Wake-up Call for Innovation

@ The United States' long-standing position as a global leader in science and technology innovation is in jeopardy now as many foreign governments strengthen their educational and research programs. At stake is more than national pride, it's economic prosperity, experts say.

Other countries make strides in science and technology, threatening the United States' competitive edge.

BY T.J. BECKER

ILLUSTRATION BY MAC EVANS

When it comes to innovation in science and technology, the United States has been the recognized global leader since the end of World War II. But today that No. 1 position is in jeopardy as many foreign governments strengthen their educational and research programs.

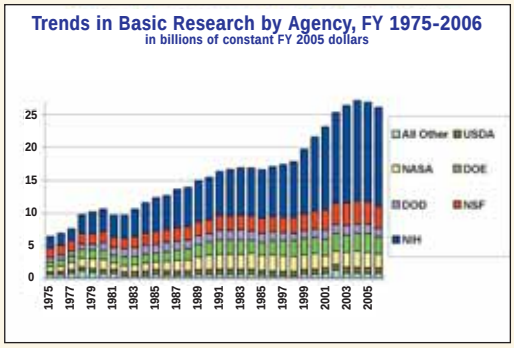
Consider:

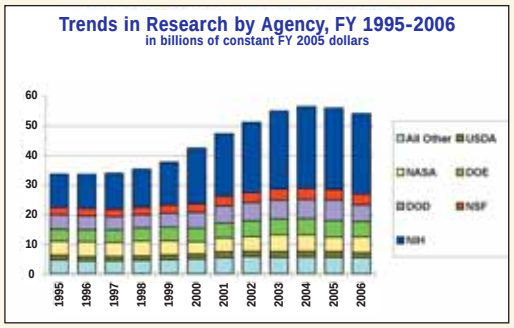
- From 1989 to 2001, U.S. patent applications from researchers in China, India, Singapore, South Korea and Taiwan increased 759 percent, while patent activity for home-grown technology grew at a slower pace of 116 percent.
- Sweden, Finland, Israel, Japan and South Korea each spend more on research and development (R&D) as a share of their gross domestic product (GDP) than the United States.
- Only 5.7 percent of undergraduate degrees in the United States are in natural sciences and engineering compared to 8 percent in Japan and 11 percent in Taiwan and South Korea. Although these benchmarks are relative — indicating percentage growth rather than absolute numbers — they reflect a disturbing trend.

"The United States continues to have an innovative edge, but at the same time, our advantage is shrinking," says G. Wayne Clough, president of the Georgia Institute of Technology and co-chairman of the National Innovation Initiative (NII), sponsored by the Council on Competitiveness (COC). A task force of business and academic leaders, NII released a report, "Innovate America," in December 2004 that recommends specific tactics for honing America's innovation capabilities.

ILLUSTRATION BY KAY LINDSEY

***ABOVE:** This chart represents growth in total R & D investments.*





***ABOVE:** The first chart represents trends in funding basic research by U.S. government agency, and the second shows total research funding by agency.*

CHARTS COURTESY AAAS

Sustaining the United States' leadership position is a serious issue — with far more at stake than national pride. Because it leads to new industries and higher-paying jobs, innovation is directly linked with economic prosperity.

Not the Usual Suspects

This isn't the first time America's competitive advantage has been threatened, but today the challenge is more complex.

"In the 1980s, the United States was inventing things, but not manufacturing them as well, particularly at the small and medium-sized establishment level," says Jan Youtie, a senior research associate at Georgia Tech's Community Research and Policy Services. "That led to government programs like MEP (Manufacturing Extension Partnership) to enhance our competitiveness. Now the real concern is whether we can maintain our pace of innovation."

PHOTO BY NICOLE CAPPELLO

> "The United States continues to have an innovative edge, but at the same time, our advantage is shrinking...
>
> In the past five to 10 years, India and China have entered the mainstream of global competition. And in doing so, they've chosen not only to compete at the low end, but also the high-end, which they're doing with gusto."
>
> G. Wayne Clough, president of the Georgia Instutute of Technology and co-chairman of the National Innovation Initiative (NII)

PHOTO BY NICOLE CAPPELLO

Philip Shapira

Another twist is a new cast of players. In the 1980s, competition came from high-skilled, high-wage countries like Japan and Germany. Today, emerging Asian countries are displaying surprising clout in technology. For example, India is winning recognition in software development, and South Korea is showing strength in electronics and computer storage and display technologies.

Yet China is sparking some of the greatest concern as it evolves from being merely a low-cost competitor to one with growing technology capabilities. From 1989 to 2001, China's high-tech industry output — which includes aerospace, computers, communications equipment, pharmaceuticals and medical instruments — jumped eightfold from $30 billion to $257 billion. In comparison, the United States' output slightly more than doubled from $423 billion to $940 billion.

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R & D Outsourcing

U.S. companies taking R & D overseas.

BY T.J. BECKER

In the 1990s, corporate America began contracting information-technology services out to other countries. Now there's a new outsourcing trend as U.S. firms take their research and development (R&D) activities overseas.

"Innovation itself is being outsourced," says John McIntyre, executive director of Georgia Tech's Center for International Business Education and Research. Instead of doing R&D in-house, a number of companies like Motorola and Dell are buying complete digital and electronic designs from Asian developers, he says.

Less about cost-saving, this trend reflects the increasing number of skilled researchers in other countries and the rise of technology clusters (geographic areas with a heavy concentration of R&D infrastructure, such as companies, talented workers, training facilities and distribution centers). "We're moving away from a world of command-and-control to collect-and-collaborate," McIntyre says. "Firms are looking for talent and opportunity, regardless of where it is."

Is this globalization of R&D a progressive strategy or are U.S. companies merely asking for trouble?

"R&D is viewed as the furnace of competitiveness," McIntyre says. "So it may seem like we're giving away the crown jewels. Yet companies aren't outsourcing R&D to grow smaller. They're doing it to grow larger."

The result should be more jobs everywhere, he says: "Granted, not all those jobs may be in the United States, but that doesn't mean it's a zero-sum game. Just because a job is created in Malaysia doesn't mean one is lost in the United States."

McIntyre believes that R&D outsourcing is only a threat if the United States drops the ball on the high level of innovation. "Our challenge is to focus on next-generation products that are more knowledge-intensive and require more creativity," he says.

CONTACT

John McIntyre at 404-894-1463 or john.mcintyre@mgt.gatech.edu

ILLUSTRATION BY DAWN HUDSON, COURTESY OF ISTOCKPHOTO.COM

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"If you had a choice 35 years ago...to be a B+ student in Los Angeles or a genius in Bangalore, India, you would choose to be a B+ student in Los Angeles. Your life choices and opportunities would be so much better. Today, you do not want to be a B+ student in Los Angeles, because that genius in Bangalore, in a flat world, can plug-and-play, compete and collaborate more directly with you or your kids than ever before."

— Thomas Friedman, New York Times columnist

PHOTO BY JOSHUA BLAKE, COURTESY OF ISTOCKPHOTO.COM

than Korea and India combined," observes Philip Shapira, a professor in Georgia Tech's School of Public Policy. In addition to manufacturing, China has dramatically increased its R&D spending and is becoming a high-volume producer of research, he says. In fact, China recently edged Japan out of second place in the number of published papers on nanotechnology and is now right behind the United States.

Shrinking Talent Pool

Knowledge economies depend on skilled scientists and engineers, and in the United States that workforce is aging. More than 25 percent of today's scientists and engineers are in their fifties, and many will retire by 2010. Because fewer students are pursuing science and technology degrees, new blood is in limited supply.

In the last three decades, the United States has fallen from No. 3 to No. 17 in global rankings of countries with college students earning science and engineering degrees. And the future doesn't look any better: Only 5.5 percent of high-school students taking the ACT college entrance exam in 2002 planned to major in engineering, down from 8.6 percent in 1992.

Compensation is one deterrent, experts say. Pursuing a business degree is viewed as an easier — and faster — payoff.

"This nation asks a lot of its people to become Ph.D.s," says Diana Hicks, chair of Georgia Tech's School of Public Policy. "Students spend a great deal of time and money to obtain doctoral degrees when they could have been out in the market earning salaries and building pensions. In a knowledge economy, smart people have a lot of opportunities. Being a scientist isn't the only interesting career."

Society is another influence, others say. "Society rewards people in its public culture and the images portrayed in the media. Yet American culture often values sports and movie stars over being a scientist," notes John McIntyre, director of Georgia Tech's Center for International Business Education and Research.

"The thoughtful people in our society don't get media play," says Kathleen Kingscott, IBM Corp's director of innovation policy and an NII participant. Kingscott sees the effect with her two children, who aren't interested in science, even though they are good students. In fact, Kingscott recalls encouraging her 11-year-old daughter to attend a science program for young girls sponsored by the National Aeronautics and Space Administration (NASA). "It was the last thing in the world she wanted to do. She didn't want to be perceived as a geek," says Kingscott. "We need to make it cool to be smart."

At the same time American students are abandoning science and engineering, fewer foreign students are coming to the United States.

That's a problem because foreign students have helped make up for the dearth of U.S. students enrolled in science and engineering. After graduating, foreign students often remain in the United States for research jobs, contributing to our nation's knowledge base.

Some of the decline stems from 9/11, with new immigration policies making it more difficult for foreign students to secure visas. Another reason, as other

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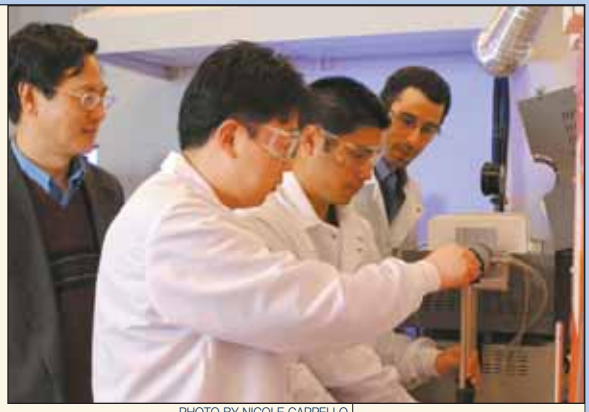

PHOTO BY NICOLE CAPPELLO

***ABOVE:** Georgia Tech Professor Z.L. Wang, left, works with students in his lab in the School of Materials Science and Engineering.*

***BELOW:** "Students spend a great deal of time and money to obtain doctoral degrees when they could have been out in the market earning salaries and building pensions," says Diana Hicks, below, chair of Georgia Tech's School of Public Policy.*

PHOTO BY NICOLE CAPPELLO

PAPER CHASE

The United States' share of published science and engineering research papers fell from 38 percent in 1988 to 31 percent in 2001, while other countries gained momentum. Asia's share of published papers grew from 11 to 17 percent, and Western Europe garnered a 36 percent share in 2001, one-upping the United States.

Scientific papers don't always have immediate commercial applications, but they remain an important benchmark of a country's knowledge base. "It's a sign that you have highly skilled people who are producing the necessary knowledge for later applications," explains Diana Hicks, chair of Georgia Tech's School of Public Policy.

Another shift: When it comes to international collaboration on scientific papers, the United States traditionally has been the go-to country. Yet Asian countries are beginning to collaborate more among themselves. "This makes the United States appear slightly less important — another sign that our dominance is starting to decline," Hicks says.

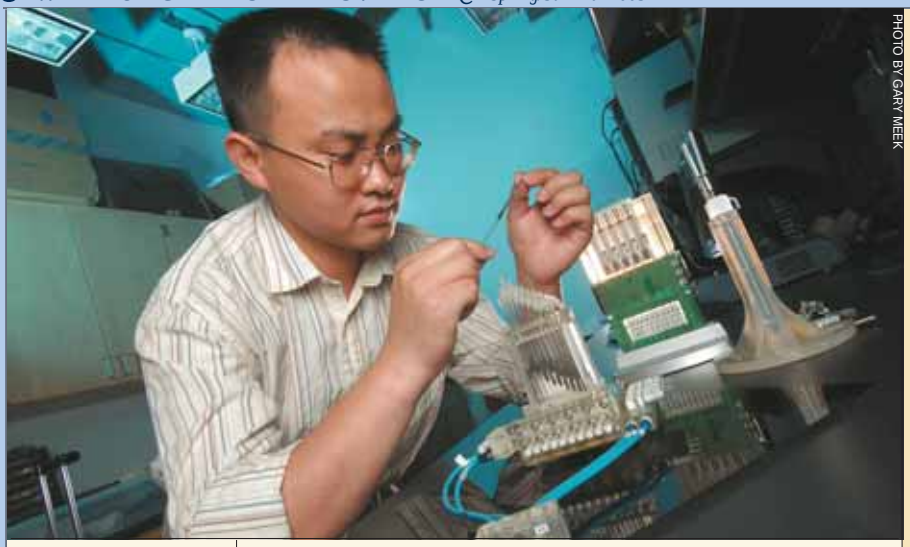

PHOTO BY GARY MEEK

ABOVE: *Georgia Tech graduate student Haihong Zhu of China works with Professor Wayne Book in the School of Mechnical Engineering on a computer-aided design prototype that is worked in three dimensions like modeling clay.*

countries have bolstered educational centers, their young people no longer are dependent on the United Sates for advanced training.

And if foreigners do choose to study in the United States, they have more reasons for returning home. In many countries with reformed economies, salaries for professors and researchers have escalated significantly.

When Xiao-Yin Jin was working at the Shanghai Industry Foundation in 1990, his annual salary was less than $1,200 in U.S. dollars. "And I held a full professor position at the time," says Jin, a visiting scholar at Georgia Tech's Technology Policy and Assessment Center. Today, Chinese professors in key universities earn more than $12,000 per year, he says.

Chinese professors can further increase their income by doing government or industry-funded research, where a portion of grant money (about 10 to 15 percent) is available as salary or bonuses. Another incentive, government policies encourage scientists to become entrepreneurs, Jin adds. If a researcher's innovation can be used to start a business, the organization is tax-free for three to five years.

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Georgia Tech Launches New Commercialization Initiative

BY JOHN TOON

Georgia Tech has launched an aggressive new commercialization initiative designed to streamline the handling of intellectual property, accelerate the licensing of technology and make the Institute's resources more readily accessible to business and industry.

The new initiative, to be known as Georgia Tech Commercialization Services, will also expand the transfer of technology to Georgia companies while providing stronger marketing and management for Georgia Tech's rapidly growing intellectual property portfolio.

Stephen Fleming, a successful Atlanta investor and entrepreneur, will head up the new unit as Chief Commercialization Officer. A Georgia Tech graduate with private-sector experience at AT&T Bell Laboratories and Northern Telecom, Fleming has been a partner in two Atlanta-based venture capital firms, and has managed investments in more than 20 start-up companies.

"Better commercializing the technological innovations we develop will enable Georgia Tech to have a larger impact on the local, state and national economies," says Provost Jean-Lou Chameau. "To accommodate continued growth in our intellectual property portfolio, we need a more effective commercialization process, one that is worthy of the kind of institution we aspire to be."

PHOTO BY EMMA HOLMWOOD, COURTESY OF ISTOCKPHOTO.COM

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FEWER FOREIGN STUDENTS

From 1994 to 1998, the number of Chinese, South Korean and Taiwanese students pursuing doctoral degrees in the United States dropped 19 percent, reflecting greater educational capabilities abroad. During the same period, the number of doctoral students staying in their own countries nearly doubled.

More restrictive immigration policies since 9/11 have also taken a toll. The total number of foreign students on U.S. campuses dropped 2.4 percent in the 2003-04 school year — the first decline since 1971-72, according to the Institute for International Education.

PHOTO BY GARY MEEK

LEFT: "Our new commercialization initiative will speed the transfer of technology from Georgia Tech and make it easier for outsiders — including entrepreneurs and potential corporate partners — to work with us," says Waynes Hodges.

Over the past decade, Georgia Tech's research program has more than doubled in size and the institution has set records for the number of patents filed, technologies licensed and start-up companies formed. The Advanced Technology Development Center (ATDC), Georgia Tech's science and technology incubator, has won broad recognition for helping build the state's technology community through support of start-up companies.

"Our new commercialization initiative will speed the transfer of technology from Georgia Tech and make it easier for outsiders — including entrepreneurs and potential corporate partners — to work with us," says Wayne Hodges, vice provost for Economic Development and Technology Ventures. "Moving more technology out into the community will lead to the formation of more start-up companies, create new high-paying jobs and help revitalize existing enterprises."

According to Hodges, the new initiative will:

- create a clear process for the commercialization of technology developed by faculty members and students, and facilitate collaboration with experienced entrepreneurs in launching new companies;
- provide a consistent set of expectations for business and industry partners who wish to commercialize Georgia Tech research; and
- help Georgia companies develop the new products and processes they need to compete in world markets by transferring technology innovations developed at Georgia Tech and partner organizations.

As chief commercialization officer, Fleming will be responsible for the complete commercialization process, including evaluation of invention disclosures, marketing of Georgia Tech intellectual property and assistance to faculty members interested in starting companies.

According to a recent survey by the Association of University Technology Managers, Georgia Tech ranks first among U.S. universities in the rate of technology licenses granted to start-up companies. Overall for fiscal year 2004, Georgia Tech licensed technology to 15 start-up companies, received 35 patents, filed 277 invention disclosures and brought in $2.3 million in revenue.

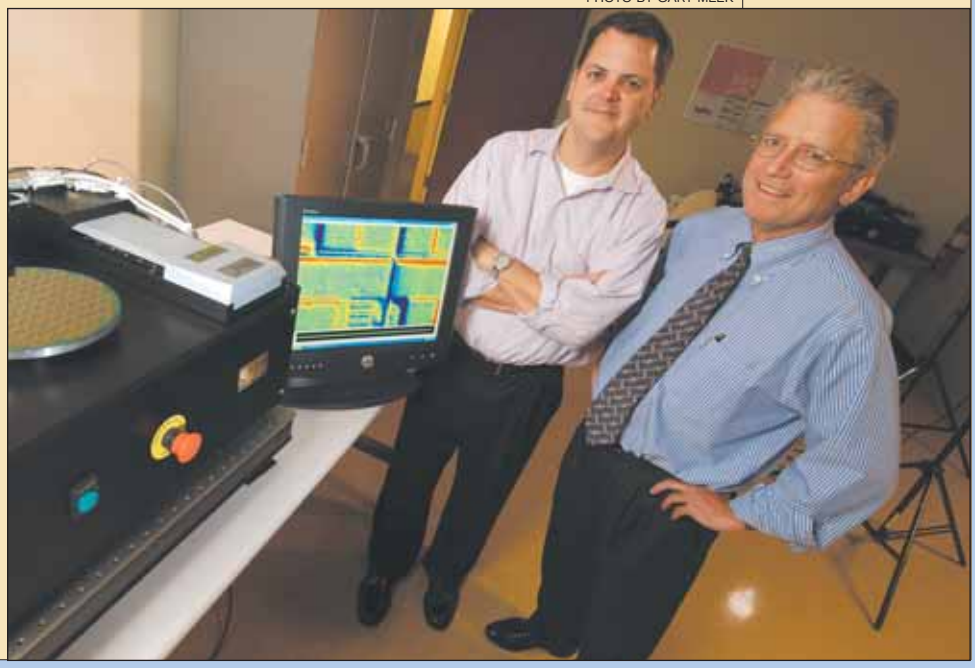
@ Read more at: **gtresearchnews.gatech.edu/newsrelease/commercialization.htm**

CONTACT

Wayne Hodges at 404-894-5217 or wayne.hodges@edi.gatech.edu

BELOW: *Georgia Tech VentureLab graduate company Qcept has developed a breakthrough, patented sensing technology, based on research by Steven Danyluk, right, a professor in the School of Mechanical Engineering. Bret Bergman, left, is CEO of Qcept.*

PHOTO BY GARY MEEK



RISKY BUSINESS

"Innovation is a riskier initiative compared to quality management or lean manufacturing. Quality and lean strategies make facilities more productive, so financial savings can occur fairly soon. In contrast, innovation requires significant upfront investment, especially for new products, and rewards are not immediate. Yet while risks may be higher with innovation, so are the rewards. Innovative firms are more profitable, with average return-on-sales being 1 percent higher. What's more, annual salaries at innovative firms average $10,000 higher than firms competing on low price."

— Jan Youtie, senior research associate, Georgia Tech's Community Research and Policy Services

PHOTO BY HAROLD DANIELS

Jan Youtie

PHOTO BY VALERIE LOISELEUX, COURTESY OF ISTOCKPHOTO.COM

ABOVE: *Basic research has the ability to create entirely new areas of commercial activity. For example, basic research funded by the government has led to bar coding technology and the Internet.*

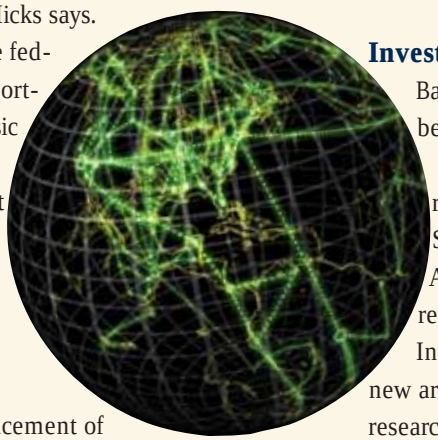
As the entrepreneurial climate heats up in other countries, there's a sort of "Wild West" allure, observes Chad Evans, vice president of the Council on Competitiveness' NII. "There's a sense that students could change the world if they go back to their own countries … that they might become the next Bill Gates," he explains.

The Money Pot

Trends in federal funding are also undermining America's knowledge base.

From the end of World War II to 1980, Uncle Sam provided the bulk of the nation's research and development (R&D) dollars. Yet the private sector now foots the lion's share (68 percent), and nearly three-fourths of that money is earmarked for development, not basic research. Sometimes referred to as "discovery research," basic research seeks to expand knowledge of a subject without specific applications in mind.

"Basic research is important because it sets up the country for the next generation of technology so we don't run out of innovations," Hicks says.



Yet the portion of the federal government's R&D portfolio that goes toward basic research has been stagnant or declining for most non-biomedical disciplines during the past 15 years, says Kei Koizumi, R&D budget and policy director at the American Association for the Advancement of Science (AAAS). Looking at 2006 and beyond, cuts for basic research look worse, he adds.

President George W. Bush's 2006 proposed budget devotes $132.3 billion to R&D spending, up a mere 0.1 percent from 2005. NASA stands to benefit the most, with increases for space exploration resulting in fallout for other agencies.

At the Department of Defense (DOD), the biggest supporter of engineering research, there would be a slight budget increase. Yet within DOD's accounts devoted to science and technology, basic research dollars would drop 12.9 percent with a 14.7 percent decrease for applied research, according to Koizumi.

The National Science Foundation (NSF) and National Institutes of Health (NIH), two large supporters of basic research, will see slight budget increases — 2.8 and 0.5 percent respectively. But once adjusted for inflation, there is actually less discretionary money for research: The size of NSF grants and the number of NIH research projects will shrink.

"Already at NSF, less than one out of five applicants receive funding, which compares to a 25 to 35 percent rate of funding in the past," Koizumi says. "Of course we want competition, but we also stand to lose a lot of good ideas."

Investing in the Future

Basic research may seem expendable to politicians because it's not about instant gratification.

"You don't pay today and see the results tomorrow. Basic research provides for the future," notes Samuel Rankin, associate executive director of the American Mathematical Society, who likens basic research to a 401(k) fund.

Indeed, basic research has the ability to create entirely new areas of commercial activity. For example, basic research funded by the government has led to the Internet, bar coding, robotics and gene mapping.

Many of the products Americans enjoy today stemmed from federally funded research initiated more than 20 years ago, says Evans of the Council on

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MISSION TO MARS?

"When the Cold War ended, Americans began to grow complacent about international innovation. Would a large-scale government program, such as President Bush's "mission to Mars," re-ignite public interest in science and engineering (S&E) and motivate youth to pursue technology careers? Probably not, says Nils Newman, president of Atlanta-based Intelligent Information Services Corp., who helps companies with technological competitiveness. "For one thing, unlike the race to the moon, there's no pressing need to go to Mars. Right now, no one is trying to beat us there," he notes.

Competitiveness. "If we aren't making that investment today, the chances of there being innovations for us to enjoy in the future are slim," he adds.

Federal funding for basic research also has a profound effect on the talent pool. "Universities need stable funding not only for research to come to fruition but also to train graduate students," Rankin says. "When students see the funding spigot turned on and off, it affects morale. They think, 'Why put up with this?' These are bright people who have other opportunities."

Georgia Tech students conduct research in a clean room in the Microelectronics Research Center.

PHOTO BY NICOLE CAPPELLO

In addition to increased funding, experts call for a diversified R&D portfolio for basic research. "We can't just put all our eggs in one basket," Evans explains. "Health sciences may be poised for great breakthroughs, but you still need the talented mathematicians for computer modeling. It's the interface of disciplines that will lead to new fields of discovery."

Increased funding is just one aspect of sustaining the United States' knowledge base; innovation depends on a complex ecosystem.

Underscoring that fact, NII's "Innovate America" report recommends 32 strategies across three categories: talent, infrastructure and funding. Implementing the plan calls for a unified effort, Clough stresses: "It can't be done solely from the government side. It requires the cooperation of industry and universities as well."

And though the United States is still at the front of the innovation race, that's no excuse to delay action, experts agree.

"This isn't a problem with a short-term fix," says Alan Porter, co-director of Georgia Tech's Technology Policy and Assessment Center. "Beyond our knowledge base, we have nothing else — no natural resources — that gives us a competitive edge in the global economy. We're fine right now, but in 15 years, this could really bite us."

@ Read more at: **gtresearchnews.gatech.edu/reshor/rh-ss05/at-risk.html**

contacts

G. Wayne Clough at 404-894-5051 or wayne.clough@carnegie.gatech.edu

Diana Hicks at 404-385-6015 or diana.hicks@pubpolicy.gatech.edu

Jan Youtie at 404-894-6111 or jan.youtie@edi.gatech.edu

Philip Shapira at 404-894-7735 or philip.shapira@pubpolicy.gatech.edu

John McIntyre at 404-894-1463 or john.mcintyre@mgt.gatech.edu

Xiao-Yin Jin at 404-894-6703 or xiaoyin.jin@pubpolicy.gatech.edu

Alan Porter at 404-894-2330 or alan.porter@isye.gatech.edu

"When it comes to prestige projects, you have to be careful what you invest in for it to pay off," Newman adds. The Cold War us-versus-them mentality is a game that has played itself out. More likely to stir up public fervor would be the development of an SUV that gets 150 miles-per-gallon of gas, Newman says: "There's a slight 'us-versus-them' element here in terms of our dependency on foreign oil. Yet more importantly, there's a real market need. Having gone through the oil crunch of the '70s, we know that Americans aren't going to give up large vehicles — or drive less."