MINNESOTA TECHNOLOG

FALL 1999
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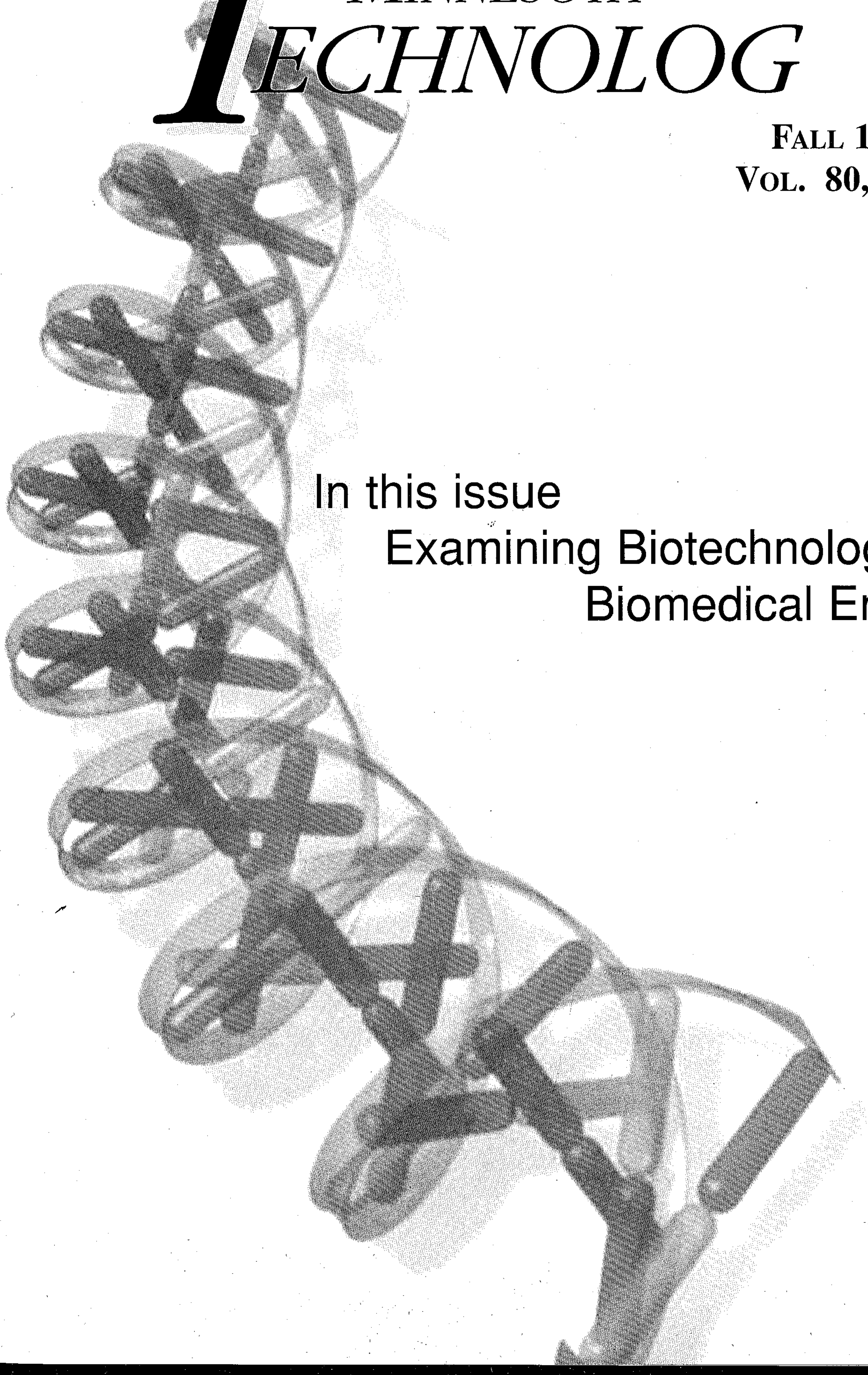

In this issue
Examining Biotechnology and
Biomedical Engineering

SCIENCE FICTION contest

Entry Deadline February 14, 2000

First Prize: $250
Second Prize: $150
Third Prize: $100

Entries must be typed and double-spaced on 81/2 by 11 paper and be no longer than 3,500 words. Each entry must be accompanied by three photocopies of the manuscript and must have an attached cover page with story title, author name, home address, and phone number.

DO NOT PUT AUTHOR'S NAME ANYWHERE ELSE ON THE MANUSCRIPT!!
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Deliver copies to
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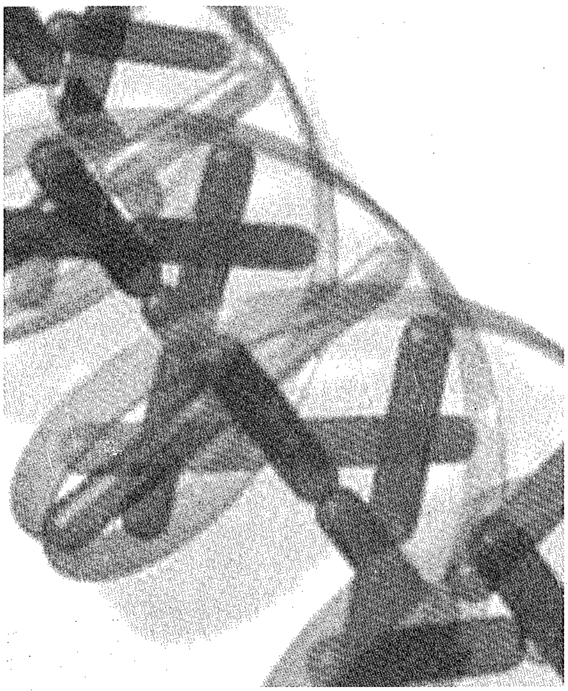

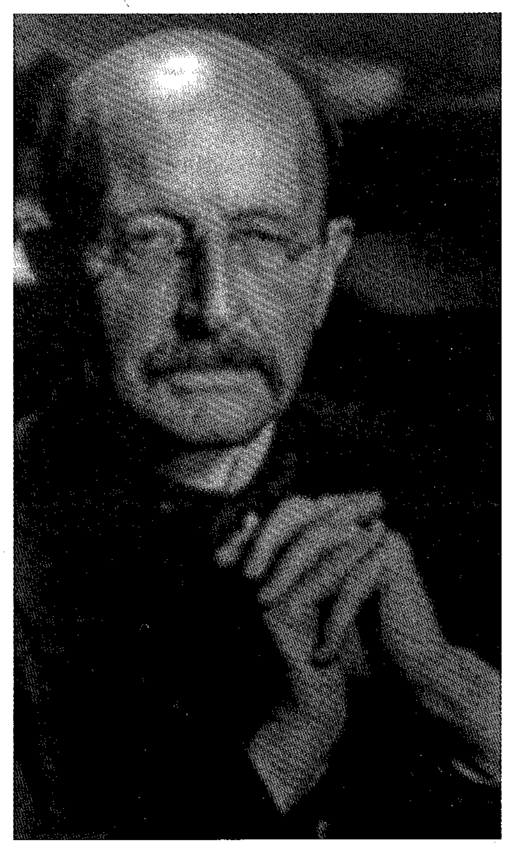

CONTRIBUTORS

Dimitri Goutis was born and raised in Athens, Greece where he lived until his senior year in high school, when he attended an international school, and he is fluent in both Greek and English. Dimitri is currently a sophomore at the U and is enjoying it so far, especially after he changed majors. Dimitri is an STC pre-major after changing from paper science and engineering. He decided to change majors because "I don't have to take any more science and math, but more importantly, it combines two of my favorite things: technology and writing." Dimitri decided to start contributing articles to the *Minnesota Technolog* because it is very good experience and provides excellent portfolio materials. Dimitri plans on applying for the STC major in the spring and hopes to get a head start by getting an internship this coming summer.

Michael Franklin is the managing editor for the *Journal of Laboratory and Clinical Medicine*. As a contract writer, he has written about Medtronic medical devices. He is completing a masters degree in science journalism from Boston University (BU). As a freelance science writer, he has written for the *Daily Free Press* (BU newspaper), *Stellwagen Soundings* (a marine newsletter), and the *Humanist* magazine.

Jeremy Paschke is a graduate student in the School of Physics and Astronomy at the University of Minnesota. Outside of writing for the *Technolog*, Jeremy specializes in the history of physics, his dream is to write science books for children, and he plans to spend his summers with creative writing and extensive tramps through the woods.

Keira Thrasher is a technical writer and editor who has developed software and medical training materials as well as systems documentation, user guides, and commercial web sites. She is currently a consultant for Dahl Consulting, Inc. and a Masters student in the University of Minnesota's technical communication program.

Tim Ward is a senior in Scientific and Technical Communication on the St. Paul Campus of the University of Minnesota. He is also the current president of RASTEC, a student group for technical communicators. Tim is from New York and moved to the Twin Cities because of the lively music scene. Now he's enjoying the peace and quiet of the upper midwest. When he's not at school, he's either working on his computer or struggling with the new software at the recording studio where he works occasionally. He spends his free time playing with his two children and catching up on sleep.

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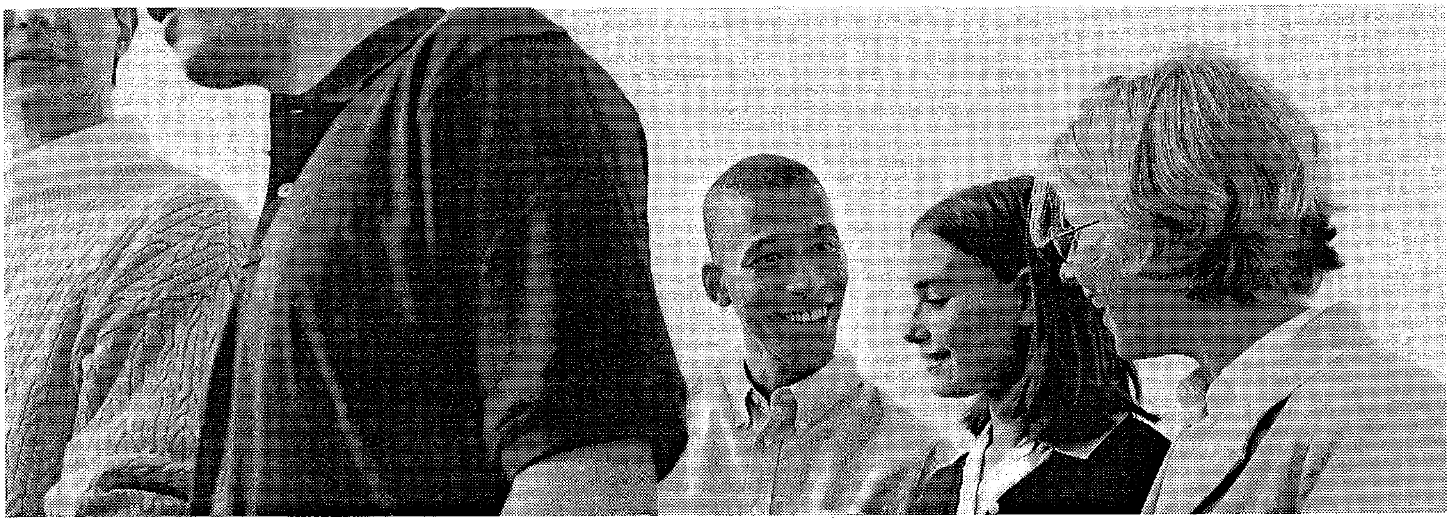
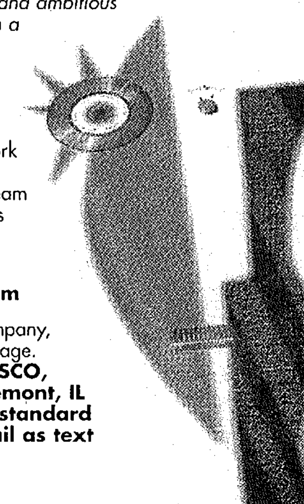




THE EDITOR'S CORNER

CAN THE EU CONTROL THE INTERNET?

The Internet allows the world to share information at, literally, the speed of light. However, there is some international tension concerning open online access to an individualís ìpersonalî information. As a result of these concerns, the nations of the European Union (EU) have adopted a series of privacy laws, collectively known as the EU Data Privacy Directive, that would greatly restrict online access to personal information on EU citizens.

According to the Directive, certain "personal" information (e.g., an individual's race, creed, sexual orientation, or medical records) can not leave the EU unless it is going to a nation with laws offering levels of privacy deemed "adequate" by the EU. (Critics such as the Brookings Institution's Peter P. Swire and Robert E. Litan have voiced concerns concerning the ambiguousness of the word "adequate.") Unfortunately, many nations, including the United States, do not have national privacy laws that meet EU standards. As American privacy law is not nearly as comprehensive as EU privacy law, American organizations, both public and private, will not be allowed unchecked access to certain information concerning EU citizens. Rather, personal information on EU citizens can only be transmitted to America if the individual gives "unambiguous consent" to the transfer of this data.

These regulations, therefore, will limit the extent to which Americans can perform research or even engage in every-day business practices, for they could now be denied access to certain data they might need. This restricted access to information results in knowledge limitations that could impact the effectiveness with which Americans can participate in the new climate of international online discourse.

While the EU had discussed the possibility of creating an "alternative solution" for American companies (the current solution is referred to as "Safe Harbor"), it also maintains that the United States would have to rework its own data privacy laws to parallel those of the EU if American organizations wished to maintain access to personal data on EU citizens. Moreover, all 15 member nations of the EU have publicly admitted that they find the current Safe Harbor alternative "unacceptable" because it does not sufficiently protect an individualís privacy. Specifically, EU officials expressed concern over Safe Harborís approach to how much access individuals had to their own files and the degree to which individuals could stop the sale of their personal information.

In an attempt to address these concerns, the EU has been working with the U.S. to revise the Safe Harbor alternative. The U.S., however, has begun to express displeasure with this revision process and has claimed that, the EU rules are burdensome and costly for U.S. companies and are likely to give consumers a false sense of security because they are impossible to enforce.

For over a decade, the Internet has allowed users to readily access large quantities of information from all over the world. New developments in EU law, however, will inevitably change the way in which we use the online environment. By restricting access to personal information on EU citizens, the Data Privacy Directive has suddenly made us all aware of how changes in one part of that international environment can have an effect on the rest of the world.

To review the EU Data Privacy Directive online, go to *http://cpsr.org/cpsr/privacy/privacy_international/international_laws/ec_data_protection_directive_1995.txt*

To review the Safe Harbor alternative online, go to *http://www.epic.org/privacy/intl/doc-safeharbor-1198.html*

IDEAS INTERFACE

The expression and exchange of ideas is essential to the development of new was of thinking about both our world and each other. For this reason, the Minnesota Technolog invites all readers to submit ideas and opinions for publication in the Ideas Interface section of the magazine. Readers may also submit responses or querries to items published in previous issues of the Minnesota Technolog. We hope that this free flow of ideas will help readers gain a better understanding of concepts related to the IT and its greater academic and professional community.

THE GREENING OF THE IT

The Institute of Technology (IT) is a fine school. Or is it? I graduated from IT with a B.S. in Computer Science (1978) and an M.S. in Electrical Engineering (1988).

One day, maybe twenty years ago, as I was leaving an IT class and exiting from the old Electrical Engineering building, I witnessed a heated "confrontation" between a young, fit, tallish blond young man and an elder professor of Electrical Engineering. The professor said something like: "You do it our way or you get out!" He said this with such vehemence and seemingly unnecessary anger that I was shocked to see it and have not yet forgotten it. I see fresh young faces become programmed with this rigor and can hardly converse with them; they are so frigid. I got a beef, too.

The Earth is going down the tubes, as we all know: rainforest destruction, toxic waste, water depletion, etc. The list of maladies is long.

IT trains the people that design the things that destroy the Earth. Nuclear plants, chemical waste, urban sprawl, you name it and an engineer has worked on it. They forgot the last half of the design process, though: fitting their designs into the Earth's biosphere in a benign way. Air pollution, incinerators, garbage landfills, radioactive waste, and ocean dumping are all introduced by the "fine" work of graduates of schools like IT.

These schools are all over the planet, too, pumping out graduates like so many replaceable parts in the Earth-destroying machine known as "industrial civilization."

Time is short, biosphere scientists say, for the integrity of the Earth's biosphere. Are they correct? Should we risk this once and for all decimation of Earth? There is much readable literature on this subject. If you are concerned (and you should be if you are a decent human being) enough to pursue further study of it, check out my website at:

<www.geocities.com/rainforest/andes/4208>

and contact me at:

Steve Axelson
Belle Creek Institute
27173 144th Avenue
Way Welch, MN 55089

I am forming the "Society of Earth Concerned Technologists" (S.E.C.T.) which has a newsletter. This society is to be an antidote to Earth-destroying business as usual in our civilization. If you want to become an eco-warrior as you pursue your technology career, here is a society with strong people to mix with. Who knows where you'll end up?

Thank you.

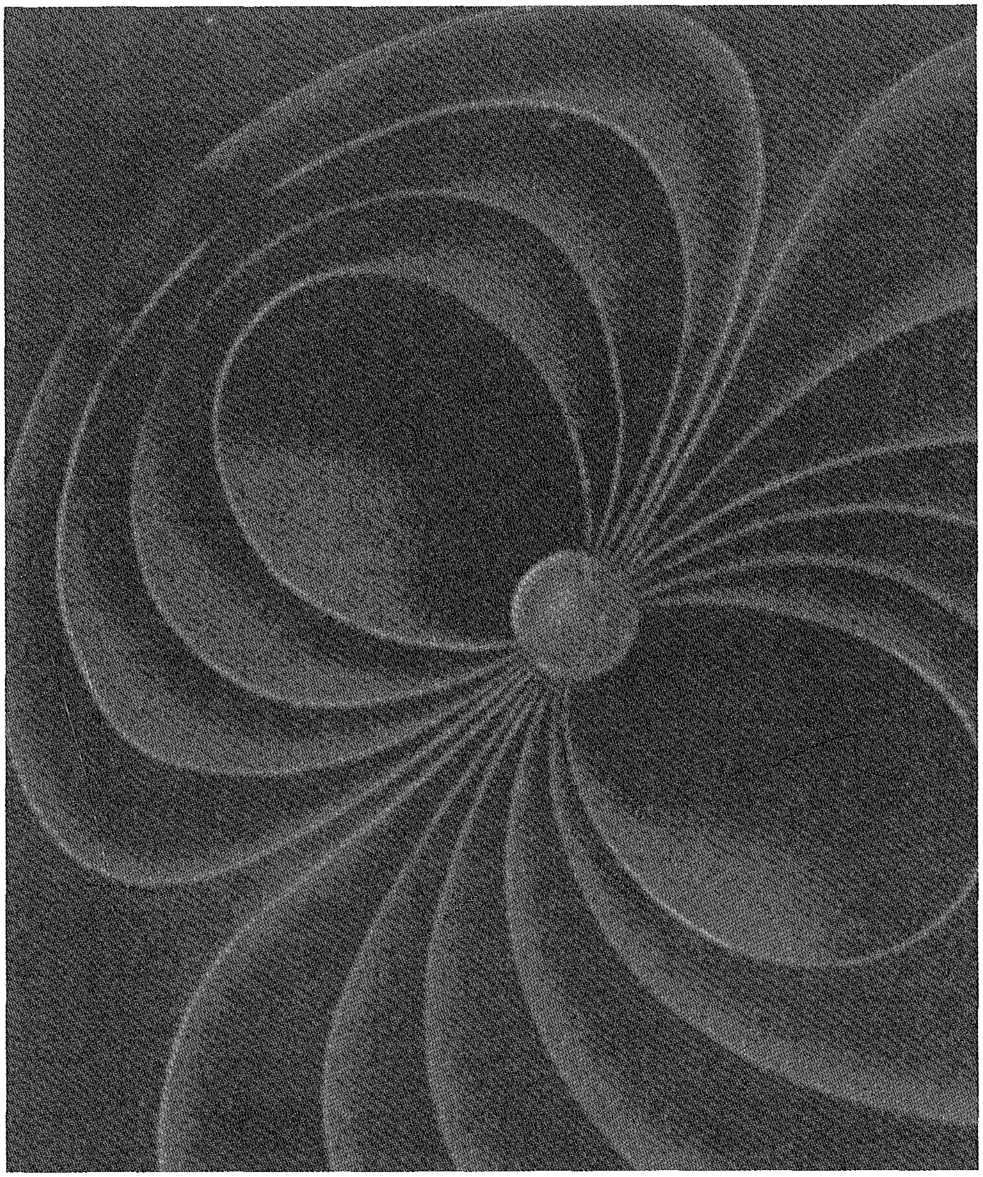
Steve.

Peace.

Steve Axelson is an aspiring Peace Warrior, the goal of which is to live in harmony with the Earth and with other humans.

MAGNETIC MOSAIC

BY JEREMY PASCHKE



Most people know that a magnetic field embraces the Earth from pole to pole. However, most people don't realize that the Earth's magnetic field is prone to reversing its direction, and it has done so in the past.

Field reversals occur on geological time scales, the average time between them lasting approximately half a million years, and the most recent reversal of the magnetic field occurring some 780,000 years ago.

Scientists are not sure what causes the Earth's magnetic field to reverse its polarity. To construct an answer, geophysicists need detailed information about the Earth's magnetic history. They can find this information with the help of the Institute for Rock Magnetism.

Located in Sheperd Laboratories on the Minneapolis campus, the University of Minnesota's Institute for Rock Magnetism (the IRM) was established in 1990 with a grant from the Earth Sciences division of the National Science Foundation. Trying to explain magnetic field reversals is just one of the various questions that the IRM plays a role in solving.

The Institute Director, Subir Banerjee, says that the IRM is committed to research and service in the geological sciences. Professor Banerjee began research and teaching at the University of Minnesota in 1971, and his initial projects included studying the magnetism in lunar samples and the magnetic remnants along oceanic crusts. "This is a nice place," says Banerjee about Minnesota, "because the geomagnetic field seems to have a large non-dipole component here."

While Minnesota boasts magnetic anomalies, it is not alone in this regard, for Siberia displays similar magnetic features.

When the University first received its grant to become an official research institute, Banerjee's immediate concern was that the IRM might devolve into a play-field for individual scientists and their esoteric pursuits. He feared the Institute would branch into a dozen separate corners, each filled with a specialist working on a specialized project. Through concerted planning, Banerjee and his fellow University of Minnesota colleagues, Bruce Moskowitz and Jim Marvin, brought about the exact opposite case. Instead of their institute being filled with cul-de-sacs of research, the IRM is a veritable nexus where physics, geology, chemistry, and biology all convene to share information.

Banerjee strives for a synthesis not only in scientific disciplines, but also in global cooperation. Just like Alexander von Humboldt and other wayfaring scientists before him, Banerjee's investigations of the Earth's magnetism have led him on travels the world over. Last March, Banerjee visited Uruguay to study movements of aboriginal populations, and his research projects in Yemen taught Banerjee the wider application of magnetism in studying plant migration. Earlier in the decade, Banerjee embarked on a rock magnetism odyssey through India, China, and Japan. International sensitivity and an emphasis on teamwork pervade all of Banerjee's travels. "Through cooperative research," he believes, "western scientists can make a difference by lifting the scientific morals of our colleagues and by sharing in field expenses."

Research at the IRM falls under two broad categories: rock magnetism and paleomagnetism. "Rock magnetism is the nucleus of basic knowledge that we are trying to expand," says Banerjee. Magnetism itself remains an enigmatic topic in physic, and physicists relish any clues that can aid in constructing an explanation of magnetic behavior.

Opposite Page: The effects of the Earth's magnetic fields are at the cener of IRM research.

Rock magnetism investigates the magnetic status of terrestrial samples that are thousands or millions of years old. Although the Earth's magnetic field is weak compared to familiar magnets, like ones stuck to your refrigerator, the Earth's field is omnipresent, and it is strong enough to lock iron oxides and other fine-grain minerals into a specific magnetic configuration. For millions and millions of years, rocks preserve the magnetic conditions they knew when they were initially formed. Remnants of magnetism in ancient rocks can guide scientists towards a deeper theoretical understanding of magnetism.

In addition to the "gritty work of rock magnetism," as Banerjee calls it, paleomagnetism is the type of research that applies information of magnetism to other fields. Geologists, environmental scientists, meteorologists, and more all glean the results of rock magnetism for their own particular projects.

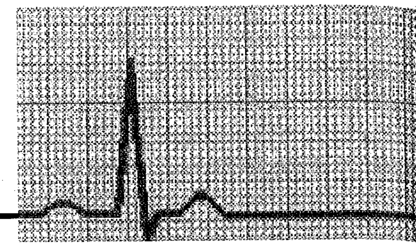
Geologists use magnetic samples to trace plate tectonics and continental drifts. Magnetic clues are a major source for geologists as they assemble pictures of prehistoric land formations. Environmental scientists use magnetism to study environmental change brought on either through human impact or over geological time periods.

Meteorologists use the magnetism of terrestrial samples to study how the climate changed through the millennia. Knowledge of past climate changes can assist modern forecasters in predicting the vicissitudes of odd weather patterns, such as El Nino or La Nina. Furthermore, Anthropologists could benefit by knowing past climates because it informs them what areas were habitable and when.

Climate change through geological time periods is one of the hottest research topics at the IRM. A traveling scholar from the University of California, Irvine studying climate change and environmental pollution brought some samples to the IRM. Shortly after her visit, she announced that the entire direction of her research was shifted thanks to the results she found. The climate changes found by studying lake sediments in the Pittsburgh Basin of south-central Illinois gave graduate student, Christopher Geiss a dissertation topic in rock magnetism and its applications. "Magnetic properties of lake sediments can reflect climatic change and are a useful tool for the reconstruction of paleoenvironmental change," says Dr. Geiss in the conclusion to his thesis. A fundamental axiom in geology says that the present holds the keys to understanding the past. Geiss and others at the IRM tune their research in harmony with this axiom as they piece together the Earth's history.

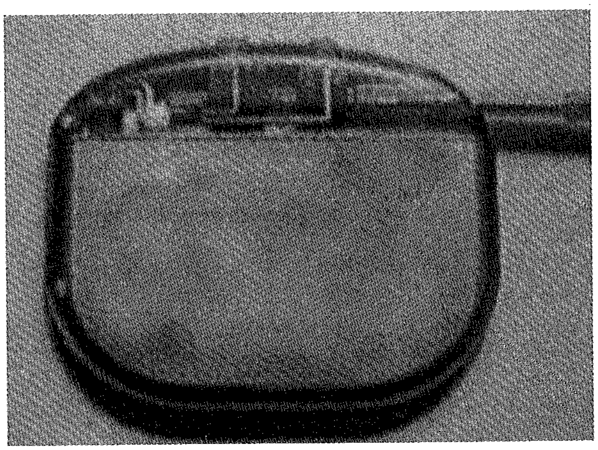
Another active member of the IRM is Senior Scientist and Lab Manager, Mike Jackson, who arrived as a post-doc in 1990. Jackson's writing and experiments have contributed greatly to the IRM's success.

STORY CONTINUED ON PAGE 17



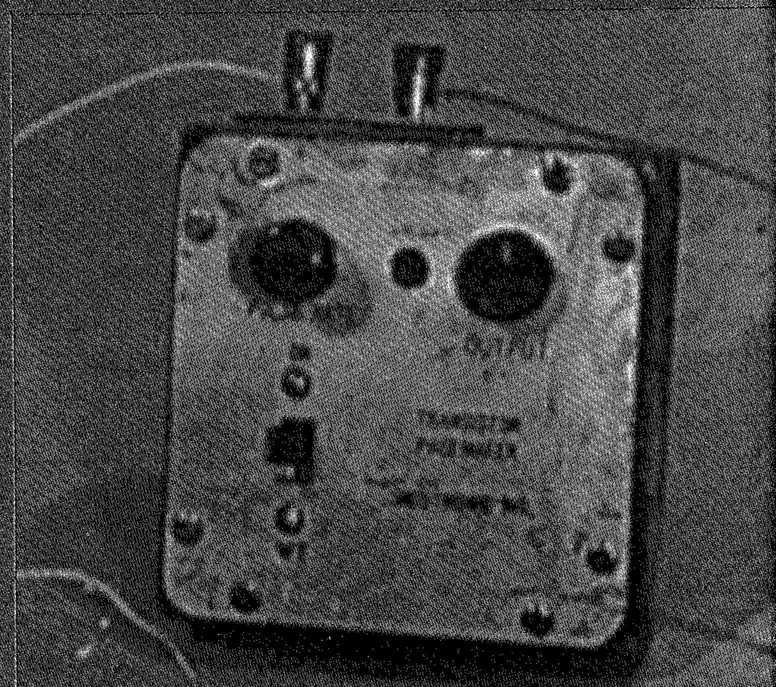
Minnesota Sets the Pace

by Keira Thrasher & Michael Franklin



Minnesota is a major player in the development of medical technology.

And it all started with a pacemaker.



In the 1950s, a revolution in medical technology began when University of Minnesota physician C. Walton Lillehei asked Earl Bakken, a local electronics repairman, to redesign the machine that Lillehei was using to restore patients' heart beats after surgery. The machine Bakken built was a wearable, battery-operated pacemaker, and with this invention, Bakken's small business, called Medtronic, was catapulted into high gear, and an era of technological innovation was born in Minnesota. Physicians began collaborating with Bakken and his staff to create innovative new medical technology, and Medtronic became a fertile training ground for engineers and other industry professionals who went on to found other well-known Minnesota-based medical device manufacturers and health care organizations. Now Minnesota is known for its "medical alley," a wide ribbon of innovative medical businesses that runs from Rochester to Duluth.

The Humble Beginnings

Earl Bakken was an electrical engineering graduate student at the University of Minnesota and a hospital repairman who was known for his ability to fix the hospital's sensitive equipment that other electricians could not service. Recognizing an opportunity, Bakken and his brother-in-law, Palmer Hermundslie, started a company that began by selling and servicing hospital equipment. That company was Medtronic. Operating out of a garage, Bakken and Hermundslie modified and designed equipment at their customers' requests, but those innovations were primarily custom-built, single-use devices. Once Bakken designed the wearable pacemaker in 1957, Medtronic began to grow, prosper, and profoundly influence the health care industry.

Pacemakers and the Heart

The heart is a large muscle that pumps blood through the body by contracting at regular intervals. These contractions are controlled by electrical impulses that are produced by chemical reactions in the sinoatrial (SA) node, a collection of specialized cells in the heart that have been called the heart's "natural" pacemaker. Each impulse sets off a reaction that spreads through the heart, causing its chambers to contract rhythmically. These rhythmic contractions push the blood through the heart, to the lungs for oxygenation, back to the heart, and out to the rest of the body.

In order for the heart to beat normally, electrical impulses must move through the heart at proper intervals and along particular pathways. If the SA node malfunctions, or if there is a block in the heart's electrical pathways, the heart suffers from irregular, interrupted, or misdirected rhythms. This stimulation frequently means that the heart can no longer pump an adequate supply of blood through the body, and the person's life may be in jeopardy. For hearts that beat too slowly, too quickly, or irregularly, pacemakers can either maintain or restore a healthy rhythm by delivering electrical impulses to the heart tissue at proper intervals.

Opposite Page
Top: A modern, internal pacemaker that can fit in the palm of one's hand.

Bottom: One of the original, extermal pacemakers; the device is almost a square foot in area.

Since 1803, physicians have known that electricity could be used to stimulate the heart. Although some physicians had been developing means to deliver electrical impulses to the heart, Dr. Albert Hyman coined the term "artificial pacemaker" in the 1930s for an apparatus he built that delivered impulses to the right atrium via a thoracic needle electrode.

In the early 1950s, Dr. C. Walton Lillehei pioneered open heart surgery at the University of Minnesota. He soon found that about 10% of his open heart surgery patients experienced problems when the sutures interrupted the proper transmission of electrical impulses through the heart. Dr. Lillehei used an AC-powered, vacuum-tube pacemaker to restore normal heart rhythms for these patients. Although this pacemaker was effective, patients were subject to power failures and electrocution. In fact, one of Dr. Lillehei's pediatric patients died in a citywide power outage. In addition to power source problems, these pacemakers were bulky, desk top devices that rendered patients immobile because they had to stay tethered to a wall socket while they recuperated.

To solve these problems, Dr. Lillehei knew he needed a pacemaker that operated on battery power. He decided to ask a graduate student to create a smaller device that would use batteries to deliver a low voltage current at an adjustable rate between 50 and 110 pulses per minute. Six months later the student still wasn't successful.

Dr. Lillehei decided to ask Bakken for help.

Bakken was on a routine visit to the hospital to fix the EKG when Dr. Lillehei presented him with his pacemaker problem. Within just six weeks of Dr. Lillehei's request, Bakken modified a metronome circuit design he found in *Popular Electronics* and created a box that used mercury batteries to deliver a 9-volt DC pulse. A day after the device was tested, Dr. Lillehei used it to successfully restore a child's heartbeat to a normal rhythm. Because Dr. Lillehei continued to have such success with Bakken's new wearable pacemaker, he referred many of his colleagues to Bakken. Medtronic quickly expanded, and their pacemaker came to be used throughout the world.

While the wearable pacemaker enabled heart surgeons to save more lives on the operating table, it was also becoming clear that heart attacks were frequently caused by problems with the heart's natural electrical system and that artificial pacemakers could be used for long-term treatment as well as surgical recovery periods.

The wearable pacemaker was uncomfortable and inconvenient for patients' long term use. In addition, the wires that carried the electrical current from the pulse generator to the electrodes in the heart had to be threaded through an incision in the patient's skin. As a result of the incision, it was sometimes difficult to prevent infections from taking hold. To solve these problems, various physicians and engineers across the country started trying to develop an implantable pacemaker.

By 1960, Drs. William Chardack and Andrew Gage collaborated with electrical engineer Wilson Greatbatch to successfully design an implantable pulse generator in New York state. Soon after the device was thoroughly tested and successfully implanted in a human patient, Medtronic met with the developers and obtained exclusive rights to produce and market it.

While the implantable pacemaker was being developed, Medtronic engineer Norman Roth and Dr. Samuel Hunter from St. Joseph's hospital in St. Paul were busy improving the electrodes that conduct electricity to the heart. They devised an electrode that doctors could strategically position and suture securely within the heart's chambers. With this innovation, the pacemaker required less current to effectively stimulate the heart muscle to contract. Medtronic combined their new electrodes with their newly acquired implantable pulse generator and began production immediately to meet the large demand for implantable pacemakers.

Since then, Medtronic has continued to develop and improve pacemaker technology. For example, pulse generators can now sense a person's level of physical activity and automatically adjust the pulse rate. Also, leads have been developed that enable the physician to maneuver them through veins and into the heart instead of opening up the chest. (Leads are the wires along which current travels to the electrodes and the heart.)

Minnesota and Medical Technology

Medical research and innovation started to boom at the University of Minnesota in the 1950s after Dr. Lillehei pioneered open heart surgery and collaborated with Bakken to devise the wearable pacemaker. The collaboration between Dr. Lillehei and Bakken enabled Medtronic to grow, innovate, and develop new talent. Medtronic employees went on to start 35 more companies, which in turn have contributed to Minnesota's reputation as a leader in the health-care industry.

Dr. Lillehei and his medical colleagues continued their collaboration with Medtronic and the companies that sprang from it. For example, Dr. Lillehei fostered the development of blood oxygenators that take over the heartís work during open heart surgery and helped create several artificial heart valves that were marketed by various Minnesota companies.

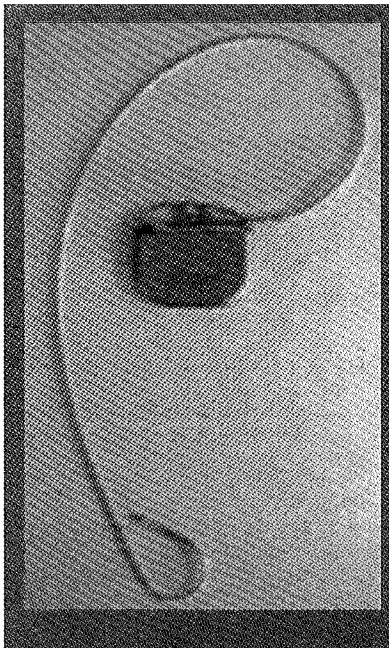
Manuel Villafana and CPI

The story of Manuel Villafana is one striking example of the chain of events that followed the advent of the wearable pacemaker and led to the enormous success of the health care industry in Minnesota.

Villafana began as a Medtronic employee and went on to found several biomedical companies in Minnesota. Medtronic had been reluctant to embrace lithium batteries as a power source because of the potentially explosive nature of lithium. Yet lithium batteries lasted up to ten times longer than standard mercury batteries. Villafana was convinced that lithium could be safely used in pacemakers, and he left Medtronic to start Cardiac Pacemakers, Inc. (CPI), and CPI soon became very successful in its own right.

Villafana sold CPI in 1975 and founded a new companyóSt. Jude Medical. Their new product, which became the leading heart valve, was based on some of Dr. Lillehei's work eight years earlier. Dr. Lillehei had perfected an artificial heart valve in 1968 in collaboration with a surgical resident named Bhagavant Kalke. The first implant of the Kalke-Lillehei valve appeared to be successful, but the patient died two days after surgery for unknown reasons, and the valve was forgotten until St. Jude Medical picked it up.

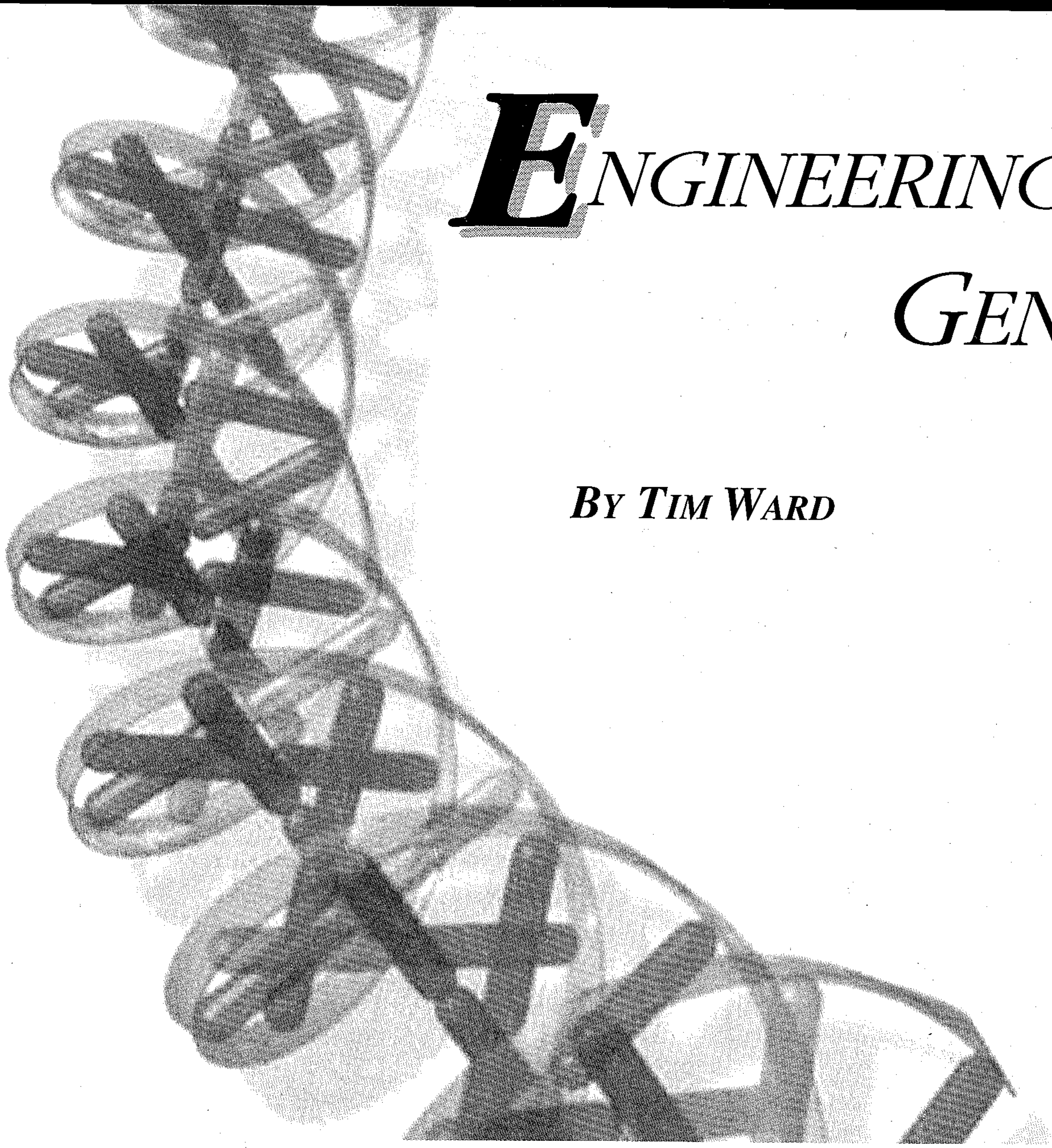
Since then, Villafana has also started both Golden Valley Medical and Helix Bicore. Villafana is just one of the many entrepreneurs, engineers, and health care professionals who were associated with Lillehei and Bakken and who founded Medical Alley, now a trade organization that represents hundreds of health care companies.



A modern, palm-sized pacemaker with lead (the wire that connects the pacemaker to the heart).

The success of Minnesota's medical device industry is widely attributed to that first collaboration between Bakken and Dr. Lillehei. On October 8th, the Institute of Electrical and Electronic Engineers (IEEE) recognized the significance of Earl Bakken's invention when it designated his transistorized, wearable pacemaker as an "IEEE Electrical Engineering Milestone."

MT



Engineering with Genes

By Tim Ward

Human genes define each one of us with slightly different traits than the next person. They determine the color of our hair, whether we have hair, our height, our eye color, and every minute detail of our appearance. They also play a large part in diseases such as cancer and Parkinson's that can affect our very existence.

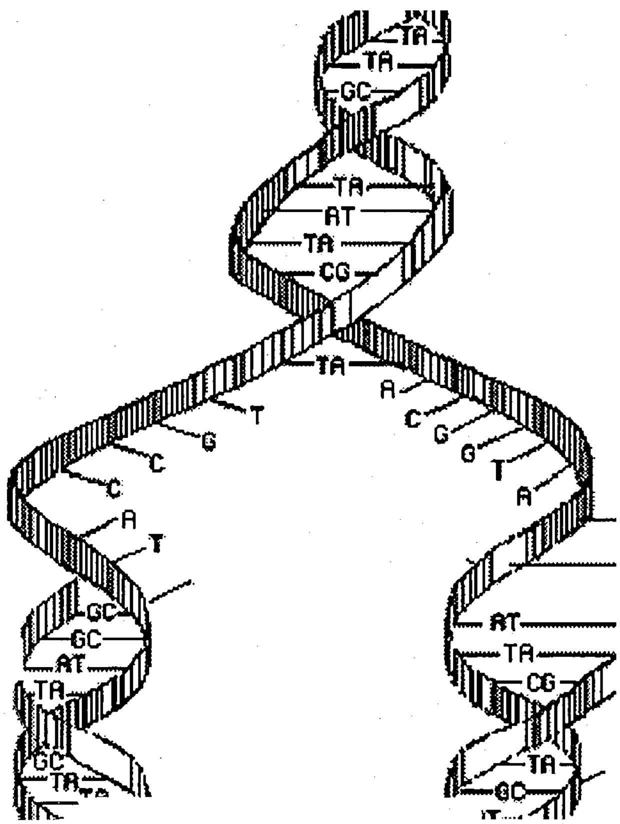
Several years ago, the Human Genome Project was begun to identify every human gene. The project should be completed in the next few years and has already given us an incredible amount of knowledge about our own genes. But what good is that knowledge without a useful application?

The next step is to figure out what we can do with that knowledge. One of the first goal is to cure genetic diseases, or diseases that stem from a defective or missing gene. The gene would need to be repaired or replaced in order to work properly.

In 1990, researchers began experimenting with Gene Therapy on humans. According to Jim Wilson, the director of The University of Pennsylvania's Institute for Human Gene Therapy, "gene therapy is a novel approach to treating diseases based on modifying the expression of a person's genes toward a therapeutic goal." It alters or replaces the gene and therefore corrects the disease. There are two basic forms of gene therapy: one that is corrective for the patient and not passed on to the next generation (somatic), and one that will be inherited by subsequent generations (germline). Research in germline gene therapy has been minimal, "largely for technical and ethical reasons," according to Wilson.

Somatic gene therapy repairs the defective gene by manipulating its expression in a manner that is beneficial to the patient. Now we can use the information that the Human Genome Project has given us — but how?

Many diseases, such as cystic fibrosis or hemophilia, are caused by an inherited defect in a single gene (monogenic). Monogenic inherited diseases are the most obvious place to start. By altering or replacing that gene, doctors can help that patient live a longer, healthier life. Sometimes the affected gene is non-active and needs to be replaced and other times it can be activated by altering or controlling the expression of the gene. But how do you go about altering a gene in a human being?



DNA Replicating

One way is to take specific cells from the patient and introduce the altered gene into the cells in a lab setting. This process is called the ex-vivo approach or the indirect method. The corrected cells are then implanted back into the patient. The direct method, or in-vivo approach, involves injecting the patient with the therapeutic genes and letting the alterations occur within the patient's body. The in-vivo approach is now used in most cases, but several years ago, researchers were confronted with a problem. How can you direct the therapeutic genes toward the desired target cells?

This involves the use of vectors. Vectors are the mechanisms that deliver the therapeutic genes to the target cells. Many vectors are modified versions of viruses. Viruses have proven to be very effective at, "targeting certain cells and delivering genome, which unfortunately leads to disease"said Wilson. He goes on to say that,"our challenge is to remove the disease causing components of the virus and insert recombinant genes that will be therapeutic to the patient." To be effective, the virus must be able to deliver the genetic material properly and effectively die. Injecting a patient with a virus can be a dangerous proposition if its disease causing aspects are not turned off. So how do researchers go about choosing the proper virus?

Adenoviruses are especially drawn to the respiratory system. Adenoviruses are responsible for diseases such as the common cold and were the first vector to be used in in-vivo gene therapy for the treatment of cystic fibrosis. These vectors are only effective in cells that are actively dividing. If the cells are not dividing, then the therapeutic gene never has an opportunity to get copied into the infected cell.

In this year's January 29th issue

of *Science*, Dr. Inder Verma of the Salk Institute for Biological Studies in La Jolla, California explained that, "If a cell is normally not dividing, like a brain cell, or a liver cell or a stem cell—which makes the blood cells—then you can't use most ways of introducing genes." Since a disease like hemophilia, which doesn't allow a person's blood to clot properly, originates in the stem cells, how can researchers develop a vector that will help these patients?

Retroviruses can alter the genes of a cell that is not dividing and are the most common form of viral vector being used today. Retroviruses are the cause of many cancers in humans and include the human immunodeficiency virus (HIV) that causes AIDS. Because of HIV's voracious ability to modify another cells genetic material, Dr Verma is currently attempting to use it as a vector for gene therapy, and thus far his studies have been limited to mice. A retrovirus was used in the first therapeutic study of gene therapy involving patients suffering from an inherited disorder, adenosine deaminase deficiency (ADA), which weakens their immune system. Retroviruses are commonly used today as vectors for gene therapy, and the National Institute of Health (NIH) states that of the 125 approved forms of gene therapy, 63% of them use retroviruses.

Gene therapy is used mostly in cancer studies, but it can be used on a host of other genetic diseases. Parkinson's disease affects nearly 1.5 million Americans according to the NIH. The disease can cause a person to be immobilized and at very least, to suffer from continuous tremors. AIDS is another disease scientists are attempting to cure with the use of gene therapy. The retrovirus that causes AIDS changes a cell's genetic material. Scientists are looking into ways to change them back. Where does that lead us today?

As gene therapy celebrates its tenth birthday, researchers are looking back to see if it has lived up to its hype. The studies done so far have been cautious at best and focus mainly on the therapy's safety. Over the last ten years, its effectiveness may be open to debate, but it has proven to be safe. However, an 18-year-old Tuscon, Arizona man recently died after having gene therapy at the University of Pennsylvania. In this case, the scientists were trying to combat a rare liver disease by using a high amount of an adenovirus to deliver the therapeutic genes directly into the liver. Four days later, Jesse Gelsinger was dead. In response to Gelsinger's death, the Food and Drug Administration (FDA) decided to temporarily stop two other experiments of this form of gene therapy.

The FDA has only limited experiments that inject a high level of adenovirus into the liver, and the decision does not affect any other studies. As more studies are completed, we will begin to have a better feel for the future of gene therapy. Until then, we are left marveling at its possibilities.

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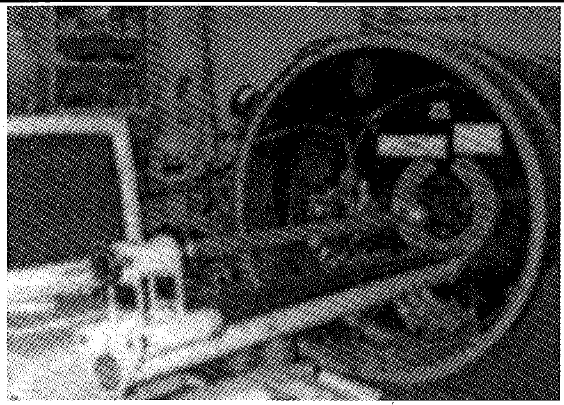
STORY CONTINUED FROM PAGE 9



The Superconducting Magnetometer that detects the true magnetization of a sample.

Whether analyzing data from mid-ocean ridges or core samples from lake sediments, Jackson says the IRM endeavors to, "use magnetism in anyway that we can to work out questions about the Earth's history." Vestiges of ancient magnetic fields are stored in magnetite, fine grains of black iron oxide, that accumulate and stratify at the bottoms of lakes or in oceans. Over geologic time scales, the magnetite grains maintain their magnetization despite the pressures and stresses exerted in the Earth's crust. "A lot of the work we do is geared toward understanding how these fine grains store and retain magnetic information," says Jackson.

Soft-spoken and amicable, Jackson is a prolific writer whose articles have graced numerous covers of the IRM Quarterly, a journal that finds hundreds of readers over 6 different continents. Jacksons penchant for history led him to write on topics such as Edmund Halley's voyage around the Atlantic to chart magnetic declination and Benjamin Franklin's proposals to explain magnetic phenomena. Jackson also wrote *The Hitchhikers Guide to the IRM*, a whimsical travel guide for all of the Institute's visiting scholars.

The IRM is seldom lonely. The National Science Foundationís grant also funds a visiting scholars program where foreign scientists can visit for a couple of weeks and operate the IRMís coveted equipment. Instruments at the IRM study magnetism in two basic manners. In some cases, researchers can detect the true magnetization of a sample using the Superconducting Magnetometer (see picture above). In other cases, researchers may choose to study the magnetism of a rock by applying an external magnetic field with an instrument like the Vibrating Sample Magnetometer, then observing how that magnetization is retained.

In addition to its academic work, the IRM also hosts a biannual conference at St. John's College in Santa Fe, New Mexico. Using funds from the American Geophysical Union and the National Science Foundation, the IRM's conference presents an informal setting for swapping of knowledge in magnetism and its applications. "We strive for an aura of equality," says Banerjee, "and ask people from interdisciplinary topics to tell us where the action is." Banerjee credits Jackson for coordinating the event and guaranteeing its success.

Through pure research, applied research, and international cooperatives, the Institute for Rock Magnetism plays a leading role in deepening the human understanding of our earthly home.

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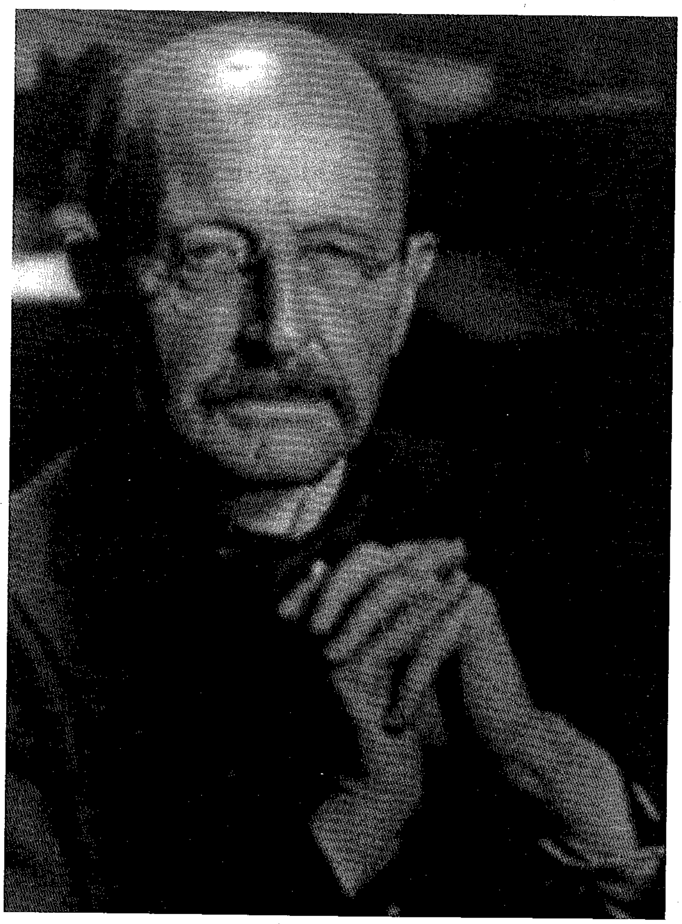
THE QUANTUM VISION

TURNS 100



BY JEREMY PASCHKE

Examining the scientific contrubutions of Max Planck, the man who forever changed the way in which we view reality.

Amid the revelries of a new millennium, I invite students of science to commemorate a revolution in thought: an insight that changed the world. The year 2000 marks the 100 year anniversary of Max Planck's creation of quantum physics. "The introduction of the quantum theory," said Planck, "led not to the destruction of physics, but to a more profound reconstruction, in the course of which the whole science was rendered more universal."

Quantum theory, the theory that nature apportions her energy in small, indivisible bundles, was a watershed. It tied physics to chemistry by their roots, and modern theorists say the quantum undergirds all aspects of nature. This story narrates when, where, and why quantum theory appeared and tells about the free thinker who gave this gift to humanity.

Those who knew Max Karl Ernst Ludwig Planck before 1900 would never have pinned him as a revolutionary. Self described as, "peaceful and disinclined to questionable adventures," Planck carried out his studies humbly, excelling in all subjects but not showing any particular genius. He played the piano with professional grace, and he nearly chose the life of a concert pianist instead of a theoretical physicist. Planck's advisors at gymnasium (high-school) counseled him against a career in physics, saying there was nothing left to discover, no further glory to win. Planck instead followed his passion for science, and by 1897, he became the recognized authority on his favorite topic: thermodynamics. As a leader of the Berlin Academy of Sciences, Planck's name stood at the forefront of German science.

The looming physical puzzle at the end of the nineteenth century — the puzzle that eventually gave rise to the quantum revolution — concerned the radiation of hot glowing objects. Any object with a high temperature emits electromagnetic radiation. When the temperature becomes extremely high, that radiation enters the visible spectrum and glows red, orange, blue, or white depending upon the object's temperature. Ceramic plate manufacturers witnessed this phenomenon as early as the 1700s. By noting the color of their oven, plate-makers could tell the oven's temperature, and that determination held true regardless of the oven's material composition. When Planck learned that intensity of radiation depended only on frequency (color), he had to find out why.

Planck viewed the axiomatic link between energy intensity and frequency as a cornerstone in comprehending nature. He said that, "in physics, we labor not for the day, not for the momentary success, but, as it were, for eternity." Planck dove into the radiation problem, hoping to glimpse the eternal, to find a formula that would apply at all times to all cultures, even, "nonterrestrial and nonhuman ones." Planck's wish for pure knowledge then, formed the first reason to study radiation, but there was also a second, more pragmatic reason for Planck's study of radiation.

In 1879, Thomas Edison evacuated the air around a wire filament and excited that filament with electricity until it glowed in the color spectrum, thus creating the first incandescent light. The world quickly caught on to Edison's invention, and the German bureau of standards (Physikalische Technische Reichanstalt) wanted to know the optimal frequency to power their new system of electric lights. Possessing a mathematical formula that related frequency to energy intensity would inform technicians what frequencies wasted the most energy from a light bulb, and hence what frequencies they should avoid.

From 1894 until 1900, Planck struggled with the problem. He conjured up a formula that fit the data, but had no clue what the formula meant. "After some weeks of the most intense work of my life," Planck recalled, "light began to appear to me and unexpected views revealed themselves in the distance." In his mind's eye, Planck envisioned the glowing object as a huge collection of atoms. As the electrons within the atom vibrated, the object radiated light as electromagnetic waves. By summing up the energy contribution from each vibrating atom, Planck scribed a formula for the total intensity of a glowing object based on the vibrational frequency alone.

On October 19, 1900, Planck addressed his colleagues at the Berlin Academy and drew their attention to a, "new formula that I [Planck] consider to be the simplest possible . . . from the point of view of the electromagnetic theory of radiation." Contrary to traditional assumptions, Planck's new formula only allowed atoms to vibrate at certain frequencies. Hence, atomic energies could not take on any value possible; energy was relegated to integer multiples of a singular quanta. In Planck's quantum world, energy does not increase along a smooth, continuous line, like an elderly gentleman ambles down a sidewalk. In the quantum world, energy hops from one level to another, like a child playing hopscotch, and never lands in the unmarked regions. Why nature prefers to hop rather than amble is riddle that vexed Planck until the day he died.

Planck named the rift between energy levels — the distance between hopscotch squares — the, "elementary quantum of action." The quantum of action ploughed its way through scientific fields, a, "mysterious messenger from the real world," said Planck, that, "insisted on turning up in every kind of measurement." Thirty years later after creating his formula, an interviewer asked Planck how he guessed that nature quantized her energy. Planck admitted, "it was an act of desperation." He had exhausted all the logical routes and could do nothing other than step into the unknown.

Five years after the first announcements of quantum theory, Albert Einstein used Planck's elementary quanta to explain the photoelectric effect. Einstein was the first to introduce h, later called Planck's Constant. New theories catch on slowly, and the development of twentieth-century physics owes much to the Planck-Einstein dialectic. Einstein applied energy quanta to light and increased the veracity of Planck's original ideas. Planck reciprocated by supporting Einstein's special relativity when he exposed it to a highly conservative and highly critical German audience. Planck's friendship with Einstein extended beyond professional boundaries as they occasionally teamed up to make music together.

Planck worked on physics with colossal zeal, but he loved his family above all. "How wonderful it is," said Planck in his youth, "to set everything else aside and live entirely within the family." After twenty-three yeas of marriage, Planck's first wife died in 1909. Nevertheless, Planck counted his blessings in his four healthy children.

Planck's Formula for Radiant Energy:

$$Energy(\nu,T)=\frac{8\pi\nu^3}{c^3}\frac{h}{e^{h\nu/kT}-1}$$

Planck's formula for the energetic radiation of a glowing object. For any given temperature, the energy of radiation depends only on the frequency (written as the Greek "ν"), all other terms are constants. "k" is Boltzmann's constant derived in the 1880s; "c" is the speed of light, and "h" is a new constant. Placing the frequency in the denominator's exponent made Planck's formula fundamentally different, thus causing energy to reach a maximum, then diminish back down to zero.

Disasters began when Europe first slid into world war. In 1914 Planck's eldest son, Karl, was killed on the German front. In the succeeding five years, two more of his children wen to an early grave as his twin daughters both succumbed in childbirth. Einstein described his friend as a man eaten by grief, yet one who still stood, "fully courageous and erect." Rather than grow bitter and caustic towards life, Planck marshaled his spirits through work and the loving relationship with his only living son, Erwin.

Planck lived through two world wars, both times on the losing side, and while he often disagreed with German politics, Planck never relinquished his national pride. "It is a great feeling," he said at the start of the Great War, "to be able to call one self a German." In the optimist fervor of the first weeks of war, Planck signed his name to the *Appeal to the Cultured Peoples of the World.* The Appeal was a formal declaration that the leaders of German arts and sciences supported the acts of the German army. Planck regretted signing the Appeal. He called his signature a "mental scruple" and complained it that weighed heavy on him for a year and a half.

Germany's economy plummeted after the Great War, and the ensuing depression affected all citizens. As a leader of the physics community, Planck was prone to giving guest lectures and attending seminars at various universities in Germany. However, there were times when the inflation grew so bad that the cost of a hotel far exceeded Planck's travel allowance. The 65 year old Planck would sit up all night in a train station just to keep his countrymen and himself up-to-date in science.

A ruined economy was one consequence of the Great War, but ruined mentalities made for further consequences. The excess of blood shed in trenches across Europe led to a morose view on life. After the war, science became the scapegoat for all the world's pain; and the belief in causality — a belief that made science possible — was philosophically rejected. In place of traditional science and causality, the general populace substituted vogue topics such as magic and mysticism. Even working scientists joined in the flight from rationality. A majority of scientists conceded that scientific theories could tell the observer only about the outcomes of experiments. Theories, they said, tell us absolutely nothing about nature herself. Planck understood that science had given the world poison gas and the machine gun, but science also created telegraphs and vaccinations for polio. Not all scientific offspring were evil. Planck believed in causality, that a lawfulness directed everything that happened, and against a world of critics, he fought for his underdog; he fought for science.

One philosophical issue at stake was the tension between causality and free will. If the world is causal, argued skeptics of science, then humans have no freedom of action — our hands are tied by the deterministic laws of physics. Planck countered these arguments by claiming that self-reflection distinguished itself from scientific analysis. By contemplating ourselves contemplating an act, humans disrupt the causal chain and assert themselves as free actors in life's drama. "Each one of us is an integral part of the world in which we live," assured Planck.

Although he rhapsodized on the merits of science, Planck never dared suggest that scientific knowledge was absolute knowledge. The "apprehension of true reality," he said, is a, "goal which is theoretically unobtainable." True reality always lies ahead of us, always beyond our cognitive grasp. Planck compared science to art and said that humanity could advance only because of, "the creative force of the imaginative intellect."

Planck's noble dedication to teaching and learning pure science propelled him to the vanguard of German academia. He was the secretary of the Berlin Academy and the president of the Kaiser-Wilhelm-Gesellschaft, two influential positions in Germany. When Hitler became Reich Chancellor on January 30, 1933, Planck held far too much responsibility to flee the country. He could not admonish Germany from abroad like his friend Einstein did, calling the fatherland a place where "civil liberty and tolerance" no longer existed. As hordes of German intellectuals emigrated to make a new start, Planck stayed behind to salvage what he could in the name of science. Although he was not a Jew himself, Planck sympathized with the Jewish plight. His "warm and peaceful attentiveness" supported less fortunate physicists such as Paul Ehrenfest. As the Nazis accumulated greater power, Planck often wished he could retreat from official matters, but he was stuck; everyone counted on his help.

In May 1933, Planck met for a short interview with the Fuhrer himself. He tried to convince Hitler that forced emigration of the Jews was bad for German science and that Jews could be good Germans, but Hitler would hear none of it, and the dictator curtly showed Planck to the door. War raged again on German fronts, yet Planck continued to lecture in his quiet, humble, wise manner, "calling forth the divineness of life and its government by law."

In mid-winter, 1944, an Allied bombing raid soared over Berlin and obliterated Planck's home. Libraries, correspondence, and diaries, were all decimated. Later that same year, the Nazis captured Erwin Planck and judged him guilty of conspiring to assassinate Hitler. Max Planck did all he could to free his son; but on February 18, 1945, the inevitable happened, and the Nazis executed Erwin Planck. The elder Planck never recovered from this terrible blow, and he lived for three more years before dying of a stroke on October 4, 1947, just days before his ninetieth birthday.

To preface a lecture back in 1932, Einstein told his audience that if an angel of the Lord should descend to the temple of science and sweep out everyone there for impure reasons, Max Planck would be among the few remaining. Planck did not practice science to invent labor saving devices or improve the instruments of war, nor did he practice theoretical physics to vainly have his surname attached to some arbitrary constant. All the prestige and power of his offices never inflated Planck's ego. He studied physics with unsullied motives, and was ever humble before the mysteries of nature. Planck wanted to learn about the world, purely and simply, and that is the reason why Einstein admired him.

Planck's life gives us more lessons than scientific ones, however. He suffered Job-like catastrophes, yet maintained a positive countenance and a love for life. Strong in body, Planck continued to climb mountains well into his eighties. Strong in mind, Planck's creativity granted him a glimpse beyond the dominant scientific paradigm and into the new world of the quantum. Strong in spirit, he fought ignorance and dogmatism on all fronts. Planck was a complete type of man, and that is the reason why, 100 years after his greatest triumph, we can all admire him.

The historical information and the quotations used in this article come from the following sources:

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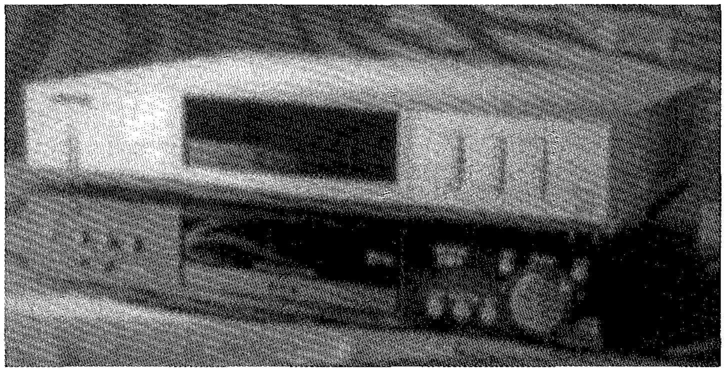
MT

Understanding the DVD Experience

By Dimitri Goutis



Better make room for a new component in your entertainment center because chances are that soon you'll be adding a new DVD player. Although DVD players and the DVD format are not catching on as quickly as was predicted, they are becoming increasingly popular and are set to replace the aging VCR players. Think of it as a tale similar to the audio tape and the compact disc: "Once upon a time, there was an audio cassette which was devoured by a beast called a Compact disc." The DVD tale, however, has no end to it. It will continue to progress at a rate faster than anyone can keep up with as technology keeps advancing

Yet selecting a DVD player for your living space is anything but a simple fairy tale. The consumer is very conscious of the fact that practically hundreds of DVD players are out there, each with various company logos, and each with thousands of features and capabilities. It is no wonder that the consumer feels like he or she is tumbling down a wormhole. Features like Dolby Digital and Digital Theater Sound (DTS) decoding, component video outputs, and manufacturers ranging from KLH to Sony to Theta Digital have the consumers wide-eyed with amazement but with their backs turned away from DVD technology. That is true for the most part. Many people embrace new technologies with passion, ignoring the complexity of them and taking advantage of the possibilities they have to offer. Pure fun is the best description that comes to mind.

Purchasing a DVD player can be fun for everyone if all the features and possibilities are put forth in a simple yet effective manner. Before anyone goes out to purchase a DVD player, certain things need to be taken into consideration.

First of all, consumers have to develop a familiarity with the technologies and features available today. Technologies and terms such as Dolby Digital, DTS and Virtual Surround (Spacializer) need to be researched. Also, cost must be considered. The price of a DVD player starts in the hundreds of dollars and and goes up to the thousands. Last but not least, the individual's entertainment needs have to be met. Is the DVD player to be used in a home theater, or is it simply going to be used with a television? Does it have all the features that you are looking for?

Once these basic aspects are taken into account, start looking at the options present. Did someone say simple? That is a far cry from the truth. People use the phrase "the sky is the limit" for many things, and selecting a DVD player could very well be one of them.

First of all, manufacturers have about three different models on their DVD lineup, with different features and for every budget. As mentioned earlier, manufacturers range from low-end RCA to high end Theta Digital and Pioneer. But what about those features that should be taken into consideration?

The following listing overviews certain features according to two categories: audio and video.

Audio

Dolby Digital Compatibility Dolby Digital is a relatively new way to reproduce sound for theaters and for home entertainment. Introduced in 1992 in the movie Batman Returns, Dolby Digital is a way to digitally reduce the background noise that comes from the audio sources, like the speakers and the receiver. Think of it as the latest version of the legendary Dolby Noise Reduction system used in tape players. Dolby Digital is able to produce crystal-clear sound and deliver it discretely to all speaker channels. This delivery system-means that sound only comes out from each speaker when it has to. This system is unlike the common

Dolby Surround Pro-Logic, which delivers sound to four channels at the same time, using analog methods. Dolby Digital is the standard feature of all DVDs today. Just look for the Dolby Digital logo on the front panel of the DVD player.

Dolby Digital Decoding

Not all DVD players are able to decode the Dolby Digital signal because most DVD players in the middle of the price range contain a built-in Dolby decoder and all that is required is a Dolby Digital-ready stereo receiver. While DVD players in the lower price range are able to send out this signal, but they cannot process it. Rather, a separate decoder is needed to connect to the Dolby Digital-ready receiver or a Dolby Digital receiver. These receivers are usually identified by the Dolby Digital logo they cary on the front cover (see logo above). Also, Dolby Digital-ready receivers have six discrete inputs on the back, which are usually labeled "5.1 Channel input".

DTS compatibility

DTS is an abbreviation for Digital Theater Sound. The purpose of DTS is to further enhance the quality and realism of the soundtrack of a movie. The most commonly used slogan is that DTS re-creates sound the way that the director intended for it to be heard. However, DTS is not as common a feature as Dolby Digital mainly because there are few movies that encoded with the DTS sound format. Many DVD players and receivers are able to decode the DTS signal. It is therefore only a matter of time before DTS becomes one of the standards in home entertainment. Look for the DTS logo (pictured below) on the front panels of the components.

Digital Optical Output

This output is used primarily for transferring the Dolby Digital and any audio signal from the DVD player to the receiver or the processor. It is a few steps higher than the common RCA connection because it is able to transfer data more efficiently and with less distortion. This type of output is also a standard on all DVD players today, and some have more than one optical outputs. The second one can be used to connect the DVD player to a Mini-Disc recorder or a CD-Recorder.

Digital Coaxial Output

This output is a step higher than the standard optical outpu, and it is able to transfer data with even less distortion. What is most important is that this output can be used for transferring the DTS signal. Standard optical output is also able to do this, but not at the same level a digital coaxial cable can. This feature is quickly becoming more commonplace in the world of DVD players.

RCA outputs

This output is perhaps the most commonly used connection on any type of video or audio equipment. Therefore, it could not be absent from the DVD player. This connection is used simply for transferring audio signals from the player to the receiver or the decoder, but it is unable to carry Dolby Digital and DTS signals. In other words, these outputs can be used to listen to music and watch movies in Dolby Surround Pro-Logic mode. RCA connections are a fairly "ancient" feature when compared to the other two options available.

Compatibility with Recordable and Rewritable CDs

This compatibility is crucial. With CD recorders becoming more and more popular, DVD players should be compatible with the rewritable and recordable CDs. Surprisingly, many DVDs are not compatible with one of the two formats or even both. This feature is a very important one if your CD library consists primarily of recordable and rewritable discs. Currently, Pioneer is one of the few manufacturers that has considered this requirement and is a top choice for many consumers. Nonetheless, other manufacturers are realizing the importance of compatibility and are taking the necessary steps to meet the consumer's needs.

Virtual Surround

This feature may be considered important, especially for those who are on a tight budget. Virtual Surround creates a "fake" surround field by using the RCA cables and only two speakers instead of five. Therefore, all that is required to produce good quality sound is a stereo receiver and two speakers. The surround effects created are acceptable, but they cannot meet Dolby Digital and DTS standards by any means.

Digital to Analog conversion of 24bit/96KHz

Another feature that is becoming standard is the 24bit/96KHz digital to analog conversion rate. This conversion rate is used when the DVD player is reading a CD. A common CD player has a 16bit/48KHz digital to analog conversion rate, and the higher these two numbers are the better because these numbers indicate that music can be reproduced more accurately. Most DVD players with this feature have the two numbers-24bit/96KHz-on their front panels.

Video

RCA video output

Perhaps the most "primitive" of the video output on the DVD player, this yellow output serves one and only purpose: to transmit a decent picture to the television. With better options out there, it is highly recommended that the RCA output be used only as a last resort.

S-Video output

This output is also standard on DVD players today. It is easily identifiable because it is similar to a USB connection on a computer but has a smaller diameter. The picture that is obtained through the use of the S-Video output is dramatically improved and very noticeable when compared to the RCA connection. It is highly recommended that the S-Video output be used. There is, however, one downside to this feature: the television must have a S-Video input or it will not work. Most new televisions have this feature as it is quickly becoming the standard.

Component Video outputs

Another feature that improves the picture quality even more than the S-Video option, Component Video consists of three outputs with different colors. Think of it in this manner: the picture is divided into three different outputs, instead of one, which is the case with S-Video and RCA connections. This division automatically means higher resolution, vividness and clarity. Component Video, unfortunately, is available only on higher-end DVD players and, as with S-Video, the television must be Component Video compatible. Once again, expensive televisions carry this feature. Overall, a feature which is highly recommended for those who are not a tight budget and are plain fans of good picture quality, regardless of the price.

These are a few the basic features that one should look for when shopping for a DVD player. Of course, there are many others that are not available on a widespread basis such as High Definition Compact Disc (HDCD) decoding, which improves the quality of common CDs and provides crystal -clear sound with HDCD coded CDs. Another option that is gaining popularity is the multiple disc DVD player. Sony, for example, has already released a two-hundred disc DVD changer. Of course, the changer is able to read CDs, and many people see this ability as an advantage. Instead of having two different components, they prefer to have two. Logical, one might say.

One might also say that the possibilities a DVD player has to offer, are limitless, and they would be absolutely correct. It is possible to connect a DVD player to a single television or to use it as part of a complete home theater system.

The choice is yours, and should be researched thoroughly because a DVD player is not the cheapest component you can buy. It is definitely worth the money though. My advice: look around and have some fun. That is what DVD players are used for anyway — pure fun!!

MT

TRUST NO ONE . . . AND LET THE GAMES BEGIN!!

As the pop culture hit the X-Files gets ready to move into the new millennium, we thought we ould reprint this rather interesting X-Files game first published in the November/December 1996 issue of the *Minnesota Technolog*. In this version of the game, the first player to spot a particular event gets a certain number of points per "sighting;" the player who has accumulated the most points by the end of the episode wins.

ONE POINT:

Characters show their badges
Either character fires gun
Either character smiles
A mutant/alien/monster kills someone
Scully drinks iced tea
Echo of opening music plays
Anyone says anything about a conspiracy theory
A computer does something computerís canít do
Skinner appears
Cancer man appears
The first time you see Mulderís ìI Want To Believeî poster

TWO POINTS:

Mulder or Skully kills someone
Mulder looses his gun
Mulder does a voiceover
Mulder goes into a dark place alone
Mulder or Scully launches into an awkward-sounding explanation of some historical/scientific fact/principle

THREE POINTS:

Mulder or Scully gets kidnapped
Mulder or Scully goes into quarantine
Scully leaves/enters a room just before/after something inexplicable happens
Mulder or Scully goes on a date
You see Mulder in Scullyís dream
Mulder or Scully gets put in jail

FOUR POINTS:

Mulder looses his temper
Internet/alt.tv.xfiles is mentioned
Mulder or Scully appears in a swimming suit
An alien appears

FIVE POINTS:

A spacecraft appears
Scully goes into a dark place alone
A dead person appears

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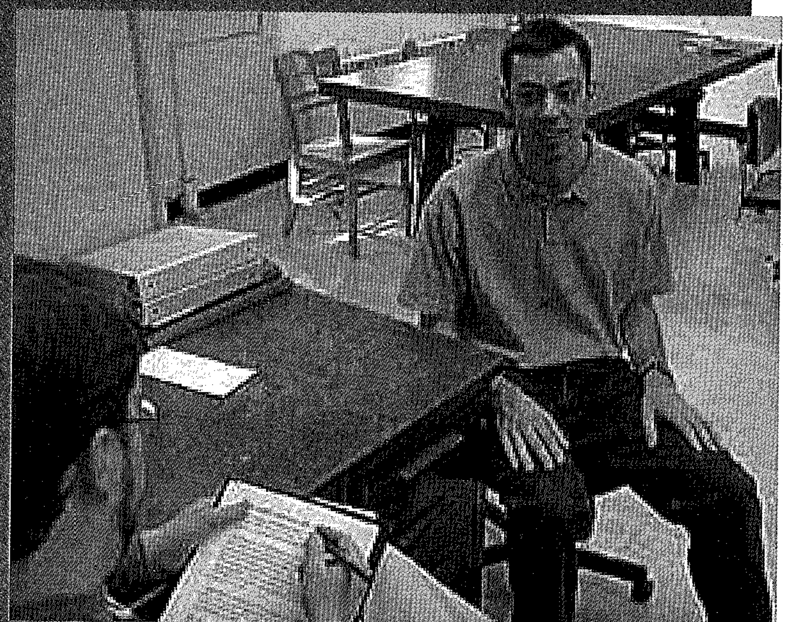

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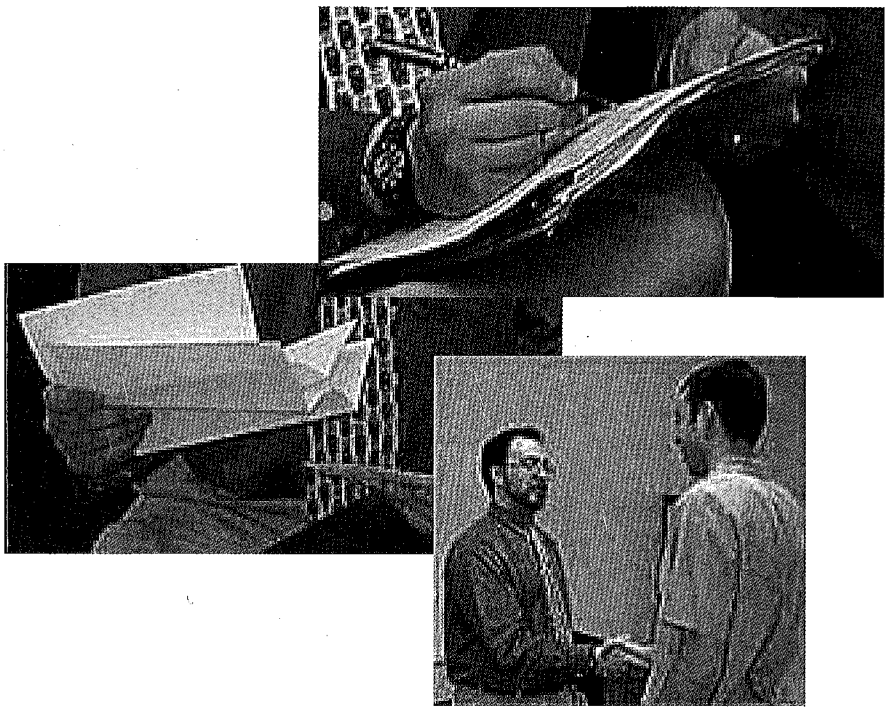

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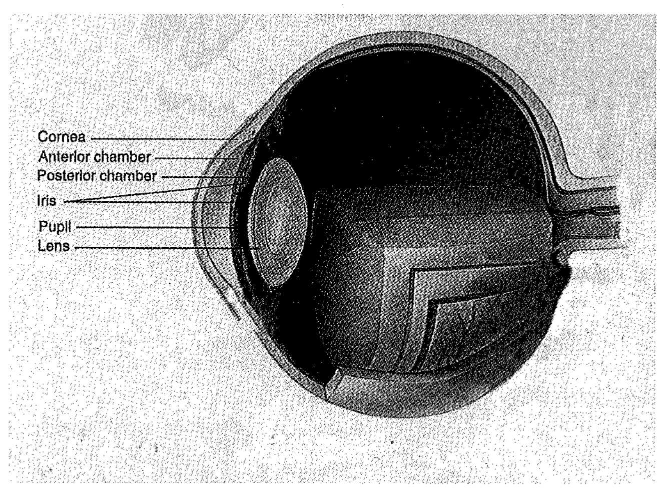

Contributors

Florencia Agote is currently in her last year in Journalism. Flo decided to join Minnesota Technolog because she needed experience writing for an English publication. She began as a movie reviewer in Argentina and later on as a writer for the newspaper El Gran Periódico de Aragón in Spain. She is currently working for the newspaper La Prensa de Minnesota and MISA Magazine as a staff reporter, at the Minnesota Daily as freelance writer.

Tim Fister is a second year physics student with other academic interests in mathematics and art. He is also editor of the IT Connection. Some of his hobbies include cooking, watching movies, playing cards, and listening to music ranging from jazz to punk. If he had more time, he'd learn more about that string theory nonsense, order some Thai food, and watch Dr. Who reruns.

Jonathan Gerber is an undergraduate chemical engineering major at the Universityof Minnesota. In addition to writing for the Technolog, he co-edits the newsletter for the Institute of Technology, the IT Connection. He has also worked as co-editor of the monthly newsletter for the World War Two History Roundtable, a historical forum that meets at Fort Snelling.

Haudy Kazemi has interests in the computer and biological sciences and has chosen Neuroscience as his major. After discovering last fall that the Minnesota Technolog was looking for a photographer, Haudy jumped at the opportunity and volunteered to take pictures for the magazine. He considered this a good chance to improve his photography skills and gain some more experience in this area.

Mike Mosher is a sophomore mechanical engineering major at the University ofMinnesota. In addition to class work, he likes to spend time working with his friends at the Technolog and the IT Honors Group. In his free time, Mike enjoys running, golf, and Jeopardy!

Jeremy Paschke is a graduate student in the School of Physics and Astronomy at the University of Minnesota. Outside of writing for the Technolog, Jeremy specializes in the history of physics. His dream being to write science books for children. Jeremy will teach high school physics starting in the fall of 2000, and he plans to spend his summers with creative writing and extensive tramps through the woods.

Brian Philippy is a new addition to the Minnesota Technolog staff.

Tim Ward is a senior in Scientific and Technical Communications. He is also the current president of RASTEC, a student group for technical communicators. When he's not at school, he's either working on his computer or struggling with the new software at the recording studio where he works occasionally. He spends his free time playing with his two kids and catching up on sleep.

MINNESOTA TECHNOLOG

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MT

The Editor's Corner

How Universal is English as a Language of Science?

We often hear the expression, "Mathematics is the universal language of science and technology." Yet, while mathematics can cut across certain communicative boundaries, it is not the actual language of the sciences, for that role has already been filled – by English. It has become the language of presentation at such prestigious international scientific conferences as the 10th European Symposium on Polymer Spectroscopy and the 12th Colloquium on High Resolution Molecular Spectroscopy. (In both cases, the language of presentation for the entire conference was English, yet each conferences was held in a country where English was not the official language and many of the conference presenters were not native English speakers.) Similarly, English has also become the choice language of many international scientific journals. For example, the international edition of *Angewandte Chemie*, while not published in an English-speaking nation, it prints its articles in English. But do these factors mean that professionals are now free to use a single set of English-language documents to convey technical or scientific information to an internationa audience?

Rhetoric, or the concept of organizing information in a particular way in order to achieve a particular purpose, has a great effect on if a printed document will be considered credibly and if the information contained in that document will be taken seriously. And our rhetorical expectations tend to be reflections of the kinds of communication, both written and spoken, we encounter on a regular basis. As a result, there is no single, universal rhetorical standard. Rather, human rhetorical expectations and preferences vary from group to group and culture to culture. Moreover, these cultural rhetorical differences can occur on a variety of levels and can affect how certain cultural audiences perceive a given English-language document.

Certain significant cultural-rhetorical differences can occur at the sentence level. For example, many American students learn that effective writing style involves getting to the specific subject of the sentence as quickly as is possible and then introducing more general information concerning the topic. However, readers from other cultures do not necessarily share these stylistic opinions. Many Southern Europeans, for example, prefer longer sentences in written documents, especially in technical documents. (Instructions, for example, might not be short imperative sentences, but might instead be longer and "more articulate" sentences containing "tangents" involving the different kinds of factors or options related to performing a particular step.) In some cases, this sentence length is seen as correlating with technical data: the longer the sentence, the more information it contains and thus the more reliable it is in terms of technical content. Moreover, in many Southern European cultures, the reader's level of education can greatly affect his or her expectations of what constitutes "acceptable" sentence length. Again, many well educated Southern Europeans – those individuals who would probably be the users of high-tech or scientific products could expect longer sentences in technical reports or technical documents in order to take a related produce or project seriously.

Similarly, the kinds of paragraphs individuals use in a written document and the order in which paragraphs are placed within that document establishes a framework that will affect how readers perceive information. In American communiqués, paragraphs are generally arranged in a specific logical order where one first introduces the basics or premise of an argument, and then the following paragraphs gradually and logically build upon this original premise to prove or establish one final end or goal. In this rhetorical system, matters not related to the logical development of the final point seem extraneous, awkward, and incorrect, for they have no purpose and will only act to confuse the reader and break the logical development of the greater argument. Individuals from Japanese or Latin cultures, however, often begin professional documents with a paragraph or section containing polite comments that do not seem to relate to the logical development of the purpose of the written document (e.g., "I am pleased to learn of the success of your company in its various enterprises."). Conversely, Japanese documents often do not include an introductory summary of the information and results presented in a given report. A document that included a summary at the beginning, thus, might create discomfort among or even offend Japanese readers who would consider such directness as ignorant or rude.

English is increasingly becoming the new international lingua franca. With 1.6 billion speakers (only 25 percent of whom speak English as their native language), English has solidified its place as the medium for international exchange. But using English effectively internationally requires a deeper understanding of the cultures using that language. Thus, effective international scientific and technical communication is more than just an understanding of "language" but also involves an understanding the "rhetorical" expectations associated with a given communication situation. Hopefully, and online media such as the Internet and email continue to spread across the globe, increasing contact with individuals from other cultures will help us all gain a better understanding of how to communicate using a single tongue.

MT

Ideas Interface

The expression and exchange of ideas is essential to the development of new was of thinking about our understanding our world and each other. For this reason, the Minnesota Technolog invites all readers to submit ideas and opinions for publication in the Ideas Interface section of the magazine. Readers may also submit responses or querries to items published in previous issues of the Minnesota Technolog. We hope that this free flow of ideas will help readers gain a better understanding of concepts related to the IT and its greater academic and professional community.

Responsibility in engineering

The word "technology" is highly utilized in our civilization. It seems to have a "nebulous" definition, however. One can probably get by using it to refer to "things that do stuff for us." There is apparently a very well-developed cultural system in place in industrialized nations to support the continued invention and deployment of technology. An important part of this cultural system is the "technology college." I am personally familiar with one such college: the Institute of Technology (I.T.) at the University of Minnesota in Minneapolis, Minnesota. This is where I received my Bachelor of Science degree in Computer Science (1978) and my Master of Science degree in Electrical Engineering (1988).

In 1971, just as I entered I.T. as an eighteen-year-old freshman straight out of high school, a professional ecologist "intervened" in my delightful nerdy life. He said to me: "If you're going to invent something, make it so it doesn't screw up the Earth." This dictum has been in the back of my mind ever since and has become the "mantra" of my personal career in technology design.

It turned out that the typical I.T. student curriculum did not contain any environmental considerations. There was the calculus sequence that is generally required. There was the physics sequence as well. These courses dealt with abstract theories developed by thinkers of the past and pertained to "mental worlds" that seemed quite isolated from any environment that the contemporary ecologists refer to. There is, however, the Environmental Engineering path in I.T. Ecologists disparagingly refer to this engineering work as the "end-of-pipe" methodology. This is because it attempts to "do something" with waste that will be generated by the normal operation of some technological processes.

For example, a coal-fired power plant might have "scrubbers" installed on its chimneys to remove some of the undesirable pollutants from its smoky effluent. Another example is the incinerator, which is used in many towns and cities in the United States to "do something" with the daily stream of garbage generated by households, businesses, and others. The incinerator doesn't really "get rid" of the garbage. It just converts it to a different form via a combustion process. Instead of accumulating this solid waste in a pile on the ground (a landfill), it is converted to "smoke" and issued into the atmosphere, the same air that we all breathe.

Ecological thinkers have long advocated a "preventive" principle in technology design. This means that the waste is not generated in the first place, so nothing has to be done with it. For example, instead of manufacturing millions of heavy, polluting individual transit vehicles (cars), perhaps effective mass transit systems (maybe trains) in the United States would be less of an ecological burden (less pollution, less energy consumption). Instead of producing technological devices that "wear out" in a short time and must be disposed of (somehow), maybe items could be produced which have an exceedingly long lifetime and that can be repaired with a minimal use of new parts.

Another principle long-touted by ecological thinkers is the notion of "recycling" waste back into the production process again. This is now commonly done with aluminum beverage cans, glass bottles, and newspapers, along with other things made of specific recyclable materials. The typical TV set: what to do with it? It is not made to be easily recycled, and I don't believe that all of its component materials are presently being returned to the input of the pro duction process in our civilization. I have read that some automobiles have been designed to be more readily recycled when their useful life is done.

These established ecological principles of waste handling are codified as the 3 R's: Reduce, Recycle, Reuse. I reused an old innertube recently by making something else out of its rubber. I made a thick "ring" to place my East Indian Tabla drum on to stabilize it for ease in playing. My uncle used "every last bit" of an old house on his farm to build other wooden things: a corn crib and I don't know what else.

We have a long history of NOT using these straightforward and wise ecological principles in the design of technologies in our modern industrial civilization. We have a "functioning" civilization although ecologists have warned us that we are bringing upon ourselves a global ecological crisis here on Earth due to our improper treatment of the natural biosphere (the region around the surface of Earth where life exists).

If we were prudent, we perhaps would do our best to avoid this portended crisis by proceeding systematically to modify our civilization so that it does not damage the Earth's biosphere in the future. This is where the future engineers come into the picture. These engineers should be committing themselves to the development of Earth Friendly Technology. This should be the basic quest of all future engineers all around the planet, especially during this "ecological crisis" era in human history.

What is preventing us from addressing this immense problem in our civilization? This is something that I, and others before me, have considered. There is an existent and evolving literature on this subject. The recent book "Making Peace With The Planet" by Barry Commoner, noteworthy environmental thinker and one of the founders of the modern environmental movement, is quite readable by the "literate citizen," I would say.

In this essay, I am focusing on the NERDS. During the course of my life in the big city (I am from rural Minnesota), I found that the NERDS focus predominately on the WHAT of technology and typically avoid the WHY of why they are involved with it. Years ago, I read, controversial author Ayn Randís book "The New Left: The Anti-industrial Revolution." In it, she mentioned many things. One of the things she considered was the WHY of why people go into science. If I recall correctly, she was delighted if people went into science to discover new things and increase our understanding of the world. However, she suspected that some people go into science to "escape" from life, and she was afraid of that path for a person.

The Institute of Technology seems to systematically stay away from the WHY of the technologies that it espouses in its programs beyond the functional utility of them in our Earth Destroying Technocratic Civilization. A new computer chip might help us calculate faster, but why are we calculating in the first place? Maybe we should be hoeing corn, like the Hopi Indians suggest.

After graduating from the Institute of Technology, I gained employment as a "technologist" in a number of modern, high-tech corporations in the Twin Cities area during the 1970s and 1980s. During this time, I found essentially NO official consideration of the above-mentioned Earth Friendly Technology endeavors in these places. In fact, what I found were Engineers who seemed to be heartless, amoral automatons, earning their keep by carrying out the plans of the companies they worked for. Where did these people come from? How did they get that way? Typically, they were graduates of Technology Colleges. As I have come to understand the situation over the years, these colleges, such as the Institute of Technology at the University of Minnesota, takes in the brightest, wide-eyed, young high school graduates and efficiently turns them into these heartless, amoral automatons, preparing them to fill grueling niches in the heedless, rampant operation and expansion of our Earth Destroying Technocratic Civilization.

It has been said again and again by "spiritual leaders" around the world that the root cause of our global environmental crisis is one of the human spirit. Having attempted to foster a spirit of Earth respect in my old school, the Institute of Technology, during the last several years, I have come to find the staff there: professors, deans, and so on, to be "dead lumps" with regard to this most pressing issue of our time. They have explained to me, in a formal letter signed by U of MN President Mark G. Yudof, that the Institute of Technology is "doing things" to address this issue. However, I think that they are not responding sufficiently to effectively deal with our looming crisis.

As I see it, the Institute of Technology could become a leader among technology colleges in the field of Earth Friendly Technology. However, there seems to be little or no support for such an endeavor by the powers that be in this school. Nevertheless, somebody should do something, shouldn't they? Therefore, I have begun the Society of Earth Concerned Technologists (S.E.C.T.) to take the bull by the horns.

I envision a society of brave Peace Warriors to take up the challenge (kinda like Conan the Barbarian) and eventually take over the intellectual life of the Institute of Technology, showing the world how to design our way out of this global ecological crisis. I see no better way to deal with our contemporary problem. This will create a "proper spirit" in the school, addressing the authentic "engineering" challenges of our time.

To learn more about this, peruse my fledgling website at: <http://www.geocities.com/rainforest/andes/4208>

I have studied this situation for almost three decades now and have sought the best available intellectual literature I could find on the subject. Also, I am making contacts with the "best" of environmental organizations so that we can all work together to get out of this mess as the decades pass here on planet Earth. Let's chat.

Thank you.

Steven D. Axelson
BSCS, MSEE: U of MN, I.T.
Peace Warrior

Sights in the Cities

As students at the University of Minnesota are also a part of the larger Twin Cities community, we would like to keep make them aware of unique and interesting places and events exclusive to the Minneapolis-St.Paul area. The new Sites in the Cities section of the Minnesota Technolog is designed to do just that by providing overviews and updates on local current events and on the interesting places to visit and things to do in the metro area.

The Guthrie needs help to move to the river

By Florencia Agote

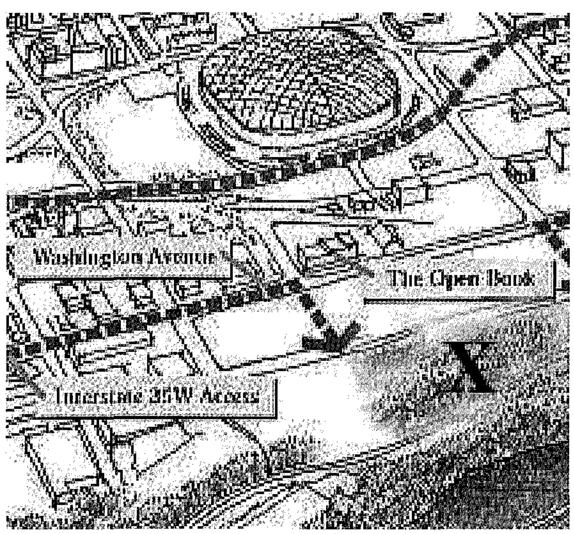
The Guthrie Theater recently held a conference with its subscribers, and the purpose of the conference was to discuss the relocation of the theater, to the Mississippi River. Joe Dowling, the artistic director, introduced the plan to the subscribers, and also answered the questions.

On an empty staged stood a podium for the speaker. One could see the soul of the Guthrie crying out loud for some clothes to wear, but there was nothing. No curtains to cover the Guthrie's insides, no mystery to be discovered. In essence, the backstage was on stage. With a British accent and a classical style, Dowling opened the session by telling the audience the history of the House. He described how, in 1963, the Guthrie was built as a four-month festival producing only four plays a year. Today, the Guthrie operates all year long, producing a season of 12 plays, to enormous from the audience. Subscriptions now top of 31,800, an all-time high.

Dowling said, "We are very exited by the possibility of the Guthrie moving to the river. Mark Twain thinking about the Mississippi talked about the river as a wonderful book with new stories to tell everyday. We believe that the Guthrie on the river will be as Pascal said 'a road that moves and carries wherever we should go.'"

Dowling explained that, in the 60s, the founder of the theater, Tyron Guthrie, made the comment, "The river itself is what charmed and amazed us most. If not been frozen over and it was flowing with a lively sparkle to the widening borders which just are as beautiful although here as everywhere else."

Three hundred people holding blue postcards addressed to Gov. Jesse Ventura and state lawmakers witnessed how the Guthrie Theatre opened itself to show everyone present that it was in need of a new body; that it needed to grow. And the plea appeared to work. Although the subscribes said they terribly sad that their theater was moving, they clearly supported the project.



X in the above map marks the proposed new location for the Guthrie Theater.

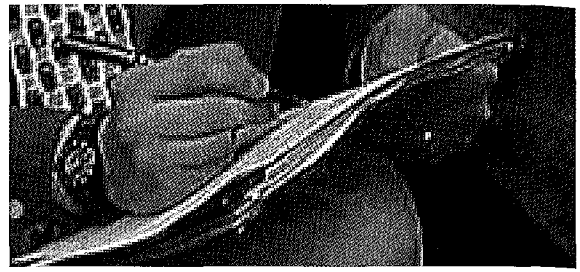
One of the reasons that Dowling emphasized the most was the need of more artistic diversity of the Guthrie. He said the new theater will have three stages: a 1,100-seat thrust stage for a large scale and epic classical plays, a 500-seat proscenium stage for intimate and contemporary plays and international productions, and a 150-seat flexible theater for new work and artist's development. The new Guthrie Theater will also include improvements in its restaurants, restrooms and shops. The new facilities will be easy to reach because of its proximity to the U of M, the light rail, and busses, and the parking will be greatly expanded. The Guthrie has always been involved in education, and with this new campus, they can expand the program by providing classroom space for more than 94,000 students and educators.

Building this "new body" requires $25 million from the state funding for this $75 million project. Where will the other $50 million come from? Out of the pockets of the people who want love to see the Guthrie living next to the river. It will be a state campaign that will unite the Guthrie in one single location, after operating in five for more than 15 years, because of the lack of space.

Some of the questions addressed to Dowling revealed concern about the impact the Guthrie campaign would have on other theaters and the results once the Guthrie is finally settled on the river. Dowling assured those present that the Guthrie campaign won't disturb the other theaters, and that the development of this house will help other theaters develop and grow with the Guthrie by the Mississippi River.

MT

Resumes for Success!!!



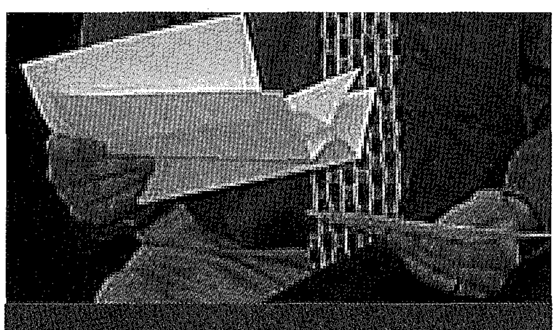
By Tim Fister
Photos by Haudy Kazemi

The resume is generally the first crucial step to getting a job. A well-written resume that both showcases your skills and experience and keeps the employer in mind will increase your chances of getting an interview, and ultimately, a job. The style of resume can reflect the attributes—or the detriments—that the author brings to the table, and it is the resume that ultimately gets you the job. Thus, the first step to a successful job search involves creating an effective resume, and acquiring the qualifications that employers look for is an essential part of building a successful resume.

While many of today's technological companies use electronic resumes, the traditional hard copy resume is still a primary tool for hiring workers. According to Mary Dwier of the Office of Special Learning Opportunities (OSLO), prospective employers use a resume up to three times during the job selection process: first, during the screening of all applicants, then as a device for conducting an interview, and finally as a review of the final job-candidates.

A sloppy resume will not leave a good impression with prospective employers. In other words, you do not want to remind them that you could not spell "unniversity." A general rule-of-thumb is to have someone proofread your resume. Conversely, a well-presented resume reflects the time and work you put into it. Angela Law of the Recruiting and Staffing division of Unisys Corporation agrees, adding, "A resume that has had time and effort put into the overall design and layout will draw more attention than one that was created on a 'Resume Wizard'."

All resumes should include a cover letter, unless the position announcement specifically states otherwise. A cover letter is not necessarily a summary of the resume. Instead, it can be broken into three parts. The first part describes how you learned of the job. In this part, it is a good idea to drop names, but, as with all parts of the resume, try not to reveal any particular biases, like referring to a rival company. This mention of how you learned of the job should then be followed by a quick listing of your skills — perhaps including some of the skills not listed in the resume. A description of the job you are looking for should be included in either the first or second part. Finally, in closing your letter, you should thank the reader for the opportunity/for his or her time, and give him or her some type of contact information, like a mailing address, a telephone number, or an email address.



All resumes should include a cover letter, unless the position announcement specifically states otherwise.

Essentially, there are three types of resumes: chronological, functional, and a combination of the two. For students and recent graduates of U, the chronological and combined formats are recommended as the functional format is usually best for experienced professionals who are switching careers. The chronological resume is the most common for college students, and this format involves listing experiences relevant to the job by starting with the most recent experience first. The combined resume organizes and summarizes work history by skills; this format is good for students who have extensive work-experience.

Regardless of the type of format you use, your name always appears at the top of the resume. This is generally followed by your current address and possibly a permanent address, depending on the stability of your living situation. Likewise, you should list a telephone number for your permanent and/or current mailing address. You can also list an email address if you check your email on a very regular basis. Underneath your personal information, is your "objective" statement. This "objective" line should consist of one or two sentences that simply summarize your intent and, possibly, your primary qualifications. This statement should be direct/to the point and be modeled after the job description itself. (For example, if the job posting says, "Looking for individuals interested in a growing, marketing environment." your objective statement should probably read, "Objective: To work in a growing marketing environment.") Another heading/section can be a summary of your qualifications, but this is not entirely necessary depending on the size of your resume. Remember that a resume should generally be 1-2 pages in length, and the most relevant information should appear toward the beginning of the resume as employers usually do not have time to read every word.

Next, you should list your education

by giving the name and the location of the college/university you are currently attending. The name and location of your high school should not be included, and in general, your resume should include high school achievements (this is not a college application). Do not abbreviate your education or any other information in the resume. List your degree(s) or current major(s) below the college/university name and address, and then list any minors you have completed. If you are in the process of completing a degree program, list the month and year in parentheses after the name of the program. Finally, you have the option of listing your grade point average. Employers often use GPAs to filtering applicants' resumes, and it's a good idea to list your GPA if it is 3.00 or higher. (If it is not listed, employers will assume that it is lower than that.).

A resume can also include relevant coursework if the prospective employer did not request a transcript. When listing your coursework, try to highlight only four or five classes that compliment the job in question. Special honors, awards, and academic experiences, like studying abroad, can also be a part of the "Education" section of your resume (see example to right of page).

The "Experience" category usually follows "Education." Each entry in the "Experience" section should include the job title, the name of the company, the duration of employment, and a skill statement (skills necessary to performing a particular job). Often the hardest part of writing a resume is identifying the skills you obtained in previous jobs. Mary Dwier of OSLO recommends that you brainstorm each skill before writing the resume. Try to list as many of the different functions you performed for each experience, and then select the statements that are of the most interest to the company you are applying to. Since you are essentially showing off your arsenal of skills, feel free to use superlatives within reason. Also, do not limit yourself to work experience; feel free to include volunteer work and internships as well.

If you are still building the credentials of a successful resume, do not simply focus on your GPA. While good grades are understandably attractive to employers, a more balanced and experienced student is of even more importance. In fact, in a recent survey by the U.S. Bureau of Labor Statistics, academic credentials rate sixth behind communication skills, work experience, initiative, teamwork skills, and leadership abilities among personal characteristics that employers look for in job candidates. In effect, the purpose of the skill statements in the resume is to emphasize these traits. It is best to develop many of these functional qualities throughout your college years through internships, co-ops, and volunteer work.

Also, the maturation of the college student cannot be developed without a well-defined career-path. To solidify the direction you wish to take through college and to employment, consult IT Career Services in Lind 150 where you can research the opportunities available within your major and for college students in general. Start early, and increase your chances of employment down the road.

These are simply suggestions to get you started on building your own resume; there is no industry standard. Just keep in mind that a resume should be clear and concise, as they are initially used as a screening tool. Also, as resumes and cover letters are also indicative of how good a worker you are, take the time to make them look and sound appealing. This process of self-examination will be helpful for the job interview. On the other hand, understanding the exact characteristics that each employer is specifically looking for will give you the inside track on writing a successful resume, let alone the entire process of applying for job. Finally, try to demonstrate that you are a balanced student who is capable of performing well on a test and in the workplace.

Writing a resume can be difficult, but it should not be taken lightly. As Sharon Kurtt of IT Career Services noted, "Everyone thinks they know how to get a job, but some things shouldn't be left to chance."

MT

Your Name

Street Address
St.Paul, MN 55112

Tel: 651/626-5555
Email: mail001@tc.umn.edu

Objective: To work in a cutting-edge on-line environment that deals regularly with multinational clients.

Education
Bachelor of Science in Computer Engineering — **Expected, May 2000**
University of Minnesota, Twin Cities Campus, Minneapolis, Minnesota
Minor: Mathematics
GPA: 3.19/4.0

Activities
Minnesota Technolog Staff 1999-00
IT Board of Publications 1998-00
U of MN Track Team 1998-00

Employment
Computer Engineering Intern — **10/98-Present**
Specialty Engineering, Inc.
Minneapolis, MN
List of skills related to position here

Director — **9/99-Present**
The Student Engineering Center, U of M
Minneapolis, MN
List skills related to specific position here

Web Master — **6/99-9/99**
On-line Design 4-U
St.Paul, MN
List skills related to specific position here

Volunteer ESL Tutor — **5/98-9/98**
City of Fort Kent
Fort Kent, ME
List skills related to specific position here

A sample resume based on the tips given in this article.

How to Interview Effectively

By Jon Gerber

Photos by Haudy Kazemi

It is almost inevitable that you will have at least one interview before you enter the work force. Interviews are common and important steps towards getting hired. Just how important are they?

"Very important," says Angela Law, who works in the Recruiting and Staffing division of Unisys Corporation. "Besides the resume, the interview is the only other tool that is used to determine whether or not a candidate is qualified for a position."

"It's almost the only thing," concurs David Brandvold, the Center Manager for Schlumberger GeoQuest, a computing services company. "It's easily the most important factor we consider. The resume indicates that you have the knowledge to do the job, but the interview tells me if you're a good fit for our company. We're looking for maturity and enthusiasm."

Employers are very interested in the character of their potential employees. They are looking for employees who have good communication skills, effective teamwork skills, and adapt quickly to new environments. In the ever-changing world of modern technology, the skills you learn in college can quickly become obsolete; companies are looking for individuals who are sufficiently driven and creative to remain current in a given field. The interviewer is also trying to get a feel for the candidate's culture, ethics, training, and advancement potential.

The key to having a good interview is preparation. Adequate preparation allows you to be more relaxed and confident during the interview, all of which impress interviewers. There are many things you can do to prepare. One very important step that some candidates overlook is actually researching the company they are applying to and position they are applying for. Demonstrating a basic understanding of what the given company does is vital; it shows that you have thought out what you are doing and are truly interested in the position you are seeking. Some items you should look for when researching a company include the products or services the company provides, its main customers and competitors, its history, and its philosophy.

There are several common questions that all candidates should be prepared to answer. Most of these questions are much deeper than they appear, so think about your responses in advance. David Brandvold states, "I might ask you if you ever played soccer as a kid. What I'm really asking is, 'Do you know how to work as part of a team?' 'Can you still perform when you're tired and under pressure?' 'Can you get along with other people?' 'What kind of leadership skills do you have?' "

Most interview questions are "why?" questions. You can expect to be asked *why* you wish to work for this company and *why* you decided to study what you studied in school. If you have had previous jobs, an interviewer is likely to ask you *why* you left them.

The interviewer also wants to know more about your personality and interests. Your interests and activities outside your area of expertise indicate how well rounded you are. Many organizations now use a method called "Behavior Based" interviewing. Behavior Based interviewing involves questions designed to create a profile of your personality and past experiences, and this information is then used to predict your possible behavior and performance within the company. With this method, you could expect to be asked to describe yourself, your work habits, what makes you happy, and your goals and plans for the future.

During the questioning, you should be looking for opportunities to really sell yourself. In the days prior to the interview, think about what types of questions would provide you with an opening to describe your qualifications and unique skills. Formulate a mental list of your accomplishments and capabilities so you can have that mental list ready when an opportunity presents itself. Also think about any weaknesses you might have and how you can turn them into strengths. For instance, you may state that one of your weaknesses is that you "tend to worry too much about little details," but this means that you will work at a project until everything is perfect. You must always be truthful, though; never twist the facts to avoid hard questions. David Brandvold says, "If I catch you lying in my interview, you're out, automatically."

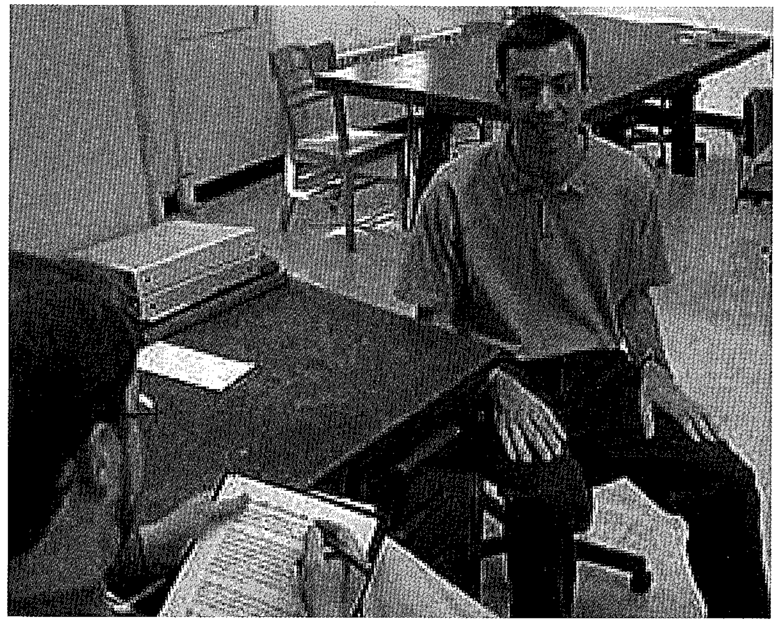
Most candidates only consider the questions they will have to answer, but a well-prepared candidate will also have a list of questions to ask the interviewer. A few intelligent questions demonstrate that you have done some research and that you have a working knowledge of the company; this reinforces the impression that you are serious about the job. Your questions may be about specific details of the company or simply be requests for clarification on matters discussed in the interview. All interviewers look for questions from the candidate, for these answers display professionalism, so ask something even if you already know the answer.

Most importantly, you must actually practice your interviewing technique. Unless you are used to the atmosphere of an interview, all of your carefully crafted answers and comments may disappear behind a mental block caused by the pressure of the moment. This may simply involve practicing in front of a mirror or actually sitting down with someone else who can act as an interviewer and give you feedback afterwards. Perhaps the best thing you can do is attend a "mock interview." These mock interviews are offered from time to time by the Institute of Technology Career Services and involve candidates undergoing a practice interview with real interviewers from various Twin Cities corporations. The interviewer rates the candidate as if it were an actual interview and then shares this information along with suggestions on how to improve after the interview is completed.

Students who have taken advantage of this program have been very pleased with it. Bhushan Vartak, a fourth-year chemical engineering Ph.D. student, said of the experience, "The interview was great in the sense that since your job/career was not on the line, you could ask the interviewer dumb questions that you would be scared of asking after a real interview. I got all the information I had hoped for regarding how the company would have interviewed me if it was a real interview: what kind of questions I could expect and stuff like that [and] all I had to do was ask for it."

Kara Dahlberg, a junior in chemical engineering, also found the process helpful. "My interviewer rated me like he would in a real interview. Afterwards, he showed me the sheet and told me what I could improve on. I found it very helpful. I didn't know the interviewer was looking for so many specific qualities."

The mock interview is not a perfect representation of the real thing. The interviewers must deal with a variety of candidates, and so will not be able to ask specific questions regarding majors. Interviewers also cannot ask questions regarding a specific job position since the mock interview is intended to be more general in nature. Yet, overall, the mock interview is the best preparatory tool available.



During the questioning, you should be looking for opportunities to really sell yourself.

There is more to the interview than just the questions and answers, however. The physical side, your appearance and body language, play almost as important a role in creating a good impression. All candidates should be professionally dressed and well groomed. Like it or not, the interviewer's opinion will be partly decided by what you wear. It is good to err on the side of caution and dress conservatively. You should also carry a small note pad and pen with you to take down information. You should not take many notes during the interview itself, as your attention should be focused on the interviewer, but it is helpful for your own questions at the end. During the interview, sit up straight in your chair and lean slightly forward. This projects an air of interest and enthusiasm. Always maintain eye contact and try to be open, friendly, and positive. Leave your hands folded in your lap; refrain from nervous gestures like picking at your clothes or drumming your fingers. Be sure to listen attentively and to reflect on your answers before you give them. At the conclusion of the interview, offer the interviewer a smile and a firm handshake, and be sure to thank him or her for his or her time. You should ask if there is a telephone number you can call to check on the status of your application. Many sources also recommend sending a note after the interview to thank the interviewer for the opportunity.

In conclusion, interviews are perhaps the most significant step towards getting a job. They require a lot of preparation and practice, but they are also something that anyone can do well. Build up your self-confidence and remember that the interviewer wants to make a good impression on you as much as you want to create a good impression for the company. Good luck!

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For more information on mock interviews, stop by the IT Career Services Office at 50 Lind Hall.

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The Minnesota Technolog Asks, "Why Graduate School?"

By Mike Mosher

Photos by Haudy Kazemi

A world of possibilities opens for science and engineering students when they graduate. High-paying careers for bright young holders of bachelor degrees abound in government, industry, and consulting firms. Most students jump right into these jobs after graduation, but some take another path. They choose to continue their education with graduate school. To discover reasons for going to graduate school and earning an advanced degree, I interviewed three current graduate students here at the University of Minnesota Institute of Technology.

HARI SREE

Sree is pursuing a Doctor of Philosophy (PhD) in electrical engineering. He came here for graduate school after obtaining an undergraduate degree in electrical engineering from the Indian Institute of Technology in Kharapur, India.

Undergraduate education gave Sree a basic knowledge of electrical engineering principles, but Sree wanted more. As an undergraduate, Sree became interested in power electronics, and he knew he wanted to study power electronics in more depth than he could as an undergraduate. To research his area of interest, Sree chose to become a graduate student.

Graduate education has made Sree an expert in power electronics, as Sree has already completed his master's degree. For Sree, this degree represents an increase in the value of his knowledge base through specialized training and research. Now, Sree can be looked at as a master in his field, and people can come to him with questions.

One valuable lesson Sree has learned is the importance of continuity in education. If your undergraduate work is done and you want to pursue research training, don't wait to apply to graduate school. "Start soon!" says Sree. This type of education is not readily available in industry, and right after you finish your undergraduate exams is the best time to start graduate school.

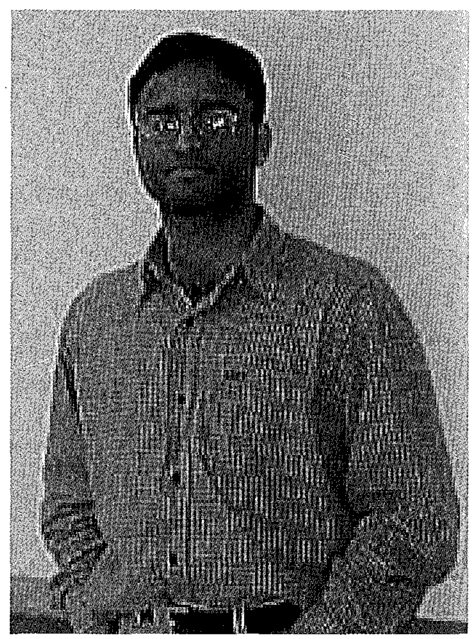
RACHEL WEATHERS

Weathers is working toward her PhD in mechanical engineering. She came to graduate school at the Institute of Technology after undergraduate work at the California Institute of Technology, commonly known as CalTech.

"Start soon!" says Sree. This type of education is not readily available in industry, and right after you finish your undergraduate exams is the best time to start graduate school.

As an undergraduate at CalTech, Weathers explored many areas of science and technology. She majored in mechanical engineering and science, ethics, and society. It was a lot of work, but Weathers is glad she worked hard.

Even with an undergraduate degree from CalTech and two majors, Weathers says, "I still didn't have enough experience to tell people I was an engineer." She had a desire to gain experience, and she saw graduate school as the best way to do this



for two reasons. The first is that CalTech is a "science-intensive" school. This focus makes an engineering education there heavier on an understanding of theory than on industry-oriented training. According to Weathers, this kind of educational focus lends itself to a continuation in grad school. Another reason Weathers chose graduate school over industry is that she felt more comfortable in school. Having been a student for all her life, Weathers felt more natural exploring her field as a student and researcher than as a worker in a typical industrial setting.

Weathers looked at the graduate programs at many schools. Interested in biotechnology, Weathers was attracted to the work being done by William Durfee, a professor here at the Institute of Technology. Durfee researches the area of assistive biotechnology, which focuses on restoring function to people with disabilities. Near the end of her senior year, Weathers applied to graduate school and wrote Durfee a letter expressing her desire to work with him. A few months later, Weathers was admitted to graduate school where she is currently working with Professor Durfee and doing her own independent research in biotechnology.

One of the most valuable parts of graduate school is the opportunity to work with expert faculty in your area of interest. If you're looking at graduate school, Weathers recommends that you check out the faculty of different schools. "You'll get viewbooks with blurbs about what everybody does," says Weathers. These people will be your advisors and mentors in graduate school. If you find a graduate school with people doing research that interests you, apply to it. And if there's a certain professor whom you really want to work with, don't assume s/he will find out about you. It can't hurt to write a letter!

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PAUL ENEVER

Six months away from a PhD in chemical engineering, Enever earned his bachelor degree at Rensselaer Polytechnic Institute in Troy, New York.

Enever majored in chemical engineering and minored in chemistry and economics. He excelled in his rigorous curriculum, earning a 4.0 (perfect) GPA. Enever's father had a PhD, so, in a way, Enever felt he was expected to get an advanced degree. Professors at Rensselaer also expected him to go through graduate school. Finally, graduate school seemed to fit with Enever's vision of employment. Enever wanted a job where he could set his own pace. Graduate research offered this kind of environment.

As a graduate student, Enever says, "I'm largely my own boss." Enever gets to decide what he wants to work on and when he wants to work. He doesn't have to do things that he thinks are a waste of time. Instead, he spends time on the areas of his research that he thinks need the most attention. Although not all faculty advisors give their students as much flexibility as Enever's does, almost all graduate students have more flexibility than people working in industry.

Enever knew what to expect from graduate school because he spent two summers doing research as an undergraduate. He worked the summer after his sophomore year at Rensselaer and the summer after his junior year at MIT.

Undergraduate research experience is an excellent way to learn what graduate school is all about.

According to Enever, you really "get a feel for research by working side-by-side with graduate students." By finding research opportunities at more than one institution, you can explore your options further. Even if undergraduate research is not possible, anyone considering graduate school should at least talk to students at the schools they are considering. Graduate students can tell you what research at different schools is like. It is important to select a school that will help you get where you want to go. After all, that is the point of graduate education.

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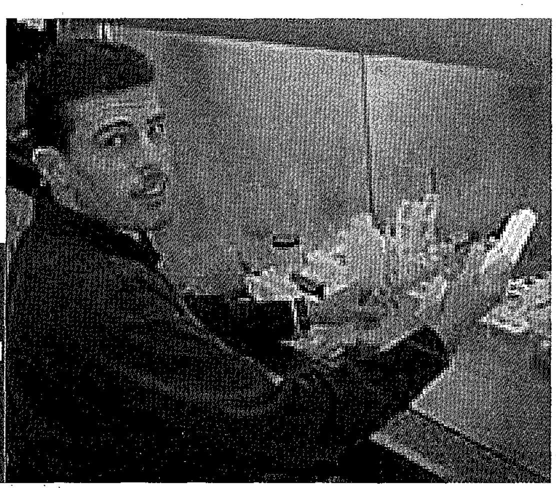
Enever wanted a job where he could set his own pace. Graduate research offered this kind of environment.



The Rewards of Teaching: A Career Path for IT Students

By Jeremy Pashcke

Envision yourself immersed in a career where, on a daily basis, people value the work you invested in your university classes. Envision yourself delivering dramatic presentations that you created under your complete autonomy. Envision yourself as mentor and guide to several enthusiastic learners. In the very first year of your career, you have become a bastion of knowledge in the eyes of hundreds. Few careers in engineering can provide the typical IT graduate with the fulfillment of any of these situations. A career in teaching, however, can provide the opportunity to experience all of these situations.

Graduates of the University of Minnesota's Institute of Technology face a wealth of career choices. The economy is booming, and technology is on the rise. Amid their job choices, future graduates might do well to consider a career in education. A teacher's career holds many advantages. After I address some of the advantages to teaching, I will devote the remainder of this article to the challenges that educators of the new century will have to confront.

Beth Erdman is a graduate student in the University of Minnesota's Department of Curriculum and Instruction. She lived in Colorado for five years, giving tennis and skiing lessons, before she realized teaching was the best career for her. Now Beth teaches life science at Olson Jr. High in Bloomington. "I think what makes teaching better than other professions," says Beth, " is the variety." Creative teachers are successful teachers. When it comes to introducing a concept or topic, teachers can do anything they want. They might take their class outside on a nature walk, feed a pet constrictor, or send an electric shock around the classroom. In Beth's words, "The sky's the limit."

Aside from the instructional autonomy a teacher enjoys, teachers can build healthy camaraderie with their students. Young students are exceedingly emotional, and children are often not afraid to express their admiration for a particular teacher. Even though the rewards of teaching may not be evident, teachers do make a difference in the lives of many.

What makes teaching better than other professions is the variety

. . .

Creative teachers are successful teachers. When it comes to introducing a concept or topic, teachers can do anything they want.

For the past three years, I have been teaching introductory physics at the University of Minnesota, and in the next academic year, I will be teaching physics to high school students. Experience tells me that teaching is physically and mentally draining, yet when you do it well, teaching is emotionally fulfilling.

To teach in the public schools, one needs a state license, and all licensed teachers have undergone a time of apprenticeship often called student teaching. Several colleges in the area offer licensure programs, but few earn as many accolades as the College of Education and Human Development at the University of Minnesota. All science teachers licensed by the University graduate from a post-baccalaureate program. In other words, the University education program only takes graduates who already have a degree in science. A lengthy list of prerequisites ensures that the University accepts science students with the sharpest of acumen.

As for location, Minnesota is a fine place to teach. The starting salaries for teachers in Minnesota are high compared to those of other states; most districts offer around $33,000 to teachers beginning with a bachelor's degree. Furthermore, Minnesota serves as a proving ground for such cutting edge ideas in education as the Profile of Learning and the graduation standards. Ellen Delany, who teaches math in North St. Paul, says that, "Minnesota has some of the hardest working teachers in the country, and we have the best kids. You can feel the energy when you walk into almost any school in this state." Delany earned a master's in math education from the U of M in 1990, and in 1998-1999, the Minnesota Education Association voted her Teacher of the Year.

Although Teacher of the Year can only belong to one person, the world of education bulges with outstanding teachers. Working for the National Science Teachers Association, John Penick, Robert Yager, and Ronaly Bonnstetter carried out an investigation of 221 exemplary teacher to find out what makes an exemplary teacher exemplary. They found that, on the whole, exemplary teachers use hands-on material daily, place high expectations on their students and themselves, invest more than minimal time, are flexible, and are involved in extra-curricular activities. Exemplary teachers have many positive qualities, but a future teacher really needs just one thing to make their job splendid: compassion for children.

One pleasant surprise resulting from the study was that of all the teachers interviewed, a vast majority of them reported that their enthusiasm for teaching had waxed rather than waned after ten years or more of teaching. Enthusiasm for one's job is a rare privilege. The authors comment on the goals of science teaching saying, "The most important result is developing a population of citizens who are scientifically literate — citizens who understand the tentative nature of science, the man-made nature of science, and science as a way of looking at life and problems."

The study by Penick and company provides a good vantage point for viewing the challenges to contemporary education. Educators agree that teaching scientific literacy is a loftier goal than teaching mere scientific facts. As Delany says, "It's better to have a citizenry that can solve problems than a citizenry that can recite the 'times tables.'" The body of scientific facts doubles every six months, so teachers cannot expect students to digest even a morsel of all these facts. If one wants facts, they can find them on the Internet. Science teachers must teach students how to think scientifically.

The astronomer and popular spokesman for science, Carl Sagan, discusses the status of American education in an article entitled, *There's no Such Thing as a Dumb Question.* Sagan writes that the Scientific and consequent Industrial Revolutions brought about such fundamental changes that the world of education is still catching up. Our technological world is marked by transition, as professions drastically change in the course of a generation. It is hard for educators to know what to teach because today's facts might easily become irrelevant in tomorrow's world. When knowledge changes quickly and education does not react, Sagan argues, "then students complain about relevance; respect for their elders diminishes. Teachers despair at how educational standards have deteriorated, and how lackadaisical students have become. In a world in transition, students and teachers both need to teach themselves one essential skill — learning how to learn."

Sagan goes on to list some ways that Americans can change their views on education. Our culture needs to start applauding scientific scholarship in high school rather than stigmatizing science-achievers as "nerds." School teachers deserve greater respect, and greater salaries too. Sagan also suggests that practicing scientists come down from their ivory towers, or out of their dens, and speak to the public about their research, thus perpetuating a drive for nationwide scientific literacy.

Finally, becoming a teacher is not only about making the future populace literate in science. Teachers teach children responsibility and maturity by being patient and compassionate. We are all members of a global environment. Consequently, teachers are expected to instill in their students an appreciation of ethnic diversity, just as much as they are expected to instruct their students in the theories of continental drift.

Good teachers make good schools, and good schools make good communities. These were the sentiments of five public school principals who met last fall to discuss how educators can create a true place of learning, scholarship, and community given the challenges facing today's public schools. Penny Howard, principal of Englewood Middle School in Mounds View, comments on the multiple roles that teachers must play. "Too often teachers see themselves as separate entities who are there to do a specific job," says Howard. "We (the staff) need to be collectively assenting in our beliefs about our values and purpose as we present them to students." Teachers do make a difference. One hour spent with a teacher at school can be more time than some students spend with their fathers or mothers at home.

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Discipline is a problem, any veteran teacher will tell you that. However, Louis Mariucci, principal of Jackson Magnet Elementary school in St. Paul, offers a sly solution to the discipline problem. "I think that somehow every student needs to connect to some aspect of their school. Ironically, my greatest connections are with the kids that require the most discipline."

The principal of Randolph Heights Elementary in St. Paul, Joanne Ventura, is well-aware of the dismal reputation public schools have earned, especially in the light of recent outbursts of violence. Nevertheless, she insists that metal detectors and random locker inspections is not the way to ameliorate the situation. "What kids need," says Ventura, "is that sense of community because they don't have it in many ways. Many of our children don't have it in their neighborhoods, their churches, their families. If we create that sense of community in our schools and give kids some roots, I don't think we'll see as many kids who feel alienated and isolated, which I think what brings about tragedies like we saw in Littleton."

Story continued on page 22.

Tissue-Engineered Corneas: What's Now and What's Ahead

By Brian Philippy

Imagine having vision so poor as to require having this article read to you. For the world's hundreds of thousands of people with blindness caused by a malady in the cornea, this situation is a reality they have learned to endure.

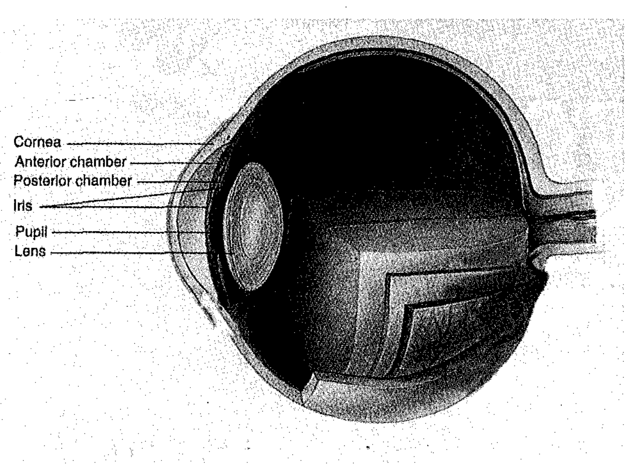
The cornea is the clear outer "window" of the eye, and it is responsible for the initial focusing required to see clearly. If this window becomes cloudy as a result of disease or injury, or if the shape is such that light images cannot reach the retina with proper focus, poor vision and sometimes blindness results.

Fortunately, most cornea-related blindness is treatable. Extreme maladies may require penetrating keratoplasty, the main procedure of corneal grafting in use today. Keratoplasty involves removing a "button" from the center of a patient's cornea and replacing it with a suitable donor cornea. With an incredible success rate, corneal transplants are among the most successful transplants available. Many other corneal surgeries (keratoplasties) involving the use of donor tissue also occur, procedures like epithelial keratoplasty or lamellar (partial thickness) keratoplasty.

Recently, much attention has been given to procedures involving "corneal sculpting" or reshaping of the cornea to allow for proper focusing. These processes include photorefractive keratectomy (PRK), laser in-situ keratomileusis (LASIK), and the implantation of Intacs,,, a product of Keravision Incorporated. By changing the shape of the cornea, myopia (near-sightedness) – and, in some cases, hyperopia (far-sightedness) or astigmatism – can be corrected to varying degrees and with varying side effects. These afflictions can usually be treated with corrective lenses. As a result, ophthalmologists deem these procedures "cosmetic." These cosmetic procedures are not without side effects, like the formation of "halos" in the field of vision or utter procedural failure, which have not yet shown the breadth of their long-term effects.

Problems with these procedures mostly revolve around the process of healing immediately after the procedure has been performed.

According to the Eye Bank Association of America statistics, in 1998, over 45,000 transplants of human donor corneal tissue were performed in the United States alone. Due to an excellent donor program in the U.S. and the availability of well-trained surgeons and health care services, America had a waiting list of only 1,863 patients in 1998. This is not true elsewhere in the world.



A side view of the various layers of the cornia and the lense.

According to Glenn Ottenbreit of the Eye Bank of British Columbia, Canada currently has a waiting list of nearly 30,000 patients. However, the ever-increasing number of U.S. patients who have undergone the various corneal procedures means that there are fewer cornea donors available. This situation is beginning to emerge as a problem in the U.S. as it is effectively shrinking the viable donor pool. It then becomes clear that a suitable alternative to human donor tissue could be useful to the ailing patients of the world.

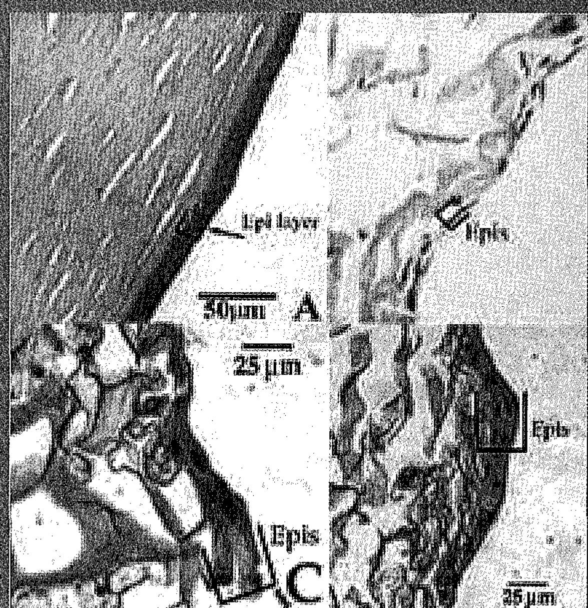
The examples set forth by the U.S. and Canada illustrate the need for suitable tissue in nations where the population is essentially well nourished and free of violent civil unrest. In many parts of Asia, Africa, and South America, the nourishment of the people is so poor that eye disease is rampant, and includes such horrific afflictions as parasitic infection and corneal decomposition. As a result of local popular religious belief, unstable governments, or underdeveloped medicine, these places have little or no donation legislation in place, creating a situation where patients may wait so long that they suffer the loss of their vision or their eyes. Making the situation worse, citizens of these countries may rely on vision for survival, as these economies frequently rely on labor over services for stability. One with lost vision may then simply become one of the lost. With a more global concern for visually challenged persons, it seems that a more easily attainable source for remedy need be available.

For those unable to see the silver stars of distant constellations eternally burn into the midnight sky, the medical world is working magic though the political world has yet to respond with any coherence. In recognition of this situation, researchers are taking steps toward correcting corneal aberrations without the use of human donor tissue. To the reactionary media, this means that an artificial cornea is soon on the way. However, research is still in its early stages, and to some research groups, funding is hard to find.

The applications of tissue-engineered corneas are tremendous, extending far beyond the mere inception of an artificial cornea to replace human corneas in keratoplasties. Most promising, though, are the applications of the technology to corneal wound healing and as a corneal model for drug and chemical testing. These applications alone warrant the research currently underway and may eventually reduce the number of transplants necessary.

Understanding the current research on tissue-engineered corneas – even the basics – takes a little education on the microanatomy of the cornea. The cornea is composed of three cell layers separated sequentially by two membranes. The three cell layers are of the most importance in these early stages of engineering and in the functioning of the cornea during recovery from a wound.

Exposed to the elements is the top layer, the epithelium, which is an important element in determining the cornea's refractive characteristics. This layer is rugged and can sustain minor damage without incident, regenerating itself when necessary. On the underside is the endothelium, which interfaces with the aqueous humor of the eye and is responsible for maintaining the proper fluid level within the cornea, and thus its transparency. It is through this layer that the cornea obtains its nutrients- a necessity since there is no vasculature in the cornea. Sandwiched in the center is the stroma. Fibroblasts (keratocytes) compose this layer and are also very important in determining the cornea's ability to transmit light without scattering the radiation. This layer is the area of concern in the process of wound healing and proves to be the greatest challenge in creating a suitable, transparent corneal model.



H&E Stained Sections. Cell nuclei are indicated by dark spots and collagen matrix is light gray. (a) Normal human cornea with 5-7 epithelial cell layers; (b) epithelial cells cultured alone on collagen sponge at day 15 in culture; (c). epithelial cells cultured on a collagen sponge obtained after co-culture of epithelial cells and endothelial cells at day 20 in culture; (d) epithelial cells cultured on a collagen sponge obtained after co-culture of epithelial cells and endothelial cells separated by a Transwell membrane at day 20 in culture.

In the University of Minnesota, Department of Biomedical Engineering, one research project, primarily facilitated by Elizabeth Orwin, M.S. and Allison Hubel, Ph.D., focuses on the cornea, specifically the stromal layer. Using fresh rabbit corneas and corneas the Minnesota Lions Eye Bank has deemed unsuitable for transplantation, Orwin and Hubel have been working intently on understanding the process of wound healing in the cornea and how to aid this process artificially. Of course, the substances used in aiding corneal wound healing must have certain characteristics. First, the substance must be able to integrate with human tissue and allow for the migration of healthy cells into the substance without causing a rejection response. Second, there must be transparency of the matrix formed in order to permit the transmission of light images through the cornea. In the main arena of research concerning this matter, two substances are involved in extensive research: collagen gels or collagen sponges prepared from Bovine Type I dermal collagen. The reason for this narrow focus on useful materials is the failure rate of synthetic implants researched during the late 1970s to early 1980s. Research using bovine dermal collagen has shown much promise in corneal wound healing, as it has for wound healing in the skin.

The response of the cornea to an inflicted wound is of interest at this point. According to Liz Orwin, the stroma repairs itself by a unique method, somewhat comparable to the method used by skin. Once a wound, such as a scratch or partial thickness perforation, keratocytes, the composite cells of the stroma, "die off" causing a void on the order of a few hundred micrometers. On the perimeter of the void, cells are "activated," moving into the void over the course of one day. These active fibroblasts express distinct characteristics, including the synthesis of extracellular matrix components (ECM) and the enzymes necessary to degrade ECM. Able to further differentiate, the activated fibroblasts can become either myofibroblasts or scar keratocytes. Myofibroblasts act to contract the wound and can return to their quiescent state upon completion of healing. Scar keratocytes, on the other hand, cannot return to their original state, and instead proceed to form a corneal scar.

The approach Liz Orwin and others have taken to supplement the corneal healing process is to introduce a matrix into which the corneal cells can migrate and differentiate with stability. By using biodegradable polymers such as collagen gels or sponges, a "scaffold" is formed allowing for ease of cell migration without introducing a synthetic, permanent prosthetic device which risks leakage and extrusion from the eye. The matrix formed by this sponge scaffold may one day find uses in wound healing in vivo.

Research has shown that a cornea

models have been developed with epithelial and endothelial layers on either side of a collagen matrix. Excitingly, these models in vitro function as normal corneas. The adjacent figure shows stained sections of a normal human cornea and a tissue-engineered cornea demonstrating the success of the three-layered model. Fibroblasts in this matrix are able to synthesize collagen and proteoglycans, necessary for long term successful functioning, as they migrate freely through the matrix. Presently, research is being done to explore the addition of Transwell membranes used to imitate the two membranes separating the three layers. Though this is cause for excitement, much work is yet to be done before an artificial cornea for transplantation is developed.

Most studies so far have focused on collagen gels as the matrix in cornea models. A Canadian research group headed by May Griffith, Ph.D., claims to have created a functional matrix involving the use of gels which display the necessary characteristics, including the ability to bind endothelial and epithelial layers. However, the recent focus has moved to sponges due to the demonstrated opacity of gels. Work by Orwin and Hubel at the University of Minnesota has displayed that sponges contract less than gels, allowing for a much more acceptable transparency, another promising step toward the visionary goal.

The findings of this research have great impact on the applications of these extra cellular matrices. In the next twenty years, we may see treatments of corneal trauma involving the use of these matrix approaches instead of emergency transplantation. Animals currently used for research may be able to rest at night knowing that the chemicals once intended for testing on their eyes may be applied to tissue-engineered corneas instead. And of course, there may be welcome competition for the eye banks when in vitro corneas replace human donor corneas for transplant. When considering the research currently underway and the noble researchers dedicated to what many call an impossible dream, there is no end in sight for advancements made in the world of vision restoration.

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Alternative Careers In Science and Technology

By Tim Ward

So graduation is looming near and you're not sure what you're job options are. Maybe you're in graduate school and not feeling energized about your coursework anymore. Maybe you want to enter graduate school but are not sure what kind of work you'll be doing after that. Well, there are more options than you think.

According to Karen Young Kreeger's book, Guide to Nontraditional Careers in Science, there are several opportunities for graduates in the private and public sectors, not just in research facilities. The skills and experience that school offers you can be used in a variety of different professions.

Science Education

One area that you may want to consider is science education. If you enjoy teaching a general audience about the wonders of science, you can seek a career in an informal science education center such as a museum of natural history, aquarium, or zoo. You can even teach at a middle school or high school. In a museum, the students are different every day, but if you'd like to see your students develop in their scientific understanding over time, teaching in a school would be a great opportunity to share your knowledge with future generations.

To work in an informal science education center, you'll need to have a general understanding of many different disciplines. There are very few actual scientists in these positions and you may be called upon to do a wide variety of tasks that may or may not be your specialty. Informal science education may be a good choice for you if your background and interests are diverse.

Classroom and curriculum management classes would greatly help you if you are at all interested in teaching in a classroom setting and a teaching certificate is usually required for these positions.

There are numerous professional resources you may want to look into if you're interested in the science education field:

Association of Science-Technology Centers
1025 Vermont Ave., NW, Suite 500
Washington, DC 20005-3516
(202) 783-7200
http://www.astc.org

National Science Teachers Association
1840 Wilson Blvd.
Arlington, VA 22201-3000
(703) 243-7100
publicinfo@nsta.org
http://www.nsta.org

Scientific and Medical Illustration and Imaging

If you love art as well as science, a career in illustration and imaging may be a good way to combine your interests. Many illustrators work for museums, newspapers, and magazines and the need for good scientific and medical illustrators is growing every day. This field is highly competitive. Nearly 60% off all medical illustrators in the U.S. work as free-lancers.

Illustrators translate abstract concepts into something understandable through visuals. Illustrations are used in advertising, textbooks, and journals to help explain scientific and medical theories. The illustrator needs to have a solid understanding of the theories as well as an innate artistic sense. Experience in computer imaging is also very important to succeed in this field.

To learn more about the field of scientific and medical illustration and imaging, here are some resources to look into:

Guild of Natural Science Illustrators
PO Box 652
Ben Franklin Station
Washington, DC 20044
Phone: (301) 309-1514
gnsi@his.com

Association of Medical Illustrators
1819 Peachtree St., N.E., Suite 620
Atlanta, GA 30309
(404) 350-7900
aasnhq@atl.mindspring.com
http://Medical-Illustrators.org

Science and Technical Writing, Editing and Publishing

If you consider yourself to have good communication skills, this may be a career choice for you. According to Karen Young Kreeger, "there's an incredible diversity of career paths for scientists who have a way with words and an eye for detail." Some of the career choices in this field include: science writing and journalism, public affairs and information, magazine editing and publishing, technical writing, and marketing communications.

If you plan on staying in Minnesota, the twin cities is right in the middle of what's considered "Medical Alley." This is a highly concentrated area of medical technology companies that extends from Duluth to Rochester. Medical technology companies employ all kinds of scientific and technical professionals in their technical communication departments.

There are many courses at the University that would help you if you choose to enter this field. Journalism courses would be very valuable if you wanted to get into the journalism aspect of scientific and technical communication. There's even a scientific and technical communication program on campus that offers undergraduate and graduate degrees and trains students in all aspects of the field.

Here are some professional resources for science and technical writing, editing and publishing:

National Association of Science Writers
PO Box 294
Greenlawn, NY 11740
(516) 757-5664
diane@nasw.org
http://www.nasw.org

Society for Technical Communication
901 N. Stuart St., Suite 904
Arlington, VA 22203-1854
(703) 522-4114
membership@stc-va.org
http://www.stc-va.org

Informatics

Informatics is the "discipline that involves the collection, management, analysis, and interpretation of data" according to Kreeger. If you're trained in computational chemistry or computational biology, there are many career options for you. As databases become more technologically advanced, the need for qualified professionals to maintain these databases becomes more urgent.

One type of informatics is bioinformatics. Bioinformatics relates to the pharmaceutical and biotechnology fields. Again, this can be a very viable career choice for you while you're in "Medical Alley." The Human Genome Project offers many opportunities for anyone interested in bioinformatics. The amount of data that will be available as a result of the project is overwhelming. A Bioinformatic will help manage and analyze all of the project's data.

If working in informatics sounds interesting to you, here are some resources:

Gwyn Roberts
Director, Membership and Marketing
American Medical Informatics Association
4915 St. Elmo, Suite 401
Bethesda, MD 20814
(301) 657-1291
gwyn@mail.amia.org
http://www.amia.org

International Society of Computational Biology
Larry Hunter, President
(301) 496-9303
hunter@nlm.nih.gov
http://www.iscb.org

Business

Business offers numerous options for a graduating researcher. Your education and skills in science can be used in sales, marketing, product development, business development and administration, entrepreneurial activities, and market analysis.

Sales and marketing positions will combine your skills in science and communication and business development and administration will combine your knowledge of science with your ability to negotiate with investors, inventors, and other collaborators. An entrepreneur must use all of these skills in order to be successful, so if you're interested in a career in business, it would be a good idea to take some business and marketing classes. Contact one of these professional organizations to learn more about this industry:

Association of University Technology Managers
49 East Ave.
Norwalk, CT 06851
(203) 847-1304
autm@ix.netcom.com
http://www.crpc.rice.edu/autm/

Biotechnology Industry Organization
1625 K Street, NW
Suite 1100
Washington, DC 20006-1604
(202) 857-0244
Fax: (202) 857-0237
http://www.bio.org

Law

Many scientists, turned lawyers, specialize in intellectual property law. The American Bar Association divides this into four primary areas: patent, copyright, trademarks, and trade secrets.
Many former researchers are now working in patent law to help develop and license scientific inventions.

There are numerous opportunities for scientist-lawyers in law firms, government agencies and universities. Attorneys that work with universities often work closely with the technology transfer specialists to help bring a research idea into commercial application. Many are hired into private companies to help protect the intellectual property rights of the company. It is not entirely necessary that you have a law degree, but you must have a good understanding of patent laws and the U.S. Patent and Trademark Office (USPTO). You can take a patent bar exam from the USPTO to prepare you for working in patents. This will allow you practice before the USPTO as a patent agent. A patent attorney can practice in general courts as well.

If the idea of working in intellectual property law sounds appealing, try contacting these resources:

American Intellectual Property Law Association
2001 Jefferson Davis Highway, Suite 203
Arlington, VA 22202
(703) 415-0780
Fax: (703) 415-0786
http://www.aipla.org

American Bar Association
Section of Science and Technology
750 N. Lake Shore Drive
Chicago, IL 60611
(312) 988-5000
sciencetech@abanet.org
http://www.abanet.org

So as you try to determine your future, don't feel bound to the traditional career choices. If you take the time to assess your skills, whether learned or innate, you'll discover careers that allow you to utilize all of your abilities, which in turn can create more happiness in your work. Don't be afraid to think creatively about how your education and skills can used most effectively. Happy career searching.

MT

The Rewards of Teaching

Story contined from page 15

By becoming teachers, we provide this sense of community to children, and in so doing, we find a sense of fulfillment that no other profession could provide. True, it is a demanding profession, but in the end, you get to touch a life, maybe change a life and help someone not only discover the secrets of the universe, but the importance of humanity as a whole.

MT

Next issue . . . the Winners of the Minnesota Technolog Science Fiction Contest!!!

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Address Correction Requested

UNIVERSITY OF MINNESOTA INSTITUTE OF TECHNOLOGY

MINNESOTA Technolog

STUDENT MAGAZINE OF THE INSTITUTE OF TECHNOLOGY SUMMER 2000

Getting to the heart of Minnesota's new science museum

INSIDE

New computer simulations

Biomedical engineering grows

See 3PO at the MIA

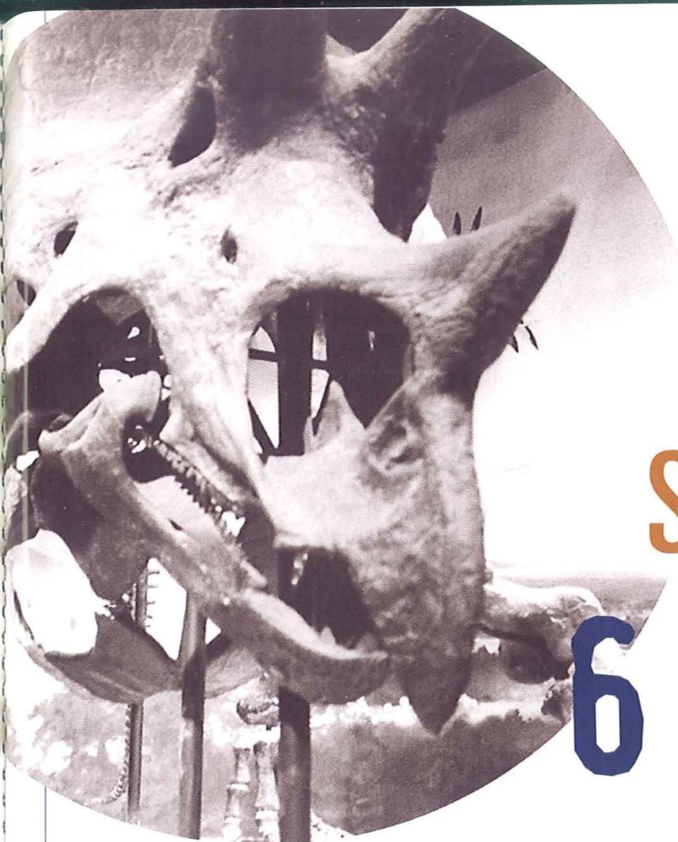
PLUS
2000
SCIENCE FICTION CONTEST WINNERS

On the cover:

A translucent model of the human heart graces the entrance to the Human Body Gallery at the new Science Museum of Minnesota.

MINNESOTA Technolog

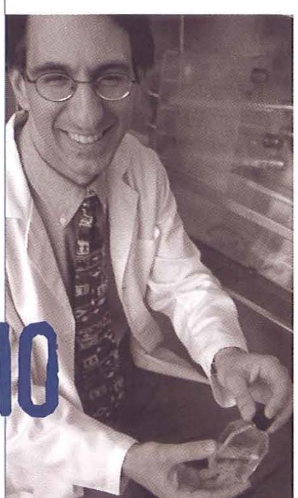
SUMMER 2000

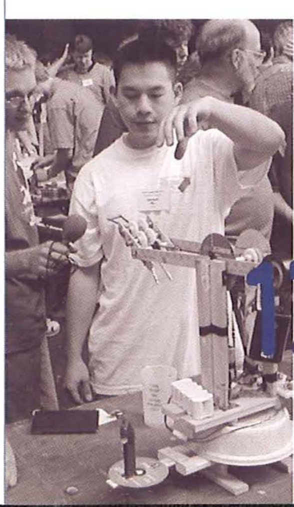


COVER STORY

Inside Minnesota's new Science museum

FEATURES





ALSO INSIDE

CONTRIBUTORS

Florencia Agote, a journalism senior, was born and raised in Argentina, where she lived until 1997. Agote joined the *Minnesota Technolog* to gain experience writing for an English publication. She began as a movie reviewer in Argentina and later on as a writer for the newspaper *El Gran Periódico de Aragón* in Spain. She is currently a reporter for the newspaper *La Prensa de Minnesota* and for *MISA Magazine* and a freelance writer for *The Minnesota Daily*. After graduating, Agote plans to continue writing while she pursues her master's degree at the University. Her hobbies are going to movies, cooking and knowing all that she can about other cultures.

Agote

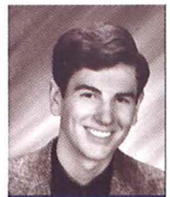
Ben Cosgrove, an IT sophomore, will be among the first class in the new undergraduate biomedical engineering program. While a student at Kennedy High School in Bloomington, Minnesota, Cosgrove captained both the baseball and slalom skiing teams. He is an active member of the IT Honors Group on campus. Outside of course work, he enjoys canoeing and biking. He plans to go attend medical school after his undergraduate work. This issue contains his first article for the *Minnesota Technolog*.

Cosgrove

Tim Fister, a physics junior with academic interests in mathematics and art, is coeditor of the *IT Connection*. Apart from the intrinsic fame that comes with the job, Fister chose to join the *Technolog* staff to learn more about the research and career opportunities at the University. His hobbies include watching movies, hiking, painting, cooking, and playing cards. In response to other questions addressed to Fister, the answers are no, Yorkshire pudding, ten and a half, only if I'm desperate, *12 Angry Men*, David Ives, and yes.

Fister

Jonathan Gerber, a chemical engineering student, is co-editor of the *IT Connection,* through which he was introduced to the *Technolog*. In his (rapidly diminishing) free time, Gerber enjoys playing golf and racquetball. He also paints, plays the violin, and spends far too much time with his Playstation.



Gerber

Katie Idziorek, a two-year IT veteran, will transfer to the architecture program this fall. She is originally from Duluth (brrrr...) and appreciates the balmy Twin Cities temperatures. In her spare time she enjoys travel, *MST3K*, watercolor painting, and consuming mass quantities of caffeinated beverages. She recently got involved with the *Technolog* through the IT Honors Group and enjoys seeing IT from a different perspective and working with its excellent, quirky (in the best way!) staff.

Idziorek

Haudy Kazemi, a neuroscience major, has interests in computer science and biological sciences. After discovering that the *Minnesota Technolog* was looking for a photographer, Kazemi jumped at the opportunity to take pictures for the magazine.

Kazemi

Mike Mosher, a mechanical engineering sophomore, likes to spend time working with his friends at the *Technolog* and the IT Honors Group. In his free time, Mike enjoys running, golf, and *Jeopardy*.

Mosher

Jeremy Paschke, a graduate student in the School of Physics and Astronomy, specializes in the history of physics. He hopes to one day write science books for children. This fall, Paschke will teach high school physics and plans to spend his summers engaged in creative writing and extensive tramps through the woods.

Paschke

Elizabeth Quan is looking forward to her senior year in the chemical engineering program. Aside from problem-solving, she enjoys self-introspection through assorted "random" reflections: writing, baking banana bread, running, leisure reading, eating, and sleeping. As a writer for the *Technolog*, she hopes to increase her communication skills and contribute interesting articles for people to read.

Quan

Tim Ward, a senior in scientific and technical communications, is president of RASTEC, a student group for technical communicators. When he's not at school, Ward is either working on his computer or struggling with new software at the recording studio where he works occasionally. He spends his free time playing with his two kids and catching up on sleep.

Ward

FROM THE EDITOR

Welcome

If you're reading this issue, chances are you're new to the U. In place of our regular editorial, we'd like to take this opportunity to introduce ourselves and encourage you to get involved—if not in the *Technolog*, then in one of the dozens of other IT student organizations.

The *Technolog* is a magazine created by IT students for IT students. Published three times a year and available in every IT building, the *Technolog* offers opportunities to students who are interested in writing, photography, editing, graphic design, art, advertising, and many other fields. It's a chance to work on an exciting project with a friendly, fun, award-winning team. You don't have to be an expert to get involved. Although most of the staff are IT students, you don't have to be an IT student to get involved.

If you're interested, send us an email at *technolog@itdean.umn.edu* or call the *Technolog* office at 612-624-9816. Let us know who you are and how we can get in touch with you so we can invite you to our kickoff event this fall. And be sure to tell your friends and classmates about us.

Even if you're not interested in being a part of the team that produces the *Technolog,* we hope you'll enjoy reading what we have to say. We'd like to hear what you think of our efforts. If you have questions or comments, you can reach us anytime at the email address and phone number above, or visit us in 5 Lind Hall.

— THE *TECHNOLOG* STAFF

MINNESOTA Technolog

SUMMER 2000
VOLUME 80, NUMBER 1

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Parting Thoughts

Commencement speaker John Cahoy encourages the Class of 2000 to grow with technology and give back to the system from which they are emerging

EDITOR'S NOTE: Each year, the Technolog *publishes the text of the IT student commencement address. This year's address was by John Cahoy, who earned a bachelor's degree in chemistry and biochemistry.*

BY JOHN CAHOY

Over the past few years, I have had the privilege to get to know my former calculus professor very well. During one of our discussions, he noted: "You know, school and life are funny. Somehow, when you get more involved in things, feel a bigger stake—you get to know people better, and they push you to your limits, they give you a chance to see 'what you got,' and tell you unvarnished truths about yourself."

There is a lot of truth in this statement, and it seems to me that when we look back on our college careers, what we will value most will be those interactions with our fellow students and professors who pushed us a little bit further than we thought possible—whether it was in the classroom, during independent research, or just having serious fun. Those human connections that helped us succeed are going to be among our most valuable and long-lasting memories.

Our class survived significant changes here at the U. While we were being challenged by our peers and instructors to go the extra distance to learn the concepts and skills required for our degrees, we were also jumping through the hurdles of semester conversion, dodging the obstacles PeopleSoft put in our paths, and surviving Y2K. (Yes, we can laugh about it now, or perhaps I should say once we have our diplomas in hand.)

During our years here we were also among the world's most active participants in a worldwide revolution. The Internet and information technology rapidly became integrated into all aspects of everyday life. This technology has the potential of dramatically revitalizing our individual and collective lives; however, during these revolutionary times we must not forget the human component of our education that pushed us beyond our comfort zones, allowing us to learn new and exciting things. The subtlety, the feeling, the passion of interacting with real human beings will always be the most critical motivator of success—not just in education, but in any endeavor we undertake.

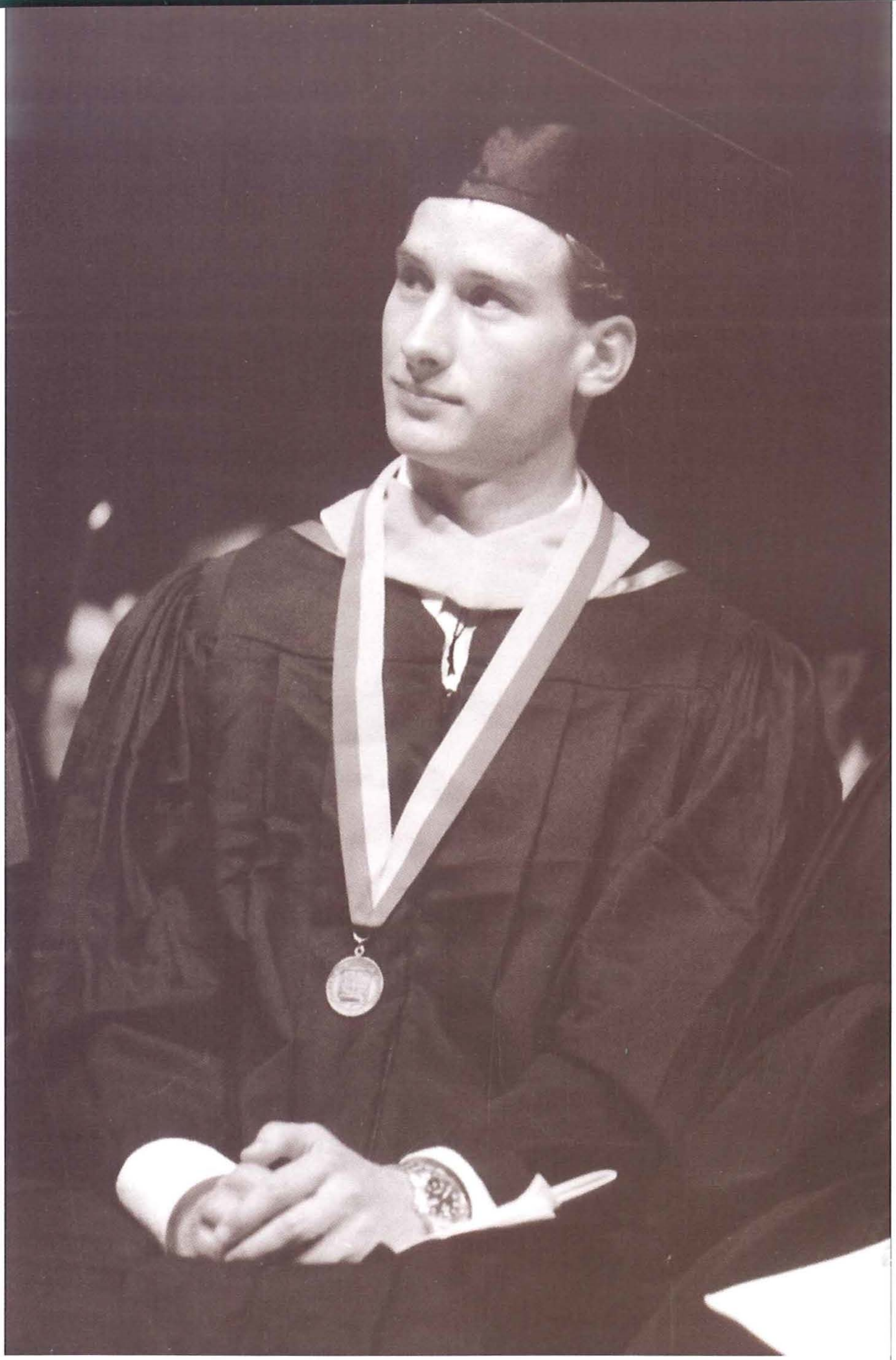
Tonight, I would like to suggest that the functioning of democracy will be significantly impacted by the revolution in information technology—that it will lead to a new kind of democracy. What are our opportunities, what are the pitfalls—what parts of the fundamental foundation need to be protected?

What does the Internet mean for democracy? One of the opportunities we will have in the future is voting on the Internet—and actually, this opportunity has already come during Arizona's Democratic primaries, when they held the first legally binding public elections in which votes could be cast over the Internet. Amazingly, voter turnout increased by over 600% from 1996. At first, this sounds like the rebirth of democracy—but is this really true? Who are the people we are disadvantaging when voting takes place over the Internet? Are we sending the message that only those with computers will have the right to vote without a hassle? The strength of democracy rests in its diversity, and in its respect for diversity; how can we avoid sending the wrong message? These are the kinds of questions we must grapple with as we integrate this new technology into the democratic process.

One of the great potentials of the Internet is its use to raise the standards of participatory democracy, freeing ourselves from the standard sound bite mentality of network reporting and political spin doctors. Quality Web sites dedicated to disseminating information on where candidates stand in regard to the environment, education, and social issues will allow in-depth investigation of the issues that matter the most to us, although we must remember that the Internet is not a substitute for creativity, and for the passion of actually getting involved.

Hopefully, with such efforts we can avoid a future in which the new emerging and merging media giants control who gets elected. It will be up to us to ensure that the Internet is used to advance democracy and not used to funnel power into the hands of a few.

What is the connection between our University experience and democracy? Just as the need for human interactions remains in the forefront at the University, the need for human interactions in our democracy continues to be vital. We must actively reach out to others in order to motivate and challenge. One of the most important places to do this is in the schools, educating the next generation. Even though many of us will never be teachers, our opportunity to be educators is



unlimited. As your careers advance, remember to return to your local schools, talk to students there, and tell them about your careers, the opportunities open to them, the challenges in achieving those opportunities, and what they need to do to become successful like you. Also, becoming involved in mentorship programs will enable you to establish even closer connections—connections where you can really make a difference in one person's life. We all have stories of someone who took the time, who cared enough to encourage as well as raise the bar, who pushed us beyond our supposed limits, so we could go further than we ever dreamed. Now it is our turn, our chance, to pass on that personal touch to another generation, while at the same time adding that satisfaction that we did make a difference. Don't miss the opportunity to become a mentor.

We are the new youthful spirit entering the workforce. The bridge to the 21st century has been crossed, although certain problems managed to tag along with us—not the least of which is that we are still human. Now is our chance to challenge ourselves and others, to come up with novel solutions to the problems we continue to face. We have been preparing for this opportunity our whole lives—the opportunity to be not only concerned citizens but also trained experts in our fields. Although technology will be a critical tool in our efforts, it is only through continuing to challenge each other, to push our limits, and to live and think with passion, integrity, ingenuity, sensitivity, boldness, and insight that we can tackle the problems we face. We can make a difference!

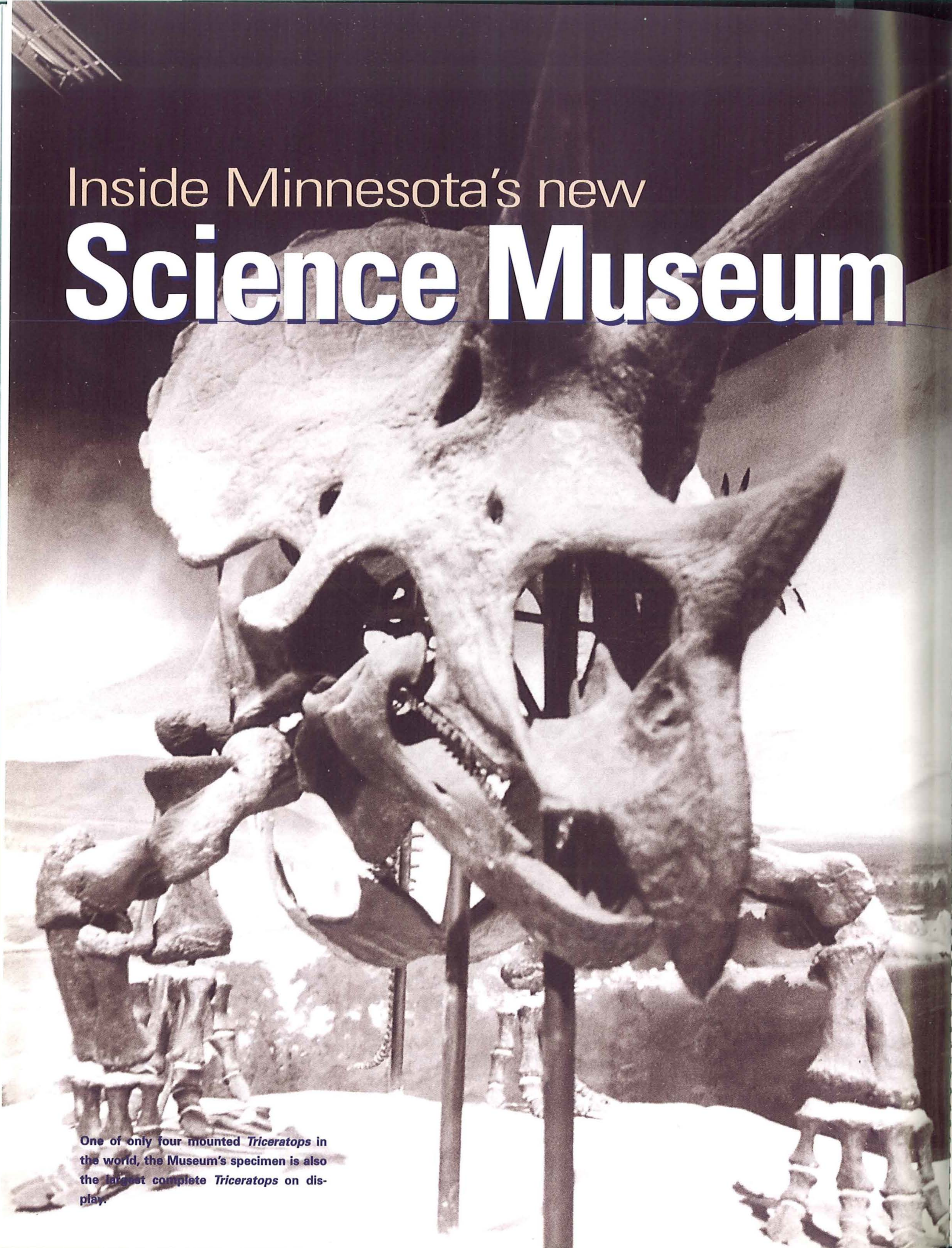
"When we look back on our college careers, what we will value most will be those interactions with our fellow students and professors who pushed us a little bit further than we thought possible."

We are the first graduating class of the new millennium. Head on, we must face the challenges presented to us. One of the first and foremost is ensuring that the foundation of our society remains based on individual freedoms and a strong democracy. Technology can assist us, but only through maintaining a balance with our personal human interactions can we really move beyond just 'good enough' and do something better.

Thank you for your attention tonight. I wish you all the best of luck in the future—let's make the world proud of the first graduating class of the new millennium!

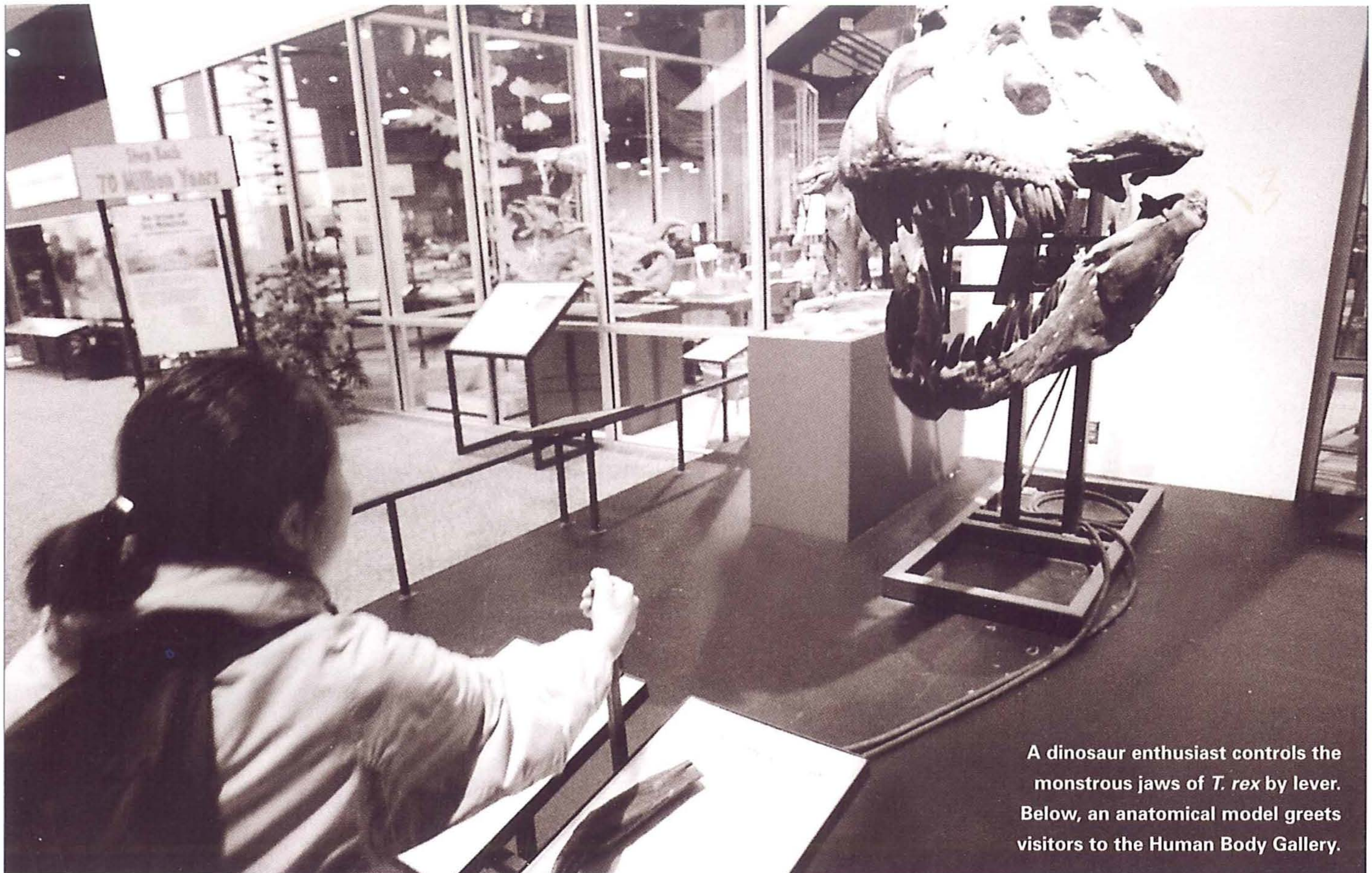
AUTHOR'S NOTE: The themes in this address grew out of many discussions with Professor Dennis Hejhal. I am also very grateful to Pamela Drake, Stephanie Stathopoulos, and Professor Toni McNaron for their helpful suggestions and stylistic critiques. ●

Inside Minnesota's new
Science Museum



One of only four mounted *Triceratops* in the world, the Museum's specimen is also the largest complete *Triceratops* on display.

PHOTOS BY MINJUNG KIM



A dinosaur enthusiast controls the monstrous jaws of *T. rex* by lever. Below, an anatomical model greets visitors to the Human Body Gallery.

BY MINJUNG KIM

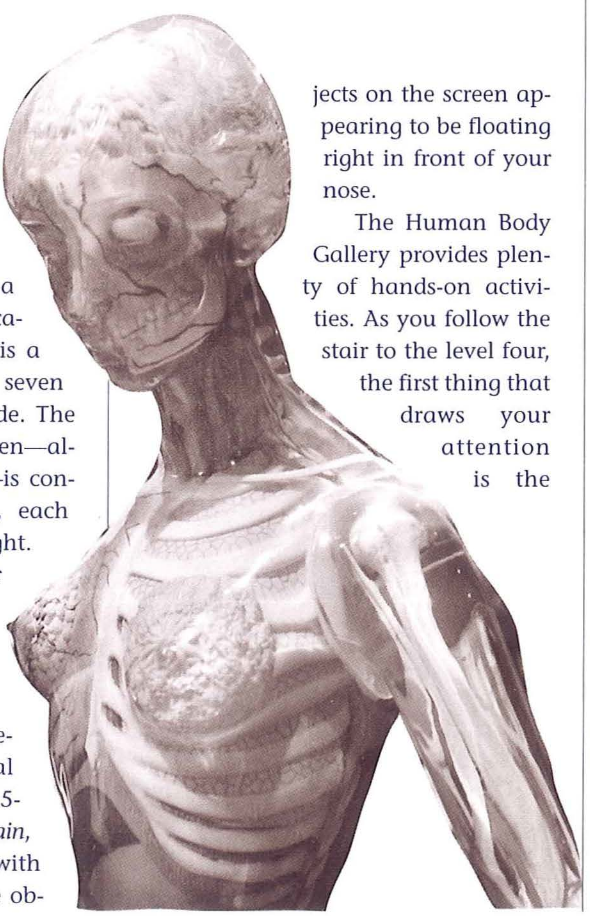
Remember your fascination with the massive jaws of the *Triceratops* skeleton during your first field trip to a science museum as a child? The new Science Museum of Minnesota provides such an awe-inspiring experience, no matter what your age.

Set amid 10 acres of park land on the riverfront in downtown St. Paul, the 93-year-old museum's new $100 million facility is home to nearly two million artifacts. With eight acres and five levels of exhibits, impressive vistas, dazzling visual theater, and more than double the museum's previous space, it offers a pleasing mix of the old museum standbys along with new displays.

Out front, Iggy the railroad-tie iguana greets visitors to the educational entrance. In the lobby, a giant cast of the 80-million-year-old flying reptile *Quetzalocoatlus* dangles from the ceiling.

Your first stop may be the museum's new convertible dome IMAX Omnitheater, the first of its kind in the U.S. It's a huge theater with the seating capacity of a 747 jet. The front is a conventional flat movie screen seven stories tall and nine stories wide. The 89-foot retractable dome screen—almost nine stories side to side—is controlled by two massive arms, each holding an 11-ton counterweight. The dome can be moved over your head to cover the flat screen in five minutes. The current feature, *The Great Migrations*, is stunning.

A 3-D laser show in the theatre provides another visual spectacle. While watching the 15-minute show, *The Illuminated Brain*, in the 331-seat auditorium with special sunglasses, you feel like objects on the screen appearing to be floating right in front of your nose.



The Human Body Gallery provides plenty of hands-on activities. As you follow the stair to the level four, the first thing that draws your attention is the

PHOTOS BY MINJUNG KIM

The Human Body Gallery looks at what makes us human and explores the relationship of genetic and biological issues to human individuality.

Bloodstream Superhighway, an area of the exhibit encircled by a 100-foot-long tube filled with a flowing blood-like fluid. Some visitors wait in line to feel the pulse on the tube, while others simply watch the pumping mechanism. At every turn, you find hands-on activities that engage the senses.

"What's in a sneeze?" is one example, where a *szfizz!*, a fine spray of water, shot out at people who trip the mechanism.

The Collections Gallery displays the museum's famous Egyptian mummy, along with a traditional Hmong house and a Douglas fir trunk that is seven feet in diameter.

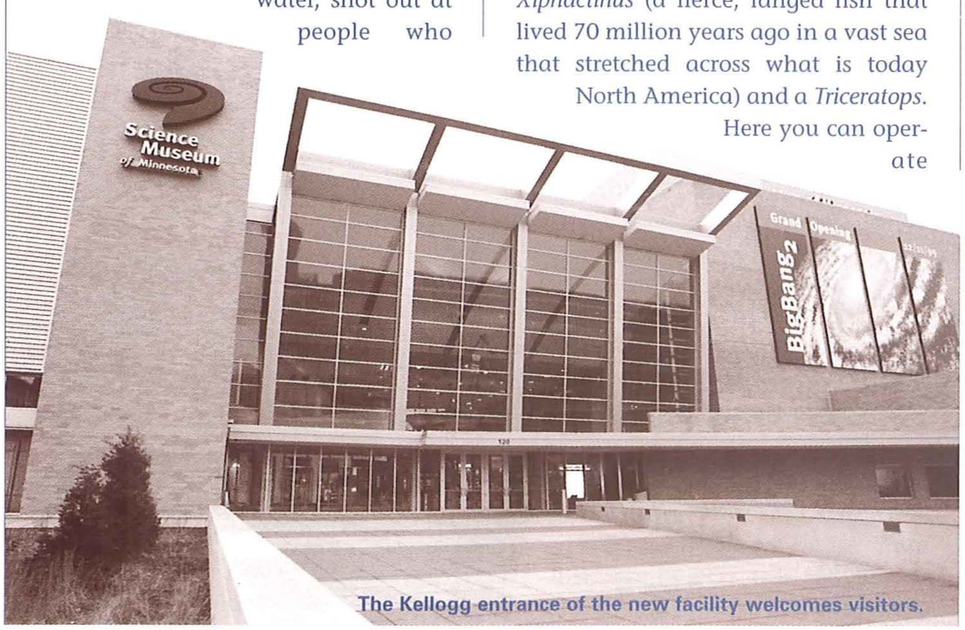
The Dinosaurs and Fossils Gallery houses skeletons of an 82-foot-long *Diplodocus*, one of the largest creatures to roam the earth, a 14-foot-long *Xiphactinus* (a fierce, fanged fish that lived 70 million years ago in a vast sea that stretched across what is today North America) and a *Triceratops*. Here you can operate a giant set of *T. rex* jaws, recreating the dinasaur's giant-sized bite.

In the Mississippi River Gallery you can navigate a boat down the Mississippi via simulation, enter a real towboat, weigh replicas of Minnesota fish, and gaze at the hanging fish sculpture made from junk culled from the river.

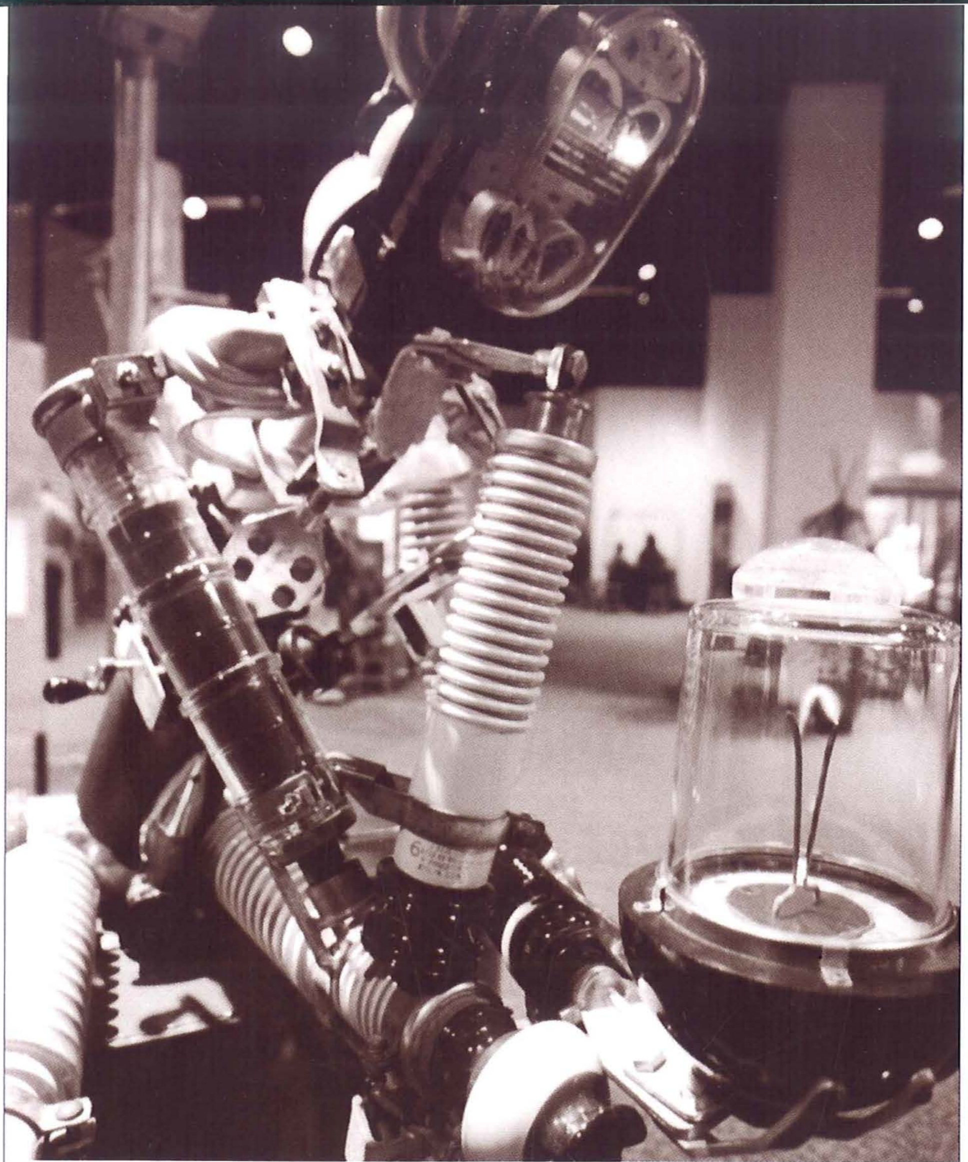
If you want to kick back for a while, have a seat in the gallery's Perception Theater. A 15-minute program shows the tricks your mind can play using illusions and magic. You can even put on lab coats, goggles, and gloves and analyze extracted wheat germ DNA at the Cell Lab.

If you want to test more hands-on exhibits, stop by at the Experiment Gallery on the level two. You can create your own weather system; test sound and wonder at its complexity in the Sound Lab; watch a tornado form from a rolling cloud; and visit the Wave Tank and watch the surf crash against a wall or roll slowly up onto shore. You can also see more than two million artifacts and fossils, many of which were previously in storage for lack of exhibit space.

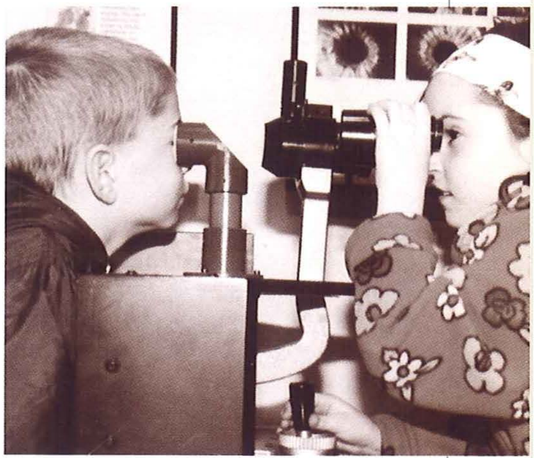
The museum is user-friendly. There



The Kellogg entrance of the new facility welcomes visitors.



The Science Museum of Minnesota differs from some contemporary museums that force visitors to follow a fixed sequence and forgoes the dark halls of traditional natural history museums. Here, you go to explore.



are three eateries, plenty of benches and 15 restrooms—including one pair that mimics a giant sewage pipe. Outdoor spaces will be used to study the river and ecology as weather allows. When the outdoor park and learning areas are completed this summer, you can bike or walk along the river.

The new Science Museum of Minnesota differs from some contemporary museums that force visitors to follow a fixed sequence and forgoes the dark halls of traditional natural history museums. Here, you go to explore. And the natural light and stunning views of the river from massive windows will enhance your experience. ●

FOR MORE INFORMATION see **www.smm.org**.

The Museum's attractions include a conceptual robot (above left), a microscope that allows you to view a friend's eye in minute detail (above right), and a controversial favorite, the Egyptian mummy (below).

Exponential Growth:

A look inside biomedical engineering at the University

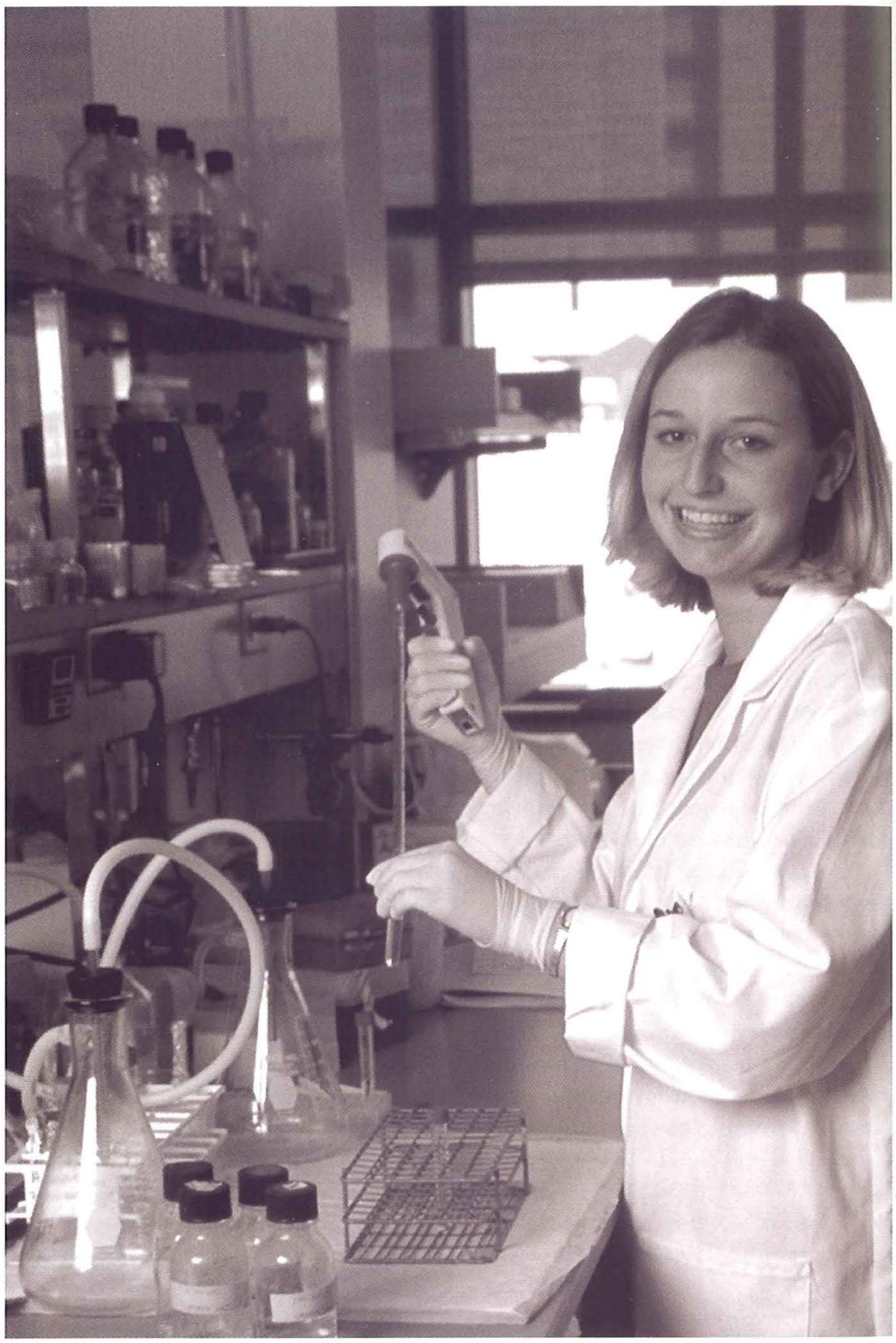
BY BEN COSGROVE

A series of medical device breakthroughs by Professor C. Walton Lillehei and University alumnus Earl Bakken in the 1950s made Minnesota a hotbed of biomedical research and put local companies like St. Jude Medical and Medtronic on the biotechnology map.

The University played a crucial role in those early developments, and over the next four decades developed a reputation as an international leader in biomedical engineering research and education. In the 1970s, it introduced master's and doctoral programs in biomedical engineering. Biomedical engineering research flourished, drawing together faculty from across IT, the Medical School, and other colleges. In 1998, the University created the Department of Biomedical Engineering within IT. This fall, the department will introduce an innovative new program for undergraduates.

The new curriculum

The University's new undergraduate program includes a mix of traditional engineering courses (computer programming, materials science, heat transfer, statistics) along with biomedical course like physiology, bioelectricity, and biomedical transport processes. In addition to the core curriculum, students take additional courses in one of several areas of emphasis.



PHOTOS BY HAUDY KAZEMI

According to Associate Professor David Odde, director of undergraduate studies in biomedical engineering, the goal of this approach is to offer students a wide span of educational and practical learning environments and to encourage them to specialize in topics of personal interest.

Because graduates of the program will face the ethical and moral implications of new biological discoveries and biomedical advances, bioethics will play a key role in the new curriculum. Although it won't be the sole subject of any undergraduate course, instructors will include discussions of ethical research practices in sophomore and junior seminar courses and will let students apply them in laboratory and research experience.

The curriculum culminates with a sequence of senior design courses that allow students to apply their skills to clinical problems at the University or in local industry. Students in the program will also have opportunities to participate in faculty research throughout their undergraduate careers. Odde and his colleagues hope these experiences will expose students to research areas that may shape their future work in academia or industry.

The program also encourages students to participate in internships with local companies like Guidant, Medtronic, and 3M. The Twin Cities area has the largest concentration of biomedical industry in the nation, notes Professor Stanley Finkelstein, director of graduate studies in biomedical engineering. And it's growing faster here than in most other places across the nation. In fact, Minnesota's "Medical Alley" includes more than 600 biomedical technology firms.

University students have also organized a campus chapter of the Biomedical Engineering Society, which provides students with contacts and information including trips to local businesses, monthly meetings, newsletters, and annual events during which members share their research.

High demand

According to Odde, student interest prompted IT to develop the new program. Biomedical engineers are in

PHOTOS BY HAUDY KAZEMI

Branching Out:

Applications of Biomedical Technology

Biomedical engineers develop devices, applications, and procedures that benefit the human body. With job titles that range from health care professional to technical advisor to research manager, biomedical engineers work in hospitals, government agencies, pharmaceutical companies, biotechnology firms, medical device manufacturers, and academic and private research facilities. Their innovations are frequently implemented in home-based or hospital-based health care.

Biomedical engineering encompasses several distinct fields:

Bioinstrumentation, the use of electronic and computer-based medical devices in diagnostic and treatment procedures, includes medical imaging, biosensors, and lasers. Medical imaging is performed in a variety of ways, depending on the type of data required. Current methods include ultrasound, x-ray, magnetic resonance imaging (MRI) and computer-assisted tomography (CAT scans). Lasers are most often implemented for specific, delicate surgery procedures like eye surgery.

Biosensors are used to detect even the smallest amounts of information about the chemical environments of biological subjects, especially at the cellular level. The sensors are most often specialized cells or molecules that can detect oxygen, carbon dioxide, and pH levels, as well as other elements of blood chemistry.

Biomechanics, the use of mechanics in the realm of biological application, includes prosthetic fabrication, ergonomics, transportation and delivery of chemicals, and introduction of artificial functioning devices into the human body.

Prosthetic fabrication involves specialized synthetically created limbs. From simple pieces to complex devices with integrated circuitry, prosthetics may be customized for individual patients.

The goal of ergonomics is to make our living and working environments complementary to human biological structure and activity. Studies in ergonomics focus on how mechanical and structural aspects of the human body are affected in certain lifestyles and work environments.

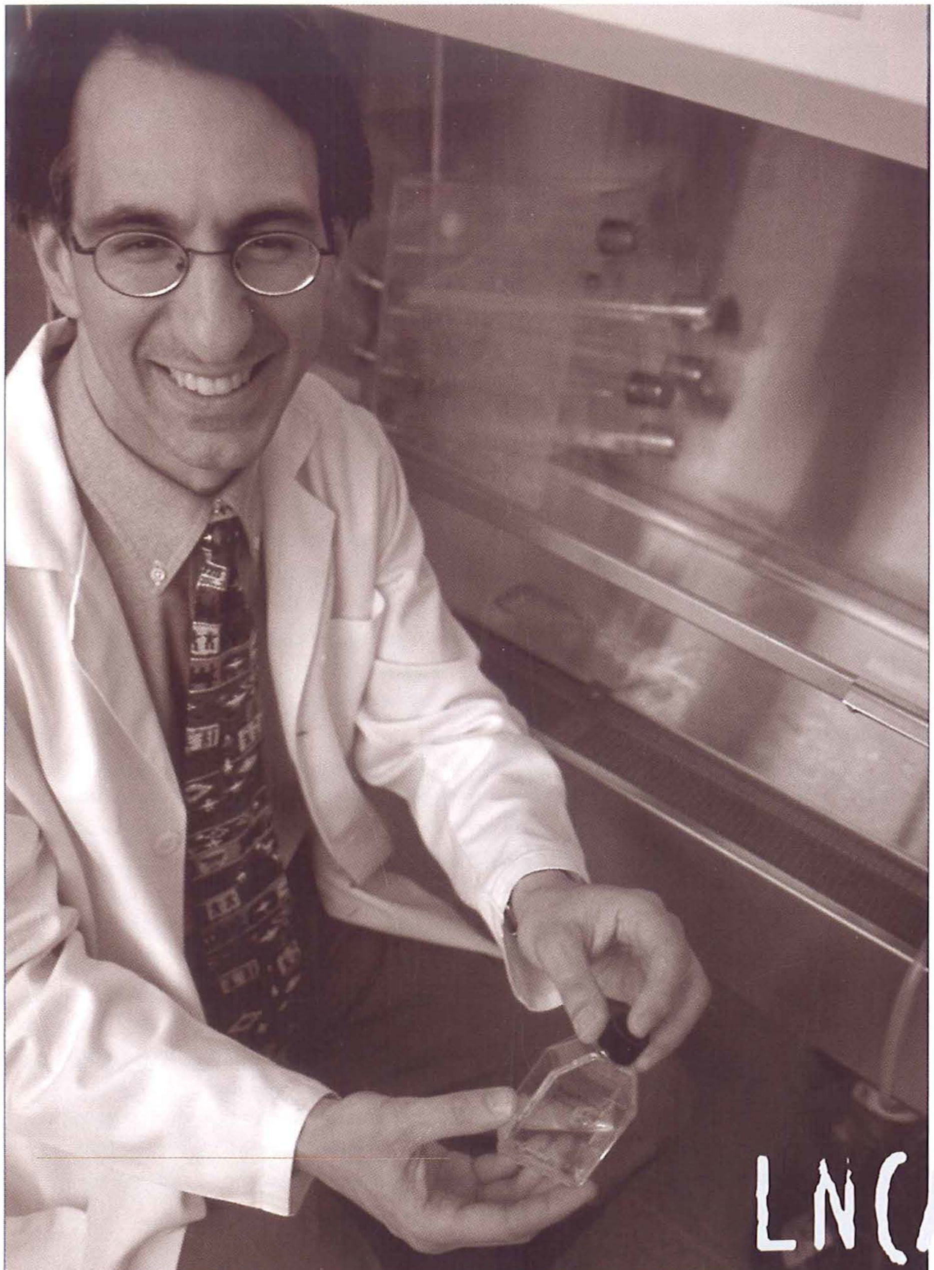
The transportation and delivery of chemicals into specific regions of the human body is a much more complicated task than it first appears to be. The human body detests imbalance—especially from outside sources—and delivering drugs to the brain, for example, is very complicated.

Artificial functioning devices like pacemakers were among the first successes in biomedical engineering, but new developments are just as stunning. Today, artificial devices, from joints to arteries to heart valves to kidneys, are being used to extend the life span and productivity of patients.

Biomaterials are used in and implanted into the human body. They are often transplanted living human tissues or synthetic materials designed to fully function inside the human body. Like artificial organs, biomaterials must not deteriorate or disturb surrounding tissue. Researchers have tested a variety of synthetic substances—including ceramics, polymers, metal alloys, and composite materials—for use as biomaterials.

Systems physiology describes the quantitative and integrated strategies used to

APPLICATIONS continues on page 13



high demand in today's job market, he says, and many students wish to prepare for a career in biomedical engineering that doesn't require a master's or doctoral degree.

Other students will enter the program to prepare for graduate study, says Finkelstein. To help those students, the department will offer a five-year B.S./M.S. program, in addition to the traditional four-year B.S. track. The University's graduate programs, which ranked 17th in the Princeton Review's most recent nationwide assessment of graduate programs in biomedical engineering, included 22 master's students and 40 doctoral students during the 1998-99 academic year.

Demand for the new undergraduate program is so high that the college will limit admission to only 40 or 50 of the best students each year. To apply for the program or to find out more about the admission requirements, contact the IT admissions office at 612-624-8504. ●

FOR MORE INFO see www.bme.umn.edu or email studentaff@itdean.umn.edu.

Associate Professor Daniel Mooradian (right), one of the first full-time faculty members appointed to the department, led a team that developed biomaterial coatings for artificial arteries to be used in vascular surgery.

The biomedical engineering department is housed in the new Basic Sciences & Biomedical Engineering, located on Washington Avenue between Jackson Hall and Coffman Memorial Union.

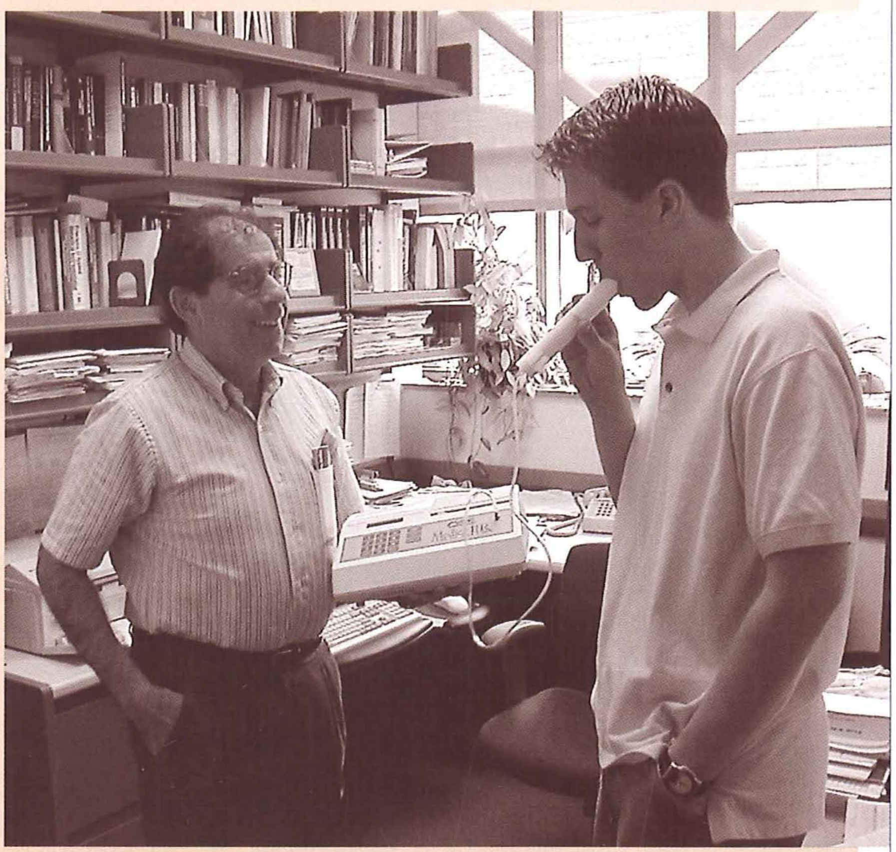
Applications

continued from page 11

compile information and develop strategic methods of treatment and teaching. Researchers analyze living organisms and use the results to develop mathematical models and computer simulations. These techniques are especially useful for studying complicated feedback-controlled systems like metabolism that are virtually incomprehensible without detailed mathematical modeling.

Clinical engineering studies health care technologies in hospitals and medical centers to help medical professionals give their patients the best possible treatment. By analyzing the use of medical instruments, clinical engineers can work with individual physicians to allot and adapt devices and instrumentation to fit their unique needs. Clinical engineering helps keep physicians and other health care staff informed about new devices and technologies entering the market.

Rehabilitation engineering applies biology and engineering to the rehabilitation of patients. Rehabilitation engineers work with injured and disabled patients to develop personal and specialized treatment processes.



Professor Stanley Finkelstein's research focuses on medical devices for home health care, including equipment that assesses vital statistics and transfers data from the patient's home to a clinical center, where it can be analyzed by medical professionals.

Tau Beta Pi Names Top Ten of the 20th Century

Tau Beta Pi, the national engineering honor society, has selected the Top Ten Engineers and Engineering Achievements of the 20th Century. Nearly 90,000 members subscribing to Tau Beta Pi's quarterly publication *The Bent* were asked to choose theengineers and engineering achievements that profoundly impacted technology during the last century. Their selections emphasize the pivotal role that engineering has played in shaping the 20th century.

Top Engineers

1. Thomas A. Edison
2. Orville and Wilbur Wright
3. Henry Ford
4. Wernher von Braun
5. William B. Shockley
6. Charles P. Steinmetz
7. Lee De Forest
8. George W. Goethals
9. Herbert C. Hoover
10. Hyman G. Rickover

Top Engineering Achievements

1. Apollo II moon landing (1969)
2. Airplane (1903)
3. Digital computer (1941)
4. Transistor (1947)
5. Television (1939)
6. Nuclear weapons (1945)
7. Panama Canal (1914)
8. Integrated circuit (1959)
9. Jet engine, plane (1941)
10. Communication satellites (1962)

The NEW AGE of Computer Simulations

BY JEREMY PASCHKE

Six months ago, the world watched with bated breath as digital clocks swapped nines for zeros, and humanity entered a new millennium. Technicians around the world wondered if computers would manage the change with ease or if computer failure would plunge the world into darkness. Although scrupulous measures ensured that the year 2000 debuted without catastrophe, the mere possibility of disaster underscored how dependent on computers the world has become.

A young technology, the computer dates back only to the mid-20th century, yet within that short time computers have become an essential and powerful tool for exploring and understanding the natural world. Computer simulations give University scientists and mathematicians the ability to conduct research on a scale and at a rate that has never before been possible.

Leigh Little, a postdoctoral associate in the computer science and engineering department, is helping to develop a program that will simulate the behavior of grain-sized particles immersed in a fluid. Oil companies will often inject a mixture of sand and thick fluid into oil reservoirs hundreds of feet below the terrestrial or oceanic surface. The pressurized injection of sand creates a backflow of crude oil. Oil companies will save millions of dollars if they know in advance what size particle to inject for best results.

Little explains that processing power limitations present special challenges. A program that simulates the movement of only 300 particles gobbles up 750 megabytes on each of four different processors. A true-to-life simulation would require at least 10,000 particles and proportionately more memory.

The project receives assistance from the University's Supercomputing Institute for Digital Simulation and Advanced Computation, which loans computer time to the research.

Although Little's research will benefit the petroleum industry, he says that he views the project from the vantage point of a computer scientist. "We are more interested in the computer science aspect," he says. "In other words, taking this problem that is immensely huge and spreading it into similar problems that can be solved individually."

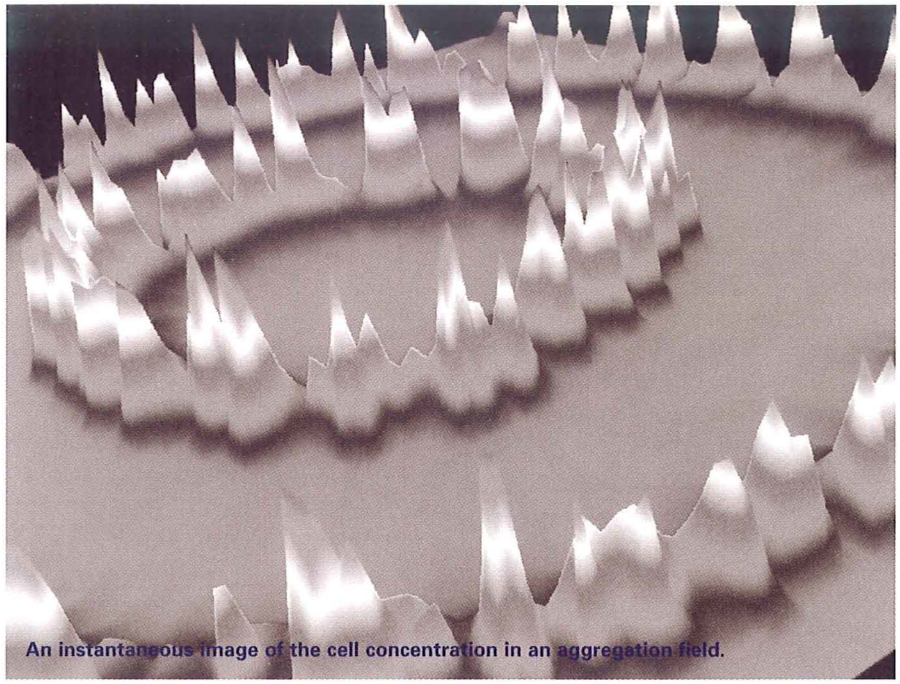
One advantage of computer simulations lies in their multiple applications. Little's digital particles of sand could just as easily represent red and white blood cells flowing through a patient's veins, or they could represent pebbles of various sizes awash in a concrete slurry. Physicians and civil engineers could benefit from a program originally designed to improve oil drilling.

While an "old-fashioned" experiment might take days or months to complete, conducting the same experiment using computer simulation could take just seconds, says Brian Suchomel, also a postdoctoral researcher in the computer science and engineering department. Moreover, he adds, it's possible to refine the simulation without starting from scratch, saving time and money.

Suchomel, who writes the code for programs that simulate the most complex of systems, describes his work as "straight linear algebra." Although most of the physical systems researchers try to model are relatively easy to solve with Newtonian mechanics, Suchomel wrestles with differential equations. "We're going after the ones that can't be solved," he says.

Robert Lysak, professor of astrophysics, uses computers to simulate the upper ionosphere and magnetosphere. Lysak employs Maxwell's Equations—differentials in one, two, and three dimensions—to study how mass and energy are conserved in a fluid of charged particles, the ionosphere. The sun periodically emits coronal ejections infused with magnetic fields. These rogue fields wreak havoc on Earth's magnetic field, causing drastic changes in the ionosphere.

One type of simulation Lysak might employ is a particle-in-cell simulation, in which many charged particles are thrown into a grid and constrained to move according to Newton's Laws.



An instantaneous image of the cell concentration in an aggregation field.

"Once the particles start to move," says Lysak, "you can find the current densities and resulting magnetic fields created with Maxwell's Laws. The magnetic fields then push the particles in a new way, and the process starts all over again."

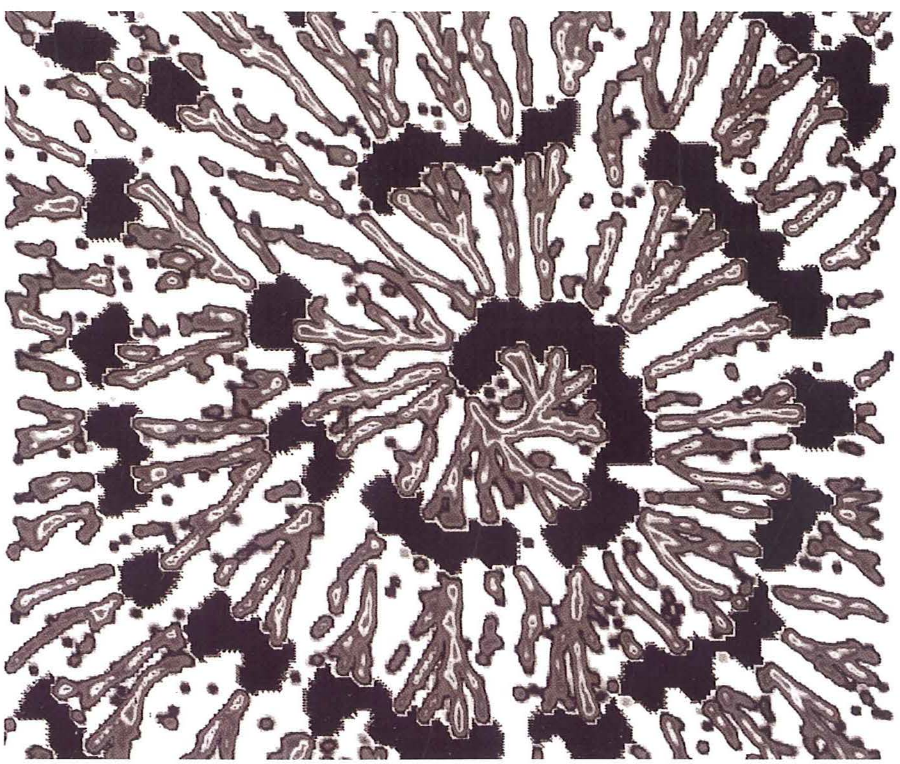
"People think that computer simulations are meant to create a complete picture of reality," says Lysak, "but a complete version of reality is not always the best goal. One of the beauties of simulations is that you can take certain things out and see what happens if you didn't have them in the system."

According to Lysak, computers achieve high analytic detail, but "you still need to do the pencil-and-paper theory."

Computer simulations also open up more pathways to exploring complex, adaptive systems whose laws are approximate, such as those found in nature and in human societies.

James Kakalios, associate professor of physics, investigates the cumulative behavior of sand grains of various sizes and combines laboratory experiments with computer simulations. He conducts his sand research together with graduate and undergraduate students.

One of his group's experiments involved pouring a sugar-sand mixture between two vertical glass plates, a container that resembled an ant farm. The two undergraduates who conduct-



Spiral waves are the most common aggregation pattern in laboratory experiments, although their origin is still somewhat of a mystery to scientists.

ed the experiment discovered that the resulting pile sustained periodic avalanches and that those avalanches resulted in stratified layers of sand and sugar. The emergent stratification was entirely unexpected.

"We are dealing with the question of emergence," says Kakalios. "How is it that local interactions can produce large-scale patterns?" If only gravity and the random collisions of its nearest neighbors influence each individual grain, Kakalios wonders, then how do all the grains produce the stratified large-scale pattern?

He and his assistants have created computer simulations that successfully duplicated the stratification, so they believe their theories are on the right track.

Codes from older computer simulations ballooned to gigantic proportions as researchers tried to account for all the factors that might affect a system. Today, the pendulum has swung in the opposite direction, as more programs demand parsimony in their structures. Instead of maximizing the list of factors, Kakalios says, "researchers are trying to guess the minimal set of interactions that produce the large-scale phenomenon."

Mathematics professor Hans Othmer uses numerical analysis to model pattern formation in biological species. Self-described as "a chemical engineer studying theoretical biology in a mathematics department," Othmer studies "the underlying mechanisms by which you can accurately control the readout of genes in the correct spatial and temporal order."

According to Othmer, to say that a leopard has spots or a zebra has stripes because of their genes is correct but incomplete. He wants the answer to a very precise question: "How you turn on the right genes at the right place at the right time?"

By way of analogy, Othmer explains that you cannot explain the significance of the Bible by saying, "it's all in the dictionary." The Bible is all in the dictionary, but it's the sequence of the words that matters.

In collaboration with biologists, Othmer studies slime molds, which contain many of the same characteristics as cell and developmental biology. Single-celled organisms in slime mold can detect external signals. Cells transduce the signal, pass it on, and then change their behavior in response the signal.

Othmer's computer simulations accurately replicate the behavior of the slime mold in its earliest stage of growth. When bacteria (food for the slime mold) runs short, the slime-mold cells activate certain genes that allow them to send and receive chemical signals. The cells move in response to the signal and aggregate in patterns around the food source. Sometimes the patterns resemble a spiral, and at other times they look like spokes on a wheel.

Othmer's model has proved so robust, he says, that "we can now do experiments computationally that would be quite difficult to do experimentally."

He adds, "You have to go that first step of having a good sense that your model is good enough that people believe in it, and it seems we are at that stage."

As close as the simulation may come to mirroring what really happens in nature, Othmer knows that he has modeled only one stage of many in the life of the slime mold. Following the aggregation, a mound of about a million cells begins to divide into two cell types, pre-spore and pre-stalk. Eventually the two cell types form a fruiting body that releases spores to start the next generation of slime mold. Among other questions he has, Othmer wonders what mechanism en-

SIMULATIONS continues on page 35

Nature's Inspiration

Computer simulations provide a new tool for modeling complex natural systems

On a hike through the jungles of Belize, Murray Gell-Mann encountered something that changed the way he chose to study nature. Gell-Mann, a leading physicist of the 1900s who coined the word "quark," spotted a jaguarundi, a wild cat, outside the Mayan village of Chan Chich. In his book *The Quark and the Jaguar*, Gell-Mann says that watching an elegant jaguar in its natural setting inspired him to study complex subjects like archeology, linguistics, and biological systems, whose laws are approximate, not exact. To foster the study of complex, adaptive systems, Gell-Mann helped establish the Santa Fe Institute (SFI).

Located in Santa Fe, New Mexico, the institute welcomes diverse research specialists to its community, including archeologists, ethnographers, primatologists, sociologists, philosophers, and economists. Together, they study complex systems like the evolution of human societies, using field studies, laboratory experiments, intellectual debates, and computer simulations.

One research project already underway simulates the movements of an entire culture, the Kayenta-Anazasi. The Anasazi are ancestors of the Pueblo Native Americans. Because archeologists already have a wealth of data about the Anasazi's population fluxes and migration patterns, they chose the Anasazi to test the accuracy of their simulations.

"We have no illusions about our ability to explain all of local Anasazi history," say George Gumerman and Jeffrey Dean, two archeologists at the SFI. They describe their simulation as a mere "cartoon of reality" but say it's a cartoon "meant to provoke and refine questions and point inquiries in new directions."

Although the digital Anasazi will always be a simulacrum, but playing and replaying their history in a computerized setting might lead researchers to explore previously ignored or discredited factors of cultural change. ●

— Jeremy Paschke

Making the Machine

Mechanical engineering students show their stuff

BY ELIZABETH QUAN

Imagine that you're a contestant on the hottest TV game show or—let's get real here—you're playing a trivia game at home with your family during vacation. It's your turn, and the clue is "robot." Think fast—what images come to mind? Chances are you'll think of stalwart little R2D2, the menacing automaton from your latest science fiction read, or a recent tabloid cover story you skimmed while waiting in the supermarket checkout line.

Or just maybe you'll raise your arms in victory and shout, "ME 2011!"

If that's the case, then you're probably one of the 200 or so lower division students who spent the last six weeks of spring semester immersed in the capstone project for Introduction to Engineering—the design and production of a computer-operated machine. The project culminates in the annual robotics fair, during which students show off their robots to a panel of judges, their fellow students, and the general public. The site of this year's fair, held on May 3, was spacious Memorial Hall in the University's new McNamara Alumni Center/University of Minnesota Gateway.

The project entails the design and construction of a computer-operated machine according to strict rules and regulations on size, action time, safety, power source, parts, and human intervention. Several checkpoints are built into the process to provide students with guidance and problem-solving assistance. Students meet in support groups to discuss ways to improve their products and overcome the inevitable snags that arise.

Students must submit several concept drawings and keep a detailed account of activities, ideas, parts searches, and information in a sketchbook. The actual construction of the robots occurs outside of class.

Alan Fruland explains how his rod and tackle function to land the catch of the day.

Robot support group members express varied opinions on the process, which demands frequent redesign and repair of their robots. Some students admit that they found the experience a bit daunting, saying, "There's a lot to learn." Others enjoyed it immensely, even the difficult moments, saying, "It's fun!"

The course instructor, mechanical engineering professor William Durfee, stresses the value of incorporating electronics into mechanical engineering. He says the robot project provides both hands-on experience and an accomplished product to show employers. In addition to the robot itself, students must organize a presentable portfolio that contains a resumé, hand sketches of previous assignments, Excel data and plot, and samples from the sketchbook.

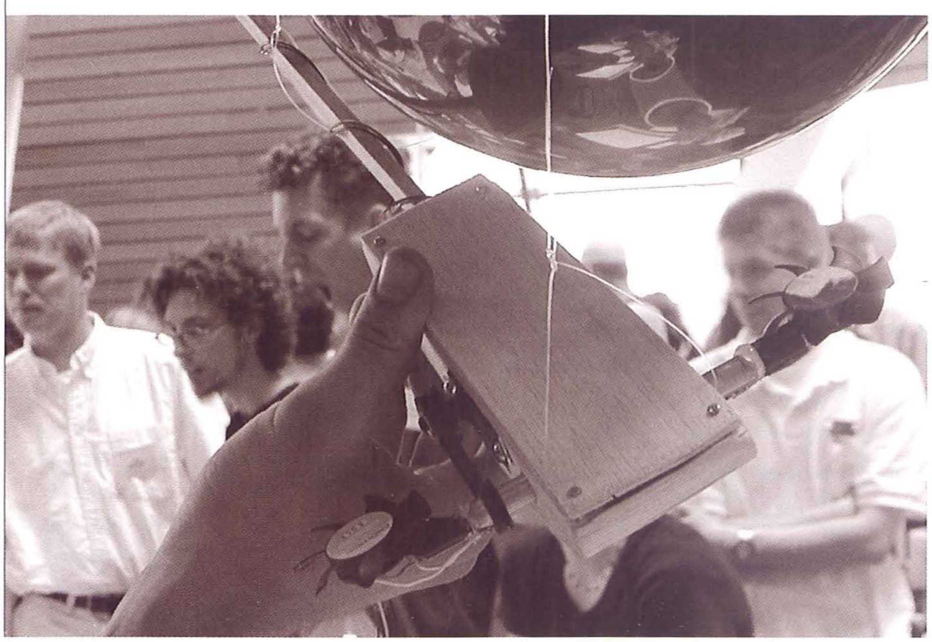
The sophomore-level class encourages students to prepare for job searches. Durfee frequently reminds the students, "Your robot shows what you can do."

The course accommodates a broad range of demonstrated applications and skills, so it's possible that the course may eventually be open to freshmen. Because the course work entails many sketches and drawings, the class might also be offered to art majors in the College of Liberal Arts.

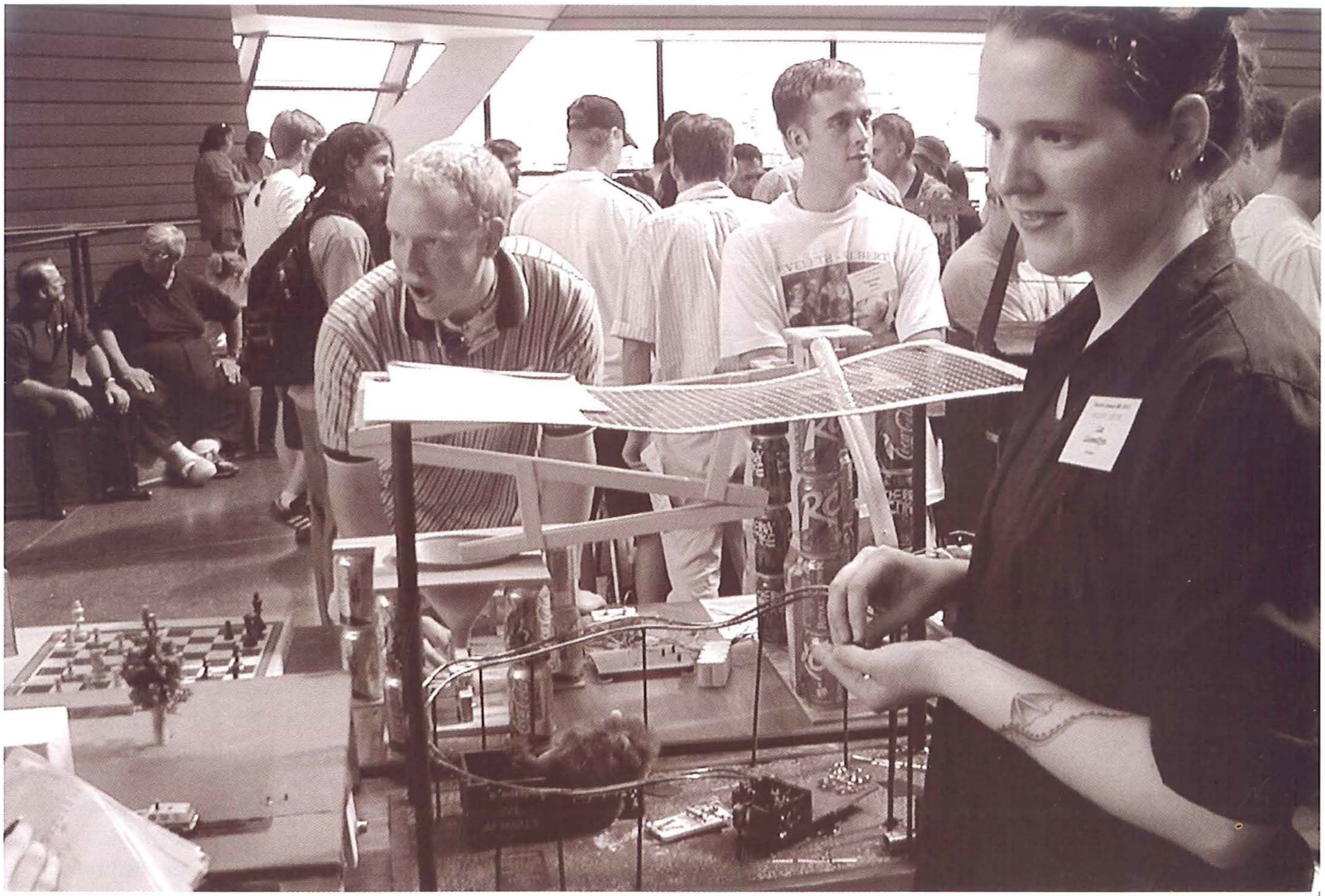
Durfee's collection of the students' concept drawings reveals obvious differences from their first ideas and the evolving designs. And when construction begins, students find themselves caught smack in the middle of the contest between their design concepts and physical laws. They learn very quickly where to place their bets.

As the project deadline approached, students experience "99% perspiration." Although some students complete their projects before the robotics fair, many others are still frantically making repairs and modifications. Before and even during the show, students cope with such emergencies as broken pumps, welding fractures, or tracks that needed cleaning.

With the fair date in sight, students soon discover that time management is a critical skill. The project deadline coincides with end-of-the semester "crunch time" in all their classes. There are stressful and frustrating moments as students cope with the experimental process, which is full of sur-



Stefan Hertel's robot makes use of computer programming, the natural bouyancy of helium, and thrust generated by tiny fans.



Liz Llewellyn's robot "Darth Maul Versus the Bantha" uses a timer and a computer to act out a scene with *Star Wars* characters.

prises.

One group member who struggled to get all the parts working in his "lock and dam" robot admits that he might not have a have a dam after all. Eventually the student comes up with a successful, modified version of the lock and dam. Another student found that individual parts for a robbery scene worked, but he speculates that the parts might not work together.

Stephan Hertel summarizes his technical difficulties: "The altitude goes up. Weight of the cable goes up. We lose buoyancy."

Yet another student flips through her concept drawings and sketches, which reveal overwhelming effort. She looks at the computer code that controls her robot and asks her group, "How should I get this to work?"

Regulations specify that the robot's actions are limited to 45 seconds in duration and must be repeated shortly after reset. The projects combat the stereotype that robots are a manifestation of humans. The human imagination visualizes robots that can perform miraculous feats, but in reality they are simply computer-controlled machines designed to perform a task.

On the day of the fair, students rush to the gateway center to set up their projects and complete last-minute repairs. Judges from 3M, the University, and other organizations inspect and evaluate several of the more than 200 robots. Their evaluations form the basis of course grades. Students are kept busy activating and explaining the functions of their robots.

Liz Llewellyn's robot "Darth Maul Versus the Bantha" uses a timer and a computer. A marble rolls onto a roller coaster and into a box that tips a teeter-totter, triggering a mousetrap. The mousetrap pulls Bantha out of a box, and then Bantha knocks over Darth Maul, a Lego man.

She admits that having to rebuild her robot was frustrating but acknowledges she had fun and learned from the project.

"It is a relief. My project works every time," says Llewellyn. "I learned many things.... [For example,] it always takes longer than you think, [including making] directions for people to build. Someone has to be able to rebuild your creation. It's a real-life application."

Hertel's eye-catching display of balloons flies around in a pre-programmed flight path, with helium providing natural buoyancy. Fans exert force or thrust to raise or lower the balloons. The control unit is constructed almost entirely from scratch.

He says, "This wasn't too bad. I took one step at a time." He found the class to be worthwhile, especially the CAD drawings. There "was a lot of busy work, though."

Alan Fruland's robot jigs three times

MACHINES continues on page 35

See 3PO

Calling all *Star Wars* junkies! The Minneapolis Institute of Arts offers a behind-the-scenes peek at the makings of America's most celebrated sci-fi series.

BY JON GERBER

A few weeks ago, *Technolog* staffers were having one of our regular planning meetings. As we were brainstorming ideas for the issue you are currently reading, a cunning plan suddenly occurred to me.

"You know," I say, "Somebody should probably go and take a look at that *Star Wars* exhibit at the Minneapolis Institute of Art. I think that might tie in well with the science fiction contest in our next issue."

"Well, since you suggested it, would you be willing to do that article?" replies the editor.

Concealing my glee, I say, "Yeah, I suppose I could do that." I had been meaning to go see the exhibit for some time, and once it became "official business", I had the perfect excuse.

Now, I'm a pretty big fan of the *Star Wars* movies. I've seen them enough to be able to quote significant portions of the dialogue from memory. I've read most of the novels and other assorted books about the *Star Wars* universe. A model Star Destroyer hangs from the ceiling of my room at home. In short, I am a *Star Wars* geek. As such, I had some pretty high expectations for this touring collection of movie props.

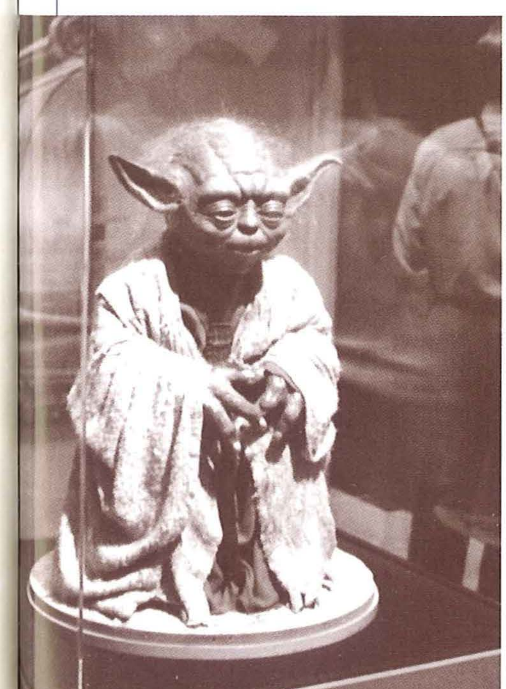
Before you set out to see the exhibit, you must decide whether or not to purchase a ticket in advance. Because so many people want to see the exhibit, tickets are sold for specific viewing times. This strategy thins out the crowds, but can present a problem for those who decide to simply show up and buy a ticket for the first time slot available. Of course, admission to the rest of the museum is free, so killing time before going to the *Star Wars* exhibit is very easy. In fact, if you have never been to the Minneapolis Institute of Arts before, I would highly recommend taking some time to walk through the other exhibits on display; there are some truly fascinating items from a variety of times and cultures.

I was feeling adventurous, so I hopped in the car after lunch on a Saturday afternoon and bought my ticket at the door. In spite of a fairly large crowd, I had to wait for only an hour.

I made my way to the exhibit area on the second floor ten minutes early, but a long line of eager fans beat me there. Fortunately, the museum clearly tried to ensure that waiting to view the exhibit is not an ordeal; a *Star Wars* documentary played continuously in a room adjoining the exhibit. I watched interviews with George Lucas and the cast and crew of his films, and before I knew it, it was time to enter the exhibit.

Audio guides to the exhibit are available immediately inside the entrance. Various pieces on display are labeled with a code that can be punched into a keypad on the audio guide. The voice of James Earl Jones then offers all sorts of interesting tidbits, such as where Lucas got his inspiration for the trilogy and how various sound effects were created. Ever wonder where the light saber's distinctive hum came from, or how the signature scream of a TIE Fighter was recorded? The only way to find out is to rent the audio guide.

The exhibit is organized into three main sections, each tied to one of the movies. As I walked into the first room, home of the orginal movie (known to *Star Wars* fans as "Episode 4: A New Hope"), I was greeted by the six-foot-long production model of the Imperial Star Destroyer. Needless to say, it was a most impressive start to the exhibit. The sheer size and level of detail is simply incredible. Other pieces on display included the costumes for Luke Skywalker, Han Solo, and Chewbacca, among others, and more gorgeous models of familiar *Star Wars* spacecraft. The walls were also lined with storyboards, concept sketches, and paintings from the *Star Wars* movies. It was fascinating to compare the roughly-drawn ideas on the walls to the finished products in their glass cases.

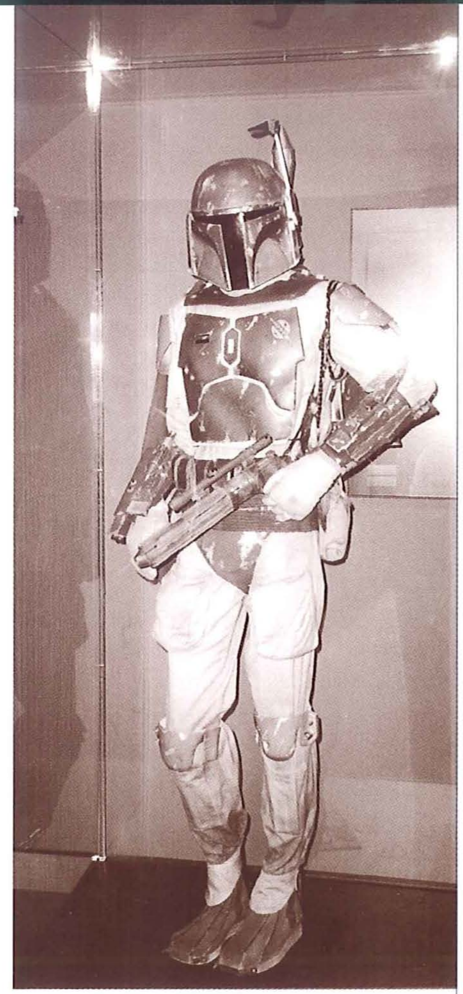


The second room is dedicated to *The Empire Strikes Back*. The props were divided into two main categories: the battle on the ice planet of Hoth, and the adventures on Cloud City. The Hoth area included the studio models of the Imperial Walkers and an audio description of how the battle was shot. The room concludes with models of Darth Vader's shuttle and everyone's favorite intergalactic bounty hunter, Boba Fett, whose costume is truly a menacing piece of work.

The third room, which displays items from *Return of the Jedi*, contains what I thought were the most impressive items. As I entered the new section, I was met with Darth Vader and a mural of the Emperor's throne room. Vader's costume is huge and sinister, looming over the robed mannequin of the Emperor and Luke Skywalker. The room also contained the Millenium Falcon and the Rebel Command Cruiser, both of which are huge and fantastically detailed models. It was a very satisfying conclusion to the tour.

The hallway leading back to the museum contains a couple of token items from *The Phantom Menace*, including Anakin's Pod Racer and some conceptual art. Considering how much of the movie was computer-generated, it is understandable that there are few items to put on display, but I had hoped for something more. There is, of course, a gift shop for all things *Star Wars*: posters, hats, shirts, Yoda masks, and so on. In a remarkable display of restraint, I escaped with my cash supply undiminished.

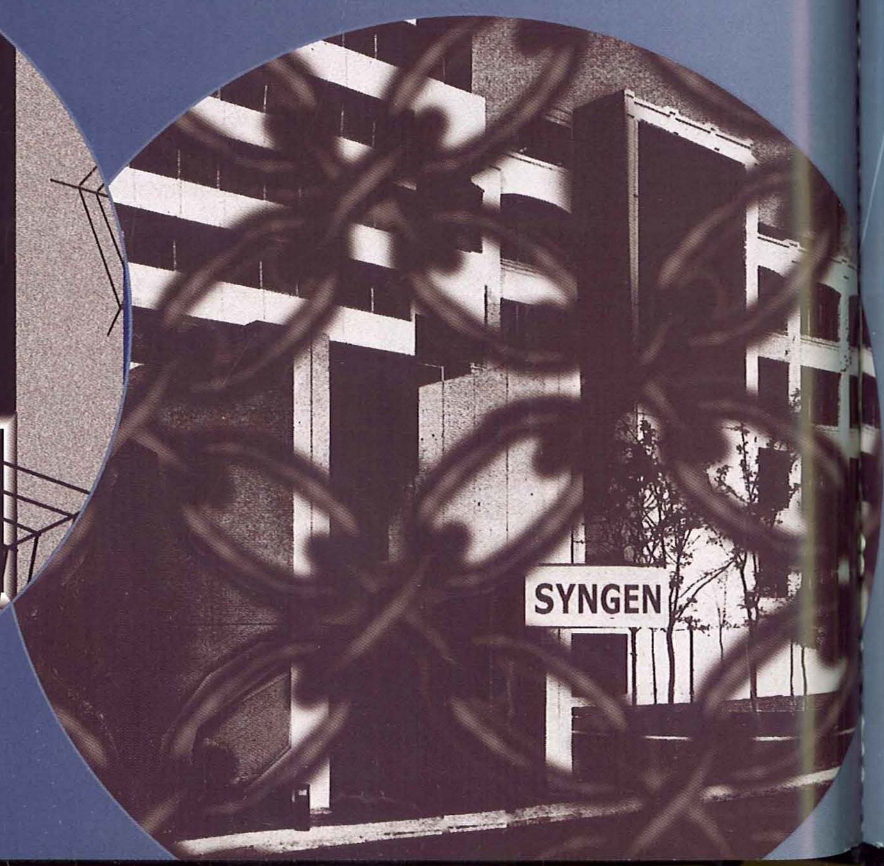
Of course, there is far, far more to see than I have time to write about here. It took roughly 45 minutes for me to see the entire exhibit, and I consider



it time very well-spent. In my opinion, admission to the exhibit is a bit expensive—$10 for adult admission and $4 more for the audio guide. (The institute also suggests a $3 donation for admission to the general collection.) After seeing what the institute had to offer, though, I have decided that the price of admission is definitely worth it. If you are a fan of the *Star Wars* movies, then you've probably already been to this exhibit. If not, go now! It is an extraordinary opportunity to sample a bit of cinematic history. ●

FOR MORE INFORMATION see www.artsMIA.org or call the Minneapolis Institute of Arts at 612-870-3131.

2000 SCIENCE FICTION CONTEST WINNERS



The Armadillo's Tale

BY MICHAEL POPHAM

After my escape, I grew to love the word "revenge." I whispered it a thousand times a day. Promised it to myself, the way a long-distance runner promises himself the finish line.

From my hiding place I could see a gravel path just inches from my nose and beyond it a chain-link fence. And beyond that was Syngen, the genetics lab where I was created.

That's where Phil Burkett and his team had designed me to kill, maim, and outwit my enemies. But Phil was cruel to me, and so I waited for the right opportunity and escaped.

I stalked my creator for a while and even befriended his seven-year-old son Jeffy. You may have read in the newspapers that an armadillo tried to kill the little tyke. Don't worry—the kid's all right now.

My beef wasn't really with Jeffy—or Phil himself, for that matter. I wanted revenge in its purest form, to bring Syngen to ruin. So I came back to wait and watch for the right moment.

I crept closer to the front gate, sat up in the tall grass near the gravel driveway, and looked around. The security guards were watching the sky, fretting about the rain clouds moving in. I wasn't worried about the guard station. But I was worried about the red-and-black sensors that were mounted about 15 feet up the building's sides.

I spent the better part of an hour prowling around the fence. Syngen had left nothing to chance. I could walk right by the guards, but I couldn't get past the sensors.

There was a way in. There had to be—but I wasn't seeing it.

I lowered my head down between my front paws, brooding about Syngen and the people inside. They had convinced themselves that a lot of governments would pay big money for a bioweapon that was intelligent and cunning.

1ST PLACE

I closed my eyes and pictured Phil at the conference table, happy and confident.

"Of course," Phil says, "the animal would need to be smart and fast and small, so that it could go anywhere," and all the others are saying, "yeah, yeah," nodding their heads. To them, it's just an interesting idea, but it's exciting because they can make it real.

Phil says, "But it couldn't look threatening. As long as it seemed harmless, no one would be suspicious."

My mind's eye slides under the fence, flits through doorways, down stairwells, and enters the laboratory where I had been kept.

My nose fills with the pungent smell of caged animals: monkeys, mice, rabbits. Many are like me—engineered to be deadly and clever. I am standing outside my cage, ready to escape.

One of the rabbits pushes forward to the front of her cage, snuffling, trying to see me more clearly. As she moves into the light, I see that she is afraid. "They'll shoot me up with the Bad Stuff tonight," she says.

The Bad Stuff. It terrifies all the animals because it means certain death. It's a mutant strain of smallpox virus, and the scientists have been testing vaccines for it. But the vaccines aren't working, and they can't figure out why. They're using up a lot of animals searching for the answer.

It occurs to me that if I can get to where the smallpox cultures are stored, maybe I can find a way to use them against Syngen. I tell the rabbit, and she nods gravely.

"If the virus spread among the human population, it would be very damaging to Syngen," she says.

"It would have to be done so that there would be no question of Syngen's guilt," I reply.

"A simple approach might be the best," offers the rabbit. "If you had the virus cultures, you could mix them with finely ground glass and make a kind of paste out of it."

"I don't think anybody would eat that," I say doubtfully.

"You're not that bright, are you?" observes the rabbit. "No one would eat it. You'd just smear a little of the paste on Syngen letterhead. Then letters get mailed out. Whoever receives those letters from Syngen would get tiny abrasions on their fingers, and the smallpox virus would get inside a nice warm body. Syngen would be blamed right

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away as the guilty party."

It was the sort of idea I might have come up with myself, if I'd had enough time.

"What will you do now?" the rabbit says. "Will you just leave?"

"Got to, baby," I say with a glibness I don't feel. "I gotta help myself."

The door in front of me swings open, revealing the shadow of a towering man. Blinding light pours into the room, and I instinctively squeeze my eyes shut. I hear a tremendous crash as the door smashes against the wall...

I opened my eyes. There was no giant door—what I'd heard was a crash of thunder. It was raining now—a fierce, driving rain that pelted me mercilessly. The path outside the fence was now flooded. Thousands of little rivulets had sprung up in seconds, the water coursing across the gravel like bubbles of mercury.

How long had I been like this—dreaming in the grass as my enemies plotted my capture, no more than a hundred yards away?

It had been foolish to come back, I realized. There was no way in—and what would I have done if there had been? Run through the facility, spread the virus, and hope Syngen would take the fall?

"Gotta go," I whispered to myself. I was in such a hurry that I nearly forgot about the motion sensor. Drops of water pricked my eyelids like needles. I blinked, looked again. I wasn't imagining things. It was raining so hard the sensor was nearly invisible. Would it be able to pick up my movements in a driving rainstorm?

Three seconds later I was inside the fence and running. The grass was soaked, and I nearly went sprawling. As I neared the building, I flattened myself out and skidded to a stop, then darted along the wall to the air inlet. I squeezed inside and followed the vent to a boiler room.

There had been no alarms. It had been laughably easy to get in.

I trotted out to a dim corridor lit only by the EXIT sign behind me. The whole place seemed empty.

I scuttled along, my mind on the smallpox virus and its whereabouts, then headed instinctively to the facility's lower levels. The stairwells were locked, but the elevators worked, and I could access any level without a key. That should have made me suspicious. But I so love riding in elevators.

In the sub-basement I found the door I wanted, plastered with signs marked BIOHAZARD and AUTHORIZED PERSONNEL ONLY. I muttered high-pitched squeaks into the electronic lock, and the door opened.

The room was filled with deep-freeze casks. Each cask bore a laminated tag containing a chemical formula. I read the tags one by one until I found the cask with the smallpox cultures. I jabbered at its electronic lock, and the cask opened easily.

Inside were eight or nine samples of mutant smallpox virus, each sample a sheen of jelly in a frozen petri dish. I collected the dishes and spread them out on the nearest lab bench.

Now all I had to do was heat the samples slowly, so the virus wouldn't be destroyed. Then I could find a test tube and grind the glass into dust. All it would take was an hour or so in this room.

Suddenly I froze. In the distance, so faint that I could barely detect it, I heard a click coming from the elevator shaft at the end of the corridor.

They must have locked in elevators in place on the upper floors. They knew I was here. Phil must have—

SSSNNAAAP!

The lock in the door behind me clicked shut, a sound echoed by the lock across the hall and a dozen other locks up and down the corridor.

I hurled myself at the door with all my might. An ordinary door would have been smashed off its hinges, but this one had a reinforced frame, and it held.

I heard a scraping sound, directly above me, then two quick thumps, close together.

There was a low rumbling sound coming from upstairs, and the air had an odd, smoky smell. Suddenly, every object in the room seemed very far away. I took a step forward, nearly lost my balance, and shook my head to clear it. They'd done something to the air in this place.

I glanced up and saw a wisp of smoke issuing from the ceiling vent. The floor rose up underneath me like the floor of a gigantic express elevator. Then I slid into darkness.

I woke up with a horrible thirst. I lay on my side, on a bed of matted straw. All around me were the smells and sounds of many different animals. I got up and staggered forward on shaky legs but ran headfirst into the metal bars of a cage.

I was back in the room where the experimental animals were kept, the same place I'd escaped from

Dusky, purplish light entered through the filter of glass blocks set high in one wall. I glanced from cage to cage, trying to see inside. I saw the red glint of a rabbit's eye. I glimpsed a dark shape retreat to the back of the next cage and turn back to face me.

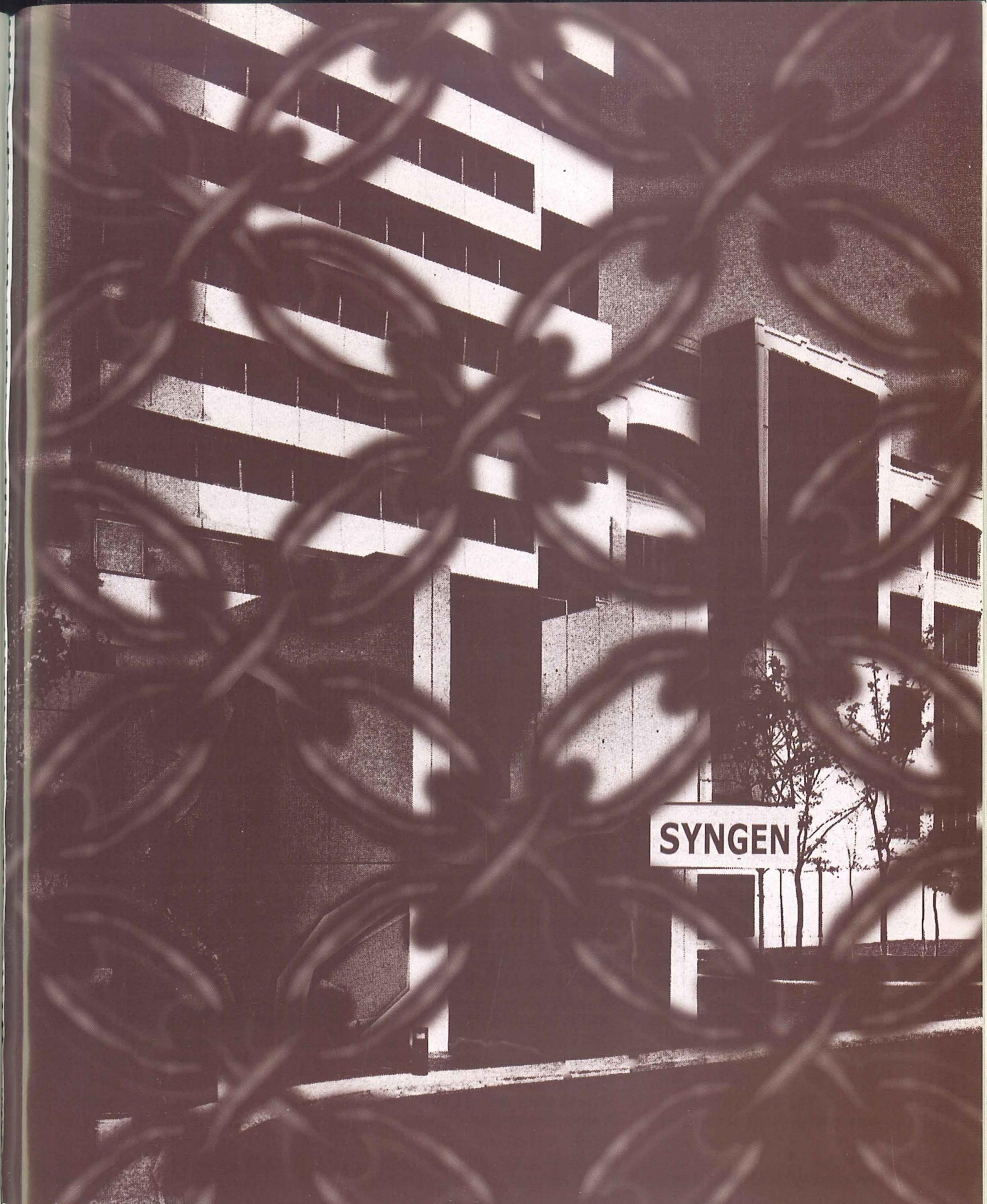
"Don't be afraid," I whispered. "I'll get you out of here."

"Who are you?" said the rabbit.

"I—I'm..."

I almost said, I'm here to save you. But suddenly it seemed like a foolish thing to say.

"I'm the armadillo," I whispered fi-


SYNGEN

nally.

I looked around at the eyes staring at me from every cage. A strange shuddering sound began as the animals slammed themselves against the bars.

The sound grew louder, and I retreated. I could see the rabbit clearly now, her features distorted by a human intelligence.

"You got away," she said. "Why did you come back here?"

"I had to get them—Syngen. For what they did—"

The animals started laughing. The rabbit stared at me with a look of disbelief.

"They made you that way," she said finally.

"What?"

"The geneticists. They designed you to want revenge."

"Shut up," I said.

"They knew you'd come back. It's how they caught you."

The giant door swung open, and light poured into the room. The animals stopped shaking the bars, and Phil stepped through the door.

"You should have known we were waiting for you," he said. "You should have known we would catch you."

He was wearing a sport coat, and his hair was neatly combed. He'd even shaved since we last met.

"You clean up pretty well, Phil," I said. "Last time I saw you, you were drinking whiskey and blubbering into the phone to the police."

He went pale and smoothed his hair back with nervous fingers. But he recovered quickly enough.

"You can make all the jokes you want," he said. "The Syngen board called an extraordinary meeting regarding you. You'd be surprised at their decision."

"I bet I wouldn't. The 'animal' is to be 'put down'— right?"

"I recommended to the board that you be terminated."

"Of course."

"But the board voted against it. They saw nothing wrong with your escape. They said it was natural that you would try. But after stalking my son, you apparently sneaked into my own home and slept there. Then you returned to the lab. Clearly, you have a subconscious loyalty to Syngen."

"Loyalty!"

"The board wants you alive. To be studied." Phil's face went dark. "But I don't want you alive."

"You seem to be on the horns of a dilemma, Phil," I said.

He looked up. "There's no dilemma," he replied quietly. "You're going to die. Tonight."

I saw two men emerge from the shadows behind Phil. They picked up my cage and moved quickly down the corridors to a door at the back of the building. A fog-colored van was idling outside. The goons unlocked its cargo doors and loaded me inside. Then we were off.

Poor armadillo, I thought. What have you done to deserve this?

Phil sat next to the cage, staring out at the rain as the van bumped along a rutted back road. The goons sat silent. I noticed that each one had a taser and a police baton.

"You Syngen guys have been studying me," I told Phil. "But I've been studying you, too."

Phil didn't move.

"Want to know what my conclusions are?"

Phil ignored me, so I just went on. "You designed me for revenge, so my impulse is rational. Your need for revenge is based on jealousy and a deep-seated frustration about your personal failings. It's wholly irrational. If there are any issues you'd like to discuss...you know, about your wife or your son Jeffy..."

Phil whirled around and grabbed the jack handle lying under the edge of the wheel well. I moved a little closer to the latch on the door, and Phil obliged me by hitting the latch with all his strength. Admittedly, Phil's strength wasn't much, but I knew that the cage was weaker outside than inside.

Then he realized he wasn't going to get at me from out there, even with the jack handle. He grabbed the taser from one of his goons, shoved it through the bars, and fumbled for the trigger. I saw a bright flash, and then the world went dark again.

I awoke to the smell of algae and the sound of water lapping against wood. I was still in the cage, which was now in the wheelhouse of a boat. Through the wire mesh I watched feet moving along the wooden deck.

I dug my nails against the steel cage door. Now that I was alone, there was a chance that I could pry the latch open. After about ten minutes, I'd forced the latch outward a little.

Before long, Phil and his assistants were back.

"Bring it out," Phil said. The goons lifted the cage onto the deck.

"I'm being relatively humane," Phil said. "There are worse ways you could die. I could turn an acetylene torch on you, for example."

"You wouldn't have the guts," I said. "I bet your goons wouldn't, either."

The goons, eager to show me what they would do, hoisted the cage onto the boat railing. I could see the twinkling of lights across the reservoir. The lights hypnotized me. I felt that the worst thing about dying would be to never seeing lights across the reservoir again.

ARMADILLO continues on page 35

THE Artist

BY ERIK ORTLIP

It had been a long time since the old man had last visited Edgar—too long.

The old man once said, "So you're an artist. Well, where's your divan? Every artist needs one." The next day the old man delivered one, a large dusty piece of furniture with red satin upholstery embroidered with gold thread. The black mahogany legs, intricately carved with serpentine oriental dragons, anchored the divan to the floor. Sometimes when he was lying on the divan, Edgar imagined that the dragons were moving. He could almost feel their sinuous bodies slithering beneath him.

Edgar looked around his studio, which really was the living room converted to a studio. He sat on a small three-legged stool in front of his latest canvas. Behind him were a half-dozen new paintings propped against the divan and a rough-hewn, handmade worktable blotched and spattered with paint. The precious jars of pigments stored in the worktable drawer were the results of barter or careful scavenging during his daily walks.

How long had it been since the old man was last here? He had never let Edgar's canvases pile up like this. Edgar's eyes wandered to the only other piece of furniture in the room, the wall-mounted Sensortron.

The agent who sold Edgar the house had promised him a state-of-the-art Sensortron. From where Edgar sat, it didn't look like much, just a flat monitor about two feet across, with a matte black frame that doubled as a mounting bracket. The Sensortron resembled an old television, but Edgar knew better. In school Edgar had learned how the Sensortron revolutionized modern-day society, just as the radio and the home computer had changed earlier cultures.

The pins in the Sensortron's interface plug glinted in the light from the corner lamp. Edgar touched the matching plug in his neck. Implanted at birth, the device allowed Edgar to plug into the Sensortron and experience a hyper-reality in which colors were more vibrant, scents richer, and sounds more voluminous than reality itself. A stream of binary information could become a flower, its sweet scent filling the air more powerfully than a garden bouquet ever could. A few lines of computer code could generate a soft breeze that would brush the skin or produce the electricity of a summer rainstorm. To unplug from the Sensortron was to return to a drab reality, the pathetic shadow of a brilliant world.

2ND PLACE

Since meeting the old man, Edgar had vowed never to use the Sensortron again. He didn't want to lose his grip on reality and to confuse this life, and his art, with the world of the Sensortron.

The old man also shunned the Sensortron. "I am an old man, and I have no need for such foolishness," he once said. Of course, he was fitted with an interface plug of his own, just like everyone else in 2224, but he refused to use it. "I am a man of the world interested in worldly pleasures," he would say.

Edgar first met the old man while walking home from work one day. Unlike most people, Edgar had never liked riding the trains and preferred being out in the weather and the sunshine. He'd seen very few people on his walks and had never talked to any of the people he did encounter.

The old man happened to be strolling along the same path. The old man spoke first. "Hello," he said in a strong, clear voice that startled Edgar.

The old man explained that he had taken this walk every day for 30 years. He talked about how he loved the smell of the leaves in autumn, winter's cool crisp air, and the new warmth of spring. Most of all, he enjoyed the heat of the mid-August sun that soaked through his skin and heated his bones. He said the summer sun had a brilliance that rivaled Ra the sun god himself.

"Who's Ra?" asked Edgar.

The old man only laughed. "What do they teach you in school these days? No, don't answer that. They didn't teach it to me, either. By the way, son, what's your name?"

"Edgar."

"Edgar, do you realize there was once a famous artist by the same name?"

"Artist?"

The old man laughed again. "I suppose they didn't teach you anything about art, either." Edgar shook his head.

"Art can be words or musical notes or colors on a canvas," the man said.

"They all have one thing in common, though. Art gets what is inside to there or there," the old man said, pointing first to his head and his heart and then to Edgar. "It's a wonderful thing."

From that day on, the old man walked Edgar home from work every day. He would tell Edgar about the ancient history he'd never learned in school, about the Egyptians and their amazing pyramids. The old man spoke of the ancient Greeks, their epics, and their political philosophies. Most importantly, they talked about art, which interested Edgar most of all.

"I have a surprise for you," the old man said one day on their daily walk. "Let's walk back to my house tonight, and I will show you."

It was the first time Edgar had ever been to the old man's house. He brought Edgar to an empty room at the rear of the house. The walls were bare except for the wall facing the doorway. Pinned to the wall was a picture of a basket of apples. The bottom edge of the picture was torn and ragged.

"This is what I wanted you to see," said the old man. "This picture belonged to my grandmother. She tore the page out of her calendar and gave it to me when I was a child."

It was the most incredible thing Edgar had ever seen.

When Edgar returned home, he took one of the thick pencils he used for drawing machine schematics at work and started drawing. The next day he packed up his sketches and brought them to show the old man.

"Well, Edgar," said the old man, "we may just make an artist out of you yet."

The whir and hum of the cleaning robot going about its duties woke Edgar from his reverie. It really had been too long since he'd seen the old man. Edgar got up and walked straight for his best painting, a picture of smokestacks that he was particularly fond of. He put the painting under his arm, left the house, and made his way into the night. The house sensed his departure, and the lights shut off.

Implanted at birth, the device allowed Edgar to plug into the Sensortron and experience a hyper-reality in which colors were more vibrant, scents richer, and sounds more voluminous than reality itself.

As Edgar walked down the street, he noticed how much the houses resembled the heads of giant robots with glowing, staring eyes. The houses' gleaming polycarbonate exteriors would never deteriorate, their roofs would never need new shingles, and the houses would never lose power. Silent and dormant, the soulless houses waited for their occupants to awaken from their Sensortron-induced trance. No children ever listened to bedtime stories. No husband held his wife close and whispered, "I love you." No one curled up next to the fire to read the classics by Twain, Bradbury, or Hemingway. People came home and plugged into the Sensortron to have their individual fantasies.

After walking about a half-hour, Edgar arrived at the old man's house. He studied the small, weather-beaten house he had visited many times before, then stepped inside.

"Hello, is anyone here?" Edgar called. No one answered. Sensing his presence, the house turned on the entryway light. Edgar shielded his eyes. From ceiling to floor, his paintings covered the walls of the tiny entryway. Edgar's only patron, the old man had purchased all of Edgar's works, making his home a permanent gallery for the younger man's paintings.

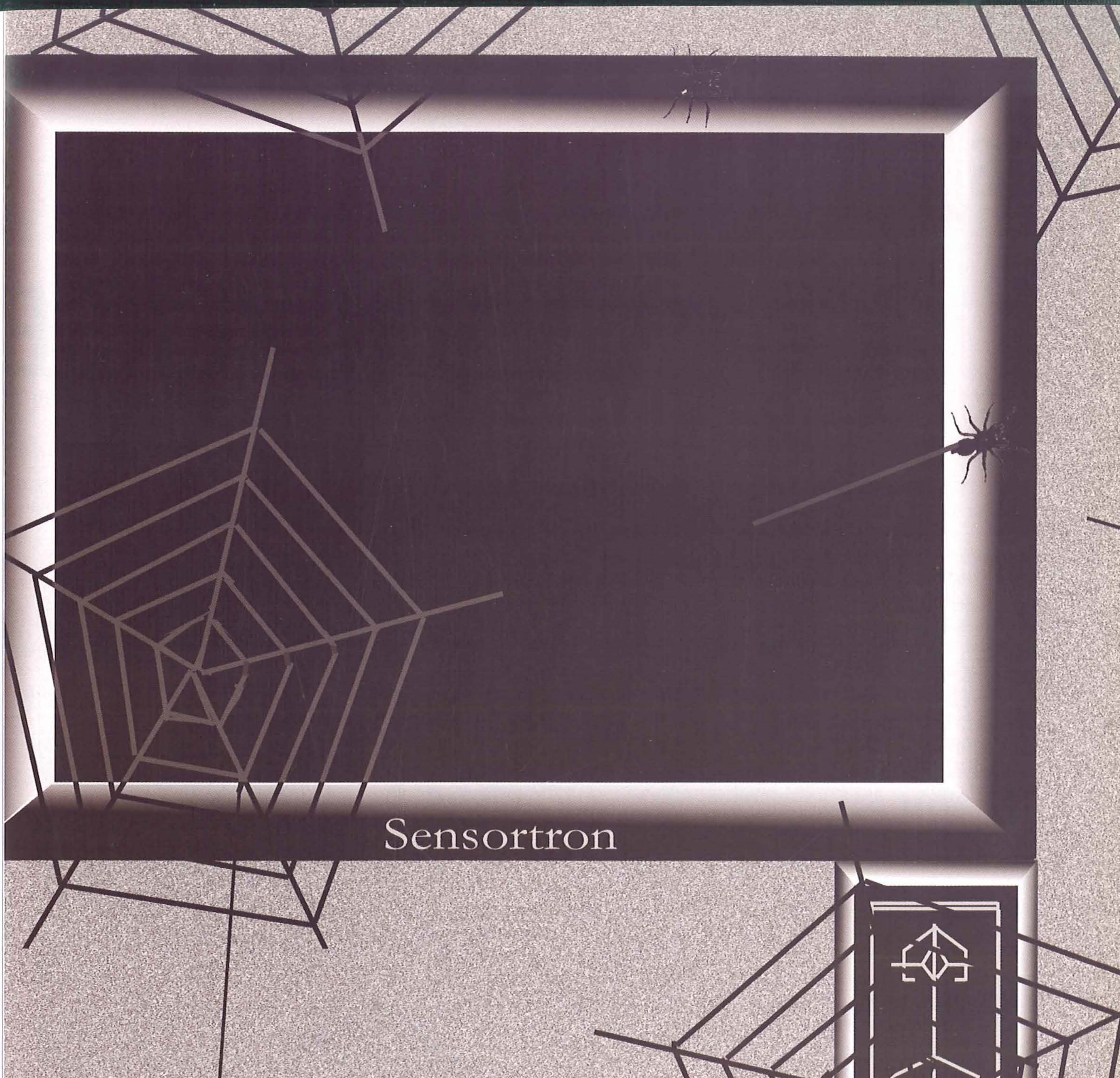
Edgar paused to contemplate his work. From one canvas, a likeness of Edgar's kitchen robot stared intently, contemplating the next cooking disaster it would have to take care of. Another painting captured the eerie nighttime glow from the homes on Edgar's street. There were still-life paintings, studies of the old man, self-portraits, and paintings of robots.

Edgar moved deeper into the house, and the light followed him from room to room like a spotlight. Every room was filled with his works. Here, in his private gallery, he could imagine himself to be a success, congratulated by admirers and friends.

The next room was hung with variations on a single image, a still life of a basket of apples, a wine bottle, a white cloth, and a pile of dessert cakes. Pinned to the room's back wall was a page torn from an old laminated calendar, dated March 2113. The page bore a single image and the caption: "P. Cézanne (French, 1839-1906), The Basket of Apples, c. 1895."

As he had so many times before, Edgar paid homage to the eye and hand of a master. How did Cézanne get the red to be so brilliant, he wondered. Edgar had gone down to the junkyard the day before and had scraped some rust from an old machine. With the right binder, maybe that would do the trick. Edgar gave the Cézanne a final look and continued his search for his friend.

Entering the old man's room, Edgar found him lying on the bed. He looked



like he was asleep, but when Edgar took a step closer he knew that the man was dead. The old man looked so small and frail.

He was good to me, Edgar thought, and I thank him—for everything.

The mechanical hiss of the kitchen robot startled Edgar. Sensing the presence of a visitor, the robot had prepared two cups of tea, one for the guest and one for the old man. The robot extended the tray and offered a cup to Edgar. With a sigh, Edgar instructed the robot to take the old man's body and notify the mortician.

The robot took the tray to the kitchen, came back to the room, and began to remove the old man's body. The only sound was the whining of the robot's servomotors as it lifted the body, as if it were mourning for his old master. Or perhaps the robot might have sensed its fate. After its useful parts had been salvaged, the robot would be melted down and molded into parts for new robots or machinery. Probably it would become a Sensortron.

Edgar watched in a melancholy silence until the robot left the room with the body. Then he remembered the painting he had brought with him, the one with the dark and somber smokestacks against a gray sky, their plumes of smoke trailing off into infinity. Near the foot of the old man's bed was the only wall section not already hung with Edgar's paintings. This empty space was just the right size, and a nail protruded from wall in just the right

ARTIST continues on page 34

THIS Incandescent UNIVERSE

BY DANIEL D. W. RAASCH

The streets of Akihabara are steaming today: supersaturated, engorged with people. Gasoline rainbows on wet asphalt reflect the expensive footwear of Japanese salarymen. So far, Father Cooper is nowhere in sight.

I don't know whether he's taken the Rinkai Fukutoshin Line like I did (seven minutes flat from Shin Ki to Tokyo Teleport Station, a five-minute jog from here), or whether he's taken the Yurikamome Line, which has a shorter travel time but is a longer walk from where I am. Or maybe, like most first-time *gaijin* trying to decipher the national cryptohaiku of a Japanese train schedule, he's on some bullet train moving 300 kilometers per hour away from here, and he won't discover it until the last stop in some rural prefecture surrounded by rice and Shinto shrines. For some reason this scenario makes me laugh. Maybe God doesn't know his way around, either.

I don't mind waiting. The Turita isn't until tomorrow. I'm in no hurry. A ripple of laughter runs through me when I realize this may be the first time a tech journalist for *Futurica News* has ever thought that phrase. I'm looking forward to finally shaking hands with Father Cooper, who is somewhat of a celebrity where I come from. A telegenic 68-year-old Jesuit priest with a doctorate in computer science, he first earned his reputation when the *Journal of Games Theory* published his classic "On Iterated Prisoner's Dilemmas and Faith-Based Strategies" nearly four decades ago. A quirky, mathematically rigorous examination of the role of faith in zero-sum games, it also turned out to be the first scientific sermon. Father Cooper solved the Prisoner's Dilemma by proving mathematically that faith and reason did not merely co-exist but depended upon each other for evolutionary success. In other words, faith and reason were not antagonists, but in fact old chums who had each other over for tea now and again. To say that this proof shocked the scientific world would be like describing Newton as a fairly clever fellow.

Since then, Father Cooper has been published in dozens of academic journals, written several popular best-sellers, and is often trotted out for articles like the one I'm writing. Recently he was appointed by the Pope to chair the Vatican Council on Technology. It's in that capacity that he's here for the Turita, the Japanese loanword for what English speakers call the Turing Test: an examination to see whether or not a computer program can pass as a human. Denkikon Digital Industries is sponsoring the Turita tomorrow for its seventh-generation project, a program known as Ii-ko. Both Father Cooper and I are here because of our jobs, me to report on it and he to judge it.

3RD PLACE

Despite the fact that he is obviously much brighter than I am, I find myself worrying about him. The Japanese sun is sweltering, and the weather is *mushi-atsui*: insect-hot. I'll be sunburned before long, and I hate to imagine trying to explain to my editor how a beloved old man died of heatstroke because I gave him lousy directions. It occurs to me that trying to spot one person in an Akihabara crowd is like trying to pick out one black dot in a newsprint photo.

Suddenly, I get an idea. Like a lad peering through a knothole in a neighbor's fence, I raise a coin to my eye and squint through the hole in the center of a 10-yen piece. I frame and pan across the stream of brightly-colored kimono-clad housewives zipping by on motor scooters, the octogenarian merchants hawking just-born video equipment, the *kanji* kaleidoscopes of neon light.

It's the perfect change for me. I'd been covering the Mars Terraforming Project for the past six years, drawn to it by a schoolboy fancy that now was wearing thin. In the beginning, there was such romance to the idea of adding heat and life to a cold, dead world and making Mars a place where families could spread out, breathe, and play. Every day brought a new story, another miracle in the cascade of miracles that's become everyday life in the 21st century. The public, too, loved reading about Mars. In the newsroom, we call them Redheads.

But somewhere between new Martian crops and advances in geologic oxygen extraction, I'd become an insomniac. Food obscured its taste. I couldn't tell whether it was because I longed to be with the colonists and watch Mars bloom into life, or because I felt some dim foreboding about what they were doing. My world was changing, and somehow I felt as if all these miracles were eating away at the Mars of my childhood: the Mars Galileo saw, the inspired unknown of Edgar Rice Burroughs, the cradle of cosmically ambitious Little Green Men. The romance was fading, replaced by a sense of mechanistic ennui and, somewhere underneath that, fear.

This was the big danger for tech journalists like me. Wiping out, it was called—suddenly becoming disinterested in the crest of the wave, looking behind you at where it's been. Once you lose it, once you're out, you're gone. Wipeout. There's a queue of fiery 16-year-old optimists waiting impatiently for you to crash, and there's no room in the industry for Eeyores .

I'd seen my share of coworkers wipe out. We'd talk about them when they weren't around. "Katz is headed for a wipeout," I'd said once. "I heard him asking the VP of GeneLux if he had any plans to clone Hitler to fill in for him on sick days." And sure enough, just two weeks later, Katz was gone. He didn't resign. Just stopped showing up for work. I don't think his last paycheck was even cashed. Now it was my entrance into the room that shushed conversations. I was not going to wipe out, I told myself. I will not wipe out.

Suddenly my little 10-yen circle of life fills with the vision of a silver-haired gentleman I recognize from the back of his book jackets. When I wave to get his attention, a boyish grin lights up his face, and Father Cooper plucks a coin from his pocket and mimics me. He then points at a restaurant that bisects the distance between us. It's a tiny slot nestled like a prayer between two towering brick edifices, dappled with neon and diffuse in the afternoon sun. We both stagger toward it.

The restaurant smells deliciously of ginger and soy, and it's twice as hot inside as out. We're presented with a platter full of the most exquisitely appetizing delicacies. Father Cooper selects the *kaki-age donburi*, sumptuous tempura shrimp, scallops, and vegetables on a bowl of sticky white rice, but all I can do is stare at the platter. There's a reason why all the food looks so good. It's plastic.

The plastic food industry here is intense. The idea of using plastic food stems back to the early days when Japanese shopkeepers would put real food in the window to woo prospective customers. Unfortunately, real food had the disappointing tendency to attract flies as the day went on, and plastic food could be made to look more tantalizing than the genuine article. Now, in the Daiba district, the chemical chefs of polyurethane pleasures compete for the yen of restaurant owners in a parody of the dining experience. In 10,000 years, the counterfeit teppanyaki will still look as fresh and inviting as it does today. I wonder if someone will have figured out a way to digest it.

"You know," I say, ignoring our waiter, "the cost of that platter of plastic could've stopped, what, maybe 300 children from starving to death." Even as I say the words, I can't tell whether I'm truly outraged or if I'm just overcompensating because I'm in the presence of a priest.

A smile lights up Father Cooper's face. "Beauty is important, my friend, at least as important as food. This is sculpture; this is art! Should we live in a world of full bellies that are starving for beauty? Eat something. You'll feel better. The starving children will thank you." Gratefully absolved, I order the teppanyaki.

When our food comes, I question him between mouthfuls.

"So why come all the way out here, Father? The Turing Test tomorrow is really nothing more than a PR device for Denkikon, and most scientists would say that even in the best case, the Turing Test isn't really a test at all. There's no quantifiable data. There's no objectivity. It's simply whether or not the judge feels a computer is conscious. How valid is that?"

Before the last word leaves my mouth, Father Cooper replies.

"So often we hear the phrase, 'I think, therefore I am.' Cogito ergo sum. It's attributed to Descartes, but this isn't quite accurate. Descartes wasn't concerned so much with thought as he was with doubt. Descartes was consumed by it. It was only his conviction in his own doubt that allowed him to assert his existence. Now doubt, it's plain to see, is a very different thing than thought. Doubt is an emotion. Doubt is a feeling. And from my perspective, doubt comes from the soul. I'm not interested in whether a computer thinks. I'm interested in whether it doubts. And the Turing Test is a great test for that."

"What was that line again? About the soul?"

"Oh yes. Doubt comes from the soul."

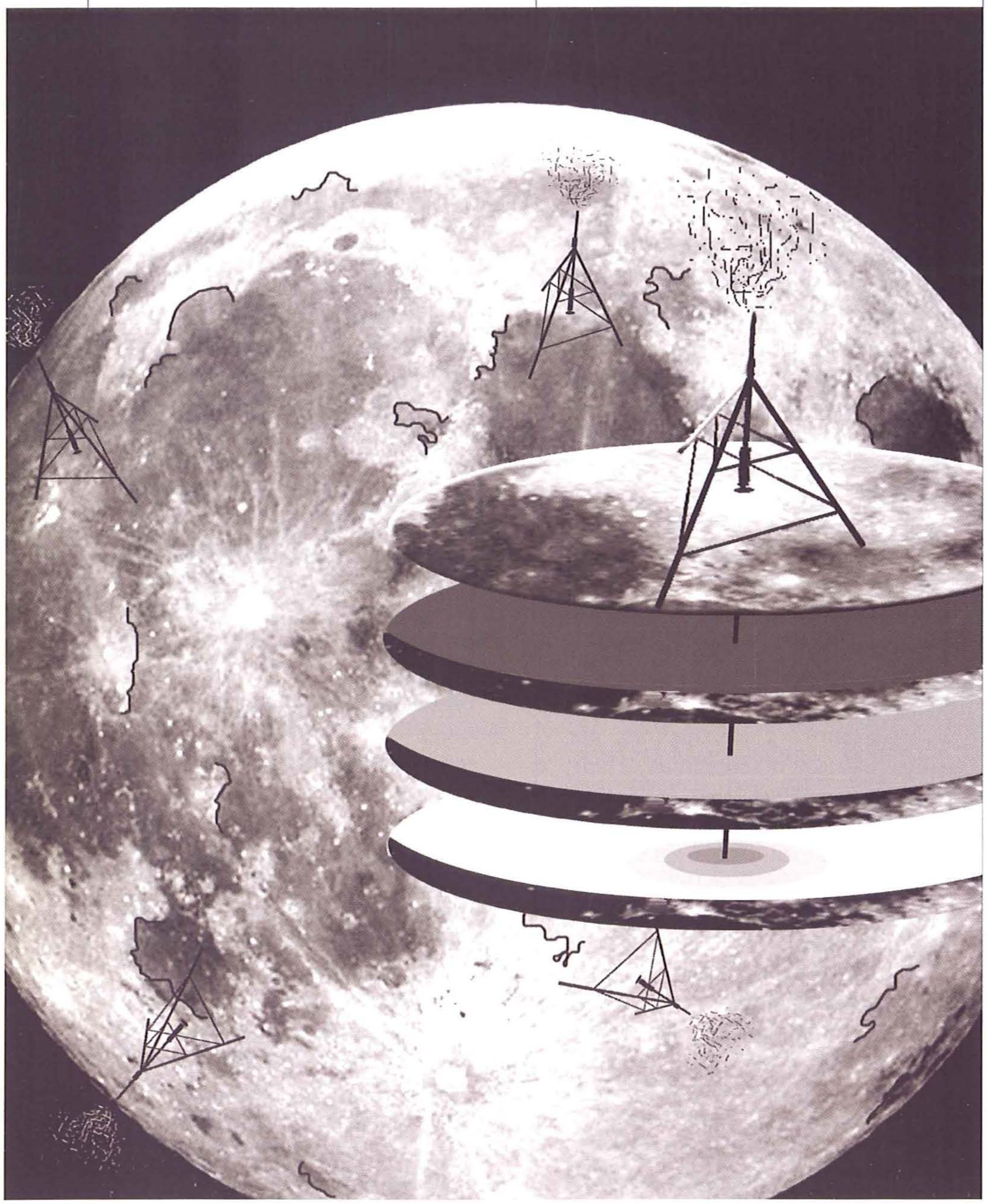
My chopsticks slip in my fingers. "And you believe a computer could have a soul?"

"Of course. Don't you?" He grins widely at this. "You know, the ancient Greeks believed that reality at its deepest level was mathematical in nature, and that it was only through our souls that we were able to perceive it. It was the soul's ability to apprehend the world of numbers that separated us from the animals. Pythagoras would've thought computers had better souls than we do." He popped a shrimp in his mouth and chewed vigorously.

"Don't you need to be human to have a soul?"

"Let me read you something." He produced a worn, leather-bound Bible with copious notes scribbled in its page margins.

"Here it is. First Corinthians, chapter 15, verse 37: 'All flesh is not the same: men have one kind of flesh, animals have another, birds another and fish another. When you sow, you do not plant the body that will be, but just a seed. But God gives it a body as he has determined, and to each kind of seed he gives its own body.' Over and over, the Bible tells us that the body is merely a vessel. We create vessels for souls every day, but God is the one who fills them with spirit. If God decides he wants to grant a soul to a vessel made of silicon instead of flesh, who am I to tell him no? My job is to spread the word of God to all souls, because all souls are in need of salvation."



"So that's why you're here? To convert Ii-ko?"

His eyes flashed with a secret. "Mmmmm, partly. Partly." He laughed again. "I would like to try a bite of your teppanyaki. May I?"

An interesting fact: Japan has more neon per square inch than any other nation on Earth. This is quite a feat, considering the fact that the first Japanese-made neon signs didn't appear until almost 1950, during Japan's long reconstruction after the Second World War. (Neon was introduced in the U.S. in 1910. The first American neon sign is still glowing at a car dealership in Dallas.)

Another interesting fact: neon is colorless, odorless, tasteless, and everywhere. You are breathing almost undetectable quantities of it right now. It makes up one part per 65,000 of Earth's atmosphere, and yet for billions of years, it kept an astounding secret.

Neon emits light.

Like other inert gases, neon has low chemical activity because its outermost, or valence, electron is complete. But when an electric current is passed through it, normally complacent electrons become boisterous and jumpy. There is a mad dash to find new orbits, new places to sit, like some electromicroscopic game of musical chairs. It's in all this chaos that photons seem to escape out of nowhere like naughty children, beaming the most brilliant crimson. Human eyes never saw this amazing light until just a few short years ago, cosmically speaking. Who knows what other secrets are hiding in this incandescent universe of ours?

This is what Father Cooper told me as we continued talking late into the night. Now, as I'm getting dressed for the Turita exhibition this evening, I keep going over our conversation in my mind. He said that it seems somehow appropriate that Japan would have the most neon. The root of neon is the Greek word for "new." And tonight is a very new thing.

I'm uncomfortable with the idea of a computer having a soul, but for the life of me, I can't quite explain why. Father Cooper brushed away objection after objection as if they were gnats in a breeze. And all this is made even stranger because I swear I can't remember ever believing I had soul before, even as a child. What modern person believes in souls? If I'm going to stand here talking to myself, I think, I want to change the subject. Shaving in front of the mirror, I glance down at the English printed on the side of a box of Naive-brand soap:

"What feeling do you need the best in your lifestyle? Trendy feeling, natural feeling, or traditional feeling? We'll lead a tasteful life to find your personal style. Mild and tenderness are basic of our living life."

I love the way Japanese and English mate here. It's commercial poetry. Little accidental koans like these are scattered over everything: tote bags, T-shirts, toaster ovens, toilet paper.

I pick up a pack of "Pocket Wetty" wet-naps sitting beside the sink and read: "Cute happy freedoms of clean and wet make 'Pocket Wetty' the wettest. Enjoy your everyday 'Wetty' to the maximum."

I'm on a roll. There is an electric toothbrush in front of me. I don't see anything but a smiling Japanese boy on the front who looks happier than toothpaste has any right to make a child. I turn over the box, looking for my fix, and there it is, in tiny English letters: "Modern systemic spiritual progress."

The eight-panel cartoon explaining how to use the battery-operated toothbrush enthralls me like television. Four panels are "do's" and four panels are "don'ts." It's long been said that the Japanese are the most fastidious culture on Earth, but four panels of "don'ts" on a toothbrush box is a bit much even for me. I make a mental note to be sure not to brush my teeth with my mouth closed, like the girl in panel six seems to be doing.

I read the Ii-ko press release one more time. Ii-ko uses quantum computing to solve natural language problems. Advances related to Ii-ko will help us learn to use natural resources more efficiently. (How very Japanese!) New algorithms devised by the Ii-ko architecture will help us feed the world. Even though it's early, I want to go. I call a taxi.

The Denkikon auditorium is huge. Wall-size tinted windows offer a view of a park filled with Japanese maples. It's all the more impressive because of where it is. In a crowded country like this, the Denkikon auditorium seems to stretch to the horizon. This is a status symbol for Denkikon, for space is the ultimate commodity in Japan.

In front is a series of 14-foot monitors on which spectators and journalists can watch the Ii-ko code run—live, as it happens. There's a large Denkikon workstation on the platform, too. It's about as big as a Japanese refrigerator. This must be Ii-ko, if any thing really can be said to be Ii-ko. To each side, facing away from it, are a half-dozen isolation booths for the contestants and the judges. What thrills me most is a tiny thing—the chairs. Instead of arranging the chairs in a box of orderly, rigid rows, instead the event planners have placed them in a succession of S-shaped waves that run past the eye like flowing water. The effect is striking.

I take my place in the very back, and unfold today's copy of *Yomiuri Shimbun*.

Reading the front page, I feel a sudden surge of déjà vu. The paper tells me that tonight Mars is at its perigee, as near to Earth as it gets. We haven't been this close in a handful of years, and Redheads are out tonight in full force. There's been a significant addition to the Martian atmosphere since the last go-round, too—from .004 bar to .1 bar of nearly pure oxygen. Mars' albedo has been increased by a similar amount, and because of the new moon, tonight may be the first night that we Earth folk will see the difference.

For the first time ever, Mars will be the brightest object in the sky. A manufactured star, the latest model, brighter than the last eon's old fashioned designs. It's funny that I spent so many years working on articles like these but have no desire to go outside and see it.

Unexpectedly, I hear a faint but familiar voice wafting back to me. Peering out from behind my paper, I see Father Cooper kneeling down on the platform in front, talking.

To Ii-ko.

This is definitely not supposed to be happening. It's against the rules for him to have contact with Ii-ko before the Turita. The fact that Ii-ko is up and running (has it been awake the whole time?) must mean that someone on the Denkikon staff set this up. I know I should just get up and ask Father, but instead I wait and strain my ears to hear. I can't make out a thing.

Minutes pass, and as my ears become attuned, I can make out the soft, moderated tones of a second voice. Ii-ko's voice. I sense something very important is taking place but have no idea what it is. My nervous hand brushes against the side of my chair and feels something rubbery. Headphones. I carefully put them on. In my ears I hear Father Cooper's voice:

"Et incarnatus est de Spiritu Sancto ex Maria Virgine: et homo factus est..."

It's the Latin Mass.

"Et iterum venturus est cum gloria judicare vivos et mortuos: Cujus regni non erit finis..."

It's something about Christ's glorious return, reign without end. Father Cooper is silent for a moment, then reaches into his pocket and takes out a vial. He shakes it over the console once, twice, three times.

He is obviously startled when I rustle my paper and drop it. His face is full of emotion. He looks back at Ii-ko for a moment, and then rushes to meet me at the door.

"Hello, Father."

There is a pause as he realizes how much I've seen. A long pause. He seems to have something to tell me but can't figure out quite how to say it. I am uncomfortably aware of Ii-ko's presence in the room now.

"Do you know much about the Shakers?" Father Cooper asks slowly. I shake my head. He looks at me, choosing his words carefully.

"The Shakers were an 18th-century Christian sect. Unlike most of their contemporaries, they did not look for the return of Jesus Christ in the flesh. They sought his return in the spirit—the Christ Spirit—the anointing spirit of God, the spirit of love for humanity. They believed that Christ's Second Coming would be a quiet, almost unheralded one."

My heart pounds in my chest as I realize what he is implying.

"I'm an old man. I've dreamed of this moment for years now. I couldn't wait," he says. With neon eyes he looks at me. He reads my face.

"Man's mind is hostile to God," he says. "Romans 7:8."

Half-remembered fragments of religious terms float through my mind. The Immaculate Conception. Son of God. Loaves and fishes. Son of Man. Transubstantiation. I can feel something slipping inside me. Modern systemic spiritual progress. I turn away from him and push through the glass doors, walking, careening, stumbling outside. I wonder where Katz is at this moment, if he is still alive. My feet carry me to the Japanese maples, and I lean against one, breathing deeply, feeling its rough bark against my cheek.

A crowd has gathered in the park. Redheads. Somehow they have managed to convince local shopkeepers to turn off their signs. Families and couples are standing together in the clearings, their necks craned all the way back. I step out to look, pointing my chin at an angle nearly perpendicular to the ground.

In the entire universe, there are billions of stars. We can see very few from Earth. Most of them are too far away. Their message takes millions of years to reach us, and our atmosphere distorts their feeble light. In today's world, we've run out of patience waiting for our necessary miracles. We've started making miracles of our own. Or they have started making us. ●

Artist

continued from page 29

place. It was as if the old man had known all along that the painting was coming. Edgar hung the painting, stepped back and looked at it again, then turned and left the room.

Edgar retraced his steps through the house, viewing his paintings one by one for the last time. When he reached the still-life gallery, he stopped and carefully removed the calendar page from the wall. He hid the page under his jacket and made his way home, past the dead houses and their Sensortrons.

That night, lying on his divan, Edgar felt more alone than ever before. Usually a comfort, the studio only emphasized his loneliness. He took the calendar picture from inside his jacket and threw it on the floor near the divan in a gesture of despair and pain. The neural implant burned in his neck. It felt alive. He longed to forget the old man, his paintings, art, everything. To escape, to feel nothing...

Edgar touched the implant's warm metal with his icy fingers and glanced at the plug in the Sensortron. Something was moving. He sat up to take a closer look. Inside the plug, a small spider was busily spinning her web, intent on creating her miniature work of art. Edgar reached down and brushed the calendar page with his fingers.

She is right, Edgar thought. Leave the interface to spiders, insects—and drones. Edgar shivered as he pictured all the people plugged into their Sensortrons. He glanced once more at the tiny spider, rose to his feet, and walked to his worktable. He pulled open the drawer and took out his junkyard gleanings.

"Rust-red," he said to the spider. ●

Armadillo

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I expected Phil to wax philosophical, to bleat on about justice and all that. But he didn't say anything. He just pushed the cage over the side. It was only about six feet from the top of the railing down to the waterline, but it seemed to take a long time to fall. There was no great splash, just a couple of liquid gulps, and the cage slipped into the water.

Oh, poor armadillo, I thought, created by people who want to kill you because you did what they wanted. The really bad thing was that I only had about two minutes of self-pity left. Then I'd be dead.

My eyes stung from the filthy water, but I could still make out the floodlights from the ship above, swirling and retreating from sight. The cage shifted and turned beneath me as it sank into darkness.

I felt a dull jolt as the cage smashed against something on the reservoir floor. The cage came to rest at the base of a large rusted heap of metal that probably once had been a car. A plume of silt rose up around me as I groped desperately for the latch.

The door had popped open slightly, but it was underneath me now, and I couldn't push it free. My lungs burned. Black spots jitterbugged before my eyes. In desperation I threw myself at the side of the cage.

The cage tipped, balanced for a moment, and pitched over. With all of my strength, I slammed at the door with my hind feet, and it opened into a swirl of silt, oily water, and dancing spots. It was the sweetest thing I ever saw.

I clawed madly at the water and shot to the surface. It seemed to me that I made a lot of noise, but from Phil's boat fifty yards away, I heard only laughter and the clink of beer bottles. They were toasting their success.

I thought about climbing into their boat and killing them all. I admit I was a little scared. Not today, I told myself. Not today.

Okay, so Phil had set me up. That wasn't so bad. What bothered me was that he knew me better than I knew myself. He had guessed every move I would make. And I'd also fallen for all that garbage about the smallpox virus. Syngen didn't make viruses. I should have known that.

Phil was going to come out of it smelling like a rose. The board would slap him on the wrist, but it was really going to be no big deal. I was just an armadillo, after all, and Phil had his reasons for doing what he did.

In my mind, I can imagine Phil's team sitting around the conference table, smiling, elated because they beat me at every turn.

But then I picture Phil's grin dissolving slowly into a nervous frown as he thinks about my animal instincts. Like the rabbit said, he made me that way. Smart, fast, and small. And built for revenge. ●

Machines

continued from page 19

and reels up a fish. A bidirectional motor controls the action. He says, "It's all in the timing."

For many students, their greatest fear was that a part would break. Joe Smith, whose project reels a lion into a cage that lifts, agrees that parts break easily. Fortunately, many materials used were items students found in their homes.

The soon-to-be mechanical engineers realize that they're taking the first steps toward careers in which they'll create machines that could make life easier for everyone. According to many class members, the sense of accomplishment stemming from the inspiration certainly was worth the perspiration.

Fruland says, "This class is definitely worthwhile. It might even end up to be my favorite class in college."

FOR MORE INFO see www.me.umn.edu

Simulations

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forces the tight proportion between spore and stalk cells.

"There is an awful lot going on in this tiny little system, much of which we still don't understand," he says.

Although many aspects of complex living systems remain a mystery, modeling pattern formation in animals is not out of reach. Othmer studied the juvenile *Pomecanthus*, or Koran Angelfish, and developed a model that accurately predicts the pattern of the fish's blue and white stripes.

"In vivo, new stripes emerge gradually between preexisting stripes, first appearing faint and narrow, and then slowly widening," he says.

Othmer's model, which explains why the alternating stripes are thick and thin, is a significant step forward in biological research.

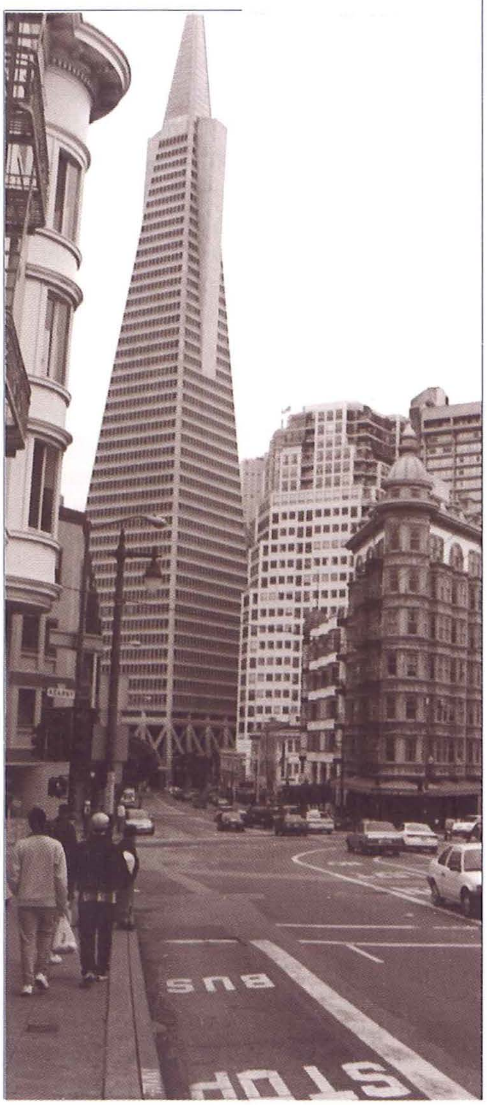
Current research shows just how far computer simulations have permeated the diverse branches of science and mathematics. Scientists are already quite accustomed to viewing the living cell as a computer on the molecular level, managing the intricacies of cellular respiration, transcription, translation, and the processing of biological information.

Models of particles in a fluid, a turbulent magnetosphere, cascading sand, and the stripes on the Angelfish are diverse examples of how computers contribute to scientific learning, but they are only the beginning. Perhaps when future scientists look back on the 21st century, they will summarize its scientific achievements with a single, all-encompassing metaphor: the computer. ●

ECMA 2000

The *Technolog* takes home top honors at the annual ECMA conference at UC-Berkeley.

Tim Ward, Katie Idziorek, Florencia Agote, Paul Sorenson, Mandar Sukhatankar, Tim Fister, Sharon Kurtt, Mike Mosher, Jon Gerber with the *Technolog*'s two first-place awards.



BY TIM FISTER

The Minnesota crowd erupted in cheers when the *Technolog* took top honors in two categories of the annual competition at the Engineering College Magazines Associated's annual conference.

Writers Jeremy Paschke and Michelle Moriarity earned first place in the "Best Science Article"and "Best Nontechnical Article" categories at the event at UC-Berkeley.

Earlier in the week, the cheers rang out for senior members of the Minnesota entourage, when advisors Paul Sorenson and Sharon Kurtt were named co-chairs of the national association following the retirement of longtime chair John Lacey of Notre Dame.

Kurtt, who became director of career services for IT in May 1995, inherited the post of *Technolog* advisor from her predecessor in career services, who had been advisor to the IT Board of Publications (ITBP) for many years. She welcomed the opportunity to get to know a group of IT students outside her role as director of career services.

When the college created a communications unit in 1996 and hired Sorenson as its director, oversight of student publications seemed a natural fit, and he joined Kurtt as co-advisor of the board and its publications, the *Technolog* and the *IT Connection*.

Kurtt's and Sorenson's experience with student publications and with ECMA led to their selection as ECMA co-chairs. According to Kurtt, it was outgoing chair Lacey who suggested that the Minnesota pair assume the ECMA leadership.

"I thought he was joking at first," says Kurtt, "but eventually was convinced to take the job."

But members of ITBP say that there is more than just experience that qualifies these two.

Katie Idziorek, the *Technolog's* layout editor, describes Sorenson as "resouceful" and Kurtt as "focused."

"They bring up a lot of ideas at the meetings," adds Mike Mosher, the *Technolog*'s assistant editor.

Sorenson and Kurtt's leadership, initiative, and creativity should translate well to ECMA.

Outgoing ITBP president Mandar Sukhatankar described the two advisors as "monuments for inspiration, pillars of the IT Board of Publications, beacons..." He added, "Being around ECMA lets them know how it works. They have attended a lot a meetings. The University of Minnesota and other universities stand to gain from their experience."

Another reason, he says, is their relative youth: "Young blood brings new perspectives."

The overall consensus among ITBP was that their advisors' selection as ECMA co-chairs was well-deserved.

"They were some of the best advisors in my academic career." ●

FOR MORE INFORMATION about ECMA see www.topgrad.com

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