INDUSTRIAL LIAISON PROGRAM℠
MIT technology insider
FROM THE EDITORS OF TECHNOLOGY REVIEW

CONTENTS | 6.04

KEY

	FUNDING
$	UNDER $2 MILLION
$$	$2 MIL.-$10 MIL.
$$$	$10 MILLION PLUS
	PATENT STRENGTH
🗋	NO CORE PATENTS
🗋🗋	CORE PROTECTION
🗋🗋🗋	DOMINANT POSITION
	TIME TO MARKET
🕒	LESS THAN 1 YEAR
🕒🕒	1-3 YEARS
🕒🕒🕒	MORE THAN 3 YEARS

AN MIT ENTERPRISE TECHNOLOGY REVIEW

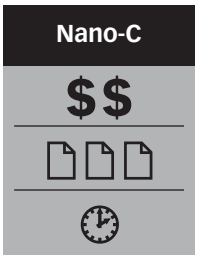
SPINOFF SPOTLIGHT

Buckyball in the Rough

NANO-C HOPES TO BRING DOWN THE COST AND INCREASE THE VOLUME OF BUCKMINSTERFULLERENE PRODUCTION—AND TO JUMP-START ITS MARKET

When a new form of pure carbon was discovered in 1985, it generated worldwide excitement. The material, the third known form of pure carbon—after diamond and graphite—was dubbed buckminsterfullerene, because its molecular structure resembles the geodesic domes of futurist and architect Buckminster Fuller.

The electrical, chemical, and mechanical properties of the stuff, often called buckyballs or fullerenes, led many scientists to imagine all sorts of uses: as semiconductor materials, in biomedical applications, and for building structures stronger than steel at a fraction of steel's weight. None of those applications has come to fruition yet because, at least in part, it is difficult to manufacture fullerenes cheaply enough and in large enough quantities to be commercially attractive.



A company founded by a retired MIT professor of chemical engineering aims to change buckyball economics. Nano-C, in Westwood, MA, is based on techniques Professor Jack Howard and his colleagues started developing in 1991. Since its founding in 2001, the company has been refining and improving the production process.

The company licensed an earlier version of its production method to Mitsubishi Corp., which along with Mitsubishi Chemical founded Frontier Carbon in Tokyo. Frontier has built a plant that, using the MIT/Nano-C technology, should be able to produce 40 metric tons of fullerenes a year. Frontier has recently begun paying royalties to Nano-C. "That's big news to a startup," says Gordon Fowler, Nano-C's CEO.

The original method for making fullerenes, known as carbon arc synthesis, is still widely used for making small quantities of the material for laboratory use. In this approach, two rods of graphite are placed in an inert gas, and an electrical current run between them vaporizes them. The process produces small amounts of fullerenes, as well as soot, which has to be washed away with a solvent.

Howard opted instead to make fullerenes via combustion, in which a carbon-containing gas is fed to a flame at low pressure to produce carbon black (a mix of carbon and other products used in inks and tires). It turns out that combustion yields more fullerenes than the arc method, but it also produces a fair amount of soot. "It's a pretty messy goo from which the fullerenes have to be removed," Howard says. And it costs almost as much to remove them as it does to run the combustion process in the first place.

Nor does the method scale up that well: as the flame gets larger and the gas flow increases, combustion conditions become more complex. So Howard, now chairman of Nano-C, went to work on refining the process. In the original laboratory method—deliberately simple for research purposes—gas flowed in only one direction. The second-generation method has multiple gas flows. And by fine-tuning a complex set of parameters—temperature, pressure, type of fuel, ratio of fuel to oxygen, velocity of the gases being fed to the flame—Howard developed a system that produces very little soot. And more than 90 percent of the output is in the form of fullerenes. Not only is that a higher rate of fullerene production, but it also eliminates the costly cleaning step.

With further fine-tuning, Howard believes, he should be able to reach an output of 98 to 99 percent fullerenes. Fowler hopes to bring the price of fullerenes, now $5,000 per kilogram, down to about $200.

If his company succeeds in making the material plentiful and affordable, Fowler says, the way will be opened for a broad range of uses in elec-

CONTINUED ON PAGE 2

AT A GLANCE

NAME
Nano-C

PRESIDENT
Gordon Fowler

CONTACT
www.nano-c.com
tel 781-407-9417

PRODUCTS
> Carbon fullerenes for use in solar cells and antioxidants

tronics, semiconductors, and pharmaceuticals—uses that have already been dreamed up but never put into production because fullerenes were so expensive. "There were literally hundreds and hundreds of applications patented in the '90s," he says. "But there was no evidence the material was going to become commercially viable. So people who were working on this moved on to other things."

Because it is a small company—11 employees—with only a couple million dollars of investment funding, Nano-C is trying to develop strategically. It produces some fullerenes, but it doesn't plan to start cranking out material, simply hoping a market develops. The company is talking with various organizations to form partnership arrangements. And it is "functionalizing" the fullerenes it does make, adding other chemicals to make them useful for particular applications. For instance, Nano-C is making PCBM, a compound that can in turn be used to make polymer-based solar cells. The fullerene makes the material a strong absorber of ultraviolet light, and its structure lets it accept electrons very easily, making for a very efficient electrical circuit. Because polymer-based solar cells can be created through a printing process, they are potentially less expensive than silicon cells.

The shape of the molecule lets it grab electrons easily, so the material is also good at attracting so-called free radicals, which have extra electrons. In the body, free radicals are believed to cause cell damage. Merck Pharmaceuticals, for instance, is looking into using fullerenes in the treatment of neurological disorders such as Parkinson's and Alzheimer's. Nano-C is in discussions with companies to provide fullerenes for nonpharmaceutical applications—skin creams to treat burns or combat aging, for example—that might benefit from this ability to act as a "radical sponge."

Girish Solanki, a chemical-industry analyst with market research firm Frost and Sullivan, says there's tremendous interest in fullerenes, but there is more research in electronics and materials applications than in pharmaceuticals. Companies such as IBM, DuPont, and Dow Chemical are all doing fullerene research, he says, adding that "fundamentally, there's still a lot of knowledge that needs to be explored in terms of fullerene physics and chemistry."

Solanki says fullerenes don't appear to be a disruptive technology or likely to open up new application areas. Still, they could improve such existing applications as semiconductors for faster computer chips and electronic circuits. He predicts the first large-scale commercialization of fullerenes in semiconductor or polymer applications in 5 to 10 years. A "Nanotech Alert" from Frost and Sullivan in January called Nano-C a "company to watch," saying its process could tilt the playing field by changing the pricing of fullerenes.

CEO Fowler, meanwhile, says Nano-C has enough potential applications in its pocket to approach venture capitalists for a first round of funding, which he hopes to complete by the fall and which he thinks should carry the company to positive cash flow. The company also just licensed another MIT patent for fullerenic black, a compound that is similar to carbon black and has some of the appealing chemical and electrical properties of fullerenes. Fullerenic black might lead to better versions of existing materials, promoting, for instance, better tires. It's also "on the company's agenda" to build carbon nanotubes for high-strength materials, says chairman Howard.

Fowler expects to have some partnership deals worked out within a month or two. "I can't wait to make the announcement about the first customer," he says.

MIT technology insider
FROM THE EDITORS OF TECHNOLOGY REVIEW

PUBLISHER & CEO
R. Bruce Journey

V.P. GENERAL MANAGER
Martha Connors

MANAGING EDITOR
Herb Brody

CONTRIBUTORS
Alyssa Danigelis, Neil Savage, Lisa Scanlon, Tracy Staedter

COPY EDITOR
Elyse Friedman

GRAPHIC DESIGNER
John Sheppard

EDITORIAL INDEPENDENCE
Technology Review, Inc. is a wholly owned and separately incorporated subsidiary of MIT that is editorially independent from the university and its administration, faculty, and community. All content of the *MIT Technology Insider* is the sole responsibility of the editors. Sponsors have no influence over editorial content, and no employee or contractor is permitted to have any financial positions in companies covered.

MIT Technology Insider
Technology Review, Inc.
One Main Street, 7th Floor, Cambridge, MA 02142
tel 617-475-8000 fax 617-475-8043
www.technologyinsider.com

NEWS LINKS

- Tim Berners-Lee Wins $1.2 Million Award

  web.mit.edu/newsoffice/2004/berners-0428.html

- Sloan Students Create Interactive Exercise Game

  web.mit.edu/newsoffice/2004/cyclescore-0505.html

- Stata Center Opens

  web.mit.edu/newsoffice/2004/stata-main-0512.html

MULTIMEDIA LINKS

- Whitehead Director Susan Lindquist on Proteins Behaving Badly

  mitworld.mit.edu/video/198/

- Cofounder F. Thomson Leighton on the Akamai Story

  mitworld.mit.edu/video/199/

Life Recorder

Ever wish you could remember an interesting fact you'd heard a few months earlier but can't quite call the conversation to mind? A program developed by Sunil Vemuri, a doctoral candidate at MIT's Media Lab, could help jog your memory. First, you use a PDA to record your conversations throughout the day. Then you transfer the data to a laptop computer, where off-the-shelf speech-recognition software translates the audio files into text. Later, when you want to find a specific conversation, you simply enter keywords into a search engine, which retrieves audio files that match your search criteria.

To make the process more efficient, Vemuri has text from news articles automatically added to the database. Say you want to retrieve a conversation you had around the time of the New Hampshire primaries. You might search the news to generate a timeline that shows when the primaries were most often in the news and use those dates to narrow your search. Since speech recognition software can still be irritatingly inaccurate, when conversations are displayed, the system displays the words that it is most confident are correct in boldface; this makes it easier for the reader to ignore the parts of the transcript that are probably nonsense.

Vemuri thinks that these technical stumbling blocks will likely be overcome in a few years but that the real obstacles to commercialization are social and legal, not technical. He's currently working on a version that will allow users to record, store, and search for conversations all on one PDA.

Center Sets Sights on Healthy Oceans

MIT, the Woods Hole Oceanographic Institution, and the Marine Biological Laboratory have formed a new research center to study oceanic environmental deterioration and its consequences for human health. The center, called the Woods Hole Center for Oceans and Human Health, was created through a joint initiative of the National Science Foundation and the National Institutes of Health.

Through the center, an interdisciplinary group of scientists will work on simultaneous projects, such as analyzing toxic algal blooms and sewage outfalls in North American coastal areas. Martin Polz, assistant professor of civil and environmental engineering, is coordinating MIT's contributions to the center. Polz's project will analyze the genetic code of waterborne pathogens in order to better understand the conditions that allow such organisms to flourish. He will be casting a wide net, looking at the genetic codes of both non-harmful variants and harmful variants to determine which genes are unique to the harmful versions. Every year, these pathogens put swimmers, fish handlers, and seafood consumers at risk for infections, such as dysentery, and even death. "One of the long-term goals is to really be able to forecast danger in a more accurate way, so we can warn people," Polz says. The center, located in Woods Hole, MA, is one of four nationwide that will receive $6.25 million over a period of five years.

A New Direction for Speech Recognition

Over the past 15 years, MIT's Spoken Language Group has honed the skills of Voyager—a conversational computer system that can provide its users with Boston-area traffic information, directions, and information about landmarks. Now, a team led by principal research scientist Jim Glass has enhanced Voyager's abilities by coupling it with a pen-based tablet PC that allows people to interact using both speech and gestures.

For example, a tourist can tell the computer to call up a map of Boston. Circling the Museum of Fine Arts, she might ask, "How do I get there from the Cambridge Marriott?" The system parses the sentence into its grammatical components to determine what the user wants. Deducing that the circled area is the MFA, the system responds with spoken directions or a route highlighted on the map. The researchers are currently expanding the number of gestures the system can recognize.

Promising New Target for Diabetes

A study that builds on previous research could lead to a new treatment for type 2 diabetes, which affects more than 120 million people worldwide. Broad Institute researcher Vamsi Mootha and his team have identified three proteins that work together to boost the number of mitochondria in cells. (Mitochondria are the tiny structures that metabolize fat, carbohydrates, and protein to produce the body's biochemical "fuel.") In an earlier study, Mootha and his team found that mitochondrial activity is reduced in the muscles of diabetics. Mootha's latest work shows that three proteins appear to form the switch that turns on the production of mitochondria. "Now we have to come up with a way to activate that switch," says Mootha. He envisions a drug made from a compound designed to activate the proteins. Taken orally, such a drug would ameliorate the symptoms of diabetes and perhaps even reduce the need for insulin.

Flexing Muscles and Minds

MIT'S BIOINSTRUMENTATION LABORATORY MIXES DISCIPLINES TO CREATE ARRAYS OF TECHNOLOGY EXTENDING FROM DNA SEQUENCERS TO ARTIFICIAL MUSCLES

AT A GLANCE

NAME
BioInstrumentation Laboratory

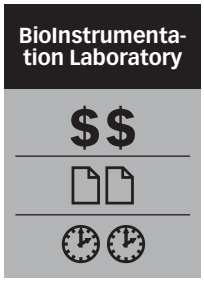
DIRECTOR
Ian W. Hunter

CONTACT
bioinstrumentation.mit.edu

MAJOR PROJECTS
> Conductive polymers
> Micro and nano instrumentation
> Needle-free injection
> Massively parallel DNA sequencer

The device in Ian Hunter's hand looks a lot like an electric toothbrush without bristles. It's a prototype of a needle-free drug injector. Norwood Abbey, an Australian medical-devices company, is working to develop this invention into a practical tool for delivering drugs.

The device uses a small fiber of conductive polymer that contracts very rapidly when a voltage is applied. The fiber exerts pressure on a small quantity of the drug, forcing it out at such a high speed that it shoots through the skin. Prior to injection, a miniature probe in the tip rapidly pokes the skin to determine how stiff it is—whether it's soft as a baby's bottom or tough as a construction worker's sunburned forearm—and adjusts the pressure accordingly.



This drug delivery system, which may be ready to sell within a couple of years, is just one of a number of inventions coming out of Hunter's BioInstrumentation Laboratory. In addition to the work with the conductive polymers, the lab focuses also on development of biomedical instruments based on microtechnology and nanotechnology. Hunter, Hatsopoulos Professor of Mechanical Engineering and a professor of biological engineering, says these conductive polymers are "bizarre" materials with "amazing properties."

The conductive polymers, Hunter hopes, will be used to build artificial muscles. Their earliest use would be as actuators that perform simple tasks, like moving a car's rear view mirror. Eventually, however, he hopes artificial muscles will enable a damaged heart to continue pumping, provide movement to prosthetic limbs, enhance soldiers' physical strength, and even lead to artificial exoskeletons for elderly and disabled persons.

"The dream is that you would put on something that looks like a scuba suit and it could mechanically assist you," says Timothy Swager, a professor of chemistry who creates the molecular designs for the conductive polymer. In addition to working in their own labs, both Hunter and Swager are at the MIT Institute for Soldier Nanotechnologies, where they are working to enhance human capabilities.

The BioInstrumentation Laboratory has spun off two companies—still mostly on paper—to commercialize the conductive polymers once they reach a more practical stage. One, Universal Muscle, was a semifinalist in this year's MIT $50K entrepreneurship competition.

Another, more mature spinoff, BioTrove, was founded by Hunter in 1997 to commercialize his Living Chip, a half-dollar-size chip that can be used for testing up to one million chemical reactions simultaneously. To test the reaction of samples of cells and proteins to various chemicals, researchers have been using a plate—slightly bigger than a cassette tape—with 96 wells into which the samples are placed. The Living Chip contains 10,000 wells.

Invention of the chip, in itself an important step, was only a beginning. Hunter's lab had to create new instruments that could put the drugs and the cells into these tiny wells, as well as optical instruments that could capture and measure the fluorescent reactions that tell researchers what's happening in the wells. "It wouldn't have been good enough for us to do this and say, 'Come and get it, guys.' No one would have been able to use the chip," Hunter says.

To create a whole array of instruments, the lab includes a setup that seems like a microcosm of MIT. The lab's suite on the first floor of Building 3 includes a small clean room, a chemistry lab, a biology lab, optical tables, tools for machining parts, and computers for performing mathematical modeling.

This arrangement not only allows students to characterize and test the conductive polymers but also lets them build new devices, such as a massively parallel machine that can sequence 10,000 fragments of DNA and measure individual mutations. Taking huge numbers of measurements should help researchers seeking the genetic bases of cancer and heart disease. Hunter is the only faculty member in the laboratory, but he works with people in other departments. On average, he supervises about 30 students, from undergraduates to postdocs. The lab has had about 10 patents issued in the last two years.

Woody Woodworth, managing director at Echelon Ventures, says that the BioInstrumentation Laboratory is an excellent source of innovations because Hunter insists that his students cross scientific disciplines. Echelon is one of BioTrove's investors, and Woodworth says he's keeping an eye on the lab to see what else Hunter comes up with. According to Woodworth, Hunter "has created an environment where they can figure out things and get the leapfrog insights that the corporations are never going to figure out for themselves."

DATEBOOK

June 18
MIT Center for Cancer Research Symposium

The Small-RNA Revolution: Biology, Technology, and Disease

Kresge Auditorium, MIT

web.mit.edu/ccr/symposium.html

July 7
Startup Clinic

MIT Faculty Club

events.mit.edu/scripts/event.pl?61141

September 29–30
Emerging Technologies Conference at MIT

Kresge Auditorium, MIT

www.tretc.com

Protein Power

A company that uses microarrays to study the effects of drugs on an entire network of proteins all at once has closed a round of preferred-stock financing. Merrimack Pharmaceuticals, in Cambridge, MA, raised $28 million in the Series C round, led by Sorenson Development. Other new investors are Unilever Technology Ventures Fund BV and GTC Biotherapeutics. Previous investors Wharton Biotechnology Partners II and MS Seed Capital also joined. To date, the company has raised $50 million.

Merrimack says its technology is better than traditional approaches to drug discovery because older methods, which can examine only one protein at a time, can miss what happens when proteins interact. The company was founded in 2000 by four MIT biology professors—Michael Cardone, Anthony Sinskey, Peter Sorger, and Michael Yaffe—along with Ulrik Nielsen, a postdoctoral fellow in MIT's biology department, and Gavin MacBeath of Harvard. The board of directors includes Robert Rubin, director of the Harvard-MIT Division of Health Sciences' Technology Center for Experimental Pharmacology and Therapeutics. MIT professors Klavs Jensen, Douglas Lauffenburger, and Luk Van Parijs serve on Merrimack's scientific advisory board.

www.merrimackpharma.com

Shot in the Arm

A new MIT spinoff has licensed an MIT patent for a new way to inject vaccines. The patent, "Delivery of Cutaneous Vaccines," has been licensed to Carlisle Scientific. The company's key technology, called microscission, creates tiny openings in the skin that allow for the painless delivery of drugs and vaccines. The technology uses compressed nitrogen to shoot microscopic particles of an inert material against the surface of the skin, opening tiny holes that are 100 to 1,000 micrometers in diameter and about 180 micrometers deep. A demonstration using lidocaine achieved full local anesthesia within three minutes.

The microscission technology was developed by Terry O. Herndon, a research affiliate at MIT Lincoln Laboratory, and James C. Weaver, associate director of the Biomedical Engineering Center at the Harvard-MIT Division of Health Sciences and Technology; they collaborated with R. Rox Anderson and Salvador Gonzales at Massachusetts General Hospital. Carlisle Scientific was established in January in Carlisle, MA, with Herndon as president.

www.carlislescientific.com

Net Gain

Millennial Net has closed a $15 million Series B funding round, bringing its total funding to $21 million. The latest round of financing was led by new investor BCE Capital, which was joined by previous investors General Catalyst Partners, Globespan Capital Partners, and Kodiak Venture Partners.

Located in Cambridge, MA, Millennial Net makes i-Beans—postage-stamp-size devices that, when attached to any kind of sensor, work with a series of routers to form a low-power, self-organizing wireless network. Transmitting information from scattered sensors to a central computer for real-time monitoring, the network allows users to collect all sorts of data, control building environments, and locate people and equipment.

Millennial Net was cofounded in 2000 by Sokwoo Rhee, who earned his doctorate at MIT and worked as a research associate in the Brit and Alex d'Arbeloff Laboratory for Information Systems and Technology. Rhee is now chief technology officer. The other cofounders were Sheng Liu, a research associate in MIT's mechanical engineering department who serves as the company's vice president for research, and Tod Riedel, vice president for business development and marketing.

www.millennial.net

Technologist Transfer

Sanjay Sarma, an associate professor of mechanical engineering and former director of MIT's Auto-ID Center, is joining OATSystems as its chief technology officer. The Auto-ID Center closed last October. It handed over its technology to EPCglobal, an international body charged with developing standards for radio frequency identification (RFID), a technology that allows companies to track components and assembled products from the factory floor to the point of sale. Companies such as Wal-Mart, Target, and Gillette, as well as the U.S. Department of Defense, are adopting the technology. Sarma cofounded the center in 1999 and helped create core components of the network RFID technology depends upon. The center was reconstituted as the Auto-ID Laboratory, and Sarma handed over the reins to Daniel Engels.

OATSystems makes the software that tracks RFID tags, the tiny radio transmitters implanted in products. Located in Watertown, MA, it was founded in 2001 by two MIT graduates: Prasad Putta, who graduated with a master's degree in mechanical engineering in 1998, and Sridhar Ramachandran, who received a master's in computer science in 2000.

www.oatsystems.com

Welcome to the Face-to-Face Economy

FORGOTTEN DURING THE DOT-COM FRENZY, SAY FRANK LEVY AND RICHARD MURNANE, WAS THAT INTERACTIONS BETWEEN PEOPLE CONTAIN SUBTLE ELEMENTS COMPUTERS CANNOT REPLICATE

> "The computerized workplace has increased the value of complex communication, which relies on human skills."

Remember Stuart? The office boy with spiked red hair who starred in Ameritrade commercials? Stuart who was going to obliterate large numbers of stockbrokers? Stuart has not been seen recently, and stockbrokers are still around. And some discount brokerages, including Charles Schwab, have added human financial advisors to their list of available services.

The failure of Stuart's ambitions points to a labor market paradox. The computerized workplace has increased the value of complex communication, which relies on human skills: careful listening, responding to emotional cues, and conveying not just information but particular interpretations of information.

During the bubble years, complex communication was an inconvenient nuisance. It was easier to assume that if you sent someone an electronic message, they would interpret it just as you had intended. That notion powered numerous business plans that claimed online information would eliminate the need for stockbrokers and thousands of other jobs requiring face-to-face interactions, as in management, sales, and teaching.

The assumption led to failure because it ignored a basic cognitive truth. All information is inherently ambiguous. What do you see when you look down from the observation deck of the Empire State Building? On the basis of visual information alone, you can't tell whether those are real cars and people or toy cars and 1/16th-inch people. Adults resolve this kind of ambiguity by imposing a context based on their knowledge of the world. We know that such teensy people don't exist. (Young children who lack this context want the toy cars.)

In the case of a potential investor, the critical element of context is whether to trust what the broker is saying. That's why good brokers work for years to establish a context of trust. As they say in the industry, "They don't care how much you know. They care how much you care."

As brokers will tell you, caring begins by discovering the real reasons an investor wants more money—perhaps to enrich the grandchildren's college fund, have more time to play golf, or simply to acquire the status that comes with wealth. The investor herself may be in the process of discovering which goals matter: they are not items she would check off on a Web-based questionnaire. Whenever possible, an effective broker complements his words with nonverbal communication. No surprise here. Psychologist Paul Ekman and others have told us that we observe a speaker's body language to ascertain what she really thinks. As one broker explained to us,

> People are looking for the intangibles. They want to know, "Can you be our trusted advisor?"...They watch for our eyes, our facial expressions, how we treat other people in the office.

And that said, this context-setting is ongoing:

> We end up being intimately knowledgeable with our clients' families, how they get along with their kids, with their spouse, with their grandkids....The client [is] looking for the human element—empathy, affinity, that kind of thing. But that only comes with face-to-face communication.

Other face-to-face occupations use complex communication for different ends. But each of these occupations relies on exchanging context-dependent information—verbal and nonverbal—most of which computers cannot process. And so it should not surprise us that in the last 15 years, management, sales, teaching, and other face-to-face occupations have all held steady or increased as a percentage of total adult employment.

These are the occupations computers were supposed to eliminate. But a moment's reflection suggests the opposite is true. Today's managers are asking two questions about every U.S. job: Can it be done at lower cost by a computer? Can it be done at lower cost offshore? Among jobs that can survive these tests, most require some face-to-face communication. For all his energetic trend spotting, this is one trend Stuart missed.

Frank Levy is Daniel Rose Professor of Urban Economics in MIT's Department of Urban Studies and Planning. **Richard J. Murnane** is Juliana W. and William Foss Thompson Professor of Education and Society in Harvard's Graduate School of Education. This article is based on their book *The New Division of Labor: How Computers Are Creating the Next Job Market*, published this month by Princeton University Press and the Russell Sage Foundation.

MIT $50K Entrepreneurship Competition Finalists and Winners 2004

The winner of the 15th installment of this annual student-run contest, which encourages teams of researchers and business majors to form new companies with market potential, develops technology to help the 10 million Americans with disabilities.

Company	Technology	Launch date (expected)	Contact	Patent(s)
GRAND-PRIZE WINNER ($30,000)				
Active Joint Brace	Affordable wearable exoskeleton that increases independence of people whose disabilities make it difficult to lift heavy objects	June 2004	Kailas Narendran, 617-216-7719 kailas@mit.edu John McBean jmcbean@mit.edu	Yes
RUNNERS-UP ($10,000 EACH)				
Hyperscore	Software and graphical interface that allow users to compose music by drawing lines of various colors and shapes	(Fall 2004)	Mary Farbood mary@media.mit.edu Kevin Jennings kevin.jennings@cs.tcd.ie Tod Machover tod@media.mit.edu	No
Liquid Piston	A novel combustion engine that provides twice the fuel efficiency of and produces significantly fewer emissions than conventional engines	(July 2004)	Alexander Shkolnik shkolnik@mit.edu	Pending
FINALISTS				
Active Spectrum	Digitally tunable radio-frequency technology that has a broad tuning range with excellent narrowband characteristics that make it useful for defense and mobile communications	(July 2004)	James White, 617-818-3332 jwhite@mit.edu Alex Slocum, 603-591-7505 slocum@mit.edu Othman Laraki, 650-814-9580 othman@sloan.mit.edu	Yes
Advanced Diamond Solutions	Diamond/copper composite used in semiconductor chips to absorb high temperatures that could damage the chips	September 2003	Barnas Monteith, 617-291-3497 monteith@advanceddiamond.com Mike Sung, 857-928-3928	Pending
LumArray	Fast and inexpensive nanolithography technology	August 2002	Rajesh Menon rmenon@mit.edu	Yes
MicroLaser	Microchip lasers for optical data communications that simultaneously emit 80 wavelengths of pulsed light and could replace as many as 160 components used in conventional optical communications	None	Felix Grawert felixg@mit.edu	Pending

INDUSTRIAL LIAISON PROGRAM℠ EDITION

CONTENTS

MIT CAMPUS
MIT Industrial Liaison Program
77 Massachusetts Avenue, E38-400
Cambridge, MA 02139-4307
Tel 617-253-2691,
Fax 617-258-0796
ilp-www.mit.edu

JAPAN
MIT Industrial Liaison Program
Sakurai Building, JF
5, Kojimachi 4-chrome
Chiyoda-ku, Tokyo 102-0083, Japan
Tel 011 81 3 3262-2240,
Fax 011 81 3 3239-4136
email: rumi@mit.edu

Beyond the Cube Farm

DESIGNING OFFICE SPACE TO REFLECT CORPORATE GOALS AND BOOST PERFORMANCE

BY MARK DWORTZAN

Ever find yourself driving along a suburban strip of concrete-and-glass shopping malls and neon-lit chain stores, and get the feeling that you could be anywhere in the country? You might experience a similar sensation if you toured the nation's corporate R&D offices: once you've seen one cube farm, you've seen them all. The reason this design is so popular may be that arrays of cubicles can be deployed at a relatively low price per square meter, require little planning, and easily accommodate the latest technology. But organizing office space this way can come with a hidden price. Cube farms rarely reflect a company's business strategy and culture, and sometimes can undermine its productivity.

"We've got a Model-T version of office space," says M. Diane Burton, assistant professor of management at the Sloan School of Management and affiliate of the School's Entrepreneurship Center and Institute for Work and the Employment Relationship. "Within an office, there is little differentiation, and it's hard to tell if some offices are for a computer company or pharmaceutical company." Burton observes that architects and designers rarely study organizational behavior or strategy, and that few managers are schooled in architectural design. By joining forces, she maintains, managers and architects can design a workspace that actually embodies the strategy and purpose of a business.

An interdisciplinary team of MIT researchers from the Sloan School of Management and the School of Architecture has been working since last spring to realize this vision in a project called workingSPACES. The team is developing a systematic understanding of the interrelationships among design, strategy, management, organizational systems, technology, culture, and business performance. Collaborating with architects, clients, and professional associations, team members are studying a set of exemplary cases and developing teaching materials for architects and managers. "We wish to establish a new platform of communication enabling architects, designers, and managers to see, use, and evaluate design as a management tool," says Burton.

DEFINING SPACE, WORK, CULTURE, AND STRATEGY

In a presentation on May 11 at the ILP Management Conference, Burton summarized the team's ideas on how office space might be designed to promote productive work and reflect a company's business strategy and culture. Towards that end, she defined space, work, culture, and strategy—four key elements that managers and architects must understand to arrive at a successful design.

First Burton defined space as an open or closed area to facilitate dedicated or shared activities by individuals or groups. For example, a lawyer's office favors individualized, dedicated work in a closed room, whereas a conference room promotes shared, group activities in an open area. Burton then described a typology of work environments developed by architect Frank Duffy, a visiting professor at MIT. Duffy's typology uses two dimensions—level of interaction and level of autonomy—to characterize four work environments: the "den" (for highly interactive, highly interdependent, process-based teams, such as finance teams), the "club" (for highly interactive, highly autonomous, knowledge-based teams, as in ad agencies or architectural firms), the "hive" (for minimally interactive, highly interdependent, process-based individuals, such as workers in a back office call center), and the "cell" (for minimally interactive, highly autonomous, knowledge-based individuals, such as lawyers, academics, or software engineers).

Burton stressed that many of today's workers occupy desks or cubicles from which it's hard to

CONTINUED ON ILP2

NEW AND NOTABLE

PROJECTS, LABS, AND CENTERS

CENTER FOR INFORMATION SECURITY AND PRIVACY (CISP) IN CSAIL
Ron Rivest, Srini Devadas, Frans Kaaschoek

CISP's mission is to conduct breakthrough, long-term research in information security and privacy. CISP's goal is to develop both the theoretical foundation for secure systems as well as to engineer practical systems.

http://csg.lcs.mit.edu/CISP/index.html

CONSUMER ELECTRONICS RESEARCH: CELAB IN THE MEDIA LAB
V. Michael Bove, Jr.

Research: innovative materials and design/fabrication methods for them; new power technologies; innovations in sensors, actuators, and displays; self-managing ecosystems of smart devices; and cooperative wireless communications.

http://cel.media.mit.edu/cel-brochure.pdf

http://cel.media.mit.edu/

SIGNAL TRANSFORMATION AND INFORMATION REPRESENTATION GROUP
Vivek Goyal

The mission of the STIR group is to perform basic and applied research in signal processing with an emphasis on representing information for accurate and efficient communication.

http://www.rle.mit.edu/stir/

INTERACTIVE EXPERIENCE GROUP
MIT Media Laboratory
Pattie Maes

The goal of the Interactive Experience research group is to radically rethink the human-machine interactive experience.

http://interact.media.mit.edu/index.html

(Beyond the Cube Farm, continued from ILP1)

see or run into colleagues—thus limiting innovation opportunities. "We can't justify the current allocation of physical space for the nature of the work done," she said. Reporting on research conducted by Professor Tom Allen of the Sloan School, she added, "The likelihood that two people will end up in a chance interaction falls dramatically with distance."

Burton next described five types of organizational cultures: the "star" culture, which emphasizes individual excellence and rewards it with larger offices and other perks; the "commitment" culture, which focuses on family, teamwork, loyalty, and equality; the "engineering" culture, which stresses project, product and team collaboration, and focus; the "bureaucracy" culture, which features formalized procedures, documentation, training, accountability, and hierarchy and allocates space based on merit; and the "autocracy" culture, in which the CEO exerts great influence over everything. "You can manifest culture physically," Burton said, "but beyond color and finish we rarely take advantage of it."

Finally, she identified four key business strategies that companies embrace to achieve a competitive advantage: cost, quality, customer service, and innovation. For example, to organize its space for innovation, BMW's Innovation Center built a glass enclosure that houses automotive prototypes within the building. As a result, both conceptual designers and engineers can view the prototypes-in-progress at all times. Emphasizing customer service, a Volkswagen auto dealership in Germany designed a factory like a theme park. It comes equipped with restaurants, lecture halls, concert space, and an assembly floor where, according to the architect, Gunter Henn, a frequent guest lecturer at MIT and affiliate of the workingSPACES project, customers "attend the creation of their very own vehicle."

PUTTING IT ALL TOGETHER

To optimally design workspace, Burton recommends that managers enlist the support of workplace design consultants, architects, and business consulting firms. "First you need to identify the strategy and culture of the organization, then communicate this in terms that architects and managers can discuss, and then determine the work that needs to be done," she says. "This becomes an iterative process of design and evaluation."

For instance, Gillette participated in this process when it sought to centralize R&D operations under one senior executive to fuel new products and innovation. The company worked with an architect to retrofit an acquired Duracell building on Route 128 outside of Boston. The resulting structure, now five years in operation, consists of offices and common space in its core with labs along the perimeter. Employees can thus easily move between the labs and offices, and brainstorm with coworkers along the way.

One key consideration in the design process is how to balance the efficiency and effectiveness of the workspace. Noting that increasing efficiency gets the most out of space, Burton points out that increasing effectiveness gets the most out of employees. "Today there's a premium on efficiency, not effectiveness," she says. "A manager may think about $20 per square foot, but neglect the cost of poorly designed space in low productivity and worker turnover."

Sometimes there's little choice in the matter. "Real estate developers build what they think is in demand, and the buyer has a limited range of options," notes Melissa Edmands (MArch '04), whose research during Burton's course "Designing and Leading the Entrepreneurial Organization" formed the basis of the workingSPACES project last spring. "Most companies that can build management goals into workplace design either own their buildings or are large enough to influence their building's design." For those firms that do have the clout to design their workspace, Burton recommends that senior executives or human resource managers see the process to completion, rather than relying solely on facilities and corporate real estate departments.

NEXT STEPS

Last year the workingSPACES team of Edmands, Burton, MIT School of Architecture professors Frank Duffy and Bill Porter, Sloan School professor Thomas Allen, and others began to evaluate the long-term viability of various workspace designs. With the support of the MIT Center for Real Estate and the MIT Entrepreneurship Center, workingSPACES delivered two short courses on the intersection of architecture and business strategy. The team now aims to continue their research, disseminate their findings, and develop future course offerings.

Much of the effort centers on bridging the gap between management and architecture. "The design problems exist inside organizations, and the answers exist in the deep recesses of architectural firms," says Edmands. "The idea of this project has been to develop ways to get managers and architects on the same page and to start a conversation."

More information on the workingSPACES project is available at www.workingspaces.org/.

NEW AND NOTABLE

PUBLICATIONS

IT GOVERNANCE: HOW TOP PERFORMERS MANAGE IT DECISION RIGHTS FOR SUPERIOR RESULTS
Peter Weill and Jeanne W. Ross
Harvard Business School Press, May 2004

http://harvardbusinessonline.hbsp.harvard.edu/b01/en/common/item_detail.jhtml?id=2535

"EXCHANGE RATE VOLATILITY AND THE CREDIT CHANNEL IN EMERGING MARKETS: A VERTICAL PERSPECTIVE"
Ricardo J. Caballero, Arvind Krishnamurthy
May 2004, working paper

http://web.mit.edu/caball/www/vertical-5-04.pdf

"TRANSPARENCY OF INFORMATION AND COORDINATION IN ECONOMIES WITH INVESTMENT COMPLEMENTARITIES"
George-Marios Angeletos and Alessandro Pavan
January 2004, forthcoming: *American Economic Review 94* (Papers and Proceedings)

http://econ-www.mit.edu/faculty/download_pdf.php?id=860

"FAST PORTSCAN DETECTION USING SEQUENTIAL HYPOTHESIS TESTING"
Jaeyeon Jung, Vern Paxson, Arthur W. Berger, Hari Balakrishnan
To appear in *IEEE Symposium on Security and Privacy*, May, 2004

http://nms.lcs.mit.edu/papers/portscan-oakland04.pdf

A Pipeline to MIT Expertise

MIT PROFESSIONAL EDUCATION PROGRAMS OFFICE PROVIDES ONE-STOP SHOP FOR LIFELONG LEARNING

BY MARK DWORTZAN

In today's rapidly shifting technological and business landscape, your college degrees can only take you so far. Keeping pace with the latest developments in your field may require learning fundamentals in one subject area, upgrading skills in another, brainstorming with knowledgeable professional peers and academics, or all of the above. How can you and your organization obtain the highest-level expertise you need in minimum time—without having to get another degree?

Short of waving a magic wand and doing a mind-meld with MIT faculty, you might consider giving MIT's Professional Education Programs office (PEP) a call. Created by the School of Engineering as an umbrella organization for MIT for all of its activities associated with lifelong learning, PEP aims to engage alumni, technical professionals, and firms in ongoing educational opportunities that enhance leadership, practice, and innovation. "We're the single point of contact for professional education in engineering and technical disciplines," says PEP executive director Jennifer Stine. "Our primary mission is to extend the benefits of an MIT education to a broad professional audience."

Learning options include full- or part-time on-campus programs, a wide range of summer short courses, customized, and offsite programs, and innovative offerings utilizing both traditional and electronic delivery methods. Led by MIT faculty from the School of Engineering and other MIT schools, these programs help participants sharpen their skills, stay up-to-date on the latest developments, and gain new knowledge that can be applied at their companies.

ON-CAMPUS PROGRAMS

PEP offers a variety of opportunities for on-campus learning. The oldest is the Professional Institute (PI), which was launched in 1949 by MIT's president James Killian as the "MIT Summer Session." PI now offers 35-45 weeklong certificate programs at MIT every June through August, and occasional offsite programs at companies. This intensive learning experience has enabled more than 600 participants each year to hone in on topics of vital interest, and to form rewarding collaborations with faculty and an international network of talented colleagues.

PI courses benefit both professors and students, notes associate dean of engineering Dick K.P. Yue, who oversees PEP. "The professors are interested in teaching them because it's a way to meet people in industry and understand what the challenges are," he maintains. "The students come to PI not only for the content, but also for the opportunity to meet professors, colleagues, and competitors."

Subject areas include computer sciences, systems design and engineering, materials and the environment, manufacturing, automotive, and biotechnology, and course topics range from bioinformatics to transportation systems. These courses give professionals access to critical information they need to advance their careers and organizations while impacting the world.

"For the first time in ten years in the workplace, I made the connection between what I learned at school in my engineering degree and my work experience."

For example, Jennifer Goode, a biomedical engineer who reviews proposed cardiovascular devices for the Food and Drug Administration's Office of Device Evaluation, found chemical and biomedical engineering professor Robert Langer's course, "Advances in Controlled Release Technology," to be directly applicable to her work. "In the past few years, we have begun to see more combination product applications, such as clinical trial and/or marketing applications for drug-eluting stents," she notes. "This course was a great introduction for me for many of the drug issues associated with the drug-device combination products that I will be responsible for reviewing."

Luc Boivin, an engineering supervisor in powertrain development for Polaris Industries, solidified his understanding of essential concepts in mechanical engineering professor John Heywood's course, "Fundamentals of Internal Combustion Engines." "For the first time in ten years in the workplace, I made the connection between what I learned at school in my engineering degree and my work experience," he says. "Professor Heywood was able to go back to the fundamentals of thermodynamics, chemistry,

CONTINUED ON ILP4

NEW AND NOTABLE

EVENTS

JUNE 10-12, 2004
Synthetic Biology 1.0
The 1st International Meeting on Synthetic Biology
MIT, Cambridge, MA;
sbconf@mit.edu

http://conference.syntheticbiology.org

JUNE 16, 2004,
6:00 PM - 8:30 PM
Entrepreneurship Lessons Learned
MIT Enterprise Forum
MIT Campus 10-250, ($25 Non-members, $20 Forum Members)

http://www.mitforumcambridge.org/events/june04.htm

JUNE 18, 2004,
9:00 AM – 5:00 PM
The Small DNA Revolution: Biology, Technology, and Disease
MIT Center for Cancer Research
MIT Campus, Kresge Auditorium

http://web.mit.edu/ccr/symposium2004/symposium2004register.html

JUNE 21-25, 2004
Current Issues in Managing Information Technology:
Implementing Best Practices in Your Organization
Center for Information Systems Research Summer Session 2004

More info: call 617-253-2348 or visit http://mitsloan.mit.edu/cisr/education.php

AUGUST 16-18, 2004
Dynamics of Biomedical Technologies: At a Distance and Close-up
A Biomedical Enterprise Program Professional Course
MIT Program on the Pharmaceutical Industry Summer Session Course

http://professional.mit.edu/ApplicationFiles/web/WebFrame.cfm?web_id=140

(A Pipeline to MIT Expertise, continued from ILP3)

and physics to explain everything."

For those seeking a more in-depth educational experience, PEP offers the Advanced Study Program. ASP enrolls professionals for one or two semesters as special graduate students to pursue a customized certificate program of MIT coursework designed to meet individual and company goals. Fellows in this 46-year-old program select classes from the MIT course catalog and participate in seminars and research projects under the guidance of faculty.

"What's unusual about ASP is not just the content, but that it gives participants a chance to experience MIT firsthand," says Yue. "They interact with students from all over the world, ask questions of the faculty, and get a transcript with grades." By participating in ASP while continuing to work or as part of an educational sabbatical from their companies, fellows can apply their learning activities to new and ongoing projects. ASP's full- and part-time programs have drawn about 100 fellows per year from more than 500 organizations in over 75 countries.

Finally, PEP offers custom programs and executive education seminars designed in collaboration with a specific organization to meet their strategic goals. Recent examples include a customized, weeklong program on emerging developments in computer science for IT managers from Novartis, and a three-year joint effort with the MIT Sloan School of Management to deliver a program in project excellence to 100 project managers at BP.

OFFSITE PROGRAMS

Current Internet-based learning programs available through PEP include Knowledge Updates and MIT World. Knowledge Updates (KUs) are short, fee-based, non-credit MIT educational offerings packaged as short, Internet-based education modules. Focused on highly specialized and emerging knowledge and methodologies, KUs are intended to complement more traditional face-to-face learning experiences. Initiated earlier this year, this program plans to develop 40 KUs around selected topics in nanotechnology, biotechnology, information technology, and other subject areas in the next three years. "KUs meet a growing need for timely, concise, sharp material that can be quickly completed over a weekend," says Yue.

Now in its third year of operation, MIT World is a free and open website that provides on-demand streaming videos of major public events at MIT. It features the most recent speakers and guests from across the campus and around the world. The current lineup of 170 videos showcase latest developments in science, engineering, architecture, humanities, and management. On the day a new video is posted, MIT World notifies individuals on its burgeoning mailing list with an email message. Last year the site received more than 400,000 hits.

TARGETING INDUSTRY'S EDUCATIONAL NEEDS

PEP was created to streamline operations and improve management of MIT's professional education programs, and to align them with academic activities at the School of Engineering and throughout MIT. Towards that end, the Professional Institute, Advanced Study Program, and MIT World were transitioned into the School in 2002 and based in the PEP office. "By moving these programs under the PEP umbrella, we hope they can grow to better meet the needs of professional communities," says Yue.

The ultimate goal of this reorganization is to increase responsiveness both to the needs of professional communities and the MIT faculty. "Companies approach us for specific custom programs and we match their needs to MIT faculty expertise," says Stine. "We also identify faculty doing innovative research who wish to communicate their findings to industry though PEP-based programs."

Stine, who runs a staff of 13, maintains that the new structure has boosted MIT's ability to create custom programs and to foster in-depth interaction and collaboration among faculty and industry participants. "The added value of the PEP structure is that it's a single point of contact to provide information on existing education programs," says Stine, "and to potentially partner with industry to develop new learning opportunities of mutual interest and benefit."

Yue regards PEP offerings as essential to MIT's role as a leading 21st century university. "It's hard to exercise real leadership without having a strong presence in professional education," he says, "especially when the technology landscape is changing rapidly, and the time between education, research, and applications are ever shortening."

More information on PEP educational offerings is available at http://web.mit.edu/mitpep/.