and categorize this list and soon reduced it to just five items, which are known within National Semiconductor as our "Critical Business Issues" (CBIs):

- **Organizational Excellence**—making people effective.
- **Operational Excellence**—whatever we do, do well.
- **Strategic Positioning**—where we can win.
- **R&D Return On Investment**—product leadership.
- **Financial Performance**—return on equity.

We subsequently added a sixth CBI: Customer Delight—which is the result of the other five.

The next major element of charting the course was to adapt the "value proposition"—viewing the business as delivering value to the customer. One of the first examples at National came from our Memory Products Division, where sales and profits were sagging. Our marketing director for this division set out to determine what customers would view as valuable. His research method was simple: He asked the customers to name three things they would like to see in memory products. One customer had three good answers, which led to National's development of low-voltage memories for cellular telephones that extended battery life. The next year the division earned $14 million, compared with a previous loss of $20 million.

With our CBIs firmly in place as our guidelines for success, the next element of transformation was creating commitment—the desire for everyone in the organization to contribute. I should make it clear at this point that the transformation process is not sequential. All of the major elements—charting the course, creating commitment, fixing the framework, and managing time, metrics and money—must proceed in parallel. Transformation must be a coordinated process, often with many steps taking place simultaneously, but all integrated into a logical, considered whole.

Creating commitment is really about change. Institutions don't change; only people change. In order to change the organization, you must find ways to change the people. After taking over at National, I began to search for an effective approach to move the notion of being a transformation leader down into the organization. I wanted everyone to contribute and to become not just a student of transformation, but a teacher of it at the same time. To get the attention, support and enthusiasm of middle managers and others, we needed to create a program that would be an experience for people, something they would remember and that would influence their thinking for a long time. As soon as the most urgent initial problems had been addressed, I organized the effort to create what would become known as the "Leading Change" program.

Leading Change incorporated five essential elements: Leadership, the Soft Skills, Promoting the Vision, Building Cross-Company Connections and Tapping the Right Brain. Many managers have since told me how much the program meant to them, often describing it as one of the most memorable experiences of their career. We originally designed Leading Change for the employees who directly reported to the 40 people who had been attending our executive offsite meetings. The expectation was that we would put about 250 people through this program. But after most attendees pleaded that their direct reporting employees also needed this training, we found a way to include those people, too.
late 1994, nearly 6,000 National managers and professionals—more than one-quarter of our total workforce—had taken the course, many in a shortened three-day version of the original five-day program. Subsequently, we adapted the Leading Change principles to our "Pursuit of Excellence" one-day program for the grass-roots level—assembly-line workers, first-level engineers, and so on—where they have a chance to hear about and make themselves heard on topics such as empowerment and how they could use it. Every National employee received some kind of training to engage them in the transformation process.

Empowerment is another favorite topic, and a good example stems from early in my first management assignment, early in my career. One of my engineers complained that he couldn't even buy a pencil without extensive paperwork and approvals, which was slowing things down. I introduced a change that allowed every professional in the department to spend up to $200 of company money on his own authority. He had to account for it and accept responsibility, but needed no prior approval. Of course, our comptroller nearly went into cardiac arrest, fearing unbridled spending. I asked him to give it a chance, saying we could change the rules if anything happened. Well, something did happen. Spending went down. When people feel empowered and accountable, they act differently. This is a valuable lesson about empowerment.

Today my six steps to empowerment are simple and clear:

- **Understand the definition of success**—what is the overall vision?
- **Understand your status**—where do you fit; what are your strengths and weaknesses?
- **Develop metrics**—benchmark against competition, against goals.
- **Develop an overall road map**—what are you trying to achieve and how?
- **Get management buy-in**—consider advice, the ideas of others and management.
- **Be accountable**—you must accept responsibility for results.

Keep in mind, empowerment is something to be seized, not granted. But the power of it is that it can multiply the effectiveness of an organization by a thousand-fold. If I personally can make perhaps 10 decisions a day, think of the impact if I can empower 1,000 managers around the world to each make 10 decisions a day, or 2,000 managers and supervisors.

Another important principle of commitment is the concept of lifelong learning. One of our guiding values at National Semiconductor is to "Learn and Share Learnings." People learn principally through feedback. Organizations don't have a central nervous system, so if you want learning to take place organizationally, managers must create feedback loops to share learning throughout the organization. These create cycles of learning, where the limiting factor is time. Shorten the cycle time of the learning feedback loops and your organization will learn more quickly than the competition. If you succeed at that, your company will ultimately win.

In addition to feedback loops, we also created a high-level, in-house educational facility we call National Semiconductor University (NSU). The NSU programs go beyond the usual instructor-and-whiteboard sessions to get to real solutions. For example, if a manufacturing process has been transferred to a new location and isn't producing up to expectations, the NSU people look on this as a learning opportunity. They get together to probe what went wrong, to capture the lessons of the experience and to make them widely known throughout the company: Problem solved, people developed, learning shared.

NSU has also built close affiliations with several universities, including Georgia Tech, the Massachusetts Institute of Technology, the University of Southern California, Stanford University and the University of California at
berkeley. From the viewpoint of the schools, NSU is an extension university. Faculty members are brought in to give undergraduate and graduate courses right on our corporate campus. If calling this operation a “university” sounds presumptuous, NSU students can actually earn associate’s, bachelor’s or master’s degrees from San Jose State University, the University of San Francisco or one of our other partner institutions.

Another important aspect of transformation is continuous improvement, or simply put, raising the bar. I like to use the analogy of a high school track coach teaching his team the high jump. How high should he set the bar? If you set it too high, too early, the team members will get frustrated and turned off. So you choose a setting where they can learn the fundamentals and gain confidence. Then you begin gradually raising the bar.

The same principle can be applied to business. But once acceptable performance is achieved, you have to raise the bar to nudge people out of their comfort zone and enable them to grow. The trick is to raise the bar in achievable notches, making sure the goals are accurately set to benefit both the company and the individuals. Every now and then, however, you want to set a goal that truly stretches your people. At National, we developed what we call the “10X program.” Instead of setting the modest goal of improving a certain performance by 10 percent, we will ask, “How can we improve this performance by a factor of 10?” When trying to break paradigms and significantly alter the way things are being done, I don’t select a typical incremental change, but opt for radical stretch goals.

The second major category of transformation centers on business leadership: fixing the framework and managing time, metrics and money.

The typical corporate structure is often represented as a pyramid, with the chief executive at the pinnacle and descending reporting levels forming neat, regularly widening layers. The management style is command and control. But as I thought about reshaping the traditional corporation into a more fluid organization that unleashes wider participation and contribution, I began to conceive a graphical representation of a three-dimensional cube, with each dimension representing a different way of thinking about the company’s activities. For example, the horizontal axis across the front of the cube might represent the various business units or product lines of the company, while the front-to-back depth axis could represent different geographic areas: United States, Europe, Asia, etc. The vertical axis might be used for the markets served: automotive, computing and so on. The point is, when a customer places an order, this is the way they want to view the company—across product lines or other internal lines, or geographic barriers. (Actually, the cube model should have more than three dimensions, making it a “hypercube,” but I don’t know how to draw that on a flat piece of paper!) The key is that our managers should work in a multidimensional structure, viewing the business across product lines, markets and geography simultaneously to address the issue of the moment.

Let me use Charlie Carinalli, our chief technical officer, as an example of multidimensional management. Charlie heads our R&D efforts, so we might consider this his “vertical” responsibility. At the same time, he has a “horizontal” responsibility as engineering leader for the entire company. In this role he works with groups that do not report to him directly to improve weaknesses wherever he finds them. The result is a higher degree of collaborative work.

Fixing the framework also demands building “organizational excellence”—one of the critical business issues. The primary aim of organizational excellence is to devise a structure in which every manager, given a challenge, would make the same decision the chief executive would make.

National challenged its people to find ways to make products better and less expensively. A new wafer, developed in the Arlington, Texas, labs, saves $850,000 a month.
There are four basic elements of organizational excellence:

- **Direction-Setting and Visioning**—know where you’re headed.
- **Eliminating Obstacles**—set guidelines and rules, eliminate roadblocks.
- **Educating**—continual enhancement of skills and knowledge base.
- **Informing**—accurate, timely information everywhere.

Organizational excellence provides the structure, but a framework for action is also needed. There are many models, but at National we have embraced the “McKinsey 7S” model: strategy, systems, structure, staff, style, skills, shared values.

Applying the 7S model to everything you do is a way of ensuring that you don’t overlook important elements in any specific efforts. I’ve found that if just one of the seven elements is omitted, the change chemistry doesn’t happen.

The key message is that you need to work organizational excellence and the 7S model in parallel to assure successful transformation.

The other half of business leadership involves the careful management of time, metrics and money.

One of my guiding principles is to use time as a competitive weapon. It’s a familiar cry that we need to shorten the development cycle, shorten time to market and speed up the entire way we do business. Many mistakenly think that shortening cycle time simply means doing everything faster. The essential reason to shorten cycle time is not just to be more responsive to customers or reduce time per unit produced, but because all experiential learning will be accelerated. It’s worth repeating the point that if you learn faster than your competition, your organization will eventually win the business with better products and higher customer-satisfaction levels.

The answer to how to use time as a competitive weapon is by using it to increase your rate of learning. So reduce the cycle time of everything you do, then address the weaknesses that this process reveals.

Next, measure everything. One of the consistent problems I’ve discovered in troubled companies is that when people are asked what success looks like, they don’t know—they can’t tell you. What I look for is an answer that says:

“Success in our company means 20 percent return on equity,” or “Success means being one of the top three suppliers in our market segment.” The measurement doesn’t have to be financial; it could be in terms of increased market share, innovation, customer awards or the like. Every company should have a clear, measurable success model. The one I put in place at National’s first executive off-site meeting looked like this:

<table>
<thead>
<tr>
<th>Metric</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross profit</td>
<td>40%</td>
</tr>
<tr>
<td>Profit before tax</td>
<td>13%</td>
</tr>
<tr>
<td>Break-even sales</td>
<td>75%</td>
</tr>
<tr>
<td>R&amp;D spending</td>
<td>11%</td>
</tr>
<tr>
<td>Return on net assets (pretax)</td>
<td>33%</td>
</tr>
<tr>
<td>Return on shareholder equity</td>
<td>20%</td>
</tr>
</tbody>
</table>

The key to managing money is to act conservatively financially and aggressive technically, not vice versa. In my experience with large corporations, there’s a strong tendency for people to act conservatively on technical
issues and then take financial risks. And often these same people would describe their actions as financially conservative.

At National I hear people say things like, "We're not going to use those new design rules; we're going to use the old rules. We need to be safe." The old rules may increase the odds that the product will function on the first try, but they decrease the odds of being performance and cost effective. This is an even bigger risk to market success. It's better to make the profit equation work by moving the technology forward. Engineers know more about technology than markets.

The five key financial factors to keep in sight are gross profit, investment performance, asset management, productivity and liquidity/cash.

The transformation process is working at National Semiconductor. At the end of fiscal 1995 in May, National made approximately $330 million in pretax income for the year—and had the highest sales and net earnings in its history. The company had a low debt-to-equity ratio and more than $450 million in cash. Long-term debt was about $85 million. Shareholders' equity, which had been at about $540 million in 1991, had increased to $1.4 billion.

For a company that faced going out of business four years earlier, this represents truly impressive performance. But I view it as just the beginning. We have completed the first phase of transformation—returning to health—but now we are concerned with becoming a great company. The transformation process goes on. We are roaring down the runway and ready to climb to new levels.
A flock of pink flamingoes welcomes visitors to Zoo Atlanta. Like swans on stilts, they wade in the entry plaza’s shallow pool, preening their feathers and fencing playfully with their beaks. Sharing the pond are a handful of scruffy dark fowl, seemingly out of place with the dignified birds. But like Hans Christian Anderson’s “Ugly Duckling,” these tufts of gray will shed their dingy dress in favor of more elegant plumage, a fitting entree to a zoo that—in the care of a Georgia Tech professor—emerged phoenix-like from near oblivion.

In 1984, Atlanta’s century-old zoological park was a decaying avenue of chipped concrete buildings and faded paint. Stressed jungle cats paced behind rusting steel bars, and monkeys chattered nervously, rendered neurotic by the lack of stimuli. The venerable silverback gorilla “Willie B.” languished in a sterile cell with little to do and only cold tile on which to nap.

Today, Willie B. lives on a verdant hillside with his family of female gorillas and his first daughter, Kudzoo. His neighbors are three other ape families enjoying the lush new lifestyle. Tigers no longer pace, but snake skillfully through bamboo forests, and lions lounge in the sun atop their own kingly mountain.

“When I took over the zoo in 1984, it was rated as one of the 10 worst zoos in America,” says Dr. Terry Maple, who has taught environmental psychology at Tech for 17 years. “I was a 38-year-old professor who had worked around zoos in a scientific capacity for more than a decade, but I had very little management experience. I was asked in the middle of a crisis to become the zoo director, to try to straighten out what many regarded as one of the worst messes in the history of zoos.”

A mess of elephantine proportion, the zoo was more animal prison than conservation park, and media scrutiny was intense amid revelations that poor treatment had endangered the very animals the zoo was meant to protect. Aggravating the situation were dismal staff morale and deteriorating community support.

“We brought to the zoo also a new scientific spirit; we tried to solve problems objectively, and we tried to solve long-standing problems that had defied solution for many years. We did it by just the operation of logic and common sense more than anything else, and a very high ethical standard.”

The $10 Million Lab

The application of scientific principles to zoo management brought rapid and dramatic change, and it set the stage for transforming a flagging 40-acre tourist attraction into a valuable...
Zoo Atlanta has had “the experience of totally rebuilding from top to bottom, rebuilding every unit, every aspect of what we do.”

“edu-tainment” complex and wildlife laboratory.

In 1987, Zoo Atlanta was honored by the Metropolitan Communities Foundation as the city’s “best-managed nonprofit corporation,” and in 1991, it was deemed by the Georgia Wildlife Federation as the “Conservation Organization of the Year.” The American Zoo and Aquarium Association twice honored the zoo for “significant achievement” in exhibit design, and it is now widely considered one of the top 10 zoos in the country.

“We’ve had the experience of totally rebuilding from top to bottom, rebuilding every unit, every aspect of what we do,” Maple says. “We’ve had a tremendous amount of help from our community, from our business community, from professors at Tech and otherwise.”

Academic contributions by Jean Wineman, head of the College of Architecture’s doctoral program; Bryan Norton, professor of environmental public policy in the Ivan Allen College; and others helped create what Maple calls TECHlab, the laboratory of animal behavior. TECHlab is a program where graduate students in psychology and architecture conduct ad-

Willie B., the zoo’s most famous resident, languished for 27 years in a cold tile cell (inset) before joining female gorillas in more natural surroundings (left). Zoo Director Terry Maple (right) has been the force behind the improvements.
Younger children learn about animals up close and personal in the zoo's Project Discovery program. It also teaches the value of conservation.

Advanced research. The zoo currently supports eight such students who not only learn about animals, but how to manage a first-rate conservation park as well.

"The Georgia Tech education is the backbone of it, but the relationship with the zoo, where this $10 million laboratory operates, could not be replaced," Maple says. "It could not be operated by Georgia Tech, but as a partner, it becomes very meaningful in the education of advanced students." The College of Architecture also offers an undergraduate course that focuses on the design of exotic-animal architecture.

"I just feel like everything has happened in this one spot that one could dream of happening. And it all happened around this locus of the scientific enterprise."

Maple, an affiliate scientist with the Yerkes Regional Primate Research Center of Emory University and author of three reference books on great ape and captive behavior, early on set about seeking community and corporate support for his scientific and education goals. He hit pay dirt with the Ford Motor Co.

"Ford really showed other corporations that the zoo was a good bet, and that the zoo was really a wonderful thing for the community," he says. "A manifestation of that support, a very tangible one, was the construction of the Ford African Rain Forest, which includes a collection of gorillas living in a very naturalistic habitat."

**Gorillas in the Midst**

The $4.5 million habitat—at 1.5 acres the largest of its kind in the nation—is home to 18 African lowland gorillas, including Willie B., 14 gorillas from Yerkes, and Ivan, the majestic silverback brought to Zoo Atlanta after spending 27 years as an exhibit in a Washington state shopping mall. Socializing the gorillas to the point where they could be brought together in family groups was an arduous process, since the males had both been isolated for long periods, but it provided an opportunity for advanced research in animal behavior.

Kyle Burks, an experimental psychology major and one of the eight Tech graduate students conducting research at Zoo Atlanta, made Ivan's socialization the subject of his master's thesis. After spending time with Ivan in Tacoma, Wash., Burks guided the silverback through eight months of socialization steps: putting him in a cage where he could see other gorillas, moving the cages into closer proximity, then finally allowing him to move outside.

"In any introduction, aggression is your first concern," says Burks, who originally came to Zoo Atlanta just to study primate social systems but has since decided on a career working with zoos and conservation. "Ivan comes in with no social experience, but he knows he's a big tough guy. It's important for the male to learn to control himself with the females.

"Ivan moved quickly. He was chasing women in just one day."

The gorillas' natural surroundings contributed immensely to Zoo Atlanta's lauded breeding program, with six baby gorillas born since the habitat opened in 1988. All of the offspring are being raised by their mothers and family groups, an unprecedented accomplishment over such a short period of time.

"Not only was it an extraordinary success for gorillas, but it established Zoo Atlanta as a highly innovative zoo," Maple says. In terms of its educational and entertainment aspects, the Ford African Rain Forest employs the newly developed exhibition technique of "landscape immersion." Zoo visitors, surrounded with tropical and tropical-looking plants and sheltered beneath a jungle-like canopy, view the gorillas and many other animals from
overlooks that seem like clearings in the rain forest. There are no steel bars, and the moats separating the animals from spectators are well camouflaged, creating a sometimes unsettling feeling of actually being in the habitat.

Another tribute to the exhibit’s success is the recent decision to move the U.S. headquarters of the Dian Fossey Gorilla Fund, one of Zoo Atlanta’s many conservation partners, to Atlanta. The organization is named for the scientist-turned-activist who was murdered in Rwanda in 1985, two years after she published her widely renowned “Gorillas in the Mist.” Zoo Atlanta maintains a research post in Kenya, helping to continue Fossey’s work at the Karisoke Research Center she founded and providing benchmarks for comparing wild behavior to captive behavior.

Technology Along the Safari Trail

The zoo also features exhibits of monkeys, baboons and orangutans, all living in habitats similar to the gorillas’. Because these animals are more arboreal than gorillas, modern technology had to intrude on nature in the form of fiberglass trees to hold up the netting that keeps the more agile denizens from escaping. Spring-loaded limbs simulate the flexibility of actual jungle flora. The vines upon which the tree dwellers depend for locomotion would not survive in Georgia’s climate, so ropes with high-tech rubberized coatings have been substituted.

Zoo Atlanta also employed a technological edge in the Masai Mara exhibit, which includes elephants, lions, rhinos, giraffes and zebras. For instance, visitors during the cooler months will notice that the lions spend most of their time napping atop a miniature mountain of boulders, but there’s more happening here than just a feline affinity for rock. The stone is actually man-made, formed of the same type concrete used to build swimming pools. And they’re heated.

“Many times when the animals are out, they need just a little bit of enticement for them to be where you want them to be,” Maple says. The gorilla habitats also feature false rock outcroppings, in this case to disguise the building where they sleep, eat and undergo regular veterinary examinations.

For humans, high-tech serves an educational function at the various habitats. For example, the Sumatran Tiger Forest, home to two of the endangered big cats, is bordered by a glass-enclosed viewing area with a closed-circuit television monitor that lectures on the tigers, their habitat and danger of extinction.

Maple says technology will be a part of all planned future exhibits—such as a new bear habitat that the zoo hopes to have up and running by 1997 or 1998—and not just at Zoo Atlanta. Because most zoos are too small to portray the natural world accurately, motion-picture, video, distance-learning and computer technologies are already being employed and will be even more in the future.

“There are all kinds of ways to interface with the natural world, and technology is going to be a part of it,” Maple says. “That’s why the zoo thing isn’t as crazy for Georgia Tech as one might think. We have to use our technology to teach you, to provide you with learning experiences, to inspire you..."
and maybe even take you on electronic safaris."

**An ARC for the Ark**

Plans to build a new carousel for the zoo—an endangered species carousel—point up the twin thrusts of education and conservation at the heart of Zoo Atlanta’s philosophy, the philosophy behind Maple’s current project, the Conservation Action Resource Center (ARC).

"It's a space where we’ll share with our public the work we are doing," he says. "There will be opportunities for them to participate and learn. There will be a lot of high technology in this center, such as computers and video displays, interactive museum-type exhibitry, and animal exhibits all interacting together to give people a closer look, a more detailed look and a more exciting look at the natural world."

Zoo Atlanta has already introduced some innovative educational programs, such as Project Discovery, an audience-participation theater that allows younger students to interact with animals and learn about conservation. Another program, Night Crawlers, brings groups to the zoo for overnight adventures in learning.

It's Maple's hope, and the hope of all conservationists, that educating the public to the very real threats to the natural world will provoke the kind of positive action that resulted from the threat to Zoo Atlanta 11 years ago. "Zoos are going to be, if they aren't already, some of the most important conservation organizations in the world. They're not all good, but if they approach a certain standard of excellence, if they begin to advance and see the whole vision, I think as an industry they are going to be doing a lot of positive things for the earth.

"We haven't up to now achieved that, and it's going to take a lot of years of hard work and advancing standards in order to gain public confidence. This zoo didn't have any of the public's confidence in 1984. Today, it enjoys a very high profile and a very strong reputation. We have to take every zoo to that position.

"Zoos by their very existence are part of the struggle to save nature, and any zoo that doesn't take on that struggle, any zoo that doesn't get involved, doesn't deserve to survive because there's no moral justification for what we do if we aren't connecting to the whole. Then we're nothing but prisons, and I think we're a whole lot more than that."

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Whitewater!

Georgia Tech engineers did Mother Nature one better, helping turn a section of the Ocoee River into an Olympic-caliber whitewater course—and two Tech students are riding it to Olympic competition.

By David Kennedy • Photography by Yaniv Adir and Gary Meek
In 1993, Mark Mobley (above) helped create a 300-foot model of the Ocoee River course. A main goal was to ensure consistency.

The Course
A five-mile stretch of intense, made-to-order rapids on Tennessee's Ocoee River, 90 miles north of Atlanta, home of the 1996 Centennial Olympic Games.

The Students
Eric M. Giddens and Scott Shipley, both of whom have taken a break from their studies to concentrate on Olympic training, are two of the four members of the men's single kayak team USA.

The Designers
Mark Mobley, ME '83, and Paul Wolff, ESM '84, MS ME '91, Ph.D. '93, both experienced kayakers and Tennessee Valley Authority engineers, helped design the run to provide a consistent, world-class whitewater competition.

"It's like a roller coaster," Giddens says. "You never really know what's going to happen. You really have to be able to finesse your way."

Last fall, Shipley won the 1995 World Cup Championship held on the Ocoee's Olympic course, riding a kayak and using a paddle he helped design.

The Future
"The United States has two spots, so the first- and second-place winners in May make the team," Giddens says.

"A lot of competitors, when they finish with the Olympics, never want to participate in their sport again. I can see myself 12 years from now still competing and doing well. Kayaking is something you do your whole life."
By eliminating fluctuation in flow, competitors like Tech student Scott Shipley (above) could rely on skill rather than luck.

The Coach

Mike Larimer, IM '74, one of the three coaches of the U.S. Olympic whitewater canoe and kayak team, is wise to the wicked ways of whitewater rapids.

He first made the U.S. whitewater team in 1987 and went to the world championships. In 1992, Larimer and his partner in the two-man kayak placed fourth in the U.S. Olympic Trials—0.8 seconds away from a trip to Olympic competition in Barcelona.

Larimer's chief coaching responsibility is canoeing, both single and two-man. Among his charges is 1992 Olympic gold medalist Joe Jacobi. "Working with some of the very best and most dedicated athletes in the world is something I really enjoy doing," says Larimer (at left with Eric Giddens).
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In the contest for the perfect chicken, there may be talent ...

Agribusiness is turning to Georgia Tech for innovation

By Mark Hodges
Photography by Rae Adams
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Agriculture is moving steadily toward more technology-intensive operations, and the industry, especially in Georgia, has found a friend in Georgia Tech. The poultry industry, Georgia's largest agribusiness sector, has been especially successful in tailoring technology to meet its needs. Since the early 1970s, the Agricultural Technology Research Program (ATRP) at the Georgia Tech Research Institute (GTRI) has helped poultry growers and processors alike to evaluate, develop, and implement technology.

At first glance, such an alliance might appear unlikely because of the poultry sector's historic image as a low-technology industry. But times have changed; today, poultry companies are increasingly making use of advanced technology to deal with limited labor availability, environmental regulation, and processing productivity.

The ATRP got its start more than 20 years ago when the Georgia Poultry Federation asked the General Assembly for $100,000 to involve Georgia Tech in studies to support the industry. From that beginning, the program has expanded more than tenfold, with fiscal 1996 funds nearing $1.6 million. Around 80 percent of this funding is invested in research; the balance supports technology transfer and technical assistance. Even though ATRP's studies are designed specifically to benefit Georgia agribusiness, the program is having a positive impact on poultry operations throughout the United States and abroad.

"The program is very, very important to us," says Jerry Lane, ISyE '72, senior vice president of Claxton Poultry Co. and chairman of the ATRP industrial advisory board. "ATRP does research that no single company or equipment manufacturer could pursue alone. It gets the ball rolling on technologies that otherwise wouldn't be developed."

Attempts to forge cooperative alliances among academic researchers and industrial companies sometimes fail because of differing interests between university and corporate cultures. But Abit Massey, executive director of the Georgia Poultry Federation, says ATRP is successful because it has emphasized the industry's practical needs. He believes program managers have maintained this focus by...
making regular visits to poultry companies and by involving poultry executives in long-range program planning through ATRP's industrial advisory board.

"The ATRP has done an excellent job of planning and executing its projects, providing tremendous help to the poultry industry," Massey says. "The program has greatly enhanced our competitive position."

Early Focus

When the Georgia Poultry Federation first sought Tech's assistance in 1973, the use of automated machinery was beginning to expand in the industry, and the oil shortage had reached crisis proportions. Not surprisingly, ATRP's initial research focused on plant mechanization and alternative energy resources such as wood and solar power.

In the late 1970s, the program's emphasis began to change as the Occupational Safety and Health Administration (OSHA) pressured the poultry industry to reduce noise levels in plants. When processing plants experienced difficulty achieving reasonable reductions, the industry turned to ATRP for help. Georgia Tech engineers isolated the cause of the problem and designed, developed and tested a unique sound-absorbing ceiling panel that reduced noise to 82 decibels from 93.

"That project, together with our growing success in the energy field, helped elevate recognition of our capabilities throughout the poultry industry," ATRP Director Craig Wyvill notes. "Within a few years, the areas in which the industry sought help from us began to expand greatly."

During the 1980s, the program's focus shifted from energy efficiency to environmental compliance, electronic-automation technology and worker safety. Midway through the 1990s, the ATRP research agenda has continued to diversify, with projects initiated in the areas of computer vision, robotics, biosensors and research scientists Mike Burrow and Wylie Holcombe (l-r) test the Ergonomic Work Assessment System being developed at Georgia Tech as a tool for assessing the risk factors related to cumulative trauma injuries such as carpal tunnel syndrome.
Researchers are developing a laser-based biosensor for microbial-contaminant analysis of poultry. The device more than halves the time needed by conventional analysis.

Graduate student Jenelle Piepmeier has developed a new machine-vision technique to enhance computer screening of complex defects in poultry products.

and computer-based learning tools.

"Much of the work started in the late 1970s and early 1980s laid the foundation for our program," Wyvill explains. "We now have five primary focus areas for our research: environmental sustainability, ergonomics and worker safety, food safety, factory automation, and computer information systems."

**Environmental Sustainability**

With the creation of the Environmental Protection Agency in the early 1970s, industry began to face increasingly stringent environmental legislation. To help poultry companies meet new standards, ATRP engineers began to evaluate and develop technologies aimed to improve waste-treatment efficiency and to reduce waste generation and water usage.

That research continues today. One current project seeks to help companies reduce discharges of nitrogen and phosphorus into municipal wastewater-treatment systems. Another study involves field research on a treatment method called sequencing batch reactors (SBR). Unlike more traditional treatment processes, SBR can be tailored to the changing characteristics of an industry's waste stream, potentially reducing the size and cost of the required treatment system.

"A lot of us are limited in the space available for waste treatment," says Walt Puryear, ISyE '73, division engineer at Gold Kist in Athens, Ga. "Anything [ATRP] can do to develop more compact systems is beneficial."

**Ergonomics and Worker Safety**

Processing operations can be physically demanding for plant workers. In addition to the threat of knife wounds or back injuries, line employees who repetitively handle poultry products may contract cumulative-trauma injuries to their wrists and hands. Such injuries can be debilitating.

When processing plants noticed increased incidents of cumulative-trauma injuries during the past decade, Georgia Tech researchers implemented an ergonomic assistance program for the industry. Tech researchers subsequently conceived and developed a computer tool called the Ergonomic Work Assessment System (EWAS), whose purpose was to help identify risk factors that contribute to cumulative-trauma injuries. The research team's ultimate goal is to use the device in modifying factory tasks to reduce risks. The studies are ongoing and include academic faculty from Georgia Tech's Health and Performance Sciences Department.

**Food Safety**

With growing public concern over food safety, poultry processors are seeking improved methods of ensuring product quality. A key challenge is the time and cost of conventional chemical-analysis techniques.
ATRP researchers have devoted the past five years to developing a laser-based biosensor for microbial-contaminant analysis. In recent tests, this device more than halved the time needed by conventional analysis approaches while maintaining comparable accuracy.

The device works on the principle that the differing optical properties of materials affect the speed with which light passes through them. By knowing the optical characteristics of pathogens, researchers can detect these substances.

A prototype of the biosensor is undergoing laboratory development. Researchers are working to refine and expand the device's range of performance while seeking a company that is interested in commercializing the device. Tech's School of Biology and the University of Georgia’s Center for Food Safety and Quality Enhancement are assisting GTRI researchers in development of the device.

Factory Automation

Although automated processing has become an integral part of most poultry plants, nearly all of it has been limited to "fixed" or "hard" automation—systems designed to perform a single function within preset tolerances. In the early 1980s, ATRP initiated research to add flexibility and adaptability to these systems by developing a class of "intelligent" automation technologies.

An early focus of the program was the development of computer-vision technology to automate visual product inspection. Current plant operations rely exclusively on human visual screening. Machine-vision systems use computers and cameras to make electronic images for analysis of product defects. Incorporating vision technology into the poultry industry has proven especially challenging. Irregularly shaped products are difficult for computers to detect, and natural surface features often mask defects.

Georgia Tech engineers have made a number of groundbreaking advances in computer-vision technology. Researchers have developed a software tool known as WinInspect for color-image processing of irregularly shaped products. They also are making advances with specialized filtering techniques and artificial-intelligence technology.

In 1990, ATRP expanded its automation research to include robotics. Tech engineers have channeled their efforts into developing a new class of "human-level" performance robots—systems that sacrifice accuracy for faster and lower-cost operation. This approach is based on the recognition that many potential applications of robotics, particularly in poultry processing, do not require the high levels of accuracy built into many current commercial designs.

Computer Information Systems

Because the poultry industry has always operated on low profit margins, process efficiency is a major focus. Sophisticated, affordable computer systems offer new tools for operations management, and ATRP researchers are developing and adapting such systems for use in the poultry industry.

In the early 1980s, researchers began a project that has resulted in a farm computer system that monitors environmental processes in poultry growout houses. This system controls house conditions within predetermined set points. It logs performance and sends warnings to growers or service managers, via computer, beepers or telephone, when problems risk flock health.

ATRP researchers are also developing a computer information system for plant operations to help managers and workers perform certain aspects of their jobs more effectively. This electronic performance-support systems (EPSS) technology should help industrial maintenance and operational staff members receive the information they need when they need it, without having to leave the factory floor. The researchers are evaluating "wearable" computer technology, which includes computer screens embedded in specially designed safety glasses. Such portable technology offers the worker hands-free access to computer files and an unobstructed view of the factory floor.

Outreach and Education

Research is not the only mission of the Agricultural Technology Research Program. Twenty percent of ATRP funding is divided among technical assistance to Georgia poultry companies and educational efforts for industry and consumers. Each year, program engineers provide technical assistance to some 50 to 60 companies and individuals, nearly half of which need extensive support.

ATRP's educational activities take several forms. For example, the program produces regular publications for the industry such as the program newsletter, "PoultryTech", and
But what really wins the prize is a great body.

But what really wins the prize is a great body.

But what really wins the prize is a great body.

articles that are published in the trade press. In addition, ATRP provides both faculty and students with critical exposure to industry issues.

ATRP engineers and learning-technologies specialists have worked with secondary schools, the Pioneer Regional Service Education Agency and the Georgia Poultry Federation to create a CD-ROM on the industry entitled "Poultry Plus" for middle schools. The multimedia presentation will provide students with practical information about the industry and real-world applications of science and mathematics.

Georgia Tech graduate and undergraduate students are making significant contributions to ATRP's projects. For instance, mechanical-engineering graduate student Jenelle Piepmeier has developed a new machine-vision technique to enhance computer screening of complex defects in poultry products. The hands-on research experience that these students receive has helped to interest some of them in job opportunities in the industry.

ATRP also conducts workshops and conferences to inform poultry company representatives about key technological issues, such as environmental control and worker safety. In addition, the program has taken on a role in educating consumers about the importance of the poultry industry and the expanding role technology is playing in its future.

The Future of ATRP

While ATRP has a well-defined focus, the program faces new challenges in helping the industry. Continuing increases in consumer demand for poultry products, Massey says, will cause a rapid growth rate for poultry companies. Upscaling of processing and growout operations will demand the infusion of technology to attain the efficiency needed for success. ATRP not only plans to assist the industry in developing new technology, but also in helping poultry engineers and executives in understanding how to incorporate new technology into established operations.

These challenges point to continued strong ties between Georgia Tech and the state's poultry industry.

Mark Hodges is a senior research associate with the Georgia Tech Research Institute.

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Disorder Creates Order

By John Toon

Bringing order out of chaos can require a little disorder. That's the conclusion of a team of physicists in the Nov. 30 issue of the journal Nature, they say adding variability and disorder to certain complex systems can help tame chaotic behavior.

This unexpected conclusion invites scientists and engineers to take a new look at the operation and interaction of both natural and artificial nonlinear systems.

It could ultimately lead to methods for improving the performance of electronic systems by exploiting variations in their components, and to new techniques for controlling disease processes, such as epilepsy, by restoring proper amounts of disorder.

"We have found that nature utilizes disorder to create organization, and that there are situations where the lack of disorder will create disorganization," said William Ditto, assistant professor of physics at the Georgia Institute of Technology. "We think many patterns we see in nature are aided by randomness and disorder. This will lead us to think about systems in dramatically different ways."

Ditto and colleagues John Lindner of The College of Wooster and Yuri Braiman of Emory University used computer simulations to study a variety of coupled nonlinear systems, including a series of chaotic pendula and a system with a hundred identical oscillators. The systems exhibited chaotic behavior over both time and space (spatiotemporal chaos), and the activity of each individual element could affect the behavior of others.

To see what would happen if they increased the disorder and variability of the chaotic systems, the researchers made each pendulum a different length, and programmed each oscillator to respond in a slightly different way.

"We expected that we would get even more disorder and even more turbulent behavior, but what we got was organized behavior patterns coming out of the systems," explained Ditto, director of Georgia

The Gene Detective

When molecular biologists anywhere in the world need help identifying and annotating genes, they're likely to think of Mark Borodovsky and a computer server known as GeneMark.

Since it was established in May 1992, the GeneMark software program has helped identify and annotate about 5,500 genes in more than 30 creatures—about half of them bacteria such as Escherichia coli, Haemophilus influenzae and Mycoplasma tuberculosis. The system has also helped identify genes from higher organisms ranging from plants and fruit flies to rodents and primates.

"What GeneMark does is very important to the current stage of molecular biology," said Borodovsky, a senior research scientist in Georgia Tech's School of Biology. "The goals of many research projects are to sequence entire genomes of particular organisms. For all of these projects, accurate analysis of DNA that shows where genes are is vitally important."

GeneMark was named after the mathematical theory of Markov models that it uses, and the notion of "marking" genes. Its development has been supported by a research grant from National Institutes of Health (NIH).
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A Tech researcher suggests complex systems use diversity, variability to organize themselves.

Tech's Applied Chaos Laboratory. "The diversity or disorder provided a mechanism by which the systems could organize themselves."

How the process works to control chaos isn't fully understood yet, but Ditto believes the disorder may help move groups of chaotic elements into similar modes of behavior.

Neighboring elements then begin to lock into the same mode, and "a local domino effect" spreads that behavior. The result is an organized system of individual elements that repeats its behavior in a complex but regular way.

But not just any amount of disorder will do.

The researchers found that a 30 percent variation in the length of pendula or behavior of oscillators produced the most regular behavior patterns.

Small amounts of disorder could not prompt changes in the system, while more disorder simply "overwhelmed" it.

The study demonstrates the importance of considering how natural and artificial systems interact with other systems in real-world conditions that include noise and variability, said Lindner, an associate professor at The College of Wooster.

Intelligent Rocket Engine Seals

A n electronically controlled "intelligent" mechanical seal could increase the payload capacity of liquid-fueled space vehicles by reducing the weight needed to keep hot exhaust gases separate from liquid oxygen.

"With the intelligent seal, you can save weight and at the same time maintain safety and high reliability," said Dr. Richard Salant, professor of mechanical engineering at Georgia Tech. "This is a distinct advantage when weight is at a premium."

At the heart of the intelligent seal is a piezoelectric crystal that deforms in proportion to the electrical voltage applied to it.

Attached to one face of the seal, the crystal would adjust the spacing between critical moving parts in a rocket engine's turbopump. A closed-loop control system would constantly monitor conditions within the seal and determine the voltage to maintain proper clearances.

Developed with support from NASA's Lewis Research Center, the intelligent seal offers a new approach to an old problem for the liquid-fueled rocket motors that power most space vehicles.

Salant's electronically controlled seal combines the high reliability and low wear rate of floating-ring seals with the low leakage rate of mechanical-face seals. The seal operates by continuously monitoring and adjusting the spacing between the two faces for optimum performance.

During a five-year study funded by the Lewis Research Center, Salant and graduate student Paul Wolff designed, built and tested the seal assembly under a variety of operating conditions.

Based on the results, the researchers believe the controllable mechanical seal offers a viable low-leakage alternative to the floating-ring seal for certain aerospace applications.

Additional work to simulate actual turbopump conditions would be required before the seal could be tested in an actual space vehicle.

In addition to potential use in the space program, there are a number of industrial applications for the seal.

"Intelligent seals could be used on feedwater pumps in factories, on coolant pumps in nuclear power plants or as pipeline seals in unmanned pumping stations," says Salant. "The seals could be used wherever low maintenance, low leakage and high reliability are required."

John Toon is manager of Research Communications at the Georgia Tech Research Institute (GTRI).
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Building a Better Leech

By Lea McLees

The lowly leech is making new contributions to humanity in a surprising way as researchers from Georgia Tech and Emory University build circuit models of the slippery creature’s nervous system. In doing so, they hope to learn a few things about simple control systems.

“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,” said Dr. Steve DeWeerth, an assistant professor in the School of Electrical and Computer Engineering at Georgia Tech.

But why the leech? Two reasons, DeWeerth says. First, its swimming and circulatory control systems contain a fairly large but manageable number of neurons, compared to other systems—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 circuitry and connections in each segment of the leech are almost identical to those found in every other segment,” DeWeerth explained. “This type of regularity is a powerful aid to our modeling efforts.”

Second, the motor systems of the leech are intricately mapped because biologists like Emory University’s Dr. Ron Calabrese have observed them for years. Calabrese studies the neural control of the leech circulatory system and is knowledgeable about biological research into leech locomotion.

The two researchers’ collaborative work is funded by a grant from the National Science Foundation and with seed money from the Emory/Georgia Tech Biomedical Technology Center.

The researchers’ future goals include incorporating the electrical systems they build into a larger one including sensor feedback and adaptation.

“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 systems, whether they be biomedical prosthetics or robotics,” DeWeerth said.

Lea McLees is editor of Research Horizons, a publication of GTRI.
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In most complex mechanical systems, lubricants help reduce friction and protect moving parts against wear. But recent research suggests that under extreme conditions, lubricants in systems such as computer disk drives may behave in unexpected ways that can harm the very systems they are intended to protect.

Using molecular dynamics simulations, researchers at Tech predict that ultra-thin films of the organic lubricants used in nanometer-scale devices may act more like solids than liquids when subjected to high pressures. The simulations also warn of possible damage from cavitation effects, as well as fatigue failure caused by repeated surface deformation.

"We believe these results could have some impact on the design and way of thinking about devices like high-density disk drives that have moving parts in close proximity lubricated by thin films," says Dr. Uzi Landman, director of Georgia Tech's Center for Computational Materials Science.

The work helps expand the understanding of elastohydrodynamic lubrication phenomena. Knowing how the behavior of lubricants can change and affect lubricated surfaces is becoming more important as the need for miniaturization leads to development of ever-smaller components.

Using supercomputers to model the complex physical processes involved, the researchers studied the behavior of a thin-film hexadecane lubricant flowing between two gold disks sliding past each other at a relative velocity of 10 meters per second.

Under these conditions—similar to the operation of a computer disk drive—the flow of liquid lubricant through the narrow space between the surfaces creates pressure high enough to cause temporary elastic deformation of the disks. Repeated deformation could ultimately lead to pits or cracks on the disk surface.

The research was sponsored by the Department of Energy, the National Science Foundation, and the Air Force Office of Scientific Research.
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Charles Eckert likes to study the interactions of things. In his own words, his work involves "mixtures of molecules, and learning how those molecules interact with each other, and seeing how we can use that for some benefit."

That said, Eckert's art—chemical engineering—does indeed imitate his life. Holder of the J. Erskine Love Jr. Chair in Engineering, Eckert came to Georgia Tech in 1989 because of how the people there interact.

"I was very much attracted by the collegial and cooperative attitudes at Tech," he says, "as well as the excellent relationship with the alumni, the community and with industry. I really liked the attitude of working in interdisciplinary areas, of working in collaborative teams and of working closely with industry in implementing engineering."

Eckert knows it's not like that everywhere. Earning both his bachelor's and master's from the Massachusetts Institute of Technology and his doctorate from the University of California at Berkeley, he also has worked at Stanford and the University of Illinois. These universities, he says, are "much more 'ivory tower' in their approach to engineering."

"In my early years of engineering," Eckert says, "it was unthinkable for junior faculty to collaborate because you had to prove yourself. It was such a delight to find a school where collaboration is not only permitted, but encouraged, where people can multiply their efforts by their interaction."

Eckert's research, both individually and cooperatively, has garnered major awards, as has his teaching. One of his greatest pleasures is watching former students go on to become professors and, in turn, influence would-be engineers themselves.

"The purpose of a university is not to turn out papers but to turn out people," Eckert says. "I really appreciate seeing my ideas about how to work with students being passed on to other academic generations."

Eckert's rapport with former students is such that some of them organized a celebration for him earlier this year when he was given the prestigious E.V. Murphree Award by the American Chemical Society, the organization's highest accolade. He says around 50 people, including friends, colleagues and family, attended "Chuckfest '95" and participated in a roast of the guest of honor. The best thing, to Eckert, was that his two children—a daughter, Carolyn Gasey, an attorney in New York; and a son, Ted, an engineer in St. Louis—were there to see their father being recognized by the people "they knew along the way."

A couple of years ago, when a former student (now a professor at the University of Texas) won an award from the American Institute of Chemical Engineers, Eckert says he was more excited for his protégé than he was when he won the same award himself 20 years earlier.

"I never get envious [of former students' success]," Eckert says. "If they do better science than I, that doesn't prove I'm a poor scientist; it proves I'm a good teacher."

Eckert's enthusiasm extends to undergraduate teaching as well. One of his favorite classes to teach is the first course in chemical engineering. Students

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**The Charles Eckert File**

- **Born:** Dec. 13, 1938, in St. Louis, Mo.
- **Education:** BS and MS in chemical engineering from the Massachusetts Institute of Technology, Ph.D. from the University of California at Berkeley.
- **Personal:** Two children—Carolyn and Ted.
- **Achievements:** Eckert holds the J. Erskine Love Jr. Chair in Chemical Engineering at Tech. Previously, he served (1980-1986) as head of the chemical engineering department at the University of Illinois. He has done sabbaticals with Stanford University. Eckert has been awarded both the E.V. Murphree Award (1995) and the Ipatieff Prize (1977) by the American Chemical Society; and the Alan P. Colburn Award from the American Institute of Chemical Engineers (1973); he has been named an Institute Professor by Georgia Tech. Eckert is a member of the National Academy of Engineering. He also served as a postdoctoral fellow at the Laboratoire des Hautes Pressions in Paris (1964-65).
- **Leisure Interests:** Enjoys outdoor activities, such as hiking, canoeing, sailing. He also loves to cook, play bridge and to read, especially history.

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**Practical Solutions**

By Michael Terrazas

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Tech's Dr. Charles Eckert wants to encourage creativity in his students, letting them know "it's all right to have ideas." Creativity, he says, is an ability engineering schools should try to instill in students in the future, so that they will be able to deal with the increasingly fast-paced and changing job market. Eckert feels that too often students in both high school and college succeed because they only know how to avoid mistakes. "I guess I'd like students who make some mistakes, because they are the ones who have ideas and who try their ideas out," he says. "If the ideas are worth trying out, some of them aren't going to work, but that's all right." Sometimes, a student will come up with a solution Eckert himself thought of and tried unsuccessfully years before, but he tries to hold his tongue and let the student learn by doing. "I've learned to be quiet, because frequently they'll make it work." Most importantly, however, is for schools to teach people how to learn. "We don't need to teach them everything if they know how to learn. Very often, industry is hiring people into specific jobs with specific skills; it's really very much to the students' disadvantage, because if they get pigeonholed in that job and things change, where do they go?"
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