

IITs

The American Connection

By DIPESH SATAPATHY

In 1998, Amitabha Ghosh, then director of the Indian Institute of Technology (IIT) at Kharagpur, wrote to Brian Halla, chairman of National Semiconductor Corp. in Santa Clara, California, inviting him to help develop a lab in India that would help designers build better computer chips.

Halla agreed.

His colleague, Bijoy G. Chatterjee, raised \$1 million from IIT alumni in the United States and from five American corporations. National Semiconductor provided a free fabrication facility and technical support. Sun Microsystems gave powerful servers and workstations; Cadence Design Systems and Synopsys Technologies provided their full suite of computer-aided design tools; Agilent

Technologies offered modern test equipment. And the VLSI Laboratory was born.

The VLSI—Very Large Scale Integration—lab helps scientists pack more and more logic into electronic devices to make them operate faster. The lab, located at IIT-Kharagpur, in West Bengal, is the only one of its kind in India and has fabricated 30 computer chips.

The lab is an example of the hundreds of collaborations that American companies have forged with the seven IITs, prompted in part by the quality of research in India. Many U.S. technology giants hold joint patents with the institutes. The thousands of IIT-trained engineers and scientists who live and work in the United States also funnel to their alma mater research contracts in such diverse fields as

disaster management and telemedicine.

The IITs are among a handful of centers of higher learning in India that encourage the faculty to pursue collaborative research with governments and private corporations, as a mandate along with promoting education and training.

Chatterjee says National Semiconductor is “pleased with the quality of research [at IIT-Kharagpur] and intends to continue this collaboration.” The California company has steadily increased its direct research investment in the institute in semiconductor-related technologies and funds projects worth more than \$300,000 a year in analog chip design and design automation.

Apart from initiating research with the five supporting companies, IIT-Kharagpur is also doing joint research



COURTESY IIT-KHARAGPUR

Above left: Professor Amit Patra with students in the Very Large Scale Integration lab at IIT-Kharagpur.



D. KRISHNAN

Left: Madras IIT's Devendra Jalihal in the TENET Group lab.

Far left: Gayatri Vaidya, research assistant at IIT-Bombay, scans chips on an electronic microscope.

with the Georgia Institute of Technology, University of Washington, University of Michigan and Intel. The U.S. chip maker has funded a large number of projects on circuit design, formal verification and image processing there.

Synopsis, whose association with IIT-Kharagpur started in the late 1990s, is also working with the institute to develop industry-level courseware on chip verification methodology.

Every year, representatives of American corporations come to IIT campuses to sign agreements for collaborative research. One such person is Ray Stata, founder of Analog Devices. Stata flies into Chennai every four months to work with 15 computer science and electrical engineering researchers in the Telecommunications and Networks Group (TENET) at IIT-Madras who are developing technology for rural applications in poorer countries.

Says Stata about the IIT team: "They are a prolific source of innovation in terms of

developing IT products for emerging markets where features and cost targets are much different and more demanding than for the developed world."

The Indian faculty is also impressed with Stata. "He has been taking a lot of personal interest, putting in his personal money and has given a lot of his time, which is invaluable," says Devendra Jalihal, one of the researchers.

Because of the collaboration, the group gets advance information on products, sometimes two years before they are released, and contributes in turn by identi-

IIT-Madras Director M.S. Ananth with Ambassador David C. Mulford.



D. KRISHNAN

ifying bugs and problems. There are many intangible benefits as well, according to Jalihal. For example, Analog Devices procures some products for the group's research work much faster than they would be able to otherwise.

Analog Devices has benefited as well. "We get useful feedback and suggestions on how to improve the performance of our products," says Stata. "IIT is a center of excellence for digital signal processing applications and software, which is what attracted Analog Devices to form a close working relationship."

Analog also supported the development of a training center in this field for students from Indian universities. It invites its customers to attend one-week training programs at IIT-Madras. Feedback on the training material developed by the faculty has been extremely positive, says Stata.

Analog is a minority stockholder in Midas Technologies, a spin-off technology company supported by the Madras group. The U.S. company is a continuing source of components and technical support for the Midas engineering team. Together with Midas, Analog developed integrated circuits, specifically for products for the successful CorDect wireless-in-local-loop technology, which the IIT designers developed to expand the availability of telephone connections in rural areas.

"I have also personally enjoyed my involvement with the start-up companies which IIT-Madras has germinated and the chance to be helpful based on my business experience over the past 40 years. It has been a mutually beneficial relationship all around," says Stata.

Major American technological giants such as Microsoft and Intel and large companies such as General Motors have several research projects going on at IITs. With Microsoft support, IIT-Guwahati has developed a new network routing procedure that can be used at construction or disaster sites, where network infrastructure needs to be set up quickly and temporarily. IIT-Kharagpur, where the company has been sponsoring a lab since 2000, has focused on building text-to-speech engines for Indian languages and English-to-Indian-language translators



Scientific Collaboration Highlights

Bombay IIT's Sauvik Mahapatra is part of a contract research project undertaken by Purdue University for Applied Materials of Silicon Valley, California, which manufactures processing tools for semiconductor manufacturing. He works with Purdue's Ashraf Alam on flash memory devices, which consist of a computer chip with a read-only memory.

Pramod Mehta from Madras IIT's mechanical engineering department has collaborated with Argonne National Laboratory in Illinois on engine emission issues.

Madras IIT's civil engineering department has a project on light-weight concrete construction with the University of Texas at Austin. J. Murali Krishnan from the same department collaborates with K.R. Rajagopal of Texas A&M University on asphalt and asphalt concrete.

In a project under the Department of Science and Technology-U.S. National Science Foundation Program for Scientists and Engineers, IIT-Delhi and Pennsylvania State University are working on electrical properties of materials at high frequencies and temperatures.

Bombay IIT's Sunita Sarawagi has collaborated with Boeing Corporation on data mining issues.

Goodyear and General Electric have sought consultancy on rubber technology from IIT-Kharagpur.

G. Sunderrajan from IIT-Madras has collaborated with DuPont, GE and International Specialty Products in the field of polymerization.

Boston-based Alnylam Inc., working on anti-cancer drug delivery systems, has contracted out some work to Bombay IIT's K.P. Kaliappan. Sharad Bharatiya from the same IIT has a project from Honeywell Corporation on control of a type of microbe that makes Rifamicin-B, a cholesterol-lowering drug.

Madras IIT's P.C. Deshmukh works with researchers from the University of Nevada, the Argonne lab in Illinois and Georgia State University on high-energy physics.

Since 1999, Kanpur IIT's Vinod K. Singh has been synthesizing organic compounds for the drug discovery program of Neurogen Corporation, a small U.S. pharmaceutical company based in Branford, Connecticut.

IIT-Kharagpur chemical engineer Ashutosh Sharma has worked with Manoj K. Chaudhury's group at Lehigh University in Bethlehem, Pennsylvania. Their research has potential applications in optoelectronics, sensors, lab-on-a-chip devices, micro electrical-mechanical systems and micro-factories. Sharma also collaborates with the University of California at Irvine.

David E. Goldberg, director of the Illinois Genetic Algorithm Lab, has

worked with Madras IIT on optical design of structural systems and also corresponds with Kanpur IIT's Kalyanmoy Deb and Nirupam Chakraborti of IIT-Kharagpur.

P. Sriram from IIT-Madras works with Wichita State University on the application of composite materials to aircraft.

R.I. Sujith of Madras IIT's aerospace engineering department has worked with Tim Lieuwen of the Georgia Institute of Technology on sound propagation in non-uniform media. S.R. Chakravarthy, of the same department, has worked with Georgia Tech's Jerry Seitzman on solid propellants. The work has implications for rapid and inexpensive development of specific solid rocket propellants. □

Above: K.P. Kaliappan, a cancer drug researcher, at IIT-Bombay.

Right: IIT-Bombay researcher Sharad Bharatiya with his colleagues.



and has completed projects on mobile telemedicine systems and devices to assist people with motor-neuron disorders. IIT-Bombay is home to four Intel-sponsored labs on technology, microelectronics, enterprise and Very Large Scale Integration. Two such labs on Internet and wireless technology run at IIT-Madras. Through its Bangalore lab, General Motors Corp. works with all IITs on smart materials, occupant safety in vehicles and modeling of the human body.

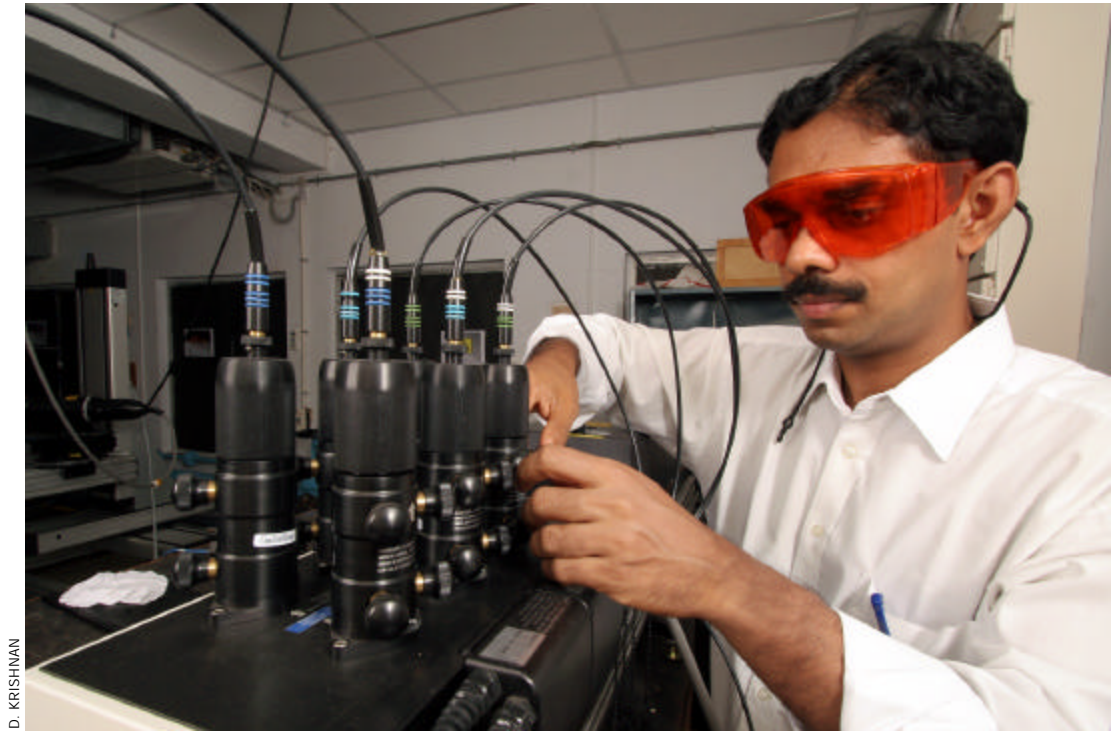
The symbiotic relationship between private corporations and research institutes is aptly reflected in what Paul Budnitz, president and founder of Kid Robot, once said: "I believe the future of business is collaborative technologies. Without it my kind of business would not be possible. For me it is not the future, it is the foundation of my success today."

The collaboration between the United States and the IITs goes back to 1958.

As an independent India struggled to rise out of poverty, its first Prime Minister, Jawaharlal Nehru, believed that only science and technology could provide the answers. He proposed that five IITs be set up by 1965, in Delhi, Kanpur, Kharagpur, Bombay and Madras. He also stressed close cooperation with technologically advanced nations. Each of the institutes was to receive assistance from a particular country.

Nehru's minister for science and technology, Humayun Kabir, persuaded the American Society of Engineering Education to prepare a report about launching an "MIT-style" institute in Kanpur. Subsequently, three American professors studied how Massachusetts Institute of Technology could help train the faculty. They recommended that a group of nine institutes (see box at right) help the Kanpur center, which began in 1959 with 100 students and some 20 teachers in a borrowed building of the Harcourt Butler Technological Institute.

Simultaneously, the state government of Uttar Pradesh granted about 400 hectares, 15 kilometers west of Kanpur, on the Grand Trunk Road. Architect Achyut Kanvinde mirrored the environmental freedom of the countryside in his design, a core of academic buildings sur-



D. KRISHNAN

rounded by community centers and housing for staff and students. Meanwhile, in New Delhi, the Indian government and IIT-Kanpur worked closely with the U.S. Agency for International Development, or USAID, and the consortium of nine universities, under the umbrella of the Kanpur Indo-American Program. The program provided for Indian engineers to undergo training in the United States, exchange of technological information and collaboration in research. Many Indian engineers spent a year or more in American universities and colleges, where some earned advanced degrees.

The Ford Foundation gave \$20,000 to

R.I. Sujith of IIT-Madras in the aerospace research lab.

relocate 11 Indian experts from the United States to serve as faculty. Over the next few years, 98 Indian experts relocated to Kanpur, promising to remain for at least two years to build a premier institution. One of these, Dr. P.K. Kelkar, recalled, "When I came to Kanpur first to join as the director of the institute, almost everybody I met asked me...if I had wanted to commit professional suicide. I did not at all worry about this because I was no longer myself but an instrument of a historical process."

Under the Kanpur program, the institute received \$7.5 million worth of equipment and 40,000 books, including difficult-to-obtain special reports by NASA and Bell Telephone Laboratories.

Today, researchers at all seven IITs—two were added recently at Roorkee and Guwahati—collaborate with American researchers, institutions and companies.

Such collaborations are formal through memoranda of understanding or are one-to-one interactions between two research groups with common interests. Most of these research projects result in joint pub-

The First Collaborators
The consortium that aided IIT-Kanpur:

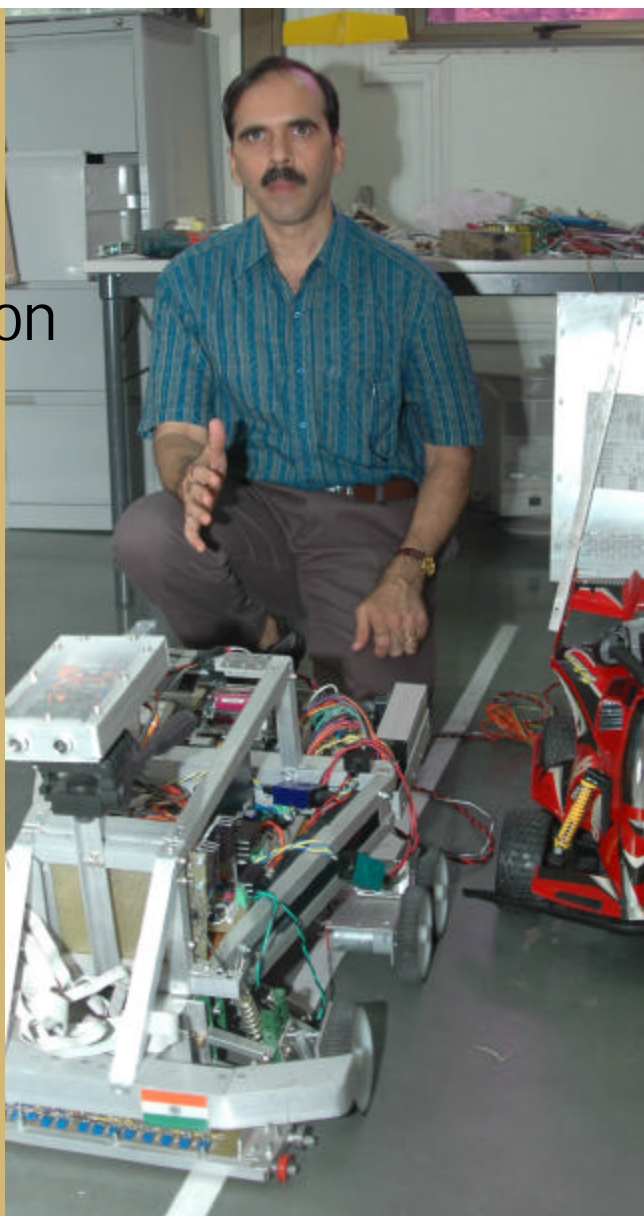
- California Institute of Technology
- Carnegie Institute of Technology
- Case Institute of Technology
- Massachusetts Institute of Technology
- Ohio State University
- Princeton University
- Purdue University
- University of California at Berkeley
- University of Michigan

Infotech Collaboration

Krithi Ramamritham of IIT-Bombay has worked with a scientist from the University of Massachusetts at Amherst to develop technologies that allow computers to automatically send updated information to client computers, which can ask for needed data without human intervention, such as in buying and selling. He has also worked with the University of California at Riverside on better, faster and more intelligent ways to disseminate data on the Internet and has been collaborating since 1999 with Chutney Technologies, recently acquired by Cisco, on developing better ways to create Web pages.

Carnegie Mellon University, IITs and the four Indian Institutes of Management signed an agreement five years ago to establish a center to develop courseware, a doctoral program and eventually a virtual university. That formed the basis for the National Program on Technology-Enhanced Learning to be funded by the Ministry of Human Resource Development. Carnegie and IIT-Madras jointly study the development of highly interactive online learning material in basic sciences.

Kanpur IIT's Debabrata Goswami collaborates with scientists at Princeton University and MIT on quantum computing,



SANTOSH VERMA

a computer technology based on the behavior of energy and matter at the atomic and subatomic level. Goswami and IIT-Kanpur Director Sanjay Dhande work with Fabrication Laboratories, or Fab Labs, designing equipment that with the push of a button can create gadgets, once the design has been selected and the raw material provided. Two of the seven

Above: Krithi Ramamritham collaborated on robotics at the University of Massachusetts and is core supervisor of a lab doing similar research at IIT-Bombay, where he also works on Web technologies with Soumen Chakrabarty (below).

Fab Labs that MIT has set up around the world are in India, at Bithoor in Uttar Pradesh and Pabal in Maharashtra.

Bombay IIT's Soumen Chakrabarty works with the University of California Riverside School of Library Sciences on a method to trawl the Web for information that academics can use. "Think of it as my desktop research librarian who can...keep track of what new material is coming up on a topic of my interest automatically," he explains. □

lications in peer-reviewed scientific journals, which may be of little interest to non-scientists, but are quite crucial. Faculty and student exchanges and specialized courses are also crucial parts of the interactions.

"More faculty now have come back from the United States," says Krithi Ramamritham, head of Kanwal Rekhi School of Information Technology at IIT-Bombay, "and that, in turn, leads to more American collaboration. Now the collaborative work is more for technical reasons than financial reasons." The collaborative research at IITs across the country ranges from crop manipulation to designing aircraft materials.

One project, funded by USAID is aimed at improving public transit service in New Delhi. The Institute for Transportation and Development Policy, a non-profit body based in New York, works with Delhi IIT's Transportation Research and Injury Prevention Program on a project called the India Livable Communities Initiative. The team has been instrumental in designing new urban bus standards. Also, the Delhi government has approved construction of a 16-kilometer special corridor from Ambedkar Nagar to Delhi Gate, as recommended by the team. "IIT-Delhi was working on this since 1995," says IIT's Geetam Tewari, who was involved in the project. "But USAID money helped us expand the understanding of the concept and interact with international experts."

Some of the projects sound like they are straight from science fiction. Can engineers build a military aircraft that can change its shape depending on the mission? M.S. Sivakumar from Madras IIT's Smart Structures Lab has been collaborating with researchers at Texas A&M University in testing materials in computer simulations, or virtual testing. "You can also create new materials virtually which have specific properties," he says. Some of their work, funded by the U.S. Army Research Office,



SANTOSH VERMA

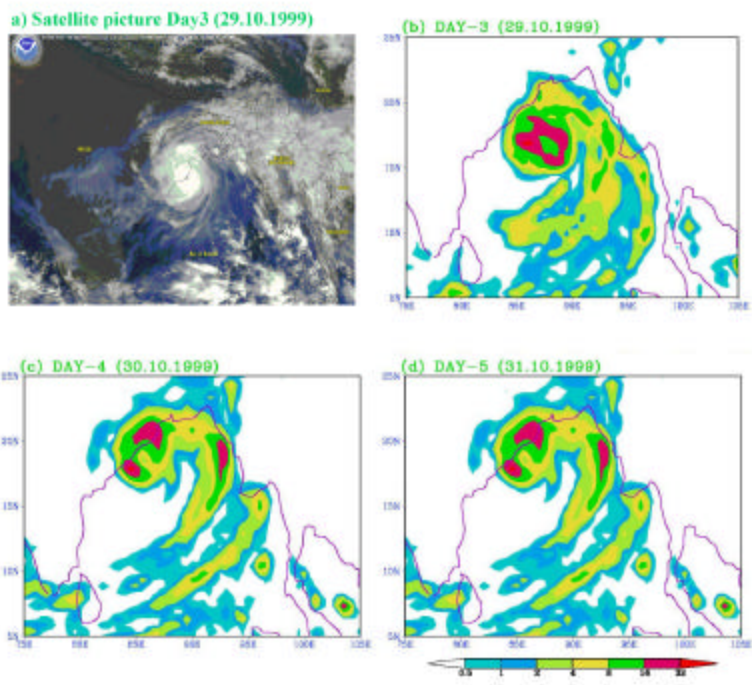
Collaboration in Earth Studies

The U.S. Office of Naval Research is funding an eight-year-old study on air-sea interaction processes over Indian seas during the southwest and northeast monsoons. The study by IIT-Delhi and North Carolina State University, which ends this year, simulates tropical cyclones, such as the 1999 Orissa supercyclone, and studies data from three major ocean- and monsoon-related experiments of the past. IIT's U.C. Mohanty says the scope of strong collaboration in atmospheric sciences between the two countries stems from the facts that both face tropical cyclones and monsoons affect global climatic changes.

The National Aeronautics and Space Administration (NASA) signed an agreement with IIT-Kanpur in 2001 on an aerosol monitoring network. Engineers installed equipment in the central Ganges Valley that provides information about aerosol and water vapor over Kanpur and surrounding areas, says principal investigator Ramesh P. Singh. The project also helps validate the data from instruments flown on NASA's Terra spacecraft.

IIT-Kanpur has been collaborating for nearly 15 years with the Earthquake Engineering Research Institute in Oakland, California, to document major quakes in India. The California center gives financial and technical support to conduct field investigations and publishes reports about them. "The 2001 Bhuj earthquake investigations led to a 400-page document describing the genesis and effects of the earthquake," says IIT's C.V.R. Murty. The California institute gives grants to developing countries to support local efforts, build capacity and develop leadership to mitigate the effects of quakes. The National Institute of Technology in Jalandhar, Punjab, has one such grant. □

Courtesy IIT-Delhi



A satellite picture of the 1999 Orissa supercyclone (figure a), followed by IIT-Delhi computer models showing simulations of rainfall on October 29, 30 and 31, the period when the cyclone struck the coast. The models fairly accurately simulated cloud clusters and predicted rainfall associated with a tropical cyclone, says IIT-Delhi's U.C. Mohanty, who works with North Carolina State University scientists.

involves studying materials that change shape depending on environmental conditions. Other applications are more down to earth: they involve alloys that dentists use to correct teeth and materials cardiologists use to design better stents to remove blocks in arteries.

Scientists at IIT-Madras are engaged in basic research to see why some materials undergo extreme expansion or deformation when exposed to heat. The 10-year project is funded by the U.S. Naval Research Laboratory in Washington, D.C.

Researchers such as Krishnan Balasubramanian of IIT-Madras have been helping the U.S. Air Force Research Laboratory in Dayton, Ohio, spot critical flaws in aircraft—say corrosion around the rivets of an aircraft wing—without destroying or breaking the material. The Madras researchers "have been great partners thus far in computational methods," says the lab's 1st Lt. Gary J. Steffes.

For the past two years, IIT-Roorkee has been working with five American universities in understanding reproductive

development in plants, which may allow better manipulation of crops. The study is sponsored by the U.S. National Science Foundation's Plant Genome Research Project. IIT-Roorkee also signed an agreement with the University of Dallas, Texas, for academic exchange and joint research.

Such partnerships particularly give IIT researchers access to equipment that they do not have because of lack of funds, says S. Narayanan, dean of academic research at IIT-Madras. "The research programs are enhanced by such joint efforts and there is also a cultural mix," he says.

Most collaborations between American research institutes and the IITs have been the result of individual contacts. But Director Ashok Misra of IIT-Bombay is aiming for more group-to-group collaborations. "I am also very emphatic on a back-and-forth relationship where U.S. postdocs come and spend time at our institutes," Misra says. "This has started but we want it in a big way." □

S. Narayanan, dean of academic research at IIT-Madras.



Technology Without Borders

By ASHISH KUMAR SEN

The 40,000 IIT graduates in the U.S. have helped change perceptions of India as geo-economics changes our lives.

One of the goals of the alumni of the Indian Institutes of Technology is to turn their alma mater into a household name in the United States, like Harvard, MIT and Stanford.

That effort received a fillip recently when Representative Tom Davis, a Republican from Virginia, introduced legislation in the U.S. Congress to recognize the contributions of Indian Americans to American society, including the economic innovations attributable to IIT graduates.

On May 20, hundreds of IIT graduates occupied members' seats in the House of Representatives to listen to a handful of congressmen speak about U.S.-India technological cooperation. Davis, surveying the IITians, joked, "It is unlikely we have ever had this much brainpower in Congress before."

Some 40,000 IIT graduates live and work in the United States today, many of them in top positions in industry and academia. "IIT alums help to promote U.S. investments in India" and Indian business in the United States, said Indian

Ambassador Ronen Sen during the IIT 2005 Global Conference: Technology Without Borders, a three-day conference held in May in Bethesda, Maryland, and Washington, D.C.

Last year, American companies outsourced \$12 billion worth of computer programming jobs, call center work and other business process operations to India. Indian companies are becoming globalized in three areas—manufacturing, services and banking.

Geo-economics and technology are making the world flat, theorizes *New York Times* columnist Thomas Friedman. "There is no such thing as an American job," he told the conference. In the next decade, some 3.4 million American jobs could move overseas, according to Forrester Research, a technology research firm in Cambridge, Massachusetts.

These developments go hand in hand with the rise of India and China, both of them hungry for new technology. Tapping the leadership qualities of the IIT alumni, Sen said, could "further strengthen the growing partnership between the world's most powerful and technologically advanced democracy and the world's largest and fastest growing democracy."

Cooperation between India and the United States in the fields of information technology, defense and biotechnology is



(From left) Former Indian Minister Arun Shourie and former General Electric Co. Chairman Jack Welch with the co-chairmen of the Washington, D.C. IIT global conference, Rajat Gupta, a senior partner with McKinsey & Co., and Sudhakar Shenoy, chairman of Information Management Consultants.



likely to step up following the visit by Prime Minister Manmohan Singh to Washington in July. President George W. Bush is planning to reciprocate the visit.

“Bush’s visit will be a remarkable celebration, similar to [Richard] Nixon visiting China,” said Ron Somers, president of the U.S.-India Business Council. Sen echoed this, saying that Bush views India not just in the narrow perspective of a sub-regional context but as an emerging global power.

“In this new economy, the role for IITs will be far greater,” said Harvard University President Lawrence Summers.

Like his counterparts in other Ivy League universities of the northeastern United States, Summers worried about the restrictions on U.S. visas for foreign students. “We should do everything we can to open our universities to more students from the developing world...If they stay in the U.S., they will make a wonderful contribution to our country; if they return, it will build goodwill among nations.”

Arun Shourie, former minister for communications, information technology and disinvestment, said he regrets that 100,000 professionals emigrate from

Arun Shourie, former minister for communications, information technology and disinvestment, addressing the IIT 2005 Global Conference: Technology Without Borders in Washington, D.C. in May.

India each year. On the other hand, they “have changed the world’s perception of India,” he said.

The number of applications to U.S. universities from graduate students from Asia has dropped and universities in other countries have taken advantage of these restrictions to lure students.

At the same time, U.S. businesses and educational institutions have signed agreements with some of the seven IITs to promote research and exchange of faculty and students.

A high priority for both educators and the alumni is strengthening India’s graduate education program, considered the backbone of the country’s future. Professor Ashok Misra, director of IIT-Bombay, said, “Students must be aware of knowledge in other parts of the world and teaching standards have to be at par. That is a big challenge.”

China produces 2,000 doctorates in computer science every year, the United

States some 900. India churns out barely 50 in this field. To move the IITs toward becoming better known as research centers, President A.P.J. Abdul Kalam commissioned a study by Professor P. Rama Rao. He said IITs will have to focus on four challenges: become a world-class teaching and research institution, attract a broader student population, preserve the best values of the IIT system, and drive the Indian economy.

Equally important is the role IITians can play in making borderless technology change the lives of all Indians. Ashok Jhunjhunwala, of IIT-Madras, said the world will not be a level playing field until the people in rural India benefit from and participate in the new advancements. “The Internet can empower rural India, the key is how soon can we reach 600,000 villages.”

One technological revolution—the explosion in the availability of telephone connections from 2 million in 1981 to 100 million today—has already shown what can be done.

Business leaders at the IIT conference said that India must develop special economic regions, and work on its labor regulations if it hopes to take the next leap forward. It must also make investors feel welcome; it has just given the green light to attract more foreign investment.

K.V. Kamath, chairman of ICICI Bank, praised the positive changes. “We’ve built the foundation for opportunities,” he said. “Now we will build the superstructure.” □

About the Author: *Ashish Kumar Sen is a Washington-based journalist working with The Washington Times. He also contributes to The Tribune and Outlook.*