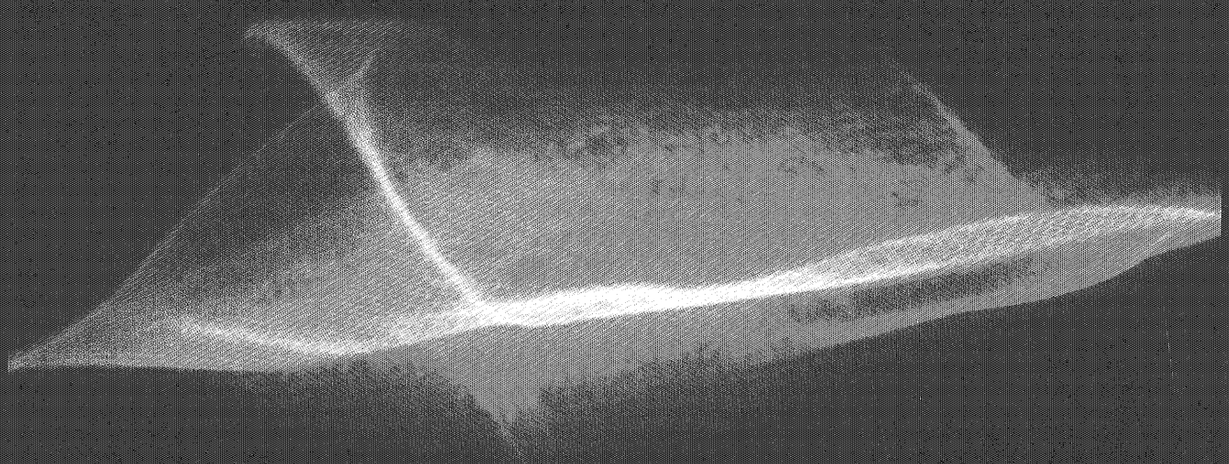
MINNESOTA TECHNOLOG

Sept./Oct. 1992 • University of Minnesota • Vol. 73, No. 1

Laser Fantasies



In this issue . . .

- Strategic Defense Initiative: refocusing the vision
- CD s, holograms and light shows — cheap lasertainment
- Living with lasers, from 1917 to the future
- Reading brain waves: BOLD research at the U
- *and more ...*

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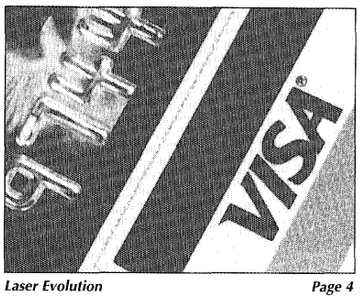

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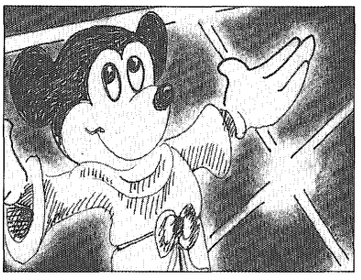

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Departments

About the cover . . .

This is the lumia effect, one of the many special laser effects seen during a laser light show at the Minneapolis Planetarium. See "Light entertainment," page 10.

Photo by Paul Owen

Laser delusions in the government

It is the mid 1980s. A young man sits in a darkened room, his profile rhythmically lit up by dazzling laser beams that dance around and saturate his mind.

He is at his first light show, and for a moment he feels overwhelmed by the beauty of the enchanting lasers. Then the music engulfs him, and three-dimensional laser images flash and sweep him up as if he were in a dream.

* * *

Meanwhile — in outer space — the government is enjoying lasers in its own way.

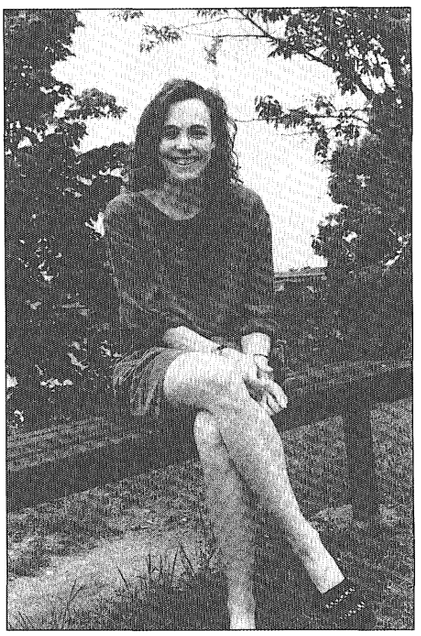
They are testing nuclear-powered laser weapons as part of the Strategic Defense Initiative for a space-based anti-missile defense system.

Politicians on earth gaze at the test site in awe, thinking what a great country they live in. The president stands in front of them and waves, eager as always to be seen on television in a powerful and patriotic setting.

* * *

Half an hour later, when the young man's laser show is over, he comes to his senses and remembers that he had experienced a mere illusion, a temporary escape from the real world. He walks home and worries about society, about the environment and about the threat of a recession.

At his house the TV is on, and the president grins boldly into the camera, trying to convey an image of control to his followers. The bystanders endure this because they have invested so much faith and hope in this man that they can't bear the thought that perhaps he, too, is merely selling them an illusion.



by

Esther Haynes
Editor in Chief

On July 21 of this year, the Energy Department officially canceled the X-ray laser program of the Strategic Defense Initiative — the drive for a space-based laser defense system designed to guard our country against enemy missiles. Congress finally admitted that the non-laser kinetic weapons we had all along were enough to defend ourselves against any communist threat. That adds up to about 10 years of testing and far too much money down the gutter.

Remember the *Star Wars* movies? Luke Skywalker fought the forces of evil, armed with only his mind and his laser light saber. A noble cause it was, but unreal. The X-ray laser weapon, originally the core of SDI — or "Star Wars" — may have also been a noble effort, but it, too, was in outer space.

In theory Star Wars sounded ideal. Reagan's introductory speech in 1983 spoke of a world without offensive nuclear weapons. If the US and Russia could produce effective space-based anti-missile defense systems, he said, offensive nuclear weapons would be virtually useless, and ultimately would become extinct.

Ideal, perhaps ... but far from realistic. After ten years of SDI research we should have something substantial to show for it, something beyond the relatively minor ground-based military laser devices that emerged from the scheme. Considering the government spent nearly $30 billion over the past nine

years on Star Wars, it should have come a bit closer to reaching the initial goals — maintaining the ultimate defense system and harboring no offensive nuclear weapons.

Our government's message was to fight the communists at all costs, not to let them control us in the "free" world. These days, with the threat of the Cold War gone, it is obvious we've been under the control of communism for quite some time now; psychological control fueled by panic instigated by our government. This robbed millions of dollars from struggling domestic programs, away from environmental programs, away from *people* — to spend instead on researching nuclear weapons and far-fetched space-based anti-nuclear weapons.

While the decision of the Energy Department to indefinitely discontinue X-ray laser testing should have happened a long time ago, it is a start. This will allow some limited improvements to be made on the kinetic defense weapons that we already have, while freeing up funding that may finally go where it can be used to more directly help the people.

Our government's message was to fight the communists at all costs, not to let them control us in the "free" world.

Congress must start providing higher funding for domestic research programs that will find solutions to our immediate social concerns. Instead of furthering military laser technology, imagine where science would be today if SDI money went to medical researchers. Perhaps better treatment for cancer, or a vaccine for AIDS.

Our empire definitely strikes out with the Star Wars plan. ◊◊◊

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Lasers, they're not just for science fiction anymore

By Peter Kauffner
For Minnesota Technolog

While laser technology has been around more than four decades, practical uses for lasers haven't. Although it was clear to laser pioneers that they had stumbled onto something important, it was not obvious what they would do with the technology. Initial critics were skeptical, branding lasers "a solution looking for a problem." Few could predict that lasers would permeate into people's lives as they have. Today, lasers are used in everything from surgery to entertainment to supermarkets. With uses that range from scribing grooves on circuit boards to shearing cloth, lasers are truly at the "cutting edge" of today's technology.

Amplified Light

Albert Einstein, in 1917, first discovered the principle of light on which lasers would ultimately be based. According to Einstein, light consists of numerous massless particles, called photons, which vibrate as they travel. When photons have wavelengths between 400 and 700 nanometers, they are visible as light. Each wavelength of visible light corresponds to a particular color. Other types of electromagnetic radiation, such as radio, TV and microwaves, are produced by photons with wavelengths outside the range.

Atoms are normally in a low energy or "ground" state. When additional energy is absorbed by an atom, the atom is said to be in an "excited" state. An atom can be excited by heat, electricity or radiation. The electrons in an excited atom are farther from the nucleus than electrons in a grounded atom.

In seconds, an excited atom can emit a photon and then return to its ground state. Non-laser, or "non-coherent," light consists of photons that have a range of wavelengths and phases, causing much of the energy of one photon to be canceled out by another photon. The human eye averages the wavelengths of the different photons from a light source to create the sensation of a single color.

By the 1930s all the basic concepts needed to build a stimulated emission device were well established. Why did it take until the 1950s for serious laser research to begin?

If a photon passes near an excited atom, it can "stimulate" the atom to emit a photon of the same phase and wavelength. The laser is based on this principle, which creates a light beam of photons that have the same wavelength and phase.

When non-coherent light is used to excite the laser material, the energy from the resulting beam is more focused than the energy from the original light source. From this concept arose the term "laser," an acronym for Light Amplification by Stimulated Emission of Radiation.

From masers to lasers: 1951-60

The biggest challenge facing early laser researchers was how to isolate the laser material so it could be excited to the heightened level. Lasers will work only if most of the atoms in the laser material are in an excited state, in a condition called "population inversion."

In 1951, Columbia physics professor Charles Townes proposed injecting ammonia molecules into a metal box, the dimensions of which were multiples of ammonia's microwave frequency. The box would act as a resonator and reflect stimulated emissions back into the system. An inverted population of molecules could be stored this way and be used to create a burst of microwave radiation with a narrow frequency range.

Townes consulted leading physicists about his idea, but they dismissed it as nonsense. Townes later wrote, "I remember interesting discussions on this point with [Danish physicist] Neils Bohr and [Hungarian American mathematician] John von Neumann. Each immediately questioned how such a narrow frequency could be allowed by the uncertainty principle."

Despite skepticism, Townes persevered. In 1953 he proved the establishment wrong by building a maser, a microwave version of the laser, which

later won him the 1964 Nobel prize in physics.

It is uncertain why it took until the 1950s for such an invention to be developed. All the basic concepts needed to build a stimulated emission device were established in the 1930s.

One possible reason: the development of quantum mechanics created a rift between the worlds of physics and electrical engineering. Developing quantum mechanics was an immense project for physicists in the 1930s. Few thought about its practical applications. Many physicists seemed unaware of how feedback principles used in electrical engineering could be applied to create an output with a narrow frequency range. At the same time, electrical engineers did not realize the full potentional of the quantum mechanical concept of stimulated emission.

Because of delays like this, research on extending the maser concept to optical frequencies did not begin until 1957. That year Gordon Gould, a graduate student at Columbia University, developed the idea of "optical pumping," a process in which laser material is excited by using a flash tube that emits light of higher frequency than the desired laser output. He also proposed placing a pair of mirrors at the opposite end of the laser material, with one mirror at a right angle to the axis of the laser material and the other tilted. This "Fabry-Perot etalon" ensured that all oscillation was along the axis of the laser material.

After a lengthy legal struggle, Gould, who coined the term "laser," was finally awarded laser patents worth millions of dollars in 1987.

By the late 1950s there were around a dozen laboratories throughout the country racing to be the first to build a working laser. Theodore Maiman, of Hughes Aircraft in California, edged out the competition by unveiling his synthetic ruby laser in 1960. Maiman excited the laser material in his invention with a flash tube wrapped around a ruby cylinder that had Fabry-Perot mirrors at each end.

The laser action in the original laser, however, was unpredictable and uncontrollable. The Q-switch, developed in 1961 by Robert Hellwarth of Hughes Aircraft, solved this problem by controlling an opaque material placed in front of one of the mirrors. When the opaque material was removed, the mirror reflected the stimulated light back into the laser material, initiating the laser action.

High hopes: 1960-68

With the "space race" in full swing and nuclear war an ever-present danger, science probably never had more prestige than it did in the early 1960s. Time magazine devoted its first issue of 1961 to "American science," and a picture of a laser appeared on the cover in place of the traditional "man of the year."

In 1962 the laser became even more popular, when Massachusetts Institute of Technology engineers Louis Smullin and Giorgio Fiocco beamed the light of a ruby laser at the moon and recorded the reflected echo.

During that time laser research took off in boomtown fashion. A bibliography of laser entries lists 752 references for 1963, compared to only 17 references in 1960. "There was not a single day that passed when something really exciting didn't happen here," said William Bennett, a former laser researcher at Bell Laboratories.

Toward the end of 1960, Bennett and his co-workers Donald Herriot and Ali Javan developed the helium-neon laser — the first gas discharge laser — at Bell Labs. Because of its noticeable red beam and widespread use at supermarket checkout counters, the helium-neon laser is probably the type of laser that is most familiar to the general public. In this system, the material in the gas laser is excited by passing an electric current through it, much as an electric current is used to power a neon light. Fabry-Perot mirrors are also used in the laser to reflect stimulated light back into the gas tube.

At that time researchers were regularly discovering new materials that could be used for lasers, including cesium vapor, neon-oxygen, argon-oxygen, pure neon, pure argon, krypton, xenon and nitrogen. In 1961 Elias Snitzer of American Optical developed a glass laser, and a semiconductor laser was developed in 1962. "I expect any day now to hear that someone has got a tube of plain air to lase," joked one scientist in *Fortune* magazine in 1963.

During the much of the '60s, the military was the engine that powered laser research. While the Air Force worked on a sun-powered laser, the Army started a project to use lasers for target designators — research that

Peter Kauffner

Age: 27
Year in school: Senior
Major: Computer Science

Peter was once a columnist for *The Minnesota Daily*. These days he is a candidate for the state senate in District 61. He says he likes to read, study history and use Ralph Nader's picture for target practice.

would lead to today's "smart bombs." The military also sponsored research to develop laser radar, battlefield beam weapons and laser range finders.

1964 marked the end of the golden age of laser research, with major labs cutting back or eliminating laser research altogether. Progressive laboratory results continued to pour in, but practical applications seemed as far away as ever. The earlier unbridled optimism now appeared premature, if not naive. The laser was a promising device, but some thought its time had not yet come.

Progress in laser research did continue, however, despite the general change in mood. The discovery of the carbon-dioxide laser in 1964 by CKN Patel of Bell Labs revived the military's interest in the laser for the battlefield. Dye lasers, liquid lasers, and solid state yttrium-aluminum-garnet (YAG) lasers were also developed during this period.

From military to civilian production, 1968-92

When the Vietnam War ended, the laser industry was forced to retrench. The military's share of the laser market dropped from 63 percent in 1969 to 55 percent in 1971. Military money for university research was sharply cut as a result of the 1969 Mansfield amendment, which prohibited departments from giving money to projects that were not directly related to their mission.

As the laser industry lost ground in its military and academic markets, the improved semiconductor laser sowed seeds of industry success in the consumer electronics field. Today, semiconductor lasers can be as small as a grain of sand — small enough to fit in consumer products like laser printers and CD players.

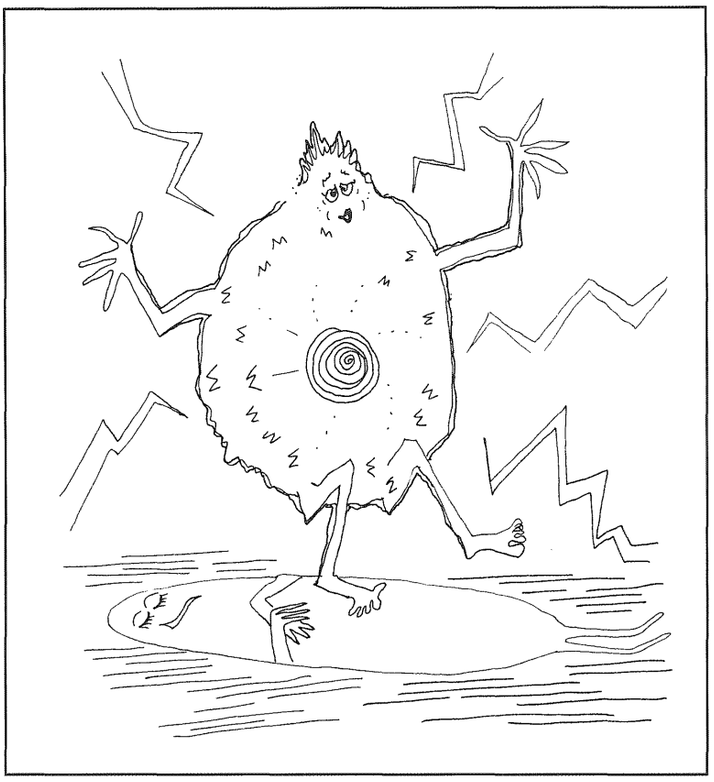

Illustration by Denese Sanders

Atoms are usually in a low energy or "ground" state. When additional energy is absorbed by an atom, the atom is said to be in an "excited" state.

The heterojunction semiconductor laser, invented at RCA in 1968, pointed the way to the future. The laser material in this type of laser consisted of alternating layers of gallium arsenide and aluminum gallium arsenide. GaAs/AlGaAs lasers are commonly used for CD players and other consumer electronics, making them the most widely used type of laser today. Nearly 12 million were sold in 1987, and they now cost as little as $5 per laser.

Heterojunction InGaAs/InP lasers caused the revolution in fiber optics communications. Now most long distance phone networks use fiber optics, which use laser light to send signals along tiny strands of fiber.

Semiconductor lasers are not the only type of laser to make a successful transition to the civilian market. High-powered carbon-dioxide lasers are commonly used in industry as precision cutting tools for material ranging from steel to cloth. Also, helium-neon lasers are commonly used for aligning construction work; and dye lasers are useful as measurement instruments in spectroscopy because the output frequency of this type of laser can be tuned.

Endless possibilities

As lasers become more compact, precise and powerful, they will likely be used in an even wider range of applications. One anticipated future use for lasers is in etching integrated chips for solid-state electronics. Some researchers believe the ultimate in high-density data storage would use individual molecules as data bits, which could be manipulated by lasers.

Lasers have also been proposed for use in detecting wind shears, a rare wind condition that poses an aviation

hazard; and range-finding lasers may be placed on trucks and other vehicles to prevent collisions.

The semiconductor laser is one particularly promising laser type. In 1991 Bell Labs announced the creation of a semiconductor laser that was advertised as the world's tiniest laser. Some speculated the new laser could be used to build computers based on lasers instead of electronic circuitry. Also inexpensive semiconductor lasers will likely soon be available that can produce output in a variety of colors.

The medical field is also taking advantage of laser technology. An experimental technique allows livers spots, spider veins, tattoos, acne, scars and other skin blemishes to be removed by lasers. And fiber optics could perhaps be used to allow internal laser surgery. In the dental field, too, researchers are experimenting with lasers for dental surgery and anesthetics.

Lasers are helping to open up atomic and molecular research as well. With lasers, scientists can manipulate neutral particles, cool vapors to near absolute zero and even stretch out the spiral DNA molecule. With the precise timing of laser pulses, researchers can influence the course of chemical reactions; and physicists at Duke University use lasers to determine the precise position of atoms in a beam.

If the early '60s was the golden age of laser development, today is the golden age of laser *applications*. Once it seemed as if scientists would announce the lasing of plain air. Now it seems the air is full of laser beams. ◊◊◊

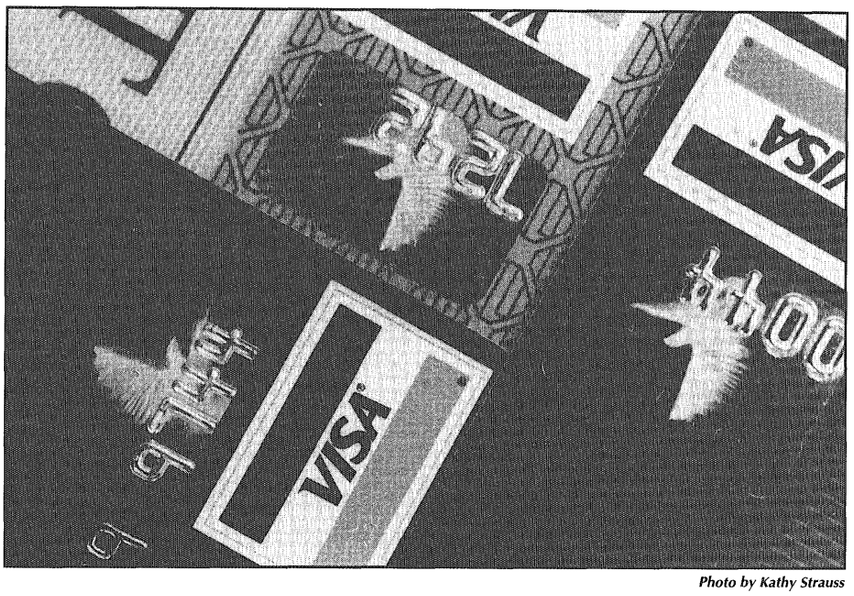

Photo by Kathy Strauss

Holograms are now commonly used to prevent fruadulent credit card duplication.

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Research at the U

BOLD: A new technique for imaging the brain

By Alice Chen
Technolog Staff Writer

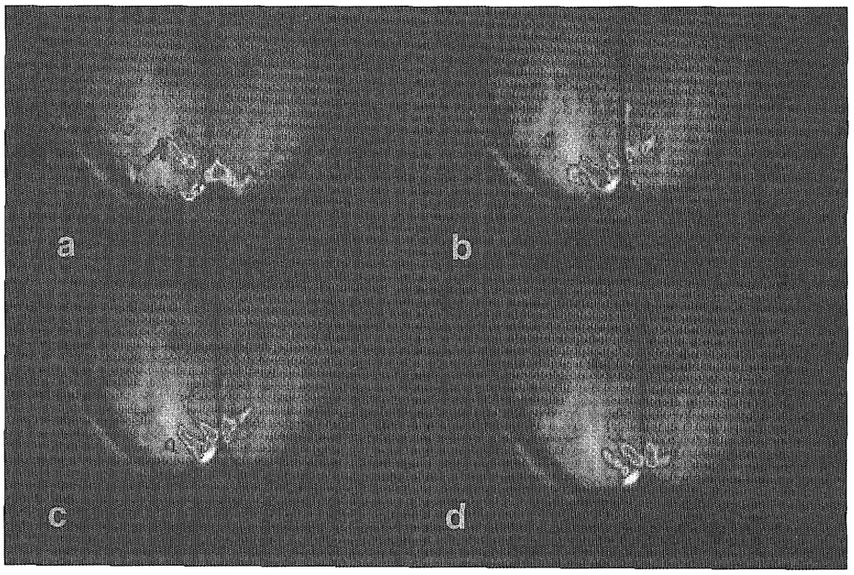

Photo Courtesy of The Center for Magnetic Resonance Research

These magnetic resonance images, produced by BOLD imaging, were taken at four-second intervals after a light was flashed once in front of the patient. The highlighted areas in each shot shows the brain's activity in response to the stimulation.

Thought much about your brain lately? Scientists at the University Medical School and AT&T Bell Laboratories have recently developed a technique that helps doctors do just that. It is BOLD (Blood Oxygen Level Dependent) imaging, a new technological development for the study of brain functions.

Seiji Ogawa, a Bell Laboratories biophysicist, was the first to develop BOLD imaging, which is a variation of Magnetic Resonance Imaging. Last year Ogawa joined Dr. Kamil Ugurbil, director of the Center for Magnetic Resonance Research at the University, to conduct further tests. The research began around July 1991 with staff members Ravi Menon, Seong- Gi Kim, Julta Ellerman, Helmut Merkle of the University, and David Tank of AT&T, Ugurbil said. They had BOLD results by March 1992.

BOLD imaging is a non-invasive procedure that detects increases in blood flow to active areas of the brain by displaying changes in the amount of oxygen bound to hemoglobin molecules in each region. Since non-active areas of the brain are not rich in oxygen, blood supplied to those regions carry deoxyhemoglobin, or hemoglobin without oxygen. Magnetic fields increase slightly in the proximity of deoxyhemoglobin, thus it is paramagnetic. BOLD imaging detects the magnetic distortion surrounding the blood vessels in non-active tissue, and produces an MRI image of the brain. This allows scientists to see the brain functioning.

The University of Minnesota has one of three 4 tesla MRI systems in the United States. Normal MRI equipment capacity is 1.5 tesla. Although BOLD can sometimes function at the lower tesla levels, the higher magnetic field strength yields images of high enough resolution to locate brain activity at a restricted scale of fractions of an inch, and it maximizes the contrast between hemoglobin and deoxyhemoglobin.

BOLD imaging is a safe and painless procedure. Since it allows normal neural conduction, brain waves and the natural electrical workings of the body are not interrupted. Also there is little possibility of burning the brain cells, Ugurbil said, because the magnetic

field is not strong enough to cause burning.

Not everybody, however, can undergo this procedure. People with pacemakers cannot safely make use of BOLD imaging, because the magnetic field affects the synaptic signal that tells the heart when to start its cycle of contractions.

BOLD could one day be applied to many scientific areas, Ugurbil said. The new method could be used in studies of the brain to find out which specific areas control certain functions. The imaging technique could also be used for many medical applications, Ugurbil added. In neurosurgery, for example, doctors could use BOLD imaging to when they need to remove tumors or malformations without disturbing parts of the brain that allow everyday operations. Researchers are currently using the technique at Massachusetts General Hospital and the Medical College of Wisconsin.

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With further research of BOLD imaging, we will learn more about how we think, how we function, and perhaps even how we feel. Not only is BOLD capable of saving lives when used for medical procedures, but its ability to map the brain at such specific, localized levels may keep scientists busy for another century.

Not only is BOLD capable of saving lives, but its ability to map the brain at such specific, localized levels may keep scientists busy for another century.

Who knows? If we can unlock the mysteries of the brain, the solutions we find could also solve what we deem "unsolvable." Take a minute to ponder that. Boggles the mind doesn't it? ◊◊◊

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University of Minnesota news release. June 30, 1992.

Alice Chen

Age: 21
Year in school: Senior
Majors: Scientific & Technical Communication and Pre-Physical Therapy

Alice aspires to one day own a library similiar to the one in Disney's *Beauty and the Beast*.

Light entertainment: fun with lasers

By Scott Taschler
For Minnesota Technolog

LASER: Light Amplification by Stimulated Emission of Radiation. A device which produces a coherent, monophase, monochromatic, blah, blah, blah ...

The laser has been around for decades, but only recently have scientists begun to find practical uses for it.

You can get a tattoo removed with a laser, have surgery done on your eye and, if you like, fire a guided missle. But there's more. The laser has taken over the entertainment industry, forever changing the way we spend our free time.

For many people, the first thoughts conjured up by the word "laser" are of purple aliens built like garden slugs who like to use their amazing "Blow-Up-The-Whole Universe" beams to burn mysterious circles in cornfields. In truth, however, most lasers in use today couldn't even warm your coffee.

Laser light is more intense than regular light, however, because all the photons in the beam oscillate at the same frequency (thus it is *monochromatic*, or one color), and all the oscillations are in phase, or *coherent*. These properties cause the light to interfere — constructively and destructively — when reflected back upon itself. Thus, a laser beam spreads very little in comparison with other light sources.

Lasers and Compact Discs

Unless you've recently joined a hermitage or isolated yourself atop Mount Kilimanjaro, the audio compact disc has become a familiar part of your life. The CD's superior sound reproduction has, in only 10 years, made the vinyl LP a dinosaur and challenged the venerable cassette tape.

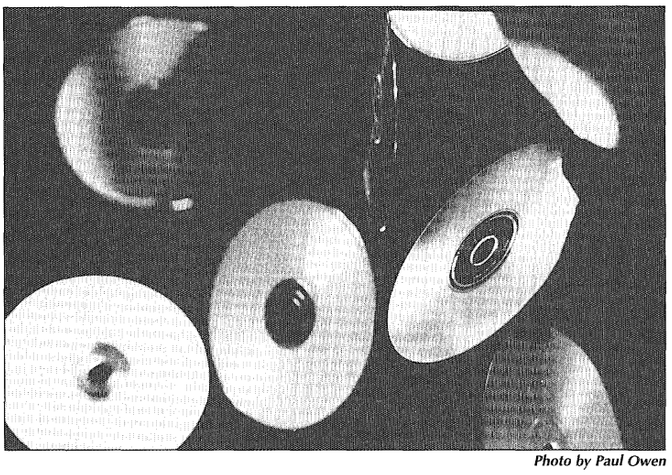


Photo by Paul Owen

The compact disc revolutionized the way we listen to music.

What is a CD anyway? Basically it's nothing more than a "reflective substratum overlaid by a protective layer of polycarbonate plastic," containing all the data necessary for your stereo to beautify Beethoven or add volume to the Violent Femmes. The data is stored on the shiny layer as a sequence of ones, representing flat spots, and zeros, representing pits with depths equal to one-quarter the wavelength of the laser light. When the laser shines on the surface of the disc, the light that hits the low areas is 180 degrees out of phase with the light that hits the flat spots, causing interference patterns when the light is reflected. These patterns are picked up by a photo detector and then transformed into music.

This technology is not limited, however, to the familiar 12-centimeter audio discs. Today Compact Disc Video is available, although its many problems thus far have prevented it from achieving the level of popularity of its audio counterparts. CDVs, which are 30 centimeters in diameter, are bulky in comparison with audio CDs, and they store only one hour of video — much too short to play a feature length movie. Also manufacturing difficulties occur in the production of larger discs; and errors — such as those caused by dust particles, small scratches and manufacturing defects — are difficult to find and correct. These complications, as well as the fact that no set standards exist to guide manufacturers, have held back the CDV.

Lasers and compact discs are also used in computers. CD-ROM, or Compact Disc Read-Only Memory, is the latest in computer storage. Although no data can be written to these discs by the consumer, they allow data to be stored in a much denser format than

standard floppy disks and hard drives. The compact disc takes the computer to a new level of entertainment and power.

Lasers and Holograms

The hologram is perhaps the most exciting thing to happen to visual entertainment since, well, at least since the final episode of M*A*S*H. To put it simply, a hologram is a three-dimensional image stored in a two-dimensional picture. These images are so incredibly real that the viewer is often tempted to reach out to touch them (but don't ... people point and laugh when you do).

With the right equipment, a basic hologram is fairly easy to produce. First, an object or scene is illuminated with pure laser light. Then very high resolution film is exposed to both the light reflected from the object and the light from the source (the reference beam). In this process, the overlapping light waves set up interference patterns on the film. When developed and re-exposed to an identical reference beam, the film diffracts the light in the same patterns as were used to expose it. Thus, an image of the object is reconstructed, and the 3-D image appears to hover in midair behind the film. Other holograms, such as those used on some credit cards, may be formed without using laser light to reconstruct the image, but it is a slightly more complicated process.

Many special effects can be produced through holographic photography. In one common procedure, the photographer takes many holographic pictures of an object, moving the film and slightly adjusting the position of the subject between each one. These holograms are arranged so that their images overlap, and then another holographic picture is taken of the resulting image. This produces a hologram that appears to move as the viewers change their viewing angles. A ghostly head, for instance, could appear to turn and watch you walk by, or a man could seem to be running next to you.

A research group from Massachusetts Institute of Technology has figured out a way to produce holographic movies. These researchers use a super computer to calculate what the image of a scene programmed in its memory should look like, one frame at a time. These video signals are sent to a special microphone which, in turn, sends sonic vibrations through an accousto-optic crystal. This type of crystal is able to change its index of refraction — the degree to which it bends light waves — as a function of the frequency with

Laser Fantasies

By Scott Taschler
For Minnesota Technolog

Close your eyes. Now open them so you can read the rest of this magazine. Imagine yourself weightless, alone and at peace in the center of the universe. Hypnotic patterns surround you and seem to reveal the meaning of life. The answers are all there — about Life, Death, Happiness — even the reason why green olives are packed in jars, while black ones are packed in cans ... *everything*.

Sound spiritually fulfilling? Exciting? ... a good place to take a date? The *Laser Fantasy* show at the Minneapolis Planetarium is just the place for you.

Although these shows may not necessarily bring you *total* enlightenment, they are quite entertaining. Laser Fantasy Inc. is a Seattle-based company that produces laser shows all over the world, including Canada, Denmark, Korea and Japan. The presentation in Minneapolis, hosted by laserist Dan Bialke, is a must-see.

The laser shows at the planetarium run every Friday and Saturday night, and are accompanied by music ranging from U2 to Metallica to "The Nutcracker Suite." Vibrant laser images and patterns are synchronized with the music to provide a psychedelic laser experience.

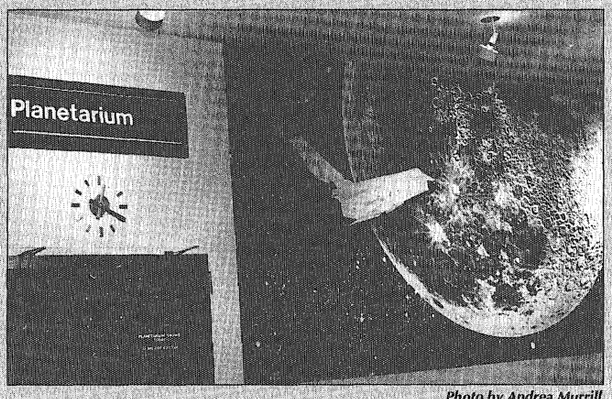


Photo by Andrea Murrill

Starting Friday, Sept. 26, the music of the Beatles will be featured at 8 p.m., Metallica at 9:15 p.m., Led Zeppelin at 10:30 p.m. and Pink Floyd at midnight. Admission is $5.50 per person. Featured bands change about every four months. For details, call the Laser Hotline at 338-7388.

which it vibrates. Then, while laser light illuminates one side of the crystal, the crystal is exposed to the encoded sound waves from the computer, and a ghostly, moving, 3-D image appears in space on the other side. Years from now this technology may be reproduced in our living rooms at home.

Laser Light Shows

Laser light shows are popping up all over the country as perhaps the most interesting and hypnotic use of lasers today. During a light show, the audience sits in a darkened room and gazes at vibrant patterns or animated figures traced out with lasers on a screen, often accompanied by music.

In light shows, only three laser beams are necessary to produce the myriad color combinations that dance before the audience: one red, one blue and one green. The beams are first reflected off an oscillating mirror — the mixing mirror — that combines the three beams into an infinite range of tones and rainbows. This mirror is manually controlled by the operator, who adjusts the oscillation rate to produce different colors or color patterns for the images on the screen.

After the beams are bounced off the mixing mirror, they are reflected to another, computer controlled mirror. This creates the swirling spirals and other patterns the audience sees during the show. This mirror moves so fast that the single points of laser light are blended together by the brain and perceived only as graceful curves traced through space.

Other effects may also be used to enhance a laser show. Fog or smoke

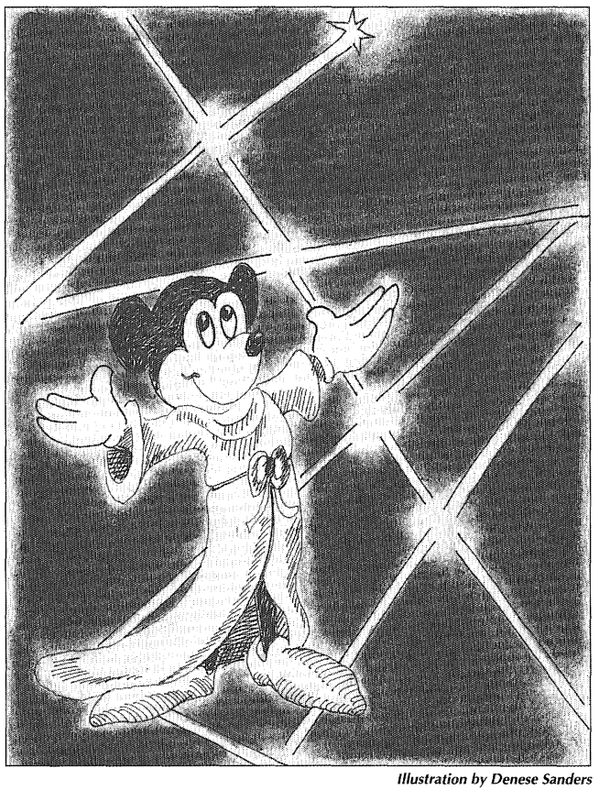


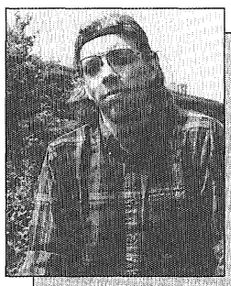
Illustration by Denese Sanders

illuminates the laser beam and opens a whole new dimension for special effects. As a result, the actual beams of the lasers show up as they streak through the room, and appear to hang in midair. Also for various different effects the lasers can rotate, and more complex shapes can be introduced. Standard 3-D glasses can sometimes be used for viewing 3-D animation if an image is traced out on the screen twice — once in red and once in blue. When viewers wear the red/blue glasses, two images appear as one three-dimensional object.

Walt Disney World is also dazzling its patrons with lasers. To celebrate its 20th anniversary last year, Disney World fashioned an ongoing light show extravaganza called "SpectroMagic." The 20-minute parade includes holograms and flickering laser-lit screens, as well as the standard Disney floats. The special effects are controlled by two computers, located under the street, that communicate with the 37 floats through radio waves.

Someday we may be able to get laser effects like this in our homes. Years from now, through holographics, you may be able to sit at the news desk with Dan Rather — in your own living room. Add a little surround sound to the digital audio, and you could be heading for cover during the latest action movie. Or why just watch? In laser video games you could one day pit your physical prowess against three-dimensional flying turtles and the evil koopas in "Super-Ultra-Better-

See Entertainment, page 19



Scott Taschler

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Scott is an honors student in the Institute of Technology. He enjoys creative writing and may one day start up his own psychedelic laser light show.

Laser Surgery: no more blunt instruments

By Linda Chandler
For Minnesota Technolog

Today lasers are used in almost every facet of the medical world, from treating cancers, to neurosurgery, to removing corns and plantar warts. Despite the recent increase in publicity about the many applications of lasers in medicine, however, laser surgery is not a new science. In fact, lasers have been used in surgery since the early 1960s, when doctors first used a ruby pulse laser to repair peripheral retinal damage. Since then, many advances have been made in laser research and laser surgical techniques. Now more than one million medical procedures are done each year using lasers.

Lasers are ideal therapeutic tools because the radiant energy from light interacts with the tissue to cause either biological, photochemical or thermal reactions — depending on the duration and wavelength of the beam. Two basic modes of operation, continuous wave and pulsed, control the beam's duration. In CW mode, the laser oscillates constantly, delivering a steady stream of power to the tissue. Most CW lasers are not operated continuously, but rather in "doses" of energy delivered to the tissue, lasting a minimum of 10 milliseconds. This is called "gating." Lasers in the pulse mode operate similarly, but the duration of the pulse is much shorter than the gating. This allows the laser to attain a power level five to 100 times greater than the maximum output of a CW laser.

The wavelength of the beam is determined by the active medium. Although lasers may use various mediums which emit thousands of wavelengths, most are unsuitable for surgical use. The three types commonly used in practice today are carbon dioxide, argon and Nd:YAG (neodymium: yttrium-aluminum-garnet) lasers. Depending on the type of laser, a doctor can use it to either shrink, cut or completely vaporize body tissue.

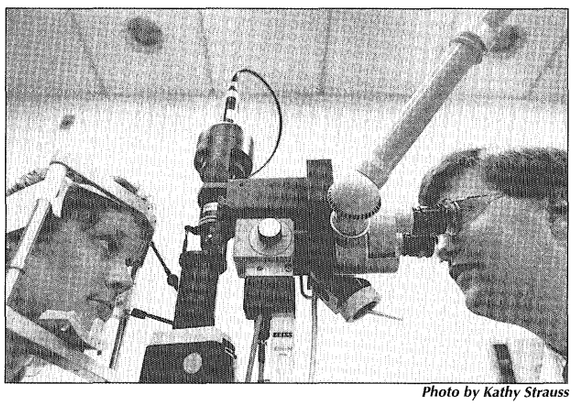

Photo by Kathy Strauss

At the U opthalmology clinic, Dr. Read McGehee and senior medical student Andrea Janousek demonstrate the use of an argon laser that can treat Diabetic Retinopathy and other eye conditions.

Three basic types of delivery systems are used to guide the beam to its final destination. The first is the "articulated arm," which is a series of hollow tubes and mirrors. This system enables the beam to maintain its highly directional and coherent nature, thus the energy leaving the arm is optically unchanged from when it entered. This system can also accommodate any laser wavelength. The articulated arm is not ideal, however, because the tubes are rigid, forcing the system to rely on the mirrors for flexibility, but the mirrors can become misaligned from bumping or jarring.

The second basic type of delivery system is fiber optics — thin, flexible tubes that can carry optical energy to virtually any part of the body. This is much less expensive and easier to use than the articulated arm. Unlike articulated arms, though, they can only carry energy in the visible and near-infrared portion of the electromagnetic spectrum, limiting its use with carbon dioxide lasers. Also, the beam loses coherence as it travels along the fiber, so the beam can only be focused to the diameter of the fiber itself.

To control the laser beam during surgery, doctors use devices called "micro manipulators" that enable the user to manipulate the laser beam over tissue. The devices are "joystick" controlled mirrors that reflect light either from the laser itself or from one of the other two delivery systems.

Laser surgery has a number of advantages over traditional surgical practices. First, lasers are extremely precise, leading to less swelling and

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Lasers in the military

By David Mirelez
For Minnesota Technolog

On March 23, 1983, Ronald Reagan gave a speech introducing the nation to the Strategic Defense Initiative, designed to protect Americans in the event of a nuclear attack. Key elements of SDI were based on laser technology. In the event of a nuclear attack, space- and ground-based lasers would be used to annihilate Soviet intercontinental ballistic missiles, or ICBMs, at various stages along their routes toward the United States.

Since then, the world's political climate has changed drastically. Communism has crumbled on virtually a world-wide scale, and many of our long-time adversaries are no longer considered dangerous to our national security. The threat of a nuclear attack seems distant. This change in world politics has called into question the need for a large-scale laser-based nuclear defense system. These events, along with the recent recession, have led to cuts in military spending, including the termination of military SDI laser testing. Nevertheless, some of the more minor laser technology associated with this program is now used in the military for other projects.

Laser Development for SDI

SDI's original focus was on laser-based anti-missile defense systems. These systems are better known as directed-energy weapons. Two types of DEWs have been the center of attention in SDI research: the hydrogen fluoride chemical-based laser and the free-electron laser.

The hydrogen fluoride chemical laser is the older of the two types of DEWs. This space-based DEW — under development for nearly 20 years — utilizes the combustion of hydrogen and fluorine, which produces a high energy, excited hydrogen fluoride. An optical resonator then converts the hydrogen fluoride into a laser beam.

The HF laser has a major advantage over other DEWs, because it can deliver large amounts of energy to its target. Some scientists believe that the development of a 5 megawatt laser with a brightness of approximately 1019 watts/square-radian could be possible in the next few years. To put this in perspective, a 20 MW laser with a brightness of 2.2 x 1020 W/sq-rad is thought to have the intensity necessary to kill a missile.

Two significant problems, however, faced researchers developing the HF laser. First, the lower atmosphere easily absorbs light of wavelengths around 2.7 micrometers — the wavelength at which the HF laser lases. Thus, the laser cannot destroy targets below altitudes of 40,000 feet. Second, the materials that compose the missiles have a strong tendency to reflect radiation of wavelengths similar to those of the HF laser. This makes killing a missile using this laser much more difficult.

The HF laser has other disadvantages as well. This laser needs a large amount of chemical fuel containing hydrogen and fluorine in order to function properly. Transporting such large amounts of fuel to the orbiting laser is a cumbersome and difficult task. The laser also needs large mirrors that can withstand and direct great amounts of energy to far away targets. Developing such mirrors would be a lengthy and costly process.

The second type of DEW, the free-electron laser, consists of three main components. The first is the accelerator, which is similar to those used in high-energy physics experiments. It is used to accelerate electrons, causing them to emit radiation. The second component — called a "wiggler" — uses a strong magnetic field to direct the radiation from the accelerator to form a laser beam. The final component is an output mirror that directs the beam out of the laser.

The FEL has two advantages over the HF laser. First, the FEL is an efficient system — the accelerated and "wiggled" electrons can be recycled backwards through the accelerator, producing a radio frequency field that is used to accelerate the next group of electrons. Also, the wavelength of the FEK can be "tuned" over a wide range. This means that a wavelength could be chosen that would direct the maximum amount of energy at a target. And unlike the HF laser, the FEL could function effectively — if the wavelength were adjusted — in lower atmospheric levels.

Today, the FEL is in the early stages of development. Many logistic and engineering problems have to be solved before this system can be fully devel-

oped. Although the FEL can deliver several megawatts of power in a single pulse, researchers are now looking for ways to sustain that power for a longer period of time. Also, scientists are uncertain whether to develop a ground-based or a space-based FEL system. They are still evaluating the costs and difficulties of both projects.

a nuclear war seems considerably less then they were five years ago. Because of these events and dwindling funds, Congress cut military spending, and the Energy Department discontinued SDI X-ray laser funding.

The cuts in military funding have forced a re-evaluation of which type of nuclear defense system — laser or non-laser — should be emphasized. The laser DEWs have two major drawbacks. Not only are they very expensive to develop, but it could take up to 20 years for any significant progress to be made. Because of these faults, an increasing amount of funds are being allocated to the improvement of non-laser, kinetic-energy defense weapons.

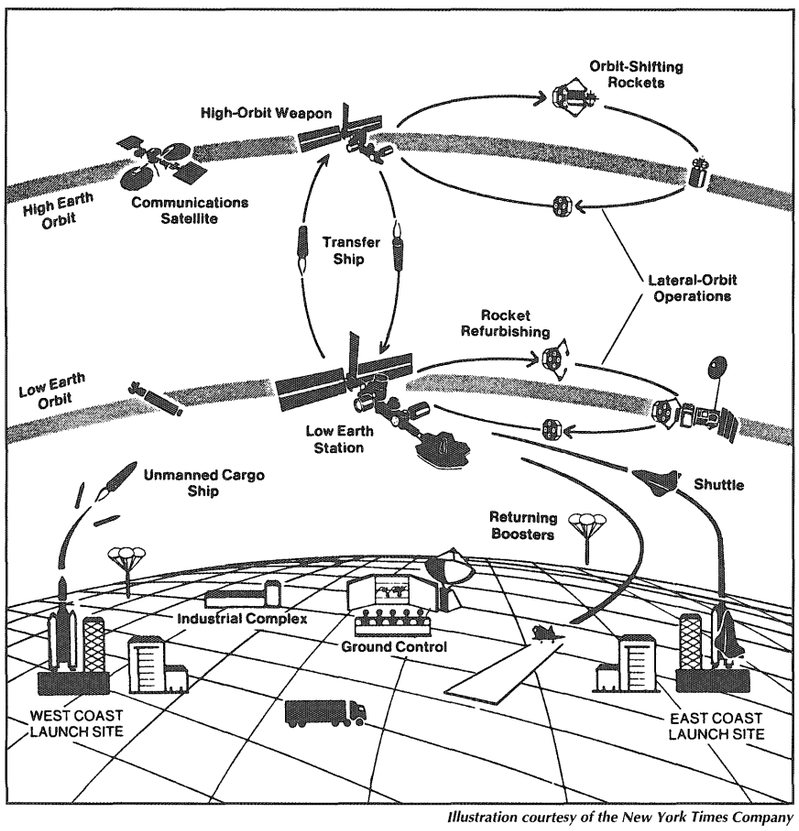

Illustration courtesy of the New York Times Company

An illustration of a theoretical support system for the deployment and maintenance of Star Wars anti-missile weapons in the United States.

Restructuring SDI

In recent years, many politicians have been asking whether such a large-scale defense system is necessary to disable ICBMs. With the breakup of the Soviet Union, the collapse of the Warsaw Pact, and the reaffirmation of nuclear reduction treaties between the United States and Russia, the threat of

Kinetic-energy weapons, also referred to as kinetic kill vehicles, are rockets that collide with the enemy's ICBMs. The concept behind KKVs is similar to that of the Patriot missiles used in the Persian Gulf War to destroy incoming Iraqi surface to surface missiles — or SCUDs — but KKVs have more complex computer hardware and thrusters than the Patriot missiles.

KKVs are relatively inexpensive compared with DEWs, and have the potential to be operational in three to five years. Although by themselves they will likely never have the capability to repel a full-scale nuclear attack, five years from now they will probably be capable of completely defeating a minor attack. These characteristics make KKVs appealing to some SDI authorities.

Laser Technology after SDI

The cuts in governmental SDI funding for the development of DEWs have not *completely* stopped the research of lasers throughout the military. The individual branches of the military sometimes use their private funds to develop specific laser weapon research for their own purposes. Some of these applications include guidance and imaging devices, communications systems and ray guns.

Laser-guided weapons have been around since the Vietnam War, but new technological advances from weapons research have led to the development of more precise and compact guidance technology. Hand-held guidance devices, for example, were used extensively by U.S. troops during the Persian Gulf War. Also, ground forces used a rifle-like laser to illuminate enemy targets at a distance of two to three miles, guiding "smart bombs" and missiles fired from air support or other ground forces.

Increased laser precision has helped researchers develop imaging

systems for Air Force fighters and bombers. One new imaging system generates two- or three -dimensional images of the ground area just ahead of the aircraft, transmitting and reflecting laser pulses off the target area. The reflection of the laser is gathered by an optical sensor, and the image is processed and stored in a computer. The computer compares that image to the images it has in memory, then locates vital targets and guides missiles or bombs into the targets.

The military also uses lasers to enhance communication. A two-way communication system for aircrafts has been created using low-power lasers. The laser medium for communication offers many advantages over its conventional counterparts. First, it is secure — it cannot be picked up by enemy aircraft, because the laser acts as a closed telephone line. Also, it is jam resistant — the laser signal cannot be interfered with like radio waves can. Finally, it is not detectable by conventional means. Present methods of communication can be detected by enemy systems, limiting communication in stealth missions. These detection methods, however, will not detect laser communication.

Ray guns, commonly known as "dazzlers," are a third use for lasers in the military. Ray guns are laser weapons that are fired at enemy troops or aircraft in order to temporarily blind them. The information on dazzlers is limited for security reasons, but some believe they are low-powered (10-100 watts), argon-based lasers with ranges of one to two miles. Newer, more powerful ray guns are thought to be under development with the use of us DEW- and other laser weapons-related research. These new weapons may be powerful enough to permanently blind enemy troops.

Although laser research programs are facing major funding cutbacks, lasers have proved useful in times of peace and war. With private laser research continuing in the military despite the cuts in government funding, more military laser applications will likely be discovered. ◊◊◊

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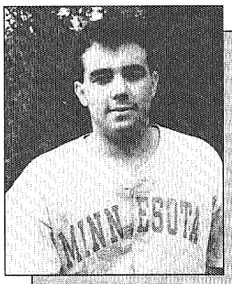

David Mirelez

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David would someday like to work in the government using his engineering knowledge, perhaps for NASA or the Department of Defense.

University researchers see it crystal clear

By Alice Chen
Technolog Staff Writer

A group of chemists at the University has discovered a way to enhance the performance of lasers by using crystals. Optoelectronics increases the frequency range of lasers by controlling the formation of crystals.

The recently deceased Professor M. C. Etter and her research team developed a procedure that allows controlled crystal packing and the design of frequency-doubling crystals.

These special crystals increase the frequency range of lasers by converting light of one rate of wavelength to light with twice that wavelength, a phenomenon known as second-harmonic generation. In developing a substance that can produce frequency doubling, the ability of single molecules to hyperpolarize is important. The arrangement of a crystal that produces second-harmonic generation must be acentric — without a central symmetry. The resulting crystal looks like a pyramid with the tops of each section sliced off.

The material used to build this unique crystal must also have the ability to phase-match and absorb light waves. Typical crystals are normally made up of several two-dimensional layers. Each sheet is positively charged on one end and negatively charged on the other. When the sheets are placed one on top of the other, the opposite charges attract. This causes the charges of each layer to alternate, forming a non-polar crystal. To form the special crystal, however, Etter and Frankenbach developed a technique that causes the sheets to be layered on top of each other with all positive charges at one end and negatives at the other.

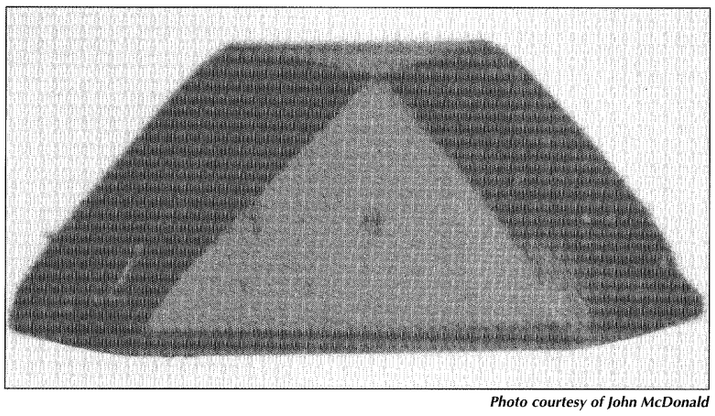

Photo courtesy of John McDonald

This crystal was formed by hydrogen bonding, a technique causing all positive charges to gather at one end and all negatives at the other.

The hydrogen bond is the fundamental component which makes these peculiar crystals possible. Bonds are responsible for the structure of crystals, as well as molecules and compounds. When elements change, the bonds change, forming a new structure. In Etter's research two molecules, 4-aminobenzoic acid and 3,5-dinitrobenzoic acid were mixed to form a cocrystal. Since the cocrystal has a combination of two materials, its hydrogen bond patterns are easier to predict than the homogeneous bonds of the unnatural structure of a typical crystal. Knowing this, Etter and Frankenbach chose molecules that naturally connected, via hydrogen bonding, to form crystals with no symmetrical center in their structure.

This patented technique is giving scientists the ability to control different aspects of crystal packing patterns that could be useful in the further development of lasers and broaden the growing field of optoelectronics. ◊◊◊

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Optical computing

By Linda Chandler
For Minnesota Technolog

In its never ending search to find smaller, faster, and more "intelligent" processors, the computer industry has consistently turned to new advances and improvements in electronics. Recently, however, computer scientists have been attracted by the increased efficiency, speed, and economy made possible through the use of optics in computer operations. Already optics have made their way into the computer industry in the form of optical storage disks, fiber optic communications, and optical processing systems.

Optical Storage

Optical storage disks operate the same way as audio compact discs. A laser reads tiny pits and peaks — representing digital data — set in the disk, and then recreates the original music, graphics or text. Optical disks have a storage capacity ranging from one-half to 10 gigabytes — about two to five times greater than that of magnetic disks, which are also slower and more expensive.

There are three basic types of optical disks: the CD-ROM (compact-disc read-only-memory), in which all the information is pre-recorded by the manufacturer and cannot be changed by the user; WORM disks (write once, read many), on which data can be recorded but not erased; and erasable/rewriteable disks that can be written to and erased many times. WORM and erasable/rewriteable disks are very useful for archival purposes in professional and industrial settings, but they are currently too expensive to be practical for personal computers.

The CD-ROM, on the other hand, is relatively inexpensive. For this reason there is a consumer market for it in the desktop computer industry. CD-ROM can replace entire reference books — such as dictionaries and entire sets of encyclopedias — with only one or two compact discs. Additionally, multimedia CD-ROMs not only save time and shelf space, but may also provide animated illustrations or video clips on a subject, and even play a country's national anthem.

Optical Processing

One of the newest matings of optics and computers is the "optical computer," which replaces electrons (particles of electricity) with photons (particles of light) wherever practical in a computer. In some instances, light has properties that make it more useful than electricity. Since photons do not interact with one another the way electrons do, light beams don't interfere with one another when they cross in space. Also unlike electrons, photons do not need be confined to a carrier, such as a wire, in order to travel from one place to another. Therefore, many more input and output connections are possible with optics than with electronics. Electronics are necessary, however, to get information off the light beams.

Optical computing may take computer efficiency to new heights. From its large memory capacity and permanent storage capabilities to its rapid processing, this innovative technique makes interfacing much easier. This is indeed the computer age of enlightenment. ◊◊◊

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Year In School: Senior
Major: English

Linda hopes to be a creative writer one day.

Entertainment from 12

Than-Ever" Mario Brothers.

... But until then, turn on a CD, lean back and enjoy the wonders of laser entertainment today. ◊◊◊

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Surgery from 13

scarring because the incisions are smaller and less traumatic to the tissue. Second, there is less risk of infection with lasers because the extreme heat of the beam sterilizes as it moves through tissue. Third, the laser beam seals and cauterizes blood vessels as it passes through them, resulting in minimal blood loss.

Laser surgery has come a long way since the 1960s, and the benefits are increasingly apparent. One day perhaps all surgery will be performed with lasers. ◊◊◊

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THE TREMENDOUS AUDACITY OF FEZ!
THE PHYSICIST
TODAY, FEZ IS TAKING LITTLE BILLY AND TOMIKA TO M.I.T'S LASEROPTIC DIVISION: LET'S JOIN THEM AT THE FRONT DESK!
HERE ARE YOUR NAME TAGS, CHILDREN.. YOUR TOUR GUIDE WILL BE -
SIR, I AM SORRY BUT YOU MUST HAVE A GUIDE. CERTAIN LABS ARE OFF LIMITS AND -
SIR! I DARESAY WE WILL NEED A GUIDE. I AM A PHYSICIST, AFTER ALL. BILLY AND TOMIKA WILL LEARN MORE FROM ME THAN SOME FIBEROPTIC FLUNKIE. PLEASE SEND YOUR TOUR GUIDE FRIENDS BACK TO THEIR COFFEE BREAK; THEIR HOLDING PENS... OR WHATEVER.
MY EGO WILL NOT BE DENIED, SIR. FAREWELL. COME ALONG YOUNG MINDS!
HOLD THY TONGUE, MISCREANT! THAT SELFSAME MOVIE WAS WHERE LASERS WERE CREATED. LASERS ARE RED BECAUSE LASERS ARE ANGRY THINGS. THEY BUILD UP ENOUGH FRUSTRATION OVER THE EONS TO DO SERIOUS DAMAGE. YOU SEE, LASERS ARE REALLY MADE UP OF TINY LITTLE MEN THAT ARE CONSTANTLY SLAM DANCING: THEY CREATE ENOUGH ANGER AND TESTOSTERONE TO BECOME A COHESIVE RAY OF DESTRUCTIVE FORCE!
BUT I SAW ON T.V. THAT DOCTORS USE LASERS TO SAVE PEOPLES LIVES ON THE OPERATING TABLE...
OH, WELL, THOSE ARE GOOD LASERS. THEY COME FROM A DIFFERENT DIMENSION. THEY ARE HAPPY LASERS AND ARE MADE UP OF TINY WOMEN.
OH...
WELL, TOMIKA, A LASER IS A RED BURST OF ENERGY. IT IS USUALLY CONTAINED WITHIN A GUN, LIKE THE ONES IN 'STAR WARS.'
WHAT'S A LASER FEZ?
THAT MOVIE WAS COMPLETELY BORING.
PLEASE TURN BACK.
DON'T COME THIS WAY.
IS OUR TOUR OVER FEZ? ...AND WHAT ABOUT WHAT HAPPENED TO BILLY?
YEESS, I'M AFRAID OUR TOUR IS FINISHED. AND I THINK THE ONLY WORD THAT APTLY DESCRIBES THE FATE OF LITTLE BILLY IS: COOL. DID YOU SEE HIS EYES? WOW!
AND HE DIED HONORABLY, MAKING THE SUPREME SACRIFICE FOR SCIENCE.. WELL, ENOUGH MOURNING! LET'S GO GET ICE CREAM: AND CANDY.
YAY!
OH MY GOSH! BILLY'S DEAD! HE GOT SLICED IN HALF BY THAT LASER!
THAT IS VERY PERCEPTIVE OF YOU, TOMIKA. HAVE YOU EVER THOUGHT ABOUT A CAREER IN HYDROPONICS OR LAW?
DANGER: STAY THE HELL BACK. COME IN AND YOU WILL DIE
WHAT'S THIS ROOM FEZ?
AHH, THIS IS THE ROOM WHEREIN GREAT, GREAT THINGS TAKE PLACE.... ...LET US ENTER, YOUNG SPONGES.
ZAP!
© DANIEL RUEN!!!!!

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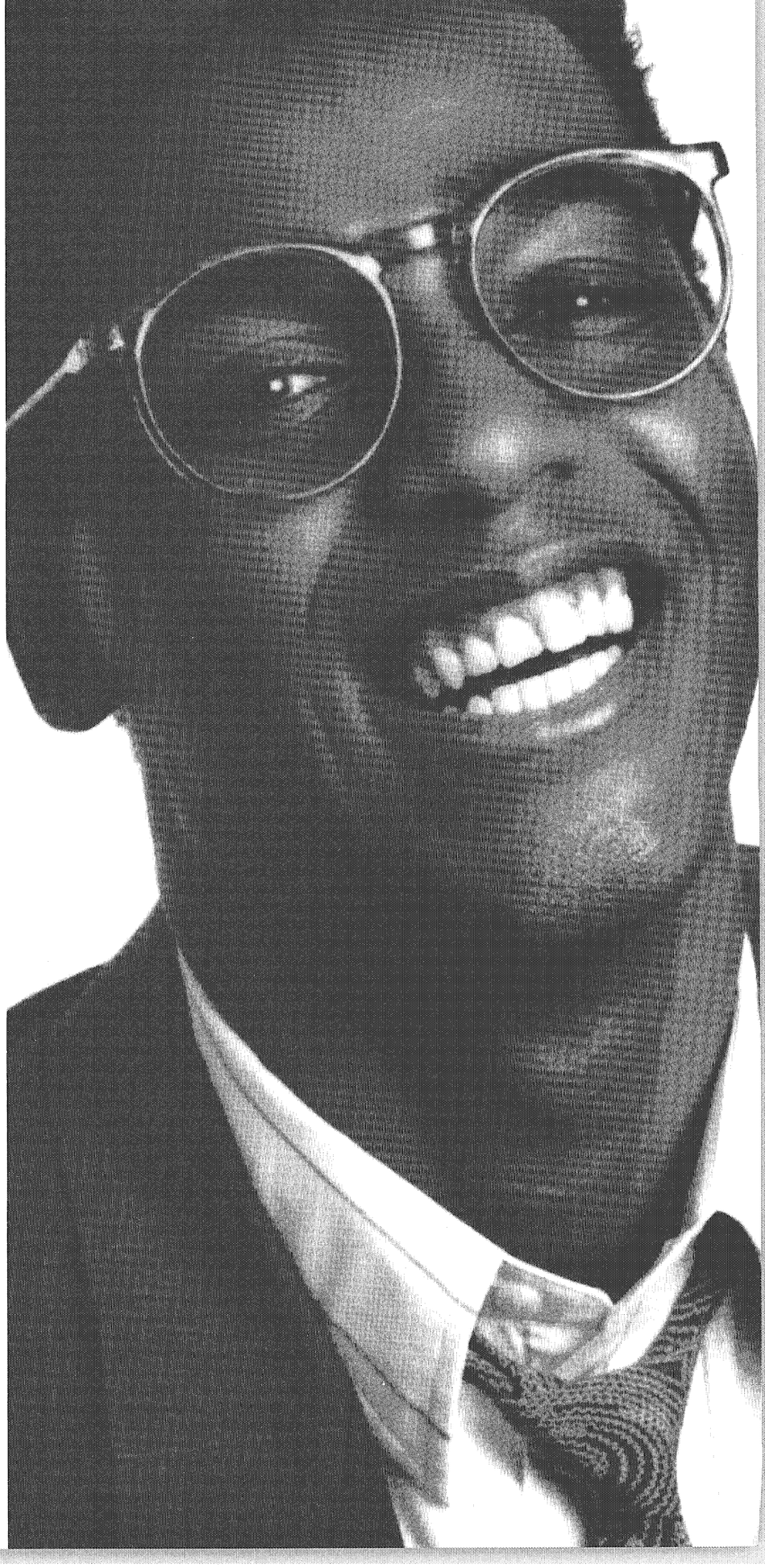

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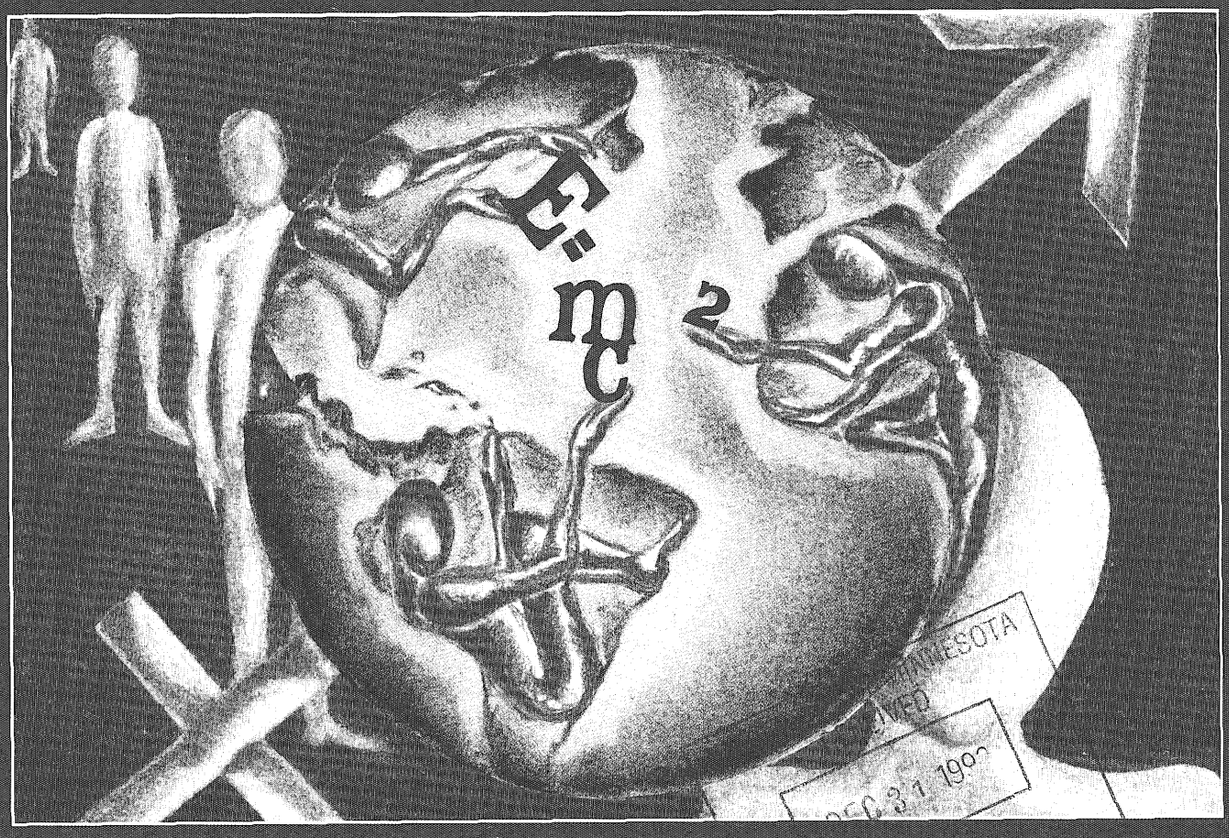
The Differences Among Us



In this issue . . .

- Genetic engineering: A line must be drawn
- Just how different are the sexes?
- What all engineers should know about their future
- Why some people live longer than others
- *and more . . .*

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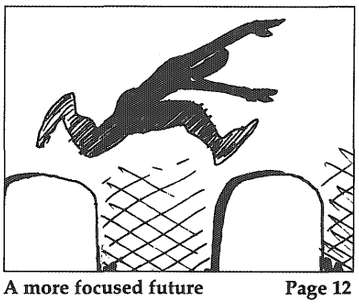
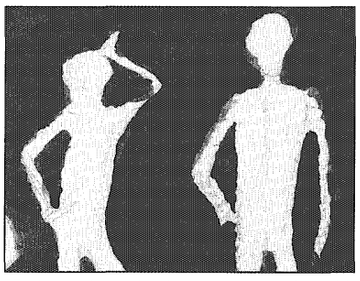
Males vs. females Page 4



A more focused future Page 12



History of mortality Page 16

Departments

About the cover . . .

Although we all live together on one planet, many factors distinguish us from one another. In this issue we take a closer look at these differences and how technology is involved.

Illustration by Jennifer Hughlett

MINNESOTA TECHNOLOG

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Genetic engineering doesn't bode well for the future

Want the perfect baby? Most future parents do. They hope for a healthy, intelligent and well-behaved child.

But many parents get more than they expected. The child may be fussy, hyperactive or a slow learner. Normal kids can fast become worries.

Genetic engineering — the practical application of gene splicing — could change all that. Expecting parents could end up with exactly what they bargained for. But the effect on society could be more than any of us predicted.

Recently, doctors have identified genetic defects in embryos only days after conception. They removed one cell from four- or eight-cell embryos, and looked for genes that cause cystic fibrosis. The test is the first of its kind that can be used to find a single gene.

The doctors threw away the "defective" embryos, and implanted the others into the mother.

A September report in The New England Journal of Medicine, stated the first child who underwent this testing has now been born. The baby, as planned, did not have cystic fibrosis.

Previously, doctors could only determine whether embryos had male or female chromosomes. They used the test to eliminate embryos at risk of sex-linked diseases like hemophilia, which mainly affects males.

Although doctors seem to be onto something big, nobody is sure exactly how far they can or will go. We have no real sense of this technology's scope or power.

Perhaps this new practice could do a lot of good, if kept in check. Some say a cure for cancer may be attainable because of it. But even though this type of genetic engineering is a leap in scientific ability, it has a side that — in the excitement of its discovery — many are overlooking.

A dark one.

We must control this innovation before it drastically changes our society.

Even doctors are concerned. "This is a glitch on the radar screen of 21st-century medicine," said Dr. Arthur Caplan — director of the Center for Bioethics at the University — in The New York Times September 24.

He said it will "fundamentally change what we think about abortion, reproductive rights and our relationships with our own children."

The technology raises many red flags.

For one thing, the test is expensive; the procedure can cost up to $10,000. The notion that rich people may be the only ones who can afford to engineer a perfectly healthy baby could create a rift between the rich and the poor like no other.

Also, the definition of disease is vague, and can include more than just serious afflictions — even allergies could conceivably be included in such genetic engineering practices.

And what if it doesn't stop with health?

If a couple wants a perfect baby, this technology may eventually enable them to craft out their child according to a recipe — a dash of this, a dash of that.

by

Esther Haynes
Editor in Chief

Natural human differences would gradually diminish. People would be more and more alike because they could all come from, literally, the same molds.

Specific limits must be made before someone goes too far. A line must be drawn between curing serious disorders and constructing perfect babies.

We are stepping dangerously close to a day when "designer" children are commonplace and only the poor have children with flaws. We have to guard against unforeseen and unintended consequences of genetic altering and counter its drawbacks before it becomes disastrous. ❖

One chromosome away from the opposite sex

Photo illustration by Kathy Strauss

"Don't ya know it really gets me way down in the solar plexus,

when I think about the differences there are between the sexes..."

— The Limelighters

By Scott Taschler
For Minnesota Technolog

Male vs. Female. Men are strong, quiet and sing lumberjack songs. Women are sensitive, caring and knit mufflers.

Sex stereotypes like these surface in many areas of our lives. Some say they are biological truths. Others say they are impressed upon us by society. Both are partially correct.

In the beginning ...

When you get right down to it, the difference between men and women can be narrowed down to one chromosome out of 46. Females posses two X chromosomes, one from each parent, and men have one X (from the mother) and one Y (from the father). In females, each egg in the ovaries contains one X chromosome, but in males half of the sperm have an X and the other half possess Y.

The sex of the fetus is determined as soon as the egg is fertilized. For the first six weeks, however, there are no visible differences between male and female fetuses. Both possess the prenatal equivalents of the genitalia for both sexes. At around six weeks the gonads differentiate into testicles, for males, or ovaries, for females. The new organs then begin to secrete hormones appropriate to the sex of the fetus.

Around the fourth month of pregnancy, the hormones cause the organs extraneous to the fetus to shrink, while other organs enlarge slightly. This explains nipples on men's chests and the clitoris on women. The hormones also cause slight changes in brain structure. In women, for example, the corpus callosum — the connection between the two halves of the brain — is larger than that of men.

Hormones take control

After prenatal development, males and females stay much the same throughout grade school. At this point there are few dramatic physical differences between boys and girls. Around the age of junior high, however, many things change. The gonads kick into overdrive and begin producing hormones — lots of them. Growth spurts occur, voices deepen and the thought of kissing becomes more and more appealing each day.

Females generally hit puberty about two years before males. The subsequent growth spurt produces the only time span in which females outsize males — making junior high dances an awkward affair at best. The first signs of puberty in girls manifest as enlarged breasts, followed by redistribution of fat, growth of pubic and armpit hair, and the beginning of the menstrual cycle.

Boys going through puberty experience a deepening of the voice, increase in sweat-gland activity, growth of body hair and definition of the muscles. Less visibly, the skeletal, cardiovascular, respiratory and excretory systems become stronger and more efficient than those of women.

With the exception of genitalia, there can be great overlap in sex characteristics. There are men who are practically hairless, and women who have considerable hair growth on the arms, legs and face. Some women are flat-chested, and some men have larger breasts. This occurs because both sexes possess male and female hormones. In all people, hormones of the opposite sex are present in greatly reduced quantities. Different people have different levels of susceptibility to hormones of the opposite sex. A person's level of susceptibility can be inherited from the parents.

After puberty, males are generally taller, more muscular and heavier than women; and females are smaller and possess a greater percentage of body fat than men. Although it may seem at first that women received the raw end of the deal, they have some advantages. The excess fat, for example, is a storehouse of energy and makes the female body more buoyant. In fact, the only sport in which women's records exceed men's is long-distance swimming — of the ten best times crossing the English Channel, eight are held by women.

During the middle-to-late years, hormonal production decreases. In men, this takes the form of a slow, steady decline that results in the diminishing ability to reproduce. This is manifested as a decrease in sperm production and the inability to achieve an erection.

The change is much more dramatic in women during those times, when hormone levels drop rapidly between the ages of 45 and 55. Accompanying the drop in hormone levels — called menopause — may be dryness of the vagina, "hot flashes", insomnia and depression.

Life and death

Women live longer than men. In the United States, the average woman can expect to live 77.7 years, whereas male life expectancy is 70 years. This difference is largely because males are more susceptible to many diseases, especially heart disease, pneumonia and cancer.

Another reason for the higher mortality rate of men is because men are more likely to participate in risky behavior, such as alcoholism and unsafe driving. Also, more men are involved with more hazardous jobs and hobbies — such as construction work, machine work and hunting.

Evolutionary selection seems to have equipped people with an X-linked immunoregulatory gene to help us overcome many life-threatening diseases. Since women have two X chromosomes, they have a double dose of this gene and so are better suited to cope with many diseases.

Women, on the other hand, are much more susceptible to auto-immune diseases. These occur when the body contains too much of an antibody, causing the body's defenses to turn and attack itself.

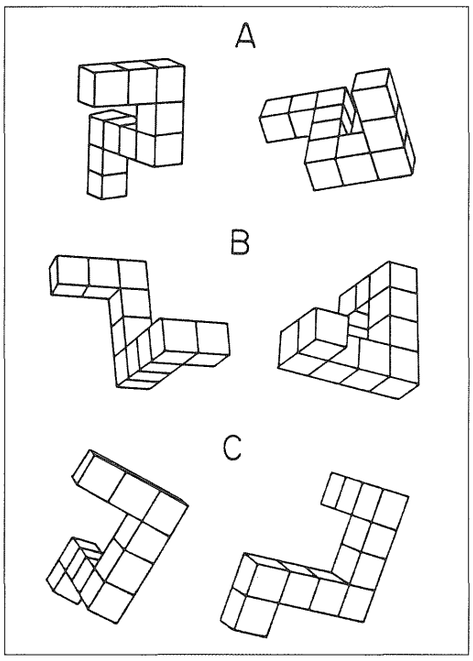
Other diseases — called "sex-linked" diseases — are caused by genes that are associated with a specific chromosome, either the X or the Y. The only "disease" that has been shown to be linked to the Y chromosome is hairy ears. The rest — some dominant and some recessive — are linked to the X.

In general, women are more likely to suffer from dominant X-linked diseases than recessive ones, since females have twice the number of X chromosomes. In males, the Y chromosome acts as a sort of "null" chromosome, so all the recessive genes on the X show up. Some examples of X-linked recessive diseases — which are much more common than dominant ones — include hemophilia and certain types of red-green color blindness.

Gray matters

Physically, male and female brains are very much alike. Female brains are typically slightly smaller than male ones, which is not surprising considering that males have a size advantage to begin with. There is also a difference in the number of cells in a small area of the hypothalamus which, among other things, controls the pituitary gland. The pituitary gland regulates hormone production throughout the body. Perhaps the most interesting difference, though, comes in the corpus callosum — the nerve bundle that connects the two halves of the brain — which as mentioned earlier, is considerably larger in females.

Which pair is not congruent?



Courtesy of the American Association for the Advancement of Science

These are examples of perspective line drawings used to test spacial ability. (A) A "same" pair, which differs by an 80° rotation in the picture plane; (B) a "same" pair, which differs by an 80° rotation in depth; and (C) a "different" pair, which cannot be brought into congruence by any rotation.

The two sides of the brain perform different functions. The left side is more or less in charge of logical thought processes. The right side controls creative thought processes.

Sandra Witelson, a renowned psychologist at McMasters University, hypothesized that "women, as a result of such a neurological organization, would be less able to dissociate their emotional behavior from verbal analysis." She added, "This difference does not make one sex superior to the other. Different advantages may be associated with the integration of emotion in the rational process and with the independence of both processes."

Psychologists have long dwelled on the question of which sex is smarter. And after much deliberation, the answer is neither — there is no significant difference between male and female intelligence levels.

Each sex does have its specialties, however. Men by and large are more gifted in spatial aptitudes than women. In one test men could more easily "lift" a three-dimensional image from a page and rotate, invert and reproduce it in their minds. In tests from trying to hit a point of light with a finger to remembering the left hand from the right in a split-second, men usually outperformed women.

Nevertheless, women generally outperform men in verbal tests. They excel in tests involving vocabulary, spelling and creative writing. And even before their first words are spoken, females seem to be more able to express feelings.

There are many different theories on how these differences have come about. Imagine our primitive ancestor Crom A. Gnonman as he scurried about, spear in hand, hunting for his evening meal. If Crom had better depth perception and spatial abilities than his neighbor, Nean D. Thall, he had a better chance at getting a meal and surviving. Thus, natural selection may have "filtered out" the males with less spatial ability.

Similarly, as women were left home to gather, raise families and de-

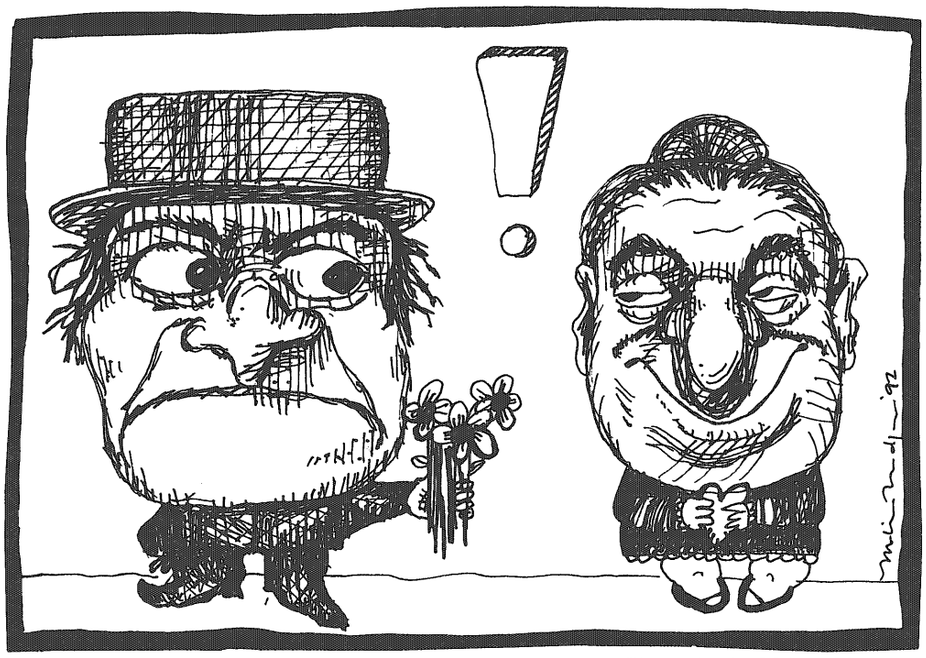


Illustration by Melissa Mendoza

velop the basics of medicine and other sciences, it was likely an advantage to possess good communication and rationalization skills.

Tempering stereotypes

Many stereotypes exist about the temperament and general personalities of men and women. Society portrays men as dominating and distant, keeping feelings bottled up. Females, conversely, are stereotypically submissive, more timid and more willing to reveal information about their lives. Some of these stereotypical traits are biological and some are just plain baloney.

Males certainly commit more aggressive acts than females — 30 percent more, in fact. This imbalance is found not only in humans, but also in much of the rest of the animal kingdom. In deer and other hoofed animals, the male is equipped with large horns—tailor-made for fighting. Also, male dogs have stronger jaws than females. Some say that this is evidence that males are "born to be bad."

Studies involving injections of testosterone — a hormone dominant in males — have linked the hormone to aggressive behavior. In studies on children, boys remember more explicitly violent scenes from movies than girls. This difference may not be entirely brought about by biology, however — it can be accentuated by social expectations of how boys and girls should behave.

Females can certainly be as aggressive as males, but they tend to express it less directly. Many more females than males attempt suicide. Women are more likely than men to glare at someone cutting into line in front of them, and in an informal poll, female-bathroom graffiti was found to be more hostile than male-bathroom graffiti. All of these are more or less anonymous methods of expressing aggression — they avoid actually bringing another person into the conflict.

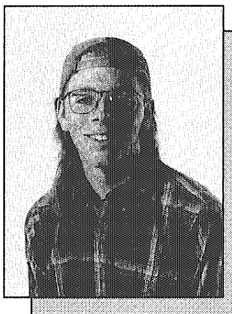
Other stereotypes have very little basis in reality. There is very little or no sex-related difference in passivity or dependency. Women do tend to show more outward signs of affection, however, and men often use playfulness to show caring.

In the end...

So what does it all mean? Certainly men and women have very distinct differences, but perhaps they are not as different as they think. These days, modern science is closing the life-span gap, and social pressures are causing traditional male and female roles to overlap more and more.

These diminishing differences bring to mind a quote from British

See Sexes, page 22



Scott Taschler

Age: 20
Year in school: Senior
Major: Electrical engineering

Scott is an honors student in the Institute of Technology. He enjoys creative writing and would like to one day build electrical toys in his office at home.

Relief for a pain in the neck

By Alice Chen
Technolog Staff Writer

In 1986 Gordon Hanson had a dream. What the world needed, he thought, was a reliable tool that measured neck movement in patients suffering from neck pain. And he would be the one to help build it.

By the time the dream was realized two years later, Hanson — president of Performance Attainment Associates — had designed numerous models, turned his home into an assembly line and spent hours standing in front of people with a plastic apparatus riding high on his head. The Cervical Range of Motion Instrument was introduced. And the medical world was better off.

In early 1988, Hanson teamed up with researchers from the University's Department of Physical Medicine and Rehabilitation to develop the CROM Instrument. Hanson, along with Director of Physical Therapy Jack Allison and Educational Coordinator Corinne Ellingham, looked at different devices that measured neck movement. They took the best qualities from each and added innovations of their own.

The team — which included the now-retired consultants and associate professors James Pohtilla and Marvin Lepley — produced nearly fifty alterations of their original prototype. The final product, the CROM Instrument, emerged in October 1988, and two patents were granted for the invention.

The CROM Instrument uses gravity and magnetism, instead of the hands, to measure neck movement — making it a more reliable source for measurements. The CROM headgear sits on the bridge of the nose and the ears of the wearer, like scaffolding for the head. A Velcro strap makes sure the instrument stays in place. Two devices, called inclinometers, use gravity to get measurements and are set into CROM's co-polyester frame. The inclinometers lay against the wearer's forehead and left upper temple. An arm sleeve located on the uppermost part of the forehead holds one of two attachment "arms" of the tool. The "rotation arm" carries a true compass, and the magnetic navigator inside the arm measures neck movement as wearers turn their heads left and right. The second arm measures the forward and backward gliding motion of the neck. A magnetic yoke around the neck prevents the metal in the equipment from distorting the readings of the compass.

Illustration by Denese Sanders

The benefits

There are several tools on the market for measuring neck motion, but until CROM there was no objective way to measure progress in treating neck patients. Previous devices were not very accurate, making it difficult to

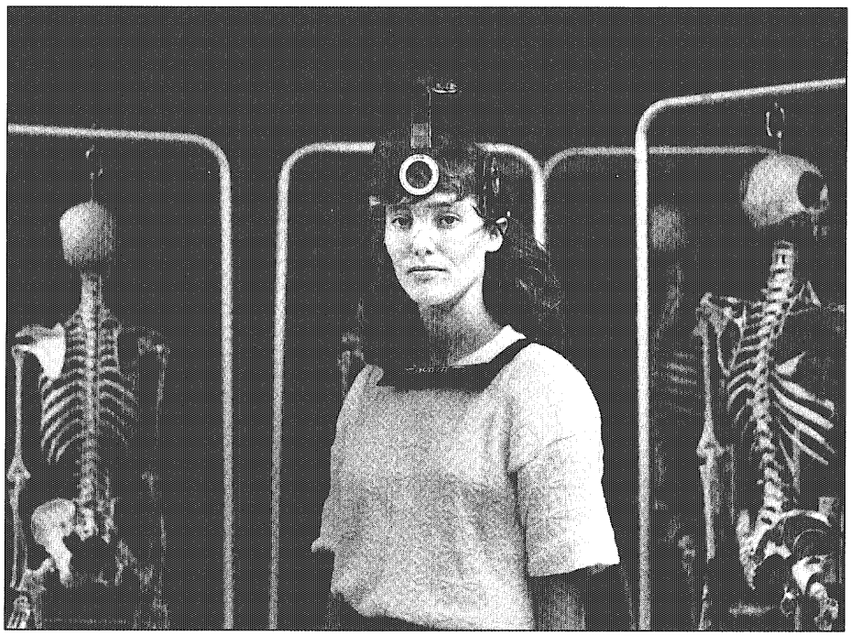


Photo by Andrea Murrill

The CROM Instrument uses gravity and magnetism to accurately measure neck movement.

use as a basis for treatment. Using the precise readings from CROM, however, a third-party payer can document the patient's progress.

CROM also helps motivate patients. With concrete numbers from CROM, patients have goals to aim for. They can see their progress as the readings show more range in neck motion. Such improvements can give patients a sense of achievement.

Also, CROM improves communication among physical therapists, occupational therapists and physicians. The numerical results can be easily understood by health-care professionals not directly involved with patient's therapy. The invention improves communication between doctors and patients as well — something many of us appreciate when we are on the examination table.

Currently Ellingham and Allison are researching the instrument's application potential among the elderly. The researchers may adapt CROM for use on an older population.

Dream fulfilled

These days, with a CROM Instrument firmly attached to his head, Hanson and his daughter Amy attend various trade shows and conferences to market the device. The invention has sold well, according to Hanson. Approximately 1,500 CROMs have been sold, at a price of $445 each — inexpensive compared to the market prices of many medical systems and apparatuses.

The success of the CROM Instrument led to a variation named Back Range Of Motion Instrument, which became available in 1990. A similar product design measures ankle range of motion.

Innovations like CROM have expanded the field of rehabilitation engineering. The ability to design equipment that transforms previously subjective data into the objective is a step toward better treatment and perhaps a faster recovery. CROM has it all: reliability, dependable results and adaptability. So when you get annoying stiff-neck pain, don't be surprised if the doctor or therapist puts bizarre-looking glasses on your head. It's CROM to the rescue. ❖

Sources

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McNulty, Sherry. Phone interview, Aug. 20, 1992.

Alice Chen

Age: 21
Year in school: Senior
Majors: Scientific & technical communication and pre-physical therapy

Alice aspires to one day own a library similiar to the one in Disney's *Beauty and the Beast.*

Engineering in China:

Students have few choices in career decisions

By Andrew Denker
For Minnesota Technolog

SATs, college applications, interviews, campus tours and acceptance letters are all part of a process most American high-school seniors must go through when seeking admittance into universities across the country.

Once these obstacles are overcome and they've chosen a school, students are faced with new concerns. Registration, part-time jobs and rising tuition are just a few — all of which can make it tough to keep in mind the benefits of attending an institute of higher learning.

Before complaining too much about these stumbling blocks, consider what students in China must go through if they want to become an engineers. Doing so might just put quarterly registration hassles into a different perspective.

Testing into your career

A Chinese student cannot choose to be an engineer — he or she must be chosen for that career field. The Chinese government assigns students to the fields in which they are most adept, based on a rugged battery of entrance exams. The tests assess skills in geometry, English, physics, chemistry, mathematics, and world and Chinese history.

For students who hope to study a technical field, scores on math and science exams must outweigh other strengths and be comparable to or better than the scores of their peers. This initial struggle may be quite difficult to overcome. If the government informs someone that he or she is suited to study languages, that person studies languages, no matter how much he or she really wants to.

With this system, the Chinese government tries to ensure a suitable number of people in every occupation, with no overpopulation in a single career field. Also, the government hopes that the workers in each occupation will be the best available.

Change in attitude toward engineers

Chinese engineers face different economic and social conditions than engineers in the United States.

Unlike in this country, money is not a large incentive for engineers in China. Until 1985, engineers made no more than the average skilled worker, such as an ironworker or craftsman. Today the Chinese government has made it possible for engineers to get second and third jobs. Taking advantage of this opportunity, some Chinese engineers have been able to increase their income by as much as tenfold.

This salary raise, however, brings added responsibility to those benefiting. It is not politically correct, as a Chinese citizen, to desire too much money or to get too far ahead of your countrymen. Thus they are expected to share with their fellow countrymen and the parent companies which employ them. It is also common for a wealthy engineer's taxes to rise, but complaining too much can get the engineer into trouble.

Engineering in China is not so prestigious as it is in the United States. Traditionally, engineering has not been respected as an intellectual profession. For much of China's history, the scholars who achieved high status for their studies were those studying intangible, theoretical subjects. People became famous for their work in philosophy, literature, languages and politics — not technical areas. Since the engineers' work had practical, real-world applications, it was thought of as physical work, no better than that of a skilled laborer, and undeserving of respect.

A reversal began when the country was opened to Western technological influences in the late 1970s and '80s. It is no coincidence that elevation in prestige and status accompanied a time when engineers could "freelance" and increase their incomes. The capitalistic influence gave all people with practical skills the opportunity to make money and climb up the social ladder. An intelligent engineer could enhance his or her image with a combination of shrewd business moves and technological knowledge.

This advancement, however, has its disadvantages. Many Chinese people today are entranced by what they consider the "American way" — working just as hard spending money as earning it. Yet traditionalists still exist who hold the ideas of thrift and humility in high regard. Successful engineers must deal with these conflicting pressures.

Improving incentives

For Chinese students who feel a patriotic urge, the field of science and technology offers an incentive to further the country's goals, particularly those of modernization. An important part of China's 1978 decision to allow more of its students to study abroad was its recognition that students were integral to modernization, particularly those enrolled in technical disciplines. With major contributions from leading engineers and scientists, China felt that it could reach its full potential as a world power.

As an incentive for research and to raise morale, the government has made attempts to improve working conditions and change general attitudes about technical fields. T. David McDonald, in his book *The Technological Transformation of China*, discusses how and why the government is working to change attitudes:

Before, the scientific and technical community went unnoticed and unrewarded, indeed, often ostracized. Now researchers are held in esteem and exhorted to bring into full play their talents as a means of increasing production and stimulating modernization. By promoting the importance of scientists, researchers, and technicians, the central government hopes to raise the consciousness of the society as a whole.

With these efforts, it seems that in China the scientific and technical community is a good place for those who feel a strong pull for ideological beliefs.

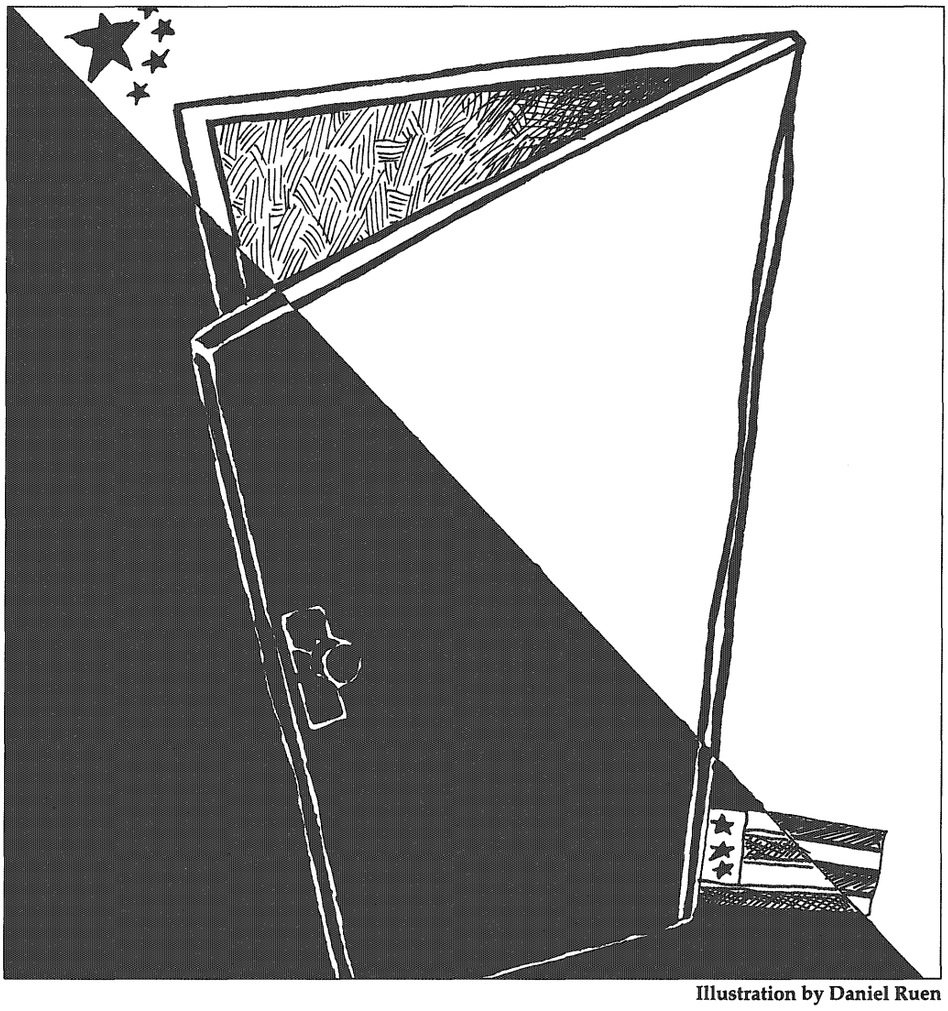


Illustration by Daniel Ruen

The search for efficiency

In the United States, if someone has the desire to become an engineer, or anything else for that matter, he or

See China, page 22

Andrew Denker

Age: 21
Year in school: Junior
Major: Mechanical engineering

Andrew likes athletics, but is restricted because of a knee injury. In the future he would like to freelance as a technical writer.

Specialization

The recipe for succes

By Wade Petrich
For Minnesota Technolog

The work force that today's engineering students are entering is vastly different from the work force of the generation before them. With both the positive progression of technology and the recessive state of the economy, not only have jobs and fields available to engineers changed, but also the way those jobs are performed.

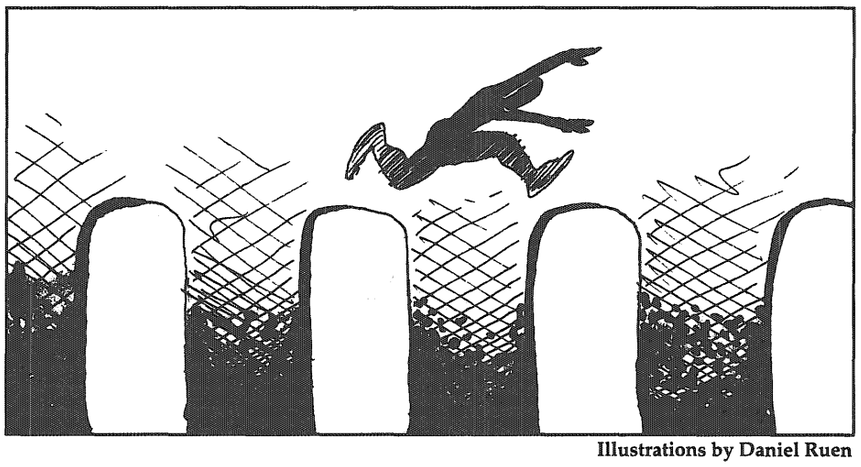
What is an engineer's lot in life? According to David J. Moore, author of *Job Search for the Technical Professional*, "A technical professional is a person who works for compensation in a field or discipline in which primary emphasis is on things rather than people." Traditionally, most engineers and industrial-technology graduates have worked in factories, design offices and in the field.

Why specialize?

Institute of Technology Professor Jim Holte predicts that engineers in the future will transfer often from company to company in order to make the most of their individual talents and skills. In the past, he said, engineers that switched among companies were not considered professional engineers, and were thought to lack adequate skills to land a full-time job.

These days, however, as technology continues to advance, engineers must become specialized. It is the specialized engineers who will be hired by companies that need the engineers' skills for specific projects. After completing a project, the engineer will move on to another company and start a different assignment, picking up new skills along the way.

If an engineer is flexible and adapts well to changes in technology and in the company, Holte said, he or she is more likely to stay there longer and rise through the ranks. Engineers who are balanced, competent, diligent and eager for new tasks should have successful and rewarding careers.



Illustrations by Daniel Ruen

...s in engineering

Pat Colgan, a representative of Technical Support Services of Northern States Power Company, claims that in the future specialty engineering skills will be in high demand. Engineers possessing specialized skills will get the jobs over those who have not specialized, according to Colgan.

"Professionals in general are becoming more specialized," said Minnesota Society of Professional Engineers representative Don Hassensta.

He added that there will be greater need for people specialized in computer science, because computers are being used more and more in other technological fields.

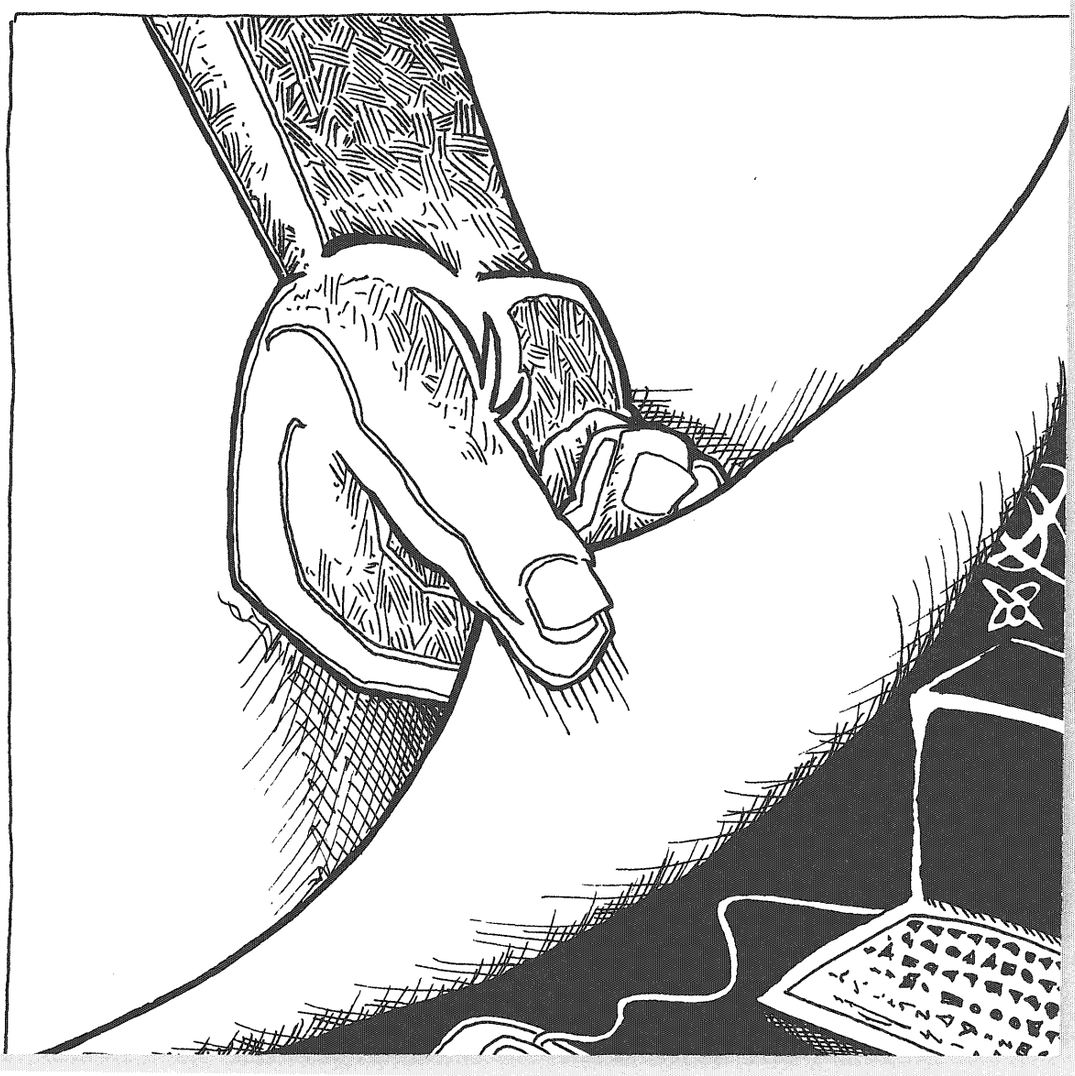
This is backed up by the Bureau of Labor Statistics. In 1990, the BLS conducted a study of 250 occupations. The report covered everything from parking-lot attendants to nuclear engineers. According to the study, between the years 1990 and 2005 computer system analysts will see the largest growth in the number of jobs available in the United States — a 79 percent increase from 463,000 to 829,000 jobs.

The BLS also predicted that occupations in operations and systems research will increase by 73 percent over the same period. Most of the hiring will be in data-processing services.

The occupations with the least job growth will be physicists and astronomers, increasing only slightly from 20,000 to 21,000 jobs— a 5 percent increase, according to the study.

Politics and engineering

Advancements in technology depend greatly on the state of the world's economic and political situations. Many countries, for example, are more concerned today about the environment than they were fifty years ago. With the increasing worry about the ozone layer and global warming, pressure is put on scientists and engineers to find ways to save the earth and its inhabitants. People are



now needed in new areas, such as environmental engineering.

Growth in these fields, however, will depend on the government's willingness to put money into environmental programs. Herb Harmison, Institute of Technology placement director, said he has not known many engineers to get hired in environmental areas, but the field could grow in the next five years. "The seed is there, but it hasn't blossomed yet," he said.

Also, dismantling the "war machine" with the end of the Cold War will force many engineers working in military technology to transfer occupations. Those working in the development of nuclear weapons and the "Star Wars" defense system will have to find other areas of research and development.

There are opportunities available for these people, though. Some engineers from military-related fields at Honeywell, for instance, have successfully switched to civilian engineering by using their technological skills to design computer software that allows high-school students to examine prospective college brochures electronically.

Energy engineering

Looking for a job in nuclear power? The United States is not the place to be. Of the leading industrial nations in the world, the United States ranks ninth in the use of nuclear power. Only 17 percent of U.S. electricity used comes from nuclear power; in France usage is 70 percent.

Also, the issue of nuclear power as an alternative source of energy to oil and coal is a major debate in the United States. The concept of using nuclear power for energy gained popularity during the war with Iraq because the instability of foreign oil accentuated the need for other energy sources in this country. Many people, however, are still against widespread use of nuclear power as an alternative energy source.

Advocates of nuclear power say that the American public has misconceptions about the subject, and they trace this to the negative press the energy source has received. Various independent studies have found that the technology for safe disposal of nuclear waste is possible and available, yet many people still worry about the environmental hazards the waste could cause.

As for the future of employment in the nuclear-power industry, Harmison said he thinks that in this generation there will not be an influx of new jobs into the field. The push right now is to find an efficient way to store the energy, he said, and this discovery will be a major turning point in the energy issue. Other alternative energy sources, such as solar energy, are not big fields

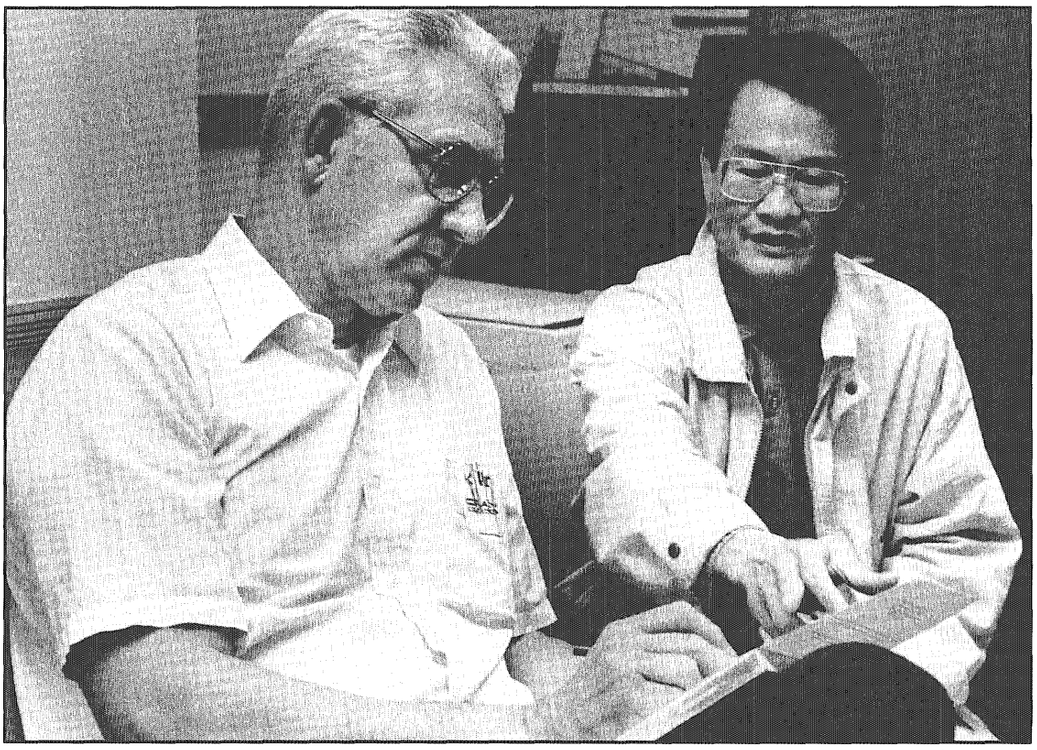


Photo by Kathy Strauss

IT Placement Director Herb Harmison (left) helps IT student John Pham build an eye-catching résumé .

to enter and will probably not be in the near future.

How much energy will we be using in the future? The North American Electric Reliability Council predicts that Americans' demand for electricity will grow 34 percent between the years 1986 and 2000. As the need becomes greater for sources of energy, so will the demand for engineers in the field.

The changing field

Apparently political and economic demands outweigh advancements in technology. It is based on supply and demand — if there is demand for a certain type of technology, there will likely be more jobs opening in that area. If politicians decide that nuclear power is not the answer to our energy needs, there will be more jobs in other fields and less in nuclear power.

Many students who are looking for jobs in engineering ask about the areas of engineering that have the brightest future. Professionals recommend exploring different options in the job market. "Sophomores should look at about ten areas that they would like to do in the field," Harmison said. A field in engineering may be growing at the time a student enters college, but four years down the line, open positions may slack off and companies no longer hiring.

If you are still wondering what engineering profession to go into, write to a professional engineering organization. These organizations have career-guidance packages that give details and information on what is happening in these professions.

Even before you begin the job search, it is important to network with people in your field. This is the best way to get your name out to influential people. Meeting others in your field of interest and discussing career plans is one of the most effective ways of finding new opportunities. Once you have an internship it is best to make yourself seen and heard, in order to be recognized as valuable to the company at hiring time. Interns who prove they can do the job well will likely get hired later on.

'Sophomores should look at about ten areas that they would like to do in the field.'

–Herb Harmison

After the job interview

If you have graduated and have a great job in some engineering profession, what happens next? Some engineers go on to graduate school and get a master's degree or a doctorate. Often companies will pay for their employees to return to school to obtain higher degrees. Some will pay for tuition and books or grant release time from work to take classes. Hassensta said that many engineers go into some type of management or administration job in the company, usually after five to seven years.

Many professional fields require that their employees acquire continuing-education credits throughout their career. Iowa is the only state in this country that requires professional engineers to get continuing education, but some companies require their employees to take refresher courses in fields related to their work.

It is difficult to predict what the future will be like ten years down the road, especially with the changes in Europe and the former Soviet Union. The best thing you, as an engineer, can do is to go into a field you enjoy. If you are good at what you do, you will likely get a good job. And never stop learning. An engineer knowledgeable of the latest trends in technology will be very appealing to companies looking to hire qualified employees. ❖

Sources, page 22

Wade Petrich

Age: 22
Year In School: Senior
Major: English

After living in the sticks up in northern Minnesota, Wade enjoys living in the Twin Cities to experience the other side of life. He hopes to be a novelist someday, or a dictator. Writing for Technolog gives him a chance to explore another area of writing.

Cheer up – your life may depend on it

By Peter Kauffner
For Minnesota Technolog

Many of us believe we know the recipe for living a long, healthy life: eat well, stay clean and go to the doctor when you're sick. The United States, however, has only the 18th-highest life expectancy in the world, even though it has the second-highest per capita expenditure on health care. Real clues to longer life spans can be found in historical records, and the answer seems to be based not in nutrition, but in psychology.

Keep the doctor away

Until the last century, going to the doctor was rarely worth the risk. In times when medical care consisted of leeches, emetics and purgatives, you were often better off staying home in bed.

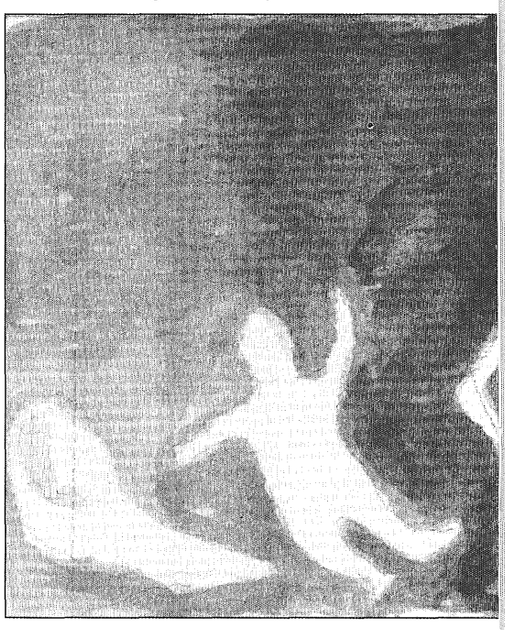
Even in the late 19th century, physicians who trained at Harvard received only two years of lectures and no practical training. And numerous degree mills churned out physicians with even less training.

Although the quality of treatment did not improve until the early years of the 20th century, there is strong evidence that life spans in Western nations were increasing long before this improvement. Vital records of the Order of the Golden Fleece, an organization of European nobles, show a steady increase in life spans since the 1500s. The most dramatic increase was in the 18th century — not the 20th century. We don't have similar records for commoners, but life spans increased from about 35 years in the 1600s to 41 years in 1840 — the earliest years for which reliable statistics are available.

Even today, few medical procedures have been proven totally effective in scientific tests. Antibiotics, once hailed as medicine's "magic bullet," can lose much of their effectiveness with overuse. And National Cancer Institute data shows that U.S. counties with higher mortality rates also tend to have more physicians.

Medicine can claim victory in treating and preventing infectious diseases caused by identified strains of microorganisms. But such diseases were never responsible for more than a small fraction of the overall death rate. Many infectious diseases — including tuberculosis, measles and whooping cough — were already brought under control before effective medical therapies were introduced.

Medicine's mixed record for improving health casts doubt on why we go to the doctor to get treated. Apparently the reason people go to doctors has little to do with the effectiveness of the treatment they receive, and more to do with the psychological satisfaction they get out of it. Patients want to talk to someone who is considerate and knowledgeable, they want an explanation for what ails them and they want to know that someone is doing their best to help them. Prescribing medicine helps to reassure the patient that the illness is being taken seriously.



Sanitation

Many people are tempted to ascribe the differences in disease rates to varying standards of cleanliness among different countries. Mortality rates in the West, however, began to drop long before the sanitation drives of the late

19th century began. And studies in Africa do not find any correlation between water cleanliness and disease rates. Projects to pipe clean water into disease-infested villages have not succeeded in reducing disease or mortality rates.

Also, in communities where farm animals live in the home and personal hygiene is unknown, every meal is likely to be contaminated with fecal material. Under such circumstances, measures like filtering the water or cleaning the streets are not going to provide much protection.

In actuality, diseases spread by poor hygiene are responsible for only a small part of the difference in mortality rates between third world and industrialized nations. Rather, childhood diarrheas and pneumonia are largely responsible for affecting the mortality rates. These diseases are caused by viruses that everyone is exposed to regardless of sanitation or personal hygiene.

Nutrition

The belief that good nutrition makes people live longer is not quite accurate either. Before 1800, there was a strong correlation between high mortality rates and high food prices, leading some to believe the deaths were caused by nutritional deficiencies. It is more likely, however, that the deaths were caused by anxiety resulting from price increases in a population that lived hand to mouth. Even today, economic downturns are associated with increased mortality — generally thought to be an indication of increased stress rather than deteriorating nutrition. Royal families, for example, presumably had adequate access to nutrition, yet child-mortality rates in these high-stress families rivaled those of the poorest families.

In fact, some evidence suggests that during times of food shortages in industrialized countries, health can actually improve. During World War II, for instance, Britain experienced severe shortages of food and medical personnel. Yet, according to a 1946 Ministry of Health report, "The year 1939 was remarkable in producing new low records for mortality at every age below 15 years." It seems bad nutrition had few fatal consequences during those times.

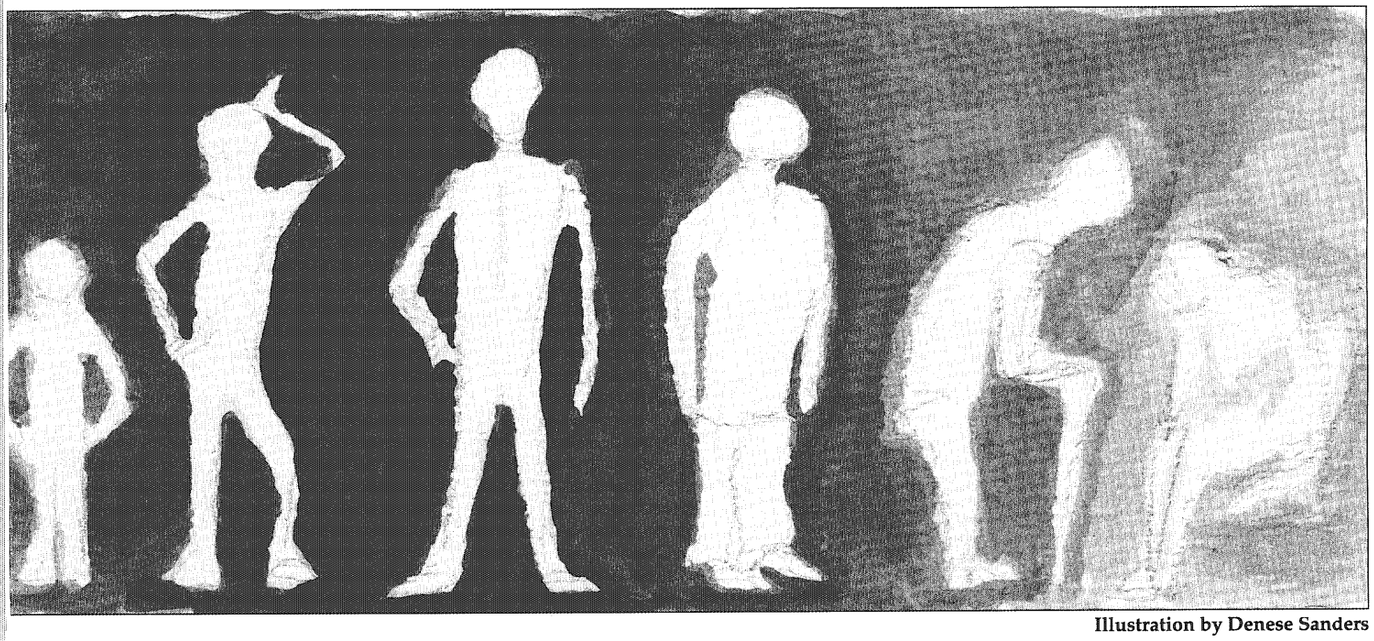


Illustration by Denese Sanders

Cheer up

There are key psychological differences between healthy citizens of an industrialized nation and medieval or third-world peasants. The peasants have no savings or resources in re-

serve. A horde of locusts, the death of a farm animal, even a heavy rainstorm can wipe them out. They therefore live under constant stress. The death of a loved one — quite common among peasant societies — is also a major cause of stress.

Also, fatalism — the belief that one is helpless in the hands of god or fate — is a near-universal attitude in traditional cultures, and is a natural defense for dealing with high levels of stress. Fatalistic attitudes can lead to feelings of hopelessness, which make it difficult to respond to stressful situations in a positive way. J.E. Nardini, a U.S. Navy psychiatrist, observed how psychological factors could affect mortality rates while he was a prisoner of war in the Philippines:

> Occasionally an individual would develop a depressive reaction in which he would lose interest in himself and his future, which was reflected in the quiet or sullen withdrawal from the group, filth of body and clothes, trading food for cigarettes, slowing of work rate to a level that invariably invited physical abuse from the Japanese and an expressed attitude of not giving a damn or 'What's the use?' If this attitude was not met with firm resistance by companions, camp leaders, or medical personnel, death inevitably resulted.

Family dynamics

Life spans in the six European countries for which there are reliable records increased from 41 years in 1840 to 72 years in 1965. This unprecedented improvement is likely caused by psychological changes in the society.

Since children in pre-modern societies had a 50 percent chance of reaching adulthood — compared with a 95 percent chance today — the change in attitudes toward raising children is considered a key in unlocking the mystery of declining death rates.

First, couples in traditional societies married mainly for economic reasons. The family structure was authoritarian and adhered to a value system in which children existed primarily for the economic benefit of their parents. Economics on the farm required that the mother return to work as soon as possible. This caused most mothers in 18th-century Europe to send infants to wet nurses, who often had many charges at once. This practice denied infants adequate access to breast milk, often the one source of uncontaminated nourishment in pre-modern societies.

Also, children in pre-modern Europe were frequently put to work at age seven and were often beaten. This sort of treatment was not restricted to the lower classes — Frederick the Great of Prussia and Henry IV of England both complained bitterly of the beatings they received as children. This kind of violent upbringing adds to the high levels of stress an individual feels, and creates what psychiatrists call a "learned helplessness" response.

In the 18th century, Enlightenment philosophers first recognized that continued, affectionate contact between parent and child was a key predictor of health. It wasn't possible for the lower classes to put such findings into practice, however, until industrial productivity increased to the point where one breadwinner could support a family. This came about in the late 19th century and allowed mothers to stay home

Illustration by Melissa Mendoza

with their children, and children could go to school instead of working.

In sickness and in health

Another psychological factor that likely contributed to the decline in mortality rates is the development of the concept of "romantic love."

The idea of romantic love can be traced back to the minstrels of the Middle Ages, but it was not until the 18th century that it was considered fashionable for a man to really be in love with his wife. Romantic love meant that for the first time a woman's satisfaction was considered important for the success of a marriage. It helped transform marriage from an institution based on economic necessity and moral duty to one based on mutual affection.

Study hard, live longer?

The correlation of health and education is another example of the role of psychology in determining mortality rates. Education is one of the best predictors of health. In fact, there is a closer correlation between education and health than between income and health. College-educated people reported to be in excellent health 30 percent more than people without a college education.

Some believe that the reason educated people are healthier is because they are more likely to follow the dictates of health authorities. But many of the treatments prescribed by health authorities in the past are now regarded as useless or even harmful. Still, there is a consistent correlation between education and health.

A likely explanation for this link may be found in the fact that increased education leads to a sense of control over one's surroundings, and banishes fatalism. Perhaps this positive attitude is more important than any of the specific measures an educated person might take to improve his or her health.

Life unraveling

The trends responsible for the remarkably high life spans in modern society have unraveled in the last several decades. Divorce has skyrocketed, child abuse has increased, academic achievement has declined, and women have returned to the work force, thereby reducing the time parents have to care for their children.

In the past, these types of conditions have historically been associated with high mortality rates. Perhaps if our society makes a conscious effort to try to lower the levels of stress, abuse and divorce, we can defer this tragic consequence. ❖

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Peter Kauffner

Age: 27
Year in school: Senior
Major: Computer science

Peter was once a columnist for *The Minnesota Daily*. These days he is a candidate for the state senate in District 61. He likes to read, study history and campaign for public offices.

Creative technology

Engineers adapt to differences in people

By Karen Bantes
For MinnesotaTechnolog

Whoever says engineers aren't creative isn't looking at the large variety of technology that exists in today's world. Since every person is different, technology has to be able to adjust to those differences. People have different body types and different needs, and technology has adapted by providing machines and chemicals to help people better survive the demands of everyday life.

Dentistry

Engineers have come up with a metallic solution to help people with missing teeth. The element Titanium is now used by dentists to strengthen bones to hold tooth implants.

The Titanium — similar in looks to a metal bullet — is drilled into the patient's gums. When the teeth are implanted, the bone grows through the metal. Titanium is very useful because it is compatible with body chemicals, so it is not usually rejected. It also aids in the secure placement of dentures, crowns and bridges.

For people with dark or stained teeth, dental technology has developed a tooth veneer to hide the discoloration.

The veneer — a kind of tooth "skin" — can change the color, shape and position of teeth. Veneers are placed on the teeth after the enamel is removed, giving teeth a more natural white color. Veneers are used mainly on adult patients with stained teeth caused by childhood fevers, harmful water minerals or chemical abuse.

There are three types of veneers. The first type, the plastic veneer, is made using heat and light. The second type is the porcelain veneer, which is heated and then ground to fit the tooth. The third type, the Dichor veneer, is made from glass. This type of veneer is the strongest and most expensive kind of veneer.

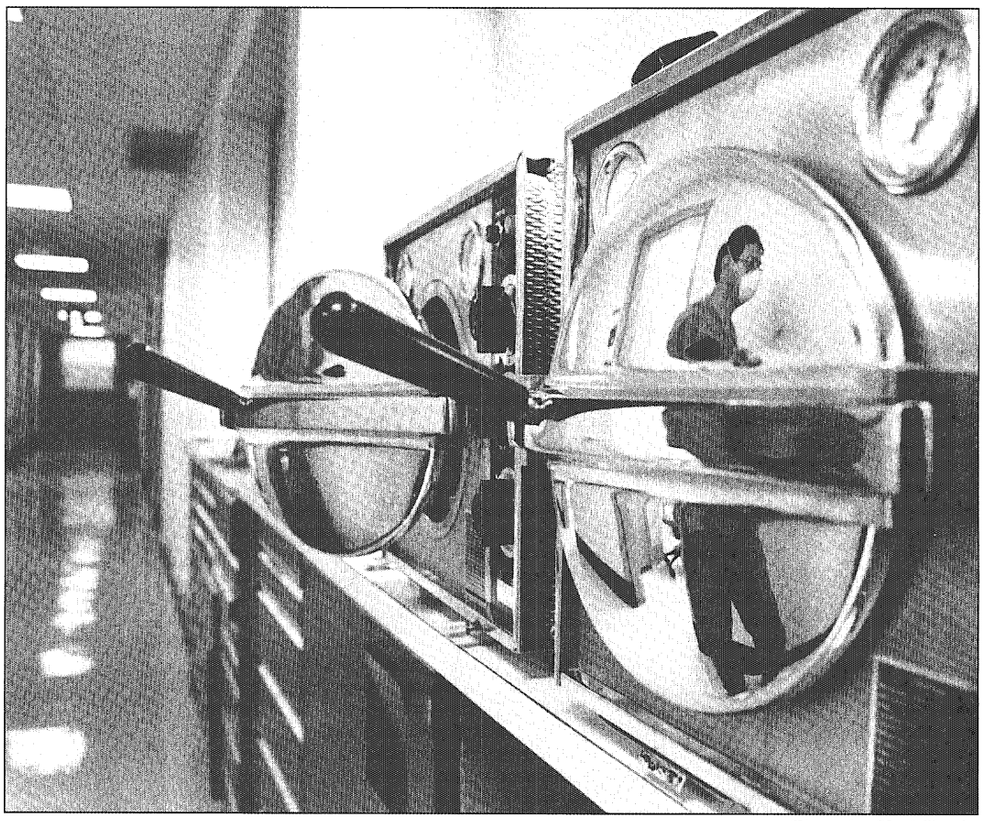


Photo by Kari Shuda

Engineers continue to create new technology to help with cosmetic and necessary dental procedures.

Another method of whitening teeth uses a bleaching tray. The tray holds a bleach containing the chemical carbomide, and is worn for two to three hours a day up to six weeks. This enables the bleach to reach all sides of the tooth.

Dental technology has also found a use for Gore-tex to aid in the cure of gum disease. Since the gum is lost around the tooth, Gore-tex is placed on top of a bone graft. The gum tissue is then sewn over the material, which is removed after four to six weeks. The Gore-tex allows for the flow of necessary body fluid to the bone graft, and prevents the migration of harmful gum cells.

NASA

People on earth are not the only ones who suffer from motion sickness. Space researchers at the Biomedical Operations and Research Branch at the Kennedy Space Center in Houston have come up with a way to treat astronaut motion sickness with a drug called promethazine. The drug is injected into the astronauts on the first day of flight to counteract the response of the body's vestibular system to zero gravity. Promethazine deals with motion sickness better than oral drugs such as scopolamine, which often has a variety of side effects.

Hair growth

In the last couple of years, researchers have used electrical stimulation on people with thinning hair. A device, resembling a beauty-salon hairdryer, uses four pairs of positively and negatively charged electrodes that sit one to five centimeters from the patient's head to cause an electromagnetic field. Intermittent electrical stimulation causes the alternate polarizing and depolarizing of the root and follicle, enabling cells to receive calcium, which stimulates the production of DNA and hair synthesis. This treatment is only for people with sudden hair loss, and they must undergo treatment for life.

Computers

Computer technology has also adapted to the differences of its users. Blind users, for example, need technology that caters to the senses of hearing and touch. A program called the Arrenstone Reader II uses synthesizers to transform words on a computer screen to an audible voice. The typewritten text is converted to an ASCII file, and with the synthesizer users are able to hear the printed computer words.

Also available for blind people is the ALVA Braille Terminal, developed by Human Ware Inc. The terminal includes a keyboard strip that contains translations of computer words and commands into the Braille alphabet. This keyboard contains 80 eight-dot Braille cells made of tiny plastic pins.

Articulate Systems, Inc. has also developed what is called Voice Navigator SW, to be used with the sound software of MacIIsi, LC, Classic II Quadras, and PowerBook 140 and 170. This software enables the computer to respond to the voices of its users — helpful for those who have hand disabilities, speak a different language or who just have difficulty using the mouse.

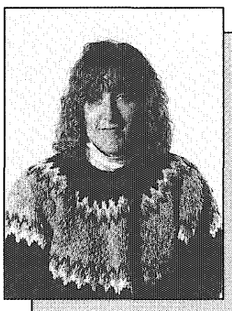
With this system, the user answers vocally to an on-screen prompt, which is faster than using a mouse. The program stores individual voices on files, so it can distinguish the voice commands of many different users. The voice command can be used for all menu items, to skip between different applications or to access windows.

At work

Engineers have also developed workstations that adapt to the differences in people's work habits. Repetitive-motion injuries are suffered by 50 percent of injured workers. To solve this problem, a company called Aero-Motive, Inc. developed "Ergomation" products that make up an adjustable workstation.

The workstation includes adjustable lights, copy holders, bins, tool balancers and torque arms that absorb up to 20 lb-ft of torque from electric power tools that weigh up to five pounds. The Ergomation products may be adjusted to accommodate users of different heights — from 5'4" to 6'1". All the components in the workstation adjust five ways: forward or backward on an upright system, as well as raised, lowered and tilted. The corners of the table and the steel components are softened, the CRT stands rotate 360 degrees and articulating arms put all the components within reach.

See Creative technology, page 22



Karen Bantes

Age: 21
Year in school: Senior
Major: Speech-communication major with a minor in Spanish

Karen would like to sail around the world and write a book, like Katherine Turner in the movie "The Jewel of the Nile."

Sexes from 7

psychologist Glen Wilson:

> I believe that men and women are equal in the extent to which they are predisposed by their biological nature to behave in particular ways and that sex roles characteristically adopted by men and women in response to their differing natures are equally valuable to the species as a whole.

Vive la difference . ❖

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China from 11

she may have many chances throughout life, despite how poor earlier attempts were. A student may get numerous opportunities to enter the engineering field. With hard work, dedication and money, a student can see the dream of an education fulfilled. This is considered one benefit of the American educational system.

One of the strengths of the Chinese system is that it matches careers and fields of study with individuals most suited for them. In theory, this makes the Chinese system more efficient than the American system, because it eliminates unqualified students from those fields. In practice, however, the efficiency has not yet been realized because the system has been difficult for the Chinese government to implement. Often finding jobs that fully use each person's education is anything but simple. For example, there have been instances of "history graduates driving trucks, graduates of cryogenic technology working in hotels, and graduates of applied physics working in warehouses." Thus, the potential efficiency of the Chinese system may be lost.

The question of which educational system is more efficient and which country will use technology to its fullest potential is a difficult one. Each system has advantages and disadvantages, proponents and opponents. With continued analysis of other countries' systems, the United States should be able to come up with a system that is more efficient and better suited for its citizens — and technological leaps could be commonplace in the 21st century. ❖

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Creative technology from 21

Another benefit of this workstation is the fact that it is not supported by other structures — it stands by itself. Also, linear screws in the workstation eliminate the problem of hydraulics, and adjustable tool balancers are included to balance tools that weigh between one and eight pounds. For the future, Aero-Motive plans to develop sit-stands and chairs to be used with the workstation.

Since few people are considered perfectly "average," today's technology is constantly adjusting to better accommodate the many differences in humans. Engineers, therefore, must be creative in order to adapt to the changing world and the variety of people in it. ❖

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THEN: "The water was everywhere.
Then our house fell apart.
It was a miracle my son survived.
So many died in the storm."

NOW: "We still remember the help CARE brought.
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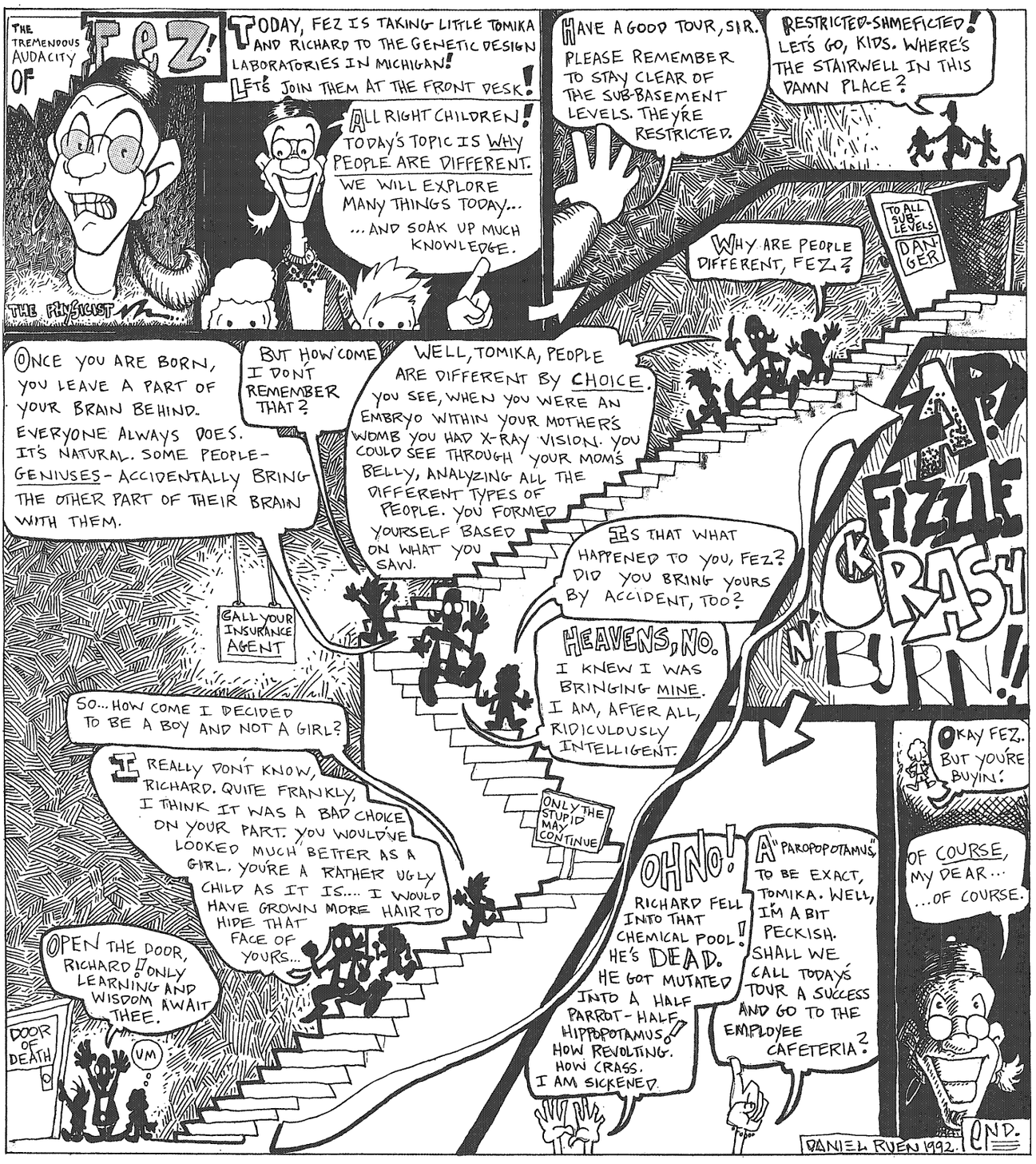
THE TREMENDOUS AUDACITY OF FEZ!
THE FINGERLIST
TODAY, FEZ IS TAKING LITTLE TOMIKA AND RICHARD TO THE GENETIC DESIGN LABORATORIES IN MICHIGAN! LETS JOIN THEM AT THE FRONT DESK!
ALL RIGHT CHILDREN! TODAY'S TOPIC IS WHY PEOPLE ARE DIFFERENT. WE WILL EXPLORE MANY THINGS TODAY... ...AND SOAK UP MUCH KNOWLEDGE.
HAVE A GOOD TOUR, SIR. PLEASE REMEMBER TO STAY CLEAR OF THE SUB-BASEMENT LEVELS. THEY'RE RESTRICTED.
RESTRICTED-SHMEFICTED! LETS GO, KIDS. WHERE'S THE STAIRWELL IN THIS DAMN PLACE?
TO ALL SUB-LEVELS
DANGER
WHY ARE PEOPLE DIFFERENT, FEZ?
ONCE YOU ARE BORN, YOU LEAVE A PART OF YOUR BRAIN BEHIND. EVERYONE ALWAYS DOES. IT'S NATURAL. SOME PEOPLE- GENIUSES- ACCIDENTALLY BRING THE OTHER PART OF THEIR BRAIN WITH THEM.
BUT HOW COME I DONT REMEMBER THAT?
WELL, TOMIKA, PEOPLE ARE DIFFERENT BY CHOICE. YOU SEE, WHEN YOU WERE AN EMBRYO WITHIN YOUR MOTHER'S WOMB YOU HAD X-RAY VISION. YOU COULD SEE THROUGH YOUR MOM'S BELLY, ANALYZING ALL THE DIFFERENT TYPES OF PEOPLE. YOU FORMED YOURSELF BASED ON WHAT YOU SAW.
ZAP! FIZZLE CRASH BURN!!
CALL YOUR INSURANCE AGENT
IS THAT WHAT HAPPENED TO YOU, FEZ? DID YOU BRING YOURS BY ACCIDENT, TOO?
HEAVENS, NO. I KNEW I WAS BRINGING MINE. I AM, AFTER ALL, RIDICULOUSLY INTELLIGENT.
SO... HOW COME I DECIDED TO BE A BOY AND NOT A GIRL?
I REALLY DONT KNOW, RICHARD. QUITE FRANKLY, I THINK IT WAS A BAD CHOICE ON YOUR PART. YOU WOULD'VE LOOKED MUCH BETTER AS A GIRL. YOU'RE A RATHER UGLY CHILD AS IT IS... I WOULD HAVE GROWN MORE HAIR TO HIDE THAT FACE OF YOURS...
ONLY THE STUPID MAY CONTINUE
OPEN THE DOOR, RICHARD! ONLY LEARNING AND WISDOM AWAIT THEE.
DOOR OF DEATH
VM
OH NO! RICHARD FELL INTO THAT CHEMICAL POOL! HE'S DEAD. HE GOT MUTATED INTO A HALF PARROT- HALF HIPPOPOTAMUS. HOW REVOLTING. HOW CRASS. I AM SICKENED.
A "PAROPOPOTAMUS," TO BE EXACT, TOMIKA. WELL, I'M A BIT PECKISH. SHALL WE CALL TODAY'S TOUR A SUCCESS AND GO TO THE EMPLOYEE CAFETERIA?
OKAY FEZ. BUT YOU'RE BUYIN'.
OF COURSE, MY DEAR... ...OF COURSE.
DANIEL RUEN 1992.
END.

MINNESOTA
TECHNOLOG
February 1993 • University of Minnesota • Vol. 73, No. 3

Scientific Mysteries

In this issue . . .

- From wormholes to cosmic strings: Will time travel continue to exist only in science fiction?
- U buckyballs bounce toward the future
- How far are we from unlocking the secrets of room-temperature superconductors?
- *and more ...*

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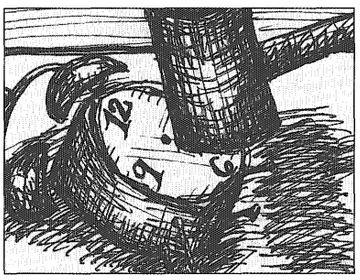
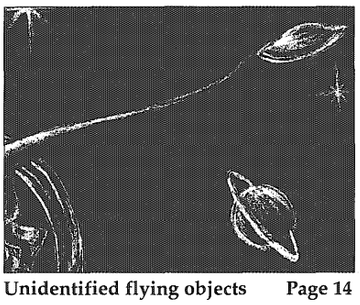


Another dimension **Page 4**



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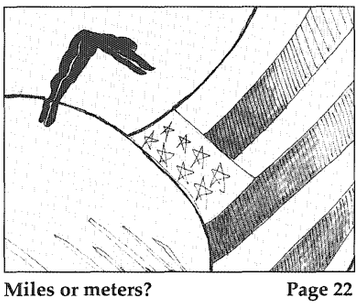

Miles or meters? **Page 22**

About the cover . . .

From superconductors to Stonehenge to space aliens, a myriad of questions are left unanswered by science.

Illustration by Jennifer Hughlett

MINNESOTA TECHNOLOG

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A computer hacker's horror

$999.

That's how much the computer system I bought just one year ago costs today.

My crumpled credit card receipt reads: $3,280.

And my heart is black.

Every weekend the computer ads in the paper jeer at me mercilessly. I gawk in disbelief at the circulars heralding supercomputers three times as good as mine, with laser printers and sound cards — all for less than my system cost me.

I wasted my money on a glorified Nintendo.

"Buying a computer is like buying a glass of water — one drink and it's gone," says one Control Data computer analyst.

Now they tell me.

Twelve months ago, my computer — an Acer 386DX with a 124-megabyte hard drive, Super VGA monitor and five drive bays — seemed ageless, invincible.

This summer, I'm told, manufacturers will stop making my machine.

With that in mind, when I sit down in front of my ancient terminal now, the excitement is gone. Even doing research pains me. As I wait for my computer to boot, the drive to load, the modem to connect, I can't help but dream ...

Recently, for instance, I needed some information about Texas. The Internet was somewhat useful, but in my mind, any worthwhile computer system would show me color photos of the state and play — in stereo — "Deep in the Heart of Texas."

Disgusted, I logged out.

So I set my sights on a CD-ROM and sound card. I'd get some of the best — a Multispin reader and Ad Lib Gold. At last, I told myself, I'd be happy.

Any worthwhile computer system would show me color photos of the state and play — in stereo — "Deep in the Heart of Texas."

Happy, that is, until I caught wind of those new-fangled optical disk players.

What can I do? Where will it end? Is it a big conspiracy to drive computer owners nuts?

I can't even turn on the TV anymore without cringing. It's just not "cutting edge" to have to turn your head to watch it these days. I should be able to open a television window on my computer screen and watch "Star Trek" with one eye while reading my E-mail with the other one.

Instead, my computer seems so outdated to me that when I walk into my office and catch a glimpse of it, it looks like it should be on the set of a science-fiction movie. Add a few lights, and three-headed aliens will be landing in my living room.

Hopefully they'll take my dinosaur machine with them when they leave.

I realize now I have only one option to save me from this insanity ... this horror.

I am once again waiting in front of my computer. This time, however, it's printing my ad: "Computer for sale," it reads. "One year old, price negotiable." ❖

by

Esther Haynes

Editor in Chief

Cosmic strings and other fancy things

By Peter Kauffner
For Minnesota Technolog

There once was a woman
named Bright,
Who traveled much faster
than light.
She went off one day
in a relative way,
And returned the previous night.
— Anonymous

The possibility of time travel has inspired scientists and writers since the early 19th century. Twentieth-century physicists have proposed various methods of traveling through time — often based on general relativity. The theory of time travel, however, creates logical contradictions and violates laws of conservation. Still, while some refuse to believe time travel is possible, others keep working with equations, trying to prove the idea is not so far-fetched. The debate has continued, unresolved, for over a century.

The concept of traveling through time is a relatively recent idea. Early forms of literature seem to be devoid of references to time travel. Some stories in pre-19th-century literature, however, talk of cultural heroes asleep in remote locations, waiting for the moment when their country needs them. The characters in essence defy the effects of time. Such stories are told about King Arthur in Britain, Emperor Frederick Barbarossa in Germany and Serbian leader Karageorge in Yugoslavia.

The earliest time-travel stories generally reflect the attitude — traditionally held by theologians — that the past is fixed and cannot be changed, not even by God. In *A Christmas Carol* (1843) by Charles Dickens, for example, Scrooge observes his past, but never tries to change it. Mark Twain's *A Connecticut Yankee in King Arthur's Court* (1889) is the first literary work in which a character not only observes the past, but actually changes events that have already occurred. It wasn't until 1895, however, when H.G. Wells came out with *The Time Machine*, that time travel was established as an enduring science-fiction motif.

Various factors in the late 19th century prepared society to be more receptive to the idea of time travel. As is evident in Goethe's *Faust* (1808), Mary Shelley's *Frankenstein* (1818) and Percy Shelley's *Prometheus Unbound* (1820), the 19th-century literary world was concerned that technology would allow humans to intrude into areas previously reserved for God. Time travel — a power beyond reasonable limit — epitomized such concerns. At one level, in his stories Mark Twain satirized the fear of progress. But at another level, he seemed to share this fear.

It is likely that new scientific theory was another inspiration for Twain and other time-travel authors. The Michelson-Morley experiment of the 1880s indicated that the speed of starlight reaching the earth was constant and did not vary with the motion of the earth — contrary to the teaching of classical physics. This experiment led some scientists to rethink their ideas about time and space.

Although Twain may not have been aware of the Michelson-Morley experiment, in 1909 he wrote the following commentary on the biblical story of creation: "It is quite manifest that [God] believed his fresh-made skies were diamond-sown with those myriads of twinkling stars the moment his first day's sun sank below the horizon; whereas, in fact not a single star winked in that black vault until three and half years after that memorable week's formidable industries had been completed."

As is obvious by this passage, Twain understood that since there is a vast distance between the earth and the stars, the starlight we see today has been in transit for many years. Twain's awareness that the finite speed of light creates different perceptions of time

for different observers came through in his writing.

In 1905 Albert Einstein proposed the theory of special relativity, which suggests that if an object goes faster than light, it will go backward in time. When the theory was first proposed, however, few could conceive of a way to approach that speed. Charged particles can be accelerated to near light velocities by electromagnets in particle accelerators, but do not break the light barrier. Massless particles such as photons — which transmit electromagnetism — travel just at the speed of light.

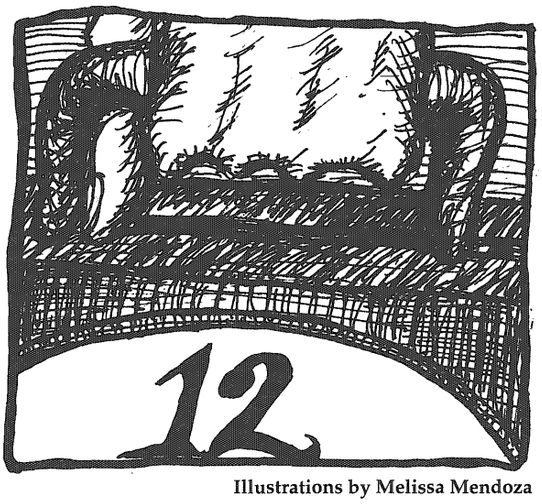
General relativity, completed by Einstein in 1905, offered one solution. According to this theory, space is warped by gravity. Three-dimensional space is depicted as a two-dimensional sheet of rubber that curves when heavy steel balls — representing planets and stars — are placed on it. If a ball is dense enough, it punches through the rubber sheet. The resulting hole, or "wormhole," is an intensely warped region of space-time where classical rules of physics don't apply. An object can go in one side and come out at any time in the past or future, at any place in the universe ... or even in another universe. In these ways wormholes resemble science fiction's "hyperspace."

Immediately after the theory of general relativity was published, Karl Schwarzchild — a German cavalry officer bedridden at the time — solved the equations of general relativity for the case of a "black hole." A black hole is a region where gravity is so intense that nothing can escape, not even light. The heart of a black hole is a called a "singularity," in which the mass of a star can be compressed to a single point. Schwarzchild's theory also included wormholes.

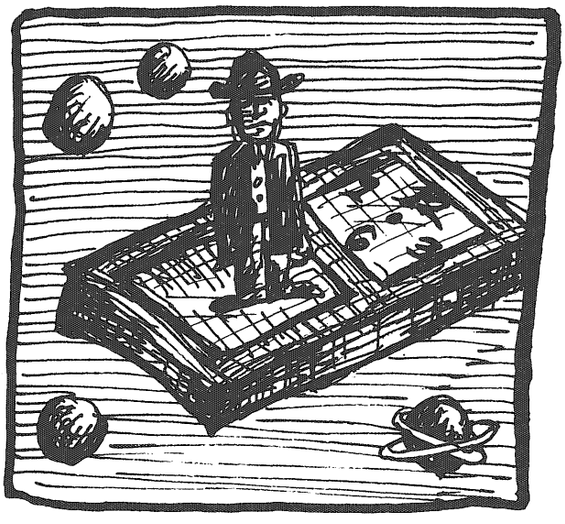
Since Schwarzchild's black hole did not rotate, however, any object falling into such an area would be "spaghetti-ized" — stretched out to resemble a piece of spaghetti — before it could reach the wormhole. This factor effectively eliminated the non-rotating black hole as a practical time machine.

With the increased use of computers in physics, however, it became possible to solve the equations of general relativity for a *rotating* black hole. In 1963, Roy Kerr worked out a description of a rotating black hole which showed that it was at least theoretically possible to survive a trip past singularity and into a wormhole.

Kerr's research launched the black hole as a popular method of time travel in science fiction, but recent research suggests that the chance of surviving a trip into a rotating black hole is actually slim to none. Unless the black hole were at least ten-thousand times as massive as the sun, a spacecraft would be ripped apart by tidal forces even before it reached the edge of the black hole. This means time travel would require a far more massive object than those generally found in most science-fiction stories. Furthermore, although wormholes may exist in time-independent descriptions of a black hole, they are unstable structures and are likely to close up at the slightest disturbance — including any effort by a spacecraft to fly through them.



Illustrations by Melissa Mendoza



In 1974, physicist Frank Tipler proposed using an extremely long cylinder as a non-lethal substitute for a black hole. A "Tipler cylinder" rotating at more than one-fourth the speed of light would give the same time-travel effect as a black hole, but without the crushing gravitational field. There's a catch, though — any cylinder of sufficient length rotating at that speed would likely collapse under its own gravitational pull.

Caltech physicist Kip Thorne showed in 1988 that a stable wormhole could exist independently of a black hole. Although it's unknown how such a wormhole could come into being, if scientists could trap a small wormhole between two electrically charged plates, it could be manipulated so as to allow travel into the past.

First, the wormhole would have to

be expanded with the help of "exotic matter" — a material with strength far exceeding that of any known substance. Next, one end of the wormhole would have to be accelerated to near the speed of light and then brought back to its original position. This setup would theoretically allow an object to return to the time when the wormhole/time machine was constructed.

In 1991, Princeton theorist J. Richard Gott proposed another method of time travel, this one involving two "cosmic strings" hurtling past each other. Cosmic strings are extremely thin, invisible strands of concentrated energy that could have been created during the big bang. According to Gott's theory, a rocket could loop around both strings and arrive home at the same instant it departed. Other physicists, however, have since attempted to demonstrate that Gott's setup is "non-physical" and could never develop in the real universe.

Photo by Viewfinders

Another approach to time travel ignores the space-warping effects of general relativity and relies strictly on special relativity. As an object is accelerated to the speed of light, its mass approaches infinity. Thus it requires infinite energy to accelerate any object moving slower than light speed to a speed faster than light. This "light barrier" could be overcome, however, if a particle were created moving faster than light. Such hypothetical particles are called "tachyons."

According to the equations of special relativity, a tachyon would move backward in time and have imaginary length and mass — giving the particle negative energy. Although conventional physicists generally view imaginary values for mass and length as non-physical, some theorists continue to research the tachyon issue. Among these is Gregory Benford of the University of California-Irvine, who proposed a "tachyonic antitelephone" in 1970. This idea uses tachyons to send messages in Morse code to anyone in the past with a tachyon receiver.

With the numerous theories about time travel today, many people still find it difficult to believe traveling through time will ever be possible. A common objection to the concept of time travel is called the "grandfather paradox." Suppose a man went back to a time before his father was born, and killed his grandfather. Then his father could never have been born, and therefore the man himself could not have been born. If he were never born, how-

ever, he could not have gone back in time to kill his grandfather. Thus the contradiction. In physics this is called a "causality violation" — the cause of an event occurs after the event that it caused.

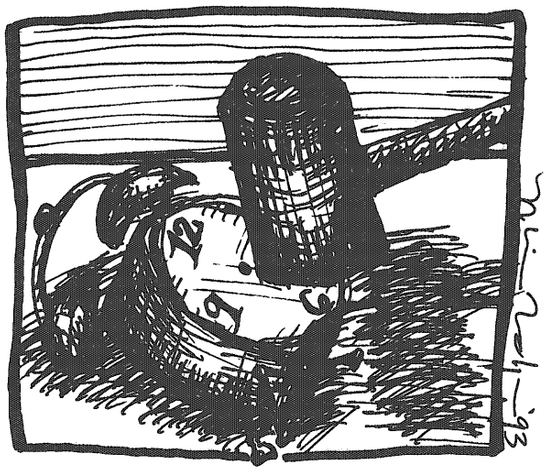


Illustration by Melissa Mendoza

One way to resolve this contradiction is by assuming the existence of parallel universes. If a person were to travel back in time, two parallel histories would branch out from the point in time to which the traveler went back. In one history the time travel would have occurred and in the other history it would not have occurred.

Another way to resolve a causality violation is to assume the future is fated or predetermined. This idea actually predates the concept of time travel. In the Greek myths of Oedipus and Perseus, dire prophesies cause characters to take precautions that in turn cause the original prophesies to come true. The characters in the myths apparently did not have the option to ignore the prophesies.

Even if scientists disregard the causality violation, however, time travel would violate some of the most basic physical laws. Suppose some people had a machine that could send an object back in time by one hour. If they put a diamond in the machine at 11 a.m., they'd have two identical diamonds at 10 a.m. — one diamond would have come from the past normally and the other one would have arrived from the future. But if additional mass could appear at unpredictable moments like this, the law of conservation of mass/energy (better known as $E=mc^2$) would be violated, as would other conservation laws.

Although a practical means of time travel may never be developed, some fear the consequences of potential technological advances in this area. Gott believes scientists should try avoid causality violations at all costs. "At some point, physics will have to find some mechanism by which these things are forbidden, or else learn to live with them," Gott said.

Nevertheless, as time-travel research continues, advances in this area could help scientists find flaws in current physical theory — and contribute to an increased understanding of the universe. ❖

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Peter Kauffner

Age: 27
Year in school: Senior
Major: Computer science

Peter's 1989-90 column in *The Minnesota Daily* was so controversial that *Daily* staffers joked he got more letters than Santa Claus. Peter hopes for a less-controversial career as a technical writer.

Superconductors still stump scientists

Photo by Michael Branscom

Dr. Allen Goldman of the physics department at the University of Minnesota, pictured here next to a superconductor, has proposed theories that explain high-temperature superconducting phenomena.

By David Mirelez
For Minnesota Technolog

For the past seven years, stories about superconductors have been the rage in bookstores and newsstands across the nation. It's difficult to browse through a bookstore or newsstand these days without seeing another piece written on the subject.

But the fact is, superconductors have been around for more than 80 years. Why are they suddenly generating so much excitement?

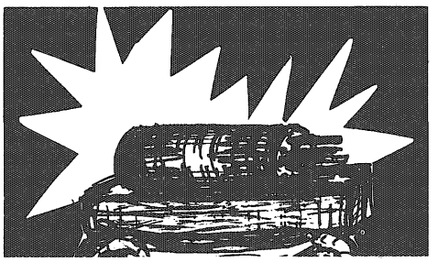
Superconductors — materials that conduct electricity without resistance — were discovered by Heike Kamerlingh Onnes in 1911. He found that mercury, when cooled to 4° Kelvin, offered no resistance to electrical current flow. This meant that none of the current's energy was lost when carried through the mercury at its "critical temperature" — 4° K.

Onnes' discovery inspired the scientific community because of the great possibilities associated with superconductivity. If an electrical current, for example, were sent around a circular wire made of superconductive material, it would flow forever without any loss of energy. This is a great advantage over conventional, non-superconductive materials — such as copper wire — which offer varying degrees of resistance to electrical currents. When a current is sent through these materials, some energy is always lost in the form of heat.

From 1911 to 1986, scientists continued to find superconductors with critical temperatures near absolute zero. In 1953, a vanadium-3 silicon composite was discovered with a critical temperature of 17.5° K. Fifteen years later, a composite of niobium and germanium was found to have a critical temperature of 23° K. Since the progress in finding higher-temperature superconductors was fairly slow, many researchers believed superconduction was only possible near absolute zero.

They were proven wrong in 1986.

Two scientists, J. Georg Bednorz and K. Alex Muller, discovered a lanthanum-barium-copper oxide ceramic superconductor that operates at 35° K. This discovery showed scientists that higher-temperature superconductors were possible, thus stimulating a new wave of research. Many scientists have since developed new superconductors based on the Bednorz and Muller ceramic — some with critical temperatures as high as 125° K.



Superconductor Theories

The discovery of higher-temperature superconductors forced scientists and researchers to rethink theories governing superconductors.

The original theory widely accepted by scientists was developed in 1957 by physicists John Bardeen, Leon Cooper and John Schrieffer. This theory, called the BCS theory, explained superconductors in terms of electron coupling. When electrons flow through a superconductive material, they are joined together in groups of two by phonons, which act as a "subatomic glue." As the electron pairs travel through a material's lattice structure, they create an obstacle-free path through which other pairs may travel. The path prevents the other pairs from colliding with the superconductor's structure. Any collisions would represent resistance to electron flow, and would result in a loss of electrical energy.

An obstacle-free path can be created only when no vibration is present in the material. To stop an atomic structure from vibrating, it is necessary to cool the material to temperatures near absolute zero — the exact temperature varies with the substance. Onnes, for example, discovered that mercury's structure stops vibrating at 4° K.

The BCS theory provided a good explanation for all superconducting phenomena observed before Bednorz and Muller discovered the oxide ceramic that superconducts at 35° K. But the theory fails to explain the new, high-temperature superconductors that were found as a result of Bednorz and Muller's discovery. In 1987, for example, scientist Paul Ching-Wu Chu found a yttrium, barium, copper and oxygen compound that superconducts at 92° K. At this temperature, enough vibration is present within the material's lattice structure to destroy any path created by electron pairs. If this is the case, why does the material superconduct?

Researchers have proposed many theories attempting to explain high-temperature superconducting phenomena. According to Dr. Allen Goldman of the Physics Department at the University of Minnesota, proposed theories fall into one of two categories: BCS-based theories and non-BCS-based theories.

One BCS-based theory reasons that oxides have unusually soft lattice vibrations. Since all high-temperature superconductors are oxides, this would explain why electron pairs could flow through high-temperature materials unimpeded. Even at high temperatures, the vibrations of oxides would remain relatively mild.

Another BCS-based theory explains high-temperature superconduction in terms of electron-

bond strength. The electrons of a high-temperature superconductor are bonded together more tightly than those of other materials, including low-temperature superconductors. This increased bond strength would keep electron pairs from breaking apart, even in vibration-rich structures.

Other researchers hypothesize that fluctuating repulsive forces are responsible for the high-temperature superconduction phenomena — a non-BCS-based theory. Between any two electrons, there exists a repulsive force. Some scientists believe, however, that this repulsive force exists only at close range, and if there is an intermediate distance between two electrons, they will attract one another. This attractive force is what would hold the electrons together in a high-temperature superconductor.

Although each of these theories has its merit, none can be proven. "(Present-day) technology is inadequate to test the theories," Dr. Goldman says. This lack of technology, he says, is a "major obstacle" in developing and proving a theory that explains superconductors.

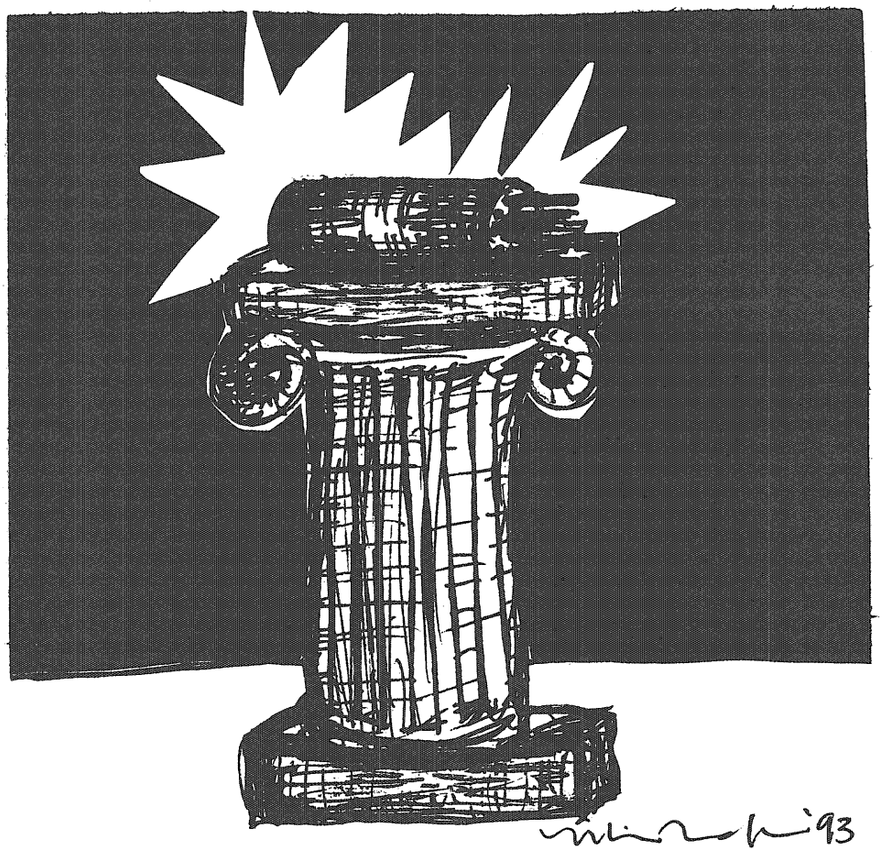


Illustration by Melissa Mendoza

Superconductor Applications

Scientists continue to look for a superconductor theory to work with, because with some basis to guide them, they could focus their attention on the search for room-temperature superconductors.

The discovery of materials that superconduct at room temperature — around 300° K — would allow engineers to finally unlock the huge potential of superconductor applications. Using superconductors in integrated circuits, for example, would vastly improve the performance of today's computers.

Currently, integrated circuits are made of semiconductive materials, such as silicon and germanium, that resist electron flow and generate heat. Because of this heat, integrated circuits cannot be packed together too tightly or they begin to melt. Superconductive integrated circuits, on the other hand, would not generate heat and could be packed closer together — greatly increasing the speed of the computer. Some computer engineers claim that superconducting computers could run ten times faster than today's best models.

Room-temperature superconductors could also be used to improve the efficiency and power output of electrical engines. "Superconductivity at room temperature is the key to any commercial application in the auto industry," says Robert Eaton of General Motors. With the increasing concern about the environment, some people have begun using electric vehicles as an alternate means of transportation. These vehicles are often less than ideal, however, because of their limited range and power. But by using superconductors, an electric vehicle would draw energy from a small, lightweight battery and have a range of several hundred miles. It would also provide the same amount of power as today's vehicles.

Scientists also envision using room-temperature superconductors in the power industry. A great deal of power is currently wasted in the generation, storage and distribution of electricity. Replacing conventional materials with superconductors would eliminate this waste. Some electric companies, for example, lose as much as $200 million each year because of inef-

ficient power distribution. If these companies used superconductors, this figure would likely be cut by 75 percent.

Another benefit of room-temperature superconductors would be the new sources of energy made available. Fusion energy, for instance, would be easier to contain with the help of superconduction. Fusion—the nuclear process of lightweight atoms joining together to form a heavier atom—produces a tremendous amount of energy without generating the toxic by-products associated with nuclear fission reactions. But since fusion reactions take place at around 200 million degrees Celsius they are difficult to control and inefficient.

Superconductive magnetic coils, however, could solve this problem. The coils create a magnetic field powerful enough to contain fusion reactions. Unlike copper and other conventional materials, superconductive coils do not generate heat and waste energy.

Complications

Although some engineers talk optimistically about the possible applications of room-temperature superconductors, many difficult problems must be overcome before such superconductors will be developed.

One problem plaguing researchers is electrical current limitations. Large electrical current loads destroy superconductive properties, even when a material has been cooled well below its critical temperature. The amount of electrical current necessary to stop a material from superconducting is called the "critical current density." When this is reached, the material reverts back to its normal conducting efficiency.

Large magnetic fields destroy superconductive properties as well. Magnetic breakdown of a superconductor occurs in two phases. First, the magnetic field penetrates the superconductor. When a material is cooled below its critical temperature, nominal magnetic fields do not penetrate or affect it. This characteristic is called the Meissner effect. But when the magnetic field reaches a certain strength, the Meissner effect is nullified. Nevertheless, at this stage the material continues to superconduct.

It is with the second phase of breakdown that the superconductivity is destroyed. This occurs at a magnetic field greater than the one required to eliminate the Meissner effect. The largest magnetic field a superconductor can withstand before breakdown is called the "critical field." As with critical current density, once the critical field is reached, the material reverts back to its normal conducting efficiency.

Researchers must overcome these problems before superconductors can be truly useful. Once a high-temperature superconductor theory is found and these problems are confronted, superconductor technology will vastly improve our lives. ❖

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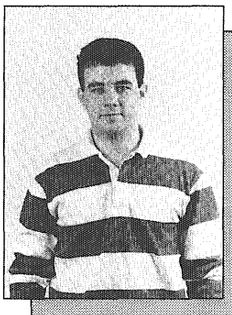


David Mirelez

Age: 21
Year in school: Senior
Majors: Mechanical engineering

David is working for 3M through the mechanical engineering co-op program, and hopes to continue working there after he completes his graduate degree. In his spare time David plays volleyball and reads fiction novels.

Stonehenge:

Ancient engineering project a mystery today

By Jeff Conrad
For Minnesota Technolog

Nearly 4,000 years ago a group of people set out on a mission — mile on end they heaved 26-ton and heavier sandstones. They went to great pains to stack them just right.

Why? No one is sure, and mathematicians, archaeologists and astronomers can only guess.

Some say Stonehenge was used as an ancient observatory of sorts, some say it was built for religious reasons and some say both. Known as one of the seven wonders of the world, Stonehenge is a group of jointed, upright stones on Salisbury Plain, in the English county of Wiltshire. No recorded history of the builders exists, however, so what information we have about Stonehenge is limited to archaeological finds.

The prehistoric engineering of Stonehenge is remarkable. To nineteenth-century poet and artist William Blake, Stonehenge was a symbol of raw power. And rightly so, because the tools available to Neolithic construction engineers were only muscles, ropes, levers, rollers and pick axes made from antlers of red deer.

Experts say the story behind the structure is complicated — and the mysterious Stonehenge hides many chapters.

Stonehenge

Stonehenge has a long history of construction, use and modification. With the use of carbon dating, climatological information and astronomical data, however, scientists estimate that the Stonehenge site was first used in the Late Neolithic period.

Stonehenge was initially erectecd over 4,000 years ago in the English county of Wiltshire. The construction took place in three phases over a period of approximately 1,500 years.

Photo by Viewfinders

A ditch 91.5 meters in diameter circles the structure's four series of stones. The outermost circle of stones is made of sarsen, a type of hard sandstone. The sarsens are 4.1 meters high and are connected by horizontal pieces across the top, called lintels. The next circle contains bluestone Menhirs, or single standing stones. The third set of stones is made up of sarsens arranged in a horseshoe shape; and the innermost ring is an oval comprised of about 20 bluestones. The largest bluestone of all — the "Altar Stone" — lies within this innermost ring. A huge upright sarsen, called a "Heel Stone," lies 4.8 meters northeast of the center of Stonehenge, near an old turnpike road from Amesbury to Shrewton.

Phase I

The building of Stonehenge occurred in three major phases over a period of two thousand years. The first phase, known as Stonehenge I, took place during the Late Neolithic period — around 3000-2700 BC.

Initially, the creators dug a ditch and constructed a bank about 2.5 meters high, in a 94-meter diameter circle. Fifty-six Aubrey holes — round pits dug into the chalk soil about one meter wide and deep — were also added at this time around the perimeter of a 86.6 meter circle. They were filled soon after they were dug. Some scientists say these filled holes could have been used for astronomical predictions.

Phase II

Stonehenge II was added around 2100 BC, during the Early Bronze Age. At that time, bluestones were added from the Preseli Mountains in southwest Wales. The stones were placed in a double circle that was never completed — resulting in a horseshoe shape. Also, an area on the northeast side was widened to about 8 meters, and a pair of Heel Stones were built. Researchers believe the builders dragged the stones from the mountains — which are 180 miles away — to the Stonehenge sight. In a recent experiment, 20 men dragging a 4-ton bluestone clocked at a rate of one mile per day.

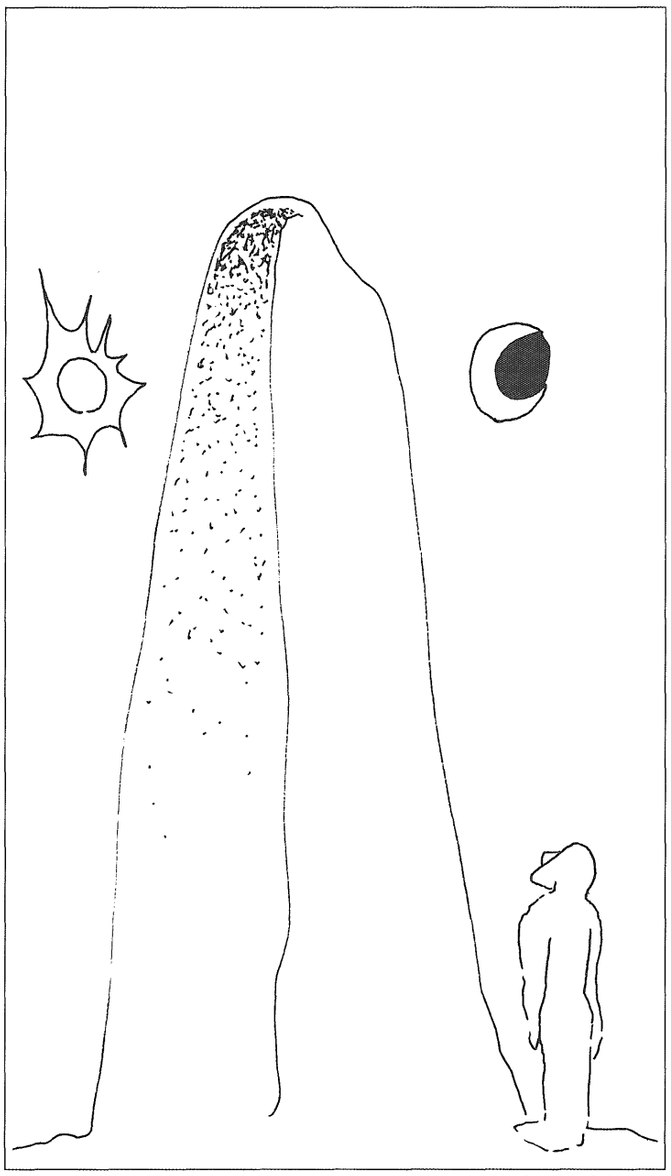


Illustration by Daniel Ruen

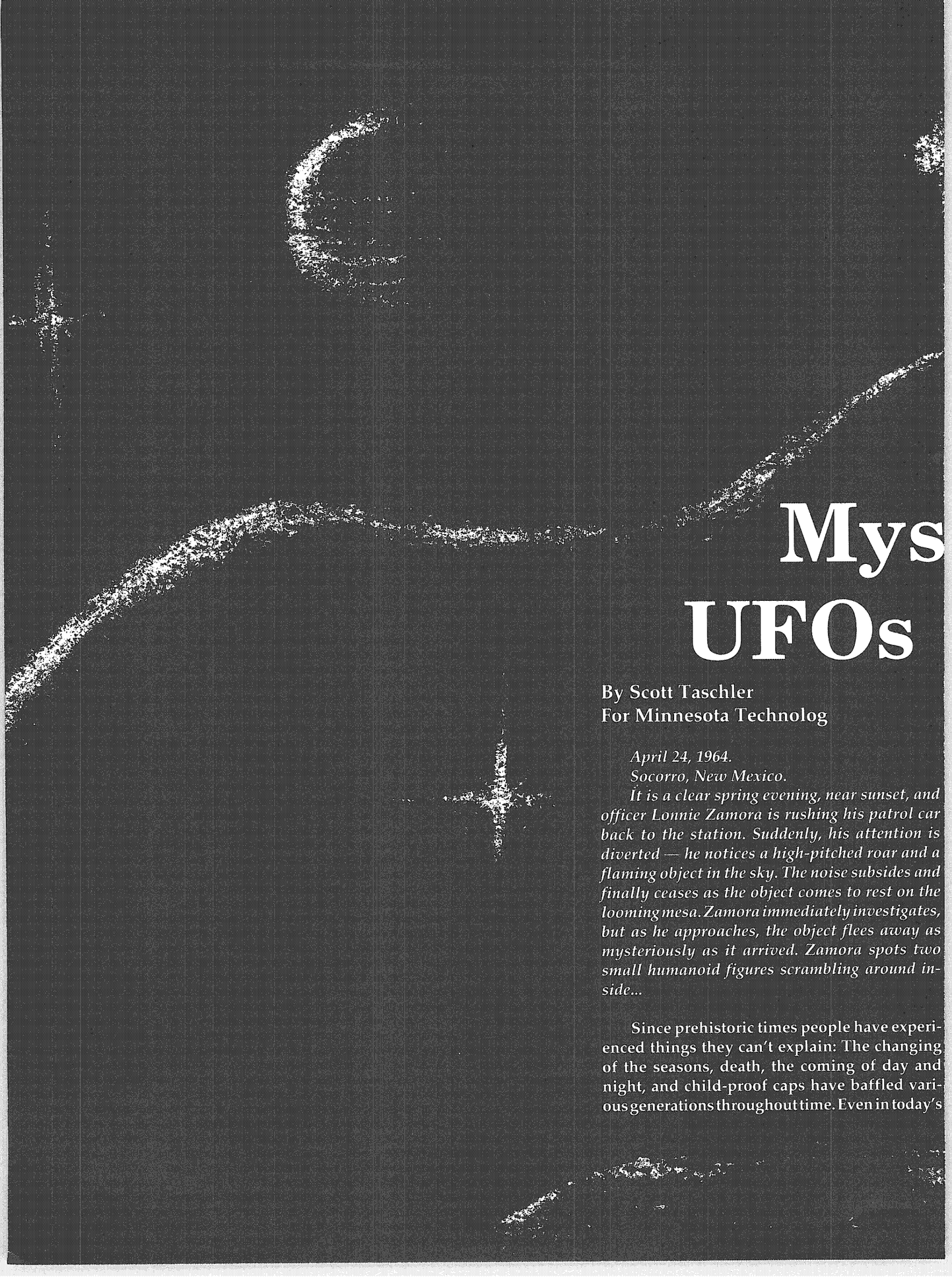
Phase III

When Stonehenge III was built in 2000-1500 BC, workers took down the stones added during Stonehenge II. The stones currently visible at Stonehenge were then added, comprising the sarsen stone circle and sarsen horseshoe. The sarsens came from a cap of tertiary sandstone, major outcroppings of which exist in North Wiltshire, at Marlsborough Downs.

Each sarsen stone has an average height of 4 meters, an average diameter of 29.25 meters^2 and an average mass of 26 tons — with the largest stone weighing over 45 tons. An arch of three stones — called a "trilithon" — lies inside the circle of stones. Each trilithon is made up of sarsens between 6 and 7.5 meters tall.

Each average sarsen, at 40-pounds pull per man, would require the strength of 250 workers to get it over the hills to the site. The largest sarsens were likely brought to the site using a land route, because water

See Stonehenge, page 25



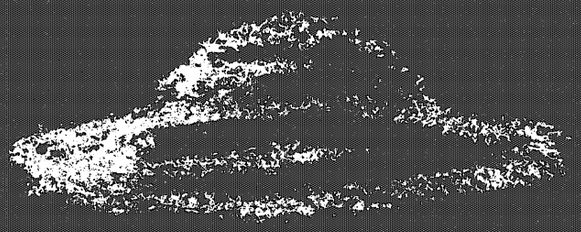
Mys
UFOs

By Scott Taschler
For Minnesota Technolog

April 24, 1964.
Socorro, New Mexico.

It is a clear spring evening, near sunset, and officer Lonnie Zamora is rushing his patrol car back to the station. Suddenly, his attention is diverted — he notices a high-pitched roar and a flaming object in the sky. The noise subsides and finally ceases as the object comes to rest on the looming mesa. Zamora immediately investigates, but as he approaches, the object flees away as mysteriously as it arrived. Zamora spots two small humanoid figures scrambling around inside...

Since prehistoric times people have experienced things they can't explain: The changing of the seasons, death, the coming of day and night, and child-proof caps have baffled various generations throughout time. Even in today's



tical

modern society people sometimes see things that few can understand.

Recently, it seems more people are seeing objects in the sky that can't be explained away. Unidentified flying objects are a diverse group of inexplicable things that have been lumped together into one class. Sure, some "sightings" can be explained as weather balloons or swamp gas, but what makes the UFO unique is that it could be anything at all.

We're limited only by our imaginations.

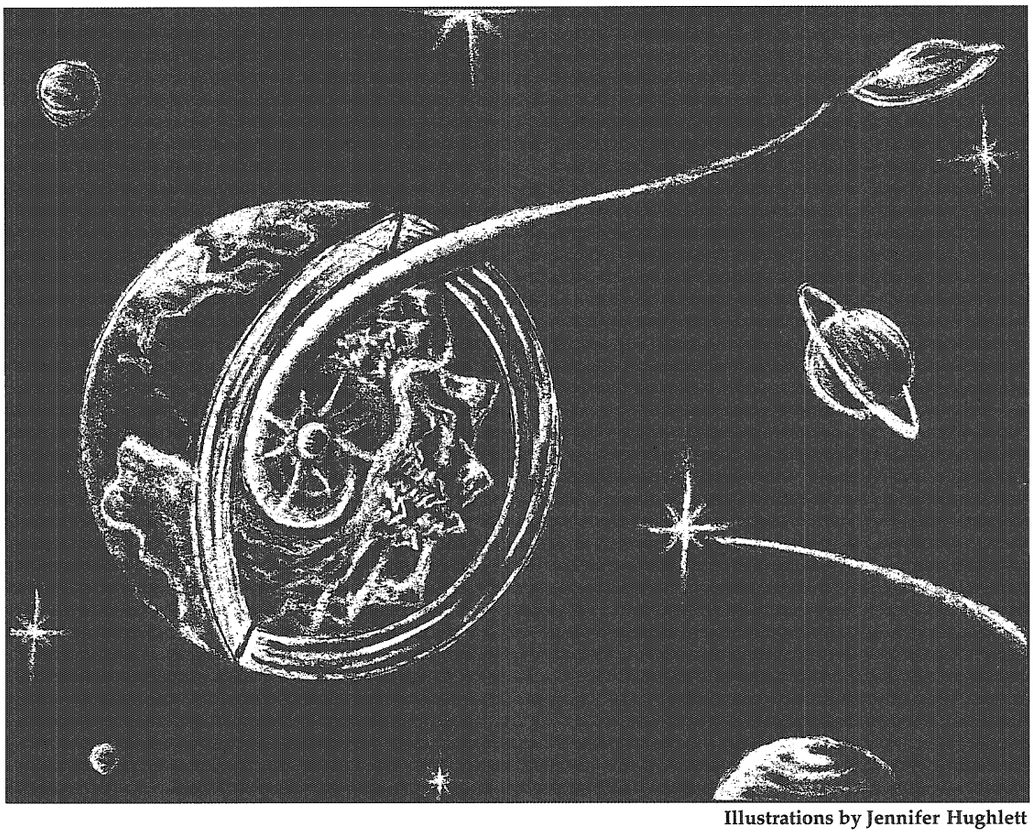
What should we do with this gray nebula in the universe of our knowledge? Well, true to our society's never-ending tendency to baffle itself, three basic factions have formed:

1) Those who believe UFOs are alien spacecraft that choose to visit our pinpoint of a planet.

2) Those who think the members of the first group are clinically insane.

3) Those who could go either way, and would rather be contemplating their navels anyway.

But who's right? Will we ever know?



Illustrations by Jennifer Hughlett

Doubting Thomas's

The fact is, a vast majority of UFO sightings are later explained. Usually they turn out to be meteorites, weather balloons or man-made satellites. But what about the rest, that small percentage that are true UFOs?

Phillip Klass, a writer in the field of avionics, put forth one theory. Plasma — usually considered the fourth state of matter — can be found drifting about through outer space and, in smaller quantities, in our own atmosphere. It consists entirely of ionized particles. On rare occasions this matter clumps together densely and forms a phenomenon called "kugelblitz," or more commonly, ball lightning.

Kugelblitz, being electrically charged and practically weightless, interacts erratically with the natural and artificial electromagnetic fields all around us. They dart and hover, or suddenly change direction at right angles to their current trajectory, should the fields around them change. At high energy they glow with an eerie aura from red to blue-white. They have even been known to appear to play "tag" with airplanes and other objects, demonstrating repellence and attraction of charged objects. In short, this phenomenon behaves exactly as many UFOs sighted by people around the world do.

July 29, 1953.
Port Huron, Michigan

Patrick Obost is an Air Force pilot making a nighttime training run on a B-24. He yawns listlessly into the night; he's done this a million times before. This time, however, will be different. His heart leaps with excitement when Air Defense Command orders him to investigate an unidentified blip on their radar screen just to his south. As he climbs above the cloud bank, a scintillating multi-colored light emerges. It accelerates towards Obost's B-24, circles, and leaps around it like a friendly puppy. After 15-20 seconds of frolicking, the object zooms off at breakneck speed: over 20,000 mph according to radar tracking. The report is confirmed by over 30 civilians.

Government looks for clues

The 1940s and '50s were the heyday of UFO research. The late 1940s hailed the beginning of the first "great wave" of UFO sightings in the United States. It fell under the jurisdiction of the U.S. Air Force to gather data on UFO sightings, as this was considered a possible communist threat. The bureaucratic paperwork formed mountain after mountain, and the first official UFO investigation, Project Sign — known publicly as Project Saucer — was formed to deal with it. After two years of intensive investigations, Project Sign came to a conclusion: People were seeing things in the sky that may or may not have been Russian weapons, but that could not be positively identified.

With these results, the bigwigs in Washington decided they needed a new name. So Project Grudge was born. And then Project Blue Book. And then the Condon Committee. And then the National Investigators Committee on Aerial Phenomena. One by one, the reports come back, and they invariably read something like: "... and the committee has determined that people, who may or may not be crazy, are definitely seeing things that may or may not exist, and cannot be positively identified. What we propose is another investigation ..."

1974.
Osyka, Mississippi.

Mrs. Kampfer is doing the nightly household chores, listening to a song on the radio. Without warning, the radio cuts out. Annoyed, she goes to the window to adjust the antenna. Sud-

denly, an oblong, shiny form screams by, just feet from the house. It flashes brilliant blue-white light, bright enough to cause the automatic street lights to turn off. Minutes later, deputies are summoned to the sight of a local shop where a burglar alarm rings into the night. They are shocked to discover the alarm ringing in synchronization with the blinking blue-white egg hovering sleepily above. The alarm stops when the egg glides into the inky blackness of night ...

Alien origins

At this point, the question is inevitable: If aliens did in fact exist, where would they come from? Researchers say the environment on the planets in the rest of our solar system are too hostile to foster native life forms. Any planetary being farther from the sun than Earth would be too cold for life as we know it. Well, Mars does get up to a scorching -27°C (-17°F) during its summer, but scientists have yet to discover evidence to suggest anything currently lives there. This leaves Mercury and Venus. Mercury has next-to-no atmosphere and temperatures ranging from 510°C (950 °F) during the day to -210°C (-346 °F) during the night. You thought last fall's temperature swings were extreme! Venus has an atmospheric pressure 95 times that of Earth, which would make walking on Venus approximately equivalent to walking on the bottom of the ocean. This, combined with its 427°C (800°F) ambient temperature — hot enough to melt lead — leads us to believe that in all likelihood, Venus and Mercury are truly lifeless.

Ruling out our neighbors leaves, well, the rest of the cosmos. At least we've narrowed it down a *little*. Could UFOs come from other solar systems? The nearest stars to our system are Alpha Centauri (4 light-years away) and Sirius (8 light-years away). This may not sound that far away, until you consider that even at 80,000 mph (twice the average speed of Pioneer 10 on its 620-million-mile flight to Jupiter) it would take over 30,000 years to reach the nearest star. Better hope there's a good in-flight movie ...

Another theory about aliens suggests that they could be right under our noses. American author William Reed first introduced this idea in 1906. Commonly called the "Hollow Earth" theory, it states that the earth has both an outer and an inner surface, and is in fact an 800-mile-thick shell with holes at both poles, allowing travel between the inner and outer surfaces. According Reed, the inside is lit by a small sun — approximately 600 miles in diameter — that gives the "Inner Earth" a wonderfully temperate climate with mountains, lakes, green vegetation and animal life. It is possible, the theory says, that the interior has its own advanced civilization, which could in turn be the source of all those bothersome UFOs zooming about our airspace.

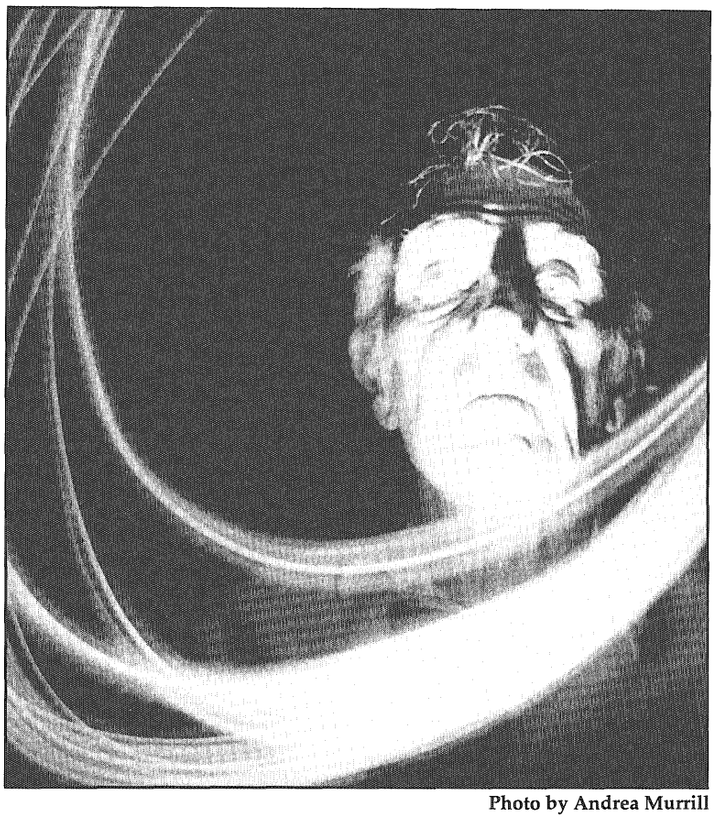


Photo by Andrea Murrill

Rear Admiral Richard Byrd allegedly reached this mystical land on an expedition to the North Pole in 1947, and again through the South Pole in 1956. It is reported that he flew 1700 miles beyond the North Pole into the polar opening, and crossed an iceless region with green vegetation, rivers and even a large animal resembling a woolly mammoth. None of these should exist near the North Pole, which led some to the conclusion that Byrd was no longer on the outer surface of the earth. They ignored the fact, however, that 1700 miles south would have put him around 65°N latitude, which is equivalent to Nome, Alaska — where they *do* have green vegetation *part* of

See UFOs, page 26

Scott Taschler

Age: 20
Year In school: Senior
Major: Electrical engineering

Scott is an honors student in the Institute of Technology. When asked what he does in his spare time, he cackles diabolically and returns to his mountains of textbooks.

Scientists get a kick out of Buckyballs

By Alice Chen
Technolog Staff Writer

Ladies and gentlemen, I would like to introduce you to a mystery in science. An award winner that is full of surprises, pure to its hollow core, and rarer than diamonds. Please welcome the C_{60} molecule, otherwise known as the buckyball....

For many in the scientific community, buckminsterfullerene — or "buckyball" — needs no introduction. The molecule is shaped like a soccer ball and gets its name from American architect Buckminster Fuller, who invented a geodesic dome with the same symmetry. At a glance, the fine black C_{60} powder looks as if a crazed student did the Mexican hat dance on a piece of charcoal. But whereas a gram of powdered charcoal is worthless, a gram of pure C_{60} fetches one- to two-thousand dollars.

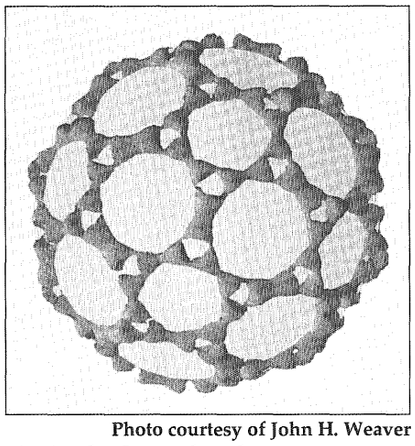


Photo courtesy of John H. Weaver

A single C_{60} molecule.

About two years ago, the University of Minnesota began research on what was named the 1991 Molecule of the Year by *Science* magazine. Today, with grants from the National Science Foundation and the Office of Naval Research, a 15-member team at the University is collaborating with scientists from Rice University and a group from Japan to learn more about this curious carbon lattice.

Pieces of the past

Although Richard E. Smalley discovered the existence of the buckyball in 1985, it wasn't until May of 1990 that Wolfgang Krätschmer and his colleagues in Germany, and Donald Huffman and his colleagues in Arizona, learned how to form C_{60} in large enough quantities for scientists to do substantial research.

Professor John H. Weaver of the chemical engineering and materials science department has studied many properties of C_{60}. Since research on buckyballs goes back only a few years, however, there is much about buckminsterfullerene that is unknown — something that Weaver and other scientists hope to change. They believe fullerenes could play a role in the technology of the 21st century.

Exploring frontiers

Fullerenes have produced several surprises. The carbon structure has been used in a process in which a substance — such as potassium, for example — is sandwiched between two layers of C_{60}. The added substance can give up electrons to fullerene, causing it to show superconducting qualities. Also, similar experiments that combine the molecule with other elements show the molecule to have magnetic properties.

Since buckyballs are made of carbon with strong covalent bonds, the structure is very difficult to break; graphite and diamond are the only other forms of pure carbon. Weaver

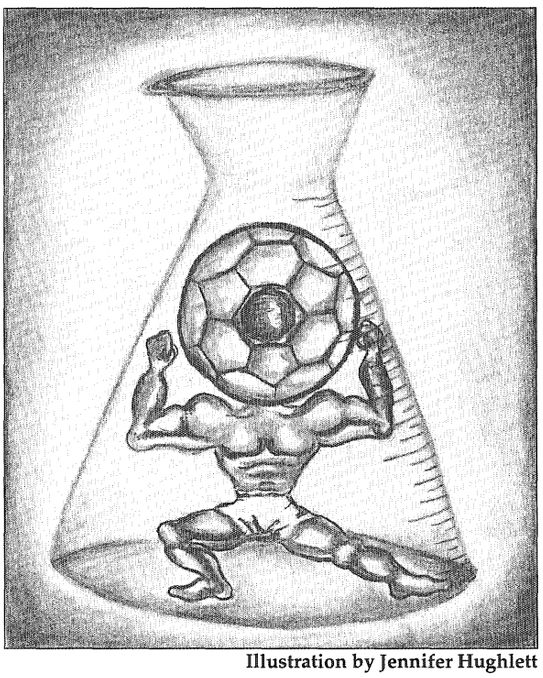


Illustration by Jennifer Hughlett

and his team of collaborators are studying ways to crack open the spherical shell long enough for an atom of an element — in particular uranium or scandium — to pass through and be captured as the shell closes. "It'll be interesting to investigate the properties of these novel forms of matter. Some may prove to be the keys of tomorrow's technologies," Weaver says .

The search continues

As more is learned about this uniquely symmetrical molecule, more questions arise. Scientists are researching to find out why C_{60} is a good superconductor, whether the molecule is toxic and what are possible future applications of the molecule. They continue looking for answers to these and other questions — answers that will lead to more mysteries, and more discoveries.

The buckyball burst upon the scientific community with an attention-getting name and an attention-getting structure. After two years of research, it is still capturing our attention with its novel "personality" and the possibility of what is yet to come. A few years from now the pieces of the puzzle may be in place, or perhaps the puzzle will still be ragged around the edges. Regardless, keep your eye on the buckyball. You never know which way it will bounce. ❖

See Buckyball sources, page 26

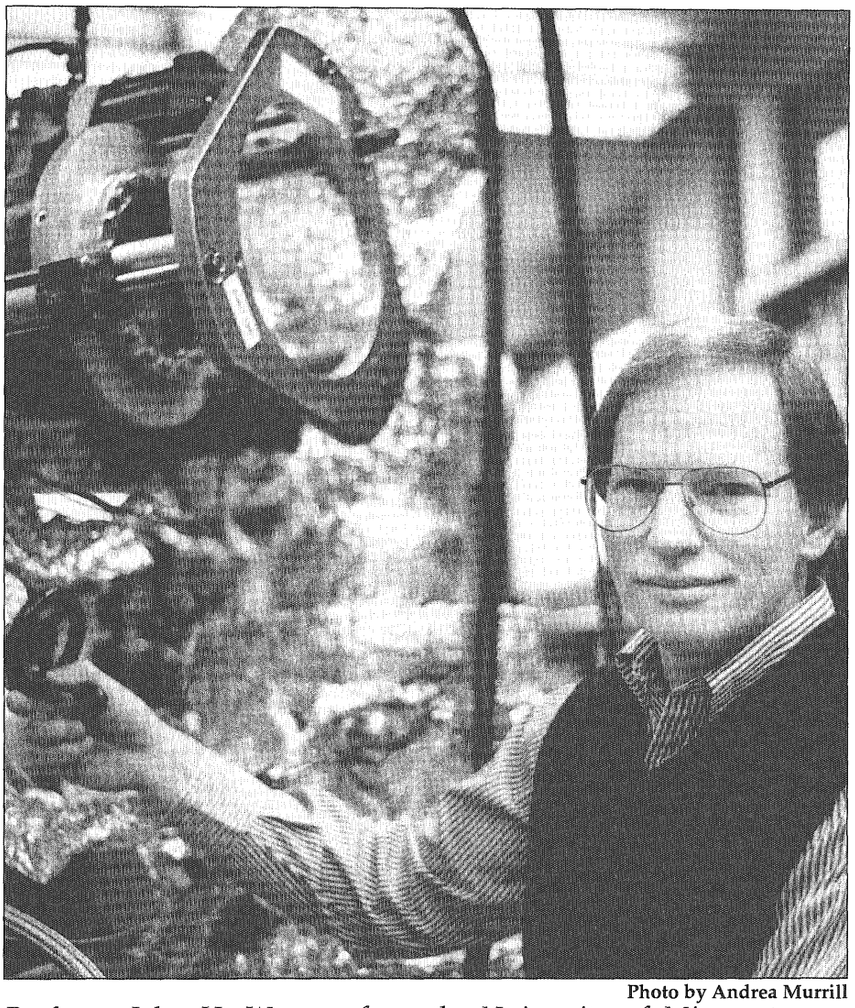


Photo by Andrea Murrill

Professor John H. Weaver, from the University of Minnesota chemical engineering and materials science department, operates equipment used to study the C_{60} molecule.

Alice Chen

Age: 21
Year in school: Senior
Major: Scientific & technical communication and pre-physical therapy

Alice is glad to be graduating in spring. She hopes to be a forest ranger this summer in Washington state or California's redwood forest.

Unearthing the Maya temples

By Wade Petrich
For Minnesota Technolog

Impressive architecture can be found all over — the Sydney Opera House in Australia, the Parthenon in Greece, the Taj Mahal in India — but few structures rival the ancient Maya pyramids in South America.

Between 1200 B.C. and A.D. 900, the Maya people lived in thriving settlements in Southern Mexico, Belize, Guatemala, Honduras and El Salvador. They were a relatively modern civilization, with advanced writing, accurate calendars and elaborate architecture. The Maya's structures were so durable that some temples still decorate the landscape of South America.

The early temples — used mainly for worship — were generally quite small, around 27 feet high. As time went on, however, the temples were built larger and larger, reaching to heights of more than 175-feet high and spanning up to five acres of land. Often the new larger temples were built directly over existing temples, resulting in pyramids built on three or four older foundations.

Since the Maya society was made up of around 50 separate states, the building and architecture varied from place to place. In general, the earliest forms of temple construction involved the piling of dirt and rock into a mound on which a summit temple was built.

One group of people — the Cerros Maya — built temples with a layered foundation of soft lime marl, or "white earth," found underneath the hard capstone of the region. The people shattered pottery and mixed it in with the white earth, along with flowers from fruit trees. After the foundation was laid, the Mayas constructed the temple in the shape of a "T" — the stem was the stairway that rose from the base of the pyramid up to the plaza, and the arms held the sanctuary room and the galleries.

The temple and the stairway were raised by members of the building team and community workers, in an effort of mass collaboration. To ensure correct proportions and to accommodate the decorative panels included in the temple, the Mayas made numerous calculations during the course of the temple constructions. The entire construction was done without the help of metal tools, wheels or animals, and all the lifting was done by the male Mayas — who averaged little over five feet in height.

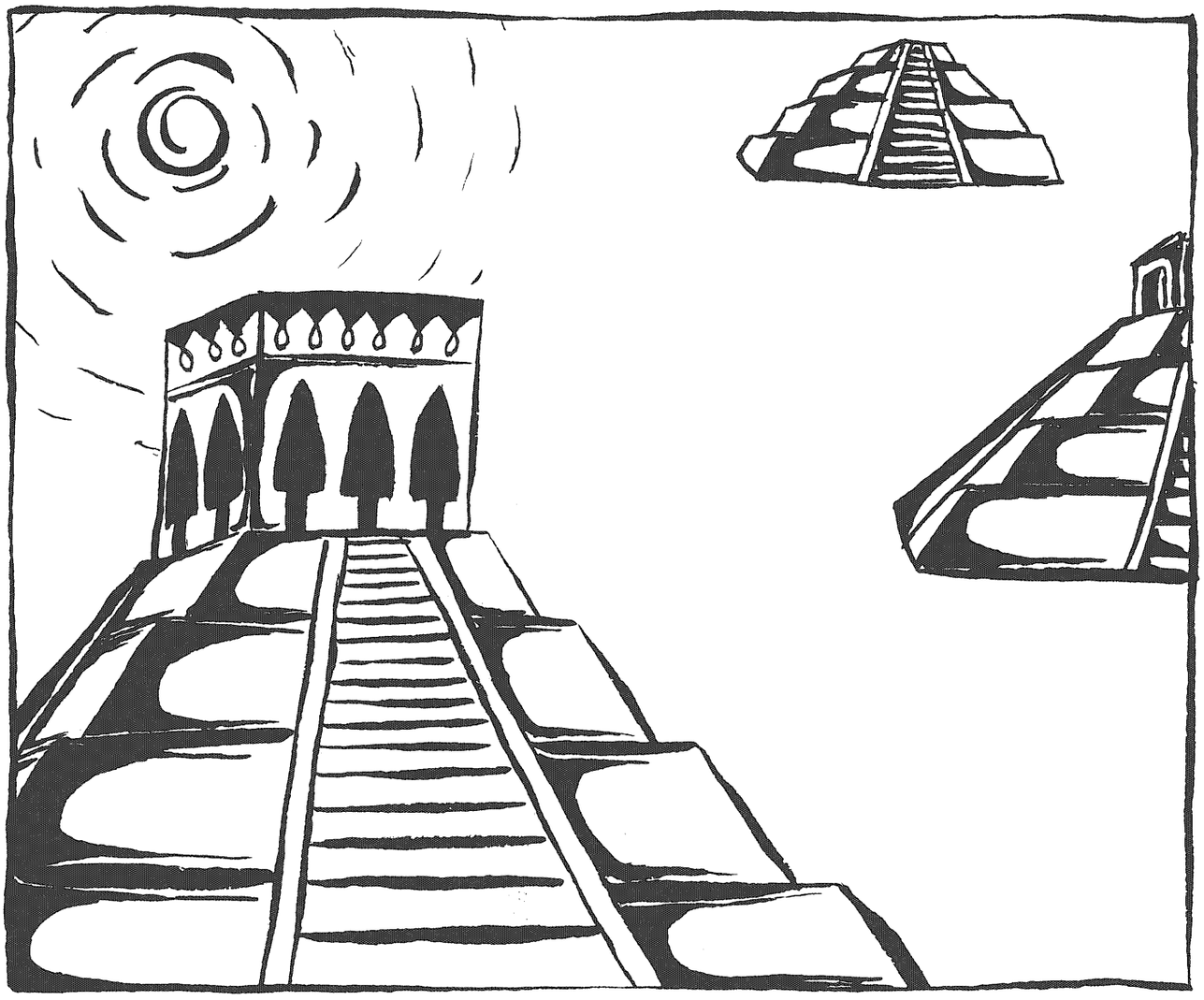
Illustrations by Jennifer Hughlett

The Maya building projects were generally established and coordinated by the king and his counselors. The king determined the decorative style of the pyramid, and the builders had to consult him throughout the construction.

The Uxmal ruins — in the lowlands of the rain forest — span an area of 250 acres. Uxmal was a city that flourished for nearly 300 years, beginning in A.D. 600. The constant rains in the area, however, were a great architectural challenge for inhabitants of the region.

One architectural trademark of the Uxmal Maya was the use of wood lintels over the doorways. The wood came from the Sapodilla tree, which grew only in the rain forest of the El Peten province 300 miles away. Great numbers of people were required to transport the wood to the locations of the temple construction sites. Regardless of the distance, the Uxmal used only Sapodilla wood, because of its durability and resistance to termites.

Tikal — one of the largest and oldest Maya ruins — was once a city that contained houses, ball courts, water reservoirs, storage bins, tombs, altars, steam baths and numerous large temples. The city's largest temple, the Temple of the Giant Jaguar, stood 187 feet tall from the base to the top of its roof comb. Other temples reached heights of 178 feet and 143 feet, covering six square miles. Massive amounts



of quarry stone were used in the temple constructions, and a large number of workers were required to burn the limestone to make plaster.

In many ways the ancient Maya were an advanced culture. The Maya temples still visible today are a testimony to the great civilization that lived and died away too early in South America. ❖

See Maya sources, page 26

Wade Petrich

Age: 22
Year in school: Senior
Major: English

Wade is a free-lance writer and an editor of a University newsletter. He enjoys living in the Twin Cities and hopes to be a novelist one day.

United States inches along behind a metric world

By Andrew Denker
For Minnesota Technolog

1983: Take off was smooth for Air Canada Flight 143 from Toronto to Minneapolis. But 41,000-feet up and halfway to its destination, the fuel tank read empty. Disaster was avoided only through the efforts of the pilot, who landed the Boeing 767 like a glider.

Just how the crisis happened was not clear until officials realized that grounds crew had unwittingly filled the airplane's fuel tanks using the wrong measurement system.

The ground crew apparently made an error in converting pounds of jet fuel to kilograms.

The United States is one of few countries in the world where the Systeme Internationale, commonly known as the metric system, is not the primary system of measurement. Instead the United States follows the English system, which, ironically, is no longer even used by England. With the United States still measuring in pounds, inches and ounces, differences in measurement arise when it deals with foreign countries — leaving situations open to confusion.

Confusion that — in cases like flight 143 — could turn tragic.

The emergence of two different systems

The invention of weights and measures is thought to have been one of humans' first developments. Primitive societies needed units of comparison for the same reasons people of today do — for sharing ideas about constructing shelters, making clothing, trading food or raw materials, and for describing the size of the fish that got away.

Early standards of measurement came from the human body. Ancient Babylonian and Egyptian records, including the Bible, indicate that length was first measured with the forearm, hand and finger. In much the same way, the first values for capacity — or volume — were likely measured by the handful. The first units of weight, however, were seeds of grain — a quantity's mass was measured by number of grains that equaled its mass.

These methods of measurement were useful at the time, but problems arose because of the lack of standardization. It was not until the early Saxon kings brought about a standardized system of units, known as the English system, that these problems were solved.

The English system has not changed much since it was first developed based on the "yard" as a measurement for the length of the kings' belts. To the system that also included the foot, inch, mile, furlong, pound and ounce, the Romans contributed non-decimal bases — 12 inches to a foot, three feet to a yard and 5,280 feet to a mile. These units and relationships became the backbone of a system with standard values and ease of use in commerce, causing it to be used widely throughout the English colonies.

In the meantime, while England was spreading this system to the Commonwealth, the French was developing another system — the metric system. Today, this system has evolved into the Systeme Internationale, a worldwide standard based on three units: meters to measure length, kilograms to measure mass and seconds to measure time. All other units in the SI system can be derived from these units. Also, in a departure from other systems, the SI system is based on decimal conversions — that is, on the multiplication or division of 10 and its powers. Conversions within the system can be made by simply shifting the decimal point.

Although the metric system was first greeted with skepticism and suspicion, its use was steadily incorporated in France following an 1840 French law making its use mandatory. From that point the metric system spread rapidly throughout the world. Today it is used in more than 90 percent of the world's countries.

Some wonder why the metric system isn't currently in use in the United States. There is no simple answer. Basically, when the opportunity arose, it was ignored. Early Congresses chose not to conform to the world's standard. It seems some Congressmen did not see the importance and others were blindly nationalistic, with the sentiment: "We're the best country in the world. Why should we conform to everyone else?"

Furthermore, after the massive industrialization of the country took place, the cost of changing systems of measurement rose significantly — doing substantial damage to the arguments of proponents of metric conversion. According to Frank Donovan in his book *Prepare Now For A Metric*

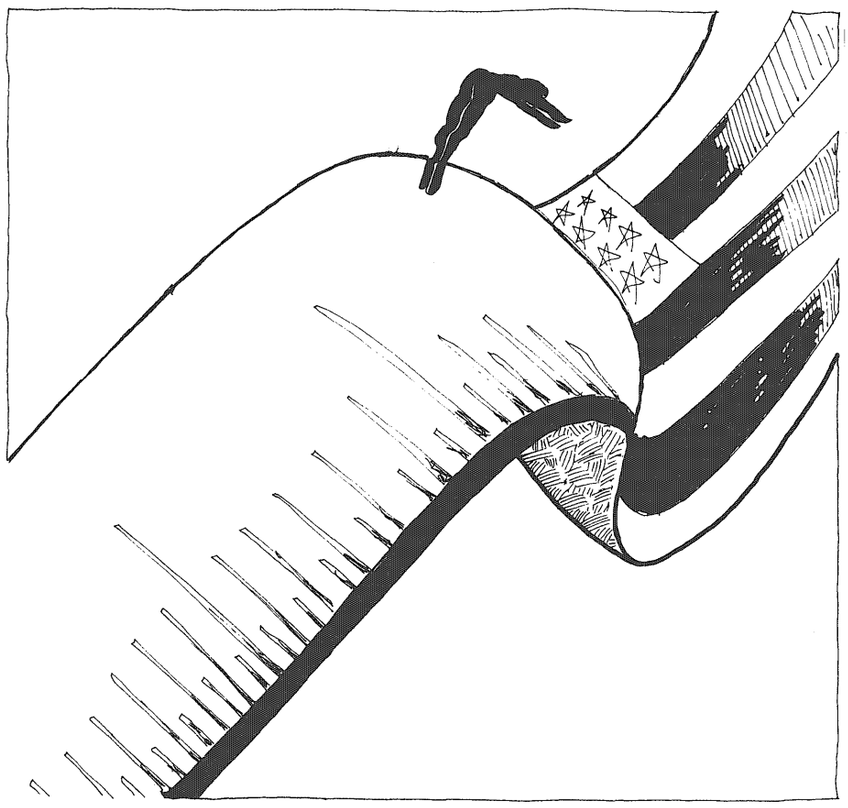


Illustration by Daniel Ruen

Future, "The debate on whether the United States should adopt the metric as its sole official system ... is perhaps the world's longest nonstop argument; it has continued for over a century and a half. At times, the conflict has quietly simmered for two or three decades ... then periodically, the controversy has livened to a raging boil." It appears currently the debate is quietly simmering.

Advantages of the metric system

The problems with the English system of measurement are in effect solved with the advantages of the metric system. Cumbersome conversion factors within the English system are replaced by the decimalized SI system, which reduces confusion over the derivation and meaning of certain units. There is also a distinct advantage in the metric system's wide-ranged acceptance and use over the isolationistic English system.

The advantages of the SI system's decimal nature can perhaps best be shown in the engineering profession. Donovan explains, "Engineers will be more affected by a change to the metric system than any other group ... for no other profession is more intimately associated with precise measurements and computations based on measurements. It has been estimated that the exclusive use of SI units in engineering computations shortens them by some 60 percent to 80 percent in length and time."

In his book *What about metric?*, Louis E. Brabrow explains one of the most confusing points of the English system: "a pound can mean either force (as in pounds required to break a rope) or weight (as in a pound of sugar); an ounce can mean either volume (as the number of ounces in a quart) or weight (as the number of ounces in a pound.)" This type of confusion is alleviated when using the metric system, in which the foregoing English units would be the Newton, kilogram, cubic meter and kilogram, respectively.

More important, the metric system defeats the English system of measurement in its worldwide compatibility. Dealing with foreign companies forces U.S. companies to either convert all units to the English system, or to manufacture their goods in the SI system. Either one of these decisions means extra work for American industries, giving the advantage to foreign competitors who already are familiar with the SI system.

As an answer to the metric system's decimal superiority, it should be noted that the United States is already using a decimal system of measurement — basically a decimalized English system. Fact is, in industries that deal with rather small dimensions, such as machining, all measurements are done in a decimalized English system. For this reason, the metric system's edge as a simpler, more user-friendly system becomes a "moot point," according to Myron Hanson, vice president of Gopher Machining. "Most of the measurement is done with respect to inches and thousandths of an inch," he says.

Jeff Tupper, a mechanical design engineer for Rosemount Engineering, agrees. "Everything we design is in thousandths of inches. I have a feel for what a thousandth of an inch is."

Nevertheless, the metric system's other advantages would compensate enough to make conversion an attractive option for the United States. It would result in a reduction of the number of units, and would also clear up the confusion surrounding the dual-purpose pound and ounce. Also it would put the United States in step

with the rest of the world regarding measurement. The ease of interchangeability between parts and tools, and the common ground in international communication would be a definite gain.

Costly conversion

The question that every proponent of metric conversion must answer is this: "Can the advantages that would be gained as a result of a changeover justify themselves over the problems that would be encountered?"

In this light, finding a strong-enough argument in favor of conversion has not yet surfaced. Concerted efforts have been made and the public nearly convinced, but the leaders of industry haven't seen a need pressing enough to change over to the metric system. And industries are not likely to make changes that do not readily present profitable advantages, especially when such changes would bring a host of problems.

The most serious problem with a mass changeover would be the initial cost. Machines would have to be retooled, gauges changed and new tools designed. Also, it would be necessary to have two sets of tools, machines and spare parts for the conversion period and for some time afterward. The enormous price tag placed on such a changeover, coupled with the time that such a conversion would take, could cost companies their livelihood. "In [totally] converting over today, we would lose ground on our competition," explains Tupper.

As yet, no one has found a reason pressing enough for metric conversion that would justify an immediate full-scale conversion. In these times of economic doldrums for the United States, industrial leaders are not looking to add to their costs with the staggering costs of such a changeover. The situation will likely remain as it is: in a state of limbo between exclusive use of either system.

Caught between an apple and an orange

Beverages are sold in liters, drugs are sold in milligrams and engines have specifications in metric quantities. These are everyday situations that Americans have become accustomed to — they know certain quantities in the English system and others in the metric system. This is the result of a major effort made in the 1970s to convert to the metric system. After this drive stalled, the changes made remained, but no additional conversions were pushed through — leaving the country in the current middle ground.

This middle ground is apparent in many companies. Some industry work is done in the metric system today, but most often if metric measurements are used in design and manufacturing, they are used along with English units. Such dual dimensioning can cause confusion if an operator mistakes one value's units to be of the wrong system. Therefore use of both systems is not a long-term solution for companies in the United States that are trying to reach a common standard with the rest of the world.

The future of measurement in the United States

In the near future, the United States will likely continue its use of both systems of measurement. The costs of immediate conversion to metric measures are just too expensive to pay all at once. If the United States hopes to keep its place in world industry, however, it cannot afford to drop the metric system altogether. Thus, U.S. schoolchildren will have to continue learning and working with two measurement systems.

The great metric debate may now be "quietly simmering" as Donovan stated, but it is definitely not dead. Professionals within the "real world" of industry, such as Hanson and Tupper, doubt that a full-scale conversion will occur in their lifetimes, but most scholars agree that a conversion is inevitable. Metric conversion will probably continue unit by unit, gen-

See metric, page 26

Andrew Denker

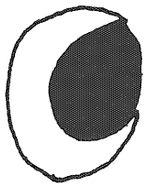
Age: 21
Year in school: Junior
Major: Mechanical engineering

Sure that '93 is the year the Cubs will finally call him up to the big leagues, Drew is keeping himself busy as a New Student Weekend counselor.

Stonehenge from 13

transport would have been nearly impossible. Over land, the largest sarsen would need to have been pulled by at least 500 men using a log and rope technique up hills, with an additional 100 workers setting down logs for use as wheels. At this rate, to transport one stone would have taken about a year.

Before the sarsens were erected, they were squared and polished with a heavy stone hammer the size of a football. The trilithons were held in place using a mortice and tenon system of joints — a system of projections and corresponding hollows for vertical connections. Also, a tongue-and-groove connection was used to hold neighboring lintels together around the circle. This technology was probably derived from wooden construction methods used at the time. The precise and smooth stones characteristic of Stonehenge's trilithons, however, are atypical for the generally irregularly shaped stone rings existing in the British Isles.



After the erection of the sarsens, the bluestones of Stonehenge II were dressed into shape, and erected in an oval on the site of another horseshoe-ring. This process was never completed, however, and the oval setting of stones was demolished. Also at this time — around 1550 BC — the unshaped stones still left from Stonehenge II were placed in a circle

At around 1100 BC, the surrounding stones were extended beyond Stonehenge Bottom, the nearby valley to pass over the hill to the east.

At completion, the Stonehenge III construction had a series of 16 lintels. Unfortunately, today few lintels remain — because stone is strong under compression, yet weak in tension.

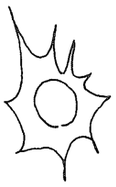
Why Stonehenge?

The proposed purposes for Stonehenge have varied: a temple of the sun, a temple of the serpent, a shrine of Buddha, a planetarium, a calendar in stone and even a gigantic gallows on which defeated British leaders were hanged.

In short, numerous plausible theories have been suggested, but none has been proven.

One common theory is that Stonehenge was an eclipse predictor – – eclipses were important phenomena to the religious men of the day. It was quite possible that by this time a calendar and astronomy had been worked out, though archaeologists question whether the mathematicians of the time were advanced enough to do so.

Experts say that Stonehenge I was likely built for astronomical purposes, and Stonehenge II and III were added for religious, awe-inspiring reasons. The stones at Stonehenge have been shown to provide predictions of lunar and solar eclipses. They could have been used in this way once or twice a year by priests as part of a death and rebirth festival. Some astronomers think that the Stonehenge structure can be used to calculate time along the Metonic cycle that occurs every 19 years. It resets the lunar orbit each time. The horseshoe-shaped circles have axes that line up with the mid-summer sunrise and sunsets. Also, the Heel Stone, when seen from the geometric center of Stonehenge, is aligned to coincide with the first sunrise on the summer solstice.



This data suggests that the builders of Stonehenge essentially wanted a clock. It seems to be an observatory and time keeper; though not a Timex, it takes a licking and keeps on ticking.❖

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Jeff Conrad

Age: 21
Year in school: Senior
Majors: Civil engineering and Russian area studies

Jeff is contemplating graduate school in environmental engineering, and says to watch for the newsgroup "alt. technolog. conrad. graduation" sometime next year.

UFOs from 17

the year. ...

So, with all this mystery around us, what should we do to make it easier for any beings that might be out there to contact us? Even now scientists are listening intently, via radio observatories, to whatever the universe has to offer — hoping to one day find a pattern hinting at intelligent intervention. Pictures, symbols and even a gold phonograph record have been sent into space on unmanned probes in order to give anyone who finds them a hint of what we're like, as well as a road map of how to get here. Scientists have also beamed a three-minute message into the great beyond, in the hopes that *someone* is listening. By the way, better mark your calendar — if anyone *is* listening, we can expect a reply in about 50,000 years. In the meantime, we earthly folk will have to be content to sit back, scan the night sky and watch the pretty lights.

Author's note: All the italicized scenes are based on actual reports on file with the U.S. Air Force. ❖

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Metric from 24

eration by generation — until the world is finally united under one standardized system of measurement. ❖

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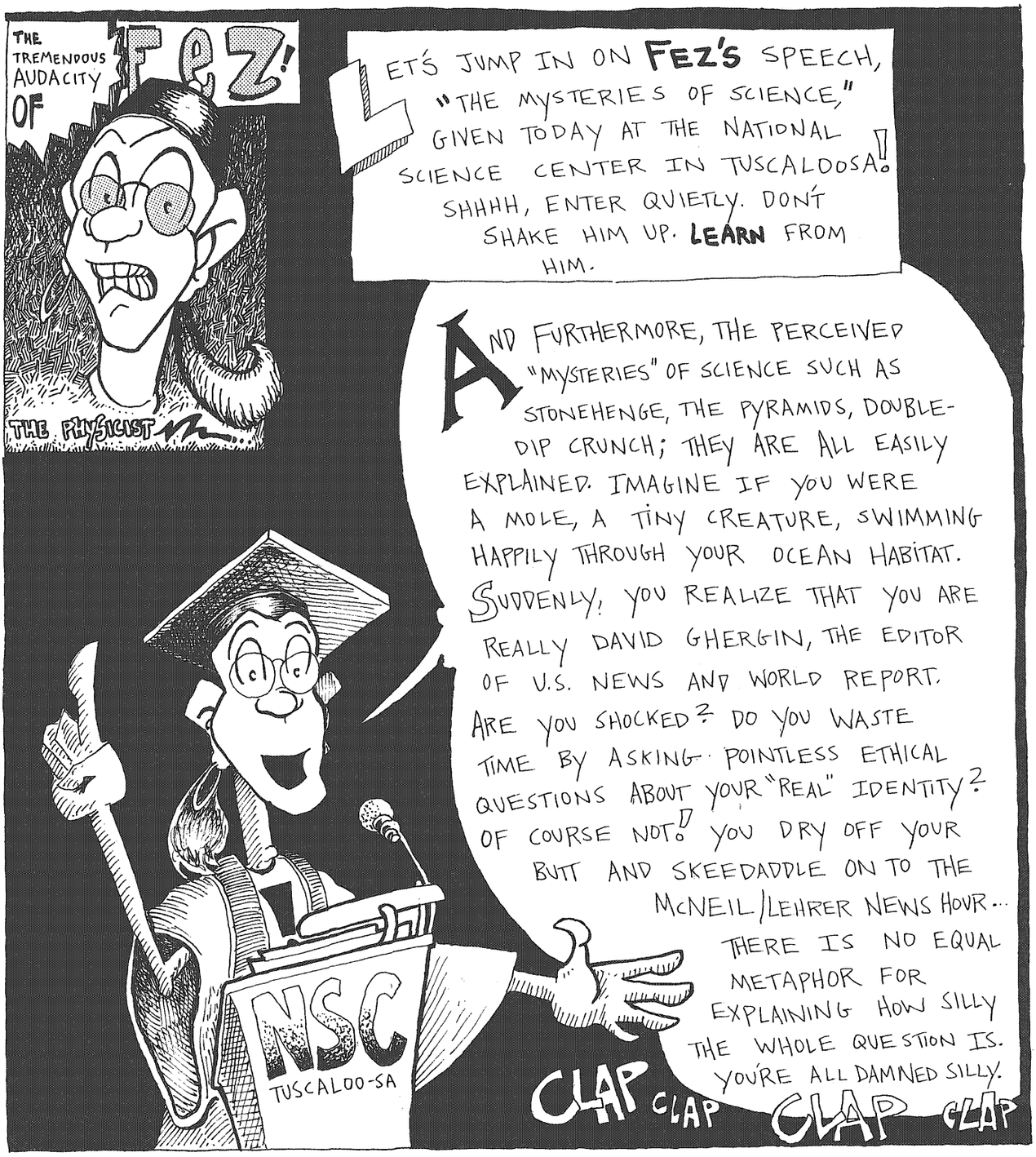
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THE PHYSICIST
LET'S JUMP IN ON FEZ'S SPEECH, "THE MYSTERIES OF SCIENCE," GIVEN TODAY AT THE NATIONAL SCIENCE CENTER IN TUSCALOOSA! SHHHH, ENTER QUIETLY. DON'T SHAKE HIM UP. LEARN FROM HIM.
AND FURTHERMORE, THE PERCEIVED "MYSTERIES" OF SCIENCE SUCH AS STONEHENGE, THE PYRAMIDS, DOUBLE-DIP CRUNCH; THEY ARE ALL EASILY EXPLAINED. IMAGINE IF YOU WERE A MOLE, A TINY CREATURE, SWIMMING HAPPILY THROUGH YOUR OCEAN HABITAT. SUDDENLY, YOU REALIZE THAT YOU ARE REALLY DAVID GHERGIN, THE EDITOR OF U.S. NEWS AND WORLD REPORT. ARE YOU SHOCKED? DO YOU WASTE TIME BY ASKING POINTLESS ETHICAL QUESTIONS ABOUT YOUR "REAL" IDENTITY? OF COURSE NOT! YOU DRY OFF YOUR BUTT AND SKEEDADDLE ON TO THE McNEIL/LEHRER NEWS HOUR... THERE IS NO EQUAL METAPHOR FOR EXPLAINING HOW SILLY THE WHOLE QUESTION IS. YOU'RE ALL DAMNED SILLY.
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MINNESOTA
TECHNOLOG
April/May 1993 • University of Minnesota • Vol. 73, No. 4

Personal Computer

In this issue . . .

- Good at math? You may be a left brainer. Some say you can use your right brain to unleash creative powers
- Artificial intelligence – soon your computer may think for itself
- Bug bacteria in computers of the future
- Nature vs. nurture: twin research at the U
- *and more ...*

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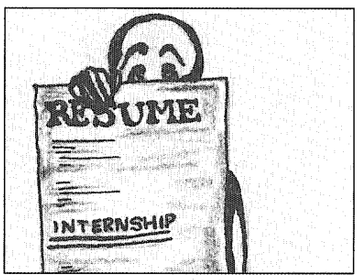
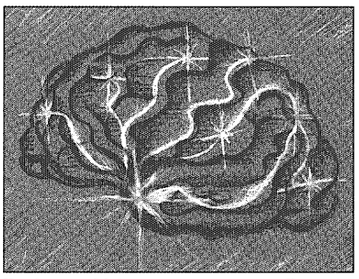
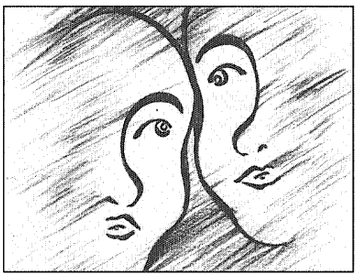
April/May 1993 • **University of Minnesota** • Vol. 73, No. 4



The only way to get a job **Page 8**



Brains and biocomputers **Page 14**



The same genes **Page 22**

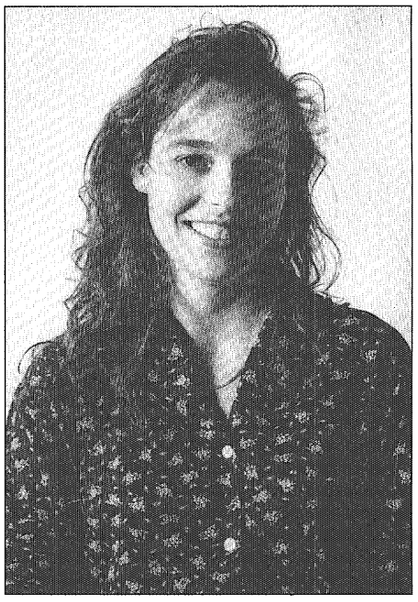
About the cover . . .

Even with new technology that attempts to imitate the brain, none yet come close.

Photo by Dilip Vishwanat

I.T. Week

Celebrate the tradition



by

Esther Haynes

Editor in Chief

This time last year, I sat at a booth at the I.T. Week Tech Fair, behind my construction-paper sign that read: "Join Technolog! Be heard!"

I patiently waited for potential writers and photographers to flock to my table and join the magazine.

I had even provided cookies to lure potential hires away from the plastic neon sunglasses that Anderson Consulting was giving away at their booth.

But instead of entertaining flocks of people, I found myself in a conversation with a man from another booth, who had no intention of joining Technolog.

He was just as bored as I was at that point, because all the other Techies were at the more-entertaining robotics exhibit.

But shortly after he left — as I was contemplating whether I should hop over to the exhibit with everybody else — I got my first real taste of the tradition of I.T. Week.

An older man approached my table and stared at my sign. For a second I actually wondered if he might want to write for me this year.

Then he introduced himself. "I was the editor of Technolog 50 years ago," he said.

I couldn't believe it. He had my job in 1942? He was more than just my predecessor — he edited during *World War II*. I was talking to Technolog history .... And I didn't know what to say.

In all my eloquence, I managed to utter one word: "Wow."

But I soon gained control and chatted with him for a while. He told me that he'd been around the world doing research and was in town for an engineering reunion.

He said he still enjoyed reading Technolog.

In those few minutes, I felt rejuvenated, motivated. It began to sink in that I was part of a long history at the Institute of Technology. I was proud to be involved.

This year is the 75th anniversary of I.T. Week at the Institute of Technology, and Plumb Bob wants everyone to show up and celebrate.

I say you should also go to get remotivated and excited about your futures in science.

I.T. Week, May 3 - 7, will feature a comedy troop, the "Building a New World" project, the Technology Fair and, as always, the I.T. Olympics.

Show up to see it all.

The week is organized by Plumb Bob, the leadership honorary society of I.T. They've been hosting it for 75 years, and they know what they're doing.

Don't forget to bring copies of your résumé to the Tech Fair on May 5 and 6, because many com-

I.T. Week logo courtesy of Plumb Bob

panies will be there to show off their new technology.

And enter the I.T. Olympics — the winner will get the "Baby Blarney" trophy, one of Plumb Bob's numerous wacky traditions. Plus you get to toss calculators and race your peers on a tricycle.

No other college on campus has a week to call its own. So go and be proud, go and schmooze the bigwigs, go and have fun.

You won't be sorry. ❖

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Are you in your right mind ...or your left?

By Andrew Denker
For Minnesota Technolog

If you're looking for new ways to unleash your inner creativity, author Betty Edwards may have the solution for you.

Use the other side of your brain.

Edwards says that people can increase their creativity and heighten their intuition — just by learning how to "awaken" the right sides of their brains. This concept is known as the two-mind theory, and Edwards says that her art students are proof that it exists.

In her book, *Drawing on the Right Side of the Brain*, Edwards lists many examples of marked improvement in the artistic abilities of her students after they did some of her right-brain exercises. Edwards says many of her students reached what she calls the "R-mode state," or heightened right-brain awareness, as they worked. They felt "alert, but relaxed — confident, interested, absorbed," she claims.

In the book, Edwards introduces several ideas that build upon accepted scientific theories about the brain. An individual's ability to draw, she says, is "perhaps mainly controlled by the ability to shift to a different-from-ordinary way of processing visual information."

People can initiate this change by recognizing that there are "two parallel ways of knowing," Edwards says. The left brain is logical, symbolic and sequential, whereas the right brain is intuitive, concrete and spatial, she says. But she doesn't stop there. According to Edwards, with the right side of the brain we "use intuition and have leaps of insight — moments when 'everything seems to fall into place' without figuring things out in logical order."

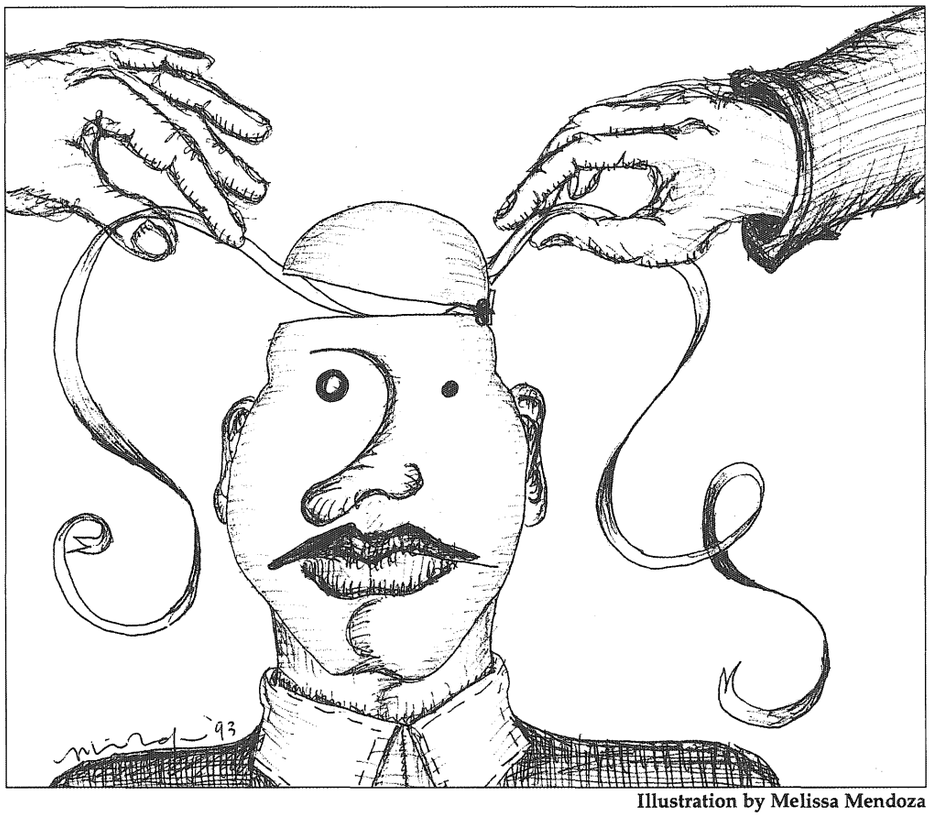


Illustration by Melissa Mendoza

Although few dispute that the two sides of the brain control vision, speech and movement differently, there is some debate as to what extent the two sides of the brain control different functions. Two-mind theorists believe that the right brain has great potential to increase creativity if only people could learn to "unlock" that potential. Others say the theory is merely scientific rumor and myth, and that the hemispheres of the brain are really quite interdependent. Either way, the idea has caught hold in our society and the concept of "right-brain" and "left-brain" thinking has infiltrated our popular culture.

Right-brain revolution

Scientists have shown that there

are functional differences between the hemispheres of the brain. The left and right sides, for example, work "contralaterally" — each controlling the opposite side of the body. Thus, the left hand is controlled by the right side of the brain. Also, studies of brain-damaged people show that speech and verbal processing are controlled, or "lateralized," in the left brain, and that spatial and visual processing are lateralized in the right brain.

It is on this concept of lateralization that the two-mind theory is based.

"By thinking in images instead of words, the right brain can recognize a face in a crowd or put together the pieces of a jigsaw puzzle, which would totally baffle the left brain," says Thomas Blakeslee, author of *The Right Brain*.

Blakeslee advocates the two-mind theory. In his book, he cites the "inner sports" theory of the mid-1970s. According to this theory, when a person plays a game, the right brain plays the game instinctively while the left brain attempts to distract the player. Thus, the key to inner sports is to enter a "zone" in which the left-brain interference has no affect.

Blakeslee says that this blending of both brains, with a heightened right-brain awareness when needed, is often what yields genius-like discoveries.

"Man's highest achievements are a result of using the full power of both halves of the brain together," he says.

People can begin this mind-melding by studying Eastern theories of thought, Blakeslee says. Nonverbal consciousness — or what Blakeslee describes as an advanced right brain — is found in some Asian philosophies, such as Taoism and yoga. Each of these disciplines, he says, is "the polar opposite of verbal Western intellectualism," and can lead to right-brain enhancement.

Edwards and Blakeslee both criticize the U.S. educational system for concentrating on what they describe as the left hemisphere's type of thought — analytical subjects and rote memorization of names and dates. This suppresses creativity and intuition, they say. They believe more information should be presented in "right-brain style," emphasizing hands-on learning.

"In time, I am sure," Edwards says, "my cognitive-shift method of teaching ... will be further developed by teachers and researchers in art and applied in other fields."

Just more labels

Not everyone, however, is as enthusiastic about the two-mind theory as Edwards and Blakeslee.

"There's a lot of overlap in the way in which the two hemispheres operate," says Stanley Coren, a professor of psychology at the University of British Columbia, "and there is little evidence that tremendous differences in thinking styles, so entrenched in the public mind, are really characteristic of the left and right hemispheres."

He says of two-mind theory proponents: "Sometimes being a scientist is more of a burden than remaining blissfully ignorant of the facts."

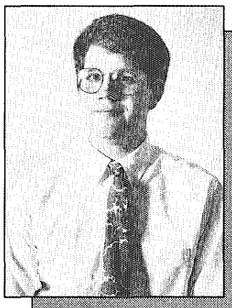
According to Coren, the popularity of the two-mind theory stems in part from the novelty of the new set of labels it gives to the public. He says the right/left brain theory serves the same function as astrology does in society: to label people and give explanations or excuses for behavior. These labels have no scientific backing, Coren says, because no one could be solely left-brained or right-brained.

Psychologists Sally Springer and Georg Deutsch are also skeptical of the two-mind theory. They claim that the popularity of the theory stems from society's tendency to try to use a simple theory to explain complex differences in people. Often oversimplification leads to overspeculation, Springer and Deutsch say. Although they agree that the left hemisphere of the brain controls the verbal functions and the right hemisphere controls the nonverbal, visuo-spatial functions, Springer and Deutsch say that anything beyond that is merely speculation or sensationalism.

Whole-brained or hare-brained?

Two-mind theorists may have little scientific evidence to back up their theories, but they're adamant that they see the results in people who have done right/left-brain exercises. Their opponents, on the other hand, call it mere sensationalism. So far, neither side has enough concrete evidence to definitively end the debate. Stuck at an impasse, they can only wait until science

See Right, page 27



Andrew Denker

Age: 21
Year in school: Junior
Major: Mechanical Engineering

Sure that '93 is the year the Cubs will finally call him up to the big leagues, Drew is keeping himself busy as a New Student Weekend counselor.

Virtual hype

By Anton Crane
For Minnesota Technolog

The idea of virtual reality has been all the rage in the past few years. Ever since the movie *The Lawnmower Man* debuted, the media has played up the vast possibilities associated with virtual reality. The entire world, people said, would be connected by computers, and everyone could sit at home in full virtual-reality gear and interact with others, seemingly face to face through computers. You could see, hear, smell and touch others who were hooked into the system. They described a completely separate world — inside of a computer.

The possibilities seemed endless.

Now it seems only the hype is endless.

It brings another hyped computer innovation to mind. Anybody remember Zork? *Zork* was a computer game in which the computer accepted written English sentences as commands, as long as there were no indirect objects, clauses or anything else that makes our language fully functional. The game was supposed to make the players feel like they had real choices and control over their fate during their wild adventures in a strange land. But it didn't always turn out that way.

Instead, the player would often get frustrated with the limits of the game's vocabulary and type "go eat yourself," or a related derogatory phrase, as a command. The offended computer would then beep and flash "bad name error" at the player, who, irritated, would load up *Castle Wolfenstein* and blow away a few thousand bad guys to forget about the annoying game of *Zork*.

So much for innovation.

The games didn't get much better. They never accepted actual written English sentences that normal people would use. So the players had to spend half their time figuring out how to communicate the exact command to the computer, in only the most generic English. *Zork* did give the player a feeling of being inside the story and tinkering with the flow of things, but it never came close to our full expectations.

Virtual reality today is as far from presenting "reality" as *Zork* was from expressing the English language, perhaps even a little further. The hyped vision of virtual reality — one of floating through space and physically journeying to other worlds by computer — fools the public into thinking that such

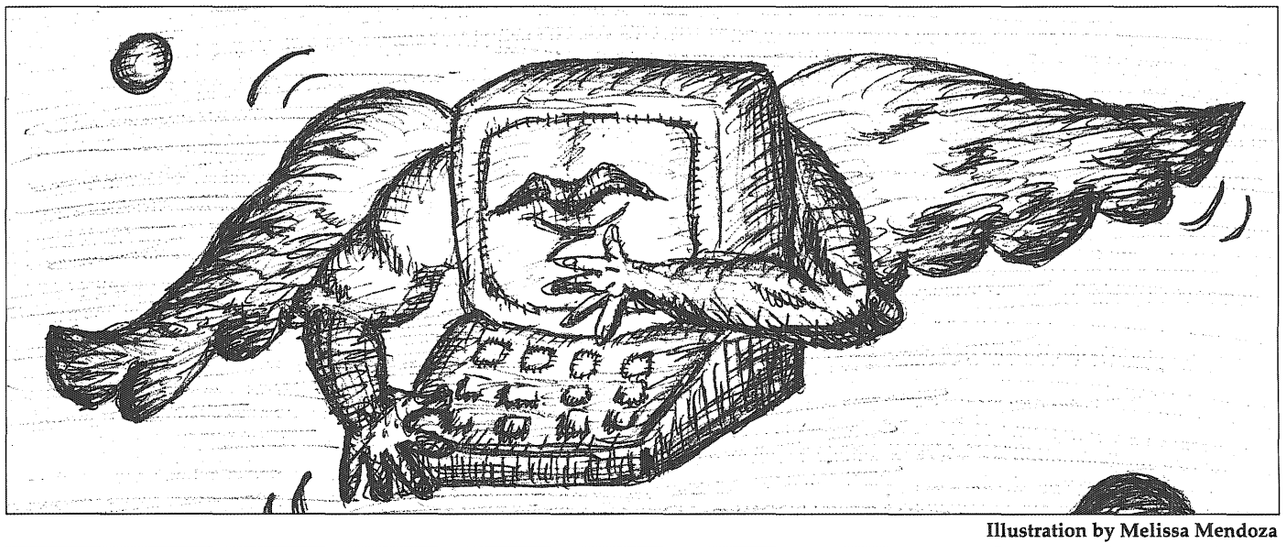
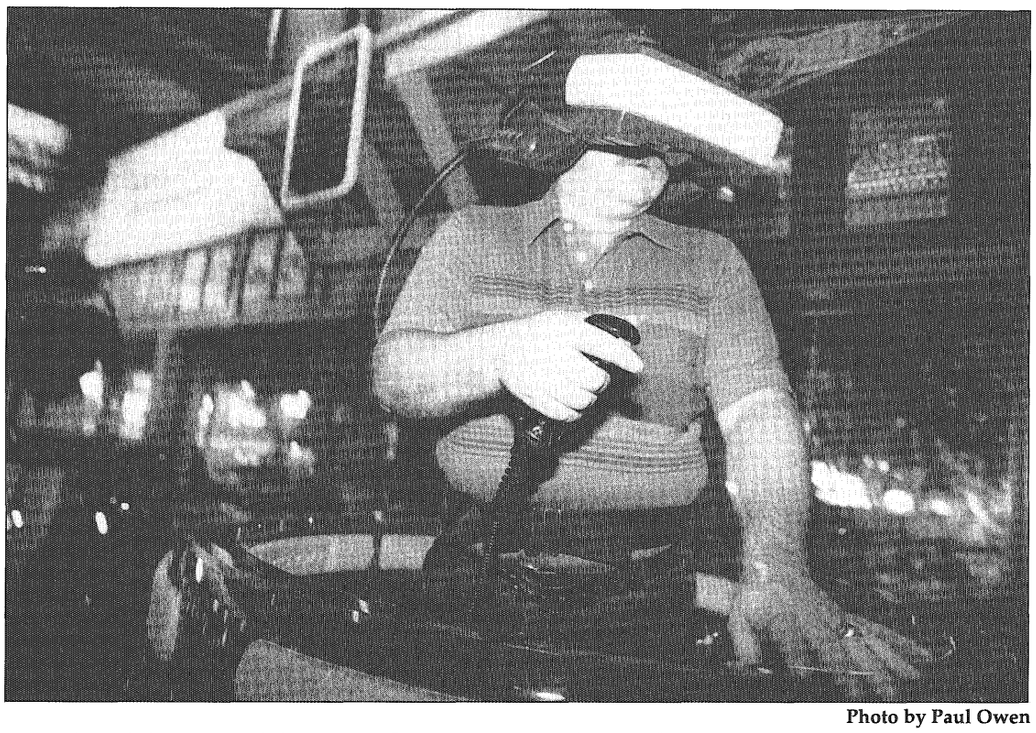


Illustration by Melissa Mendoza



This is one of the many eager participants of the virtual reality game at America's Original Sports Bar in the Mall of America.

Photo by Paul Owen

technology is just around the corner. It is not.

At the University of North Carolina, virtual reality research is underway for pharmaceutical applications. Henry Fuchs, professor of computer science, sums up the discrepancies between the public's perception of virtual reality and the actual reality: "We haven't a clue how to do that."

The hype over virtual reality is growing at a far faster rate than the capabilities of virtual reality itself.

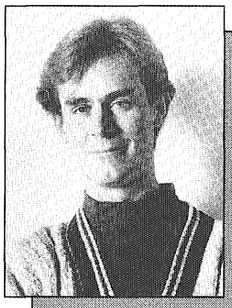
In actuality, the limits on attaining the virtual reality as envisioned in *Neuromancer*, *The Lawnmower Man* or any of a score of science fiction novels, is speed. Computers would have to operate at a speed at least a thousand times faster than today's best to even come close to producing a reliable virtual reality model.

Another limiting factor is money. Supertechnology is within our reach through parallelism — the technique of linking several thousand microprocessors together to form a computer capable of performing faster than today's best supercomputers — but many corporations are hesitant to "downgrade" toward parallelism. With many budget cuts in research programs across the country, many argue against speeding up the quest for true virtual reality because the price for today's technology will be cheaper five years from now. Why allocate funds for research now when it will be cheaper, and hopefully the economy more optimistic, later?

The military and the entertainment industry are responsible for much of the hype over virtual reality. In entertainment, virtual reality video games and movies give virtual reality an unrealistic reputation. And the media has promoted the military's Patriot missiles — guided like "cybernetic sharks" to the correct target — as if the missiles used standard technology that could perhaps soon be used in everyday life.

When *Zork* first came out, people

See Reality, page 27



Anton Crane

Age: 23
Year in school: Junior
Major: Astrophysics

Anton graduated from the University of Illinois with a bachelor's degree in rhetoric. He is now trying for a B.A. in astrophysics, and he's not sure what he is going to do with that degree either.

Looking for a job? Better get an internship

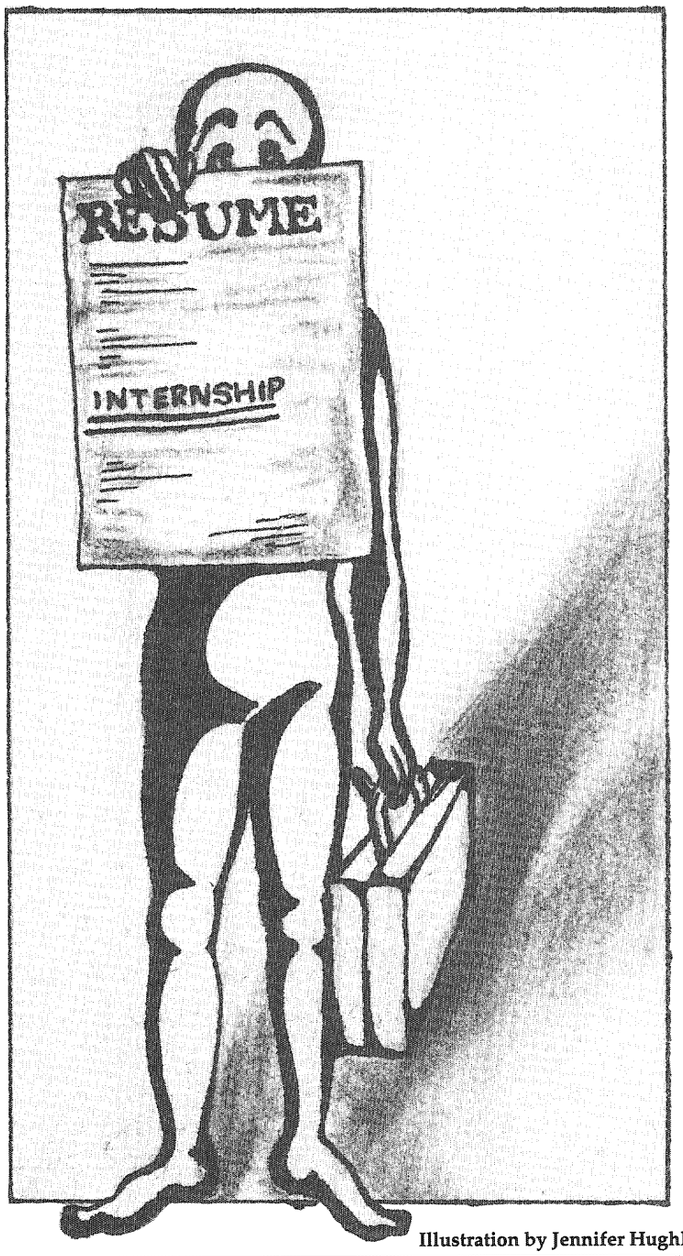


Illustration by Jennifer Hughlett

By Adam Talle
For Minnesota Technolog

Like many students, Institute of Technology senior Steve White is concerned about where he's going to work after he graduates.

But if experience counts for anything, White may have less to worry about than others. He's got an internship on his résumé.

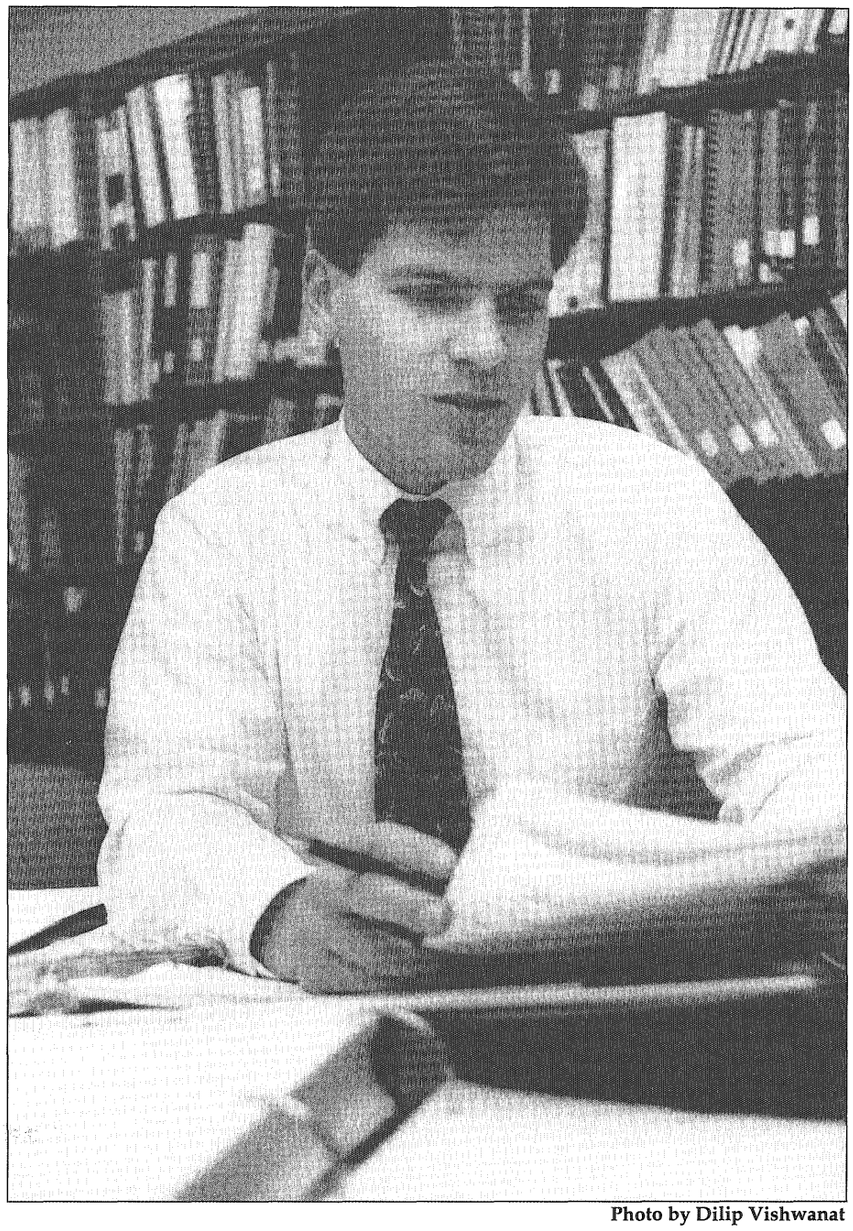
White was one of seven University of Minnesota students to participate in last year's annual Minnesota Technical Assistance Program internship. MnTAP — a University organization that helps Minnesota companies reduce waste — pairs volunteer interns with companies to come up with new methods of waste reduction within the company.

MnTAP interns have not only helped the environment, but they've saved companies money too. As a MnTAP intern, White worked for SCIMED Life Systems in Maple Grove, Minn. When he started, the company was using CFC-113, an ozone-depleting chlorofluorocarbon, as part of a cleaning process for manufacturing medical equipment.

But White soon came up with a better alternative.

He proposed using isopropyl alcohol as a cleaner instead of CFC-113 — and saved the company $20,400 per year.

White said saving money for SCIMED was a fortunate result of the



MN Tap's internship director Rich Bosshardt helps find U of M students to take part in waste-reduction programs in Minnesota.

Photo by Dilip Vishwanat

environmentally conscious internship. "I'm glad I could do something for the environment," he said.

Hands-on experience

The companies involved in the MnTAP internship seem to be pleased with the results too.

Don Mosch, human resources director of Continental Machines, Inc. in Savage, Minn., said his MnTAP intern was so critical to the company's waste-reduction efforts during the summer of 1991 that the intern was asked to continue his work later that year.

"He kept the cohesiveness of the program going through the summer," said Mosch.

Val Sybrant, human resources recruiting specialist of SCIMED, said interns are a "positive thing," and are generally trustworthy because they go to school and tend to be dedicated to

their work.

"We look at (internships) as a good tool to use," Sybrant said. "There's the opportunity for future employment if they work out well."

MnTAP's internship director Rich Bosshardt said White's hands-on experience is important for both students and companies. Internships are practical for companies, he said, since today's hard economic conditions have forced many institutions to scale back in-house training programs and campus recruitment for full-time positions. And student interns gain valuable experience to increase their marketability.

Bosshardt said it's difficult for students to get engineering jobs without experience. "Employers want to know what you have done outside of the classroom," he said.

Start now

But although internship experience can help your chances, it's no guarantee of a good job right after graduation. Mosch and Sybrant both said the bottom line has forced their companies to downsize the number of their employ-

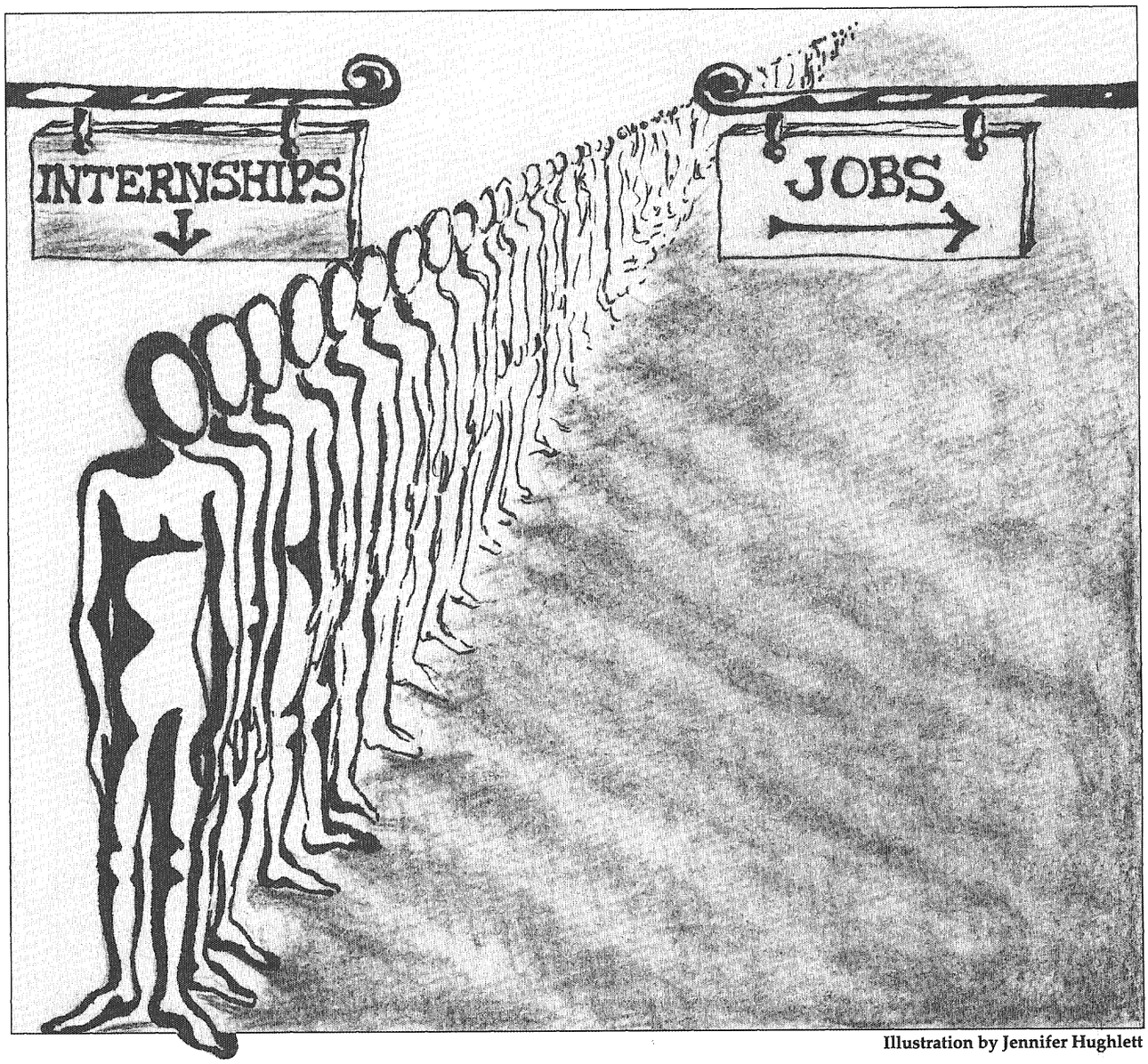


Illustration by Jennifer Hughlett

ees, limiting who they hire.

Sybrant said her company can only afford to hire engineers with at least three years' experience, and Mosch said that in order for Continental Machines to stay competitive the company can't afford to replace employees who leave.

Unfortunately, the future doesn't seem to be getting much brighter.

The 1993 Northwestern University Linquist-Endicott Report, which tracks the job outlook for college graduates, states that 49 percent of the companies surveyed will decrease campus visits this year. Only 23 percent foresaw increased visits.

Furthermore, 42 percent of the companies surveyed said they will decrease hiring of college graduates with bachelor's degrees in 1993.

These statistics are only slightly better than in 1992. The decrease in college job recruitment reflects the growing trend of companies offering internships instead of jobs to graduates.

"Companies are more often looking at internships before hiring," said Herb Harmison, IT director of job placement. "Companies want to find out if the students are good or not before hiring them. It can be a gamble."

Harmison said he expects a decrease in the number of recruiters on campus this year, with Goodyear, IBM and General Motors scaling back. Instead, Harmison said, companies are posting internship notices on campus without offering jobs.

Competitive selection process

But getting an internship these days may not be as easy as it sounds. According to one of last year's MnTAP interns, the screening process for the internship is no cake walk.

Each applicant for the MnTAP internship has to submit an application, a résumé and an essay about their goals, achievements and experience.

The applications and essays are reviewed by Bosshardt who look for academic achievement, creativity and a self-starting attitude.

"They do a good screening job," said White. "I tried not to worry too much about it."

When Bosshardt has whittled the number of students down to a reasonable number, interviews are arranged with the companies that will be working with the interns.

Bosshardt said over 100 IT students have expressed interest in this summer's internship, but only five or six applicants will land a spot with a company.

'Companies want to find out if the students are good or not before hiring them. It can be a gamble.'

–Herb Harmison

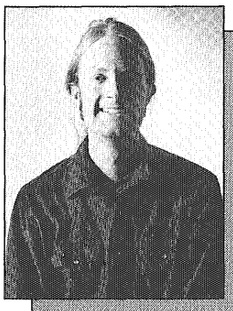
Companies applying for the free intern help are also screened. MnTAP reviews company proposals, visits the companies' facilities and then chooses the organizations that best fit the spirit of MnTAP's pollution-prevention efforts.

"We also consider how long the project will take to complete, so that the student can make progress on it over the summer," said Bosshardt. "We try to keep the programs focused."

Employers and job-placement directors say internships like MnTAP's are the ammunition students need to track down jobs.

Harmison's advice for soon-to-be graduates: "Be persistent" and "look for internships."

"The more you learn the earlier the better off you'll be," he said. ❖



Adam Talle

Age: 23
Year in school: Senior
Majors: Journalism

Adam is looking forward to graduating this spring, and hopes to be writing for a Minneapolis weekly paper. If he's still jobless by June, he says he'll re-read all his Hemingway novels and seek adventure overseas.

Research at the U

Unlocking the mysteries of the brain

By Alice Chen
Technolog Staff Writer

Imagine a puzzle, a complex one. Then suppose the puzzle is just a tiny part of another puzzle. Next imagine both puzzles as part of yet another puzzle, one that is exponentially more complex than the first. This pattern keeps going until you realize that if you are going to solve this mystery, you aren't going to do it by looking at each individual section. It gets so complex that just comprehending the nature of the puzzle becomes a formidable task.

Dr. Robert A. Gross of the University's Department of Neurosurgery is trying solve this puzzle — the human brain. Gross is studying the brain to determine how nerves turn on and off.

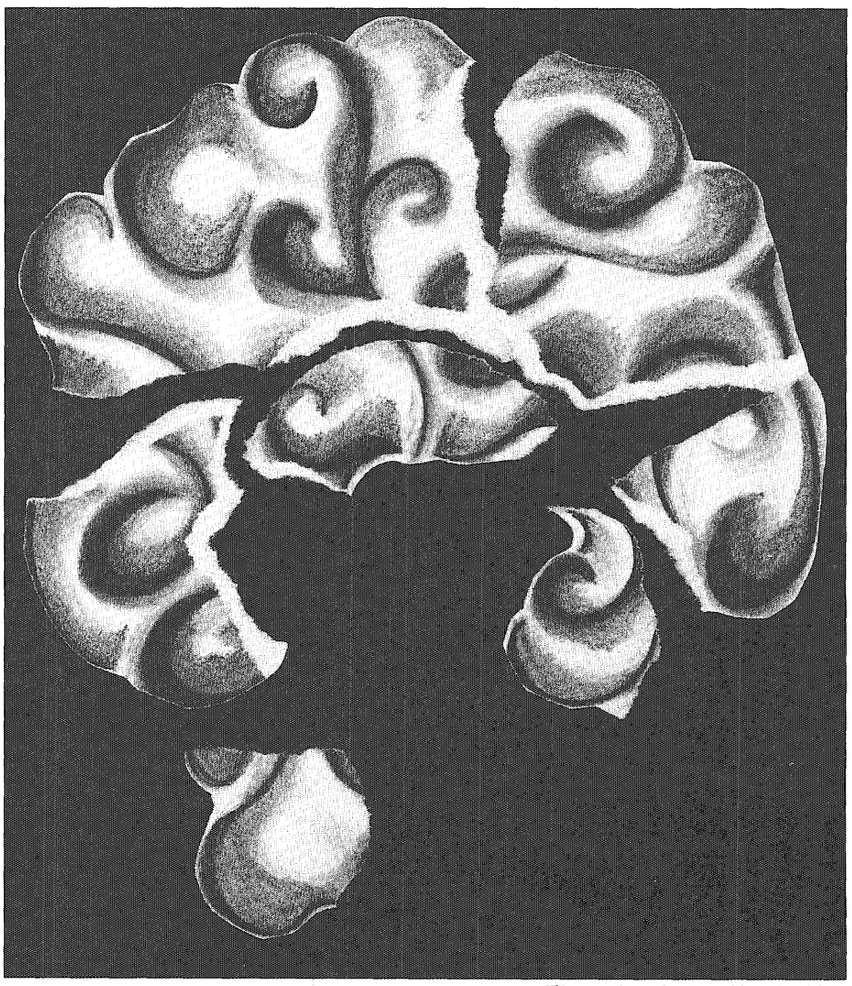
Gross's research has several focal points, all involving the mechanisms by which ion channels are regulated. Ion channels are gateways that control the electronic current flow through cell membranes by selectively moving ions into or out of the cell.

The first area involves calcium channels. The flow of calcium through ion channels controls the process for releasing neurotransmitters — chemicals that cause nerves to communicate among themselves — that activate a variety of enzymes and other ion channels. Gross's research in this area will lead to a better understanding of the nervous system and how it works.

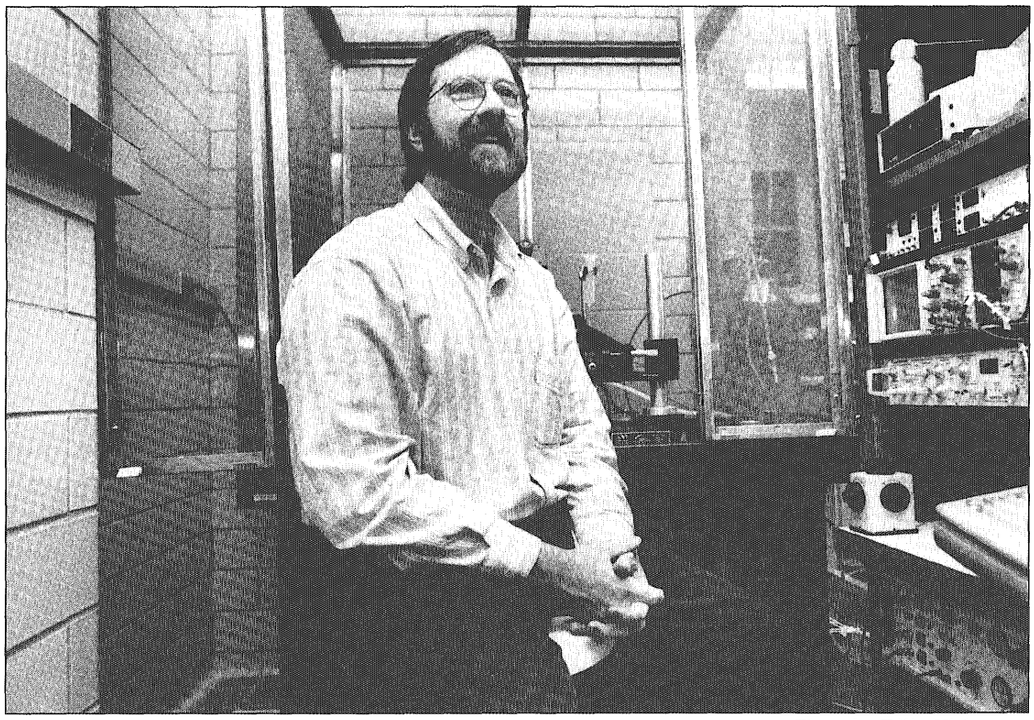
Gross also analyzes how anti-convulsant drugs — such as valproic acid and ethosuximide, two drugs used to control epilepsy — affect neuronal calcium channels.

"If we can determine differences in basic signaling processes in normal and diseased brains, we may be able to develop new pharmaceuticals to help those with neurological diseases like epilepsy and Parkinson's disease," Gross says.

Another focus of Gross's research is the amino acid gamma-amino-bu-



Illustrations by Jennifer Hughlett



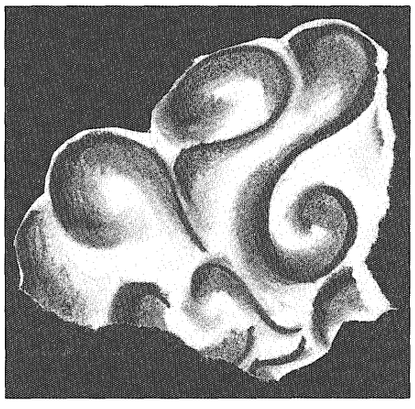
University of Minnesota Neurologist, Dr. Robert A. Gross M.D., Ph.D. is conducting research in an attempt to understand how nerves turn on and off.

Photo by Dilip Vishwanat

tyric acid, or GABA. GABA is an inhibitory neurotransmitter that activates a chloride ion channel. Gross first studied GABA at the University of Michigan with Dr. Roy Twyman and Dr. James Ferrendelli. Gross and other researchers are attempting to determine how GABA changes the shape of the channels and how certain anti-convulsants affect the GABA channel.

Although the solutions to the mysteries of our nervous system may take a lifetime to find, along the way scientists will gradually gain a better understanding of how nerves turn on and off. The answers, when found, however, will likely be just a small piece of a puzzle within a puzzle within a puzzle.

"The brain is incredibly complex," says Gross, "and recently, the rate in the growth of knowledge about the brain has increased tremendously ... but there is much more to learn." ❖



Alice Chen

Age: 21
Year in school: Senior
Major: Scientific & Technical Communication and Pre-physical Therapy

Alice is glad to be graduating in spring. She hopes to be a forest ranger this summer in Washington state or California's redwood forest.

Brains and the emerg

Brainy computers are teaching themselves

By David Mirelez
For Minnesota Technolog

Science-fiction writers and moviemakers have long toyed with the idea of artificial intelligence. They've created worlds populated by robots, and computers that think like humans — only better.

In the *Star Wars* trilogy, George Lucas conjured up robots R2D2 and C3P0 as companions for our movie heroes. Authors Isaac Asimov and Arthur C. Clarke have both written novels in which machines do everything from flying spaceships to performing surgery. And in the *Terminator* movies, Arnold Schwarzenegger plays a robot that eventually saves the world.

But today's scientists are trying to make those ideas more than just fiction. And although researchers may not have come up with anything rivaling the *Terminator* yet, in recent years they have made significant progress building computers that can simulate human intelligence. Such studies are done by scientists in the field of artificial intelligence — or AI, as it is commonly known.

Expert systems

AI specialists have used a variety of approaches to mimic human intelligence with computers. Expert systems, for example, are AI programs that use knowledge from specialists in a particular field to solve specific problems. To make expert systems, the computer programmers interview experts in a given

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computers...
ing future

Illustration by Jennifer Hughlett

Biocomputing: synthetic brains

By Scott Taschler
For Minnesota Technolog

No scientist has yet been able to devise a computing machine more advanced than the human brain. The brain can recognize a face in a crowd in fractions of a second, and still allow us to walk and chew bubble gum at the same time. But scientists are not about to give up trying to outdo evolution.

Based on a model of the brain's structure and its chemical processes, researchers are attempting to construct what some have termed the "sixth generation" of computers — the biocomputer.

Biocomputers are difficult to define because the molecular computing field is still in its infancy. But, in general, a biocomputer is a type of molecular computer that uses organic molecules to detect, process, transmit or store information.

Natural biocomputers include every plant and animal in our biosphere. And although man-made biocomputers have yet to be fully developed, primitive prototypes are beginning to show up. Such artificial biocomputers are blurring the boundary between the living and non-living, the organic and non-organic ... and will perhaps one day even cross the border that separates humans and machines.

Real computer bugs

At the Max Planck Institute for Biochemistry in Germany, scientists are studying one potential biocomputer component: bacteria from ancient bugs.

The bugs grow in warm stagnant pools, and contain a unique pigment,

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Computers from 14

field, and then put the relevant information into programs that reflect the behavior of human specialists.

One of the first expert systems, called MYCIN, was developed in Stanford in the early '70s. MYCIN diagnoses infectious blood diseases by applying if-then rules to patient symptoms. These rules were made based on knowledge gathered from medical doctors who regularly performed such diagnoses. An example of the type of rules found in MYCIN is: "If patient A exhibits characteristics X and Y, then the infectious blood disease is not M." MYCIN saved doctors time and money, allowing physicians who were not experts in hematology and neurology to receive knowledgeable advice from a computer.

Neural networks

Some AI practitioners prefer to use a different method for creating intelligent computers. One technique involves modeling computer processing elements to resemble the architecture of nerve cells in the human brain. These computer elements are called neural networks, because they function much like organic neurons.

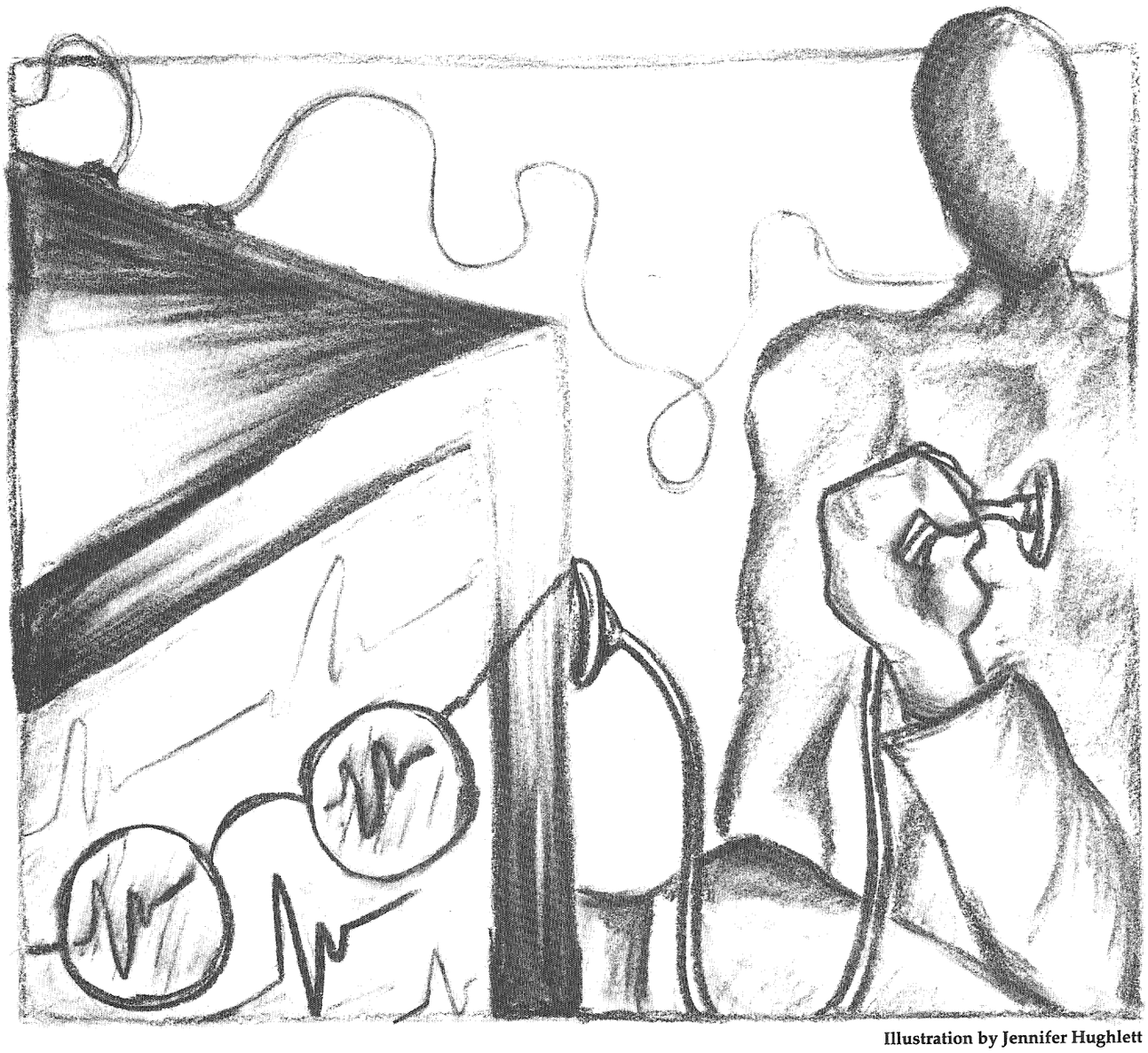

Illustration by Jennifer Hughlett

The billions of neurons in the brain act as transmission lines for brain signals. The neurons are linked together and transmit signals to the entire body via chemical and electrical impulses.

A transmitted brain signal flows through four different regions of an individual neuron before moving on. One end of the neuron consists of receivers, called dendrites. The dendrites receive chemicals — named neurotransmitters — that trigger an electrical impulse through the body of the neural cell. From the body of the cell, the electrical impulse travels into a long, thickened area called the axon. When the signal reaches the end of the axon, it emits another neurotransmitter that diffuses across a barrier to adjacent neurons. This barrier, called the synapse, determines how much influence a neurotransmitter will have on its neighbors. If the synapse is strong, neurotransmitters will not affect neighboring neurons.

Computer neural networks are made up of processing elements that are very similar to those in the brain. The components that represent neurons are called units, and they transfer data back and forth through connections — called links — that act as artificial dendrites and axons. Computer synapses are created by weighting the links between units; the weights determine how strongly the units influence their neighbors. A large weight, for example, indicates that a unit has a strong influence on its neighbors.

Standard neural networks have three layers of units: the input, hidden and output layers. The input layer is composed of units that take in information from the computer user on the outside. This information is sent via links to the units in the hidden layer. The hidden layer modifies the data and transfers it through the links to the output layer. Then the output layer sends the final data back to the computer user.

This type of system is faster than conventional computer systems because each transistor is hooked up to most, if not all, of the others. Thus, a signal entering the system spreads out rapidly across the entire network.

Computers that learn

Scientists believe that human learning occurs when the effectiveness of the synapses change. If a particular neuron contributes to the wrong answer on a test, for instance, the brain minimizes that neuron's transmission by increasing the strength of its synapse. In doing this, the neuron can no longer affect its neighbors, and the undesired result — the wrong answer — is eliminated.

This process occurs in neural networks as well. If data for a particular problem is fed into the network and the output answer is wrong, the weights of the links between the units are changed.

In some systems, the programmers have to change the weights of the links themselves. But recently, using a controlled method of altering weights, AI practitioners have developed neural networks that — like the brain — learn from their own mistakes. Such networks are "trained" with sample problems in a three-step training process.

First, a programmer gives the network an example problem, and the computer develops an answer. Then, the network compares its answer with the correct one. Next, using various mathematical methods, the network modifies its weights and develops a new answer that more closely resembles the correct answer. Then the computer repeats the process, and continues to do so until the network's answer precisely matches the correct one. At that point, the computer considers itself trained, and the final weights are permanently stored for future use.

Often, numerous example problems are necessary in the training process to give neural networks the ability to solve many problems. The McDonnell Douglas Corp., for instance, developed a neural network to act as a flight controller that assisted pilots in flying damaged airplanes. The network required training that used hundreds of example problems involving a variety of in-flight predicaments — such as fractured wings or failed engines. With the training, the computer was "taught" how experienced pilots successfully dealt with dangerous situations. At the end of the network's training process, pilots who tested it found they could fly slightly damaged airplanes as though the planes were new.

From handwriting to EEGs

There are hundreds of applications for neural-network technology. In fact, neural networks have already affected most people's lives in one way or another. AT&T uses neural networks to filter long-distance phone calls. Ford

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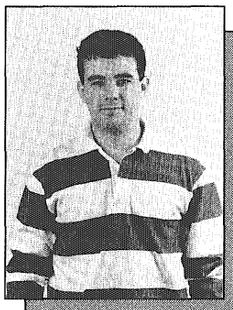

David Mirelez

Age: 21
Year In School: Senior
Major: Mechanical Engineering

David is working for 3M through the mechanical engineering co-op program, and hopes to continue working there after he graduates next year. In his spare time David plays volleyball and reads fiction novels.

Biocomputers from 15

called bacteriorhodopsin. This pigment enables the bugs to carry out photosynthesis, the process of converting light energy into chemical energy.

Scientists at the institute believe that if the bacteria's light-processing material could be captured, it could lead to new kinds of storage and processing materials for optical computing, and could outperform the best electronic switches.

Scientists have already isolated the bacteriorhodopsin and have used it as a film on glass that can be used in a similar way to photographic film. Unlike photographic film, however, the color change in the film can be reversed, and the film re-used.

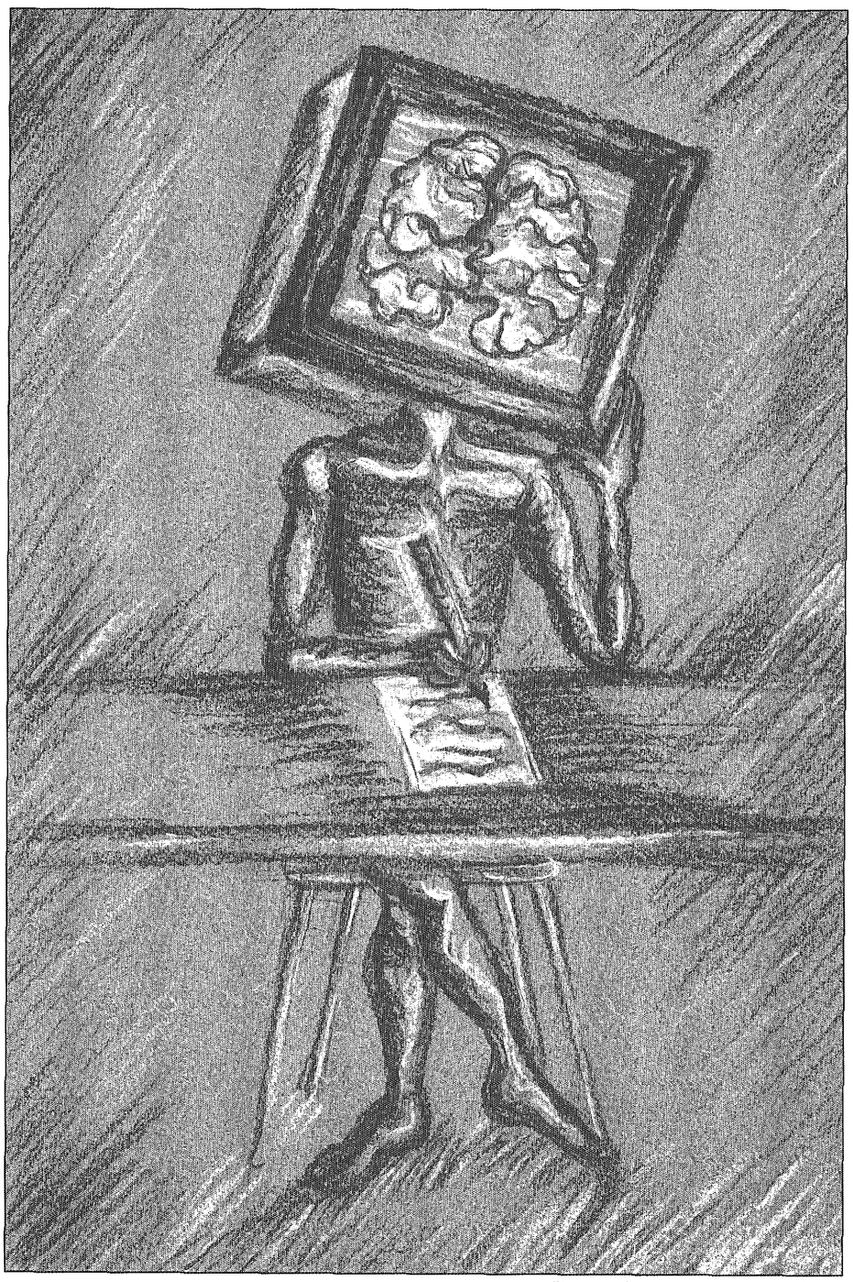

Illustration by Jennifer Hughlett

The bacteriorhodopsin film has been used to record holograms and three-dimensional images. This could be used to aid in pattern recognition. Three-dimensional images of specific people, for instance, could be stored in the computer and compared with images from a camera scanning a crowd. The computer could recognize the patterns and could pick out the people from the crowd.

Imitating the brain

To some extent, artificial biocomputers attempt to imitate the brain. Each neuron in the brain is connected by synapses to up to 80,000 other neurons. Based on their inputs, the neurons produce electrical output signals, taking the form of ions diffusing through membranes. Then the synapses weight these signals and transport them to other neurons.

The brain also transmits information to the rest of the body. This is done in part through hormones released into the bloodstream under the direction of the brain. Hormones are molecules that travel throughout the body until they happen upon cells possessing the special receptor substrate for that hormone. The hormone fits into the substrate much the way a key fits into a lock, and triggers the desired response in the cell. The substrate acts as a sensor for the particular hormone molecule.

Insect communication is a good example of hormones in action. Through special hormones, called pheromones, one grasshopper can detect another kilometers away. The grasshopper's antennae possess the "lock" into which the pheromone "key" fits, allowing the insect to detect just a few airborne molecules of the hormone.

Von Neumann architecture

Biocomputers attempt to capture these typically organic kinds of infor-

mation systems and use them in a controlled structure.

Most modern computers are based on a structure called "Von Neumann architecture." In such a structure, all of the computer's instructions are stored in memory, and the central processing unit accesses and performs them sequentially. The Von Neumann computer is very straightforward to design, control and program.

This type of computer, however, is much slower than it has to be. For example, even if instruction B utilizes entirely different sections of the CPU than instruction A, B must still wait for the CPU to finish with A before it gets any attention from the CPU.

Parallel architecture

Biocomputers will break from the silicon mold in many ways. Most of the designs that have been proposed use a "non-Von Neumann", or parallel, architecture. This structure — which links many smaller computers together to form a type megacomputer — allows many instructions to be evaluated at the same time, cutting computation time dramatically. Although some modern computers use a limited form of parallel processing, none utilize it to the degree that biocomputer researchers hope to one day achieve.

Biodevices naturally perform functions that are difficult or impossible for today's technology. For example, consider the above mentioned "lock/key"-based molecule detectors. Using this idea, a biodevice could be constructed, on the molecular level, to detect a specific perfume present in the air.

The signals inside biocomputers will be continuous (analog) signals as opposed to the discrete (digital) signals — made of a code of 0's and 1's — found inside today's computers. This ability to deal with analog data will allow biocomputers to more easily recognize patterns — video, audio, etc. — and make correlations. Consider how easily we can sometimes recognize acquaintances after several years, even though their physical characteristics may have changed. This task is quite difficult for digital computers, which must first digitize the visual representation of the person, then compare individual features to a database until a match is achieved. This provides the computer with a huge amount of data, and the time required to find a match, within a database of any useful size, is staggering.

If computers dealt directly with analog visual data, however, the operation would be much more efficient. It would greatly reduce the amount of data the computer needed to sift through. Biological organisms already have this ability naturally, and can carry it out in fractions of a second. Bioengineers, on the other hand, are still trying to discover how this is done.

One significant advantage of the biocomputer would be its size. In current technology, silicon devices are running up against what some have called the "sub-micron wall." It has become increasingly difficult to make devices smaller than about 0.8 microns. In fact, the chemistry of silicon makes it *impossible* to go much smaller.

In contrast, consider a single cell, 1 micron across. The DNA in that cell contains all the information necessary to reproduce an entire human being — that's 700 *megabytes* of information. If researchers could unlock these biological secrets, the resulting biocomputer would be a valuable tool.

Bio-obstacles

Unfortunately, biocomputers have a long way to go before we will see them in useful products. There are some fundamental obstacles to hurdle. First, we must gain a better understanding of the structure of our own bodies before we can figure out how its structure fits into the technological revolution.

Also, researchers must find the proper tools for analog computation and programming. Perhaps entire new systems of mathematics will need to emerge. Analog data is much less straightforward than the 1's and 0's of the digital world, and learning to work with this data may take a significant amount of time.

Finally, there's the question of society. We will be forced to rethink some of the fundamental ways in which we view computers. Some fear that, combined with advances in artificial intelligence technology, biocomputers could become as "human" as you and I. After all, what is the human organism if not one incredibly complex and well-integrated biocomputer?

Perhaps T. Kaminuma and G. Matsumoto said it best in their book *Biocomputers*:

> Science in the 20th century has demonstrated that the biological organisms are a kind of chemical computer, but the science of the 21st century will undoubtedly open the road toward engineering implementations of such

See Biocomputers, page 27

Scott Taschler

Age: 20
Year In School: Senior
Major: Electrical Engineering

Scott is an honors student in the Institute of Technology. When asked what he does in his spare time, he cackles diabolically and returns to his mountains of textbooks.

Saving the Earth is worth losing personal comfort

By Steven D. Axelson
For Minnesota Technolog

Steven Axelson has a bachelor's degree in computer science and a master's degree in electrical engineering. He is currently writing essays on technology and the environment.

These days, most people in the United States live very comfortable lives, compared to those in other countries. We do not have the seemingly unconquerable starvation and malnutrition of some nations. We do not have ongoing civil violence as do countries such as Ireland. We have not been physically attacked by another nation in recent years, as have countries in the Middle-East. We have managed to overcome difficulties as a nation and regain personal comfort and relative individual freedom. Except in aberrant situations, nobody really tells a free U.S. citizen what to do with his or her time and life. This is left to the individual. Naturally, there are legal limits on what a person can do, but these are formulated more for telling us specifically what we should *not* do.

Looming in the background of this contemporary condition of personal comfort is a pervasive problem associated with our entire U.S. culture. It is both an intellectual problem and a practical problem for the society of the future. It is a problem that I feel scientists and engineers of the immediate future should one way or another voluntarily devote their life efforts to solving.

It is the problem of the corruption of our environment.

Our culture has evolved, piece by piece, over a long period of time. When the first settlers arrived in the "New World" from the Europe, they brought with them their culture, and they applied their knowledge and skills toward the creation of a new culture here in the United States. They also brought with them knowledge in many areas, including ship-building, metallurgy, textiles and clothes-making.

Since then, we Americans have engineered the means for many individuals to have food available daily, with fewer people working in agriculture. We have engineered environments that protect us from the climate, and services for transporting people and heavy loads. We have also engineered clever ways to send messages from one place to another. All these human-service systems — food, shelter, transportation, communications and others — are well-established, and they continue to evolve. The technical evolution of these human-service systems is spearheaded by scientists and engineers. Unfortunately, the processes underlying the development and maintenance of these widely enjoyed services have the loathsome phenomena of environmental pollution and resource depletion associated with them.

Although successfully supplying living humans with food galore, our food-supply system remains a science and engineering problem entirely unsolved. While healthy Americans chomp down on a plethora of pure or highly processed foods, the system that supplied the food is causing erosion of the soil, depletion of natural petroleum deposits, and depletion and contamination of natural ground water. In essence, our food-supply system is depleting and degrading the Earth.

But it's not only the food-supply system that is dangerous. During the winters here in Minnesota, I appreciate the well-heated buildings that we have. During the summers, I also enjoy the coolness of the air-conditioned buildings. The temperature in such buildings, however, is currently controlled through the use of finite, nonrenewable fuel resources — coal, oil and gas. Needless to say, this cannot go on forever. Also, modern building materials, such as metals, plastics, ceramics and adhesives, are all brought to their final form through the use of our finite fuel resources and their associated environmental pollution.

Our modern transportation system is another pathetic source of environmental pollution, and it also depletes our finite fuel resources. For these reasons this issue has received much media coverage in recent years.

Furthermore, the modern communications system that we now have is a source of environmental pollution and another consumer of our finite fuel resources. It might be argued that the human species could survive comfortably on Earth without the modern communications system that we now have. Nevertheless it is still used extensively, and many high-tech companies are major polluters of the environment.

Thus, our human-service systems may carry out their designed functions today — supplying food, shelter, transportation and communications — but they are performing these functions

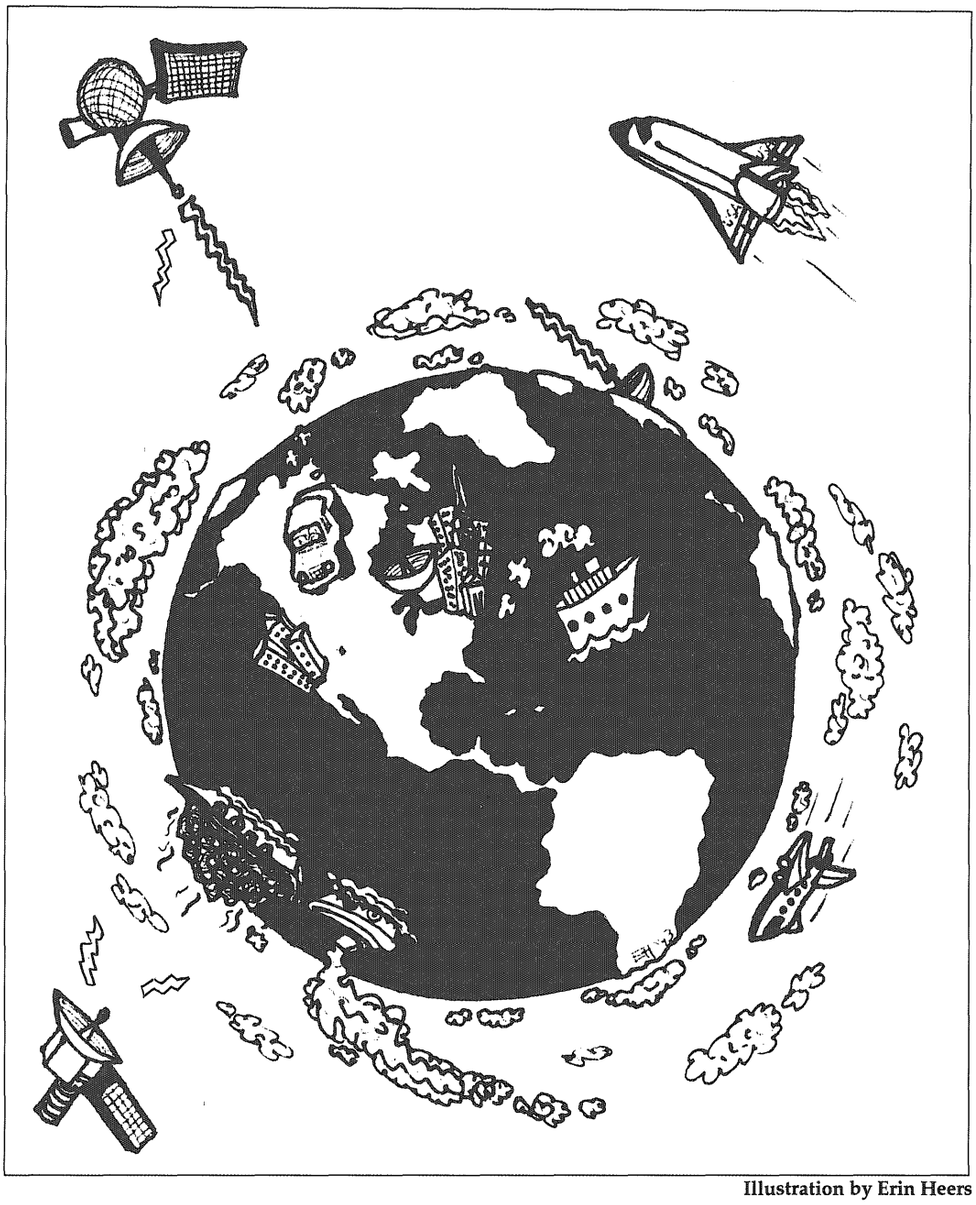

Illustration by Erin Heers

with hidden costs that are becoming more and more apparent in our U.S. society. We should start working now to design and develop human-service systems that work well into the future. Let's help out our future generations. ❖

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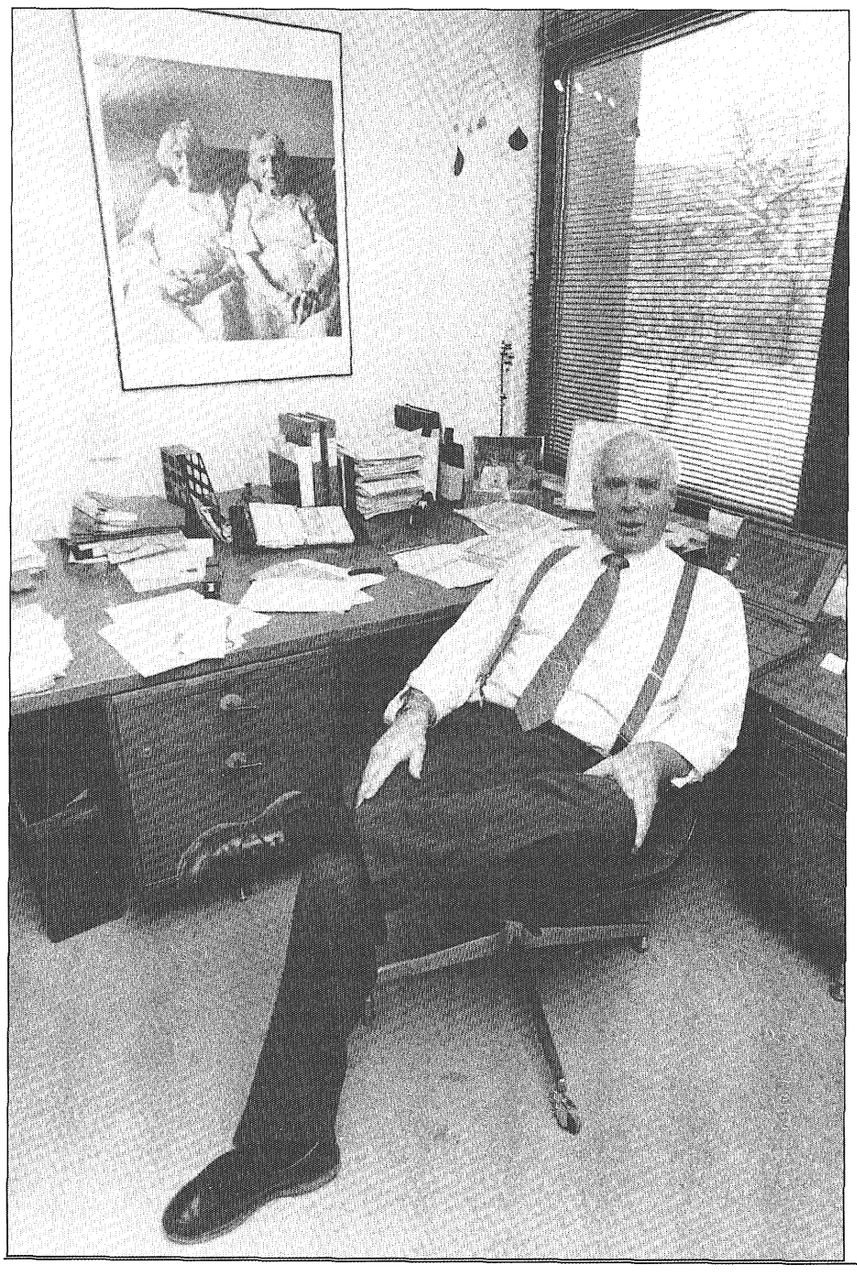
Failing calculus may not be your fault



Dr. Thomas Bouchard heads the Minnesota Center for Twin and Adoption Research, which has been studying identical twins reared apart since 1979.

Photo by Natasha Frost

By Peter Kauffner
For Minnesota Technolog

At a New Jersey firefighter's convention, Fire Chief Jerry Levey was asked if he had a twin. Jerry laughed, "If I had a twin I'd certainly know." The questioner persisted, insisting there was a firefighter who looked exactly like Levey in Paramus, N.J. So a meeting was arranged between the two fire chiefs. Upon meeting, they stared at each other skeptically. "Lop off a few extra pounds and I was looking in the mirror," Jerry said later.

Although each man knew he had been adopted, neither had any idea that he had a twin. Jerry Levey and Mark Newman soon discovered they had more in common than just looks. Both were compulsive flirts and had never been married. They shared a sense of humor and a boisterous laugh. They both drank the same brand of beer and held their beers in the same peculiar way: with the little finger awkwardly placed under the beer bottle.

"It was spooky," said Levey. "We kept making the same remarks at the same time and using the same gestures."

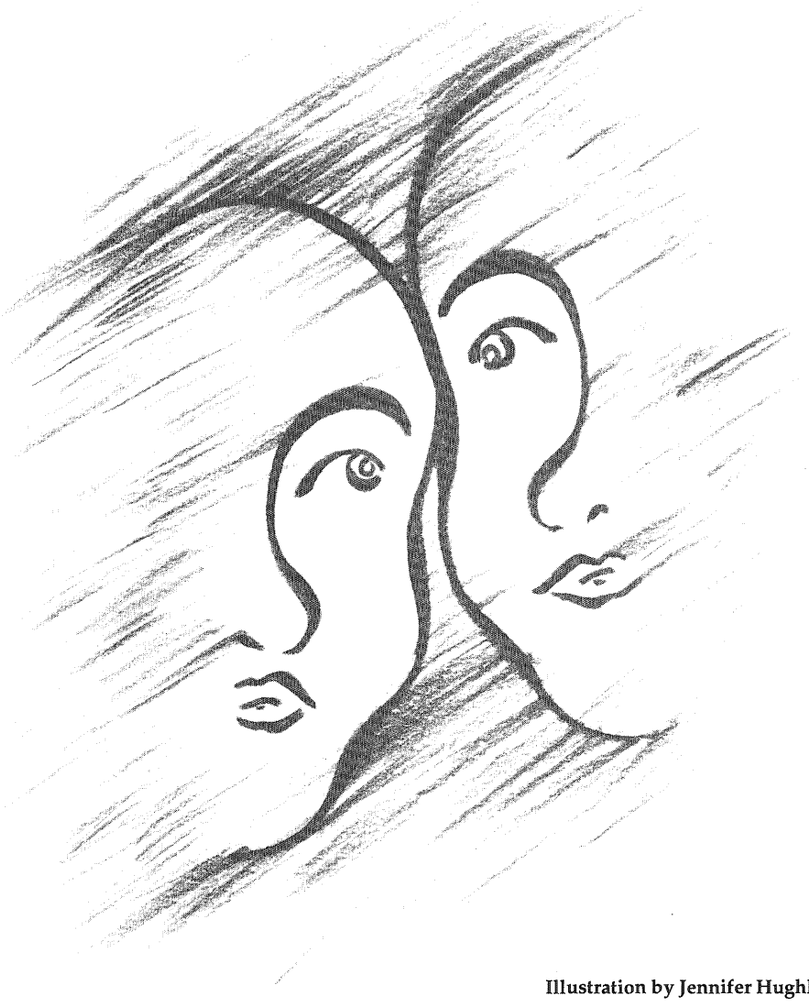


Illustration by Jennifer Hughlett

Twin research at the U

Since identical twins such as these who are raised apart are quite rare, they represent a valuable opportunity for researchers to separate the effects of upbringing and genetics on human personality. Identical twins have no genetic differences, so any differences between them are presumed to be the result of environmental factors.

The Minnesota Center for Twin and Adoption Research (MICTAR), at University of Minnesota, studies identical twins who were raised apart. MICTAR, headed by Dr. Thomas Bouchard, has analyzed about 120 sets of reunited twins or triplets since 1979. Participants in the studies are subject to a six-day test marathon, during which about 15,000 written questions are asked. Each individual twin is asked to write about his or her life history and sexual history, and then take a battery of medical, IQ and personality assessment tests. The tests are repeated every 10 years. "This is a long term study," said Bouchard. "I told one man that by the time he came in for the third time, I would be 70."

A 1990 *Science* magazine research article by Bouchard and other researchers concluded that intelligence is largely inherited. "Like the prior, smaller studies of monozygotic (identical) twins raised apart, about 70 percent of the variance in IQ was found to be associated with genetic variation." This finding puts Bouchard at the center of a politically charged debate on whether heredity or environment has greater influence on the development of intelligence.

The study still leaves room for debate — it did say 30 percent of the variance in IQ is due to environmental influences. And although the study carefully compared twins based on social class and the educational background of their adoptive parents, the

participants in the study were predominately from the United States. A handful were from Western Europe. So, the twins largely grew up in similar cultural and economic conditions.

Since even poorer Americans are well-off by third-world standards, all the twins in the study grew up with adequate food, water, shelter and a means to educate themselves. Some speculate that the comfortable Western culture may allow individuals free rein to develop the personality imprinted in their genes. If so, environmental effects would be greater in people brought up in more restrictive cultures. "No one denies that if someone is brought up in a deprived environment, that will affect their behavior," said Bouchard.

Perhaps one of the more surprising results of the University twins research is the discovery that those brought up separately show no greater differences in personality than twins who are reared in the same home. This suggests that parents have much less influence in the development of their children than previously thought.

Illustration by Jennifer Hughlett

Nature vs. Nurture

The MICTAR study is only the latest contribution to the "nature vs. nurture" war. The controversy began in 1869 when Sir Frances Galton, a cousin of Charles Darwin, published *Hereditary Genius*, which presented evidence to support the claim that talent can be inherited. Its innovative statistical method made the book a scientific breakthrough.

Galton, however, was also the founder of eugenics, a political movement that advocated policies to improve the gene pool that would be inherited by future generations. Critics branded the movement "Social Darwinism," and claimed that such policies would lead to the breeding of humans like cattle.

Eugenics was a highly influential movement in the 1920s and 1930s. Margaret Sanger, founder of Planned Parenthood, argued that providing birth control to the lower classes would help to reduce the number of children born with undesirable genetic qualities.

On the other side of the issue, American anthropologist Margaret Mead wrote about her studies in the South Pacific islands, claiming to have found a paradise of free love and sexual equality. This, Mead hypothesized, proved that sex roles were culturally determined. Today, however, it's generally accepted that genetics is an important factor in determining sex roles, and that males are inherently more aggressive and competitive than females. Some say that Mead's discovery had more to do with her ideas for social reform in America than

with her observations in the South Seas.

In 1937, Chicago social scientists Horatio Newman, Frank Freeman and Karl Holzinger did the first study of identical twins raised apart. Nineteen pairs were examined, and researchers found it difficult to distinguish between the effects of heredity and environment. These results helped turn the scientific community against eugenics. The field soon fell into disrepute due to its ideological similarity to the beliefs of the Nazi party.

In 1962, a British psychologist named Sir Cyril Burt published a study of identical twins raised apart. His study claimed that 80 percent of intelligence was linked to genetics. Then, in 1969, Berkeley psychologist Arthur Jensen used Burt's data to support his claim that racial intelligence differences were caused by genetic factors. Jensen's article provoked a storm of protest. Years later, however, Princeton psychologist Leon Kamin proved that Burt's study was a fraud.

Still, eugenic policies are not completely dead. The government of Singapore, for example, revived the ideology in the 1980s. Singapore now pays bounties to encourage its college-educated citizens to marry and have children with other college-educated citizens. In a 1983 speech, Prime Minister Lee Kuan Yew cited Bouchard's study in support of these policies.

Politics of genes

The debate between geneticists and environmentalists continues as one of the oldest controversies in political theory. Are there differences among humans that justify the existence of social rank? Many liberal environmentalists believe that unequal distribution of wealth and power is the result of discrimination, prejudice, exploitation or other social factors that need to be changed. But if personality and intelligence are genetically programmed, it would suggest that social engineering schemes to eliminate inequalities among the classes, races or genders are doomed to fail.

If personality and intelligence are genetically programed, social engineering schemes may be doomed to fail.

In *The Mismeasure of Man*, Harvard biologist Stephen Jay Gould claims that geneticists are apologists for the existing social order, and that this prejudice makes their work suspect. Bouchard disagrees. "A study done in Stockholm and published recently in Psychological *Science* confirms our study to the decimal place. So our study has been reproduced," he said.

Even the most conclusive scientific resolution of the nature vs. nurture debate, however, would not resolve the underlying issue of social equality. But to present the argument as "traditional power structure" vs. "utopian social equality" is to set up both sides as a strawperson. Few people today would agree that those with high social status should have exclusive rights to lead society. Even fewer would believe that communism's "from each according to his ability, to each according to his need" is a practical way to run a society. Rather, the question is: "How much social equality is practical given other social goals?" Thus, politically, the twin studies could help to set a measurable limit on how much social equality is reasonable to expect. ❖

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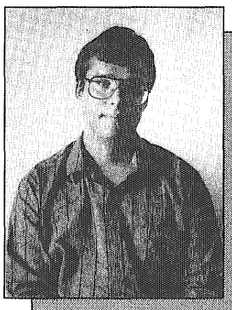

Peter Kauffner

Age: 27
Year in school: Senior
Major: Computer Science

Peter's 1989-90 column in *The Minnesota Daily* was so controversial that *Daily* staffers joked he got more letters than Santa Claus. Peter hopes for a less-controversial career as a technical writer.

Computers from 17

Motor Co. uses them to analyze and ensure quality products in its engines. And networks are used at Poquet Computer Corp. to decipher users' handwriting in its pen-top personal computers.

Many companies are using neural networks today not only because they are faster than most conventional systems, but also because they have the special ability to solve problems using limited or "noisy" input data. Noisy data contains interfering data that distorts the accurate reading of the desired information. Scientists at Johns Hopkins University took advantage of this distinct ability of neural networks by developing a new type of EEG monitoring system.

An EEG, or electroencephalogram, is a device that monitors the electrical activity of the brain for potential abnormalities — such as seizures, tumors and strokes. In hospitals, EEGs hooked up to patients must be continually watched for warning signals, to protect the patients against serious brain complications.

One problem with EEGs, however, is that the data they provide contains noise, which causes false alarms in conventional-software-based automated monitoring. Because of this, the researchers at Johns Hopkins University developed the neural-network EEG monitoring system.

So far, the system has been successful. In tests run by doctors at Johns Hopkins, the neural-network system had an error rate of 10 percent — a great improvement over the previous top monitoring systems that had error rates of around 20 percent.

Another advantage of neural networks is their ability to process and recognize categories of information. JFK airport in New York, for instance, uses neural networks to scan for bombs in suitcases. At the airport, gamma rays are shined on luggage passing along a conveyor belt. Then the neural network analyzes the wavelengths of the gamma rays that bounce off the luggage, and determines the chemical composition of the materials inside the luggage. Based on the results of the analysis, the neural network recommends which luggage should be pulled aside and inspected for bombs. If a suitcase contains an unusually high amount of nitrogen, for example, it will be pulled aside and inspected by airport security.

Neural networks also have unprecedented pattern-recognition abilities. If the computer is shown three or four different views of a person, for instance, the network will instantly recognize the person from any other angle. This can be useful in product assembly and inspection, as well as in the military.

Network drawbacks

There are some disadvantages to using neural networks. First, neural networks do not readily explain their results. When a network solves a problem, the user generally has little way of knowing how it comes up with its answers. Thus, some users have less confidence in the answers because there are no explanations.

Another problem with neural networks is their inability to deal with constraints. It is not always possible for a user to limit the answers a network can generate. For instance, the researchers at Johns Hopkins have found that certain EEG abnormalities are not unusual in some patients. In such cases it would be useful for the AI programmer to be able to place constraints on how the neural network monitoring the EEGs interprets signals for individual patients. Without the constraints, the monitoring network can cause false alarms.

Also, AI practitioners have sometimes run into problems with training neural networks. It can be difficult for programmers to determine how many examples are needed for the network to be able to solve a certain class of problems. If the network is trained with too few examples, it will not give good answers. If the network is trained with too many examples, on the other hand, it "memorizes" answers and loses its ability to solve noisy or incomplete problems. Programmers say that giving the proper amount of training to a neural network can be frustrating and time-consuming.

AI technologies and neural networks are helping researchers overcome complex problems. But don't expect to see half-human cyborgs running around your neighborhood anytime soon. Neural networks and other AI technologies still fall short of accurately duplicating the intricacies of human thought. With more research, however, scientists will discover more about both the mind and machines — leading the way to computers that think for themselves. ❖

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Right from 5

provides a better understanding of the brain. ❖

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Reality from 7

were calling it a revolution in computer games — a game that accepted written English sentences instead of cryptic commands. The hype made reality all the more disappointing.

Virtual reality will likely have the same fate.

What will we do when we're frustrated with the hyped virtual reality computer? Let's see what happens when we scream: "Go eat yourself." ❖

Biocomputers from 19

chemical computers.... The question of whether they should be called computers or living objects will become nothing more than a matter of personal preference. In spite of those obvious differences... we believe that it will gradually become more and more difficult to enumerate what their differences are. ❖

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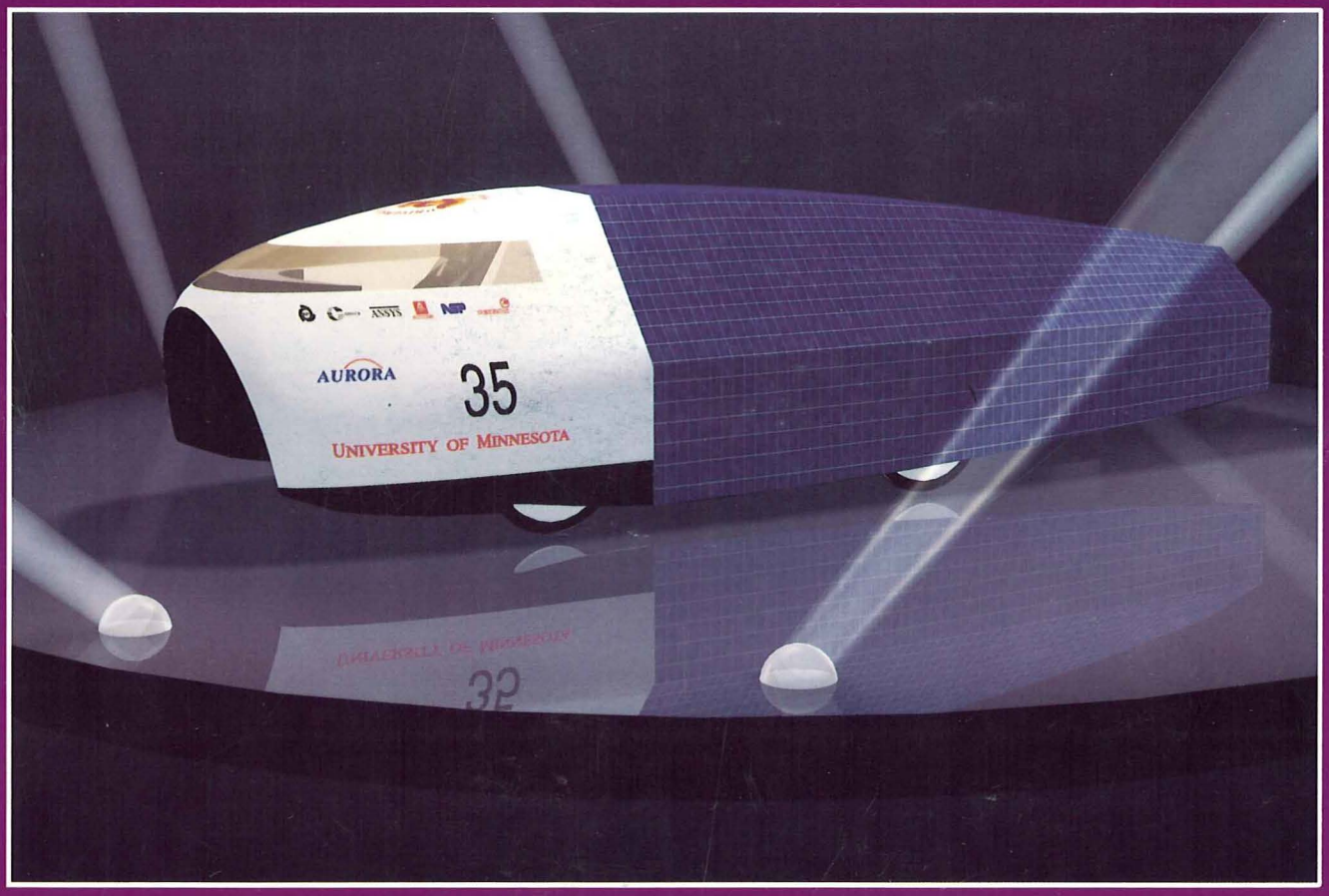
It's FEZ! THE PHYSICIST
fez. by tomika
TODAY, LITTLE TOMIKA HAS ASKED IF SHE COULD DRAW A 'FEZ' ADVENTURE! WE SAID: "WACKY! GO FOR IT, HONEY!"
one day fez went for a walk.
la la la
but then he got hit by a big truck in the face.
Yaaa!
POW!
and then his head rolled off.
WOOO!
and then i saw his head and sold it to billy for five bucks.
me →
← billy
5 bucks
i went to the store and bought a water gun.
here ya go
then i went and found billy and shot him so i could take back fez's head.
AAAAA!! im shot
squirt!
WOO!
but fez's head was all goopy and dumb so i took it home and threw it in the garbage.
clank clank
la la la la
the end
DR'93

MINNESOTA TECHNOLOG

June 1993 • University of Minnesota • Vol. 73, No. 5

The Future of Technology?



In this issue . . .

- No more gas guzzlers — the Aurora is here
- Why men join the Society of Women Engineers
- Help save the Earth while you work: A proposal for a new profession in engineering
- Researchers make videos at The Geon
- *and more ...*

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The extensive use of chlorofluorocarbons has caused a hole to form over the South Pole. NASA and other organizations are researching to find ways to stop this destruction and to protect us from harmful ultraviolet rays.

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Society of Women Engineers not just a woman's world

Some men join the organization to help recruit more women into the male-dominated field of engineering, others just hang around for the cheap pop.

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Aurora — lighting the road to the future

After two years of work, the solar vehicle of the Institute of Technology is nearly ready for the big race.

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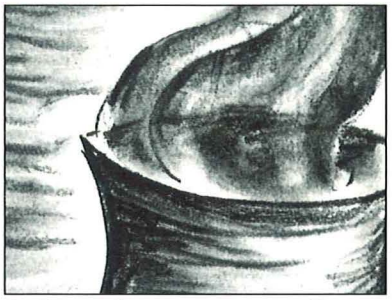
A new profession on a poisoned planet

Steve Axelson explains his theory about a new field for engineers of the future — directing our nation to become more ecologically aware.

The solar future **Page 10**



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About the cover . . .

Society may have gone too far in some areas of technology, but future engineers at the University are building a solar car that is friendly on the environment and uses no fossil fuels.

Photo courtesy of Scott Grabow

Editorial

Danger: No privacy ahead

When I was little, I used to think how cool it would be if I could see my best friend Kristin while I talked to her on the phone.

We could almost do it—our houses were close enough that if I looked out my back window I could faintly see her waving at me.

That was fun — but not very high tech. Instead, we wanted special phones. Phones with little screens, so we could see each other when we discussed whether Hohos or Dingdongs tasted better.

But that was twelve years ago.

Now the idea isn't quite so appealing.

I went shopping the other day and I saw that the new video phones are already on sale. They looked a bit smaller than I had imagined when I was ten, but still, there they were.

At first I was impressed — we've all been taught that technology and progress are good for our well-being. But then I got to thinking about what life would really be like if everyone had that new breed of telephone.

I envisioned sleeping late one day and my new date calling me at noon and waking me up. Would I really want him to see me with dried drool and pillow wrinkles on the side of my face?

I guess you'd always have the option to turn the video screen off, but once you've talked to some friends with the monitor on, it would look a bit suspicious if you showed them a blank screen the next time they called.

I know I'd certainly wonder if I called my boyfriend at noon and he wouldn't turn on the monitor. "What are you doing? Who's there? What's going on?..."

And what if you had to call in sick to work? "(Cough, cough) Uh, I'm really sick today, can't make it in..."

"Oh really? You don't *look* sick..."

Or what about when you just get out of the shower and you forget that the screen is on? The phone rings, you rush to pick it up. Hair dripping, cold and buck naked, you tell the repair man you'll pick up your stereo on Friday.

No thanks.

I'm content with traditional phones. Real phones. They give you that anonymity and privacy you don't enjoy when talking with someone face to face. Granted, video telephones may be a breakthrough for the scientific world, but they signify a step backward for those who think technology is dangerously close to eliminating our private lives. Because these days it seems nothing is private.

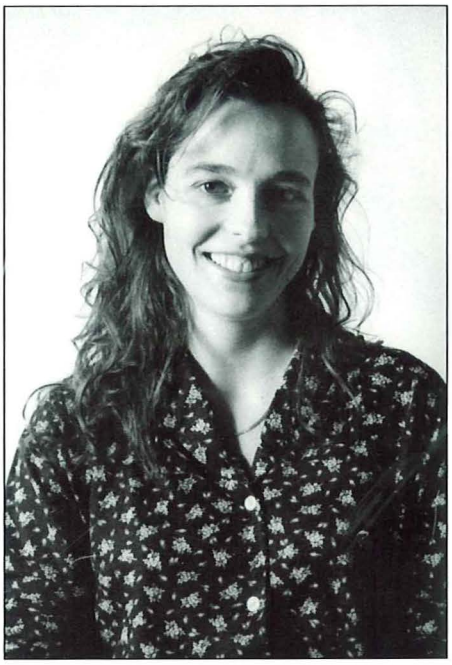
And it's only getting worse.

With CD-ROM computers, the amount of information readily available to the public has increased dramatically. Already phone books from every state are available on compact disc. So if someone has the money, he or she can get the name, address and phone number of anyone in the nation.

It's not that this information wasn't public before, it's just that now it's so easily accessible. That's the scary part.

Credit bureaus have data bases with financial information about millions of people in the country. And companies buy that information for their own use. This can affect whether you get approved for a loan or not. But what's particularly disturbing is that these records are not always accurate. In other words, if someone at the bureau has mistaken you for somebody else, you could feel the consequences of another person's mistakes — and you may never find out what went wrong.

Also, new spying and surveillance device companies are part of a multi-million-dollar industry. But this



by

Esther Haynes

Editor in Chief

shouldn't be a surprise, considering that these are times when husbands and wives hire private investigators to spy on each other. One gadget on the market alters your telephone voice to make it sound as though you have a secretary who is answering for you. With a product called "Mail Inspector," you can coat envelopes with a spray that allows you to read their contents. And if you want a step-by-step guide on invading the privacy of your friends, you can send off for a book called "How to Eavesdrop on Your Neighbor."

Sound good?

Such new devices are slowly eating away at our right to privacy, and the more people buy them, the faster we will lose this right.

I'm not saying that video phones are going to turn our houses into Big Brother's domain. But I do think we need to put limits on how far we can go. Before it's too late.

Our society has stretched the boundaries in other areas of technology, and the effects have not always been beneficial. With our nuclear weapon arsenal we have the ability to destroy the Earth many times over. And with the corruption of the environment by pollution, we are threatening our lives and the lives of future generations. We are paying the price now because we've pushed the technological limits.

Let's not pay the price again with our privacy. ❖

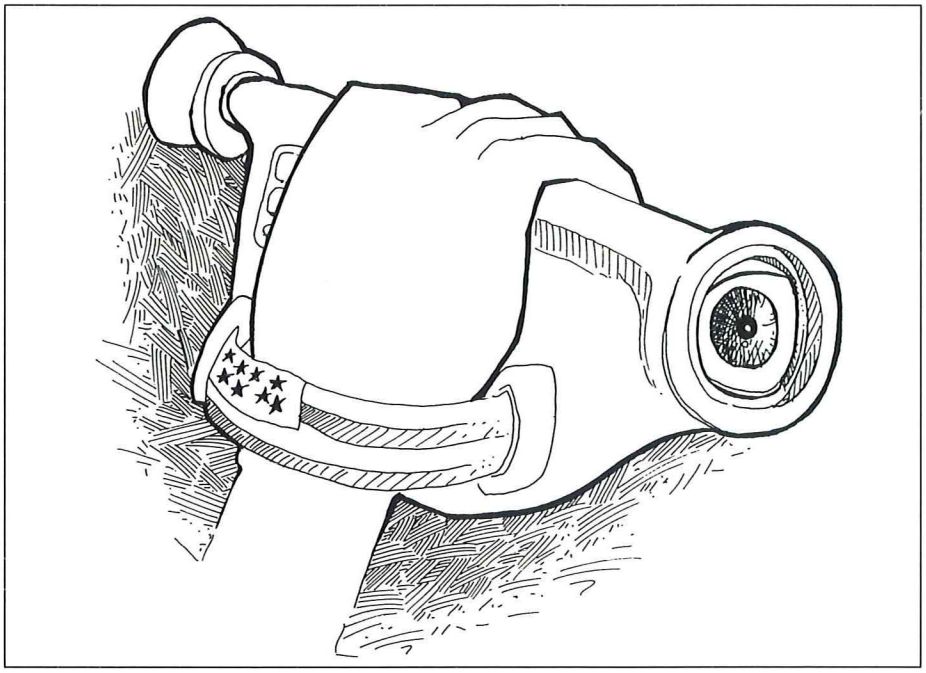


Illustration by Daniel Ruen

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Earth's 'protective blanket' is unraveling

By Wade Petrich
For Minnesota Technolog

During the long, cold winters in Minnesota, it can be difficult to believe that the entire planet is heating up. Still, each spring it seems that somebody claims the sun is warmer on Earth than it was the previous year. That's because studies have shown that with the depletion of the ozone layer, the sun's rays on Earth are indeed getting more intense as the years go by — and the negative effects of this could grow to be considerable if the situation continues.

The ozone layer is often portrayed as if it were a large protective blanket that spreads over the Earth like a shield. Ozone is comprised of O_3 particles, which are present in high concentration in the Earth's troposphere and stratosphere. The largest concentration of ozone — 10 parts per million — is about 25 km above the surface of the Earth. But as the ozone layer in the Earth's atmosphere slowly thins, more ultraviolet rays penetrate, causing increased sunburns and other negative effects on humans.

In recent years, scientists have learned a great deal about the ozone layer. In 1985 the British Antarctic Survey discovered that the ozone in the atmosphere over Antarctica had decreased 40 percent from 1977 to 1984. This dramatic loss in the ozone layer caused a hole to form above Antarctica.

Unfortunately, it is difficult to restore the ozone layer once holes have occurred. "Ozone never becomes larger," said Konrad Mauersberger, professor of physics and astronomy at the University of Minnesota.

Researchers have pinpointed chlorofluorocarbons as the major cause of ozone depletion. Since CFCs are used as coolants, every time people turn on the air conditioners in their cars, these gases are released into the atmosphere — leading to the breakdown of ozone particles. Refrigeration, aerosol sprays, foam-producing agents and cleaning agents for electronic parts also cause the release of chlorofluorocarbons.

When CFCs are exposed to ultraviolet light, they break down, releasing chlorine. The free chlorine then causes the ozone molecules to break down, resulting in less absorption of ultraviolet light. Since nothing naturally reacts with chlorine to break it down, it can stay in the troposphere for 50 to 100 years

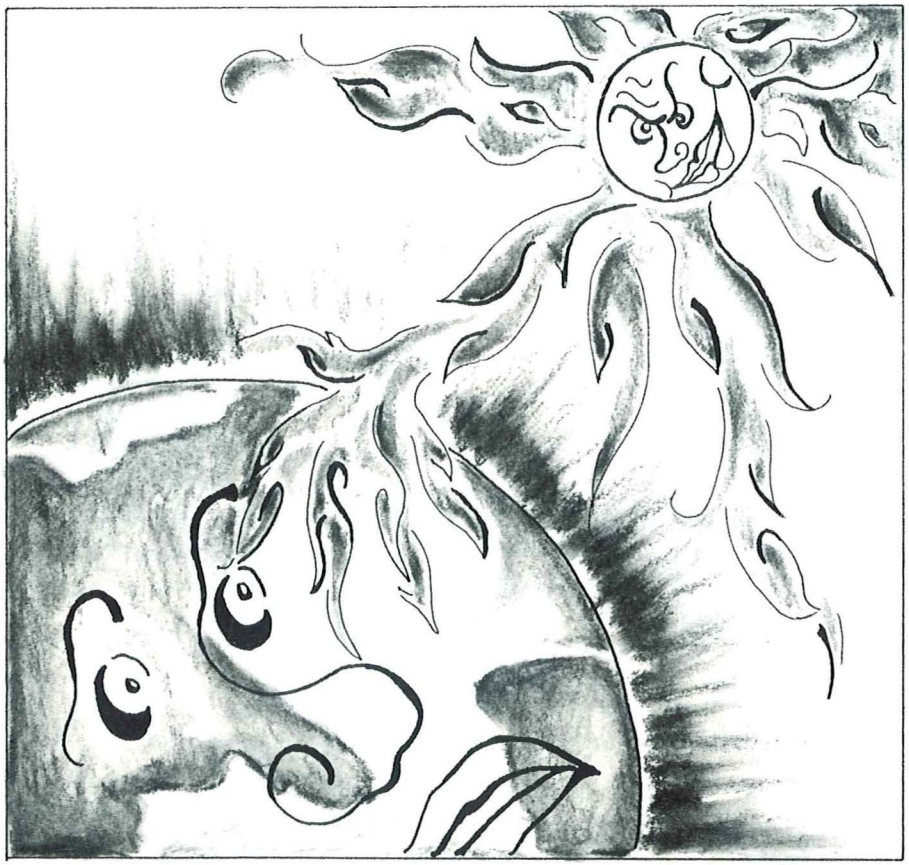

Illustration by Jennifer Hughlett

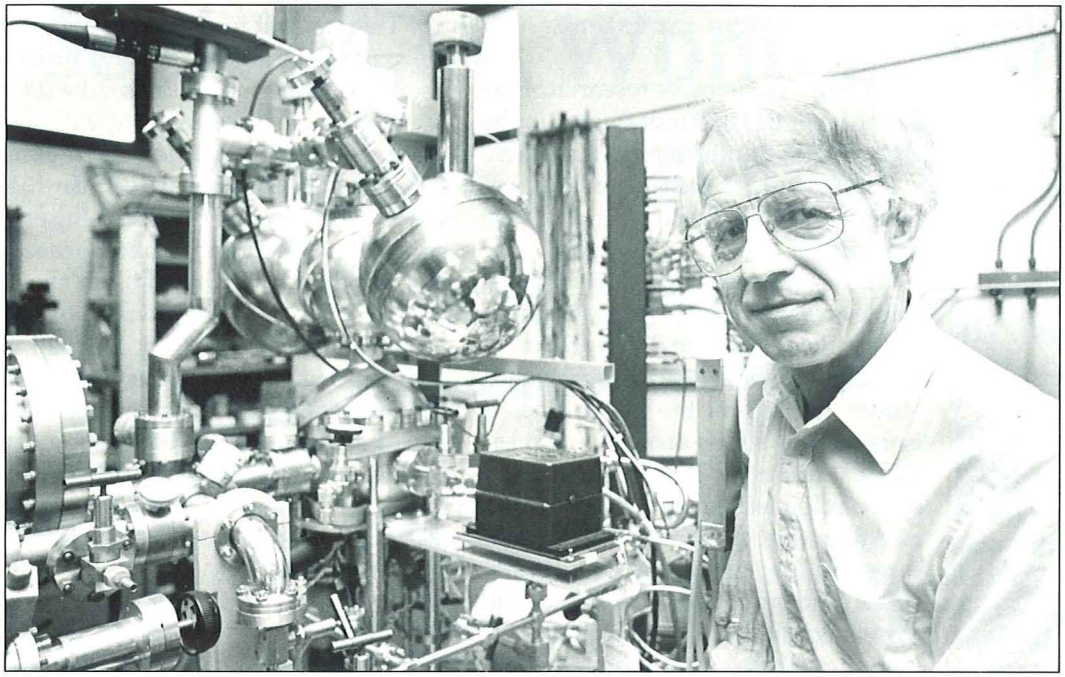

Photo by Dilip Vishwanat

Professor Konrad Mauersberger is one of many scientists from around the world who is conducting research at the University to help save the ozone layer.

Frying the Earth

What are the consequences of the loss of the ozone layer? Most people have heard that with more ultraviolet rays hitting the Earth's surface, skin cancer is more likely to occur. But ultraviolet rays can affect more than just your skin.

"Eye defects will be more common — the retina and the lens are very sensitive to ultraviolet light," said Mauersberger.

Animals and wildlife are also affected by the depletion of the ozone layer — the ultraviolet rays could harm certain crops and aquatic life, affecting the food chain.

NASA and ozone research

With the launching of space shuttles and satellites that disrupt the ozone particles in the atmosphere, the space program has taken some blame for the decrease in the ozone layer. But some say organizations like NASA are committed to protecting the ozone layer.

"NASA is doing a lot for the environment," said Mauersberger. NASA conducts research, he said, and tests to find out what affects the ozone layer and how to minimize its depletion. But Mauersberger said that there's not much that NASA — or anyone else — can do to fix the ozone layer right now, except warn politicians and work with the United Nations to find answers about environmental destruction and ozone depletion.

'Eye defects will be more common – the retina and the lens are very sensitive to ultraviolet light.'

– Konrad Mauersberger

Ozone research could lead to more atmosphere-friendly technology in the future. NASA is currently developing a civilian aircraft that can reach speeds of up to Mach 2.4, and one requirement of the airplane is that it cannot further the destruction of the ozone layer.

Industrialized countries are particularly worried about the consequences of ozone depletion, since they are creating products that destroy ozone particles in the Earth's atmosphere. The United States, Great Britain, France and Germany are all searching for ways to stop the further depletion of the ozone layer. The elimination of aerosol spray cans is one of the ways that some of these countries are trying to control the release of CFCs.

Greater public concern about the ozone layer has led researchers to develop several tools to measure the layer. Balloons carrying research equipment monitor the atmospheric air chemistry. And ground-based equipment and satellites measure the thickness of the ozone layer, based on the idea that the ozone is brought to a standard pressure and temperature directly above an object at the earth's surface.

Researchers determine the thickness of the layer by measuring the radiation that strikes Earth. By mea-

Illustration by Jennifer Hughlett

suring at different wavelengths and determining the amount of radiation absorbed by the ozone layer, scientists can find where the ozone has decreased.

Scientists are also looking for ways to produce cloud particles in laboratories that might aid in the reconstruction of the ozone layer. Mauersberger and a former University graduate student named David Hanson have already found ways to produce cloud particles using nitric acid trihydrate. Their research, done in 1988, has provided much information on the formation of polar stratospheric clouds containing H_20 and HNO_3.

"We did the right experiment at the right time," said Mauersberger.

Southern exposure

The most extensive research of the ozone layer has been conducted in the area over the South Pole, because there is a reduction in the ozone layer between 12 and 22 km in altitude above this region.

Low temperatures, darkness, stable air mass and cloud particles are factors that cause the deterioration of the ozone layer over the South Pole. In winter, the air in the South Pole is isolated and swirls around in circles, like a hurricane. Then polar stratospheric clouds form over the continent of Antarctica, when winter temperatures are low enough to have water vapor and nitric acid condense and freeze. Scientists believe that the formation of these clouds cause the destruction of chlorine reservoirs. When the sunlight returns in spring, its rays free the chlorine, allowing it to attack the ozone. Mauersberger said that the hole over the South Pole came about mainly because the air is very stable there in the spring.

Fortunately, there is less ozone depletion over the North Pole. The air is less stable in that area, making it nearly impossible for polar stratospheric clouds to form as they do over the South Pole.

There is still much to learn about the ozone layer and the factors causing its destruction. Scientists like Dr. Mauersberger have made great discoveries over the last decade to help save the ozone layer. As we near the year 2000, technology is increasing our body of knowledge and, in some cases, our standard of living. But are these advances causing the downfall of life on Earth? The world is closer than it ever has been to destroying every living thing on this planet, through the use of artificial products. So the next time you think about going to the beach to get that perfect tan, or plan to drive with the air conditioner on full blast — think again. ❖

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Wade Petrich

Age: 22
Year in school: Senior
Major: English

After freelancing for various Twin Cities publications, Wade will finally graduate this summer. He hopes to be novelist someday, and says he enjoys writing for *Technolog* to experience another area of writing.

Society of Women Engineers not just a woman's world

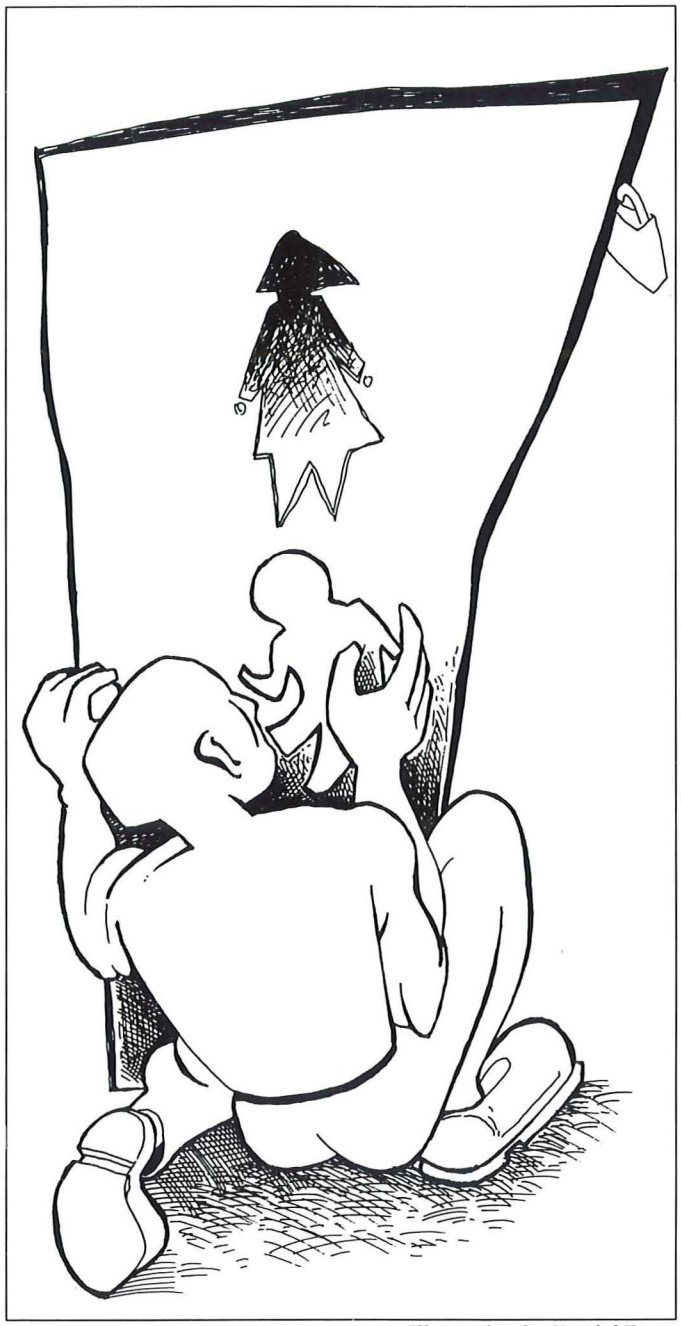


Illustration by Daniel Ruen

By Janet Szuba
For Minnesota Technolog

As I strolled into the office of the Society of Women Engineers, past the file cabinets and the faded blue couch, I expected to find at least one SWE member to talk to. After all, the door was wide open, as I had often seen it.

So I was surprised when I found a group of guys looking up at me expectantly.

"I'd like to leave a message for one of the SWE members," I said.

"I am a SWE member," they all said.

Men? In the Society of Women Engineers?

Better get used to the idea. Because men now comprise 15 percent of the 142 SWE members at the University — and they're proud to be in it.

Actually the concept may not be as strange as it sounds. Men have been associated with the organization for decades, according to Estelle Zito, the membership supervisor of SWE's professional society. When SWE first started in 1949, she said, no men were allowed. So the male engineers started their own group to help with the cause, calling themselves the Men's Auxiliary of the Society of Women Engineers. Then SWE changed its rule in 1976, and decided to accept both male and female members. Men have been involved ever since.

Mohammed Al-Aidy says he became a member of SWE because he is

Photo by Allen Smith

These are five of the men that make up 15 percent of the Society of Women Engineers. From right to left: Ivan Hyde, Thomas Enebo, David Hendrickson, Steve Ebel, Dave Grinnell.

very interested in women's issues.

"I know that there is still discrimination," says Al-Aidy, who was recently elected secretary of the organization. "I hear women students complaining that maybe they don't have a fair share in class. They talk about an instructor who doesn't ask women engineers for answers to questions, but will ask men. Maybe this isn't done intentionally, but it's important to bring it to their attention."

Al-Aidy says he has benefited by being a member of SWE. "There are so many things I've become more aware of and more sensitive to just by hanging out with women engineers," says Al-Aidy. "SWE's goal is to advance women's issues and they're only going to do that by bringing men in and making men understand what the problems are"

SWE's male co-director of outreach says being a member of the organization brings him personal satisfaction as he helps recruit more females into the field. "I pushed to become the outreach director because that was what I wanted to do — make sure that high school and elementary students don't shy away from science and math," says Ben Root.

He says he thinks it's a shame that young women are pushed into preset roles. "You can see that there are so few women in engineering compared to men. There was a talking Barbie doll on the market recently that said, 'I hate math.' If these young women can see men reaching out to them, especially when men are probably the ones pushing them away, then these young ladies might consider going into math and science."

Eric Hendrickson, the current SWE vice president, says he was initially attracted to SWE because he had friends who were members. He claims both men and women can benefit from males being members of the group. "When women in SWE get out in the career place they're going to be working mostly with men," he says. "So, an organization made solely of women isolates them from interacting with men."

Hendrickson says he approves of allowing men to be elected to any leadership position in SWE, including president. "I don't think there would be any problem with having a man as president," he says. "Men and women need to work together, and as long as the main goals are being carried out, I don't see any problem with it."

Although Felix Lin has now graduated, he was a SWE member for four years and vice president of the group in 1992. He says he first joined the group because he heard about the fringe benefits. "There were test files, 40¢ pop, a small refrigerator and a quiet place to study," he says. "That was in the old SWE office, in 338 Walter Library. It was like a clubhouse."

But soon Lin got swept up in the activities and recognized other advantages. "SWE is great for networking," he says. "Right now I know four or five alumni who are members of the professional society that I can call and they can help me out, and they're in big corporations like 3M, Honeywell, and General Mills. You also get to know so many people. The campus has 45,000 students, 20,000 of which are I.T. That's like the population of a small city. But being in SWE, suddenly I knew faces walking down the street."

Lin says that he learned a lot from being a involved in the women's group. "In SWE you see that men and women can relate in a professional manner, working together," says Lin. "I've also learned that you can't say, okay, this is a group of women and they all gossip, and they all do this, or that. That's wrong. You have to take people individually because they're all so different."

'There were test files, 40¢ pop , a small refrigerator and a quite place to study ... it was like a clubhouse.'

– Felix Lin

Unlike Hendrickson, Lin believes the position as president can only be filled by a woman. "I would never presume, being a male, to know anything about women's issues," he says. "The general meetings and seminars that SWE schedules can be held on a variety of levels: on a professional level, to an interpersonal level, to discussing discrimination. For a man to have the responsibility of trying to set direction for SWE — I think it's ridiculous. I think this is one position that needs to be filled by women."

Female SWE members welcome the men into their organization. The women say they believe the males in the group come out of the experience more open-minded. "The men who join SWE aren't going to be the ones who sit back and bash women," says SWE member Julie Smolarek. "They're going to be different."

Nancy Ghoneim, the newly elected co-president, says she believes SWE needs men. "Men also want to support women in engineering, just because there's not that many [women] there," she says. "When we go out on outreach programs we like to have at least one man come along. That way we can show kids it's not a male-dominated field, but men and women can work together."

And so it's up to the men to weather the surprised looks and the occasional snicker — but most are used to it by now. "The men jibe me a little bit about being a member," says Root. "But I just give them all the same response: Men can promote women in engineering just like women can." ❖

Janet Szuba

Age: 24
Year In School: Senior
Major: Journalism

Janet hope to find a job writing and editing after she graduates this quarter. If she's still jobless by June, she says she'll fly to Europe and try her hand at travel writing.

Lighting the road to the future

By Adam Talle
Photo by Kari Shuda

Americans have been building and racing cars for decades. Johnny Cash sang about building his own Cadillac in the song "One Piece at a Time." Burt Reynolds raced his Trans Am against a field of exotic cars and dingbat cops in *Smokey and the Bandit*. And soon some Institute of Technology students will merge these two tributes to American cars, as they race across the country in their own homemade vehicle.

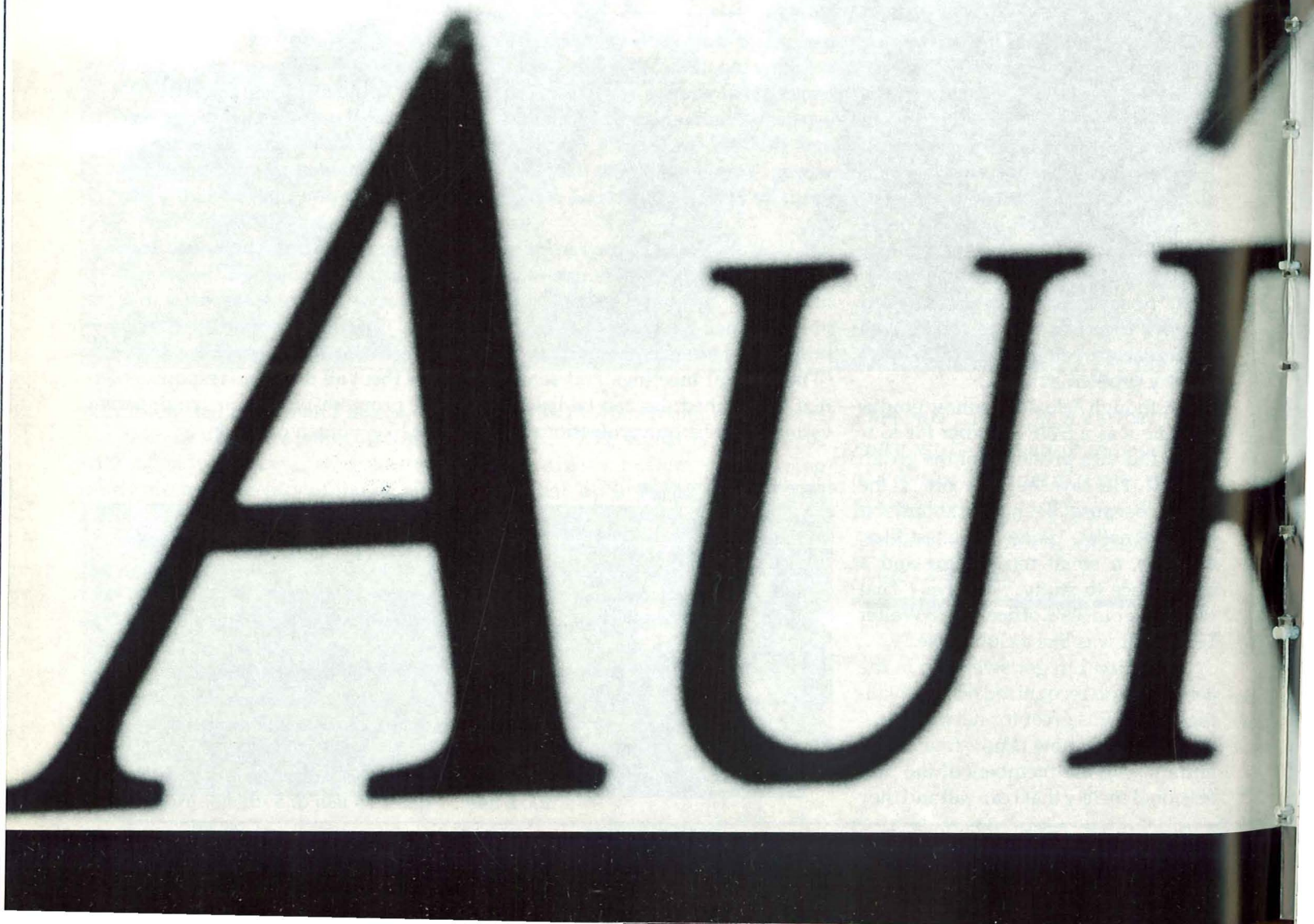
But unlike most cars, this muscle machine guzzles no gas. Instead, the "Aurora" — built by University students to race from Dallas to Minneapolis in June — needs only the sun to turn its crank.

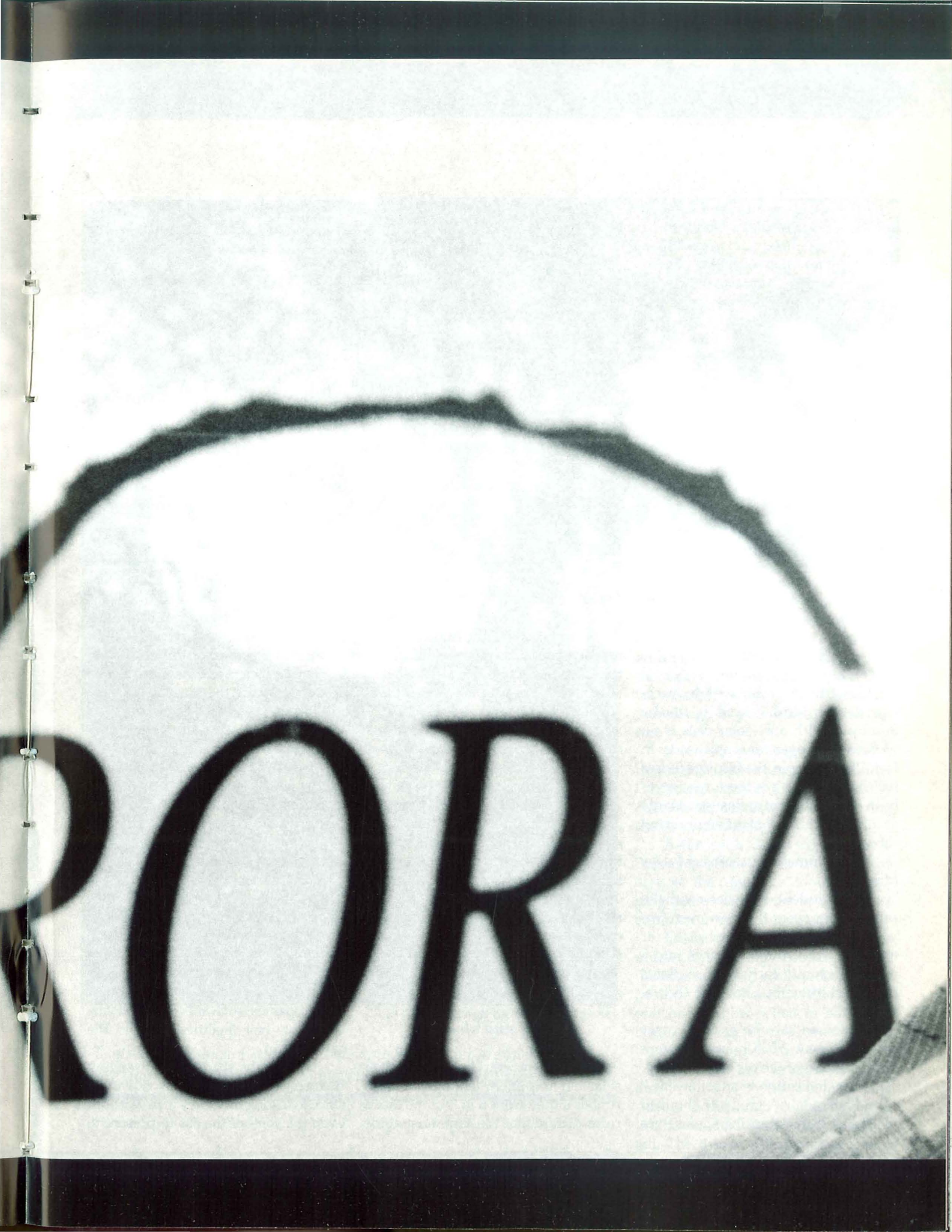
The solar-powered car is the culmination of two years of work by I.T. students, proving that they not only have a need for speed, but they can also apply their classroom skills to a practical project.

The students are preparing the Aurora to run in the 1993 Sunrayce, a solar vehicle race sponsored in part by the U.S. Department of Energy, General Motors Corp. and the Environmental Protection Agency. The race is a national acid test for future solar cars, and universities from all over the country will be taking part.

But the project has not exactly been easy. University students involved with the Aurora say the road to completion of the solar-powered car seemed much longer than the 1,000-mile racecourse they will face this summer. They say their dedication to the car has exhausted them, but it has also given them a sense of accomplishment.

"The caliber of the people is matched by the caliber of the project," says I.T. student John Anderson, who spent nearly 40 hours a week designing

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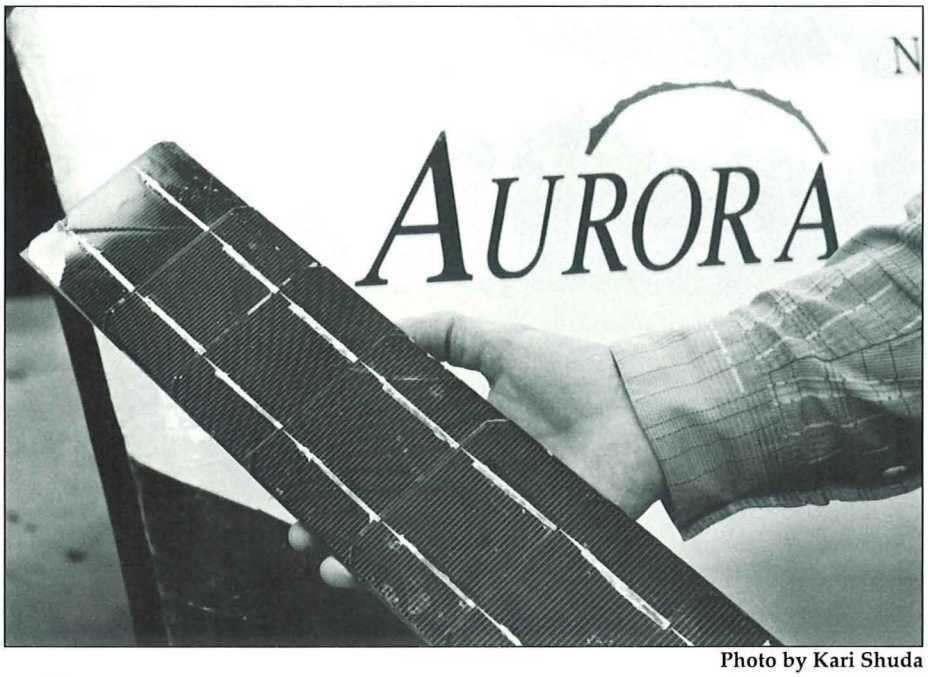


Photo by Kari Shuda

These solar cells power the Aurora solar race car.

and building the car. "People watching what we do have been surprised."

Elbow grease

Constructing a car with a space-age design, and racing it in the Sunrayce, with only solar cells is no weekend job, even for motorheads. In fact, Virgil Marple, the faculty adviser for the project, says there has never been an I.T. student endeavor as large as this in the history of the engineering school.

"It's a humongous project," says Marple.

Some students have been with the project ever since it began over two years ago, Marple says, and as the car emerged from rough sketches into a racing machine, nearly 20 I.T. students dedicated numerous hours to the vehicle.

Anderson says he and the other students spent 2,000 hours just constructing part of the car's underbody.

"The dedication is unbelievable," says Anderson. "A group of about 15 to 20 has been knocking themselves dead."

Anderson says most of the students involved with the Aurora project are full-time I.T. students — but sometimes their devotion to the vehicle's completion compete with class attendance and work at their other jobs.

"It's not easy for many of the volunteers to keep up with school work while constructing the car," he says.

During the construction of the Aurora, students used advisers only to secure financial help through University channels. Otherwise, Marple says, the project belongs exclusively to the students.

And at a total cost of nearly $130,000 the students say they hope the car not only surpasses their expectations, but also wins the race.

"It's no soapbox derby car," says Anderson.

Big and sleek

I.T. student Scott Grabow says their solar car is punchy enough to burn rubber if they want it to, but the race's rules dictate that the cars must abide by highway speed limits. The race guidelines also limit the cars' power, to create a more level playing field. The rules state that any batteries used in the vehicles must be available in general stores, and the electric motor can be no larger than 10 horsepower — about the size of a golf-cart motor.

The University's 700-pound, 20-feet long car — described by Grabow as a "three-dimensional airfoil" — balances aerodynamics with its large frame, to make room for as many solar cells as possible.

"It's the biggest vehicle to ever enter the Sunrayce," says Anderson, who describes the design as "unique."

Grabow says, "We had to be efficient while keeping in mind that we had friction with the road and a finite amount of power to deal with."

Even when it was no more than a computer image, the Aurora awed and intimidated people. "We've been told that we're the school to beat," says Grabow. "We're up there with Michigan who won the last [Sunrayce]. It makes us feel good that the national champions are wondering what we're doing."

Pay to play

But being the best costs money — and more than once the Aurora project was nearly penniless, says Marple. The students had to depend on donations from computer and software manufacturers for technical equipment, and on companies, such as Northwest Airlines, for their facilities to build the car's mold.

University students say selling themselves hasn't been easy, however, since for a long time they were without even the shell of the car to present to

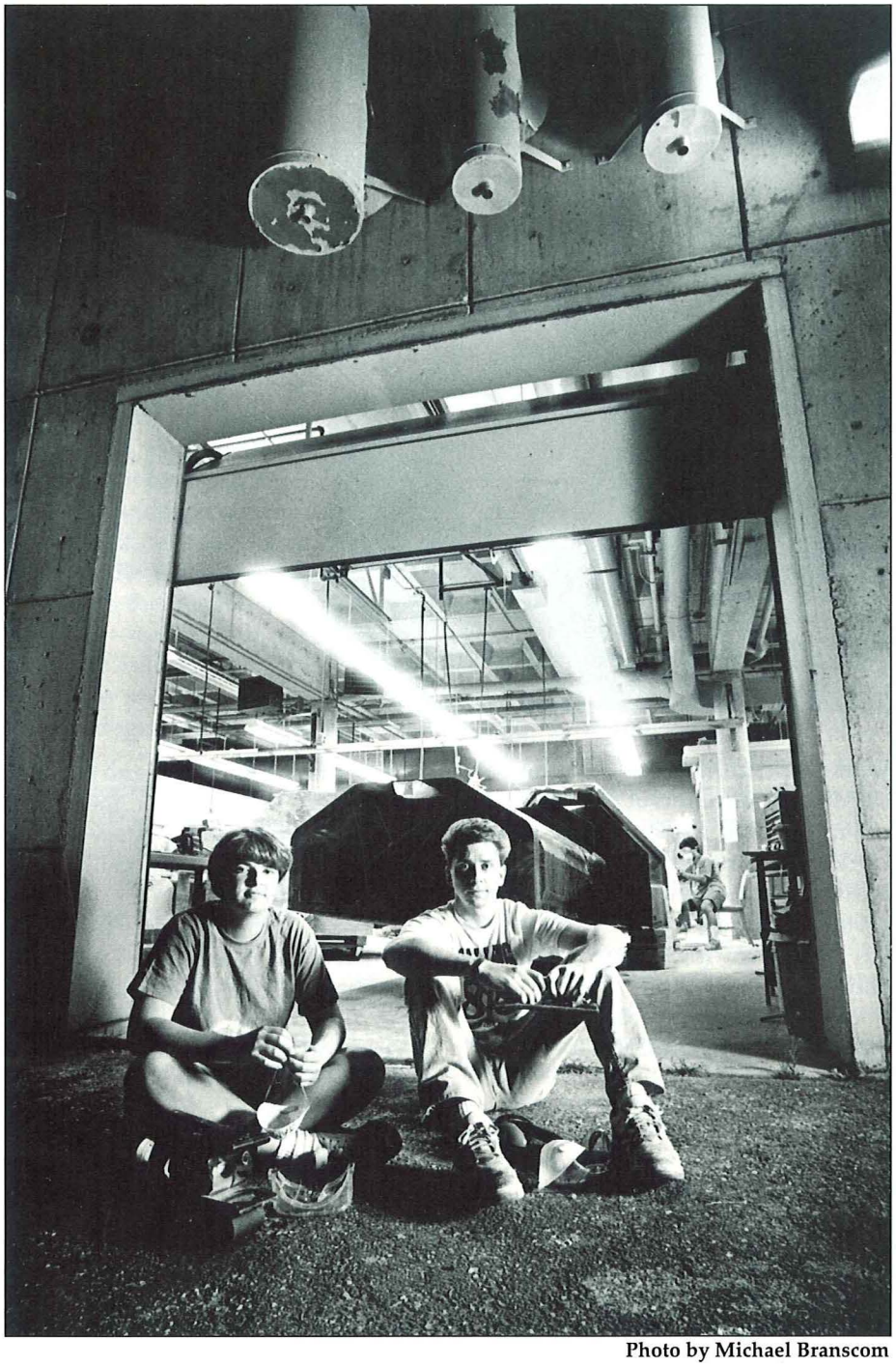


Photo by Michael Branscom

I.T. students Jessica Gallagher (left) and Rob Miller are two of the more than 20 students who are working on the Aurora project.

potential investors.

"It's been a hurdle to get money," says Marple. "It's taken quite a bit of energy away from work on the car."

Anderson says they could only afford to spend money on items that went directly into the car, which hurt promotion of the Aurora. But, he says, that students involved with the project have a new appreciation for the work involved in finding donations for science projects.

"Once we were able to get in contact with some alumni with money, we learned a lot about networking." he says. "We had limited funding success before the University helped us."

Racing with the sun

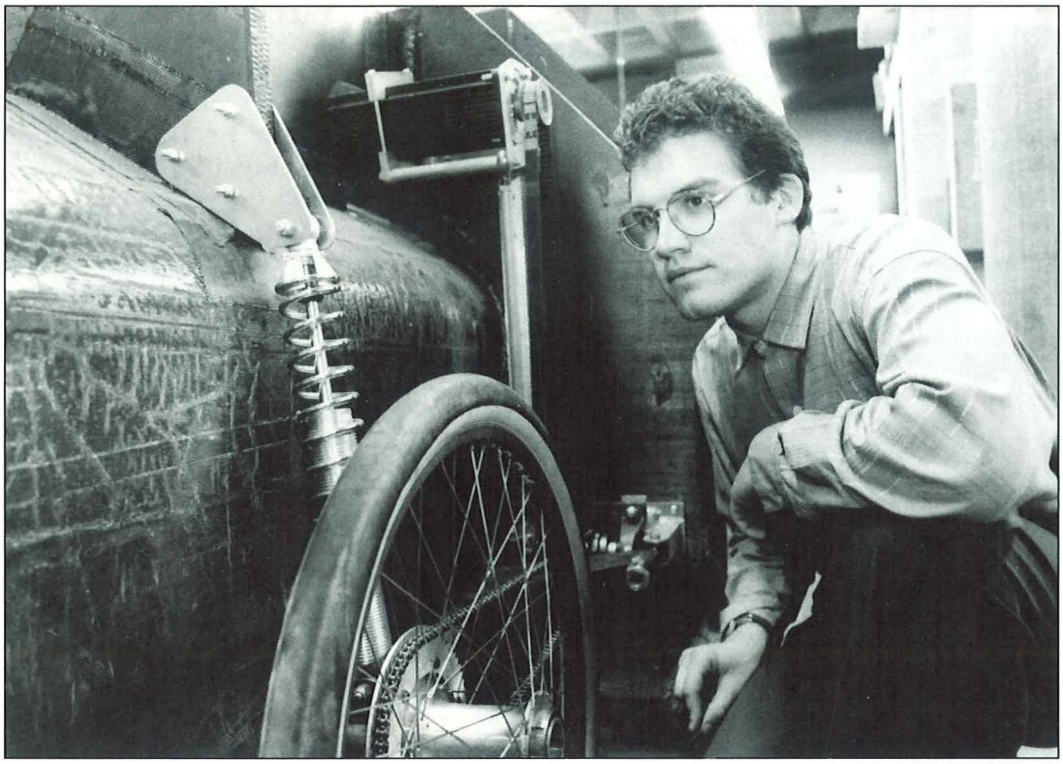
The catalyst for much of the solar car work, say Anderson and Grabow, is the students' desire to win the Sunrayce competition. But coming up with a winning strategy requires much foresight about the road between Dallas and Minneapolis, and intimate knowledge of every inch of the Aurora.

It's no flat-out drag race. Instead, the racers will have to consider weather conditions, damage to the fragile solar cells and the position of the sun during the seven-day event.

After each day's competition, Sunrayce officials will impound the cars for the night at a common stopping point. The car with the lowest cumulative elapsed time will win.

Racers will need to consider how much stored energy they'll need for the next morning, while jockeying for position with other cars. "The strategy will be to know when to have two hours to charge up the batteries or to try to gain ground," says Grabow.

Anderson and Grabow say they don't know yet who will drive the Aurora in the Sunrayce, but he or she can be no taller than 5 feet 10 inches tall. The driver will stay in constant



John Anderson, a junior in electrical engineering, has been working on the Aurora project for two years.

Photo by Kari Shuda

contact with a University crew, to monitor the vital signs of the solar car.

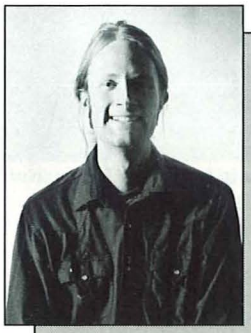
"We want to bring everyone who was really involved in building the car," says Anderson. "If [the car] breaks, they built it, and they would have a great deal of control in all the 'what if' situations."

The race also presents a good opportunity to cultivate connections for those interested in continuing their work in the sun. Anderson and Grabow say that job recruiters at previous solar car races hired students right off the track. They say that they, too, would like to continue their solar car research after graduating, but they realize the job market for their solar interests is small.

"Corporate America won't develop solar cars until it's forced to," says Grabow.

But even if Anderson and Grabow can't predict what trouble they'll encounter down the road, they say they've seen the future of automobiles while working on the Aurora.

"We're at the stage where we can look back 100 years, when race cars with internal-combustion engines were lucky not to blow up," says Grabow. "We're sort of in the same place now because we're developing solar cars of the future." ❖



Adam Talle

Age: 23
Year in school: Senior
Majors: Journalism

Adam is looking forward to graduating this quarter, and hopes to be writing for a Minneapolis weekly paper. If he's still jobless by July, he says he'll re-read all his Hemingway novels and seek adventure overseas.

A new profession on a poisoned planet

By Steven Axelson
For Minnesota Technolog

With the environmental movement in the United States only about two decades old, there is already a widespread awareness that the rapport between human civilization and the Earth's biosphere is not very good. But despite some efforts by Congress — such as the passage of the Clean Air Act and the Clean Water Act — to help protect the biosphere, ecological degradation continues unabated.

Modern civilization's excessive use of energy from earthly fuels has played a significant role in the corruption of the Earth. But, still, this has been just *part* of the problem. Another factor that should not be overlooked is that many poisonous wastes are generated in the production of modern artifacts. And the extent of this detrimental situation is becoming more obvious as time passes. I believe this problem is so urgent that it calls for a new science — named *artifact ecology* — to help counter this plight in our society.

Historically, it seems humans got off on the wrong foot, as far as the environment is concerned. People have continually introduced new technologies that, while beneficial to humans in some specific ways, later turned out to be profoundly harmful to the biosphere.

One example of this is the introduction of the steam engine. Using coal as fuel, the steam engine had numerous applications — factory machine operation, water pumping, electricity generation, ocean transport and so on. At its onset, the steam engine was a great blessing to society, changing the nature of work for many people so that life required less physical toil. Today, however, the Earth's biosphere is paying the price for our quest for convenience.

The introduction of the automobile is another example. Since its first large-scale proliferation during the early 1900s, the automobile has allowed people to significantly expand their ranges of travel. This has allowed for a greater separation between the workplace and the home, giving rise to suburbs and "bedroom communities." Now, millions of people are dependent on the automobile for their economic, and thus physical, survival in our contemporary culture. But in the meantime, toxic fumes from those automobiles continue to corrupt the environment.

The invention of new chemical products has also been a mixed blessing. As the attractive, sellable products leave the company through the front door, the chemical wastes that result are quietly — and sometimes secretly — deposited somewhere in the biosphere.

Cultural analysts and ecologists have said that a profound change in the way we live may be necessary to halt the degradation of the biosphere so that the human species can have a long-term, healthy existence on Earth. This, of course, cannot be known for sure. But with our excessive use of finite and polluting fuels, with our culture continually generating malignant artifacts, and with the known corruption that is continuing to take place, it seems that we are now slowly headed for "eco-suicide."

This is where my proposed field of artifact ecology comes into play. The

Illustration by Jennifer Hughlett

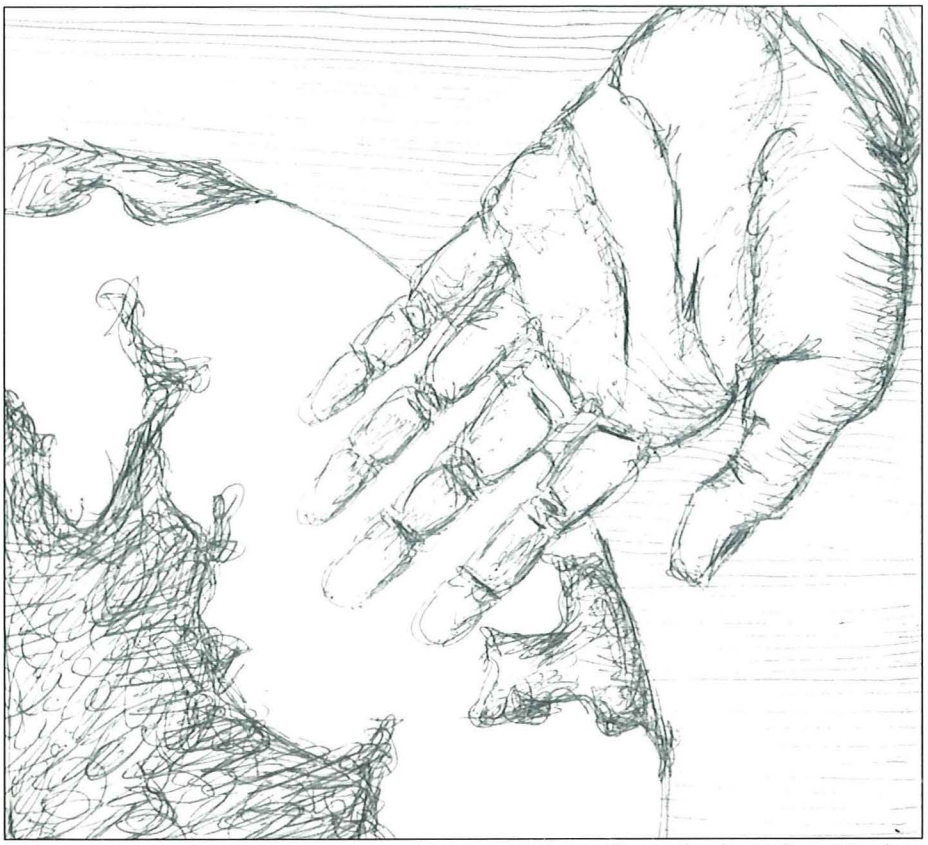


Illustration by Melissa Mendoza

dictionary defines *ecology* as the science of the relationship between an organism and its environment. I generalize this definition by referring to the relationship between an "entity" and its environment. An entity could be an organism, a man-made artifact or something else. With the qualifier *artifact*, I limit the study to the relationship between an artifact — the material result of human endeavor — and the environment. The dictionary defines *science* as any methodological activity, discipline or study. Since the new professionals in this field would work methodologically in the study of the relationship between artifacts and their environment, they would be working in the *science* of artifact ecology. Thus the new experts in this field could be called scientists of artifact ecology, or artifact ecologists.

This new order of technical professionals is needed to help coordinate the technological progression of our society so as to avoid the further degradation of the biosphere. High-performance technical specialists of the past created the means to destroy our environment. It now seems necessary for a new generation of professionals to rethink the standards for what are considered "good" technological innovations.

One principle that artifact ecologists would promote in order to direct a cultural evolution is that the entire environment be kept in mind whenever a new artifact is invented. It is not necessarily easy to anticipate all the ramifications of a new invention. Learning from history, however, the artifact ecologists would assess the likelihood and extent of harmful impacts associated with the existence and production of a new artifact on the Earth's biosphere. They would then report their findings to society at large, so that an informed society could choose whether or not to allow proliferation of the artifact.

The artifact ecologists would analyze and report on presently used artifacts as well. In pursuit of a benign culture for the future, perhaps some such artifacts would have to be left out, simply because they may be too detrimental to have around. Or the scientists may determine that a limited production of an invention is ecologically acceptable.

As part of the evolution toward an ecologically benign culture, artifact ecologists would gradually establish a realm of knowledge within which inventors would work to design nonharmful artifacts for eventual introduction to society. They would provide ecological information about materials and artifacts that may be under consideration for use in new inventions. Currently, this sort of knowledge is, to a large extent, unavailable to contemporary engineers — and probably unwanted as well.

Some scientists are already pursuing this type of study to a certain extent, but there is much more work to be done. The development of our understanding of the ecology of artifacts will likely become increasingly important, in order to make cultural decisions that will affect generations of humans yet to be born on Earth.

The thought of attempting to achieve "ecological benign-ness" in our culture can be overwhelming. The magnitude of the project could be used as an excuse for some to ignore the issue, and those people may feel more content hiding in a secure, traditional career, working out the details of some malignant technology. But the environmental situation should instead be seen as a great personal challenge and potential career path. With an optimistic attitude toward success in the endeavor of redesigning our culture to be environmentally friendly, artifact

Illustration by Jennifer Hughlett

ecologists may be applauded by society as cultural heroes, and thus inspire others to work toward a healthy rapport between human civilization and the remainder of the Earth's biosphere.

The notion of deliberately "evolving" our culture with ecological analysis as a guide for choice-making seems to be generally non-traditional. Many ecologically significant choices of the past have been based on ideologies that did not consider the goal of ecological benign-ness important. It seems that many choices leading to significant cultural changes that have turned out to be ecologically detrimental were made for the sake of immediate convenience or for the desire for more money. Consider again the introduction and use of the automobile. Did Henry Ford manufacture cars to create a better culture for humans, or to make money, or both? And why did people buy his cars? We are now paying the price for these conveniences.

Perhaps some innovators truly believed that no ultimate harm could result from the utilization of their artifacts, and society later accepted them with few questions. This seems to be the case with the now-infamous chlorofluorocarbons. Invented in the 1930s, CFCs were found to be an improvement over previously used refrigerants, such as ammonia, methyl chloride and sulfur dioxide, all of which have noxious or toxic properties. But now, decades later, CFCs have been linked to the degradation of the Earth's stratospheric ozone layer. Artifact ecologists could help prevent such harmful situations from occurring in the future.

With the CFC case as a punctuation mark, I suggest that what is now known about the relationships between our countless artifact species and the environment is just scratching the surface. Who is going to bring forth credible knowledge of these relationships so that human society of the future can make intelligent choices in the evolution of human culture on Earth? ❖

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Steven Axelson

Steven Axelson has a bachelor's degree in Computer Science and a master's degree in Electrical Engineering. He is currently writing essays on technology and the environment, and hopes more people will get involved in the effort to protect the Earth.

Research spheres turned inside out

By Alice Chen
Technolog Staff Writer

Some researchers have all the fun. A team of mathematicians at the University is working on a video project that shows how a sphere can be turned inside out ... with no creases or tears.

But it's no joke — six or more team members have been working on the project part time over the past four years.

A mathematician named Steven Smale came up with the sphere theory in 1957, and in 1964 Arnold Shapiro proved it in practice. The theory shows that a sphere made of an abstract material that can stretch, bend and pass through itself could turn completely inside out without ripping or folding. And now the video by a team at The Geometry Center is putting this concept into visual form, using a method invented by Bill Thurston in 1974.

Visual mathematics

Tamara Munzner, the technical director for the program, says the purpose of the video — called *Outside In* — is education. "We hope to communicate the fun and beauty of mathematics through visualization," she says.

And the video is indeed visually pleasing. It is entirely computer-generated animation, with vibrant colors and imaginative associations with everyday things, to help the viewer understand the sphere theory.

Other members of the team include Stuart Levy of the University of Minnesota, Mathematical Director Silvio Levy (the Levy's are not related), from the West Coast, and Artistic Director Delle Maxwell, from the East Coast.

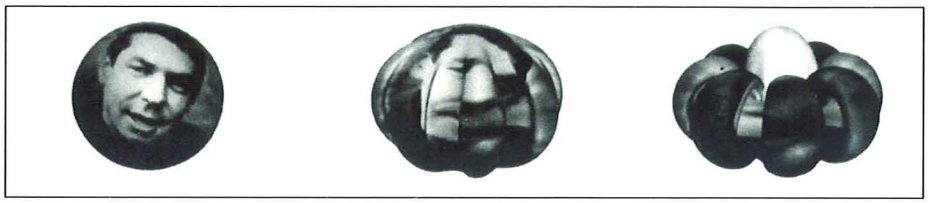
The video project has also drawn students from both sides of the United States. David Ben-Zvi, an apprentice at the center, is deferring his undergraduate studies at Princeton to research the sphere; and another apprentice, Nathaniel Thurston, is a graduate student at Berkeley.

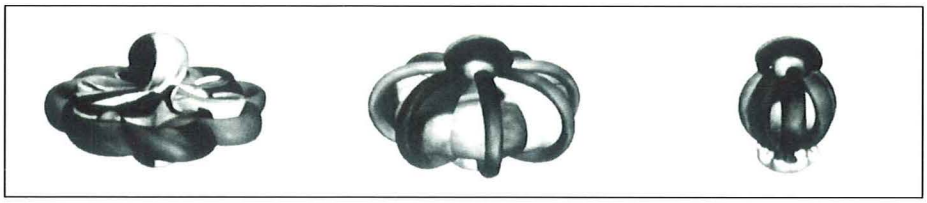
The group works together on all aspects of the video. "Everyone is involved in producing graphics and writing the script," Ben-Zvi says.

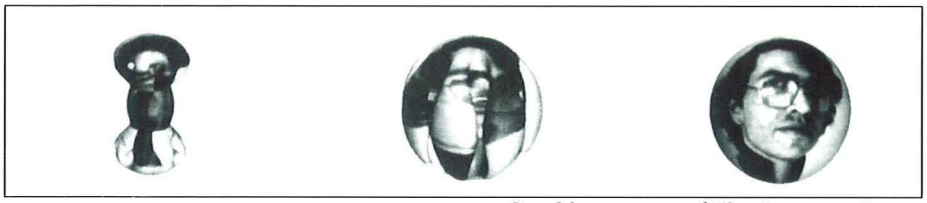
Munzner hopes to complete the project within the next year. She says the *Outside In* project receives funding from the National Science Foundation, the Department of Energy, Minnesota Technology, Inc. and the University of

Photo by Dilip Vishwanat

Mark Phillips, Stuart Levy, Tamara Munzner and David Ben-Zvi (clockwise from left) are developing a video about turning a sphere inside out without tears or creases. The video is being made at the University's Geometry Center.







Graphics courtesy of The Geometry Center

These computer graphics show eversion — the process of turning an object inside out. Bill Thurston's face is displayed on the outside of the sphere first, and then Steve Smale's face is shown on the inside-out sphere.

Minnesota.

The Geometry Center also received grants in the past for a similar type of educational video project. "The first video, *Not Knot*, was a guided tour of hyperbolic geometry and knot theory," says Munzner. "Both videos are made for a wide audience that ranges from mathematicians to junior high school students."

Spheres of the future

Currently there are no applications for turning a spherical surface inside out — but applications are not necessary. The growth of knowledge from pure research tells us more about the world, and can entertain us at the same time. Who knows, maybe someday we'll discover that the dimension of time is like an inside-out sphere, or that the universe twists and turns, following the same route of a sphere's eversion.

But that's in the future. Right now, says Stuart Levy, "What we want to do is make mathematics visible." ❖

Alice Chen

Age: 21
Year in school: Senior
Major: Scientific & Technical Communication and Pre-physical Therapy

Alice is glad to be graduating this quarter. She hopes to be a forest ranger this summer in Washington state or California's redwood forest.

Diversions


THE TREMENDOUS AUDACITY OF
FEZ!
THE PHYSICIST
We have caught fez and the kids in an interesting setting.... the Park.
Oh, dear.
fez, i've been thinking
NO TALKing
i've been thinking that maybe too much science is detrimental to our lives. i mean, we know so much about stuff... atoms and ions and physics; but haven't we sort of misplaced our humanity somewhere? where's the soul, fez? where's the moral conviction? i'm talking on a societal scale, here.
mm-hmm, tomika, don't eat the dirt.
munch munch
i mean, look at all the death, fez. sure, we have cool weapons- 'smart' bombs and infra-red goggles; but at what price? it's the system, and it's eating us alive.
NO CALLOUS DEATH ENDINGS
...right... tomika honey, get out of there.
OH WOW, Tommy got killed by that tiny nuclear explosion.
ZZK-FLASH!
No, i'm pleased to say that tommy has lived, but he's going to be hard-pressed to find a mate. his face is horribly scarred
Plastic surgeon! computer generated facial reconstr- uction!
come back, mr. bunny.
NO DAMNED FRISBEES
oh, me! oh, life! to live in the heart of the beast and—
Tommy, i think you—
Tomika! Put those down at once!
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END.