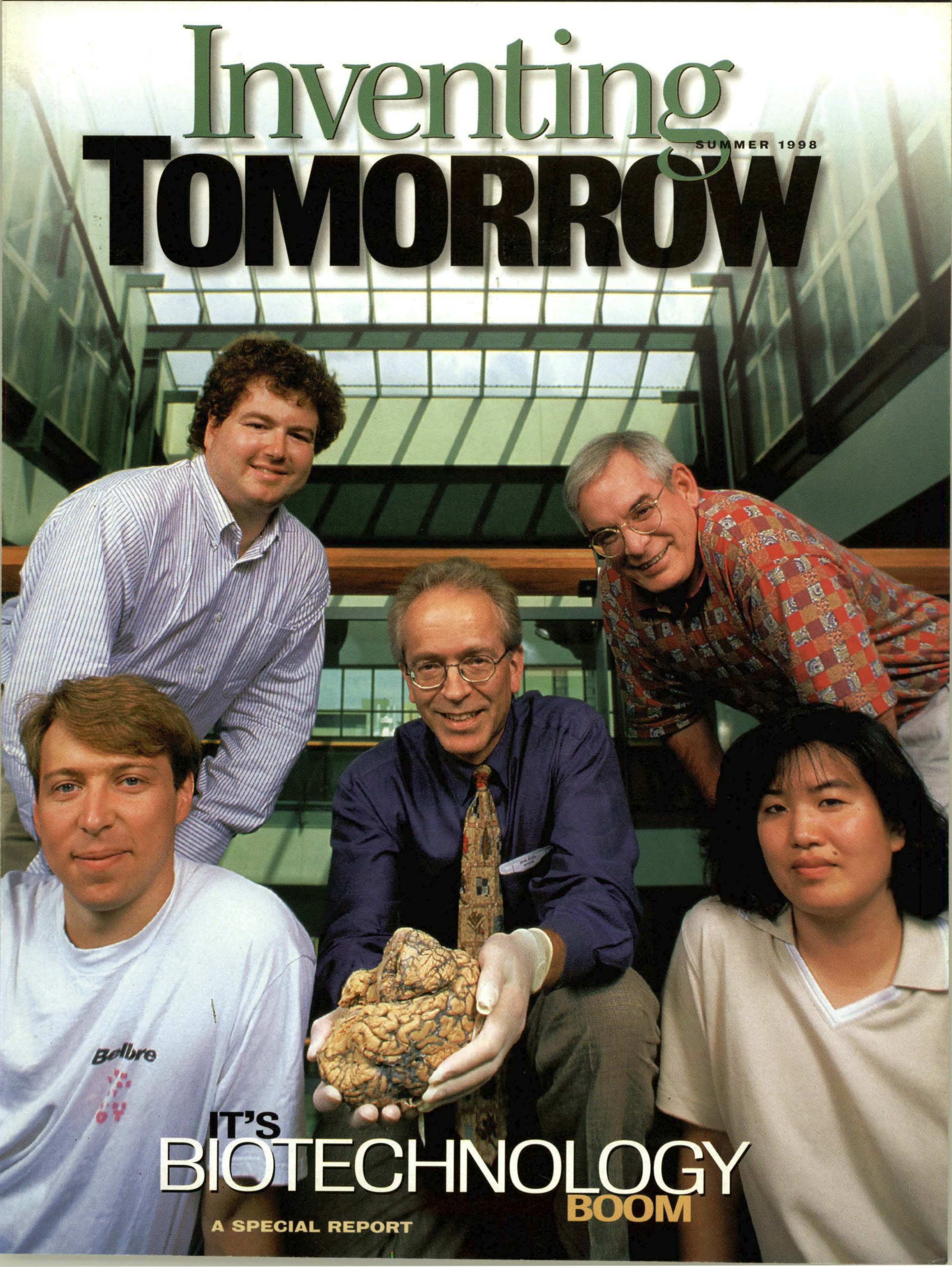
UNIVERSITY OF MINNESOTA INSTITUTE OF TECHNOLOGY

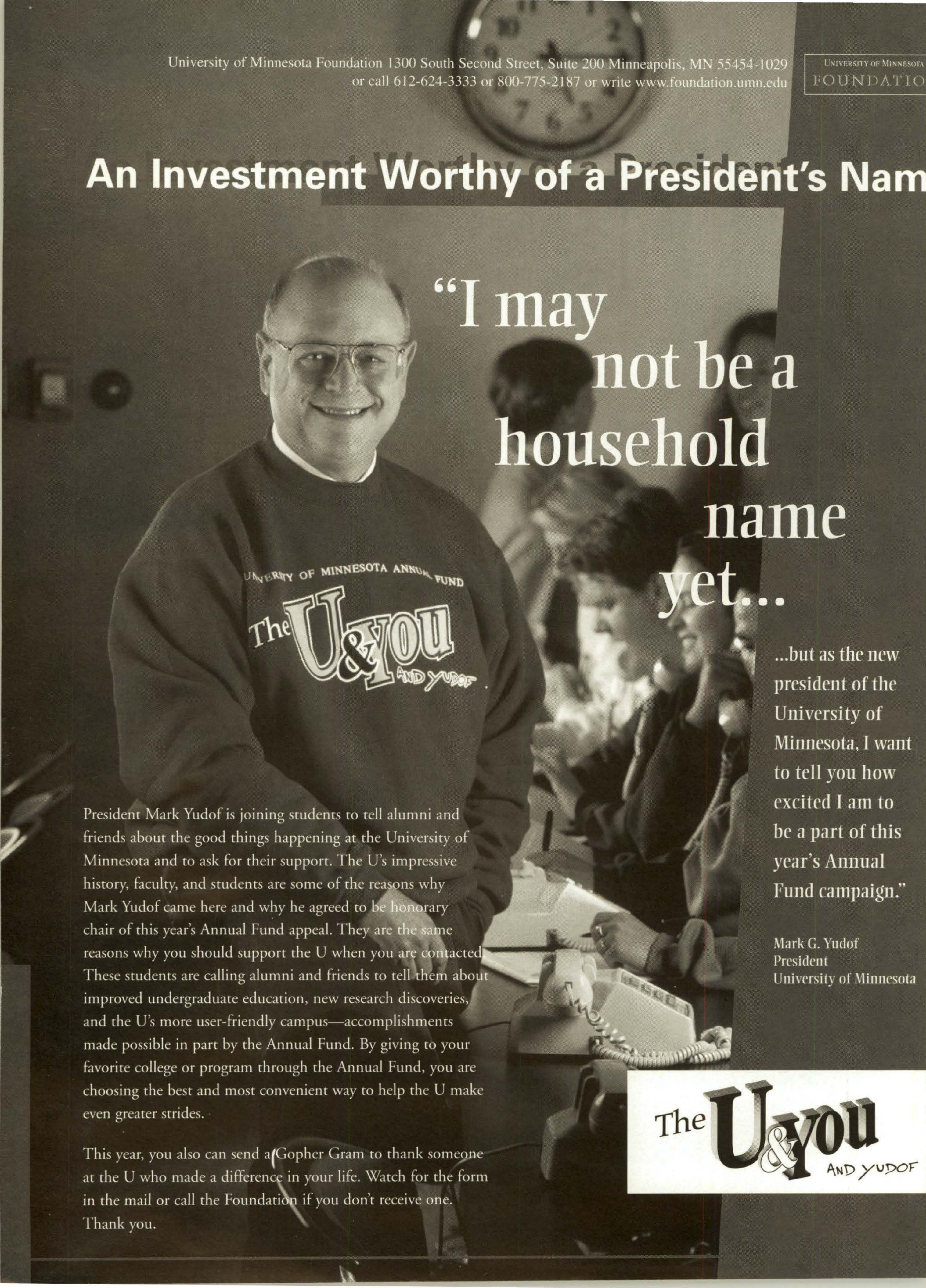
Inventing TOMORROW

SUMMER 1998



IT'S BIOTECHNOLOGY BOOM

A SPECIAL REPORT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University of Minnesota
FOUNDATIO
An Investment Worthy of a President's Nam
"I may not be a household name yet...
...but as the new president of the University of Minnesota, I want to tell you how excited I am to be a part of this year's Annual Fund campaign."
Mark G. Yudof
President
University of Minnesota
President Mark Yudof is joining students to tell alumni and friends about the good things happening at the University of Minnesota and to ask for their support. The U's impressive history, faculty, and students are some of the reasons why Mark Yudof came here and why he agreed to be honorary chair of this year's Annual Fund appeal. They are the same reasons why you should support the U when you are contacted. These students are calling alumni and friends to tell them about improved undergraduate education, new research discoveries, and the U's more user-friendly campus—accomplishments made possible in part by the Annual Fund. By giving to your favorite college or program through the Annual Fund, you are choosing the best and most convenient way to help the U make even greater strides.
This year, you also can send a Gopher Gram to thank someone at the U who made a difference in your life. Watch for the form in the mail or call the Foundation if you don't receive one. Thank you.
The U&you AND YUDOF

Inventing TOMORROW

MAGAZINE OF THE UNIVERSITY OF MINNESOTA INSTITUTE OF TECHNOLOGY • VOLUME 23 • NO. 3 • SUMMER 1998

FEATURES

COVER STORY

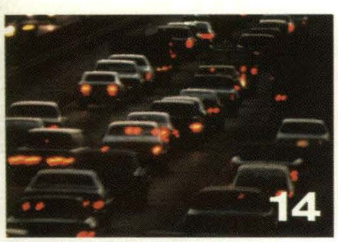
IT's Biotechnology Boom

From biomedical engineering and medical device development to genetic research and biological process technology, IT researchers play a major role in the growing field of biotechnology. Here is a look at 13 of the innovative projects underway.

SPECIAL SECTION: PAGES 19-37

DEPARTMENTS

ON THE COVER: (clockwise from center) Robert Elde, John Carlis, Salina Yee, Alex Safonov, and Joseph Konstan display a human brain. Turn to page 34 for the story.
Photo: Chip Pearson.



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Inventing Tomorrow

MAGAZINE OF THE UNIVERSITY OF MINNESOTA INSTITUTE OF TECHNOLOGY

INSTITUTE OF TECHNOLOGY

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PRESIDENT	Mark Yudof

REGENTS' PROFESSOR H. TED DAVIS

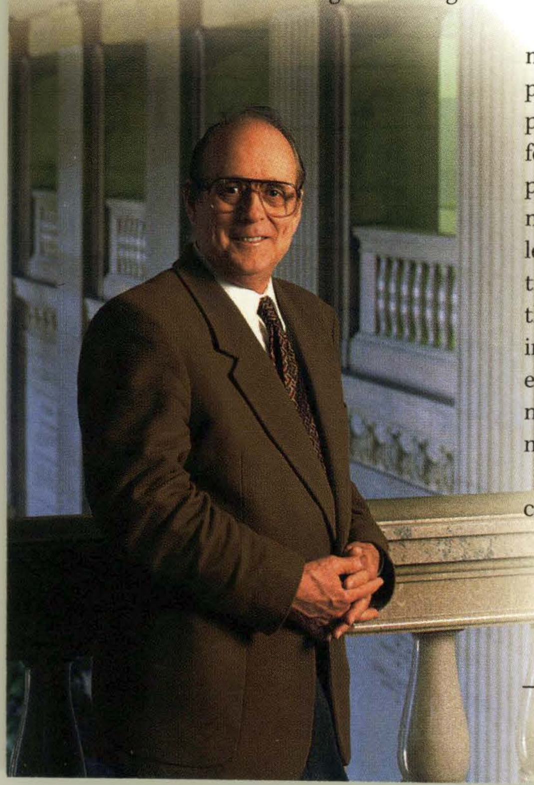
IT's biotechnology boom

Innovations help lay the groundwork for the next scientific revolution

FROM GENETIC ENGINEERING to biomedical device development, biotechnology is one of the fastest growing areas of research in both industry and academia. It's also one of the most interdisciplinary, spawning an unprecedented number of collaborations among researchers from seemingly disparate fields.

In this issue, we feature more than a dozen current biotechnology research projects from across IT's science and engineering departments. Although you may not think of IT as a hub of biotechnology, the scientific and technological expertise of our faculty and students plays a leading role in much of the University's biological and biomedical research, and our alumni have founded more than 50 biomedical and biotechnology companies, including Medtronic, Cardiac Pacemakers, and others.

Over the past several years, IT has formed partnerships with the Medical School, the Graduate School, the College of Biological Sciences (CBS), and the College of Agricultural, Food, and Environmental Sciences (COAFES) that have generated new intercollegiate research centers devoted to biotechnology. The unique interdisciplinary environment of these centers — like the Biological Process Technology Institute (BPTI), the Center for Interdisciplinary Applications in Magnetic Resonance, and the Center for Metals in Biocatalysis — helps drive innovative research.



Of course, IT is also home to two longstanding intercollegiate units that focus on biotechnology. The Department of Biosystems and Agricultural Engineering, which is part of both IT and COAFES, meshes engineering and biology to find new ways to improve food products and the environment. The Biomedical Engineering Institute (BMEI), a joint department in IT and the Medical School, applies the principles of engineering to human health problems. BMEI recently achieved departmental status and completed a successful $12 million endowment campaign. You can read more about it on page 21.

President Yudof's digital technology and molecular and cellular biology initiatives will provide further opportunities for interdisciplinary research. Part of the money allocated for digital technology faculty will fund new positions in computational biology and genetics, which the University hopes to fill with leaders in the field. Moreover, Yudof's initiatives call for state-of-the-art facilities with the resources necessary to support continuing biotechnology research. Thanks to a generous $242 million allocation from the Minnesota legislature, those initiatives — and many others — will soon become a reality.

Although the breadth and depth of IT's current contributions to biotechnology are remarkable, I am confident that the future holds even more breathtaking innovations and discoveries. I am committed to building even stronger relations between IT and the bioscience components of other colleges.

For example, IT is working with several other colleges to develop a strategy for making the University a leader in genomic engineering. In a few years, the entire genome of many varieties of plants and animals — including humans — will be mapped out. In fact, the entire genome of a plant called arabadopsis has already been determined, and the genome of corn is understood well enough to enable plant geneticists to introduce genetically modified strains that are resistant to herbicides. Similar genomic modification for disease resistance in humans seems imminently possible.

Dealing with the informational content of genomes — in particular, DNA sequences — will require new techniques for storing, mining, and visualizing extraordinarily large databases, including new computer hardware and software. (Professor Vipin Kumar and an intercollegiate research team are already exploring these techniques. You can read more about their work on page 28.)

Researchers must also develop physical and mathematical models to understand how the behavior of cells and organisms is related to genetic structure. Once functional genomics is understood, geneticists will have unlimited opportunities to engineer new plants and specialty biochemicals as well as new ways to control diseases and genetic defects in animals.

The revolution of the 21st century will be driven by biology, assisted by information technology. Our college intends to be a major player in that revolution.

News

FACILITIES

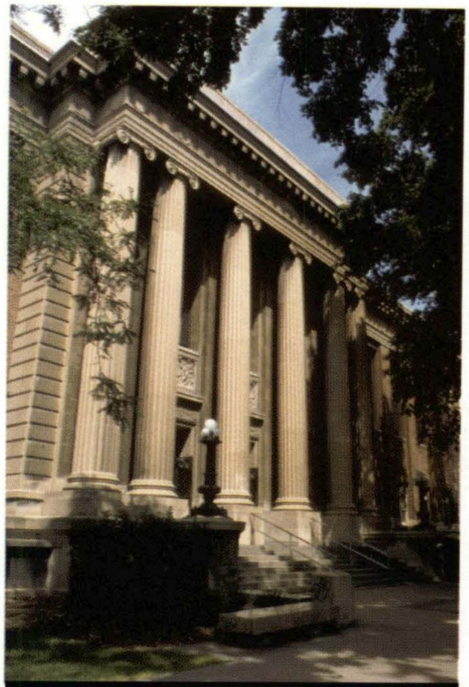
Successful legislative campaign to bring unprecedented campus construction activity through 2001

by Paul Sorenson

AS A RESULT OF ITS SUCCESS DURing the 1998 legislative session, the University will undertake an unprecedented number of construction projects during the next three years.

The legislature appropriated $207 million to fund or partially fund more than two dozen projects, including nine on the Twin Cities campus alone. Among them are buildings for several high-profile initiatives, including digital technology, new media, and molecular and cellular biology.

"The people of Minnesota, through their elected representatives, were extraordinarily supportive of the University's capital request in the 1998 legislative session," wrote University president Mark Yudof in a June announcement to the faculty and staff.



Walter Library will close for renovation in 1999.

Several previously planned projects, including the construction and renovation of mechanical engineering facilities, will also take place during the next several years.

When these projects are completed, many faculty, staff, and students will be able to work and study in new or newly renovated facilities. However, during the construction period, the University will vacate more than a half-million assignable square feet of space, closing hundreds of classrooms and offices and displacing 34 departments and thousands of faculty and staff.

"To illustrate the magnitude of this effort," added Yudof, "this represents space equivalent to 80 percent of the space assigned to the College of Liberal Arts."

The IT dean's office and the Science and Engineering Library are among the units that must be relocated during the construction period, but temporary locations have yet to be identified. Walter Library is expected to close for two years, beginning in March 1999.

Demolition and construction on several projects have already begun. Most of the work currently planned should be completed by mid-2001.

The next round of renovations will target other historic buildings, including Vincent Hall and the Tate Laboratory of Physics.

Plans are also underway for a new facility to house the Newton Horace Winchell School of Earth Sciences. A fundraising campaign for that project will begin in 1999; a target date for construction has not yet been set. ■

FOR MORE INFORMATION and continuing construction updates, visit the Facilities Management web site at http://facm.umn.edu

MAJOR CAMPUS CONSTRUCTION PROJECTS

NEW CONSTRUCTION

- **Dance Center** (1998-99)
- **Gateway Center** (1998-99)
- **Minnesota Library Access Center** (1998-99)
- **Molecular and Cellular Biology Building** (1999-2001)

RENOVATION AND EXPANSION

- **Amundson Hall** (1998-99)*
- **Architecture** (1999-2001)*
- **Ford Hall** (1999-2000)*
- **Gortner Labs** (1999-2000)*
- **Haecker Hall** (1997-98)
- **Jackson Hall** (1998-99)
- **Mechanical Engineering** (1998-2000)
- **Murphy Hall** (1999-2000)*
- **Peters Hall** (1999-2000)*
- **Snyder Hall** (1999-2000)*
- **St. Paul Gymnasium** (1998-99)
- **Walter Library** (1999-2001)*
- **Williamson Hall** (1998-99)

* funded by the 1998 legislative allocation

ALUMNI

Golden, Johnson earn the University's highest alumni honor

by Christopher Sharp

DAVID GOLDEN AND LEE JOHNSON are the latest IT alumni to receive the University of Minnesota's highest alumni honor, the Outstanding Achievement Award, which recognizes exceptional personal achievement in a professional field.

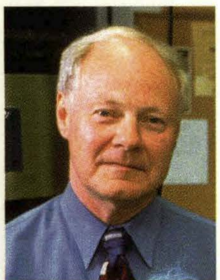
Golden, senior staff scientist at the Molecular Physics Laboratory of SRI International in Menlo Park, California, received the award at IT's commencement ceremonies in June.

PHOTOS: PATRICK O'LEARY

He received a bachelor's degree in chemistry from Cornell University in 1956 and a doctorate in chemistry from the University of Minnesota in 1961. He joined SRI (formerly the Stanford Research Institute) as a postdoctoral fellow in 1963, following stints as a lieutenant in the Army and as a postdoctoral fellow at Princeton University.

Early in his career, Golden made contributions to the field of chemical kinetics, providing organic chemists with rules to predict the behavior of almost any organic compound. During the late 1960s and early 1970s, he helped establish the field of thermochemical kinetics, which deals with molecular behavior. Later, Golden contributed to the understanding of how fossil fuels burn, becoming among the first to recognize the usefulness of computerized simulations of combustion. In the late 1970s, he turned to atmospheric chemistry. In 1987 he published experimental evidence that chemical reactions occurring in stratospheric cloud particles are instrumental in opening the Antarctic ozone hole. This finding laid the groundwork for future study of the phenomenon and ultimately led to public policies against production and use of chlorofluorocarbons.


Golden


Johnson

Golden is a consulting professor of mechanical engineering at Stanford University and a former editor-in-chief of the *International Journal of Chemical Kinetics*.

He is a fellow of the American Association for the Advancement of Science (AAAS) and the American Physical Society. In 1989 he won the Newcomb Cleveland Prize of the AAAS, and in 1990 he received the American Chemical Society Award for Creative Advances in Environmental Science and Technology.

Johnson (Mechanical '57), chief operating officer of Reell Precision Manufacturing, will be honored at a fall event to mark the groundbreaking of the new mechanical engineering facilities. He and RPM are profiled on page 44 of this issue. ■

Members of the Solar Vehicle Project

STUDENT PROJECTS

Solar vehicle team launches adopt-a-cell program for Aurora 4

by Paul Sorenson

FANS OF THE UNIVERSITY OF MINnesota Solar Vehicle Project can now support the team by adopting one or more of the 1,000 solar cells that will power the new car, Aurora 4, in Sunrayce 99 and the World Solar Challenge.

For a minimum $25 donation, "adoptive" supporters will receive the team newsletter and daily coverage of the its progress during Sunrayce 99. Their names will also appear on the team's web site with a notation of the number of solar cells they adopted.

Sunrayce 99 is an intercollegiate competition that pits the top 40 engineering schools from across North America in a 1,500-mile race from Washington, D.C., to Orlando in June 1999. The World Solar Challenge, the world's premier solar car race, follows the 1,880-mile Stuart Highway across Australia in October. The trip to Australia will be the team's first entry in the worldwide race.

"We are going to Australia as ambassadors for Minnesota, to demonstrate what can be accomplished when the community, corporations, and IT come together in the name of technological advancement," says Kevin Grotheim, co-manager of the solar car project.

Team members also participate in outreach activities at schools, nature centers, and parades as well as at the Minnesota State Fair.

"One of our goals," says junior Jenny Hoffman, the project's public relations team leader, "is to educate children and adults about the exciting opportunities that science and engineering education make possible."

"This project is more than just racing solar vehicles," adds mechanical engineering junior Elizabeth Watkins, the project's other co-manager. "It's also about educating the community about alternative energy sources." ■

FOR MORE INFORMATION visit the Solar Vehicle Project web site at http://www.umn.edu/umnsvp/

COMMENCEMENT '98

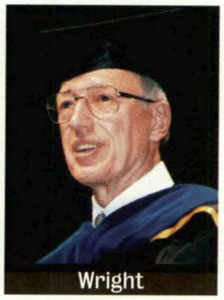
Wright delivers IT commencement address

by Paul Sorenson

LOS ANGELES TIMES CEO DONALD Wright (Mechanical '57) delivered the keynote address to more than 500 graduating seniors and a crowd of nearly

PHOTOS: PATRICK O'LEARY, CHIP PEARSON

4,000 at IT's 1998 commencement ceremonies at Northrop Auditorium on June 5.



Wright

Hang Trinh, who earned a bachelor's degree in computer science, spoke on behalf of the graduating class. University president Mark Yudof, Regent Maureen Reed, and Dean H. Ted Davis presided over the ceremonies.

IT awarded 904 baccalaureate degrees, 345 master's degrees, and 214 doctoral degrees in the past academic year. ■

STUDENT LIFE

Fun and games highlight 1998 IT Week festivities

by Paul Sorenson

A CAREER FAIR, GOOFY GAMES, AND a picnic for parents highlighted the 1998 edition of IT Week, IT's annual community celebration.

Lighthearted activities filled much of the week. Students tossed bales of straw, raced across Northrop Mall bound in cellophane, and took part in other games designed to provide relief from the seriousness of their studies. On one evening, the Physics Force entertained audiences with an educational presentation in Northrop Auditorium; on another, the *Minnesota Technolog* offered a free science fiction film festival. In all, more than a dozen student organizations sponsored activities and events.

The week wasn't all fun and games, however. A two-day career fair brought 47 companies to campus, where they set up information booths in a tent on Northrop Mall. The fair was organized by Plumb Bob, the honorary student society responsible for planning the week's events.

"It was our most successful career fair ever," says the group's advisor, Gail Fraser. "We had to rent a larger tent — the biggest yet."

At the week's end, nearly 100 parents and students braved wind and rain to join Dean H. Ted Davis and dozens of faculty members for the annual IT Parents Organization spring picnic.

"We had a great turnout despite rainy weather," says Kristine Kosek, who coordinates the parents' program. "This event is a good opportunity for parents and students to interact one-on-one with the dean and faculty members. It's a lot of fun for everyone."

IT Week began in 1903 as Engineers' Day. The festivities were extended to a week in the 1950s, when a rivalry between engineering students and forestry students introduced new pranks and hijinks each year. In 1981, the celebration was renamed IT Week to more fully embrace the college's science and mathematics components. ■

For more information call 612-626-1552 or visit the Plumb Bob web site at http://www.tc.umn.edu/nlhome/g033/

IT Week's cellophane racers prepare for competition.

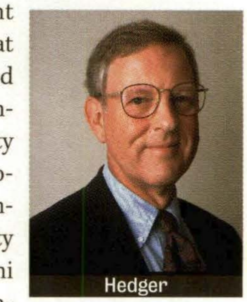
IT ALUMNI SOCIETY

Richard Hedger elected alumni president at ITAS annual meeting

by Kristine Kosek

THE IT ALUMNI SOCIETY ELECTED Richard Hedger as its president for 1998-99 at the ITAS annual meeting in June. Nearly 70 alumni attended the meeting, which took place during a cruise on Lake Minnetonka aboard the *Lady of the Lake.*

Hedger (Electrical Engineering '62, M.S. '68) is director of process improvement at DataCard. He spent more than 31 years at IBM Rochester and for a time ran his consulting firm, Quality Software Technologies. A lifetime member of the University of Minnesota Alumni Association, he joined the ITAS board in 1995. He has also served on the industry advisory group for the Department of Computer Science and Engineering and is a member of the Institute of Electrical and Electronics Engineers, the Association for Computing Machinery, and the American Society for Quality Control.



Hedger

ITAS also elected four vice presidents, welcomed several new board members, and honored retiring past president James McLinn (Physics M.S. '74), outgoing president Robert Rosene (Civil '45, M.S. '48), and former alumni relations director Frank Robertson at the event. ■

FOR MORE INFORMATION visit the ITAS web site at http://www.technology.umn.edu/itas

PHOTOS: JAIME CHISMAR, PATRICK O'LEARY

Events

August 10-14

Twenty-third Annual Short Course on Rheological Measurements: Application to Polymers, Suspensions, and Processing. For more information call 612-624-5763.

August 11

Estate Planning Seminar. 10:30 a.m., 206 Coffman Memorial Union. For more information call 612-624-5537 or 1-800-587-3884.

August 20-September 22

New Student Orientation. IT welcomes freshmen and their parents to the "U." For more information or to help in the orientation planning, call 612-626-8282 or 1-800-587-3884.

August 25

Boston-area Chemistry Alumni Breakfast. 7:30 a.m., Marriott Copley Place, Boston. For more information call 612-626-8282 or 1-800-587-3884.

August 25

Boston-area IT Alumni Reception. 5:00 p.m., Marriott Copley Place, Boston. For more information call 612-626-8282 or 1-800-587-3884.

August 27-September 7

Minnesota State Fair. Visit IT in the Wonders of Technology Pavilion. For details, call 612-626-8282 or 1-800-587-3884.

September 10

Donor Recognition Event. 5:00 p.m., Northrop Mall. For more information call 612-626-9354 or 1-800-587-3884.

October 15

Donor/Scholar Recognition. 4:30 p.m. Coffman Memorial Union. For more information call 612-626-9354 or 1-800-587-3884.

October 23-24

Class of 1948 50th Reunion. Featuring two days of events, including campus tours and dinner with the dean on Friday, October 23. For more information or to participate in the planning process, contact Kristine Kosek at 612-626-8282, e-mail itas@itdean.umn.edu, or call 1-800-587-3884.

October 24

University of Minnesota Homecoming. The Golden Gophers take on the Michigan Wolverines, 2:30 p.m., Metrodome.

The Homecoming halftime show, featuring the Minnesota Marching Band

Ongoing Events

The following departmental seminars and colloquia meet weekly throughout the academic year. Call or check the web for details.

Aerospace Engineering & Mechanics
Fridays, 2:30 p.m., 209 Akerman Hall
612-625-8000 or http://www.aem.umn.edu

Astronomy
Fridays, 3:00 p.m., 131 Physics
612-624-0211 or http://ast1.spa.umn.edu

Biomedical Engineering
Tuesdays, 3:30 p.m., 108 MechEng
612-624-9603 or http://www.bmei.umn.edu

Biosystems & Agricultural Engineering
Fridays, 1:30 p.m., 106 BioAgEng
612-625-7733 or http://www.bae.umn.edu

Chemical Engineering & Materials Science
Tuesdays, 1:25 p.m., B75 Amundson Hall
612-625-1313 or http://www.cems.umn.edu

Chemistry
Mondays/Fridays, 4:15 p.m., 331 Smith Hall,
612-624-6304 or http://www.chem.umn.edu

Civil Engineering
Fridays, 1:10 p.m., 210 Civil Eng,
612-625-5522 or http://www.cme.umn.edu.

Computer Science & Engineering
Mondays, 2:30 p.m., 108 MechEng
612-625-4002 or http://www.cs.umn.edu.

Electrical & Computer Engineering
Thursdays, 3:35 p.m., 108 MechEng
612-625-2855 or http://www.ee.umn.edu

Geology & Geophysics
Thursdays, 3:30 p.m., 110 Pillsbury Hall
612-624-1333 or http://www.geo.umn.edu

Mathematics
Daily, various times and locations
612-626-0230 or http://www.math.umn.edu

Mechanical Engineering
Wednesdays, 3:25 p.m., 108 MechEng
612-625-8000 or http://www.me.umn.edu

Physics
Wednesdays, 4 p.m., 131 Physics
612-624-7886 or http://www.spa.umn.edu

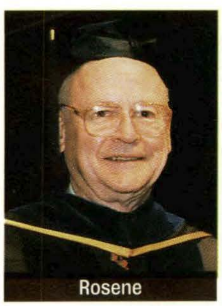
Solid & Continuum Mechanics
Tuesdays, 1:30 p.m., 227 Akerman Hall
612-625-3072 or http://www.aem.umn.edu

PHOTO COURTESY UNIVERSITY BANDS

ITems

APPOINTED

Professor **Avram Bar-Cohen** (mechanical engineering), as executive director of the Center for the Development of Technological Leadership and chair of the U.S. Scientific Committee of the International Heat Transfer Assembly • Associate Professor **Saifallah Benjaafar** (mechanical engineering) as associate editor of the *International Journal of Flexible Manufacturing Systems* • alumnus **Krzysztof Burhardt** (Electrical Engineering Ph.D '71), as vice president of the Honeywell Technology Center, a collection of advanced research laboratories that develop new technologies and advanced product concepts for internal and external customers, after 26 years with 3M and two years with Imation • **Sean Garrick** of the State University of New York, who studies numerical simulations of turbulent flows, combustion, and stochastic processes; as an assistant professor of mechanical engineering • **Dihua Jiang**, a number theorist from Yale University, as an assistant professor of mathematics • **Ivan Marusic** of the University of Melbourne, who specializes in the experimental and theoretical study of turbulent boundary layers; as an assistant professor of aerospace engineering and mechanics • alumnus **Timothy Rolfe** (Computer Science M.S. '89), to a two-year position as visiting associate professor of computer science at Eastern Washington University.

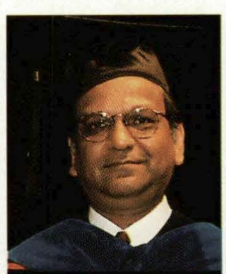

Rosene

PROMOTED

from associate professor to professor: **Stephen Campbell** (electrical and computer engineering), **Jeffrey Derby** (chemical engineering and materials science), **Emi Ito** (computer science and engineering), **Ravi Janardan** (computer science and engineering), **Christopher Palmstrom** (chemical engineering and materials science), **Haesun Park** (computer science and engineering), **Friedrich Srienc** (chemical engineering and materials science), and **Robert Tranquillo** (chemical engineering and materials science) • from assistant professor to associate professor (with tenure): **John Bischof** (mechanical engineering), **Prodromos Daoutidis** (chemical engineering and materials science), **Mark Distefano** (chemistry), **Craig Forsyth** (chemistry), **Jerome Hajjar** (civil engineering), **Susan Mantell** (mechanical engineering), **Karin Musier-Forsyth** (chemistry), and **Roger Ruan** (biosystems and agricultural engineering) • alumnus **Kathleen Berger** (Chemical Engineering '90), to group brand manager for Vitamin E, at Henkel Nutrition and Health Group, where she will develop strategic customer co-promotion programs and public relations and advertising activities.

HONORED

with 1998 IT Student Board Best Instructor Awards: Professor **Gordon Beavers** (aerospace engineering and mechanics), Associate Professor **Bruce Wilson** (biosystems and agricultural engineering), Professor **Edward Cussler** (chemical engineering and materials science), Professor **Louis Pignolet** (chemistry), Associate Professor **Joseph Labuz** (civil engineering), educational specialist **Philip Barry** (computer science and engineering), Professor **Anand Gopinath** (electrical and computer engineering), Professor **David Kohlstedt** (geology and geophysics), Associate Professor **Chester Miracle** (mathematics), Professor **Tarald Kvalseth** (mechanical engineering), Associate Professor **Charles Scott** (mechanical engineering), Professor **Serge Rudaz** (physics) • teaching assistants **Derek Adams**, **Eric Granstrom**, and **Steve Rankin**, with 1997-98 Chemical Engineering and Materials Science Outstanding Teaching Assistant Awards: • administrator **Arlene Bennett** (civil engineering), with an Employee Recognition Award for 25 years of service to the University • Professor **Victor Bloomfield** (chemistry), with the 1998 Distinguished Service Award from the Biophysical Society • **Anna Boeing**, **Matthew Ricker**, and **Louis Rudnicki** (civil engineering), with the Claire and Simon Benson Memorial Award for outstanding undergraduate performance • alumni **Otto Bonestroo** (Civil'49, Ph.D. '50), **David Holt** (Civil '59), and **Robert Rosene** (Civil '45, M.S. '48), along with their colleagues Joseph Anderlik and Lawrence Kloiber, by the American Society of Civil Engineers Committee on Curricula and Accreditation, for their contributions to the Department of Civil Engineering • associate professors **Stephen Campbell** and **Bapiraju Vinnakota** (electrical and computer engineering), with IBM Partnership Awards • graduate student **Yaoyuan Chuang**, with the John Wertz Award for Outstanding Graduate Research in Chemical Physics • the **Department of Civil Engineering**, with a U.S. Department of Education GAANN Fellowship Program Award for its contributions to environmental education • the University of Minnesota **Concrete Canoe Team**, for its second place finish in the American Society of Civil Engineering Midwest regional competition with the 21-foot, 70-pound canoe *Power Loon* • Professor **Edward Cussler** (chemical engineering and materials science), with the 1998 American Society for Engineering Education Union Carbide Lectureship • professors **Dan Dahlberg** (physics) and **Wayne Gladfelter** (chemistry), with the 1998 IT Distinguished Professorships • associate professors **Prodromos Daoutidis** (chemical engineering and materials science) and **Jerome Hajjar** (civil engineering) with the 1998 George Taylor Career Development Award • Professor **Andrew Drescher**, with the Bonestroo, Rosene, Anderlik and Associates Undergraduate Faculty Award for excellence in undergraduate teaching and advising in civil engineering • Professor **Ding-Zhu Du** (computer science and engineering), with the Computer Science Technical Section Prize from the Institute of Operations Research and Management Science for excellence in the interface between operations research and computer science • Associate Professor **Craig Forsyth**, with the 1997 Zeneca Pharmaceuticals Excellence in Chemistry Award • Professor Emeritus **Theodore V. Galambos** (civil engineering) with an honorary degree from his alma mater, the University of North Dakota, in recognition of his achievements as an engineer, professor, and scholar • Assistant Professor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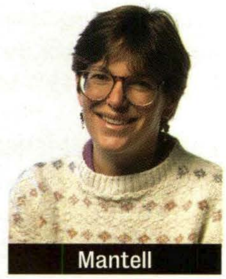

Mantell

PHOTOS: PATRICK O'LEARY, FILE

Marc Hillmyer (chemistry), with the 1998 3M Nontenured Faculty Award • professors Thomas Hoye, Wayland Noland, and Louis Pignolet, and associate professors Craig Forsyth and Karin Musier-Forsyth (chemistry), for contributions to the Undergraduate Research Opportunities Program • Professor Yutaka Hosotani (physics), with Japan's Invitation Fellowship for Research at the Society for the Promotion of Science • professors Wei-Shou Hu (chemical engineering and materials science), Richard James (aerospace engineering and mechanics), and Keith Olive (physics), as 1998 Distinguished McKnight University Professors • Professor Roger Jones (physics), with the 1998 Award for Innovation in Technology Enhanced Learning • Professor Francis Kulacki, as an American Society of Mechanical Engineers Distinguished Leader • Professor James Leger (electrical and computer engineering), with the Optical Society of America's Joseph Fraunhofer Award/Robert M. Burley Prize for significant accomplishments in optical engineering • professors Kenneth Leopold and Jeffrey Roberts (chemistry), with 1998-99 Bush Sabbatical Supplement Awards • Professor Marvin Marshak (physics), with the 1998 President's Award for Outstanding Service • professor Ned Mohan (electrical and computer engineering), with the 1998 George Taylor/IT Alumni Society Distinguished Teaching Award • Associate Professor Eric Munson (chemistry), as a 1998 McKnight Land Grant Professor • alumnus Julio M. Ottino (Chemical Engineering Ph.D. '79), as the 1998 Chemical Engineering and Materials Science/George T. Piercy Distinguished Professor and as head of the chemical engineering department at Northwestern University • Professor David Shores (chemical engineering and materials science), as a fellow of the Electrochemical Society • Associate Professor John Shutske (biosystems and agricultural engineering), with the 1998 Nolan Mitchell Young Extension Worker Award for outstanding contributions through extension education and research in agricultural safety and health • Assistant Professor J. Ilja Siepmann (chemistry), with the Alfred P. Sloan Research Fellowship • alumnus Dennis A. Siginer (Mechanics Ph.D. '82), as a fellow of the American Society of Mechanical Engineers and chair of the mechanical engineering department at the New Jersey Institute of Technology • Associate Professor Karl Smith (civil engineering), as a fellow of the American Society for Engineering Education • Professor William Smyrl (chemical engineering and materials science), as a fellow of the Electrochemical Society • Associate Professor Mark Snyder (civil engineering) with the Transportation Research Board's K.B. Woods Award • Professor Ephraim Sparrow (mechanical engineering), with the Donald Q. Kern Award for excellence in applications-oriented and applied heat transfer • assistant professors Andreas Stein (chemistry), and Zhi-Li Zhang (computer science and engineering), with National Science Foundation Career Awards • professors William Tolman (chemistry) and Michael Ward (chemical engineering and materials science), with the George Taylor/IT Alumni Society Distinguished Research Award • senior Hang Trinh (computer science and engineering), as the student speaker at IT's commencement ceremonies • Professor Donald Truhlar (chemistry), with the 1998 George Taylor/IT Alumni Society Distinguished Service Award.


Hajjar

AWARDED

a five-year, $500,000 National Institutes of Health First Award to Associate Professor John Bischof (mechanical engineering) for the study of cryosurgery on prostate cancer • a $36,000 grant from Sandia National Laboratories to Professor Jeffrey Derby (chemical engineering and materials science), for a study entitled "Modeling the High-Pressure Vertical Bridgman Growth of CZT Crystals" • a $1.3 million, two-year contract with the Coordinating Research Council to the Center for Diesel Research to develop and evaluate diesel aerosol sampling methods for engine laboratories and on-highway research programs • a National Science Foundation grant to Assistant Professor Merve Erdal (mechanical engineering), to study "Solid Freeform-Based Fabrication of Porous Structures and Flow Characterization," and a University Grant-in-Aid Research Award to study "Particle Filtration in Resin Transfer Molding of Ceramic Composites" • a Greenfield Coalition/National Science Foundation grant to Professor Arthur Erdman (mechanical engineering), for the development of a Windows NT version of LINCAGES-4, a mechanism synthesis software package for mechanical design engineers • a $400,000 air force grant to Associate Professor Caroline Hayes (mechanical engineering), to construct a methodology called Task-Builder, and a $30,000 grant from the Army Research Laboratory to augment an ongoing research project called Co-Raven • a University Grant-in-Aid Research Award to Assistant Professor Raymond Hozalski (civil engineering) • a grant from the National Science Foundation to the Institute for Rock Magnetism, for acquisition and upgrades of instrumentation for high-field, low-temperature magnetic measurements and for Mossbauer spectroscopy • a $5 million Air Force Multidisciplinary University Research Initiative to Professor Richard James (aerospace engineering and mechanics), the largest individual grant in the department's history • a $60,000 Petroleum Research Foundation Award to Professor Steven Kass (chemistry) for "Studies of Antiaromatic and Related Compounds" • a three-year National Science Foundation grant to Assistant Professor Perry Li (mechanical engineering), for his work in passive control of mechanical systems with coordination requirements • a two-year contract with the Office of Naval Research to professors Chris Macosko, Friedrich Srienc, and Matthew Tirrell (chemical engineering and materials science) along with Dan Urry and Michael Flickinger of the Biological Process Technology Institute, to study "Materials Characterization of Elastomeric Polypeptides." • new three-year grants from the National Science Foundation and the U.S. Department of Energy to Professor Donald Truhlar (chemistry).


Trinh

RETIRED

professors Leon Green (mathematics), Hans Weinberger (mathematics), Malcolm Hepworth (civil engineering), Russell Hobbie (physics), Paul Kellogg (physics), Richard Kain (electrical and computer engineering), Edwin Layton (mechanical engineering), Harold Swofford, Jr. (chemistry) • associate professors Lisl Gaal (mathematics) and John Sivertsen (chemical engineering and materials science) • administrators Mary Hessburg (mechanical engineering) and Iona Quesnell (astronomy).

REMEMBERED

alumnus Louis Lindenbaum (Mechanical Engineering'42), who died June 28, 1995 • alumnus Merwin Parks (Mechanical Engineering '34), April 12, 1998 • former dean Athelstan Spilhaus, March 30, 1998 • alumnus Charles Taylor (Chemical Engineering '39), March 3, 1998.

the science behind the sorority

The University is home to the first chapter of Alpha Sigma Kappa, a sorority for women in technical studies. Each year, its members sponsor an event to interest young girls in science and engineering.

by Paul Sorenson and David Hyland

IT WAS A VISIT TO EMILY EELKEMA'S high school by University professors that propelled her interest in aerospace engineering. This spring, the IT senior returned the favor.

Eelkema and other members of Alpha Sigma Kappa, a sorority for women in technical studies, brought more than 50 middle school girls to campus in May for the group's fourth annual Science Exploration Day.

Jenny Cordina, the sorority's scholastic chair and the project's chief organizer, says the purpose of the event is to get young girls excited about science and engineering.

"We want to show them that women can be scientists and engineers, that it can be cool, and that we aren't all technical nerds," she says.

To generate interest in the event, sorority members visited area schools to meet with classes of girls and invite them to attend. According to aerospace engineering senior Dorothea Czernik, they were met with a surprising level of enthusiasm.

"When we told them to sign up [for Science Exploration Day] early because space was limited, one girl wanted to go home immediately and get her mother's permission to come," says Czernik. "She didn't want to miss out." As in the past, the event quickly filled to capacity.

For this year's event, sorority members designed five fun, hands-on experiments that demonstrated applications of aerospace, civil, electrical, mechanical, and chemical engineering.

The day began with a lecture from aerospace engineering professor Ellen Longmire. Using wooden planes and a model of the space shuttle currently in development, Longmire demonstrated how planes and helicopters fly.

As the day continued, the girls learned about polymers by making a Silly Putty-like substance from sodium borate and white glue. They discovered the mechanical workings of an injection molding machine that

SORORITY SISTERS: Aerospace engineering seniors Jennifer Cordina, Emily Eelkema, and Dorothea Czernik helped organize Alpha Sigma Kappa's annual Science Exploration Day.

PHOTOS: JAIME CHISMAR

heated chocolate and forced it into the shape of Goldy Gopher, and explored aerodynamic principles by watching water flow across an airplane wing.

But the most popular experiment demonstrated the principles behind quicksand. The girls immersed their hands in a tank of wet sand that sorority members changed into quicksand by flowing water through the tank.

"Wet sand is stable," explains Cordina. "But when water flows through it, it becomes unstable. Presto! It's quicksand!"

Cordina says Science Exploration Day changes from year to year depending on the expertise of the students involved. In the past, the event has included experiments in math, physics, chemistry, geology, and statistics. Funding from the IT Student Board and the Program for Women in IT helps defray the cost of busing the girls to campus.

THE SORORITY BEGAN AS A "LITtle sister" organization to Triangle Fraternity, a national engineering and technical fraternity. In 1989, members of that group organized what became the first chapter of Alpha Sigma Kappa, an independent social sorority for women in technical studies. A second chapter was founded at the University of Oklahoma in 1996.

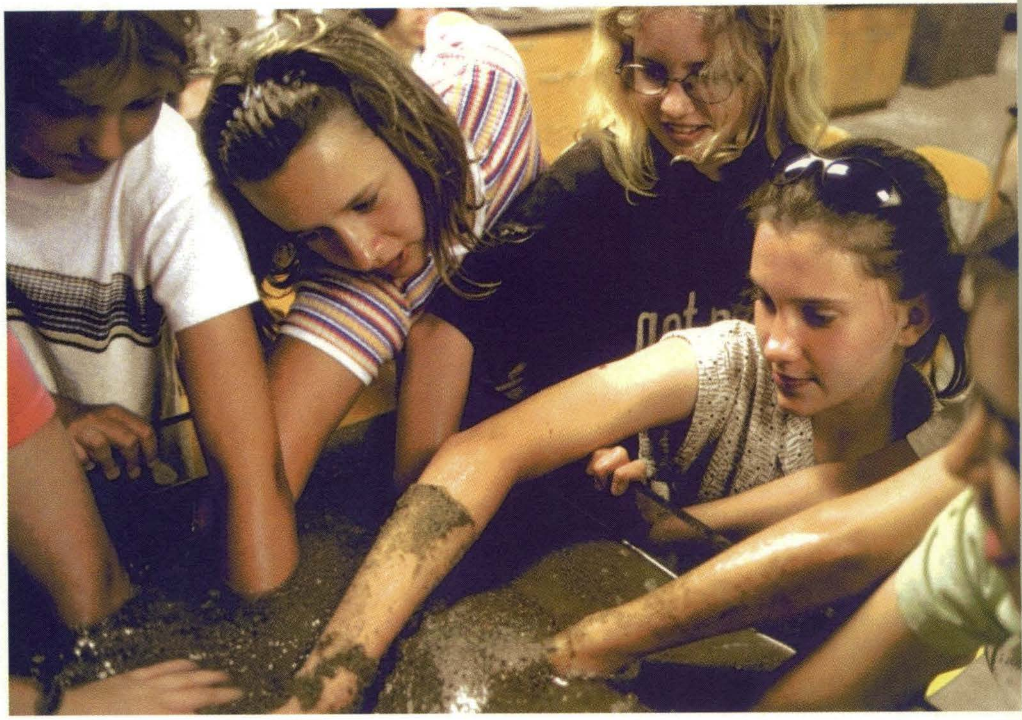
According to Eelkema, the 25-member sorority is less formal than other Greek organizations at the University and emphasizes academic excellence over social activities.

She and other sorority members hope that some of the girls who attend Science Exploration Day will one day join their ranks — if not in Alpha Sigma Kappa, then in the science and engineering workforce.

"I know how important it is for students to be encouraged when they're young," says Cordina. "I was, and that's why I'm here today." ■

FOR MORE INFORMATION visit the Alpha Sigma Kappa web site at http://www.tc.umn.edu/nlhome/g015/ask

HANDS-ON: Girls who attended Science Exploration Day participated in hands-on experiments in several engineering fields, including mechanical engineering (opposite page) and chemical engineering and materials science (left). The students test a device that demonstrate how water flowing through a sediment bed can create instability (below). They also used glue and sodium borate to create a Silly Putty-like substance (bottom).



"I know how important it is for students to be encouraged when they're young. I was, and that's why I'm here today."

■ JENNY CORDINA

Mentors make a difference

An award-winning IT Alumni Society program matches current students with alumni mentors in their field. The program helps students succeed, and mentors are discovering that it holds rewards for them as well.

by Paul Sorenson

THANKS TO THE IT ALUMNI Society, Benjamin Root is giving IT students an opportunity he always wished he'd had.

Root (Mechanical Engineering '93) is one of more than 100 mentors participating in an award-winning ITAS program that matches IT alumni with current students who share their career interests. The program offers students access to thoughtful and honest feedback, an objective perspective, a more experienced point of view, and the chance to process new challenges and opportunities with a trusted confidant.

"As a student, I would have benefited from this program," says Root. "I wish I had had someone who could have given me a better idea of what to expect, what I really needed to know [to be prepared] for life on the job. The mentor program allows me to help provide that vision for someone else."

This year, Root shared that vision with sophomore Ford Boone, who was uncertain about his career path and turned to his mentor for guidance. Together they discussed career opportunities, toured an Anderson Company window factory, and talked about Root's life as a process engineer with the company.

"I knew I wanted to do something practical, but had no idea beyond that," says Boone. "Ben helped me narrow down my options and choose what worked best for me."

According to fellow mentor Kenneth Merdan (Mechanical

Engineering '90), each mentor-student relationship is different.

"To some extent, the relationships are driven by what the students want to get out of them," says Merdan, who has worked with several students during his five years in the program. "Some are very active, others are more casual."

Mechanical engineering freshman Nicholas Skadsberg, Merdan's current student, took an active role in building the relationship. He and Merdan talked frequently, toured Merdan's workplace, and participated in several events sponsored by the American Society of Mechanical Engineering.

"Ken was a great mentor," says Skadsberg, whose interests in biomedical engineering meshed well with Merdan's role as a design engineer with SciMed Life Systems. "I learned a lot about the opportunities in today's realm. He's definitely made me more confident in my decision to pursue engineering."

The program also helped Skadsberg build personal and professional contacts. "Ken and I have become good friends," he says. "He's also helped me do some networking and make connections in industry," he adds. "Down the road, those connections may help me when it comes time to search for a job or an internship."

Chemical engineering senior Sandy Choi had already earned an internship with General Mills when she was paired with Amy Abouelenein (Chemical Engineering '89, M.B.A. '96), a research and development manager with the company.

"Our first meeting was a little nerve-racking," says Choi, who had interviewed with Abouelenein for the internship but didn't yet know that she would be offered the position.

"It turned out to be especially helpful to have Amy [as a mentor] because I got to ease into the internship and see what the work environment [at General Mills] was like before I began."

Abouelenein says she enjoys the opportunity to return to campus. "The mentor program gives me a connection to the University and an opportunity to find out about the issues facing students today," she says. "Some are the same [as they were in the

REAPING REWARDS: Junior Nathan Ziegler, senior Sandy Choi, and freshman Nicholas Skadsberg participated in the IT mentor program.

Carol Mordorski

1980s], but many are different."

Abouelenein and Choi did find a lot of common ground. "We had many of the same classes and profs," says Choi. "It was interesting to compare notes and see how things work out for her."

But mentors and students learned from each other's differences as well.

When her first student match lost interest in the program, Carol Mordorski (Civil Engineering '80) asked to be assigned to another. Although she wasn't sure what she'd have to offer freshman Azwan Shaharun, a chemical engineering major, she eagerly accepted the charge.

"I'm a civil engineer, and he was interested in chemical engineering, so I wasn't sure I could help him," says Mordorski, a project manager with the Metropolitan Council. "However, I found that environmental engineering, Shaharun's special interest, is the same in both fields, even though we don't share the same major."

Mordorski encouraged Shaharun in his studies and shared general information about life as an engineer and success at the University and beyond. "I hope he found that helpful," she says.

The interaction also turned out to be enriching for Mordorski in ways she hadn't anticipated. She learned about the people and culture of Malaysia, Shaharun's home, and was impressed by his personal courage.

"Azwan is an inspiring person," she says. "He's only 17 years old, already in his sophomore year, and halfway around the world from his home. That's pretty brave, and I really admire him for that."

According to Kristine Kosek, director of alumni relations, Mordorski's experience isn't unusual.

"Alumni really find the mentor program rewarding in many different ways," she says.

"It's more than just an opportunity to give back something to the University community. It's a chance to learn and grow, make friendships, and have fun," she adds.

Mentors can also benefit from working one-on-one with a new generation of leaders who may see opportunities and approaches that a mentor may not. Moreover, adds Kosek, mentoring provides an opportunity to explain what alumni have learned and accomplished over the course of their careers.

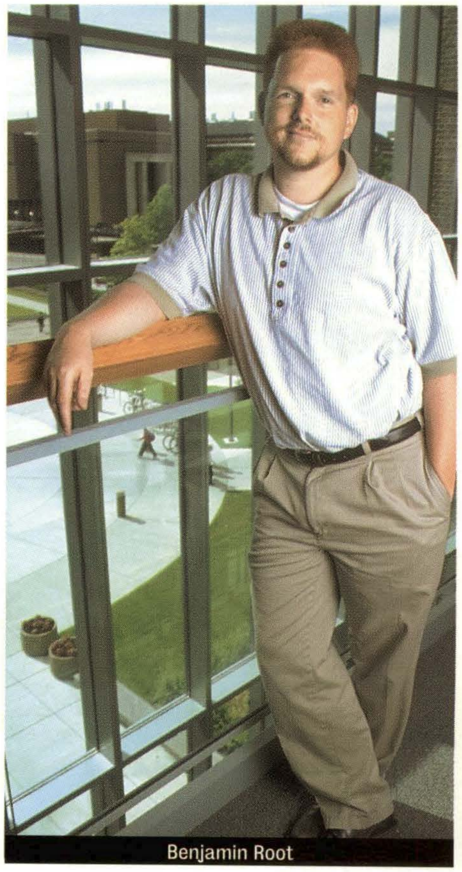
"It's really a positive experience for everyone involved," she says.

Indeed, that sentiment is echoed by mentors and students alike.

"This has been one of the most valuable activities I've been involved with at the University," says civil engineering sophomore Nathan Ziegler, who was paired with former ITAS president Robert Rosene (Civil Engineering '45, M.S. '48) this year and plans to sign up for the program again next fall.

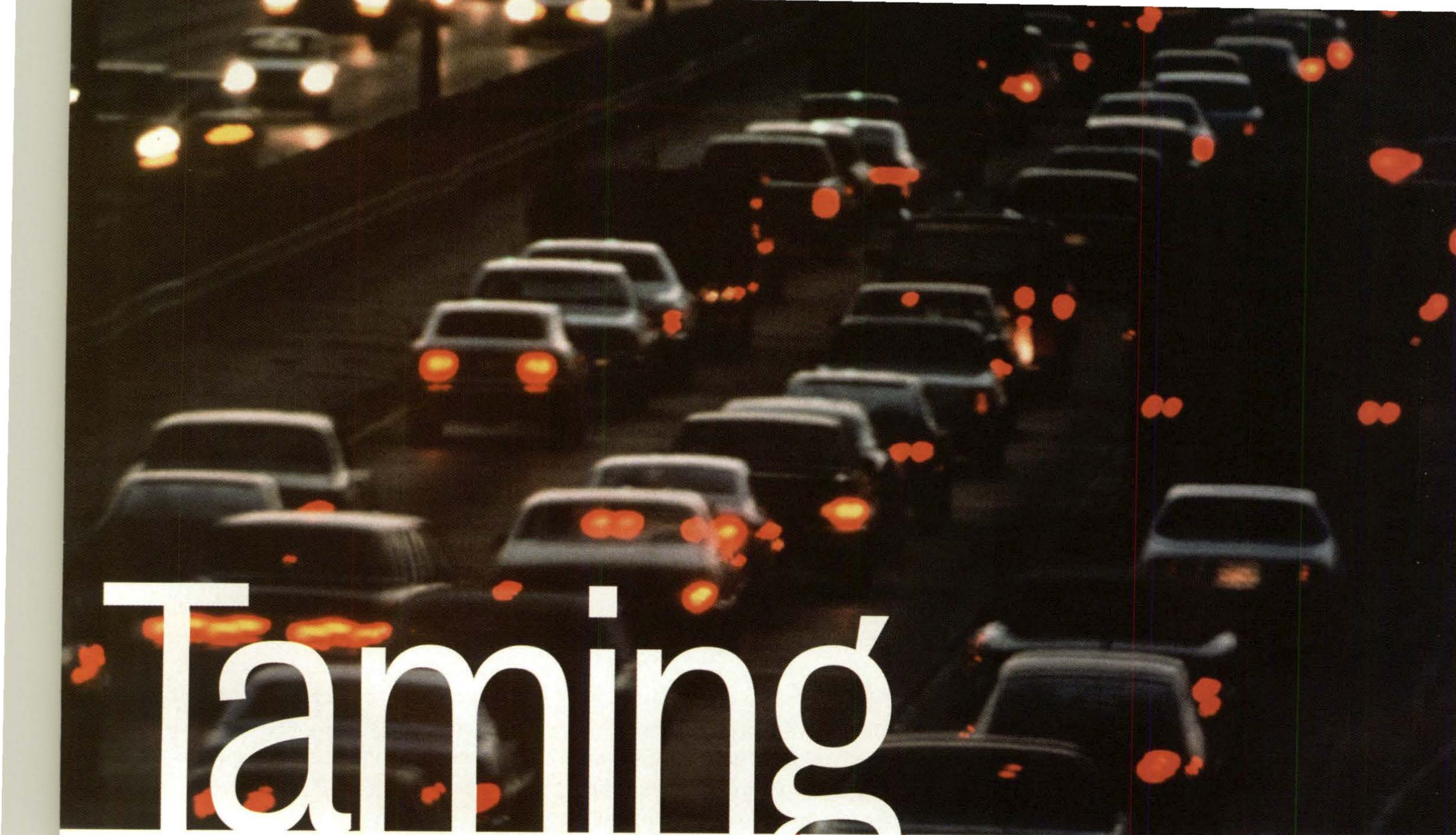
"You can't get this kind of experience in a classroom," adds Skadsberg. "Someday I'll return the favor and become a mentor myself. I'd like to help another kid like me." ■

FOR MORE INFORMATION about this and other ITAS programs, contact Kristine Kosek at 612-626-8282 or e-mail itas@itdean.umn.edu



Benjamin Root

PHOTO: JAIME CHISMAR



Taming tangled traffic

Professor Panos Michalopoulos' new computerized traffic management system eases congestion by monitoring traffic and adjusting signals interactively. It may be coming to an intersection near you.

by Josh L. Dickey

THREE STORIES ABOVE the intersection of Washington Avenue and Union Street on the University's East Bank campus, a solitary white camera monitors the bustling traffic below. The camera, perched on the corner of the Transportation and Safety Building, relays images to a blue box in the Center for Transportation Studies, where civil engineering professor Panos Michalopoulos and his students monitor the comings and goings of University commuters.

The blue box contains a revolutionary new traffic management system that uses a computer to process video images of roadways and intersections. The system, called the Autoscope, detects cars, classifies them by vehicle type, and continuously measures their volume, speed, occupancy, headway, density, and queue lengths. Researchers and traffic management engineers can use this data — more accurate and detailed than anything previously available — to guide traffic more efficiently through intersections and congested highways and to detect accidents or stalled vehicles.

Researchers at the center also gather data from 36 cameras mounted above Interstate 394 between Louisiana Avenue and Penn Avenue, where the busy freeway crosses U.S. Highway 100 in St. Louis Park. The data is recorded by a computer and later analyzed to develop traffic management strategies for the area and further improve the Autoscope's effectiveness.

Although the technology behind the Autoscope is new, the road to its implementation winds back nearly 20 years. Michalopoulos first developed a method to control oversaturated intersections for his doctoral thesis in 1975 but was unable to apply his ideas without adequate traffic-measurement technologies and advanced traffic flow models. He started to develop a model in 1977 but lacked the instrumentation for field testing and validation.

Existing devices like loop sensors wouldn't work because they couldn't provide continuous vehicle detection information. "Loops don't measure the density of the traffic, which varies with space and time," explains Michalopoulos. "So models based on loop measurements resulted in systematic errors."

His model needed more extensive data — vehicle speed, queue lengths, flow rates, density delays, lane changes, and stops — the type of data only an eye could detect. But placing human monitors at freeway intersections to gather data was too inefficient.

So Michalopoulos decided to develop his own technology for model testing, validation, and advanced traffic management.

BACKED BY THE MINNESOTA Department of Transportation, the Federal Highway Administration, and the Center for Transportation Studies, Michalopoulos and a team of scientists and engineers began work on a vehicle detection system that used artificial vision to replace the human eye.

In 1984, after seven years of research and development, the team unveiled a prototype of its new system, which used video cameras mounted atop utility poles and tall buildings to capture traffic images. Unlike loop sensors, which can detect traffic at only one point, the cameras provided continuous information about a wide area of the road.

The prototype's computer system could analyze the digitized images at 30 to 50 frames per second. However, like any first-generation technology, it wasn't without problems.

"We had to filter out much noise," says Michalopoulos. "There are many 'artifacts,' such as rain or snow or shadows, that can cause a false signal. Separating the cars from the shadows, for example, was a nightmare." Even the frantic, wind-driven flapping of an American flag at a roadside restaurant tripped the otherwise untrained sensors.

"It took a lot of trial and error and a lot of signal processing. Some things would cause problems that you would never anticipate until you actually installed the cameras."

By the time a patent was awarded in 1989, the Autoscope was ready for field testing. When the University's Office of Patents and Licensing was unable to secure a private partner to provide the $10 million needed to develop the prototype into a commercial product, Michalopoulos founded Image Sensing Systems Inc. (ISS) to further develop and market the system. ISS later wooed Econolite, a small California traffic signal control company, to join its push to put the product on the market.

In 1992, ISS sold its first Autoscopes to the city of Troy, Michigan, which eventually installed units to control more than 300 intersections.

But the first commercial model, like its predecessor, encountered problems. Once again, artifacts appearing in the Autoscope's field of vision created false signals and background variations that hindered the data-gathering process.

"We started fixing hundreds of problems, one-by-one," says Michalopoulos.

And while other companies tried unsuccessfully to duplicate the technology, the Autoscope underwent another series of improvements. The fourth-generation device, Autoscope 2004, was ready to go by the time ISS stock went public in 1995.

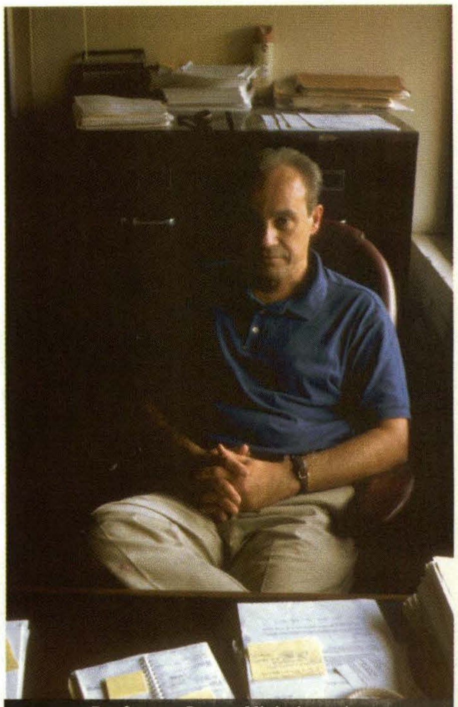
Up to four cameras can be linked to the Autoscope 2004, a blue processing box about the size of a standard personal computer. The video signals can be transmitted to the computer through radio signals, coaxial cable, or fiber-optic cable.

In 1995 and 1996, the fledgling company lost more than $2 million. But in 1997, ISS recorded $487,000 in profits and expects further growth as the technology catches on. Michalopoulos estimates that the University has already made more than $1 million in royalties from the Autoscope.

With more than 2,000 Autoscope units in more than 30 countries worldwide, including such major U.S. cities as Houston, Detroit, New York, and Minneapolis, city and state governments are becoming aware of the new technology's benefits.

"Right now, people are happy to have a detection device other than just loops," Michalopoulos says. "The market is being educated."

Other applications of the Autoscope are attracting the interest of the private sector as well. In May, ISS announced a partnership with a Massachusetts-based company, SmartRoute, that works in conjunction with telecommunications companies to provide up-to-the-minute traffic and transit reports for commuters. This service is already available in Boston, Cincinnati, Philadelphia, and Washington, D.C. Several other metropolitan areas, including Detroit, New York, and the Twin Cities, are scheduled to receive it soon.


Professor Panos Michalopoulos

"The combination of Image Sensing Systems' state-of-the-art Autoscope system and SmartRoute's SmarTraveler Advanced Traveler information services will greatly improve the performance, flexibility, and efficiency of traffic information and management processes," says Spiro Voglis, ISS president and chief executive officer. "ISS is excited about the potential this integration has for commuters and traffic managers as well as for our two companies."

ISS RECENTLY TEAMED WITH THE Minnesota Department of Transportation to install 130 Autoscope units at more than 65 intersections near and around the Target Center in downtown Minneapolis as part of an adaptive traffic control project.

Each of the 130 intelligent cameras uses the fifth and newest generation of the Autoscope, the Autoscope Solo. Each Autoscope Solo camera is self-contained, with the digital processing units located inside the camera's housing, thus eliminating the need for

TRAFFIC continues on page 18

PHOTO: CHIP PEARSON

Tuning in to edu

More than 300 students attend IT classes each quarter through UNITE instructional television. This fall, UNITE will expand its reach by offering courses over the Internet. Stay tuned!

by Andrew Tellijohn

As a mechanical engineer for Rosemount Inc. in Eden Prairie, Minnesota, Tim Bremer helps design temperature sensors that are produced in countries throughout the world. He's also working toward a master's degree at the University. But he's not doing it in the traditional way. Bremer is one of 300 students each quarter who attend University classes at their work sites through University-Industry Television for Education (UNITE).

Broadcasting on four microwave channels from the IDS tower, UNITE offers approximately 55 courses each quarter to employees at local companies. The broadcasts reach hundreds of Twin Cities students within a 35-mile radius of downtown Minneapolis. They are also transmitted to students near Rochester, Minnesota, and Chippewa Falls, Wisconsin, through alternative delivery technologies.

UNITE participants "attend" the same lectures as students who are physically present in the University classrooms, which are equipped with strategically located camera systems.

UNITE students typically watch the broadcasts in small classrooms at their

PHOTO: CHIP PEARSON

ON THE AIR: Technician Binh Truong monitors a UNITE broadcast featuring Professor David Lilja.

workplace, with homework assignments and proctored exams exchanged between the instructors and students using a mix of courier service, fax, and web-based delivery. Through a complex audio/video system, "the people in TV-Land see and hear their on-campus classmates as they ask their questions," says Ed Thorud, UNITE station manager.

Students like Bremer enjoy UNITE's amenities. "I appreciate the convenience," he says. "I don't need to drive to class each day or to find and pay for parking. I can tape my classes when there are conflicts in my schedule. I much prefer taking classes this way than going to the U."

Jody Wetterlind works at Seagate in Bloomington, Minnesota. She agrees with Bremer and mentions that the only inconvenience of taking television courses is not meeting her classmates.

"It's hard to work on team projects," she says but admits that the conveniences outweigh that sole disadvantage. "I have the ability to record classes. It's nice for business people when they're traveling. You don't end up just missing them," Wetterlind adds. She's been working toward her master's degree in computer science since winter 1993. After completing two more classes, she will have earned her degree by taking all of her classes through UNITE.

On average, 25 students annually earn master's degrees in computer and information sciences, computer engineering, electrical engineering, mechanical engineering, and materials science through UNITE. Many other working professionals take graduate courses through UNITE for career development without the objective of obtaining a degree. Though tailored primarily for graduate students, UNITE also serves undergraduates, with about five students per year finishing their bachelor's degree through the program. "I don't foresee UNITE replacing on-campus programs," says the program's director, associate professor Douglas Ernie. "What UNITE brings in are new students who, because of family or jobs or physical limitations, cannot come to campus to take the classes."

Deb Williamson, training and development coordinator for Medtronic, says the program is a convenient way for the company's employees to continue their training. About 60 Medtronic employees participated in the program during the 1997-98 academic year, she says, adding that the company pays the cost of their tuition. Williamson believes that Medtronic employees find the program to be worthwhile.

INSTRUCTORS ADMIT THAT THERE are some inconveniences associated with televised courses at the workplace. Occasionally students miss a televised session because it conflicts with an important job-related meeting. But overall, the convenience of not driving and the financial incentive most students receive from their companies make it worthwhile, acknowledges David Lilja, professor of electrical and computer engineering.

"It works pretty well," he says, adding that UNITE students often perform at a higher level than students who attend classes on campus because experience and drive compensate for many obstacles. "They're taking time out of a full-time job to do this," says Lilja. "They wouldn't be doing it if they weren't really motivated to learn the stuff."

Ernie emphasizes several areas in which the program is designed to excel. He says that providing a customer-oriented, quality product with enough delivery modes to make the broadcasts convenient is critical.

"We do our best to make the technology transparent to the faculty who teach the courses and, more importantly, to the students taking the courses," he says.

As part of this customer oriented approach, UNITE specializes in providing a complete set of courses for students who want to earn a master's degree, making the program more attractive.

"If students see a whole academic program, they'll know they can get their master's degree out of it," adds Fran Schirmers, UNITE administrative director. Currently, students should be able to obtain a master's degree through UNITE in about three years.

Founded in 1971, UNITE was also one of seven original members of the National Technological University (NTU), a cooperative effort of 49 major universities. This national effort constitutes more than 500 academic courses and 14 master's degree programs for technical professionals. Through NTU, some of UNITE's televised classes are broadcast to more than 1,300 sites in North America. The program supports itself through funding from companies whose employees attend classes.

Within the next two years, UNITE will convert to a digital broadcast format and add additional channels that will permit the program to expand its programming. "Our goal is to deliver enough courses for master's degrees in one or two more areas than we do now," says Ernie.

Also in the implementation stage is a pilot program that would deliver UNITE courses over the Internet using a technology called asynchronous streaming video. Students would be able to view a digitized version of the class session on the web using a viewer within an Internet browser like Netscape. This technology will allow anytime, any-place delivery of UNITE's programming.

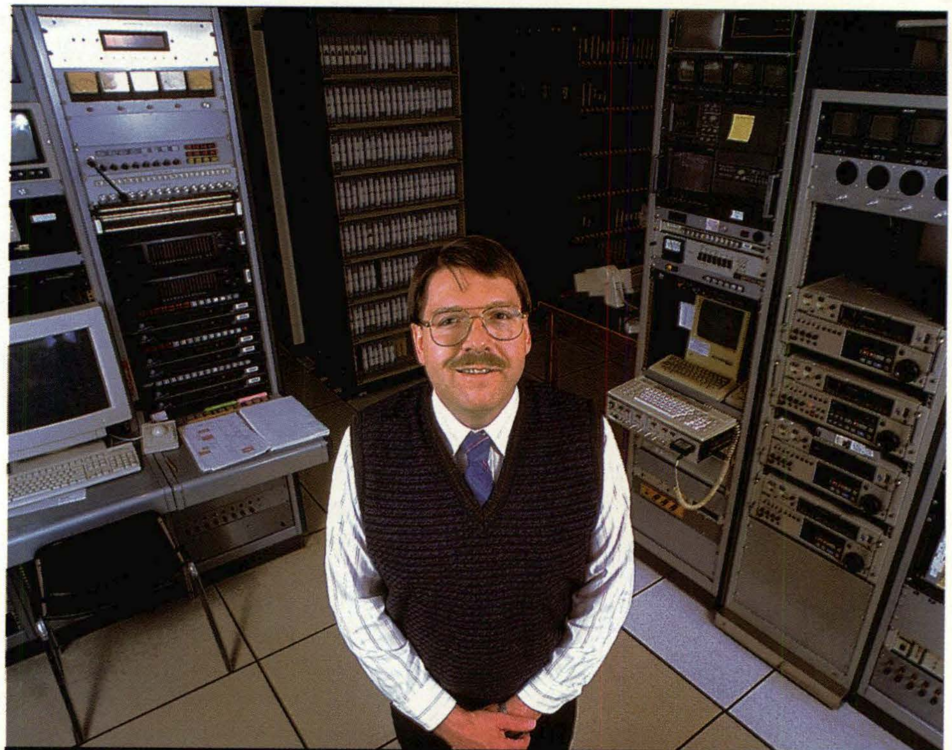
This capability will help working students who must miss a lecture due to job-related duties. Currently, students can videotape a missed class, but this method is inconvenient and unreliable, especially for students who are out-of-town on business. With this added capability, students could "connect via the Internet from their hotel

ational television

and get the course that evening so they're not falling behind," adds Thorud.

In addition, the use of asynchronous streaming video technology will allow UNITE to reach students outside its current broadcast range, giving employees of companies in Greater Minnesota better access to University courses and degree programs. If everything works out as planned, even students with slightly aged Internet equipment would be able to participate, Ernie says.

The current plan is to offer four classes via the Internet during fall quarter to on-campus students (and students at companies with high-speed network connections) using high-speed, near-broadcast quality delivery technology. In the winter, eight classes will be made available over the Internet, four using the high-speed delivery technology and four designed for slower delivery through 28.8 Kb modem connections. The latter delivery mode will allow students with lower bandwidth Internet connections to access UNITE programming.


Associate Professor Douglas Ernie

Most new UNITE students learn about the program through their company's training directors and site coordinators, through personnel contacts within their company, or from UNITE alumni who have joined other companies and introduced the program to their new employers.

"Up until the last few years, there hasn't been as much interest in distance learning," Ernie says. "Now, with more nontraditional students, it's become more important." ■

FOR MORE INFORMATION call 612-624-2332, send e-mail to unite@cs.umn.edu, or visit UNITE's web site at http://www.unite.umn.edu.

Traffic: continued from page 15

the blue boxes.

The two-year project was completed in June 1998 with the addition of another computer to the central control location.

Roger Plum, an engineer for the Traffic Management Center in Minneapolis, says the new hardware will expand the capabilities of the Autoscope's applications.

"We've set up the detectors to feed into a central computer," Plum says. "With the new computers, we can start calibrating 'on the fly.'"

As information comes into the central video hubs, the system will adjust the timing of traffic signals to move traffic more efficiently.

Additionally, Lockheed Martin Federal Systems awarded ISS an undisclosed contract to install Autoscope technology through major traffic arteries in St. Paul.

Michalopoulos believes that within several years the Autoscope will be able to interactively move traffic along much more efficiently, and video image sensing could have other unforeseen traffic-control applications in the future, such as at border crossings, prison perimeters, and railroad crossings. But several barriers still hinder the development of traffic control systems that can automatically whisk cars through intersections and clogged thoroughfares.

"The problem today is, we have the new technology, but the logic that takes advantage of it is not there yet," Michalopoulos says.

He explains that programs to eliminate specific "dilemma zones" at intersections — such as holding cars at a red semaphore going in one direction while a latecomer speeds through a yellow in the other — could easily be developed.

"You can do this stuff tomorrow," says Michalopoulos. But if such a system were implemented and an accident occurred, people might find it easier to blame the traffic control system rather than human error, he notes. Because the state would own the equipment, it could be held liable for the accident. "It would be hard to convince more conservative [officials] that this sort of thing will work 100 percent of the time.

"Of course, nothing works 100 percent of the time," he acknowledges. "But even an imperfect solution is better than no solution at all. When we deal with humans, there are no guarantees." ■

FOR MORE INFORMATION visit Michalopoulos' web site at http://www.ce.umn.edu/faculty/michalop or the Minnesota Department of Transportation web site at http://dot.state/.mn.us

PHOTO: CHIP PEARSON

From biomedical engineering and medical device development to genetic research and biological process technology, IT researchers play a major role in the growing field of biotechnology.

Here is a look at some of the innovative projects underway as part of IT's . . .

biotechnology BOOM

building a bioartificial LIVER

BY ALLISON SCHLESINGER

IT WAS THE TOUGHEST TIME OF her life. Ten years ago, Liddy Howe watched as her husband died while waiting for a liver transplant.

Now the leader of a support group for families of patients awaiting an organ transplant, she says she is amazed at the medical advances that help people who suffer from the ailments that killed her husband. Gordon Howe died of liver failure due to viral infection.

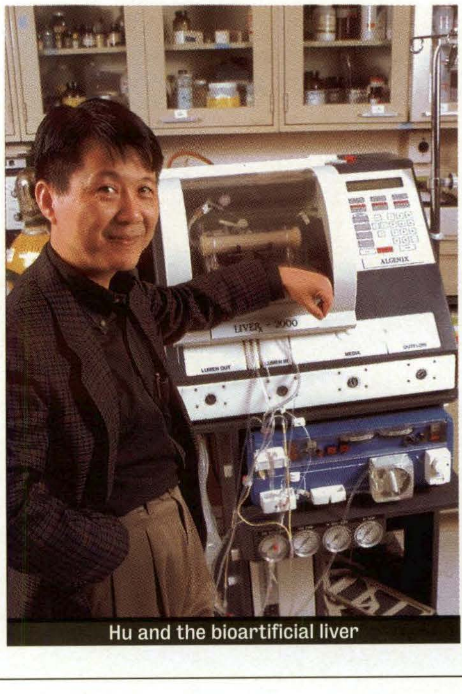
"It's a happy time when I can tell someone in my group 'your loved one can have more time.' No one told me that," Howe says.

Professors and researchers at the University are developing a machine that could aid patients like Gordon Howe. Scientists say that an artificial liver, which uses living pig liver cells, could be the bridge to a transplant. It could buy time for patients whose liver has shut down and even give some livers enough time to heal, thereby avoiding a transplant altogether.

"It should help the patient survive for a few days until a donor organ is available or until the liver can recover on its own," says chemical engineering and materials science professor Wei-Shou Hu, who leads the project along with surgery professor Frank Cerra, the University's senior vice president for health sciences.

Thousands of patients could be helped by the device. According to representatives of the American Liver Foundation, about 4,100 people receive a liver transplant each year and more than 8,000 people are on waiting lists for livers.

The new regulations set forth by the United Network of Organ Sharing underscore the importance of finding alternatives to liver transplants. The private group of transplant experts, which is overseen by the U.S. Department of Health and Human Services, has changed the rules that determine which patients will receive liver transplants.


Hu and the bioartificial liver

The bioartificial liver, which uses living pig liver cells, can be the bridge to a transplant, buy time for patients whose liver has shut down, and give some livers enough time in which to heal, thereby avoiding a transplant altogether.

Because of the chronic shortage of livers for transplants, people who suffer a sudden, unexpected illness will receive special priority for transplant. These patients often have illnesses that disable their livers, like mushroom poisoning or a rampant viral infection, says Jill Iverson, an American Liver Foundation representative.

One of the body's most important organs, the liver removes toxins from the blood and regulates the amounts of glucose, fat, and protein that enter the blood stream. It performs synthetic functions, produces molecules, detoxifies many compounds, and modifies the body's chemistry.

Liver ailments like fulminant viral hepatitis prevent the organ from removing toxins from the blood. When toxins seep into the blood, they cause the brain to swell and rupture, the most typical cause of death from liver failure. The artificial liver takes over these functions so the liver has time to heal.

The artificial liver uses pig liver cells to remove toxins from the blood stream and functions like a kidney dialysis machine. Two layers surround the pig cells — an outer casing of porous fibers surrounds an inner layer of collagen gel, which contains the cells. Blood is circulated out of the

PHOTO: CHIP PEARSON

patient's body and around the outside of the fibers, then returned to the body. Because only small molecules can pass through the protective layers, the pig cells extract the toxins without coming in contact with human blood.

This precaution is crucial, says Hu, because the human immune system will attack and gradually kill the pig cells if they come into contact with human blood. Furthermore, he says, the bioartificial liver's design reduces the risk that endogenous retroviruses in the pig cells might infect a patient. Even though the pig cells don't come into direct contact with a patient's blood, Cerra says that project scientists are developing tests to verify that retroviruses cannot pass through the layers of gel and fiber and into the patient.

Research on the bioartificial liver began about ten years ago when Hu and Cerra were faculty advisors to a student whose doctoral project involved the artificial liver. Officials from the U.S. Food and Drug Administration gave researchers permission to begin human trials two years ago. This fall, scientists will again perform the tests on more than a dozen patients who suffer from fulminant viral hepatitis.

"We hope to finish Phase I clinical trials in a year," Hu says. Phase I tests the machine for safety, and Phase II trials determine if the machine works on patients. If human trials go well, researchers hope the FDA will allow them to make the bioartificial liver available for therapeutic use in four years.

Researchers are also collaborating with a Minnesota company to conduct the human trials. Algenix Inc. has licensed the machine from the University and is looking for investors to raise the $6.5 million necessary to support further testing.

Investors are important at this stage of the project because research and development are the expensive steps in the invention of a medical device, says Hu. The University has already spent about $2.7 million on the project, most of which has come from federal grants, foundation awards, and private sector support.

University researchers are not the only scientists who are developing an artificial liver. A device developed by a Massachusetts company, Circe, has already been tested on ten patients, and researchers in Japan and Germany are also working on a similar machine.

However, Hu says, the University's device is superior because it keeps the pig cells alive and functioning longer and, unlike the other devices, prevents them from coming into contact with human blood and tissue.

Iverson says that patients and families are excited by every advance in the artificial liver field. "This is a chance for more people to live a little longer, and I think it's a chance many people have been waiting for." ■

FOR MORE INFORMATION visit the biomedical engineering web site at http://www.bmei.umn.edu or the chemical engineering and materials science web site at http://www.cems.umn.edu

A bright future for biomedical engineering

BY PAUL SORENSON

BUILDING ON MINNESOTA'S LONG tradition of biomedical innovation and excellence, electrical engineering professor Dennis Polla envisions the University as a world leader in biomedical engineering education and research.

"Imagine what we can do," Polla urged a crowd of medical technology experts who had gathered to welcome him as the new head of the University's Biomedical Engineering Institute (BMEI) at a May event showcasing current biomedical engineering research and his vision for BMEI's future.

That vision includes five initiatives that will build upon BMEI's existing strengths and thrust it into an international leadership role in the 21st century, says Polla. They include:

- creating an undergraduate program
- forming multidisciplinary research teams
- expanding interactions with industry
- redefining the BMEI faculty
- creating a national academic model for biomedical engineering

Undergraduate Program "Creating the undergraduate program is a top priority," says Polla. Students admitted into BMEI's first freshman class in fall 2000 can choose between a four-year bachelor's degree program or a five-year program that combines a master's degree in biomedical engineering with a bachelor's degree in another engineering discipline.


Polla

BMEI faculty members are working with IT, the Medical School, and other University officials to develop the undergraduate curriculum and to revamp BMEI's existing master's and doctoral programs.

"The undergraduate program will be tremendously successful because of the rich set of experiences we can offer in science, engineering, and medicine," says Polla.

BIOMEDICAL ENGINEERING continues on page 41

PHOTO COURTESY DENNIS POLLA

safer, simpler SURGERIES for cataract patients

BY PAUL SORENSON

CATARACT REMOVAL, THE most common surgical procedure in the United States, may also become one of the simplest, thanks to new tools designed by researchers at the Biomedical Engineering Institute.

Professors Arthur Erdman and Dennis Polla, in collaboration with Cleveland-based Micro Medical Devices Inc., developed two revolutionary handheld tools that help surgeons remove cataracts and deploy new replacement lenses.

In the first stage of cataract surgery, one tool operates like a jackhammer to break up and vacuum out fragments of the lens. Because the fragile capsule beneath the cornea will leak vitreous fluid if the surgeon inadvertently punctures it during an operation, the device includes sensors that differentiate between hard and soft tissues and emit visual and audio warning cues to guide the surgeon.

After the cataract has been removed, the surgeon uses the second tool, including a plastic cassette that attaches like a bayonet, to deliver a folded replacement lens that gently opens when it reaches the eye. This tool contains a tiny electric stepper motor that operates like an inchworm, explains Erdman.

During the operation, the motor pushes a miniature rod out of its barrel at a rate of one less than one micron per step. Voltage waveforms achieve the smooth motion necessary for surgical precision.

Polla, who heads the Biomedical Engineering Institute, worked with colleagues and graduate students at the Microtechnology Laboratory to create the devices' sophisticated electronic components. Erdman, an expert in microelectromechanical devices, designed their housing and mechanical systems in cooperation with graduate students and colleagues in several University shops.


Erdman and a projected image of the surgical device

That process wasn't easy, he says.

"First off, the entire thing had to fit within a handpiece that was no larger than a fountain pen," explains Erdman. "That in itself was a big challenge." The device also had to deliver one-half to three-quarters of a pound of force in tiny increments of 30 to 50 nanometers, have a total displacement of one-and-a-half inches, incorporate sophisticated electronic sensors, and withstand harsh medical sterilization procedures.

One device helps surgeons break up cataracts and vacuum them out of the eye. The other automatically deploys replacement lenses. Each contains a tiny electric stepper motor and is smaller than a fountain pen.

"Our job was to make it all work," he says.

Once the prototype was complete, Erdman also designed a testing apparatus to ensure that the device worked properly. The team received a patent for the model, and Micro Medical Devices manufactured it for clinical trials.

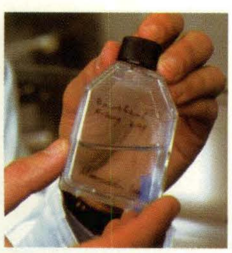
After three years, those trials have demonstrated several immediate advantages for patients, including an incision almost one-third smaller than that required by existing techniques (which reduces the risk of infection, astigmatism, glaucoma, or even blindness), a shorter recovery time, and more affordable costs.

Members of the research team have also benefited from seeing their design implemented, says Polla. Team members were thrilled to be present when patients' bandages were removed after the surgery.

"Improving the human condition is an exciting motivation," he says. "The tremendous positive reinforcement leads to outstanding research." ■

FOR MORE INFORMATION visit the biomedical engineering web site at http://www.bmei.umn.edu

PHOTO: JAIME CHISMAR



better bioartificial arteries

BY PAUL SORENSON

FOR DECADES, SCIENTISTS have aspired to create effective biocompatible "replacement parts" for human tissues damaged by injury and disease. Although many of these new parts are fabricated from inorganic substances, two University researchers have undertaken the challenge of creating artificial coronary arteries from biological material.

Daniel Mooradian, an assistant professor of biomedical engineering, and Robert Tranquillo, an associate professor of chemical engineering and materials science, began developing the bioartificial artery as part of a collaborative tissue engineering project in 1992.

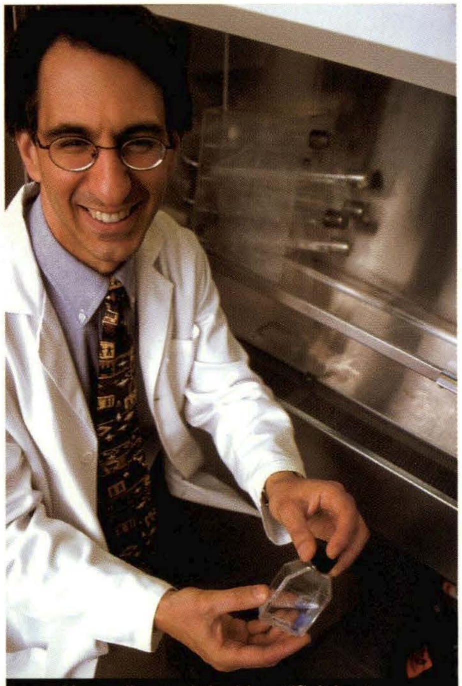
The two researchers have been exploring ways to grow smooth muscle cells that mimic both an artery's form and its internal structure by using three-dimensional collagen matrices as a framework for the cells.

A natural polymer-like collagen offers many advantages, explains Tranquillo. Not only is collagen in ample supply, it also provides an excellent natural substrate for cell growth that can be reabsorbed into the body.

However, notes Mooradian, "When you build an artificial artery on a biological base rather than a synthetic base, several things, most notably mechanical strength, become an issue."

The team's early efforts, carried out by an undergraduate summer fellow in Mooradian's laboratory, produced a cell-populated matrix that maintained the shape of an artery but lacked the internal structure and strength necessary to function.

"To be successful, we knew we would have to mimic the cellular structure of an artery, not just its form," says Mooradian.



Mooradian and the bioartificial artery

That meant, among other things, increasing the artery's mechanical strength and finding a way to grow its cells in a circular alignment.

"The biggest obstacle [to increasing mechanical strength] is that collagen gels are so flimsy," explains Timothy Girton, a graduate student in Tranquillo's laboratory. However, advanced techniques in materials science and engineering have provided important insight into possible solutions.

Girton, Tranquillo, and Mooradian demonstrated that fabricating the cells in a magnetic field and incubating them on a rigid cylindrical rod greatly stiffens the resulting bioartificial artery. Moreover, the magnetic field causes the collagen and cells to align around the circumference as they do in a natural artery.

The researchers have issued several joint publications on the technique, and a patent is pending.

"Magnetic field processing has the advantage of being a scale-independent technique," explains Tranquillo. "We can use it to create arteries of any length, and the material aligns uniformly at all points."

The bioartificial arteries are grown in a collagen matrix and mimic both the structure and form of natural arteries. They may someday be used to replace diseased or damaged coronary arteries.

Having shown that magnetic fields can be used to engineer the artery's microstructure, Tranquillo's team must now investigate how cyclical stress affects its mechanical properties. Future experiments will replace the rigid rod used during the incubation period with an inflatable one that applies stress at the human pulse rate. This is an area of great interest to Mooradian as well.

"The mechanical connections between cells and collagen are reciprocal," explains Mooradian. "Cells exert a force on collagen, leading to compaction, remodeling, and an increase in mechanical strength." In turn, the pulsing flow of blood deforms the collagen, exerting pressure on the cells that changes their behavior.

"Our efforts have focused on understanding how this process — 'mechanotransduction' — takes place at the molecular level," says Brenda Ogle, a graduate student in Mooradian's laboratory. Ogle has identified specific proteins produced by vascular smooth muscle cells that play a critical

ARTERY continues on page 47

PHOTO: JAIME CHISMAR

putting tumors on ice

BY PAUL SORENSON AND DAVID HYLAND

FREEZING COLD CAN'T CURE cancer, but it does provide doctors with new surgical tools and techniques that may revolutionize treatment of the deadly disease.

Cryosurgery, the use of selective freezing to destroy diseased tissues, provides an alternative to standard surgical techniques and, in some cases, may offer new treatments for previously inoperable tumors.

The procedure destroys cells by freezing them with probes cooled by cryogens such as liquid nitrogen or expanding gases like carbon dioxide, argon, or nitrous oxide. Commonly used to treat surface skin disorders, cryosurgery is evolving as a method to destroy visceral tumors in the prostate and liver and — in the future — breast and uterine fibroids. In these operations, the surgeon inserts a probe through a small opening in the body and uses ultrasound or other imaging techniques to locate the tumor and to apply cooling agents to the targeted area. The tissue then freezes and forms an ice ball that kills the surrounding cells.

Cryosurgery has been performed successfully in more than 100 medical centers worldwide. It is a more localized, less invasive treatment than traditional surgery, and some evidence suggests that it elicits a sympathetic immunological response that assists the body in ridding itself of a tumor after treatment. Still, surgeons are reluctant to embrace the technique without a more complete understanding of how and why it works.

Associate Professor John Bischof in the Bio Heat Transfer Laboratory

John Bischof, an associate professor of mechanical engineering and biomedical engineering, hopes to provide that understanding. An expert in thermal science in biological systems, Bischof created the Bio Heat Transfer Laboratory to answer basic questions about how the application of extreme temperatures affects individual cells and whole tissues. How much of the tumor and surrounding tissue is destroyed? What biophysical changes occur in surrounding tissues and cells? How well does the body respond to the procedure? Bischof's answers may provide the key to improved techniques and success rates.

Cryosurgery, the use of selective freezing to destroy diseased tissues, provides an alternative to standard surgical techniques and may offer new treatments for previously inoperable tumors.

"Compiling quantitative data to understand what happens when a surgeon inserts the freezing probe into tissue and begins freezing is the obvious first step," says Bischof, "but it's not easy to do."

Cryomicroscopes can measure the freezing process in light-transparent single cells, but little data is available for the biophysics of freezing in whole tissue, which is opaque. Using a group of novel tools and techniques — including low temperature light microscopy and differential scanning calorimetry — Bischof can quantitatively measure the biophysical events that occur during freezing that affect tissue preservation or destruction. Working with urologist John Hulbert and cell biochemist Ken Roberts, Bischof is using a rat prostate tumor model to investigate biophysical as well as biochemical changes after cryo-injury.

"Although cryosurgery is expected to kill all of the tissue during the procedure," ex-

PHOTO: CHIP PEARSON

plains Bischof, "the mechanism of death is what remains unclear." In the rapidly frozen tissue nearest the probe's tip, for example, most of the water freezes inside the cells and kills them outright. However, in areas located farther from the probe, where the cooling rate is slower and the tissue dehydrates extensively, surviving single cells have been rescued and used to grow a new tumor.

Bischof's research indicates that the mechanism of cryosurgical destruction is not always cellular. "In fact," he adds, "it is likely to be linked to the destruction of the vascular space and perhaps an immunological mechanism within the body."

More complete understanding of these processes will benefit patients by improving cryosurgical procedures.

"Our results indicate that optimum practice to kill the tumor in the body may not be the same as optimum practice to kill tumor cells in the lab," says Bischof. "Therefore, in contrast to current practice of cryosurgery, faster cooling rates, longer freezing times, and lower temperatures may not always increase the effectiveness of a cryosurgery."

He recently completed work on a new surgical insulating probe that can be used with the freezing probe to more effectively freeze diseased cells without harming normal ones. In addition to work in thermosurgery, he also studies the use of freezing techniques to preserve sperm and liver cells.

Bischof's colleagues recently recognized his contributions by electing him to the board of governors of the Society of Cryobiology, an organization whose interdisciplinary membership typifies the burgeoning field.

"[Cryobiology] is a blend of engineering, biology, and clinical science," says Bischof. "It is a field that will only continue to grow." ■

FOR MORE INFORMATION visit Bischof's web site at http://www.me.umn.edu/groups/bhmt or the Biomedical Engineering Institute web site at http://www.bmei.umn.edu

developing double-duty DIAGNOSTIC TOOLS

BY PAUL SORENSON

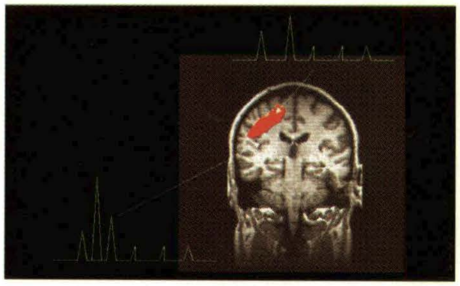
IN A CAVERNOUS BUILDING TUCKED below campus on the Mississippi River flats, researchers at the University's Center for Interdisciplinary Applications in Magnetic Resonance are working to integrate two very different tools that allow medical experts to probe the inner workings of the human brain.

Led by center director Bruce Hammer, an associate professor of radiology and biomedical engineering, and Priscilla Cushman, an associate professor of physics, the research team is developing a device that will perform simultaneous magnetic resonance imaging (MRI) and positron emission tomography (PET) scans.

Used separately, the two techniques have provided important insights into brain functions. Combining them, says Hammer, will enhance their strengths and minimize their limitations — opening the door to further insights and discoveries.

PET scans are used to study physiological functions of the brain and to diagnose anatomic anomalies such as strokes, brain tumors, and aneurysms. The technique measures positrons emitted during the decay of radioactive elements injected into the body. The positrons combine with electrons to produce two energetic photons. These energetic protons are converted into visible light by a ring of scintillation crystals through which the patient's body is passed.

During a PET brain scan, for example, a patient is injected with glucose treated with radioactive tracers. Because glucose is the primary source of energy for the brain, regions with high levels of activity correspond to higher levels of glucose, hence high tracer concentrations. Therefore, regions of high gamma radiation detection coincide with regions of high metabolic activity in the brain.



SIMULATED SCAN: A coronal MRI scan with simulated magnetic resonance spectra from a normal region of the brain and a region of the brain affected by Parkinson's disease. The red overlay is a simulated PET image of neurotransmitter distribution. Unlike MRI images, PET images do not display anatomical landmarks.

In contrast, MRI scans use radio waves and a strong magnet to produce detailed cross-sectional images of a patient's anato-

IMAGE COURTESY BRUCE HAMMER

my. Unlike other types of medical scanners, MRIs provide very good soft tissue resolution and are used extensively to diagnose a wide variety of diseases and injuries.

A hybrid scanner would allow medical experts to correlate the two types of images, says Hammer. For example, a magnetic resonance image obtained at precisely the same location and time as a PET image could be used to determine the precise structural location of metabolic activities.

"Simultaneous PET and MRI scans would also be more accurate and less troublesome for doctors and patients alike," says Hammer. Simultaneous scans also eliminate the need to transfer patients from one piece of equipment to another.

Moreover, Hammer's earlier research suggests that PET images could be sharpened by acquiring them in a magnetic field. A strong magnetic field perpendicular to the positron's path causes the positron to spiral, thus limiting the distance it can travel and improving the scan's resolution.

"You want to detect the energy where it was created, not where it ends up," says Cushman.

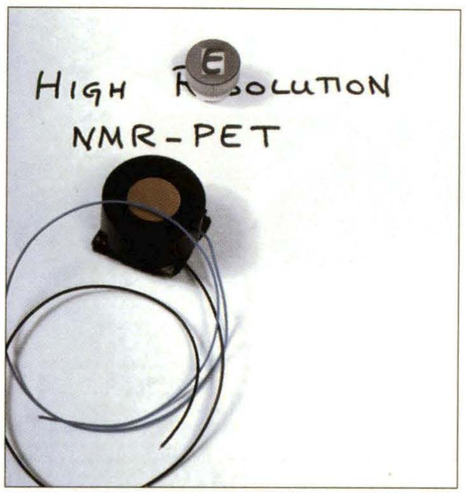
Higher resolution images would clearly make the technique more useful, adds Hammer, and resolutions could be further improved by using smaller scintillation crystals, low-noise detectors, and smaller-diameter detector rings.

But combining the two techniques presents significant challenges. The technology needed for magnetic resonance techniques can adversely affect the performance of the PET detector, and vice versa.

In particular, the photomultipliers that PET scanners use to convert photon energy into electrical signals do not work in a strong magnetic field. Conversely, some photomultipliers with magnetic components can distort the uniform magnetic field that is essential for clear magnetic resonance imaging.

To overcome these obstacles, Cushman turned to technology she had developed in 1994 for use in high-energy physics experiments.

Using that technology, she developed a PET detector based a photodiode potted inside a proximity-focused image intensifier called a hybrid photomultiplier tube. Unlike conventional photomultipliers, the new detector will function in a strong magnetic field.



DOUBLE-DUTY: Associate professors Bruce Hammer and Priscilla Cushman (above) display the giant magnet used in the development of their MRI/PET ring, which is based in the Center for Interdisciplinary Applications in Magnetic Resonance. Cushman's hybrid photomultiplier (left) makes the dual-purpose device possible.

According to Cushman, the key is turning the hybrid tube at a 90-degree angle with respect to the scintillating crystals to align it with the field. But that also requires the use of fiber-optic material to direct the light produced by the crystals around the 90-degree bend and into the tube.

"We will lose some energy [in the transition]," says Cushman. "The question is, how much?"

Because hybrid scanners based on this technology can be made in a relatively compact size, they have many potential research applications, including the study of metabolic functions in small laboratory animals, says Cushman.

This summer, she and Hammer plan to build one segment of a MRI/PET ring at the center and test its effectiveness by scanning a radioactive source embedded in material that simulates human tissue and by analyzing the resulting image. Once the initial tests are completed, they will apply to the National Institutes of Health for further funding to build and test a full-scale prototype.

Cushman is hopeful that the NIH will share her team's enthusiasm for the project.

"Our scanner has the potential to go to sub-millimeter resolution," she says. "That represents a significant advance." ■

FOR MORE INFORMATION visit the center's web site at http://www.ciamr.umn.edu

PHOTOS: CHIP PEARSON

unraveling RNA and understanding its role in HIV infection

BY PAUL SORENSON

Karin Musier-Forsyth

ASSOCIATE PROFESSOR KARIN Musier-Forsyth is using her expertise as a chemist to solve important health-related problems and to understand some of life's most perplexing biological mysteries.

Armed with a wide variety of chemical and physical tools, Musier-Forsyth is exploring how proteins and viruses recognize and interact with ribonucleic acids (RNAs), the complex molecules that translate and carry out genetic instructions encoded in DNA. Those explorations, coupled with her interest in health-related issues — led her to study RNA's role in the life cycle of HIV, the virus that causes AIDS.

"Because HIV is a retrovirus, its [genetic material] is coded in RNA, not DNA," she explains. "When HIV infects a host cell, its RNA genome has to be converted into DNA. HIV actually recruits an RNA from the host cell to perform the first step in that process," called reverse transcription.

"Why is that specific host RNA used? How is it recruited? And how does that 'priming' step work? Those are the questions we hope to answer."

If successful, Musier-Forsyth's research will provide chemical insights that may lead to new therapeutic approaches for the treatment of HIV. "If you understand that first step, you can design inhibitors that may prevent it from happening," she says.

But new HIV treatments based on this research are a long way down the road, cautions Musier-Forsyth, and are not a certainty. "First we have to get an inhibitor to work in a test tube, then we will have to collaborate [with medical experts] to test it out in vivo," she says.

Now in its fourth year, the HIV project has expanded to include a collaboration with Professor Paul Barbara. "We are on the verge of making some breakthroughs in this area," she says. "It's very exciting."

Musier-Forsyth's research team is also studying how RNAs interact with amino acids as they assemble protein molecules according to the instructions encoded in a cell's DNA.

During that process, special enzymes cause a reaction that attaches specific amino acids to RNA molecules called transfer RNAs that are encoded to receive them.

"It's essential that each transfer RNA binds with the correct amino acid," says Musier-Forsyth. "If the system gets messed up, then the wrong amino acid is delivered to the site of protein synthesis, and the cell will die."

To learn more about how amino acids recognize transfer RNAs, Musier-Forsyth chemically synthesized transfer RNA molecules that were missing specific atoms and observed how the absence or presence of those atoms affected enzyme recognition. This research led to the discovery that, unlike the universal genetic code of DNA, recognition of the code in transfer RNAs may vary through evolution.

RNA plays a critical role in the life cycle of the HIV virus. Understanding that role may lead to new therapeutic approaches for the treatment of HIV.

Musier-Forsyth has also detected variations in the transfer RNA recognition process between bacteria and mammals, a discovery that may yield important medical benefits.

"Now that we are beginning to understand these species-specific differences in transfer HIV recognition, we can design inhibitors that may kill bacteria and leave human cells unaffected," she says. "With the recent emergence of antibiotic-resistant microbes, this approach holds promising new medical potential." ■

FOR MORE INFORMATION visit the chemistry web site at http://www.chem.umn.edu

PHOTO: CHIP PEARSON

harvesting genomes to feed the world

BY PAUL SORENSON

GENETIC ENGINEERING PROMISES to revolutionize both medicine and agriculture by giving doctors new tools for diagnosis and treatment and by enabling biologists to create new strains of fruits, vegetables, and grains that are hardier, more nutritious, and more flavorful.

But those breakthroughs won't happen overnight. Before researchers can precisely manipulate an organism's DNA to create a desired effect, they must map and analyze its entire genetic code, or genome, to determine which genes correspond with specific traits. That process involves collecting and organizing enormous amounts of genetic information.

"Researchers are generating [genome] data on a scale no one ever dreamed of before," says Ernest Retzel, director of biocomputing for the University's Academic Health Centers. The challenge, he says, is to find a way to organize and analyze unprecedented amounts of data.

Toward that end, he and an interdisciplinary research team led by Professor Vipin Kumar are designing new computer techniques for working with genetic data.

"At one time, data acquisition was the slow part," says Retzel. "We could analyze data using old computer techniques on new CPUs and keep ahead. Now, [researchers] are generating so much data, the bottleneck is in the analysis."

FEEDING THE WORLD: Researchers are gathering and analyzing data that will help them genetically enhance rice and other grains to better meet the nutritional needs of the world's population.

Kumar

Srivastava

Analyzing genetic data is unusually difficult because so many variables in the data are interconnected, and different labs have varying standards of data collection. Moreover, few existing techniques apply to this kind of "high-dimensional" data.

"This is perhaps the most challenging data-mining problem that exists," says Jaideep Srivastava, an associate professor of computer science and member of the research team. "The knowledge to be gained is of the most complex kind."

To meet that challenge, the team is developing new computer programs to help biologists integrate and visualize genetic data from various sources and examine it to identify structural and functional patterns linked to specific traits. Once researchers link patterns to functionality, they can begin to manipulate both.

"You don't need to think of a cell as magical anymore," says Retzel. "It's a system you can tweak like anything else."

Retzel and research associate Elizabeth Shoop provide the biological expertise and data around which the project is built. Kumar, Srivastava, and fellow computer scientists Ravi Janardan, George Karypis, and Shashi Shekhar are working to formulate and solve the computational problems. Once those problems are solved, the team will produce a collection of data-mining, data-integration, and data-visualization software for other biologists to use.

Computer scientists are working with biologists to develop new software tools to collect and analyze genetic data from a wide variety of plants.

The project is being developed and tested using genetic information from a wide variety of plants — including soybeans, rice, eucalyptus, and corn — because the group wanted to avoid the ethical issues that might arise from working with animal or human DNA. They also share a common concern about the world's food supply.

"Food production and population growth are way out of sync," says Retzel. "The 21st-century problem will be sustainable agriculture." He hopes the team's research will speed development of genetically enhanced crops to better meet the nutritional needs of the world's burgeoning population.

"For example, 90 percent of the world relies on rice as a major source of food," he says. "Using these tools to enhance its yield and improve its resistance to disease should be a top priority." The group is collaborating with researchers in other University departments and in universities and companies

GENOMES continues on page 47

PHOTOS: JAIME CHISMAR

porcine vaccines with human potential

BY JOSEPH CARLSON

If Anuradha Subramanian is successful, the livestock of the 21st century will provide not only food but also vaccines for humans and other animals.

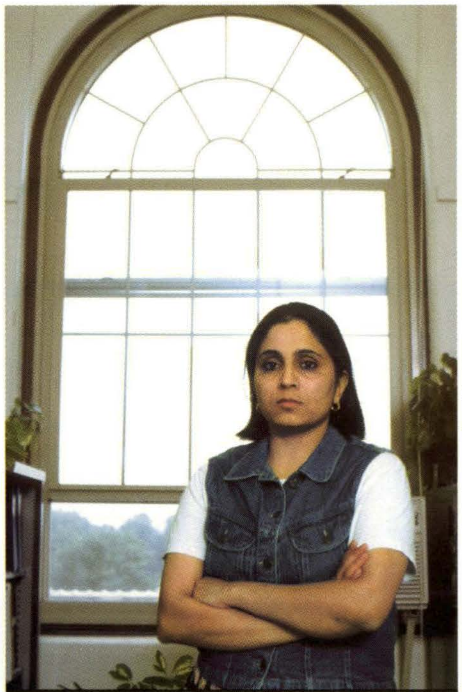
Subramanian, an assistant professor of biosystems and agricultural engineering, is working on a new project to produce a vaccine to fight a common disease in pigs, Porcine Respiratory and Reproductive Syndrome. But PRRS — pronounced "purse" — is just the test subject for a cutting-edge technique that employs DNA recombination and the bellies of mammals as bioreactors to produce proteins and other essential biological components.

It's a long road to that point, however, and Subramanian's work faces many challenges. Researchers in the Department of Veterinary Pathobiology had already accomplished the difficult first step, isolating the virus's genetic code. So rather than reinventing the wheel, Subramanian obtained a copy of the PRRS nucleotide sequence, the genetic recipe for the virus.

Department researchers had been working on decoding the DNA of the virus for years before Subramanian had embarked on her project, says Kay Faaberg, a senior research associate and head of a project studying PRRS. In fact, several scientists shared Subramanian's theory of using DNA technology to find a vaccine.

"There are several researchers who have done this before," Faaberg says. "It's just a question of being able to create the system in order to produce these things."

Certain proteins are responsible for the creation of antibodies that fight the virus. A vaccine simply tells the body how to produce the biological weapons that fight the virus; these proteins carry the instructions. Ironically, the PRRS virus carries the means of its own self-destruction, the protein that instructs the body how to produce the killer antibodies. It's just a matter of getting enough of the protein to produce an adequate level of antibodies.



Anuradha Subramanian

"There are many diseases that affect humans and animals, and what you need are proteins," Subramanian says. "Nucleic acids help in making many copies of the virus, and the proteins create antibodies."

Her experiment separates the proteins in the virus from the nucleic acids that help it to reproduce. Once Subramanian has isolated the protein, she hopes to manipulate its DNA so that it will produce the vaccine after it is inserted into the genetic sequence of other cells.

> Subramanian is developing a cutting-edge technique that employs DNA recombination and uses the bellies of mammals as "bioreactors" to produce proteins and other essential biological components.

The next step will be to insert the proteins into an animal, causing it to reproduce the compound inside its body. The animal's milk will then contain ample amounts of the protein, which can be filtered out using noninvasive techniques that do not harm the animal.

If her project is successful, Subramanian hopes it can be applied to human needs as well. Hemophiliacs, for example, could benefit from it without depleting the already-low blood supply. The chemical they need could simply be produced by animals, she says.

Right now, creating vaccines and compounds for human use is a long way off. But Subramanian is encouraged by the support she's received from the Pork Producers Council for her efforts to find a vaccine for PRRS. With that support, she hopes to further her research and develop the technique for use in other areas of genetic science.

"There is a need for research to better understand this disease," she says. ■

FOR MORE INFORMATION visit the biosystems and agricultural engineering web site at http://www.bae.umn.edu

PHOTO: CHIP PEARSON

purifying proteins with new chromatographic techniques

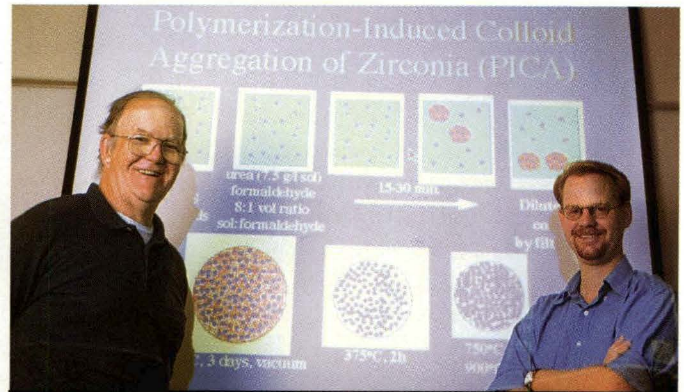
BY PAUL SORENSON AND JOSEPH CARLSON

LIKE FARMERS SEPARATING wheat from chaff, scientists developing new drugs must find ways to isolate useful proteins from other molecules, including undesirable toxins and molecular debris. Liquid chromatography, the technique normally used in this process, is limited by the type and temperature of material with which it can be used. But a team of IT researchers is developing new materials that will remove those limitations and broaden chromatography's effectiveness across a wide range of applications.

Liquid chromatography works through selective adsorption, explains chemistry professor Peter Carr, who leads the team of researchers developing the new technique. In a chromatograph, particles of silica gel are packed together in a dense columnar mass that acts as a selective adsorbent. As fluid moves through the column, molecules of different types pass through it at varying rates. By carefully adjusting the surface chemistry of the silica particles, scientists can design chromatographic media to purify and analyze a wide range of substances, including proteins and amino acids.

> Scientists use chromatography to purify proteins and separate mixtures of complex molecules. Researchers have engineered a new medium that improves its effectiveness with a broad range of chemical materials.

Although liquid chromatography has been widely used for years, Carr and Alon McCormick, an associate professor of chemical engineering and materials science, discovered that the technique could be improved by using zirconia as the chromatographic media rather than silica. For example, zirconia-based liquid chromatographs can function at higher temperatures and process materials under more acidic and basic conditions.



Peter Carr and Alon McCormick

According to Carr, zirconia-based chromatographs are also more useful in biotechnology applications because, unlike those based on silica filtering agents, they can be sterilized with a strong base to remove pyrogenics, the toxic by-products of protein harvesting that "stick like hell to everything."

The new media will also improve liquid chromatography's applications in environmental and chemical analysis, forensic science, biochemistry, and industrial chemistry laboratories, he adds.

Carr began exploring the use of zirconia in liquid chromatography during a collaboration with 3M in the early 1980s. The company eventually pulled out of the project, leaving Carr to continue the research with McCormick and other colleagues, including Professor Michael Flickinger and Assistant Professor Anuradha Subramanian, at the University's Biological Process Technology Institute.

Since then, Carr and McCormick have focused on the complex chemical analysis and modifications required to develop zirconia as effective chromatographic media, earning several patents for their work.

In 1995, the University licensed several of those patents to ZirChrom Separations, a company founded by Carr and a former graduate student to manufacture the zirconia-based chromatographs. According to Clayton McNeff, ZirChrom's vice president and director of research, most of the company's sales are to large pharmaceutical corporations like Novartis.

ZirChrom also has earned state and federal research grants to develop the technology further. With that funding, the company is sponsoring a collaboration with McCormick to discover ways to improve the raw colloidal materials used to create the zirconia. Another grant supports a joint project with Subramanian to develop techniques for purifying monoclonal IgG antibodies and other larger molecules.

Future University-industry collaborations are inevitable, says Carr.

"The biotechnology applications alone [for this new technique] are staggering," he says. "We've only just begun exploring the possibilities." ■

FOR MORE INFORMATION visit the Biological Process Technology Institute web site at http://biosci.cbs.umn.edu/bpti

PHOTO: JAMIE CHISMAR

redesigning antibiotics to beat resistant bacteria

BY PAUL SORENSON AND DAVID HYLAND

SINCE THE DISCOVERY OF PENIcillin in the 1920s, physicians have used antibiotics to treat bacterial infections ranging from pinkeye to pneumonia. As a result, many once-deadly illnesses no longer pose significant health threats to the general population.

But as doctors prescribe antibiotics with increasing frequency — often improperly — many pathogenic bacteria are becoming resistant to the drugs. These new strains of resistant bacteria may cause virulent infections that are immune to current treatments, posing a serious threat to human health.

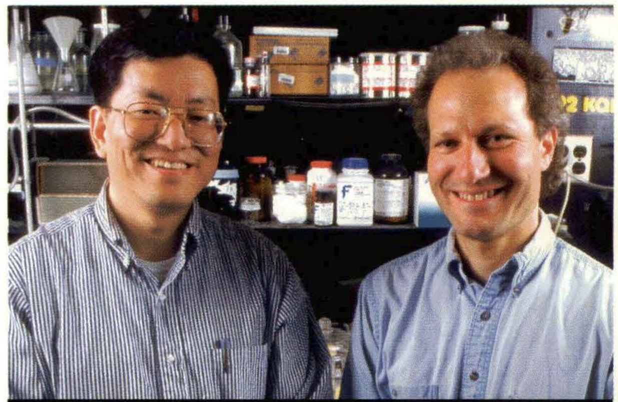
Although some researchers have begun arbitrarily screening compounds in search of new antibiotics, chemistry professor Hung-Wen Liu and his colleagues are using genetic engineering techniques to redesign existing antibiotics to overcome bacterial resistance.

Liu's research focuses on a group of antibiotics called macrolides, which kill pathogenic bacteria by binding themselves to special receptors on the bacteria's ribosomal RNA, thus preventing protein synthesis. By altering those RNA receptors slightly, bacteria can prevent specific macrolides from binding with the receptors.

> Hung-Wen Liu and David Sherman are using genetic engineering techniques to redesign existing antibiotics to overcome bacterial resistance.

"However," explains Liu, "if you then modify the macrolide's structure slightly, you may be able to bypass the bacteria's defense mechanism."

To make those modifications, Liu is working with Professor David Sherman of the Biological Process Technology Institute to alter the genetic sequence of the organisms that synthesize the macrolides. These genetic changes may cause the organism to synthesize macrolides with a structure different enough to fool the bacteria's defenses, says Liu.


Hung-Wen Liu and David Sherman

"If we shuffle genes or exchange them with genes from different organisms that produce similar [antibiotic] molecules, we can create a library of new macrolides with slight variations that may overcome the bacteria's resistance," he explains. This technique is known as combinatorial biology.

Although their early efforts have led to several successful new antibiotic variations, Liu and Sherman face several challenges.

"The biggest obstacle is toxicity," says Liu. "We want to create new antibiotics that are effective against various pathogens yet will not destroy the organisms that synthesize them."

"Organisms that produce antibiotics in nature develop self-defense mechanisms to protect themselves," he explains. "We want to learn from these natural protection strategies to come up with a general strategy to incorporate into our combinatorial approach."

Liu's other research focuses on enzymes and their role in processes like sugar biosynthesis, fatty acid metabolism, and protein regulation. Understanding how enzymes carry out these essential processes may enable researchers to design chemical inhibitors, or drugs, to control these cellular functions. For instance, Liu's work on fatty acid metabolism may be useful in developing a method to slow down blood sugar production, which could be an effective therapy for diabetes.

Liu says that the broad diversity of his research — "at the interface of chemistry and biology" — is one of its most exciting aspects.

"We use chemistry to study biological problems," he says. "Our lab has evolved over the years to use an integrated, multidisciplinary approach that includes organic synthesis, enzymology, and molecular biology."

In the future, Liu hopes to address problems in protein regulation, aging, and drug development technology. "Chemistry has an enormous potential to help address everyday health issues at both the practical and fundamental levels," says Liu. "I would like to make some of this potential a reality." ■

FOR MORE INFORMATION visit Liu's web site at http://www.chem.umn.edu/groups/liu

PHOTO: CHIP PEARSON

exploring the mathematics OF THE LIVING WORLD

LIFE MAY LOOK DIFFERENT from mathematics — but that's because we have the wrong idea about mathematics. Most people have some sort of mental image of what biologists, or physicists, or astronomers — or indeed bank managers — do. They study living creatures; they carry out huge, expensive experiments on the fundamental constituents of matter; they look through telescopes at the stars and planets; or they lend money to people.

I'm not worried here about the extent to which such images are correct — they capture some of the essential spirit of those enterprises, even though they are actually rather wide of the mark when it comes to details.

What concerns me is that when we think of mathematics, the only mental image that most of us have is what we did at school, and we tend to assume that this is all the mathematics that exists.

Not so. Mathematics is not a long-dead subject preserved in dusty tomes, in which all the questions have been solved and all the answers are listed at the back of the book. It is a vibrant, lively, ever-growing subject. Indeed, more new mathematics is being created today than ever before.

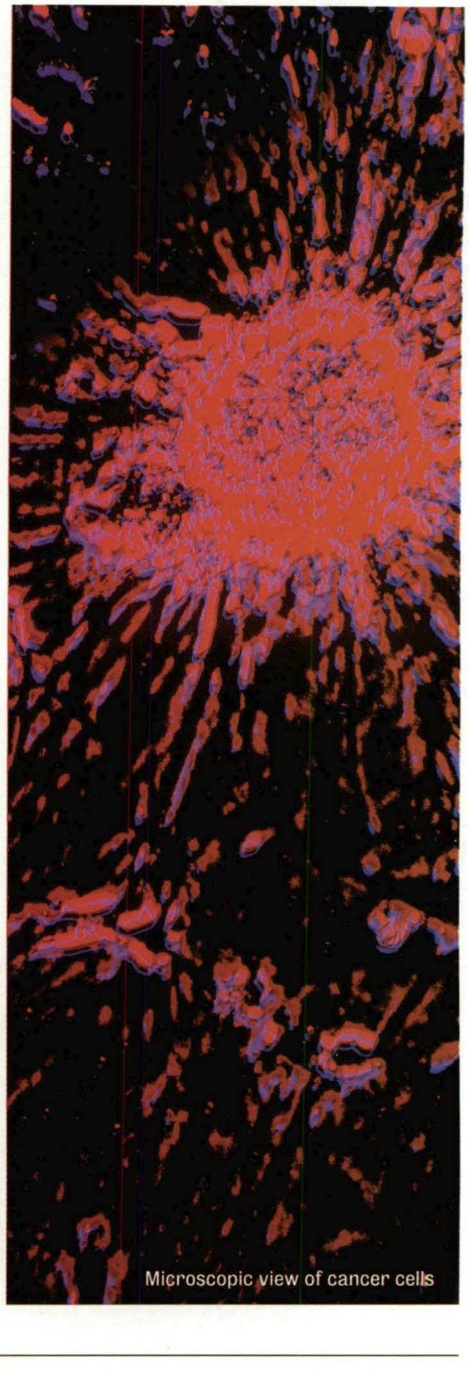
Furthermore, this new mathematics is not just ever-more-complicated answers to bigger and bigger sums. It lies on a far higher conceptual level. Mathematics is the study of patterns, regularities, rules, and their consequences — the science of significant form — and nowhere is form more significant than in biology.

This view of mathematics may sound rather abstruse, but it actually makes the mathematics of life more interesting and easier to understand than the prosaic techniques taught at school. A fair analogy is the difference between practicing scales on a musical instrument (school mathematics) and composing (creative mathematics). The mathematics that may one day provide an understanding of life in all of its richness and depth will be the creative kind, not the prosaic. ■

From The New Mathematics of the Living World, *by Professor Ian Stewart, a visiting scholar at the Institute for Mathematics and Its Applications.*

The ima is devoting its 1998-99 program to mathematics in biology, featuring a series of workshops that will highlight some of the mathematical challenges emerging from the consideration of biological issues and will demonstrate how mathematics can be applied to their resolution. The program will focus on particularly rich areas of investigation that complement activities carried out at the ima in previous years, including magnetic resonance imaging, molecular biology and neurobiology. The fall quarter component will focus on "Theoretical Problems in Developmental Biology and Immunology," with "Mathematical Problems in Physiology" and "Dynamic Models of Ecosystems and Epidemics" following in winter and spring.

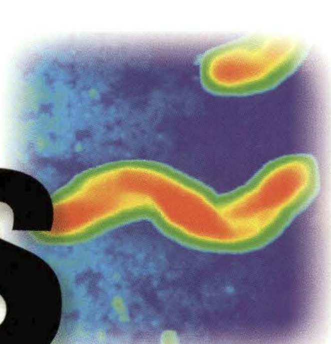
FOR MORE INFORMATION, contact the IMA at 612-624-6066 or visit its web site at http://www.ima.umn.edu.


Microscopic view of cancer cells

FILE PHOTO

'critters' with a compass

BY JOSEPH CARLSON



TWO BILLION YEARS OF CONtinental motion, climatic changes, and magnetic field shifts are locked inside the rocks forming the layered strata of the earth's crust. To Bruce Moskowitz, one possible key to this wealth of geologic history lies in the fossilized magnetic skeletons of magnetotactic bacteria.

As he talks about his work, Moskowitz holds an old black and white photo encased in a cracked frame, glancing at it with a certain fondness. The photo depicts a bacterium magnified a hundred thousand times. A typical magnetotactic bacterium is tiny — about two microns long, 25 times smaller than a single human hair.

The bacterium resembles a translucent hot dog bun with a flagellum, except for one strange feature — a string of about ten flat black squares running along what would be its spine. Those dark cubes, Moskowitz explains, are tiny magnets the bacterium uses for "magneto-navigation," employing the earth's magnetic field as a navigational tool, just as ancient mariners used the stars. The cell passively aligns itself with the Earth's magnetic field, leading the bacterium downward toward sediments and away from potentially toxic concentrations of oxygen in the surface waters.

Magnetotactic bacteria (pictured below) grow internal compasses to guide themselves. Studying them may reveal a great deal about Earth's history and the evolution of biomagnetic organisms.

"Essentially, they grow their own compasses," explains physics professor Dan Dahlberg, who studies the bacteria along with Moskowitz and geophysics professor Subir Banerjee.

Dahlberg, Moskowitz, and former graduate student Roger Proksch produced the first detailed magnetic images and cross-sections of the bacteria at the physics department's Magnetic Microscopy Center. The information revealed in those images may help explain how tiny magnetic particles switch their magnetization, says Dahlberg.

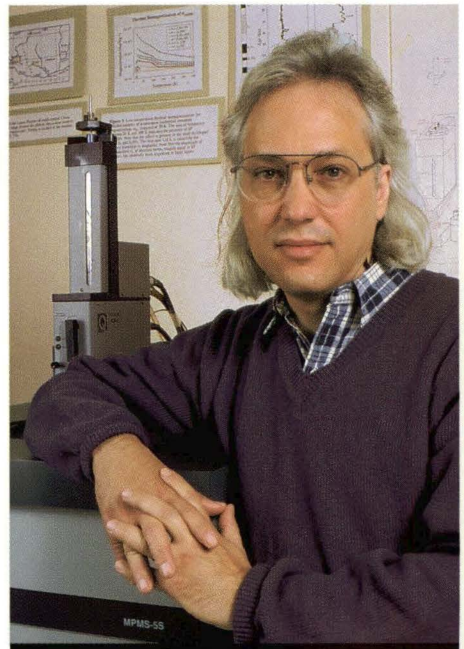
According to Moskowitz, the fossilized remains of magnetotactic bacteria provide equally important insights. By analyzing the remains, which are sealed in sedimentary rock with their magnetic alignments intact, paleomagnetists can calculate the latitude at which the bacteria were fossilized and compare that measurement to the location where the remains were unearthed.

"It gives you the geologic history of plate motions back two billion years," says Moskowitz. "It can basically produce paleographic maps that, through time, can assemble the continents."

But geologists aren't the only ones interested in magnetotactic bacteria. "These bacteria have broad cross-disciplinary appeal," says Dahlberg. "Geologists are interested in their relationship to geomagnetic history. [Physicists are] interested in them as a model for the general problem of magnetic reversal. And biologists are interested in understanding their evolution and environmental significance."

Magnetotactic bacteria were thrust into the international limelight in August 1996, when several NASA scientists published a paper in the journal *Science* claiming they had discovered evidence of life on Mars. According to the article, one of the major pieces of evidence was the discovery of small bits of magnetite distributed throughout an alleged Martian stone.

"I thought it was interesting they were basically using evidence from magnetotactic bacteria . . . as one of the cornerstones for making this claim," says Moskowitz, who "wasn't particularly convinced" that the particles were the remains of ancient bacteria on Mars.



Bruce Moskowitz

The fossils may also yield information about climatic change over long periods of time, says Moskowitz, and may suggest the natural ebb and flow of weather patterns.

"One can look at the geographical factors that control climate and try to decouple these from human factors, such as global warming," he says. "We can see whether any of these changes are actually important." ■

FOR MORE INFORMATION visit the Magnetic Microscopy Laboratory web site at http://www.spa.umn.edu/groups/mmc

PHOTO: CHIP PEARSON

A team of computer scientists and biologists has developed new brain-viewing technology that allows neuroscientists in different parts of the world to scan brain images simultaneously and consult each other immediately.

browsing the human brain

BY JIM MARTYKA

Utations of brain photography sometimes forced neurologists to wait several days before they could review a colleague's work.

As brain-imaging technology improved over the past decade, these brain photographs became more accurate and abundant. Instead of a few photographs, scientists can now download thousands of digitized images.

And a recent brain-viewing technology project undertaken by University researchers also promises to enhance this image-sharing capability by eliminating the boundaries of time and space.

Using this Neighborhood Viewer brain-image browsing technology, neuroscientists can view multiple images of a selected point in the brain and its surrounding area from different angles. Truly revolutionary, the technology will allow scientists in different parts of other immediately.

Although the images are incredibly detailed, alone they do little to guide researchers through the vast amount of existing neurological research data.

The technology project will establish a vast library of neuroscience research — annotated, organized, and located at relevant points in brain images, all stored in a main database.

"Not only do you get more complete, multiple images of the brain to view with a colleague anywhere in the world, but we also hope to put comments on brain images so people in the field can look at them and see the research at any time," says John Riedl, associate professor in computer science.

Riedl and other project participants also say this unique technology has the potential to change how neuroscientists do their work in the future.

FILE PHOTO

Elde's Brainchild Recent discoveries in the neurological sciences produced a wave of researchers interested in brain activity, says Robert Elde, professor of biology and dean of the College of Biological Sciences. As more researchers examine how molecules contribute to controlling the brain, the need to organize research data increases proportionately.

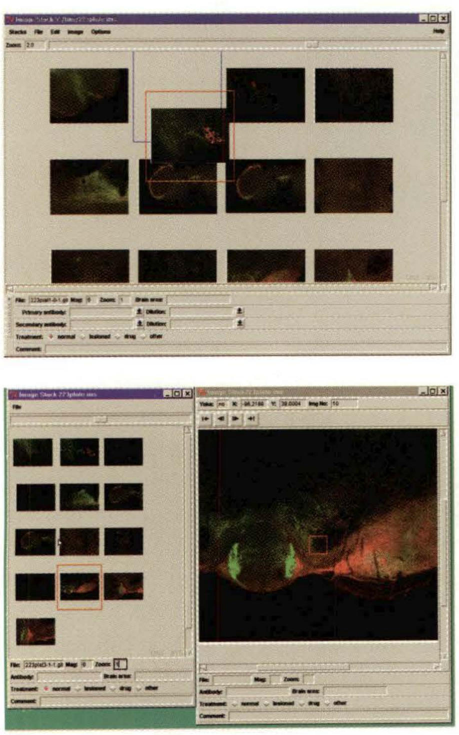
"There are a lot of people interested in this explosion of molecular biology, but there is so much existing data that people are simply lost," Elde says.

In the technologically ancient days of a decade ago, sharing neurological research was a very time-consuming process.

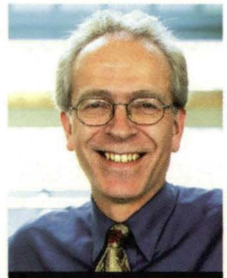
Researchers took microscopic pictures of the brain area under scrutiny, made elaborate and expensive copies, and mailed them to fellow researchers, who then returned their comments by mail. Only then could researchers discuss their findings.

As computer and digital technology advanced over the past few years, the quality and quantity of these images increased.

"These two things have drastically changed how we view the brain," Elde says. "But there is no order; it's like a library without a Dewey decimal system."



INTERACTIVE SEARCH: The Neighborhood Viewer displays the results of an image search (top) and provides a detailed view of selected images.



Elde

Thus, University researchers, inspired and led by Elde, decided there must be an easier way to use this technology, to organize, and to share the research.

About five years ago, Elde began talking about a system of brain images and organized research with colleagues in computer sciences, including Riedl and Associate Professor John Carlis. Several coffee meetings and phone discussions later, Assistant Professor Joseph Konstan and research assistants Alex Safonov, Douglas Perrin, and Salina Yee joined the project.

Together they worked to fulfill Elde's vision: to change and help the way people conducted neurological science.

Some of Elde's colleagues lobbied the national government and federal agencies for funding. Out of these efforts came the Human Brain Project and a $500,000 grant from the National Science Foundation, that should fund the project until next summer. Officials say this grant is the only source of funding for the project, and they stress that now is the time to develop this technology.

The Human Brain Project consists of two interrelated segments: new brain-viewing technology and a system of organizing brain research data.

A New Look at the Brain "In the past, bringing up such detailed images was more of a challenge because of slower technology. Now such imagery comes up 100 times faster and more precisely, allowing researchers to get thousands of images," says Konstan, who joined the project team two years ago.

The images are loaded with a confocal microscope, which takes a picture and uses a laser to bounce light off the image to a detector. The detector then "talks" to the computer and digitizes the image on the screen.

This technology allows researchers to juxtapose multiple brain images. For example, scientists can examine side-by-side images of diseased and healthy brains. Instead of using a three-dimensional brain image, the technology features multiple images, or slices, of a specific point in the brain viewed from several different angles.

Perrin compares this visual perspective to a blueprint. "It's more like looking at something from side to side, top to bottom, with very detailed images of the areas," he says.

"It actually allows you to pretend that you are walking through the brain," Elde says. "It's better to have the multiple slices because you can see more of what you're looking at."

With this technology, scientists can scrutinize an unlimited number of points in the brain from various perspectives. As the name Neighborhood Viewer suggests, scientists can also survey the areas surrounding the targeted points.

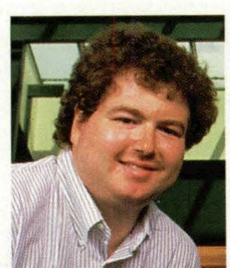
Via a network connection, the technology enables researchers in different parts of the globe to study the same images simultaneously and to discuss their findings with each other immediately. Scientists say that this synchronous viewing will make neurological research more efficient. As a scientist examines different areas with an image, the technology simultaneously moves the other images on the screen, allowing a consistent view of the surrounding area. The number of images one viewer can download is limited only by the number of monitors in the room.

"Sometimes you just need more than one view to see exactly what you want," Konstan says.

"This is the base," adds Riedl. "There's no telling where it can go from here."

Neurological Library The project's second segment involves organizing a neurological library that can be stored on the brain images.

In the past, researchers stored almost all their work in hard copy and were reluctant to share it. No large organized information databases existed. Thus, if neurologists wanted information on a particular part of the brain, it was generally easier for them to conduct their own research rather than dig through volumes of published work.



Konstan

The University's research team will organize the vast amount of information into a neurological library. The team also wants to store the information di-

PHOTOS: CHIP PEARSON

rectly on the brain images using a series of annotations.

"People can leave notes on a certain part of the brain for future viewers," Konstan says. "It would be stored in the database and tied to that location."

Not only could viewers read the results of past research, but they could also add their own comments, consistently updating the images.

The annotations would appear as dots on the screen at various points in the brain image. With a few clicks of a mouse, that dot would bring up a virtual reference library of research on that portion of the brain.

Officials say this capability would assist neurological research by storing the images and research data in the same place.

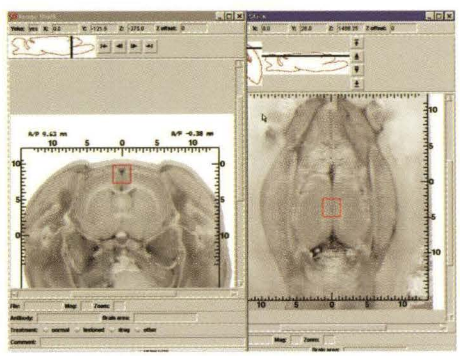
"The visual part of the project is fascinating, and everyone oohs and aahs, but if you don't have the data behind it, it's worthless," Carlis says. "Now everything will be together."

University researchers continue to stress that use of the technology is restricted to scientists, at least for the time being.

"We're trying to build a tool to help the working scientist," Carlis says.

However, officials say that they would hope to make some of this technology available to the public eventually .

Although the imaging technology and the use of shared databases are not unique, researchers say that their application in the field of neurology is unprecedented.



SLICES OF LIFE: Graduate student Alex Safonov (above) displays sample slices of a human brain. The neighborhood viewer (left) shows two electronic images of another brain cut along both horizontal and coronal planes. The red rectangle indicates where the images are yoked together at the point where the axes of those planes cross. Moving the rectangle in one image automatically updates the other. The electronic images, created through magnetic resonance imaging, were scanned from a living patient.

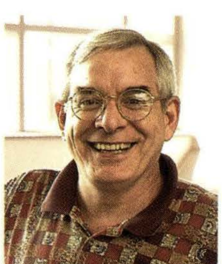
Using the Technology Elde introduced the technology this year in his neuroscience labs in order to study rat brains.

Most brain research uses rat brains because they're abundant, low-tech versions of the human brain.

"Its a lot easier to cut up rats than people," says Perrin jokingly.

When Elde's students investigated the effects of antibodies on proteins in the brain, they used the software tools to track the development of the antibodies.

"The only way to tell was to see if they were working in the brain," Elde says. "So we did visual comparisons using the image technology."



Carlis

Elde and the team want to use the technology in more classes in the near future.

An Optimistic Future In addition to these major projects, researchers continue to work on smaller projects, which include:

- compressing large images for transmission across the Internet
- developing images with crisper, more detailed resolution
- enhancing the brain annotations and research library that will eventually include an index of brain research
- incorporating voice commands into the technology
- preparing multiscreen images and the hardware necessary to view larger brain images

"There are years of work left," Konstan says.

Team members say they are happy with what they've accomplished so far and are optimistic about what their future efforts will achieve.

From the project's beginning, team members set several goals. They wanted to make the fruits of past research available to neurologists and to simplify current research methods. They also wanted to provide the labs with a notebook containing extensive research data that can be used in the labs. In addition, they hope to help scientists collaborate more effectively.

"One major goal is to have a digital library of images that is a public tool kit for researchers," Safonov says. "And that is becoming a reality."

Although the project still has a long way to go, the team has made enormous advances in the neurological and computer sciences.

"The big hope is that we will eventually change how people do neuroscience," Konstan says. "And this technology looks like it could do just that." ■

FOR MORE INFORMATION visit the project web site at http://www.cs.umn.edu/neural

IMAGES COURTESY ALEX SAFONOV

toying with technology

Alumnus Rebecca Schatz founded a unique hands-on museum that teaches young visitors about technology using an enticing mix of special effects and science.

by Judy Woodward

IN A SMALL MUSEUM IN A SUBurban Minneapolis shopping center, a little boy named Teddy may be learning more about the expansive possibilities of technology in a morning's visit than he's picked up in his previous seven years of life. He races from exhibit to exhibit, barely noticing a couple of trailing adults who watch as he explores the intricacies of miniature cars controlled by optical sensors. Then he veers off to check out a goggle-eyed, plastic-encased creature whose head swivels in Teddy's direction. The laser-driven stone harp astonishes Teddy by producing beautiful sounds without strings, and the irresistible Face Warp transforms a small boy's gap-toothed grin into a dental Grand Canyon, thanks to the artful remapping of photographic pixels.

Watching Teddy's high-energy odyssey is a slender, rather puckish IT alumnus named Rebecca Schatz. Teddy doesn't know it, but he owes his crash course in techno-wonder entirely to her.

Schatz is the founder, chief administrator, and general life force behind The Works, a three-year-old interactive learning site for children ages five to 15 located in the Eden Prairie Center. Here kids learn about the intricacies and mysteries of the technology that their elders often take for granted. The Works is a kaleidoscope of bright colors, eye-catching special effects, and clever packaging that combines solid technological principles with awesome industrial magic.

LAUGHING AND LEARNING: 7-year-old Eilise Rooney and her mother, Susan, enjoy the educational exhibits at The Works.

Teddy puts it a little differently. "This place is s-o-o-o cool," he exclaims.

When Schatz earned her master's degree in information sciences from the University in 1986, she seemed poised for conventional career success as an engineer specializing in communications networking. Twelve years later, she's using her degree in ways that no one could have predicted.

How did Schatz transform herself from a rising young engineering manager to a woman who spends her mornings orchestrating the techno-fantasies of kids like Teddy?

She traces it all back to her mother.

In 1985, Schatz was working as a manager at NCR Comten when her mother decided to retire from her teaching career. "My mom loves Japanese things, and I wanted to take her to Japan when she retired. I was actually looking for tourist information about Japan, but I wandered into the wrong office."

Schatz had accidentally found her way to the University's fellowship office. While there, she was persuaded to apply for the prestigious Henry Luce program for professional study in Asia. She became the University's first successful candidate for the award and spent the following year as a visiting faculty member at Japan's Tsukuba University, where Schatz recast her thinking about technology and education in ways that led to the creation of The Works.

"It was the mid-1980s," says Schatz, "and the Japanese economy was taking over various electronics markets." Schatz was im-

PHOTOS: CHIP PEARSON

pressed with the way Japanese education at all levels prepared children for the technological demands of the workplace.

A major difference between Japan and the United States, she decided, was that in Japan all students are given a serious technical education because all jobs are considered to have a technical component. "Our U.S. engineering schools are the best in the world," she says. "But technical education shortchanges everyone else. Every occupation is becoming technological, but American [factory] assemblers, secretaries, and clerks aren't getting the skills they need."

Schatz began to think about ways to improve technical education by introducing children to the same hands-on approach that drew her to engineering. "As a student at the U," she explains, "I learned the joy of engineering, how much fun it was. I wanted to be able to share this fun with others."

A turning point came when she visited the San Francisco Exploratorium, brainchild of former IT faculty member Frank Oppenheimer. A mammoth display space that reminds some observers of an abandoned airplane hanger, the Exploratorium offers young visitors the right mix of knock-'em-dead special effects and good science. Schatz was hooked. "I thought, I have to have this in my backyard," she reports. "With visionary fervor and naïveté, I planned a 100,000-square-foot museum."

Since then she's come to appreciate the virtues of a smaller, more personal display space. Even in her most grandiose plans, it was clear that Schatz had found the outlines of what has become her life's work. Several years and endless hours of fundraising later, The Works first opened its doors as a temporary display at the University's Bell Museum of Natural History in 1995. It's moved twice since then and now makes its home in a modest suburban shopping mall, nestled next door to a Fannie Farmer Candy Shop, a fortuitous arrangement for young museum visitors.

Schatz has carefully designed the physical layout of The Works to avoid "the dark, silver gray, cold, male techie" stereotype. Warm, vibrant colors greet visitors, and girls of all races are pictured as often in displays as are boys. Schatz comments, "If you call it a technology center and say it's open to everybody, you still won't get everybody." By giving the center a deliberately ambiguous name like The Works, she hopes to lure in even those passersby for whom technology is a turnoff.

She continues, "At the Science Museum of Minnesota, the visitors are disproportionately white and male. We try to buck that trend by including people of both genders and all ethnicities among our staff, volunteers, and board members. We have special Girl Scout nights, and we try to bring in female engineers to talk to the kids."

There is plenty at The Works to appeal to the hard-core technophile of any race or gender. While Schatz describes her organization to an adult visitor, young Teddy has been exploring the persistence-of-vision phenomenon with the aid of a cooperative light beam and three spinning mirrors over at the Laser-mation exhibit. With rapt concentration he varies the motion of the mirrors in order to create differences in light patterns that only an engineer could truly appreciate.

Then he sets off for the Tracker, a cartoonish, three-dimensional, antlered beast whose yellow and purple eyes and slowly swiveling head evoke exaggerated mugging from the little boy. Teddy's gyrations actually control the figure's movement, because infrared sensors embedded in the Tracker's lurid hide read the play of light reflected off Teddy's body. Schatz explains that the Tracker's technology is based on the same principle that governs the heliostat in a rooftop solar energy collector, although the Tracker accomplishes its task with a lot more wit and verve.

HOW DO SCHATZ AND HER STAFF come up with the ideas that transform workaday technology into something like The Tracker?

Generating new ideas is not a problem, according to Schatz. "We have more ideas than we can implement," she declares. The challenge is to translate ideas into substance.

Schatz explains that the staff tries to organize learning concepts thematically. Imaging and optics, for example, is the field that has captured Teddy's interest on this visit, and that's because most of the current displays are designed to illustrate concepts in that area. But there are constraints that affect an exhibit's design. "We operate in a museum environment," says Schatz, " and that means that if it takes [the visitor] more than 20 seconds to figure out a display — forget it! If we're trying to explain a process, for example, that has eight steps, we'll only show the four steps that work well in a museum setting. Museums fail when they try to explain too much. At The Works, we don't push facts so much as change attitudes and create enthusiasm for our subject."

When it comes to mounting exhibits, The Works also gets a lot of help from its friends. "We couldn't exist," notes Schatz, "without our volunteer exhibit designers. Everybody's got cool ideas [for exhibits], but most ideas don't work. What we need especially are people who are willing to build things for us."

Many of the best volunteers at The Works come from the University. Schatz notes that the stringless light harp that so fascinated Teddy was designed and built by an IT team that included Scott Mazar and other graduate students.

Professor Emeritus William B. Schwabacher has been a mainstay when it comes to building exhibits, and several current and retired faculty members serve on The Works' board, including Dean H. Ted Davis.

Retired professor of education Eugene Gennaro was a "wonderful resource person," according to Schatz. He helped her transform the ideas into something of practical educational value that would also entertain kids.

VIRTUAL VIRTUOSO: Alumnus Rebecca Schatz demonstrates the light harp, one of many interactive educational exhibits at The Works, a nonprofit educational museum she founded in 1995.

SCHATZ IS ALWAYS ON THE LOOKout for volunteers from the University community. "Volunteers are the heart of The Works. We're looking for faculty who will create exhibits and develop curriculum, but we also offer internships and staff positions to students," she says.

Schatz makes a special pitch for student helpers. "Kids learn so much better from other kids. I'm much too old — and besides, I don't have a ring through my nose," laughs the conservatively dressed mother of two.

Schatz acknowledges that there can be a gulf between the "techies" who create the exhibits and the communication-savvy museum guides who serve as interpreters for the youthful visitors. "I started from the technical side," admits Schatz, "but I'm learning to communicate." She says it's not easy to find people who can master both skills. "Explainers must radiate love and interest in the children and also be able to understand technology. It's easier to find people who love kids and then teach them about technology," she believes, than to transform technologically adept types into people who work well with children.

One staff member who manages to strike a perfect balance between technical understanding and personal enthusiasm is Richard Pollard (Electrical Engineering '96). With his small beard and enthusiasm, Pollard looks like everybody's energetic young uncle who knows all the cool things that parents seem to have forgotten. He claims to love all aspects of his job. "The only thing I like more than working with the science and technology is working with the kids," he says. Pollard describes the "moment of surprise" when the "kids notice the technology" that lies behind the dazzling effects he has helped to develop. He says that when the children "get" the underlying concept, "you can see it in their faces."

Pollard is a versatile employee who added the role of technological crimestopper to his resume. He describes the time a would-be scam artist came by the museum trying to pass himself off as a power company employee. Pollard remembers, "The guy told me that our transformer by the entrance was about to go out and that we'd lose all power."

The con man even identified the particular "transformer" that was about to fail. Pollard realized that the supposed expert was solemnly pointing at the doorbell. "He'd picked the wrong person to try that scam on," says Pollard, who admits that a background in electrical engineering is not typical preparation for a career in children's museum work.

But as Teddy and other children have discovered, The Works is not a typical museum. Rebecca Schatz sees to that. ■

FOR MORE INFORMATION about The Works, call 612-941-2211 or visit The Works web site at http://www.theworks.org.

"As a student at the U, I learned the joy of engineering, how much fun it was. I wanted to be able to share this fun with others."

PHOTO: CHIP PEARSON

Biomedical Engineering: continued from page 21

The Basic Sciences and Biomedical Engineering Building

Research Teams BMEI's major research efforts will focus on physician-driven health care problems, says Polla, with its 40 faculty members organized into multidisciplinary, intercollegiate teams that will tackle the problems.

"BMEI has given us a leg up in this process," says Polla. "The close relationship we have developed between IT and the Medical School should make some of the traditional barriers [to collaboration] transparent."

Several current projects fit this model, adds Polla. For example, he and electrical engineering professor William Robbins are collaborating with Susan Mantell, an associate professor of mechanical engineering, and Ronald McGlennen, an assistant professor of laboratory medicine and pathology, to design microchip-based tools for human diagnostics.

"That project provides an opportunity for people from IT disciplines to work with a medical expert to design a solution for a specific health care problem and then immediately test it in clinical trials," says Polla. "That is the type of thing we can excel in."

Industrial Interaction Fostering interactions with industry has been part of BMEI's mission since its inception, but Polla hopes to develop creative new research partnerships with companies from Minnesota's "Medical Alley" and countries around the world.

To help achieve that goal, BMEI has established five industrial interaction laboratories that provide research opportunities and resources for its corporate partners. Those laboratories focus on blood and biocompatibility, rapid device prototyping, tissue characterization, medical instrumentation and devices, and microtechnology.

"Scientists from industry can spend time in these labs learning techniques that will be useful to them," explains Assistant Professor Daniel Mooradian, director of the Blood and Biocompatibility Laboratory and one of BMEI's associate directors for external relations. "A lot of small companies also make use of this opportunity to do early research and development work" that they couldn't otherwise afford.

"We need to be able to do this work with local companies, since that's such an important part of the local economy," he adds.

BMEI's planning and policy board, which includes faculty and representatives of industry, also plays an important role in helping faculty members effectively collaborate with industry, says Polla.

Redefined Faculty As the first faculty member tenured in biomedical engineering, Mooradian represents an important milestone in Polla's plans to establish a formal Department of Biomedical Engineering, perhaps as early as next year. The new department would be shared between IT and the Medical School.

Although BMEI has functioned as a department since 1995, it must meet several requirements to gain formal departmental status from the Board of Regents, explains Polla. However, two of the most important hallmarks of a formal department — tenure-granting authority and an undergraduate program — are in place or in the works, and Polla expects BMEI to clear the final hurdles in the next several months.

Biomedical engineering will also hire five to seven additional faculty members during the next several years. Polla also hopes to encourage more faculty members from both colleges to participate in biomedical engineering research.

A National Model BMEI's innovative approach to research, education, and outreach has garnered national attention, says Polla. Other institutions regard the University as a model for their own programs.

"The interdisciplinary model we're developing here is the first of its kind," says Polla. "It has not been duplicated anywhere in the world." ■

FOR MORE INFORMATION visit the biomedical engineering web site at http://www/bmei.umn.edu

"The interdisciplinary model we're developing here is the first of its kind. It has not been duplicated anywhere in the world."

■ **DENNIS POLLA**

FILE PHOTO

MISSION: BOSNIA

LIGHTING THE PATH TO RECOVERY

IT alumnus Jim Sellner spent six months rebuilding the Bosnian infrastructure, reopening the nation's coal mines, and restoring electricity to the war-torn nation

by Mark Speltz

IN NOVEMBER 1996, LIEUTENANT Commander Jim Sellner arrived in Bosnia armed with only the essentials: full military gear, a nine-millimeter handgun, and his undergraduate thesis.

After a decade in the navy reserves, IT alumnus Sellner had been recalled to active duty as part of NATO's 34,000-member multinational peacekeeping force. His assignment was to help rebuild the Bosnian infrastructure and spur economic development by reopening the coal mining industry.

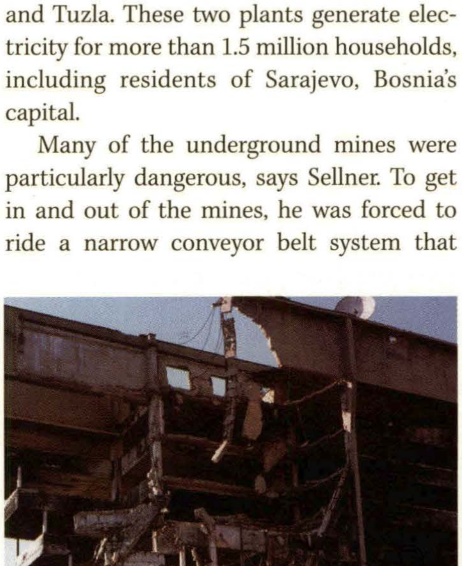
Many Bosnian mines had been inactive since fighting began in 1992, and coal production had dropped to 10 percent of its prewar output. Because 80 percent of Bosnia's electrical power is coal-generated, many Bosnians were without electricity and heat.

"My mission was to increase coal output from 10 percent of prewar production to 25 percent," recalls Sellner, the only mining engineer assigned to the mission. The long-term goal was to boost production to 75 percent by the year 2000.

When he arrived in Bosnia, Sellner was stunned by the devastation the civil war had wreaked on the once-picturesque country. Bombed-out buildings loomed ominously over cities and villages, live landmines littered the countryside, and corpses still turned up amongst the rubble. "No doubt about it, it was a war zone," he says.

Sellner's first responsibility was to tour and to assess the damage to Bosnia's resource-rich open pit and underground mines. Traveling across the country in a humvee, he examined 17 mines that supplied coal to thermal power plants in Kakanj and Tuzla. These two plants generate electricity for more than 1.5 million households, including residents of Sarajevo, Bosnia's capital.

Many of the underground mines were particularly dangerous, says Sellner. To get in and out of the mines, he was forced to ride a narrow conveyor belt system that barely cleared the ceiling. Once inside, he battled poor ventilation and risked the collapse of structural supports as he inspected the mines.



"In the United States, every one of those mines would have been closed for safety reasons," he says.

Because he couldn't speak the native language, the mining industry provided a translator, Gorana Kadric, who accompanied him throughout his mission, serving as a guide and aiding communication with officials and miners.

"Gorana's father had worked in the mining industry, so she knew both the native languages and the mining terminology," explains Sellner. "I couldn't have done it without her."

ONCE HIS ASSESSMENTS WERE COMPLETE, Sellner detailed the steps necessary to increase coal production and to rebuild the mining industry. To do so, he turned to his 1982 undergraduate thesis in mining engineering, for which he created a fictitious mining company and outlined all aspects of its operation. Despite obvious differences between the fictional company and the Bosnian mining industry, he was able to apply the basic principles of the thesis to his recommendations.

"My education proved to be invaluable throughout the mission," says Sellner, who also earned a master's degree in geological engineering in 1985. "I really put what I

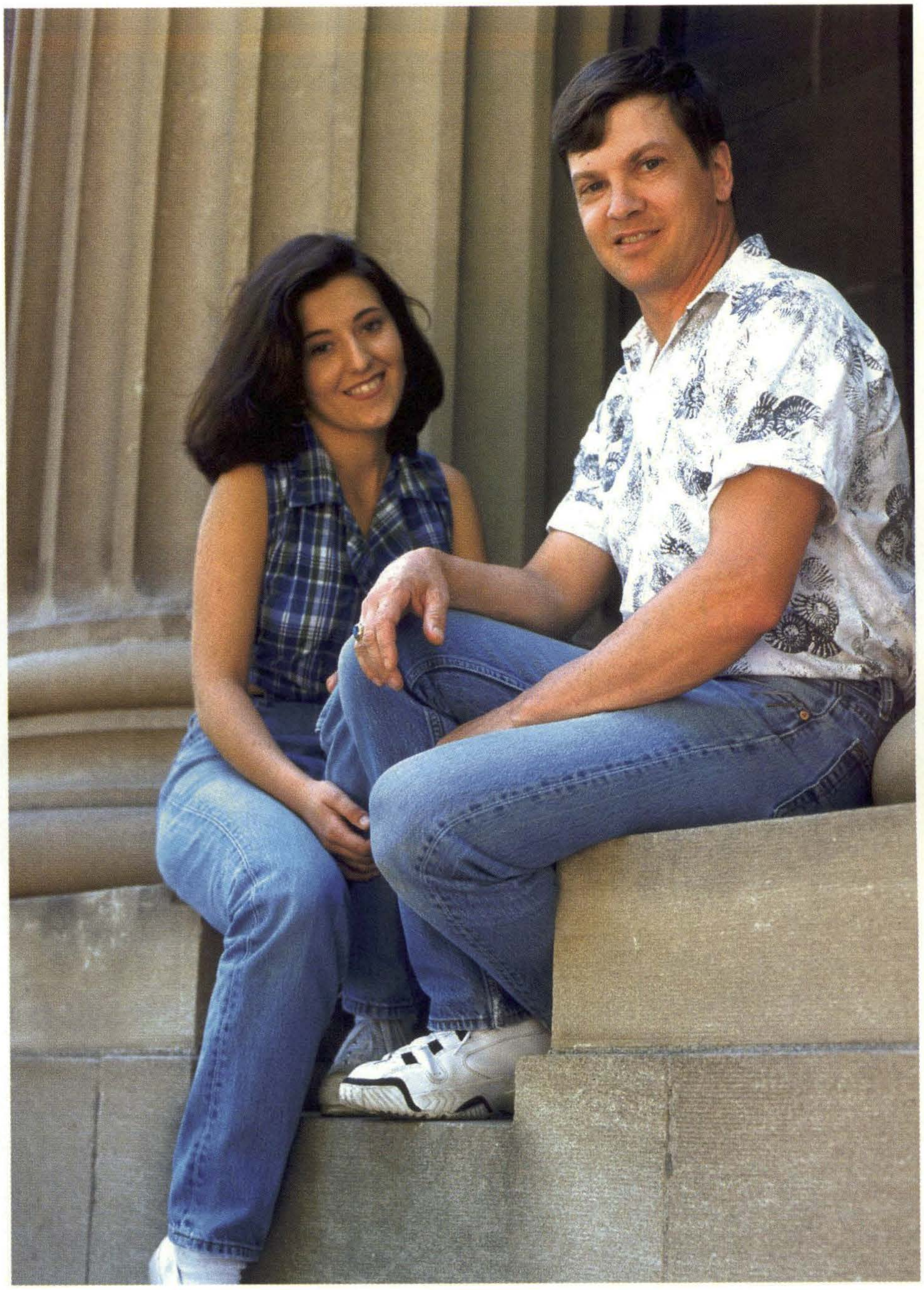
BOSNIA PHOTOS COURTESY JIM SELLNER

learned into practice."

To concentrate the country's resources on its most valuable and strategically located mines, he advocated closing many others and recommended structural changes, capital improvements, and more efficient mining practices. He also served as a consultant on the design of a coal processing plant and a railroad network that would link four mines to the Kakanj Thermal Power Plant.

Because much of Bosnia's mining equipment had been destroyed or damaged during the war, Sellner helped mining officials learn about new technologies and recommended equipment purchases. He also ensured that $10 million in equipment from Caterpillar, purchased with USAID funds, was delivered and assembled properly.

Although Sellner's recommendations were well-received, the Bosnians often lacked enough money to implement them. Sellner helped win funding from the World Bank by convincing its officials of the situation's severity. He also worked to secure a $2.6 million aid package from Japan that funded a wastewater treatment plant and additional mining equipment.



SELLNER WORKED 13 HOURS A DAY throughout his six-month tour. When it ended, he had reached his goal, increasing coal production to 25 percent of prewar levels.

But Bosnia and its mining industry still face several challenges, he says, including an 85 percent unemployment rate and sagging wages. The average miner now earns about $200 a month — $1000 a month less than before the war — and must often wait months to receive a paycheck.

That's because the mining industry is struggling to adjust as the country shifts toward a free market economy, says Sellner. Under socialist rule before the war, mining companies rarely worried about competition.

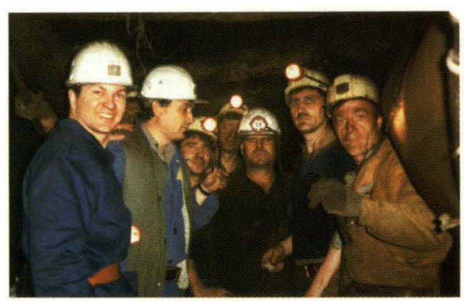
In April 1997 Sellner returned home to Pengilly, Minnesota, where he has worked as a geological chemist and physicist for the Minnesota Department of Natural Resources for 14 years. He continues to travel with the navy reserves at least once a month.

"I've always wanted to serve my country in the military," he notes. "The best part of it all is the fact that I can serve my country while working on projects in the field I went to school and was trained for."

Although he earned medals from NATO and the defense department for his work in Bosnia, Sellner considers bringing electricity to war-weary Bosnians his greatest reward. "The official awards were secondary to the rewards of working with the local miners and succeeding," he says.

As Sellner was preparing to leave Bosnia, workers at one of the mines gave him a pin decorated with a mine emblem and the word "sretno" ("good luck" in Serbian). The pin is an honor usually given to miners after 20 years of service.

"It was very touching," he says. "They were very appreciative, even though they thought I was just a kid, a kid with a good education." ■



TOUR OF DUTY: Alumnus Jim Sellner stands in front of the bombed-out building that houses Bosnia's electric utility commission (opposite) and pauses for a photograph with the workers in a Bosnian coal mine (above). In May, he brought his Serbian translator, Gorana Kadric, to the University (top).

PHOTO: CHIP PEARSON

From business savvy to philanthropic ideals, the IT alumni who founded Reell Precision Manufacturing are

three of a kind

by Paul Sorenson

SOMETIMES, NICE GUYS finish first.

At least that's the case with three mechanical engineering alumni who built Reell Precision Manufacturing (RPM) from a home basement prototyping laboratory into a multimillion-dollar company.

Today, RPM is the premier manufacturer of wrap spring clutches — the mechanisms that feed paper through photocopiers and similar devices — and its three founders have earned acclaim for their business acumen, creativity, and strong spiritual values.

Like the company they founded, Dale Merrick, Robert Wahlstedt, and Lee Johnson rose from humble beginnings to achieve great success.

DALE MERRICK GREW UP IN ST. PAUL, Minnesota, and came to the University in 1944 as part of an army training program.

"I never really considered going anyplace else," says Merrick. "At the time, I didn't really know what I wanted to be or do, but I knew engineering would be at the core."

After dabbling in aeronautics, Merrick settled on mechanical engineering. He married his wife, Millie, shortly before graduating in 1949. When it came time to choose a job, he put the needs of his new bride first.

"I had job offers from General Electric and several others," recalls Merrick, "but my wife was a local school teacher, so rather than uproot her, I accepted a job [in the Twin Cities] with 3M."

Merrick spent 11 years at 3M before deciding to strike out on his own. Motivated by a desire for independence and the opportunity to put family priorities above those of the job, he established the Dale Merrick Company and began working out of his home as a sales representative for various manufacturing companies.

The sales business did well in its early years. When it became apparent that he would need a partner to meet the growing demands of his customers, Merrick turned to Robert Wahlstedt.

WAHLSTEDT WAS BORN AND RAISED IN Roseville, Minnesota. He came to the University in 1950 and worked his way through the mechanical engineering program as a night clerk in the Nolte Center dormitory, staffing the front desk and sharing a room with another co-worker.

Between working and studying, Wahlstedt found time to make mischief as chairman of the annual Engineers' Day festivities, which fostered IT's lighthearted rivalry with the College of Forestry.

"One year, we cut a car in half and welded it back together around a tree in front of the forestry building," he recalls with a chuckle. "We got a lot of publicity out of that prank. The TV stations loved it."

In 1955 he graduated and accepted a position with the duplicating products division of 3M, where he met Merrick. He married his wife, Aileen, in 1959.

A series of health problems in 1960 caused Wahlstedt to reexamine his priorities. "I realized that the emphasis I had placed on work had become detrimental to my health and my family," he says. "The level

Merrick, Wahlstedt, and Johnson on the floor of Reell Precision Manufacturing

of responsibility I wanted to achieve wasn't possible in a large company without sacrificing things I didn't want to sacrifice."

A chance meeting while vacationing in Wisconsin brought Merrick and Wahlstedt together again a short time later. When Merrick mentioned that he needed a partner, Wahlstedt jumped at the opportunity to join the company. The two began working together in 1963.

AS THE DALE MERRICK COMPANY GREW, the partners reflected on their long-term goals, observing that the "rep" business seemed better suited to younger workers.

"We didn't really want to grow old as a small two-person operation in the rep business," recalls Wahlstedt. "As we saw it, our choices were to grow as a rep company or take on manufacturing."

As those discussions continued, Merrick and Wahlstedt entered into a contract with Marquette Metal Products, a manufacturer of wrap spring clutches. The partners quickly identified several potential new applications of the clutch mechanism, but Marquette's long lead times and high sample prices hindered their sales efforts.

"Marquette took an awful lot of money off the top," says Merrick. "Because they sold largely to manufacturers of capital equipment, a few dollars here and there didn't make much of a difference. We saw 3M's thermofax division as a big potential customer for Marquette's clutches, but for them every nickel and dime counted."

Unable to persuade Marquette to change its strategy, Merrick and Wahlstedt became convinced that there was a niche in the wrap spring market that could be filled successfully by another manufacturer.

But they deferred their dreams of starting their own manufacturing business. In 1970 they decided to expand their sales force by adding Lee Johnson to their team.

A ST. PAUL NATIVE, JOHNSON KNEW AS A youngster that he wanted to attend the University and become an engineer.

"My parents saw the importance of a college education and imbued that in my brother and me," says Johnson, whose father had struggled because he had only an eighth grade education.

When Johnson was only 10, his father died suddenly, leaving his mother to raise their two sons alone. "My mother was widowed at a very young age. Sending me and my brother to college was a real sacrifice to her," he says. "For purely economic reasons, the University of Minnesota was probably the only place I could have gone to college."

Johnson and his brother worked summers to earn money for books and tuition but continued to live at home throughout their college years.

"I was only an average student," recalls Johnson. "When I was admitted [to the engineering program], the dean took one look at my high school grades and told me I'd have a rough time. He was right. It was challenging, but I was determined to prove him wrong."

Johnson graduated in 1957, married his wife, Betty, and went to work at 3M, where he met Wahlstedt and Merrick.

"I liked 3M, but I was not cut out for a big company. Even though I had a good job as

PHOTO: CHIP PEARSON

"Whatever success we have had has its roots in IT and the University."

an engineering manager, I wanted to have more freedom and independence. I wanted something smaller, to be more a part of something I could influence."

He stayed in touch with Merrick and Wahlstedt after they left 3M and later approached them about joining their sales company. They agreed, but the timing couldn't have been worse.

"The economy went sour that summer [of 1970], and [the sales business] couldn't support the three of us the way we had anticipated," recalls Johnson. To make ends meet, the trio decided to set up a new company to manufacture a better wrap spring clutch. In October 1970, Reell Precision Manufacturing was born.

THE PARTNERS' FIRST CHALLENGE WAS to name the new company. "One of Marquette's major competitors, Precision Specialties Inc., was known by its acronym, PSI," recalls Wahlstedt. "That was easy for engineers to remember because it also stands for 'pounds per square inch.'"

Merrick suggested that RPM would be as easily remembered and that "revolutions per minute" was more directly related to the performance of clutches. His idea was quickly accepted, and the group turned its attention to coming up with a full name.

"'Precision Manufacturing' came pretty easily," says Wahlstedt. "But we had some trouble with the 'R.'" After searching a dictionary without finding a suitable "R" word, Johnson stumbled upon the word "Reell" (pronounced "ray-el") in a German dictionary.

"It means 'honest, dependable, or having integrity,'" explains Wahlstedt. "We thought it was perfect. Ironically, though, it's usually 'Reell,' not 'RPM,' that people remember."

MERRICK, WAHLSTEDT, AND JOHNSON each contributed $1,000 as initial capital for the company.

"We bought a combination lathe and mill and set it up in my basement," says Johnson. "Dale and Bob continued to split their time between the rep business and the new business, while I focused entirely on developing the new clutch."

In 1972 they introduced that new product — less expensive and more reliable than the competition's — and sold several hundred units to 3M. The photocopying industry was beginning to boom, and over the next two years they sold similar clutches to a variety of manufacturers, including Xerox and Kodak. RPM moved out of Johnson's basement, set up shop in Roseville, and began adding office and assembly staff. The company turned a profit for the first time in 1973.

The next big break came in 1975, when Xerox asked RPM to design an electrical clutch.

"Up until that time, clutches were mechanically actuated, so this was a big step forward," says Merrick.

Within a month of that request, the company had developed a working prototype. Although it took several years for it to reach the market, the new clutch set the industry standard. "It turns out that the clutch we designed for them is still accepted as the best design in that type of device, even today," says Merrick.

RPM CONTINUED TO GROW IN FITS AND starts. Merrick served as its chairman, with Wahlstedt as president and Johnson as chief executive officer. The company added new products based on its technologies, including solenoids and specialized hinges used in laptop computers and other devices.

One of the key components in many RPM products is a precision spring. For years, RPM purchased the springs from a New York firm, the only supplier that could meet its stringent specifications. Because this component was so critical to its success, RPM began to develop the technology to wind its own springs in 1989. In the process they exceeded the capability of the New York company and eventually spun off the technology into a new venture, Vadnais Technologies, in 1994.

In addition to winding springs for RPM, Vadnais Technologies has developed the capability to wind precision coils for the medical industry.

"Devices like catheters and pacemaker leads require precisely wound coils three-feet-long wound with wire the size of a human hair," explains Johnson.

TODAY, RPM AND VADNAIS TECHNOLOGIES employ nearly 200 people and generate millions of dollars in sales each year. Although Merrick has retired from day-to-day operations, he continues to work with Wahlstedt and Johnson to shape the company's future and to determine its philanthropic priorities. Among those priorities is the Institute of Technology.

In May, RPM announced a $100,000 contribution to the Campaign for Mechanical Engineering. In addition, each of its founders has set up a personal trust fund to support IT and provide scholarships to its students.

"Since the very beginning, we've given 10 percent of our profits to charitable organizations," explains Merrick. "We all feel that we're grateful for our education. The University provided the sound foundation that got us started."

"Whatever success we have had has its roots in IT and the University," adds Wahlstedt, noting that RPM employs many other IT alumni.

"My education played an important role in my success," says Johnson. "I've been able to achieve so much, so to walk away without leaving anything wouldn't be right. I want my children and grandchildren to know how important my education was to me."

The trio's generosity isn't limited to financial support. Wahlstedt serves as an executive fellow at the University of St. Thomas, where he is helping faculty members teach and develop courses on spirituality in management. Merrick is active in the University of Minnesota Alumni Association. And Johnson, who also mentors IT students and serves on the mechanical engineering campaign steering committee, was recently honored with the University's Outstanding Achievement Award for his involvement.

"I clearly feel it's payback time," says Johnson. "We have been very, very blessed." ■

RICHARD HATFIELD, DIRECTOR OF DEVELOPMENT

Giving securities

Combining charitable giving with effective estate planning

Tremendous benefits can result if you take the time to plan your charitable donations. Giving securities is one way to combine your charitable giving with effective estate and financial planning.

Like cash gifts, gifts of noncash property are tax-deductible; however, tax laws offer special incentives for gifts of noncash property, especially those that have increased in value since purchased or acquired. If you own stocks and bonds that have appreciated in value, you can reduce your tax liability and increase the value of your gift by donating securities. This method is often more advantageous than selling and making a gift of cash.

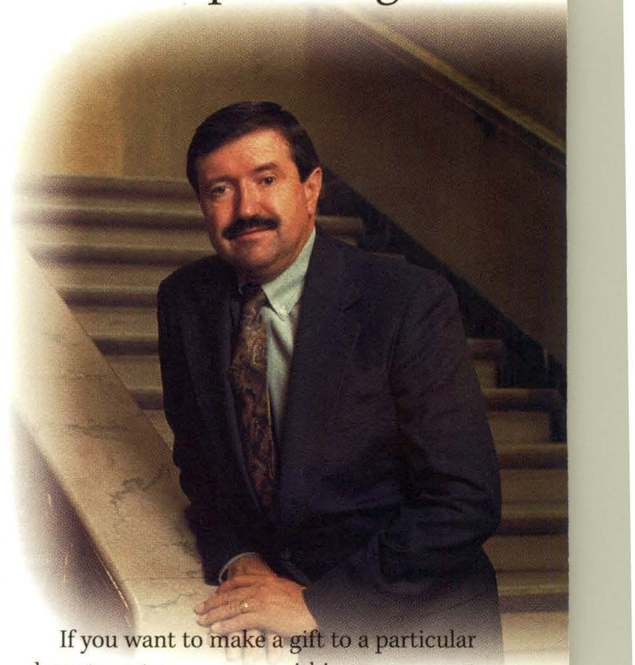
By donating appreciated securities, you can avoid capital gains tax and receive an income tax deduction based on the fair market value of the securities on the date of the transfer. The deductible amount includes what you paid for the securities and its appreciated value. ■

If your securities have dropped in value below their original cost, you may benefit more by selling them and donating the cash proceeds. You may then be able to take a capital loss on your tax return as well as a charitable deduction for the cash gifts.

NOTE: In order to deduct appreciated securities at their full present value, you must have owned them for at least a year. You can deduct up to 30 percent of your adjusted gross income in the year of the gift. Any amount in excess of 30 percent may be deducted over the next five taxable years.

Some investments represent savings which you plan to use for income and security in later years. In this case, a gift of securities may be used to fund a life income gift, such as a unitrust or charitable remainder trust, and you can receive a life income that in some cases may exceed the income you had been receiving from the stock.

Getting maximum tax benefits from charitable giving is not always easy. Tax laws are complex, and you should work with your tax advisor, lawyer, or financial advisor when you are considering making a gift.



If you want to make a gift to a particular department or program within IT, you must specify your intention in a letter of agreement with the University. ■

FOR MORE INFORMATION, call the Office of Development and External Relations at 612-624-5537 or 1-800-587-3884, or send e-mail to development@itdean.umn.edu.

Genome: continued from page 28

around the world to achieve that goal.

Unfortunately, creating successful new breeds of super-crops may prove far more complicated than mixing and matching genes. "If you change the data in a tomato to make it stay ripe longer, how will that affect its nutritional value?" asks Kumar. "We don't know."

But the pace of genetic research is accelerating, and computer tools may someday allow biologists to predict those effects. "The techniques we're developing will allow molecular biologists to ask and answer questions that they cannot even consider asking today," says Kumar. ■

FOR MORE INFORMATION visit the computer science web site at http://www.cs.umn.edu

Artery: continued from page 23

the bioartificial artery.

"Our goal now is to manipulate those proteins — or the collagen with which they interact — in order to control both structure and function in the bioartificial artery," adds Mooradian. This approach is complementary to Tranquillo's, he says, and future collaborations are likely.

Mooradian is currently organizing a symposium on tissue-engineered blood vessels for the 1999 meeting of the Society of Biomaterials in Providence, Rhode Island.

"It's an opportunity to showcase work being performed at the University of Minnesota and explore how we can integrate our activities with [those of] experts from around the world," he says. ■

FOR MORE INFORMATION visit the project's web site at http://www.cems.umn.edu/~rtt_grp.

PHOTO: PATRICK O'LEARY

Athelstan Spilhaus

Remembering an accomplished scientist and visionary leader

BACK IN 1967, AT THE END of his tenure as dean of the Institute of Technology, Athelstan Spilhaus was asked to imagine the world at mid-21st century. He described a breathtaking range of technological achievements, from pollution-free factories to underwater cities, and one social change on which all else depended — a global agreement controlling birth rates in every society.

It was a vintage Spilhaus vision in which science and engineering could solve just about any of the problems bedeviling humankind — provided the humans were willing to remake their lives to achieve the solution.

Spilhaus, who died March 30 in Washington, D.C., was perhaps Minnesota's leading futurist for two decades following World War II. In that role he championed an experimental city of a quarter-million people in the bogs beyond Grand Rapids, produced a Sunday comic that explained "Our New Age" to five million readers, and fielded reporters' calls when satellites or computers made news.

He came to the University as a 37-year-old oceanographer and meteorologist of remarkable accomplishment. The bathythermograph, his invention for plotting seawater temperatures against depths, had been used to map oceans and hunt submarines. He had served the armies of the United States and his native South Africa, adapting instruments to military purposes and training others in their use. On one assignment in China, it was said, he dined on ducks' eyes and chicken feet with a couple of guerrilla leaders named Mao and Chou.

The Institute of Technology flourished under his leadership style, which today might be called "empowering." Disinclined to adopt the bureaucrat's obsession with details, he supported department heads who wanted to take risks and think big. He had many big ideas of his own, including the hotly debated concept of the Minnesota Experimental City and a less well-known ambition to be University president.

When the presidency went to someone else, Spilhaus left Minnesota on a path that took him to Philadelphia for a stint as head of the Franklin Institute and a variety of government and academic posts. He continued to press his ideas for self-contained, problem-free cities afloat in the ocean.

Except for his longtime advocacy of recycling in the widest sense — returning junk autos to factories to be rebuilt, for example, or piling them up to make artificial ski slopes — many of his visions seem quaint and dated today, impossible to square with modern skepticism about the limits of technology.

But in an age when nearly every social problem can seem a permanent consequence of human nature, it can be inspiring to reflect on the sweeping vision and unshakable faith of Athelstan Spilhaus, who once told an interviewer: "I'm impatient with the past and irritable with the present. The future is where my concern lies, and I'm very optimistic about it." ■

"I'm impatient with the past and irritable with the present. The future is where my concern lies, and I'm very optimistic about it."

■ ATHELSTAN SPILHAUS

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