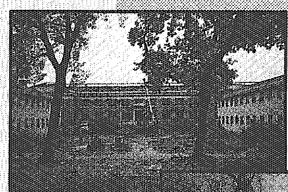
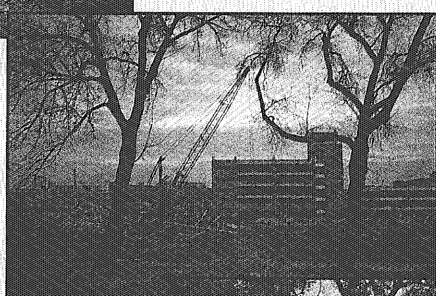
minnesota TECHNOLOG

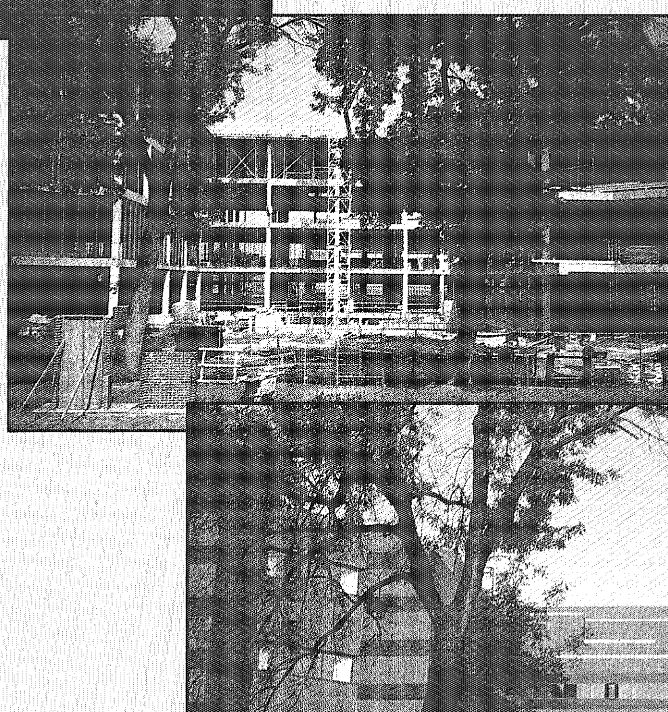
Fall One, 1988

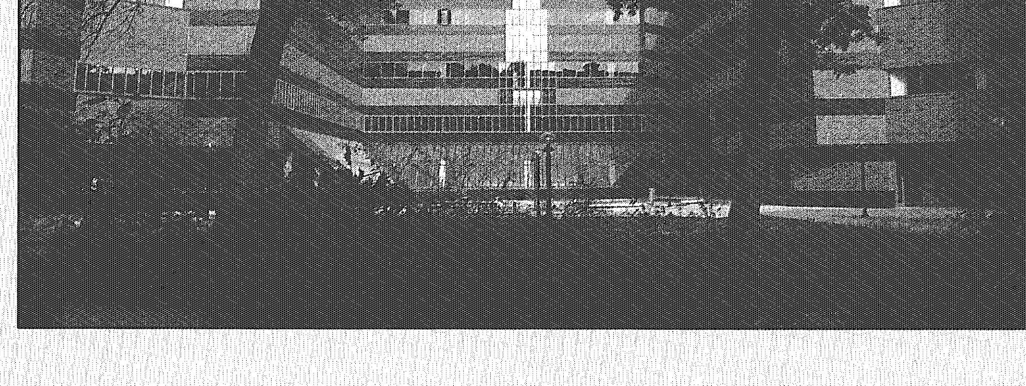
Electrical Engineering/Computer Science

- EE/CSci Building
- Computer Architecture
- Software Piracy
- Polla Interview
- Graduation Address









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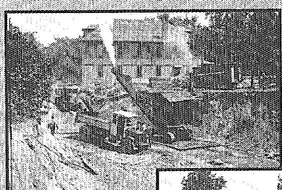
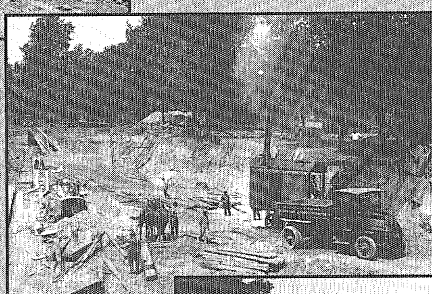
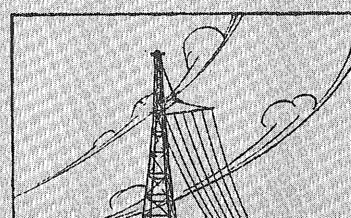
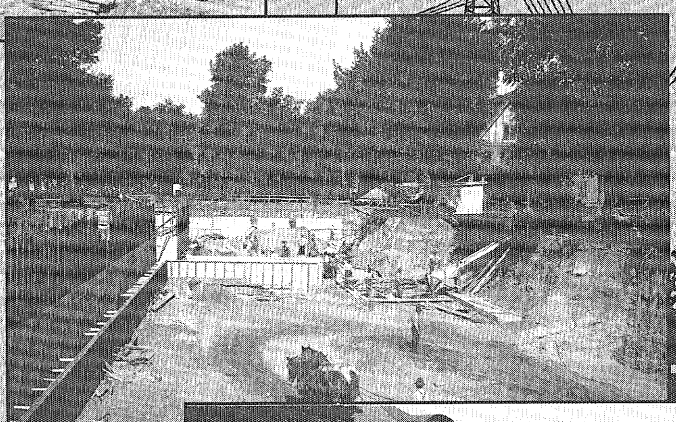
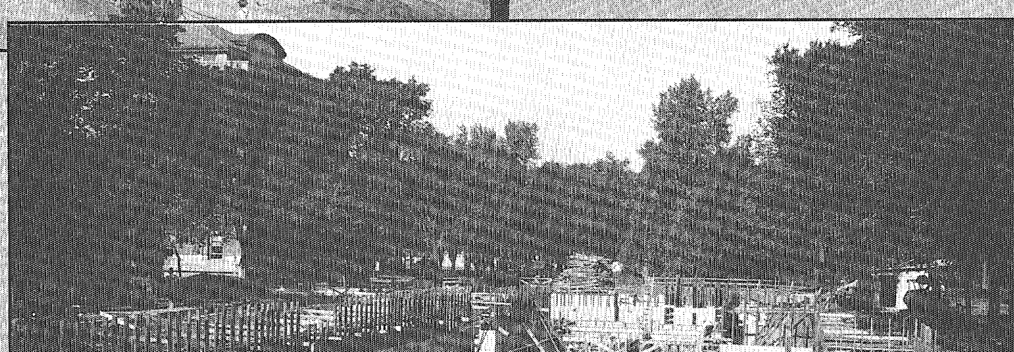

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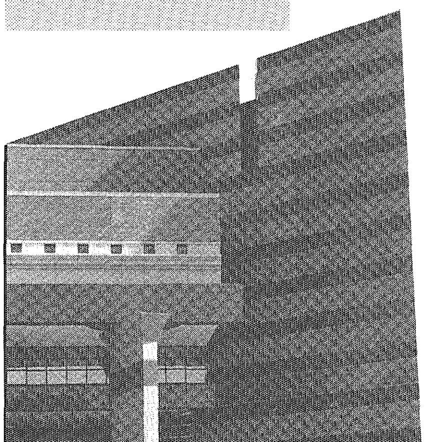

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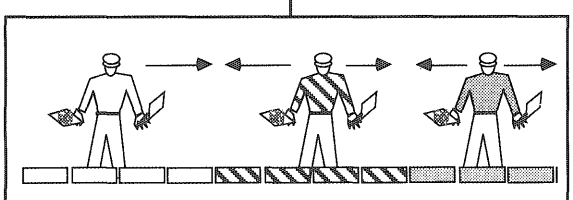

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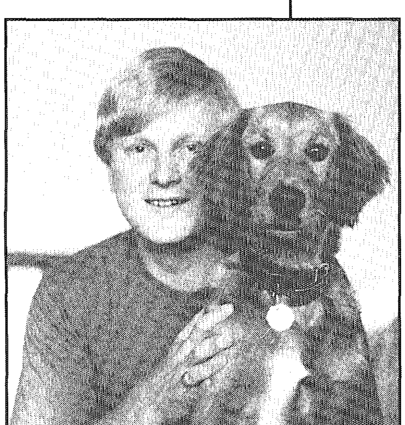

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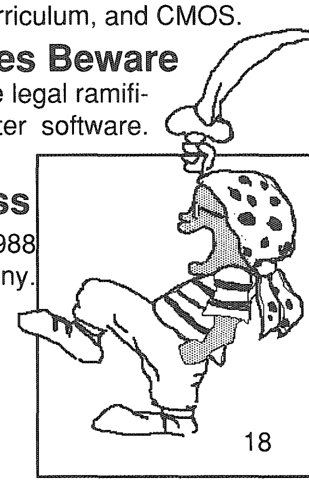

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On the cover
The Electrical Engineering/Computer Science Building in successive phases of construction.

On the facing page
The original Electrical Engineering building, completed in 1924. The overlay is the December 1924 Minnesota Techno-Log cover, when the current EE building was built.

Bloom County character by Berke Breathed and drawn by Conrad Teves.

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Building with Purpose

by Steve Kosier

Welcoming Institute of Technology students to the 1988-89 school year is a new building—the Electrical Engineering/Computer Science building. In response to the explosive growth of the electrical engineering and computer science industries in the past decade and a half, it provides new classrooms, labs and study space for students. For faculty, it provides larger offices and modern research labs. The building is attractive and easily accessible. The only thing it lacks is modern instructional equipment. The consequences of this omission will be discovered after examining the building itself in more detail.

The building will help attract blue chip faculty, and it will serve as an incentive for technology-based businesses to expand and/or locate themselves in this area. It should advance the university's standing and reputation in the fields of electrical engineering and computer science. Success in these areas will more than justify the cost of the building. This success, however, will not be fully attainable, especially in the long run, without increased emphasis on undergraduate education.

In general, there are many undesirable repercussions for an institution when it turns out students which are not as capable as other institutions' graduates. The reputation of the department from which they graduated suffers, making it difficult for the department to recruit the brightest students and best faculty. Without these quality people, new knowledge is not created as fast as it could be. This low output discourages companies which require technical support from locating in this area, which results in jobs not created and tax dollars not collected. This decrease in the money pool translates directly to a decrease in quality of the department, the university, and the new graduate.

This full-circle scenario, or a variation of it, is very real. Once started, it is difficult to elude. An institution's reputation is an abstract concept, but one thing is certain: it must be earned. The only way it can be earned is by improving performance. The performance of an institution is measured, in the long run, by the performance of its graduates. Therefore, the institution cannot afford to have graduates which are anything but the best and the brightest.

With this established, one turns to the question of how to produce more capable graduates. Any answer to this question must have quality laboratory experience for its students at the head of the list.

Quality laboratory time to supplement theory is essential to a technical education, for it solidifies otherwise abstract concepts, creating a far more lasting impression than theory alone could. Experience on modern equipment is vital to a technical education, and the quality of this experience is directly proportional to the newness of the lab equipment. Skills acquired on outdated equipment are of questionable value, as current research is seldom performed on equipment used in the past. These outdated skills reduce the competitiveness of new graduates, both in industry and graduate school.

In order to obtain maximum benefit from I.T.'s newest building, the U should equip it with new instructional equipment. In this way I.T. can continue as a great technical school far into the future.

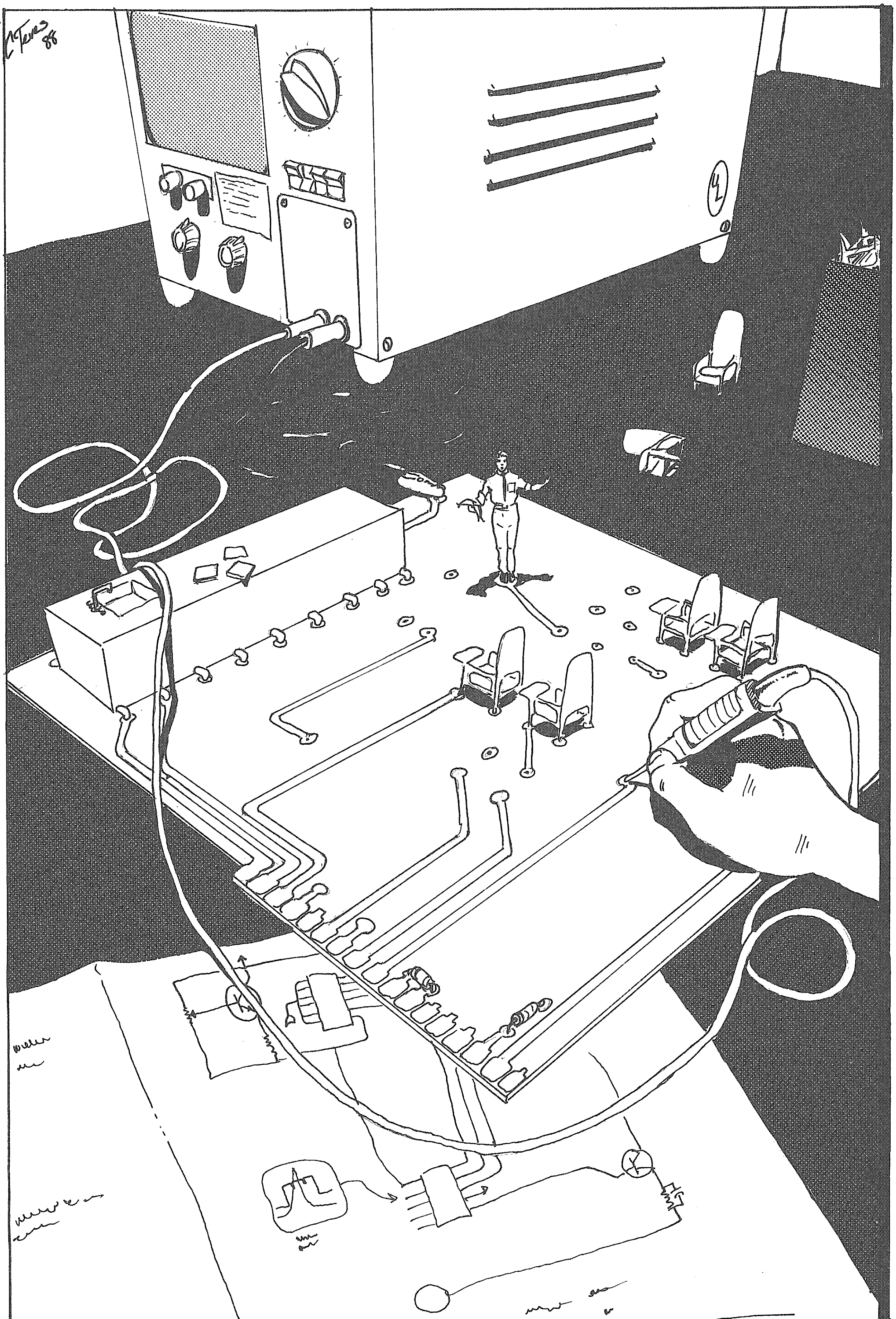


Illustration by Conrad Teves

The Electrical Engineering

By Steven Subera

After much anticipation, the Departments of Electrical Engineering and Computer Science have joined the 20th century with the completion and opening of the $44.3 million Electrical Engineering and Computer Science Building. A sophisticated microelectronics laboratory, advanced data communications network, air-conditioning, spacious classrooms and a well-lit student commons highlight the structure, which will accommodate over 2500 students in the two departments.

"It's a very logical layout. I think people will really like it once they get in," Peter Zetterberg, associate to the Dean of IT, said. Zetterberg said the new building will benefit both departments equally, but noted, "It will be an entirely new world for computer science. Here you have one of the University's largest departments that has essentially grown up in no space at all."

The new building is different from other University buildings in three ways, according to Zetterberg. It has air-conditioning, a sophisticated microelectronics laboratory, and a very sophisticated data communication system. Excluding the microelectronics laboratory, Zetterberg said the rest of the Electrical Engineering and Computer Science building does not contain exotic features. "I think initially when the building was proposed everyone thought it was all going to be like that [the microelectronics facility]," he said.

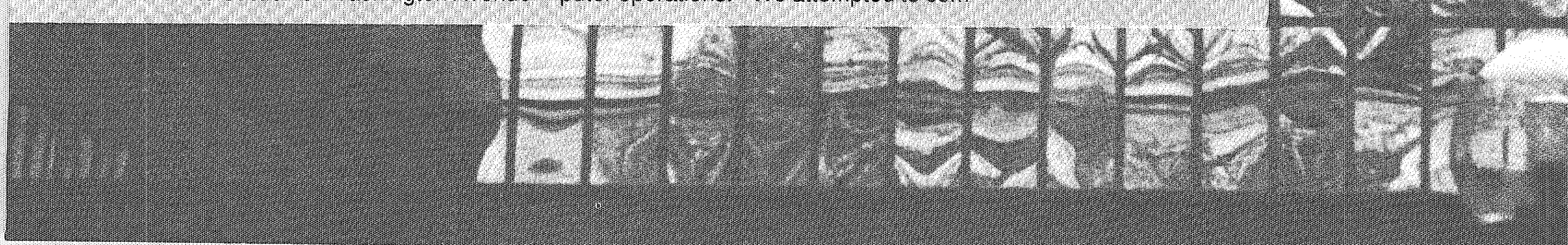
The architectural firm Hammel, Green, and Abrahamson provided the design. The building is U-shaped with a central outdoor rotunda in the middle. A large diagonal slab on the corner of the building at the intersection of Washington Avenue and Union Street is present to provide a pedestrian entrance to the Institute of Technology. Zetterberg said the architects were aware of the tremendous amount of pedestrian traffic from the Health Sciences Complex area and wanted to maintain the diagonal with a physical structure leading students into IT.

Computer science occupies the south side of the building, while electrical engineering is in the North and East wings. It is large enough to accommodate the departments, but does not provide space for easy expansion. There are six classrooms in the new building, five on the 3rd floor [ground level] and one on the 2nd floor. Each is equipped with audio-visual capabilities and a preparation room for faculty members. Departmental offices are adjacent on the fourth floor, sharing a common hallway. Faculty and teaching assistant offices occupy the fourth, fifth, and sixth floors, interspersed with electrical engineering and computer science laboratories.

The second floor [just below ground] contains one classroom and many of the electrical engineering laboratories. The laboratories are in one central area with their back walls against a service chase. This long, unbroken corridor provides easy access for hooking up water, gas or other needed laboratory supplies. The laboratories also have sophisticated data communication links which allow faculty members direct links from their offices to the laboratories.

The data communication system in the new building is considerably advanced, according to Larry Dunn, director of computer operations. "We attempted to combine the best features we had seen at other sites," he said. The other sites included recently built commercial engineering buildings and some academic buildings. Every office and laboratory is equipped with communication jacks for phone, serial, AppleTalk, and EtherNet connections. Some jacks are also serviced with Apollo Domain. Cable trays running horizontally route cable to six vertical communication closet risers containing the communication trunking electronics. "Most of the active electronic items are interconnected with fiber optics," Dunn said.

Unused communication jacks allow for future expansion with fiber optic cables. Once manufacturers begin to use fiber optic cables in their communication networks and the price goes down, cable can be pulled up into the unused communication jacks. "The fiber optics are reasonably cost effective now, but their higher available bandwidth will allow a smooth transition to faster devices in the future as prices come down," he said.



Computer Science Building

The lower floor houses four clean room bays, the building's most sophisticated laboratories. Operated by the University's Microelectronic and Information Sciences Center, the laboratory will provide space for semiconductor and other sensitive electronics research. The laboratory's structural columns are stabilized in bedrock, isolating it from the rest of the building and making it highly vibration resistant. Unisys corporation recently donated a $2 million electron beam pattern generator for use in the laboratory. Unlike the rest of the building, this laboratory will not be completed until approximately December of 1988.

The need for extremely efficient air filtering and movement of large quantities of air in the clean rooms contributed to the cost of the building's mechanical system. Zetterberg said approximately one-third of the $44.3 million was spent on the mechanical system.

The old electrical engineering building will be renovated and space provided for mechanical engineering. Lind Hall and the link to old Electrical Engineering will be largely used by Math teaching assistants. The IT placement office, currently in Wulling Hall, will also move into Lind hall and expand its facilities.

Originally, plans for a new electrical engineering building were developed in the early 1970s before computer science had become firmly established. Hammel, Green, and Abrahamson were the architects for the building and one was designed. However, construction money was not appropriated and the project was discontinued. Finally, in the fall of 1983 the University included a new Electrical Engineering and Computer Science Building in its capital request, asking for $54 million. The legislature appropriated money [$44.3 million] for its planning and construction in 1984 and 1985 respectively. Groundbreaking was October 1, 1985.

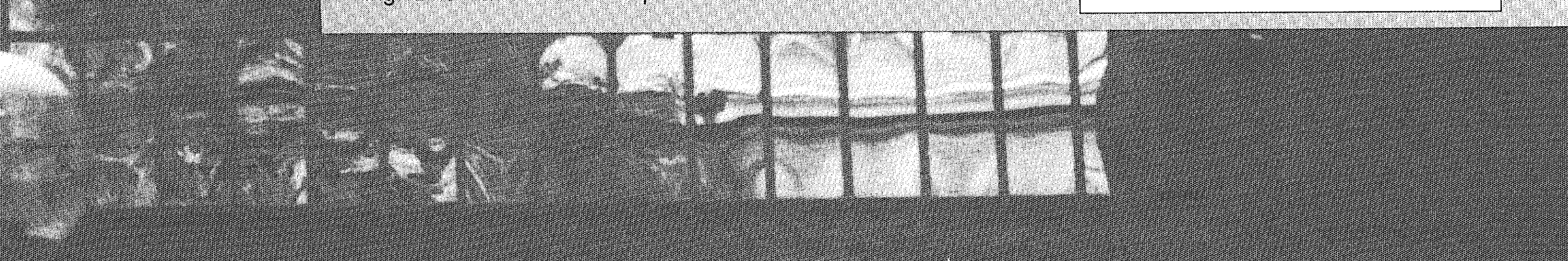
Zetterberg was on the initial Building Advisory Committee, which included the Physical Planning Office and the people who will eventually use the building. The committee was responsible for developing a "Building a Facilities Program." This provided a room-by-room breakdown of what needed to be in the building, such as the number of labs, office space, and other necessary components. As the building neared completion, Zetterberg worked on a day-to-day basis and stayed on top of any problems. He said the construction went smoothly and made its projected budget.

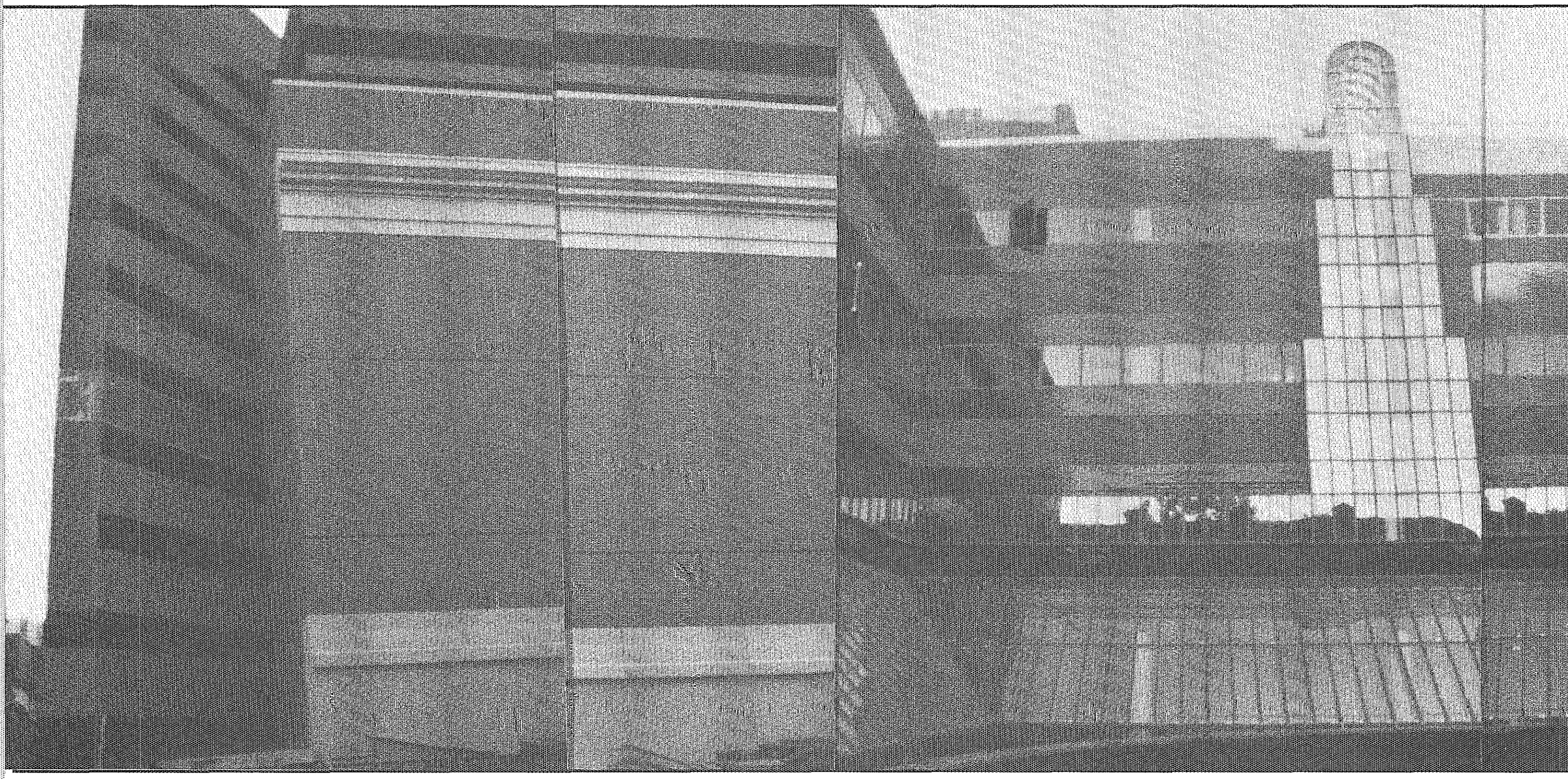
Professor Robert J. Collins, Department of Electrical Engineering head, finds it difficult to identify any one significant improvement. "You ask a man who's been starving for ten years to sit down in front of the best smorgasbord he's ever seen and then say 'what do you like best?'," he asked. More importantly, Collins said, is that the new building gives electrical engineering students an identity, and on a broader scale it provides the Institute of Technology with an entrance to the college of engineering. Previously, the department was housed in several facilities and the last EE classroom was renovated for laboratory space in the 1960s.

Collins noted that there is a very small change in the total laboratory space the department will receive. Currently, instructional and research laboratory space is at 19,000 and 24,000 square feet, respectively. The new building will provide 20,000 square feet of instructional space and 27,000 square feet of research space.

Facts and Figures

The new building contains 158,146 square feet of space. It is the largest departmental building on campus. The original request was for 180,287 square feet. Electrical engineering has 88,071; computer science, 41,050; classroom space, 12,868; the microelectronics laboratory, 9248; and 6,909 for student commons and study areas. Despite the loss of more than 20,000 square feet the student commons and study area space was nearly double its original size. EE lost the most space with over 20,000 square feet not included.





The computer science department has used Lind Hall as its main headquarters since its inception, but most of its operations have been scattered. "In the last three years the department's activities of every kind have been hampered by lack of space," said Professor David Fox, Department of Computer Science head. He said previously there wasn't adequate laboratory or faculty office space and graduate students have been housed in several buildings, making it difficult to locate personnel.

Having the faculty and teaching assistant offices in the same building is just one improvement, Fox said. Other improvements he noted included the good electronic data communication system and a doubling of laboratory space. "The fact that we're getting a new building is marvelous. The fact that we have very little new equipment is going to be a problem," Fox said.

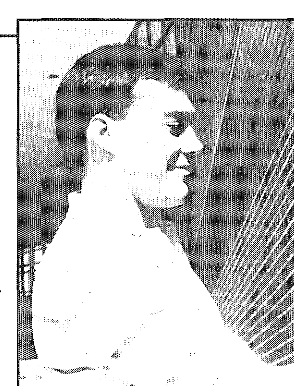
Despite the features of the new building, it suffers from a well-publicized lack of new equipment. According to Zetterberg, when a new building is planned and funded, the University does not appropriate money for equipment. He said he is confident a request for more than $10 million will be approved because the University would not commit over $40 million and then leave an empty building. "Private industry has done more than their share in the way of providing research equipment," Zetterberg said. "It is the University's responsibility to fund instructional equipment."

New computing equipment may be donated to the computer science department, but University funds are needed to pay for the maintenance costs of machines, Fox said. In the past three years the computer science department has not received any money for equipment. Fox said a self-analysis of the department revealed that approximately $7-8 million was needed to make the department competitive and place the department into the top five in the nation. He expects to receive $300,000 this year.

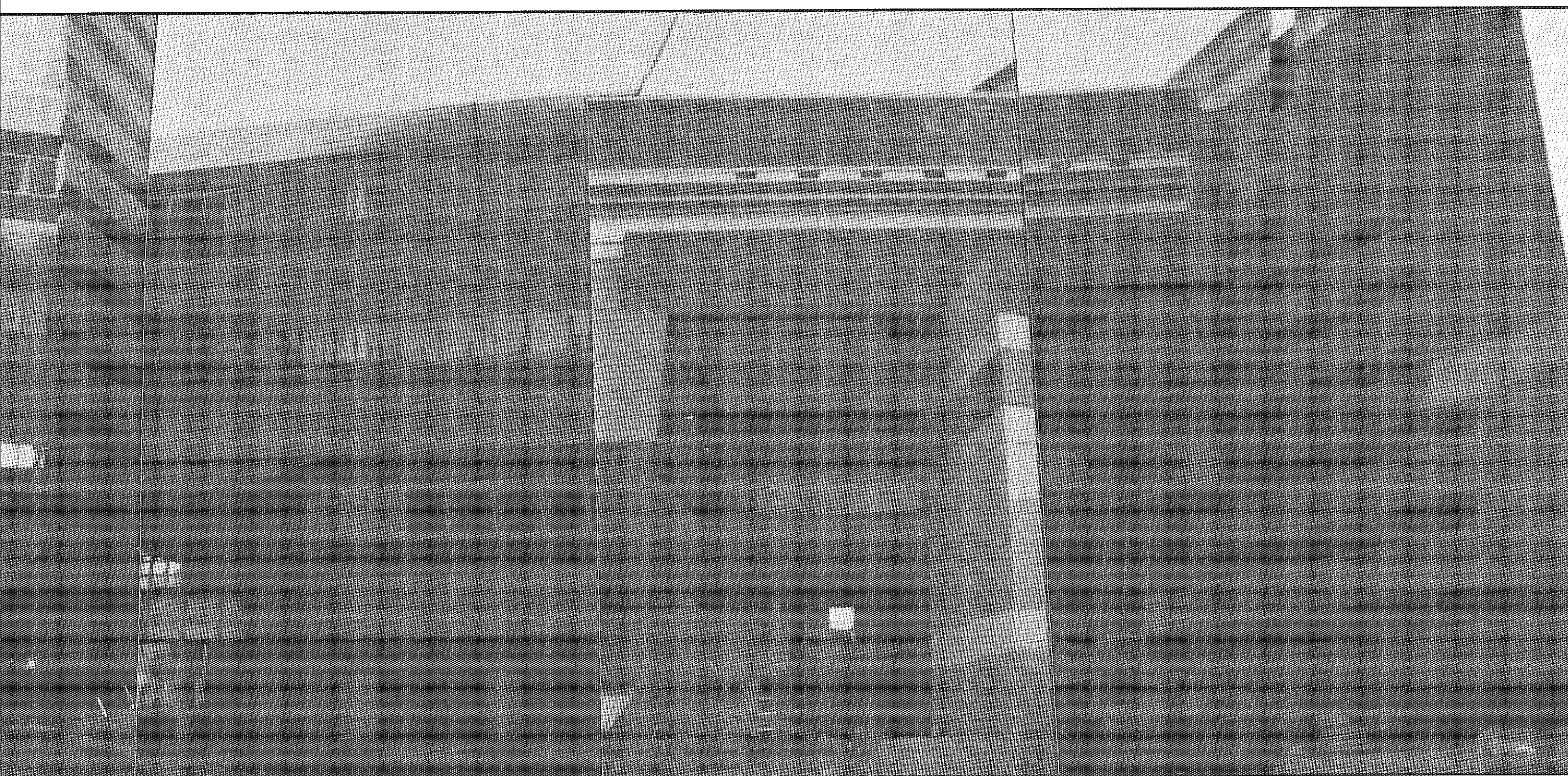
The electrical engineering department also has a problem with outdated and broken equipment, most notably spectrum analyzers. Each one costs $23,000 and the fourteen the department has do not work properly. However, Collins said new spectrum analyzers have been obtained and will be incorporated in the junior level labs as soon as possible.

Zetterberg would have liked more space in the building and he said the teaching

Author Bio



Steve Subera, electrical engineering senior, is a prolific writer, having written often for the *Technolog* and the *Minnesota Daily*. In his spare time, Steve enjoys pirating computer software (see article this issue) and shopping for textbooks. He says he lives for Bloom County and idolizes George F. Will.



Artwork by Dave Jensen

assistant offices are "piecemeal," but overall he is quite pleased with the result. Both Collins and Fox stress the importance of the building's ability to provide coherent space and a sense of identity. All three seemed to agree that the building would help provide a positive image to the public and show the University's commitment to electrical engineering and computer science excellence.

Sources:

Collins, Robert J., interview: August 23, 1988, University of Minnesota.

Dunn, Larry, interview: August 31, 1988, University of Minnesota.

Fox, David W., interview: August 22, 1988, University of Minnesota.

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"Technology Dean Decries Shell Game," *St Paul Pioneer Press Dispatch Business Twin/Cities section*, Monday, June 27, 1988, p.1, 8.

Computer Architecture

By Steve Adams

Improving the speed of computers is important to a number of different fields. Faster computers allow better computer simulations for aerodynamics, biomedicine, pilot training, physics, and any number of other disciplines. There are many methods to improve computer speed. Researchers are seeking faster memory systems. Chip technology is increasing the number of transistors which fit on a computer chip. Research in computer architecture is also improving computer speeds.

Computer architecture deals with the arrangement of elements inside a computer, including how the central processor and the memory elements communicate. It also includes the physical set up of a computer's central processor. Some of the more important areas in computer architecture are pipelining, interleaved memory, and parallel processing. In this article, I will explain the key concepts in each of these areas.

Pipelining

How do you perform multiplication on non-integer numbers? Do you use your HP? Would you use long multiplication on a piece of paper? Would you use scientific notation? You face an array of choices when you are forced to perform multiplication. Your HP, your IBM, your Mac, or your mainframe, however, don't have a choice. They all use the same method all of the time.

Computers multiply using a procedure called floating point arithmetic. If we give a calculator two non-integer numbers in decimal form, the first thing it will do is

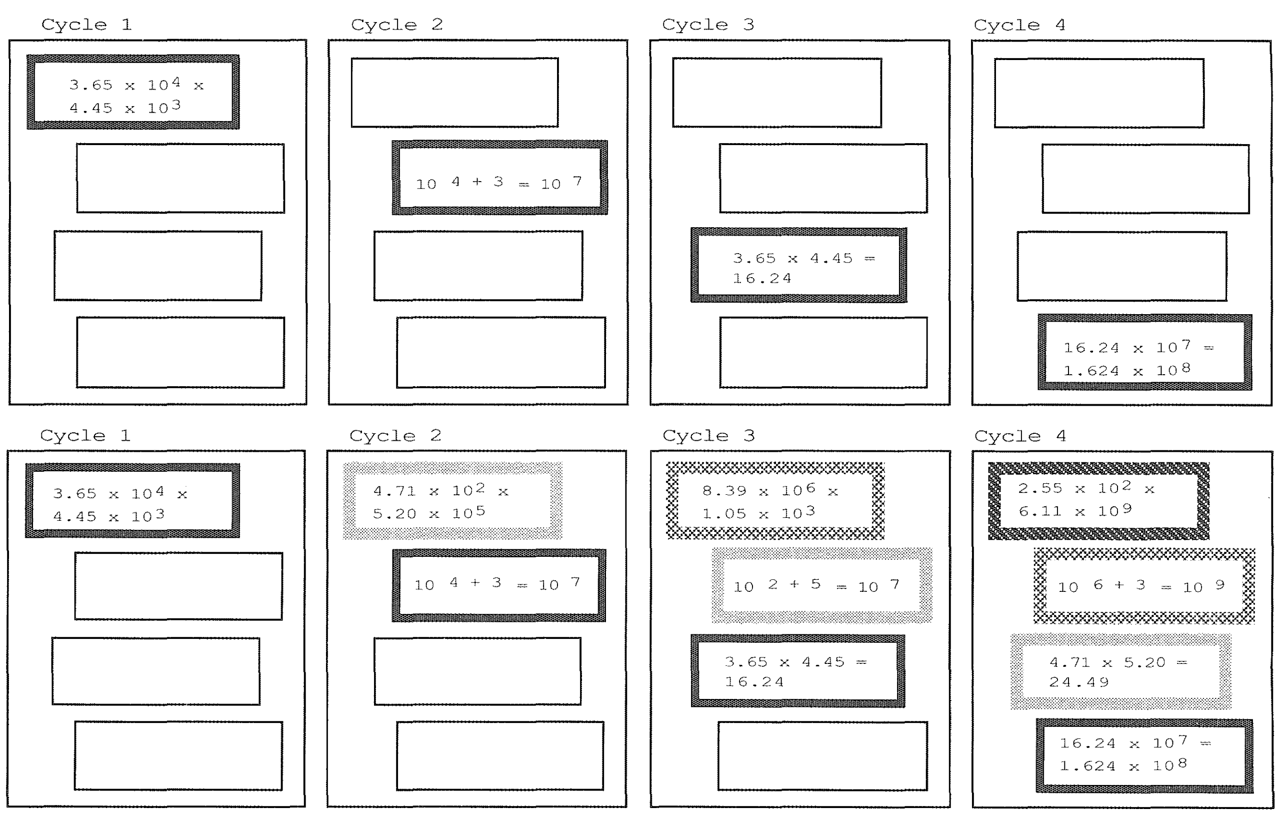

Illustration by Jerry Fiala

Pipelining is used to increase processor speed. Conventional processors (top) leave many registers idle when performing computations. By pipelining the computations (bottom), the processor is able to keep more registers active.

convert those numbers to scientific notation. If we use 36,500 multiplied by 4,450 as an example, the computer will change those numbers to 3.65×10^4 and 4.45×10^3.
Then, the processor will add the exponents: $10^{4+3}=10^7$. After that, the processor will multiply the mantissas: $3.65 \times 4.45 = 16.24$. Finally, it will combine the exponent and mantissa back to scientific notation: $16.24 \times 10^7 = 1.624 \times 10^8$.

The conventional method of executing these four separate steps, floating point multiplication, represents an inefficient use of processor time. During each step, much of the processor isn't doing anything. One strategy to make a single processor more efficient is called pipelining.

Pipelining doesn't actually change the steps executed in arithmetic; it utilizes parts of the processor which remain idle during certain phases of computation. If we use floating point multiplication as an example, assume that we have a simple processor which has only four logic sections. Section 1 converts the operands to scientific notation, section 2 adds the exponents, section 3 multiplies the mantissas, and section 4 combines the exponent and mantissa into scientific notation.

Without pipelining, while any one of those four logic sections is functioning, the other three remain idle. With pipelining, if more than one set of data is to be multiplied, the computer will utilize as many of the logic sections as possible. If we take the example of two data sets to be multiplied, section 1 will operate on the first data set in the same manner as if pipelining were not being used. But as soon as the computation of the first data set moves on to section 2, the second data set is accepted into section 1. In effect, one data set "follows" another through the processor, something like an arithmetic assembly line.

Pipelining can also be applied to requests that the processor makes to memory. If a computation requires two or more requests from memory, a pipeline can be designed which will allow the requests to "follow" one another.

Pipelines are useful for highly repetitive computations. They can be used whenever a large number of similar computations must be made. Like assembly lines, they are not effective for a small number of operations, as they take too long to start producing. This can be seen with an assembly line analogy. If someone wanted to build 50 bicycles, they would not set up an assembly line with 50 stations. If they did, then the moment the line started producing finished bicycles, it would stop new bicycle production. That would not be cost or time efficient. A 50 station bicycle assemble line would be efficient, however, if it were used to produce 2500 bikes. Similarly, pipelining isn't effective unless a large number of computations or requests are needed.

INTEL has already implemented pipelining on its 80386 processor, which is used in the IBM PCs. INTEL has measured the performance of the 80386 at 3.64 MIPS. The 80386, which is a single chip, matches the performance of the mainframes of only ten years ago.

Interleaved Memory

In conventional computers, while data or instructions are being fetched from memory, the logic circuits in the processor remain idle. The processor has to wait a certain length of time for each and every piece of information retrieved from memory. Also, if more than one value must be retrieved from memory, a sort of "waiting list" will result. If more than one value or instruction is needed from memory, the processor must wait for all the necessary information to be located and retrieved. Once again, this represents a waste of processor time because while the processor waits, its logic circuits sit idle and unproductive.

With interleaved memory, the processor has a number of separately accessible memory units (8 or 16) instead of just one. Each memory unit has a certain number of addresses where operands can be stored. In an eight memory unit system, for example, the first value to be stored goes to the first address of the number one unit,

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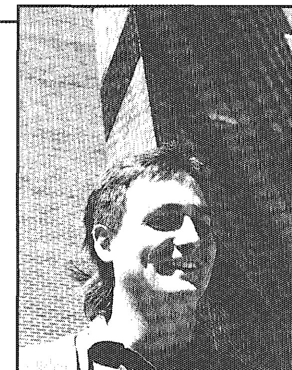

Steve Adams is an eternal junior in EE. This is his first contribution to the *Technolog.* He is actively searching for a good flight simulator program to pirate (see article this issue). This Mound native's interests, other than studying, include aviation, boating, and ski instructing at Burnsville's Mt. Buck.

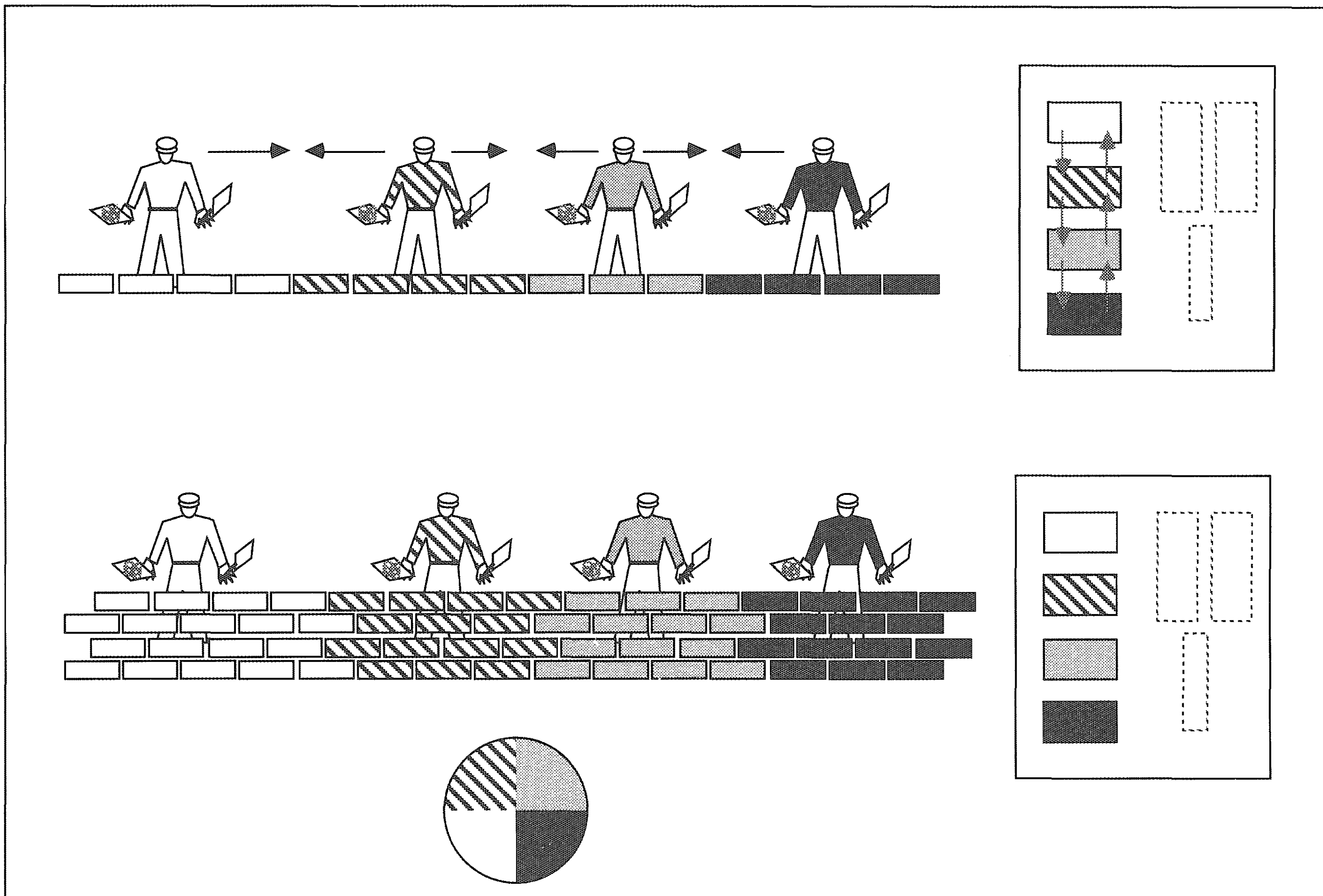

Illustration by Jerry Fiala

Group completion of a project is a good analygy for parallel processing. All workers (processors) work on the same project, each doing their own specialized task. Communication between group members ensures the project will turn out as intended. By having many workers working on the same project at the same time, vastly decreased job completion time is possible.

the second to the first address of the number two unit, and so on until the ninth value is reached. The ninth value is stored in the second address of the number one unit, the tenth is stored in the second address of the number two unit, etcetera.

By organizing memory in this way, the computer designer allows the processor to perform computations while instructions or data are being retrieved from memory. Since there is more than one path from processor to memory, the processor can initiate requests for data through one path while it receives information through another path. This allows the processor to operate on one data set while it waits for another, something conventional processors cannot do. In this situation, the processor spends much less time waiting for information to travel both directions through one path. Occasionally, it will have to do so, but that will be the exception rather than the rule.

Without interleaving, the processor has to request one value, wait for it to arrive, request the second, wait, request the third, etc. Interleaving allows a number of operands or instructions to be fetched from memory simultaneously. The advantage is that if the processor needs to operate on many separate values, it can request them all at the same time. That means that the requests that the processor makes will spend less time on the "waiting list."

Interleaved memory is used to improve the speed of a single processor machine. It is useful for computations which are highly repetitive, such as vector calculations.

Parallel Processors

A different approach to improving the speed of computers is available. Instead of only one processor, some computers have a group of processors which operate simultaneously, or parallel processors. Parallel processors execute several instructions or groups of instructions at the same time.

In parallel processing, there are a number of individual, communicating processors working on different aspects of the same problem. If we consider a four member work team to be our conventional "processor," think about how that team might save time (or how they might improve their processing speed).

Let's say a wall which takes one worker three days to build needs to be built in one. Our "processor" now needs to improve its speed. Assume that on previous jobs, all four members worked on the same part of the experiment at the same time. In other words, they acted as a unit on jobs.

If the job can be divided into four separate parts of roughly 3/4 days each, the group could split into four "specialized" processors. Ideally, they could finish the experiment in 3/4 days. Even if one part of the wall depends on results of another part, the group should still use the separate processor approach. Through communication and properly timed action, the "processor" of one part should be able to give the "processor" of a different part information necessary for completion of the job.

Parallel processing works in a similar manner. In a parallel architecture of four processors, for example, the work is divided among the processors. If the program calls for a large number of similar computations to be performed, the processors might divide the computations equally. If the program calls for a more intricate operation, one processor might read instructions while the other performs calculations.

Parallel processors must be highly customized machines. They have to be tailor-made for their application. If the application calls for a large number of similar computations, nearly all of the processors in the computer will be identical. If, however, the application is more complicated, the processors might be vastly different. Some will specialize in reading instructions, some in computations, and some will coordinate the communication of processors and execution of instructions.

The instructions which are sent to the processors depend on the computations which are to be performed. If we go back to the wall analogy, we can see how the situation dictates the instructions for our human processors. Jobs can usually be divided into two categories: repetition of procedures under different conditions, or a sequence of procedures under identical or varying conditions. In the first category, our four identical processors could work independently without much communication. In the second, however, they would have to synchronize their work to prevent errors caused by one part of the group using incorrect data.

In an actual parallel machine, many more than two processors are used. The Goodyear Massively Parallel Processor, for instance, incorporates 16,384 simple processors. The Connection Machine uses 65,536 simple processors.

Major problems arise when such a large number of processors need to communicate with each other or with memory. Connecting them directly to one another is out of the question, because if there are 10,000 processors, there must be 10,000 connections for each processor. Since parallel machines are still a new technology, the optimal interconnection method has not been determined. Options being considered are busses, switching networks, or localized memory. Busses are currently used in computers. Switching networks work like the telephone system, with switching terminals which route information. Localized memory is something like interleaved memory, but the difference is that each processor would get its own memory unit.

There are quite a few methods which can be used to improve the speed of computers. Pipelining can be used in highly symmetric, large database computation applications. Interleaved memory can be used to improve the speed at which a single processor gets the information it needs. Pipelining also improves the speed of a single processor. Parallel processing utilizes a number of processors to "share" the workload. In ten or fifteen years, these, and other areas of computer architecture will bring the power of today's mainframes into your home for a fraction of the cost.

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Students' Choice

by Dave Jensen

"How's CMOS?" I asked. I was fortunate enough to have had Dr. Dennis Polla, who was voted "Favorite IT Professor" last year by IT students, for a class in analog electronics. In class we studied, among other things, semiconductor devices and CMOS technology.

"Dog's doin' fine. It's doubled its weight in the last three weeks," he laughed, leaning back in his chair.

"How'd you decide on a name like that for a dog," I wondered, scratching the stubble on my chin.

"I don't know," Polla replied. "I guess I once mentioned to one of my classes at [UC] Berkeley that the MOSFET was the love of my life and my wife remembered it. So she said I had to name the dog MOSFET or something. So I decided CMOS. Those were in my days when I was a nerd," he adds, smiling.

Perhaps he refers to his extensive schooling at prestigious institutions. From MIT, Polla received his bachelors of electrical engineering, bachelor's of physics, masters of electrical engineering, an engineer's degree [MIT's degree awarded between the masters and doctorate]. He received his Ph.D. of electrical engineering from Berkeley. As if this was not enough, Polla has also earned a Masters of Business Administration [MBA] from Berkeley.

Polla, 31, was recently awarded the prestigious Presidential Young Investigator award for his work in microelectronics. UC/Berkeley, Yale, Honeywell, and EastmanKodak all nominated him for this award. His research involves incorporating sensors, both chemical and physical, onto silicon chips. He is one of the nation's acknowledged experts in this area.

Polla enjoys one-on-one interaction with the students the most. His favorite part of teaching is the office hours, because he enjoys being able to sit and talk to his students. He always encourages his students to come by at any time. "Students should not be restricted to come by at certain times," he said. "I am a state employee and should be available to students at all times."

A tenet of Polla's teaching philosophy is to de-emphasize competition. He feels that competition is a distraction to the learning process. "If they [students] try to extract as much as possible," he says, "they will learn more than if they try to place on a class curve." To relieve the pressure, Polla gives his classes one optional midterm. If students choose, they can take this midterm and it will replace another with a lower score.

Some students, especially the ones who had different professors for the same classes Polla teaches, say Polla grades too leniently, allowing his students an unfair GPA advantage. Polla denies this, saying, "When I looked at our department summary of grades for the past five years and looked at my averages for the three classes I taught, I found that my overall GPA is right in line with the department average. If I give the impression that I grade too easily, it may be due to my philosophy that people on the outside [industry] place too much emphasis on grades. I don't believe that in all cases the people with 4.0's are the best people to hire."

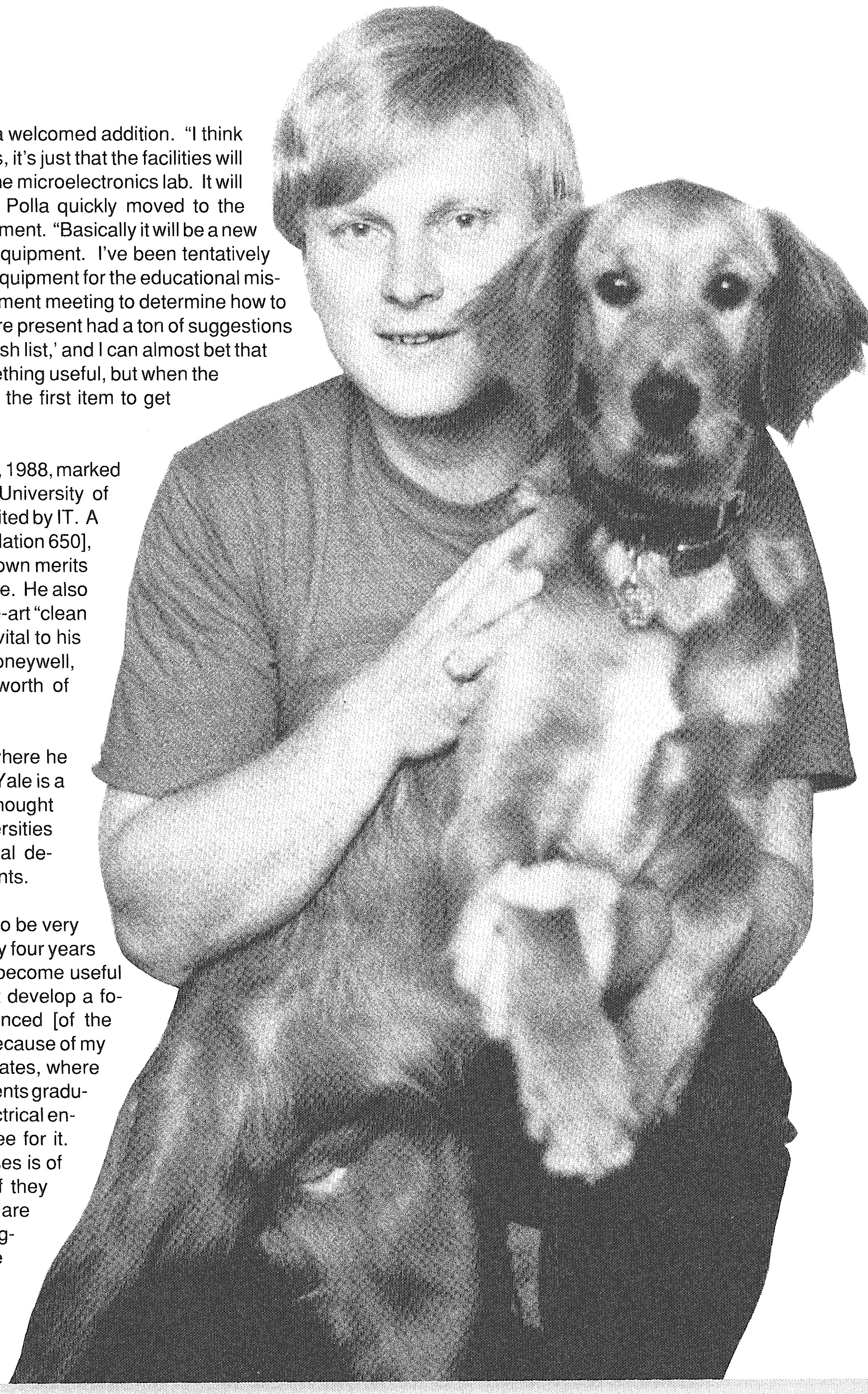
Polla thinks it is very good for students to get to know each other. He feels they often tend to be so involved with their work that they miss the other part of a college education: the rich friendships. "There is a substantial number of students who study by themselves and essentially take their undergraduate major in a vacuum." He said he feels many of the engineering extracurricular activities act as very good catalysts to get students together. He likes the Senior Design Project, a required course in the electrical engineering curriculum, because "it forces students to work together to approach a problem and find a solution." However, he feels this should be done earlier. "This is their first chance to work together, which is what they will experience when they work in an industrial setting," he noted.

> Polla enjoys the one-on-one interaction with students the most. His favorite part of teaching is the office hours.

"Get pretty warm up here?" I asked as we sat in his 3rd-floor office and experienced one of the many record-setting 90+ degree days that would put 1988 in the record books.

"Unbearable, actually, in the afternoon these past couple weeks. We have these air-conditioning units, but if we turn 'em on, the circuit breaker trips. So they're completely useless," he says as he switches his table fan from oscillating mode to stationary, wiping some sweat from his forehead.

"You would think someone in the electrical engineering department would know how to rewire it so that wouldn't happen," I joked.



He says the new EE/CSci building is a welcomed addition. "I think we're still going to feel space problems, it's just that the facilities will be very, very new. The good thing is the microelectronics lab. It will be state-of-the-art for a university." Polla quickly moved to the question of modern instructional equipment. "Basically it will be a new building with obsolete and outdated equipment. I've been tentatively told that about $1 million might go for equipment for the educational mission." He said that a recent EE department meeting to determine how to improve things, "All the faculty that were present had a ton of suggestions on equipment to get. We drew up a 'wish list,' and I can almost bet that that 'wish list' will be regarded as something useful, but when the financial squeeze comes on it will be the first item to get chopped."

The date of my interview, July 1, 1988, marked Polla's one year anniversary at the University of Minnesota. He was very actively recruited by IT. A native of Floodwood, Minnesota [population 650], he said he chose the University on its own merits rather than a desire to be near his home. He also knew that there would be a state-of-the-art "clean room" and microelectronics lab, both vital to his research, in the new EE building. Honeywell, Inc., also donated over $1 million worth of equipment for his research.

Polla came to Minnesota from Yale, where he served as a Visiting Professor. Since Yale is a liberal arts college, I asked what he thought about the recent criticism that universities have received because their technical degrees have few liberal arts requirements.

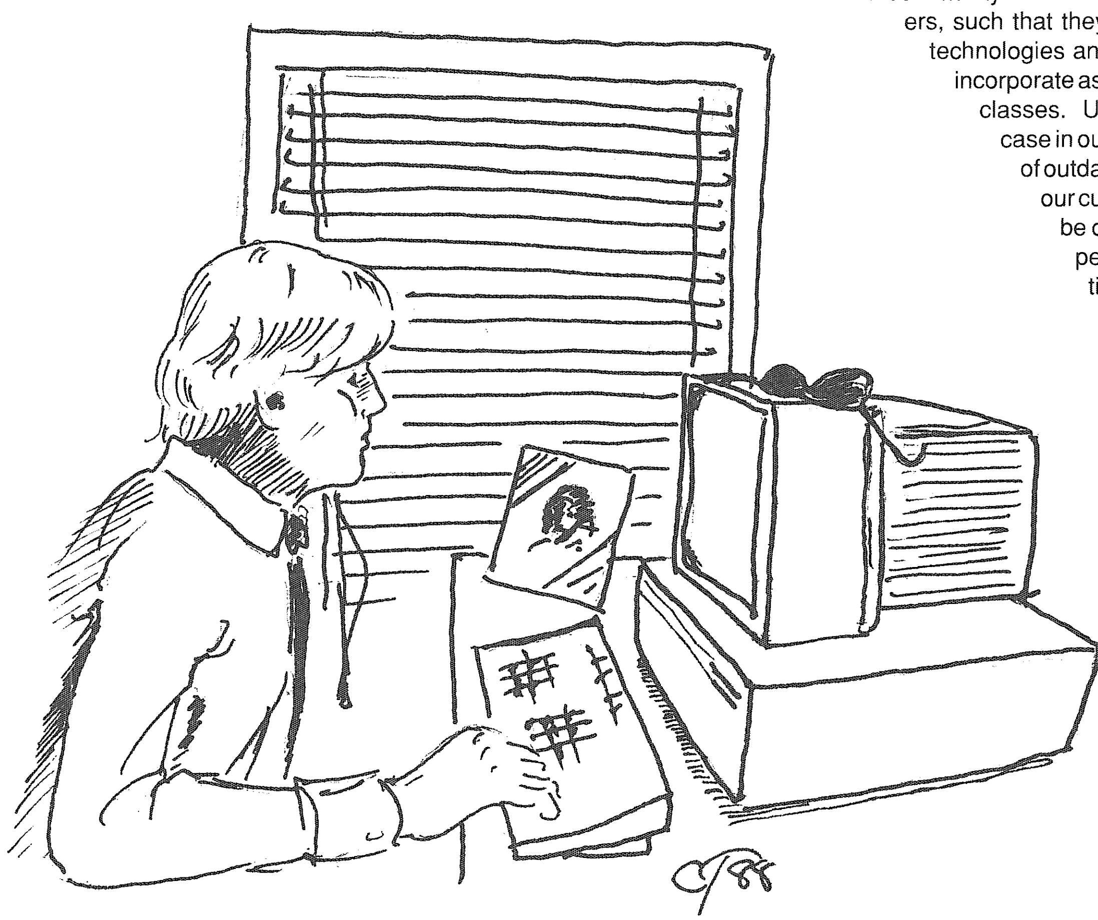
"I think they [technical degrees] have to be very specific. Students essentially have only four years to do their thing. In order for them to become useful to their potential employer, they must develop a focused study. I'm not entirely convinced [of the benefits of liberal arts requirements] because of my experience teaching Yale undergraduates, where the curriculum is very superficial. Students graduate with only 8 semester classes in electrical engineering, and get a bachelor's degree for it. Supposedly, the balance of their classes is of their choosing, primarily liberal arts if they desire. I don't believe those people are any better equipped to meet the long-term challenges of industry than more focused students. So, I would say that in our department's function of being responsive to needs of the state of Minnesota or the needs of industry, we are constrained to offer the demanding curriculums that we do."

Polla talked further about technical education. "Although IT is not different from any other school, a change should be made in all technical colleges to better prepare its graduates for the industrial setting. Somehow, the colleges should develop a business training for their potential graduates. Maybe some basic courses in technical marketing, which I find that a lot of undergraduate students find themselves going into. Unfortunately, that is where a lot of undergraduates find job openings." Polla said this is unfortunate, because students must go through rigorous technical education but never utilize their skills directly. "If students knew in advance, they could take more business classes," he added.

"Undergraduate education," Polla said, "is something that I would like to see emphasized more." He feels many research universities short change their undergraduate programs. "In talking to students who come by to shoot the breeze with me, I hear a lot of things that disappoint me about other faculty and other courses. I think there are a lot of things we, as a department, could do to improve our undergraduate program. For instance, modernizing our courses; trying to see if there are any new couses we should be adding or any courses that we should be taking out. Individual content of these courses could be improved considerably. In a lot of cases, the things that are incorporated into these classes are, in my opinion, not directly relevant to what I believe to be a modern electrical engineering education. And those type of things should be cut out."

"I think they [technical degrees] have to be very specific...I'm not entirely convinced [of the benefits of liberal arts requirements] in my experience..."

To account for this shortcoming, Polla addressed a sensitive area. "In our department the average age of our faculty is high. There is nothing wrong with that fact as long as those faculty members are very active researchers, such that they are in touch with current technologies and, therefore, know what to incorporate as discretionary topics in their classes. Unfortunately, that's not the case in our department. There's a lot of outdated things incorporated into our curriculum...things that would be obvious to eliminate if these people were either more active in their research or were more in touch with the needs of industry."



He is looking for the magical solution to bring students and teachers together, breaking down the barriers which often separate them. At Yale he would invite students to his house. "The large class sizes at the U prevent that," he said. "If the class size could be reduced, it would equate to a big plus for undergraduate education. I have lecture classes that range from 120-150 students which often have no classroom participation. Class sizes of 40 to 50 would be more manageable and less intimidating." At the beginning of class, he asks if there are any questions. No one raises their hand. "Reducing class sizes would encourage more participation," says Polla. He attributes the large class sizes to increased undergraduate enrollment and would like to see a change, either in more faculty or less students.

Robert Collins, Head of the Electrical Engineering Department, recently released a memo that showed that the University of Minnesota was 76th in the nation in the area of research expenditures per faculty member. Stanford was number one. So I asked him about the research scene.

Polla said teachers at every school are under pressure to bring in research money. He outlined two routes that a university and its faculty can follow. "First, they could focus on research. But then the training becomes very sloppy. Or, a university can focus on teaching, but then, in a very short time the faculty becomes stale. A university needs to find a balance between these two extremes. The University of Minnesota is very close to reaching that balance, in theory," he added.

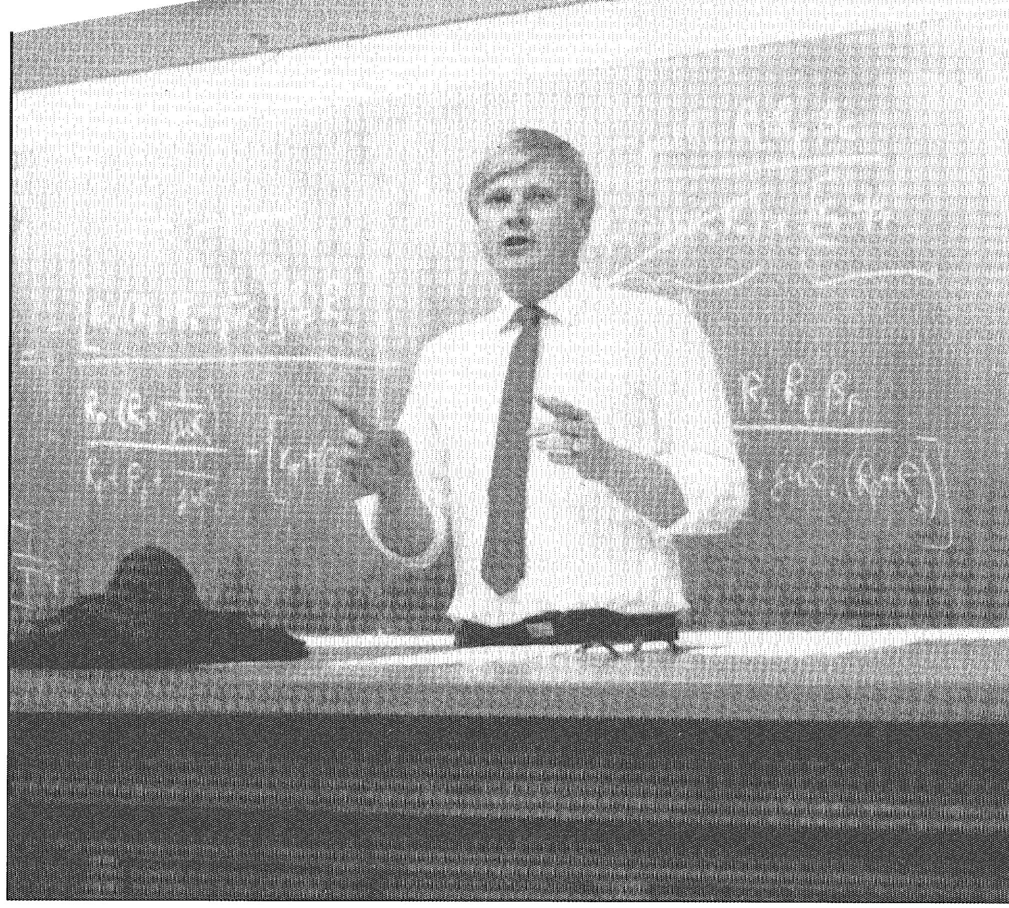


Photo by David Jensen

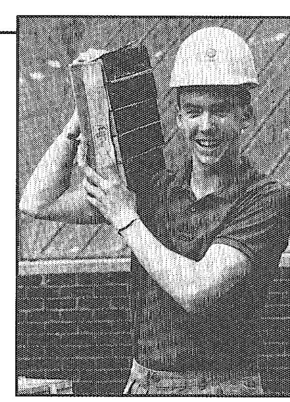
I asked Dr. Polla if there was a potential for Minnesota to improve its standing in total research expenditures per faculty member.

"The potential has been there for a long time, but something has gone wrong. If you look at the computer industry, a lot of its infancy was developed in the Twin Cities area. You would expect the Computer Science department to be the best [in the country], but it's not." He said this deficiency could be due to the organizational philosophy of the department. "For example, it is possible that their philosophy has been to do basic research instead of trying to satisfy the problems of industry. Because of that fact, it is possible that industries in the Twin Cities area might view the things that we are doing as not directly relevent or a direct benefit to them. As a direct result the amount of financial support is reletively small. Twin Cities companies may argue that, 'We do support the University. We set up these endowed chairs, foundations, etc.,' but when you look at amount of their emphasis at the University of Minnesota is small in comparison to Stanford or MIT. They key is for our faculty to be in touch with the needs of industry because that is where we are preparing our students for careers in, and it is also something that industry will benefit from. I think it is largely the fault of our faculty for not keeping in close contact with the needs of industry, otherwise I'm sure the funding would be much higher."

He adds, "Stanford probably got to be number one with its very tight coupling with industry in Silicon Valley. If you look at most faculty in electrical engineering department at the University of Minnesota, most of their research money comes from the Department of Defense, National Science Foundation, and various other government agencies. Stanford does the same, but then draws alot of money from industry," he said.

After spending only one year at the University of Minesota, Polla has already grasped the potential that the EE department holds. His visionary insights should help the department greatly in the future. His outgoing personality has already made him a favorite of the students. If his vision and enthusiasm spread, the EE department may soon have the best program in the nation.

Author Bio



David Jensen is a senior in Electrical Engineering. He is properly addressed as cadet, and hopes to someday be addressed as space cadet. Actually, he is in Air Force ROTC and hopes to be an astronaut. This is his first article for the *Technolog*. He works at Honeywell where he does the jobs that no one else will do.

Pirates Beware

By Jim Willenbring

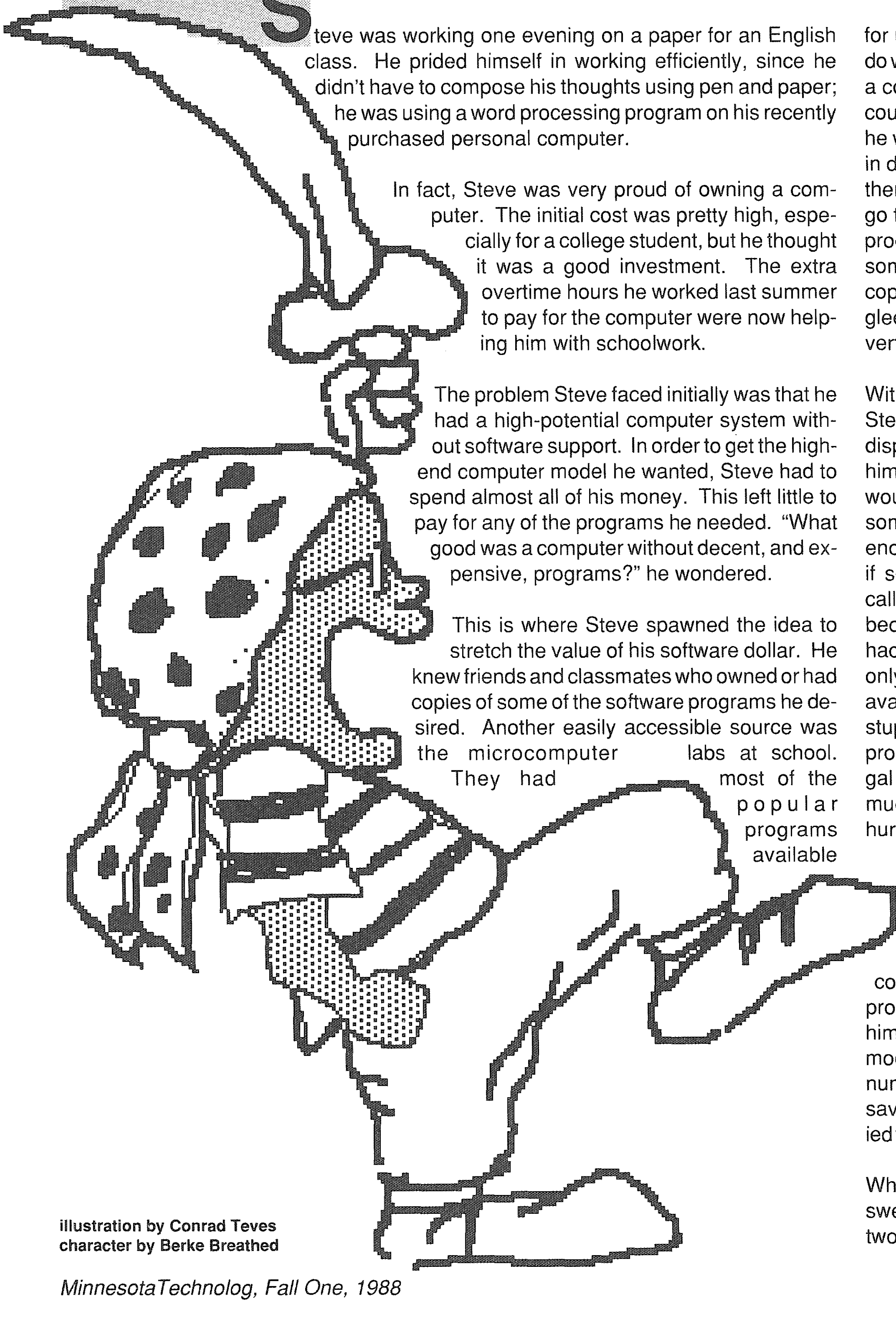


illustration by Conrad Teves
character by Berke Breathed

Steve was working one evening on a paper for an English class. He prided himself in working efficiently, since he didn't have to compose his thoughts using pen and paper; he was using a word processing program on his recently purchased personal computer.

In fact, Steve was very proud of owning a computer. The initial cost was pretty high, especially for a college student, but he thought it was a good investment. The extra overtime hours he worked last summer to pay for the computer were now helping him with schoolwork.

The problem Steve faced initially was that he had a high-potential computer system without software support. In order to get the high-end computer model he wanted, Steve had to spend almost all of his money. This left little to pay for any of the programs he needed. "What good was a computer without decent, and expensive, programs?" he wondered.

This is where Steve spawned the idea to stretch the value of his software dollar. He knew friends and classmates who owned or had copies of some of the software programs he desired. Another easily accessible source was the microcomputer labs at school. They had most of the popular programs available for use on their computers. All he had to do was approach his friends and purchase a computer access card. From there, he could obtain just about any software that he wanted by simply inserting the original in drive A, one of his disks in drive B, and then letting his top-of-the-line computer go to work. In a matter of seconds, $400 programs were his to use freely. Even if some companies had the gall to install copy protection on a program, Steve just gleefully used programs designed to subvert that protection.

With the investment of only cases of disks, Steve soon had a software library at his disposal. He even met other people like himself in his quest for programs who would exchange copies they had with something new Steve had obtained. Soon enough, Steve's reputation grew to where if someone needed a program, he was called up first. This made him feel good because others were recognizing what he had been telling himself all along: "I have only made use of the resources that are available to anyone. If companies are stupid enough to not copy-protect their programs, then they deserve to have illegal copies made. Anyway, they make so much money that my copying isn't going to hurt them."

Steve was reflecting on his success during his break from writing his English paper when his phone rang. The caller wondered if he could get a copy of the newest release of a word processing program. Steve didn't know him, but since he was in a charitable mood, he gave the caller his dorm room number and told him to come on up. He saved what he was working on and readied the disk that had what the visitor wanted.

When Steve heard the knock and answered the door, he was shocked to see two police officers standing there. One officer confirmed Steve's identity and started reading him his rights. Flabbergasted, Steve said, "What's the charge? I haven't done anything wrong!"

The officer said, "Theft."

Steve replied, "I haven't stolen anything. I am not a criminal!"

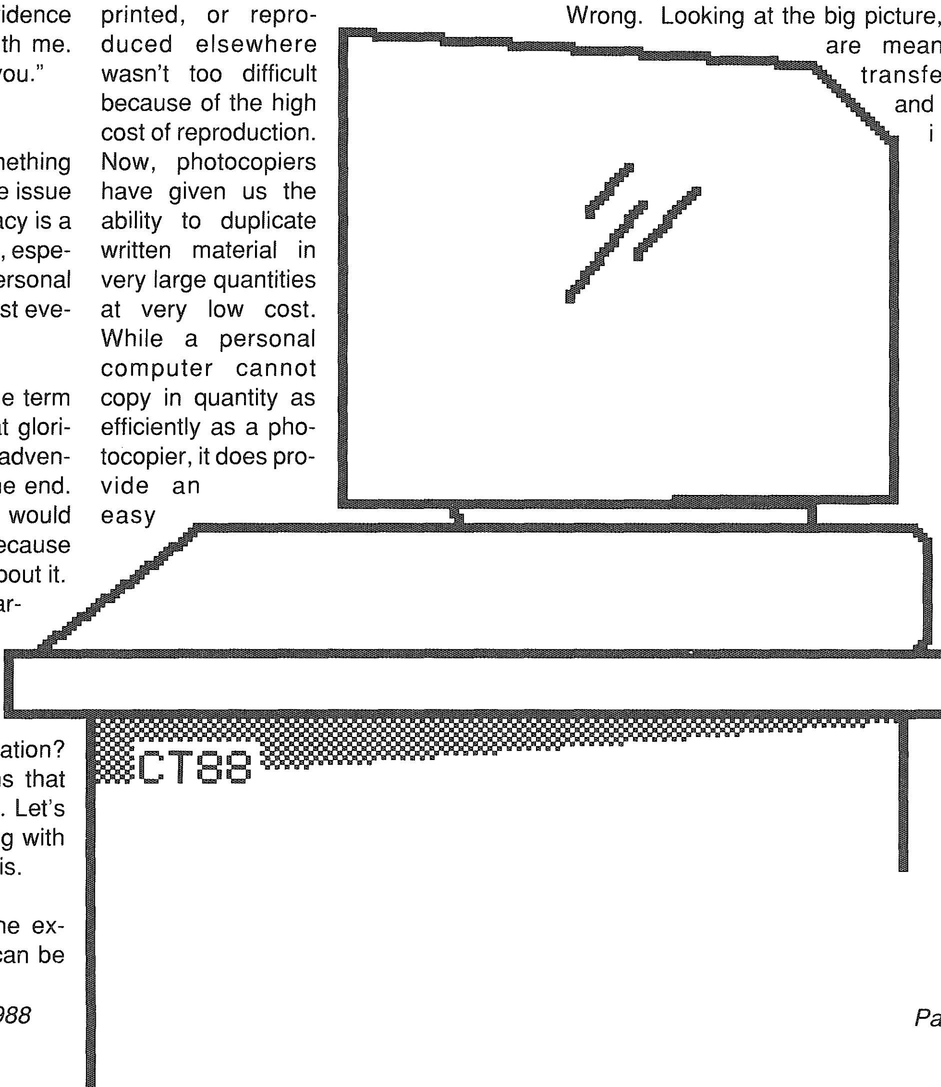
As the officer handcuffed Steve, he replied, "You are under arrest for computer software piracy. We have a search warrant for these premises, but I don't think we will find anything we don't already know. We already have enough evidence to support our charge. Come with me. You've got a long night ahead of you."

Did this really happen? Or is it something waiting to happen? Either way, the issue is what is important. Software piracy is a growing and controversial problem, especially in academic settings where personal computers are used often by almost everyone.

The use of the word "piracy" in the term software piracy gives a somewhat glorious connotation: one that implies adventure, risk, and ultimate booty in the end. Software manufacturers probably would like it simply called software theft because they don't see anything glorious about it. But is it true theft? What about the argument of prohibitive costs to students and budget-strapped university faculty and staff? How about the Fair Use Doctrine or the idea of free exchange of information? These are all legitimate questions that focus on intellectual property rights. Let's answer these questions by starting with what intellectual property actually is.

Intellectual property deals with the expression of ideas. These ideas can be spoken, written, drawn, painted, sculpted, constructed, or communicated in just about any other way available to us. An original idea and the way it is expressed are owned by the originating person. They are protected in our society by means of patents, copyrights, and codes of conduct. Backed by these legal and ethical rules, the author controls the way this idea can be communicated to others.

Before modern technology started to impact society in the form of personal computers and photocopiers, protecting your ideas from being manufactured, printed, or reproduced elsewhere wasn't too difficult because of the high cost of reproduction. Now, photocopiers have given us the ability to duplicate written material in very large quantities at very low cost. While a personal computer cannot copy in quantity as efficiently as a photocopier, it does provide an easy method to accomplish small amounts of another kind of duplication: that of software.



Photocopying and software duplication seem to be very different. In one, an inactive, tangible piece of paper is duplicated by means of light and ink. On the other hand, software is active. Copying a disk is different because software performs tasks. You can't really touch it like a piece of paper because it is closed up inside that little plastic case. So they are different, right?

Wrong. Looking at the big picture, both are means of transferring and storing

ACSS Software Piracy Policy

Academic Computing Services & Systems (ACSS) is the University organization that operates many of the computer services on campus. It has this software duplication warning posted next to the personal computers in its microcomputer labs:

WARNING
UNAUTHORIZED SOFTWARE DUPLICATION IS THEFT

Software developers have a legitimate right to be compensated for their efforts, and unauthorized software duplication is theft of the developers' intellectual property. The price of software does not justify unauthorized copying. The money paid for a software product represents a license fee for the use of one copy. It does not represent an authorization to copy. Although the cost of software piracy is initially borne by the software developer, it is ultimately paid for by legitimate users in the form of higher prices for software. Reproducing computer software without authorization violates the U.S. Copyright Law and is a Federal offense. Civil damages for unauthorized software copying can be as much as $50,000 or more and criminal penalties include fines and imprisonment.

If you choose to ignore the law by reproducing and using unauthorized software copies, you expose yourself (and the University) to prosecution. ACSS does not condone software piracy and our staff will not assist anyone using unauthorized software copies.

communication. In a photocopier, light transfers the images of the original and the ink forms symbols on the copy that appear as letters and words to our eyes. Similarly, the computer electrically transfers the information stored magnetically on one disk to the other. The type of information being passed is also the same, although you don't actually see the characters that have been copied by the computer. The magnetic fields on the disk represent the binary digits 1 or 0. Strings of these digits eventually represent words, letters, and numbers used exactly the same way that they are used on paper. All that is different is the medium used. On one hand it is light and ink. On the other, electricity and magnetic fields do the trick.

So in effect, software duplication and photocopying are similar in principle, and unauthorized copying of any copyrighted material, whether it be of paper or computer disks, can easily be seen to violate U.S. Copyright Law. This violation is true theft under the law.

According to Russell K. Hobbie, Associate Dean of the Institute of Technology, something called the Fair Use Doctrine confuses many people here at the University. It legally allows single copies of portions of scholarly material to be made. The problem arrives when people assume software is included as scholarly material. "The Fair Use Doctrine does not apply to computer software," he said.

Hobbie also believes that software piracy is a very large problem here at the University. "The students don't realize the seriousness of copying," he said.

In the story above, Steve believed that software costs were prohibitive to students, so he felt justified in copying programs. "To me that's akin to the argument that if I am poor, I can rob a store," Hobbie said. "The University recognizes that a lot of software is expensive and has been trying to have either site licences or discounts through the bookstore. For example, Microsoft Word, normally a $300 package, is $89 through the bookstore."

Hobbie believes that software piracy can be better controlled here at the University in several ways. "I think one of the best ways is sufficient publicity to change people's attitudes," he said. "Another is to get prices down through the University bookstore to the point where everybody can afford it." Thirdly, Hobbie thinks the University should seriously consider disciplinary action against students and faculty who are caught duplicating software.

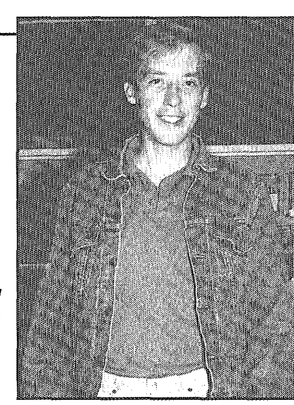
However, the consequences of being caught could vary. Unauthorized software duplication is a criminal offense so it could go to court if the software company chooses to prosecute. Additionally, illegal copying may be a violation of the University of Minnesota Student Conduct Code. Although not specifically mentioned, software piracy could be included under any of the following concerns listed in the Code:

- Matters that impinge on academic achieve ment and integrity.
- University obligations to enforce its contractual agreements. This directly concerns site licenses at microcomputer labs.
- Violations of federal and state laws with special relevance to the University, including theft and property damage.

In the case of a University student caught with a small amount of illegally copied software, developers probably would not try to prosecute for theft. Past cases have shown that they are concentrating on larger violators. However, the University could investigate the student under the conduct rules listed above. According to Hobbie, he knows of no student ever prosecuted for this offense, but he believes it could happen in the future.

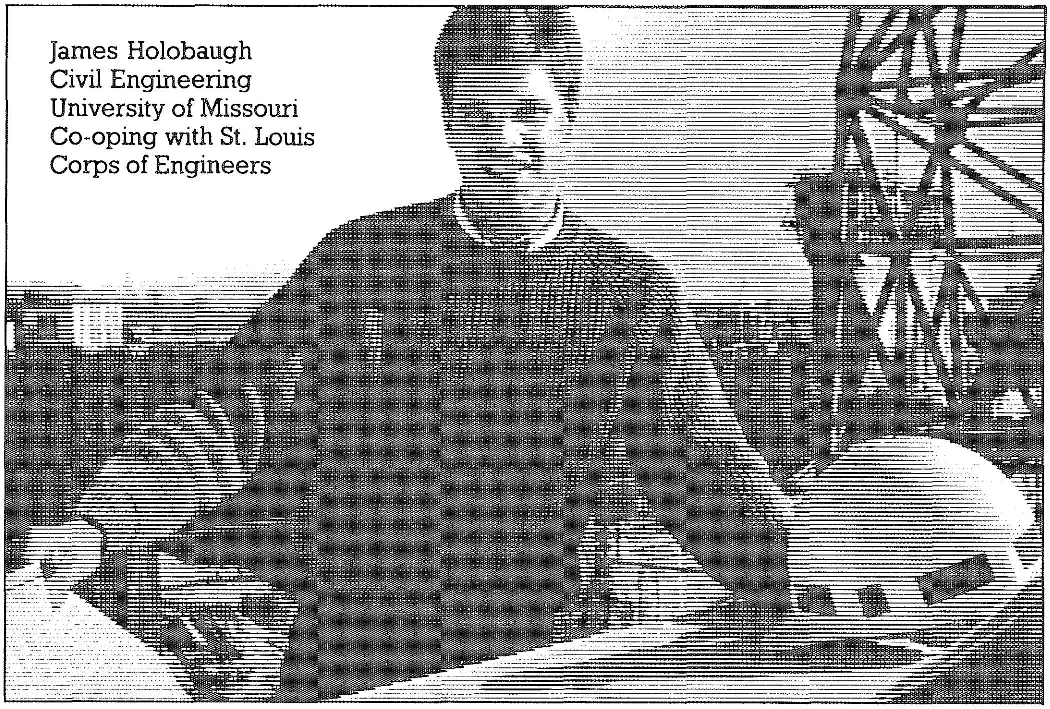
Pirates to page 23

Author Bio



Jim Willenbring is an electrical engineering senior. He was last year's *Technolog* editor and has been active with the IT Board of Publications since his freshman year, having served as secretary, vice president, and currently, president. Jim maintains his physique by refereeing soccer games in the summer.

RESERVE OFFICERS' TRAINING CORPS



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Graduation Address

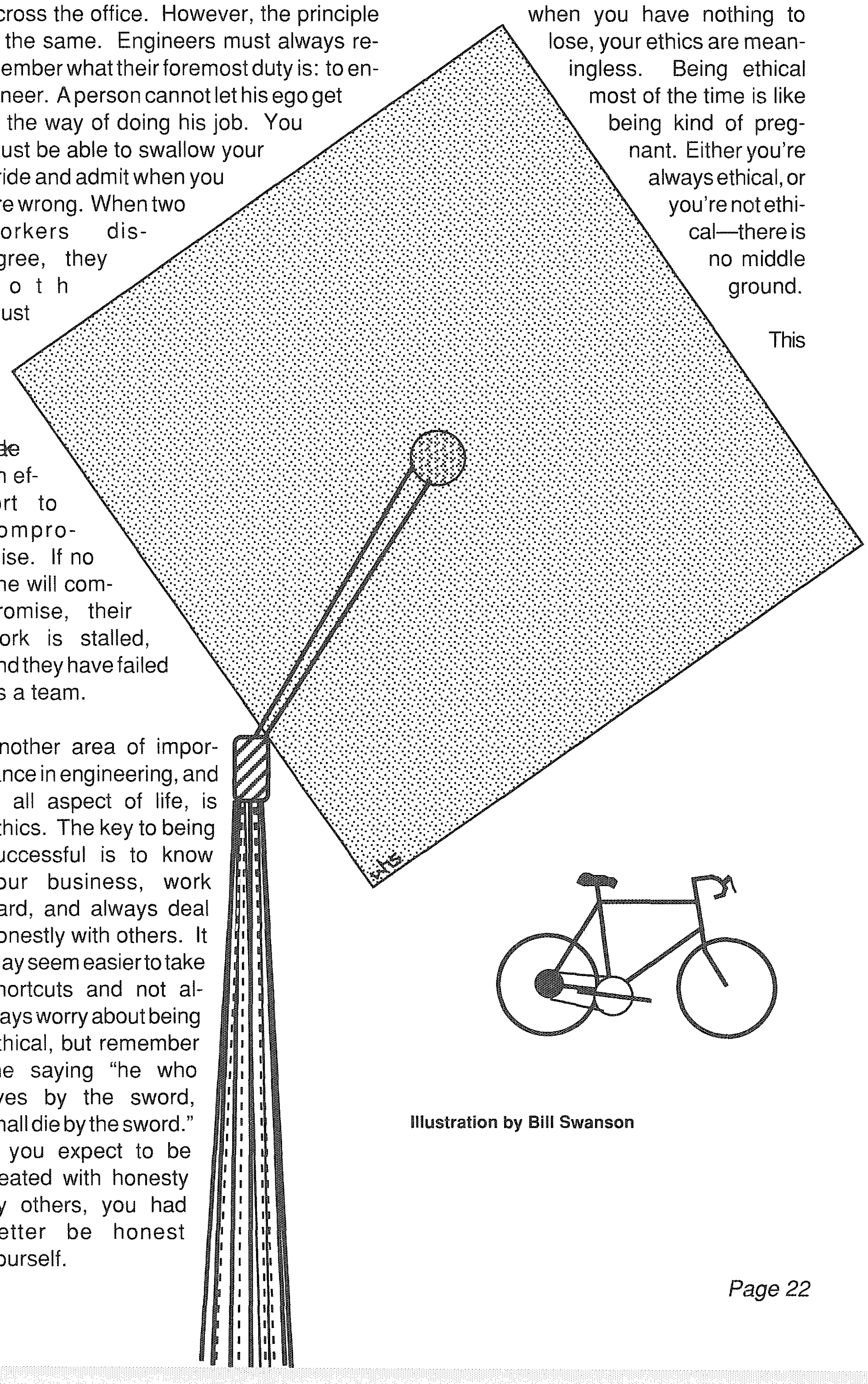
Delivered by Keith Reckdahl

Although this graduation ceremony marks the end of our college education, this certainly doesn't mean that it marks the end of our education. Education is a life-long process that, in many ways, is just beginning. I remember during my freshman year, I would look at kid still in high school and wonder if I had been that immature when I was young. Now that I am a senior, I look at the college freshmen wandering around campus, and wonder if I was that green during my first year. The cycle continues, as I'm sure that there are quite a few parents out there are looking at me now and wondering a few things of their own.

Becoming educated involves far more than just reading, writing, and arithmetic. A key aspect of being successful, and one that is oftentimes overlooked, is the ability to interact with people. There are many smart people, especially in technical fields, who do not become successful because they don't work well with their fellow employees. A common reason for this is the lack of communication skills, which prevents them from being able to transfer their ideas accurately to someone else. Another example is a person who can communicate fine, but who doesn't know when it is necessary to compromise.

When we were in kindergarten, we were taught that we can't always have our own way. Yet, there are grown men who have gone through half a lifetime or more, and still have not learned this basic lesson. An example of this is the situation we have in the Middle East. The people in Israel are notorious for their subbornness. The Arabs in the surrounding countries aren't any better. Until both sides realize that they both will have to compromise, the fighting will continue.

The same concept applies here when we are at work. The chances are pretty slim that a disagreement with a fellow engineer will lead to blunt objects being hurled across the office. However, the principle is the same. Engineers must always remember what their foremost duty is: to engineer. A person cannot let his ego get in the way of doing his job. You must be able to swallow your pride and admit when you are wrong. When two workers disagree, they both must make an effort to compromise. If no one will compromise, their work is stalled, and they have failed as a team.



Another area of importance in engineering, and in all aspect of life, is ethics. The key to being successful is to know your business, work hard, and always deal honestly with others. It may seem easier to take shortcuts and not always worry about being ethical, but remember the saying "he who lives by the sword, shall die by the sword." If you expect to be treated with honesty by others, you had better be honest yourself.

A person's ethics is something that cannot be for sale. If you are honest only when you have nothing to lose, your ethics are meaningless. Being ethical most of the time is like being kind of pregnant. Either you're always ethical, or you're not ethical—there is no middle ground.

This

Illustration by Bill Swanson

speech can be summed up with a simple analogy. Life can be thought of as a bicycle. One pedal is represented by knowledge. The other pedal is represented by the ability to cooperate. It may be possible to get by with just having one of the pedals, but you will be much more successful having both. Still, a bike is dangerous unless it has handlebars to steer. Your steering in life will be provided by your ethics. A bicycle must contain all three of these components to be complete, it is up to you to make sure your life is complete.

Pirates from page 21

A better awareness of the illegality of software piracy and increased respect for intellectual property will be the key to controlling it in the future. "The main difficulty now is that personal computers are relatively new and a real tradition has not developed yet," Hobbie said.

He believes an excellent analogy is equating a book with a computer program. Borland, Inc., maker of Turbo Pascal, uses this analogy in their license agreements. It reads in part that "just like a book that can't be read by two different people in two different places at the same time, neither can software be used by two different people in two different places at the same time." By saying just like a book, Borland means that this software may be used by any number of people and may be freely moved from one computer location to another so long as there is no possibility of it being used in one location while it is being used at another." Well written, clear and with no ambiguities.

As for the far future, Hobbie hopes that software piracy will be non-existent. "I think what will happen probably is that the technology will become such that if I go use that software base or go use that program, it will be able to keep track of the fact that I've used it and bill me for it. Of course, that it isn't much different from what happened in the old days on central computing when I logged in on the Cyber and the clock started and I got billed for what I used."

But until that time, the Steves of this world and this university need to realize that software piracy is not harmless. It not only undermines the efforts of the software developers and companies trying to serve the burgeoning computer industry, but also disregards legal and ethical rules of our society

The only solid piece of scientific truth about which I feel totally confdent is that we are profoundly ignorant about nature...It is this sudden confrontation with the depth and scope of ignorance that represents the most significant contribution of twentieth-century science to the human intellect.

Lewis Thomas 1913-
The Medusa and Snail [1979]. The Youngest Brightest Thing Around

Ungraduate enrollment

Engineering degrees are expected to be a less popular choice for students in the years to come. Total engineering enrollment has peaked and the number of graduates will begin to decline in 1987 or 1989. This downturn results from a decline in the pool of 18 to 22 year-olds (most engineering bachelor's degress are awarded to students who proceed directly, without interruption, from high school to collegiate studes), compounded by the declining interest of college freshmen in engineering.

Source:

"The Engineering Student Pipeline," Engineering Education, May 1988, pp. 733–734.

Computer Viruses

Is your computer feeling ill? It may have a virus. Computer viruses are destructive programs passed unsuspectedly from computer to computer. They usually remain undetected until a certain date or specific user command causes them to execute, possibly destroying valuable data and countless hours of work.

Many of these programs are not really "viruses" because they do not actually destroy any data. Some only print messages on the computer screen or ask harmless questi*ons. However,* one notable case reported by the New York Times involved a virus program in Israel. It was a "time bomb" set to destroy all infected files on May 13, 1988, the fortieth anniversary of the end of the Palestine state. Fortunately, it was detected and dismantled before it had executed.

Many experts believe computer viruses are limited and too much attention is being given to them. Some fear the publicity will increase the number of people creating viruses.

Defeating a virus is a challenge and no single method has been developed. One current program, Data Physician by Digital Dispatch, Inc., of Minneapolis, checks for unauthorized changes in files and it can remove some viruses.

The best way to avoid infecting your computer is to know where and who your software comes from. Be wary of electronic bulletin boards and public domain software and always maintain backups of your work.

By Steven Subera

Source:

"Computers: Fighting Parasites," ***The Futurist*****, July-August 1988, p. 54.**

IT Board of Publications

Would you like a chance to become involved with the *Minnesota Technolog* or *IT Connection*? More specifically, would you like to get involved with the daily operations of these periodicals, setting policy and determining and interpreting guidelines?

If you think this sounds like fun, read on. You'll get to do these things and more when you join the IT Board of Publications. Members of the board interact with editors and writers, allocate financial resources, plan special events, meet with faculty, and many other exciting and educational experiences.

The time commitment is surprisingly small. The board meets for about two hours every two weeks, and members are expected to have one or two office hours each week. Schedules are flexible, so even the most devoted student can join with a clear conscience. For more information, stop by Room 2, Mechanical Engineering Building or give the office a call at 624-9816 and and ask about a board position.

Career preferences of college freshmen, in percentages, 1976-1987

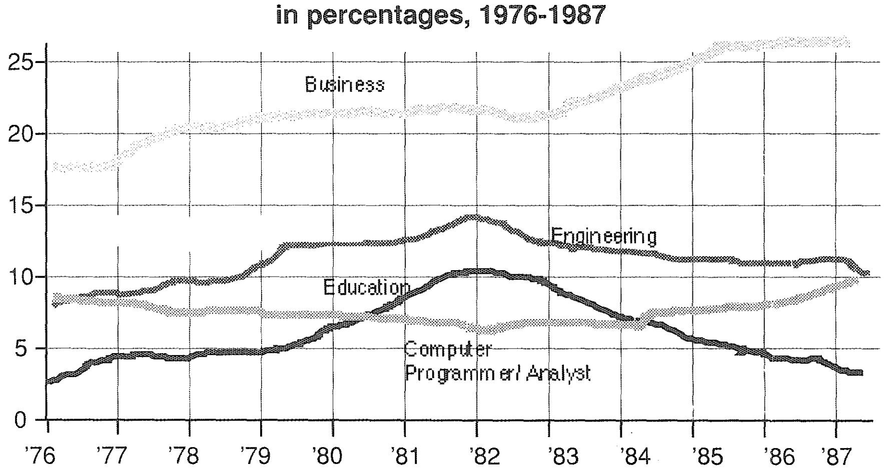


Illustration by Steve Kosier

Ozone Deterioration

Recently, there has been much discussion about the need to ban the production of chloroflourocarbons (CFC's), the aerosol chemicals suspected of causing the antarctic hole in the ozone layer. The first laboratory replication of antarctic winter, done by University of Minnesota physicist Konrad Mauersberger and graduate student David Hansen, seem to enhance the arguments for CFC regulation.

The University scientists' findings, which will be published later this year, support the leading theory that the ozone hole is fomed primarily through chemical processes. Previously, theorists had proposed a series of chemical events leading to the formation of chlorine "cloud particles" in the stratosphere that attacked ozone.

Mauersberger and Hansen have reproduced the low temperatures and pressures of water vapor and nitric acid that occur over Antarctica, showing that such conditions can lead to the formation of cloud particles. This new knowledge weakens the contention that the ozone hole is caused by atmospheric motions that leave ozone-poor air over the continent in spring.

According to their results, the chemical sequence begins during the antarctic winter, when stratoshere temperatures to minus 121 degrees Fahrenheit. These extremely low temperatures cause the condensation of icy particles composed of three parts water and one part nitric acid. Molecules of hydrocholoric acid adhere to these particles and react with chlorine nitrate gas to produce chlorine gas.

By mid-spring, sunlight is strong enough to split the chlorine molecules, thereby releasing single chlorine atoms. When these atoms combine with ozone they destroy it, producing a hole seen between seven and fifteen miles above the earth's surface. It isn't until warming air evaporates the particles, releasing nitric acid gas, that the destructive power of chlorine is neutralized by nitric acid. The ozone hole then disappears. The researchers stated that most of these steps have now been demonstrated in the laboratory.

According to Professor Mauersberger, "The mechanism of ozone destruction is a puzzle, and we feel we have made our contribution by putting a few important pieces in place." He went on to say that CFC's should be stricly regulated, pointing out that ozone absorbs ultraviolet radiation, something which has been linked to skin cancer. Said Hanson: "It's a good indication that we have to consider how human activity will affect the environment."

By John Bessler

Source:

University News Service

Remember, then, that it [science] is the guide of action; that the truth which it arrives at is not that which we can ideally contemplate without error, but that which we may act upon without fear; and you cannot fail to see that scientific thought is not an accompaniment or condition of human progress, but human progress itself.

William Kingdon Clifford 1845-1879
Aims and Instruments of Scientific Thought [1872]

1. In the 1700's, a widely accepted chemical theory held that for anything to be combustible, it must contain a hypothetical spirit-like substance which escaped when the material burned. What was this substance called?

2. Sir Isaac Newton transcended a major optical limitation of existing telescopes in his day. What was the optical defect he overcame?

3. During the evening hours, long-distance reception in the A.M. broadcast band improves significantly. Why?

4. When a computer or other piece of equipment fails, we say it has a "bug." What is the origin of that term?

5. What influential 13th century English scholar argued against basing one's opinions on fallible authorities and customs, and instead advocated use of the experimental technique as a means of discovering reliable knowledge?

6. It was once believed that a substance called "the ether" permeated all space and was the medium of electromagnetic wabes. A crucial experiment was performed to detect the presence of the ether. Who were themen who performed it?

7. When choosing between two plausible scientific hypotheses proposed to explain a given phenomenon, it has been said that the simplest one should be selected. What is this principle called?

8. In 1928, Friedrich Wohler synthesized an organic compound, thus becoming the founder of a new branch of chemistry. What was the compound he created?

9. While orbiting the sun, small particles of a few centimeters or so and smaller encounter "drag" due to outward bound solar photons striking them on their leading edges. This drag causes them to slow down gradually and spiral inward toward the sun. What is this effect called?

10. What is the major of every writer in this issue of the *Technolog*?

Scoring

0-3 Chances are you hate Trivial Pursuit.

4-7 You knew reading those "historical asides" in your textbooks would pay off someday, didn't you?

8-10 There is only one place where your talent will be appreciated–on a game show.

Answers

1. The material was called "phlogiston" and the theory of combustion was therefore known as the phlogiston theory.

2. The problem of chromatic aberration, cased by different colors being refracted at different angles in glass, was solved by Newton's reflector telescope.

3. Long-distance A.M. broadcast reception is poor in the day because of an effect known as "D-layer absorption." The ionosphere, composed of four major layers (D,E, F1 and F2), changes considerably at night when solar radiation is no longer present to sustain it. The D-layer, which tends to absorb at A.M. broadcast frequencies during the day, returns to a neutral state at night, allowing the higher, less dense layers to refract A.M. signals back to Earth.

4. According to one version, the term "bug" was coined when an early computer, ENIAC, failed without warning. Technicians later discovered that a moth had been caught and killed in one of its electromechanical relays, thus causing ENIAC to halt. This moth was the original computer bug.

5. Roger Bacon (1214-1294), of Oxford University, was a major proponent of the scientific method. Through the experimental study of science, Bacon argued, man would one day be able to construct self-propelled boats and land carriages, and submarines and flying machines. For these ideas he was reprimanded and placed under surveillance.

6. The experiment was called the Michelson-Morley Experiment and it was carried out by the two men whose name it still bears.

7. The principle is known as "Ockham's razor" after William of Ockham (1295-1349).

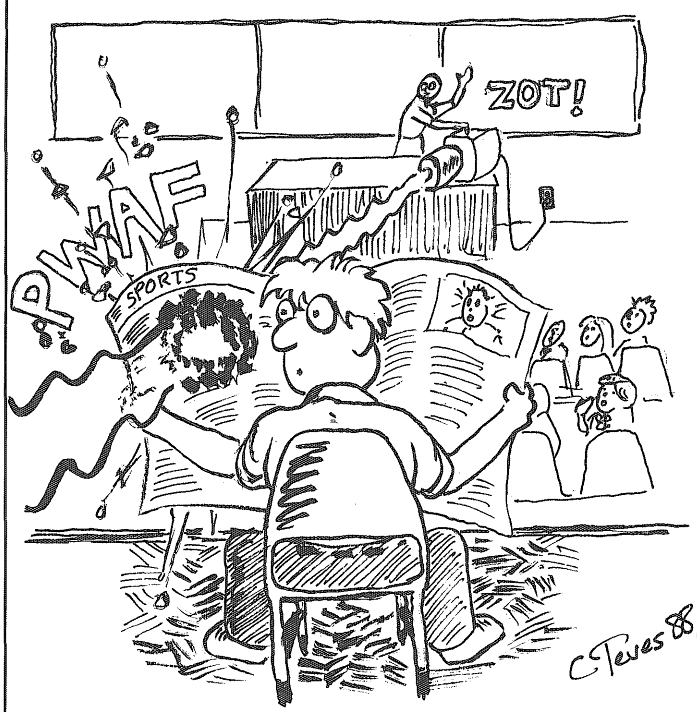
8. Urea.

9. The Poynting-Robertson effect clears the solar system of small particles. It was first predicted by the British physicist Poynting (1903) and was later amended by the American physicist Robertson (1937) to take relativity into account.

10. Electrical Engineering. Where are all the writers from the other majors?

The Near Side

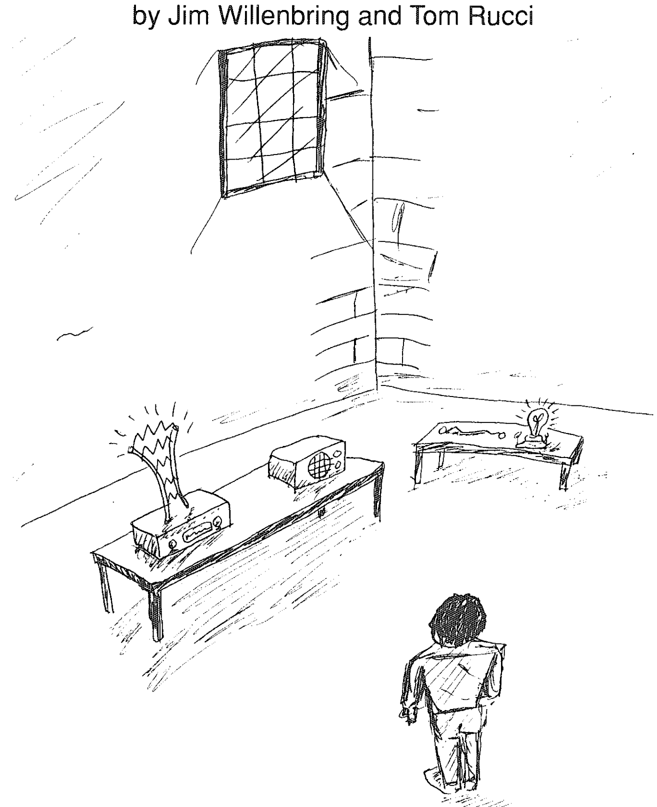
by Steve Littig and Conrad Teves



Professor Hawkinson, who's on the cutting edge of SDI research, has a unique way of keeping his students alert in class.

The Flip Side

by Jim Willenbring and Tom Rucci



John decided to look in on IT's entry in the "Best Equipped College Engineering Lab" competition.

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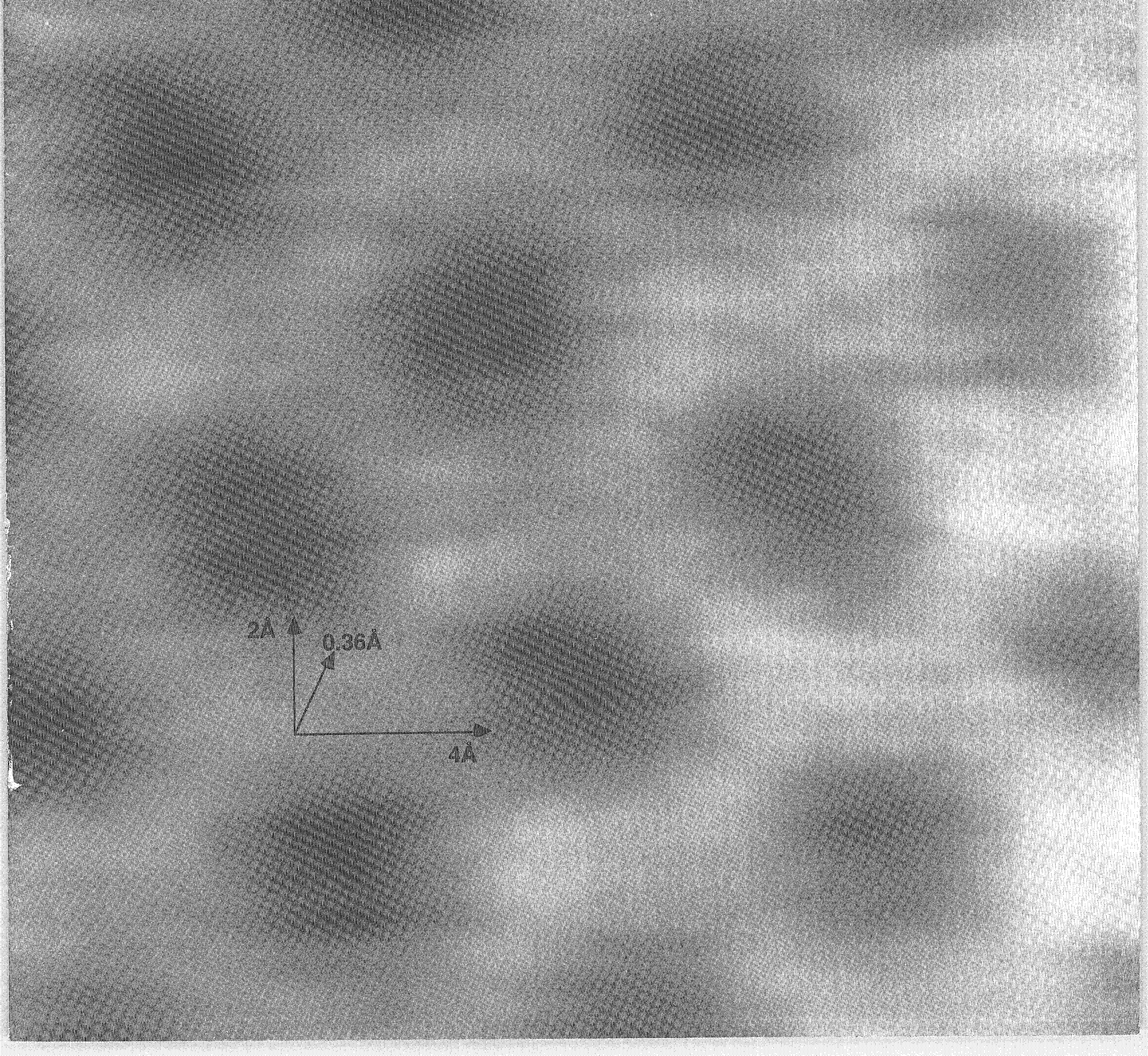
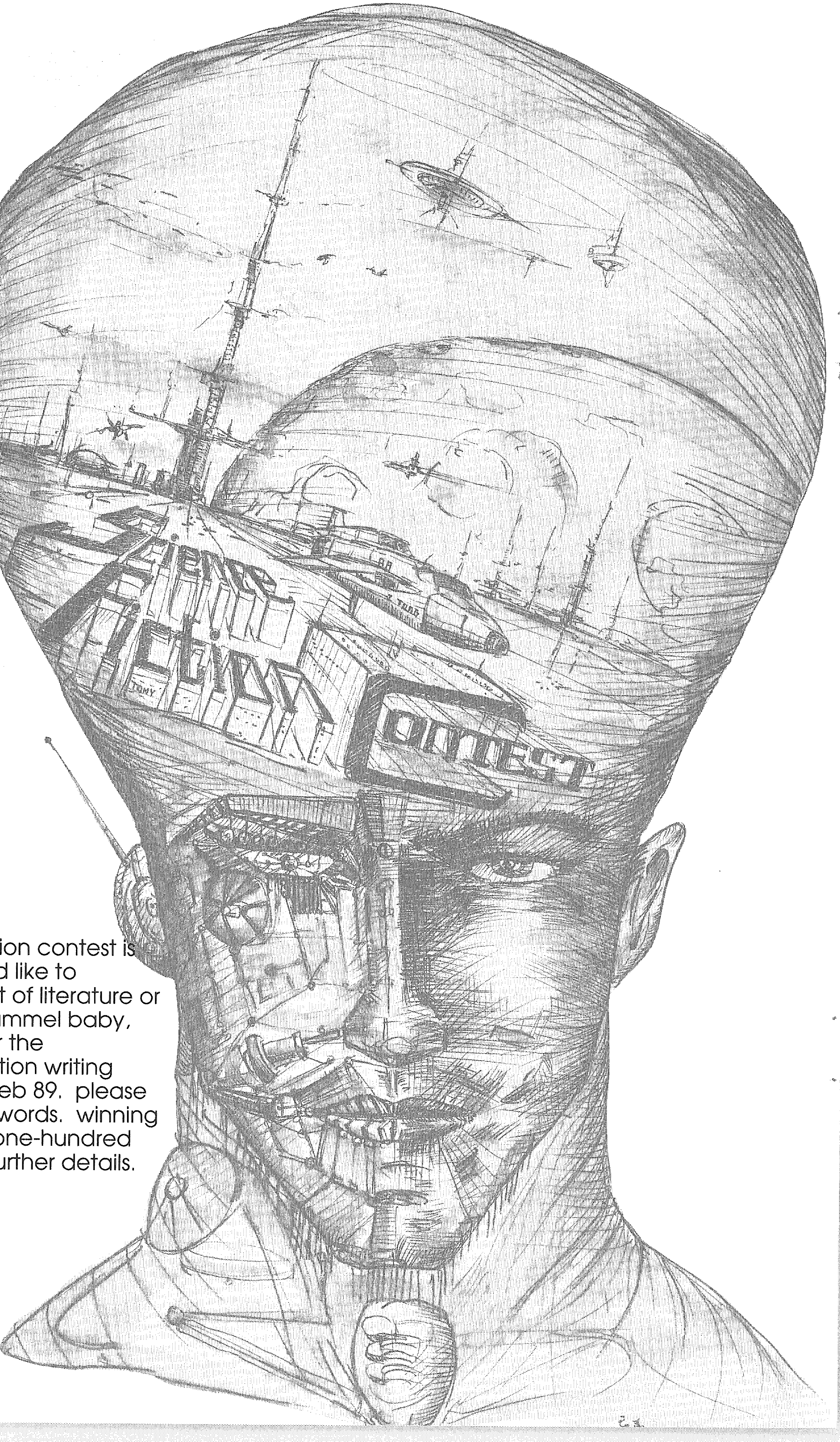
TECHNOLOG

Fall Two, 1988

The Quantum World

- Quantum-Tailored Electronic Devices
- The Scanning Tunnelling Electron Microscope
- Student Production Process





a call for papers

the annual science fiction contest is underway. if you would like to dabble in the finer craft of literature or if you're just a beau brummel baby, you are invited to enter the technolog's science fiction writing contest. deadline is 8 feb 89. please limit your entry to 4000 words. winning entry will be awarded one-hundred clams. stay tuned for further details.

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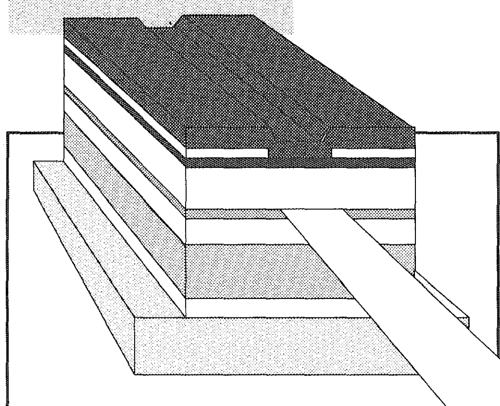
The official undergraduate publication of the Institute of Technology, University of Minnesota



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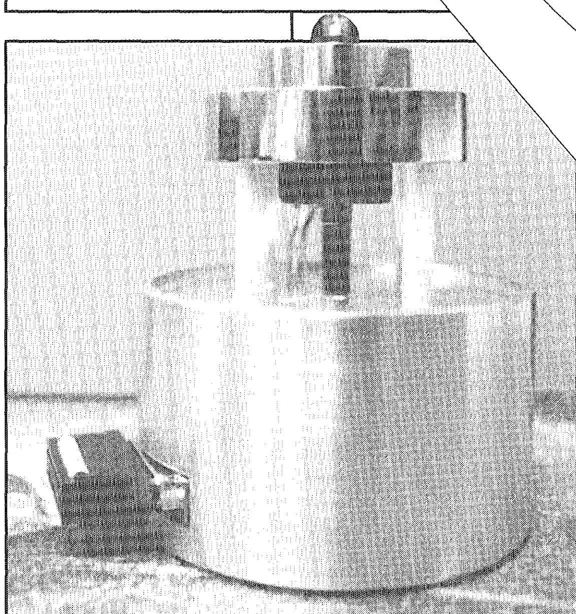

10

Departments

On the cover
This STM photo shows a cleaved graphite plane. The dark nodules are Individual carbon atoms in the crystal lattice.

Thanks to U graduate ChemE student Erik R. Scott for use of the STM. Photo by Paula Zoromski.

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The Chips Are Down

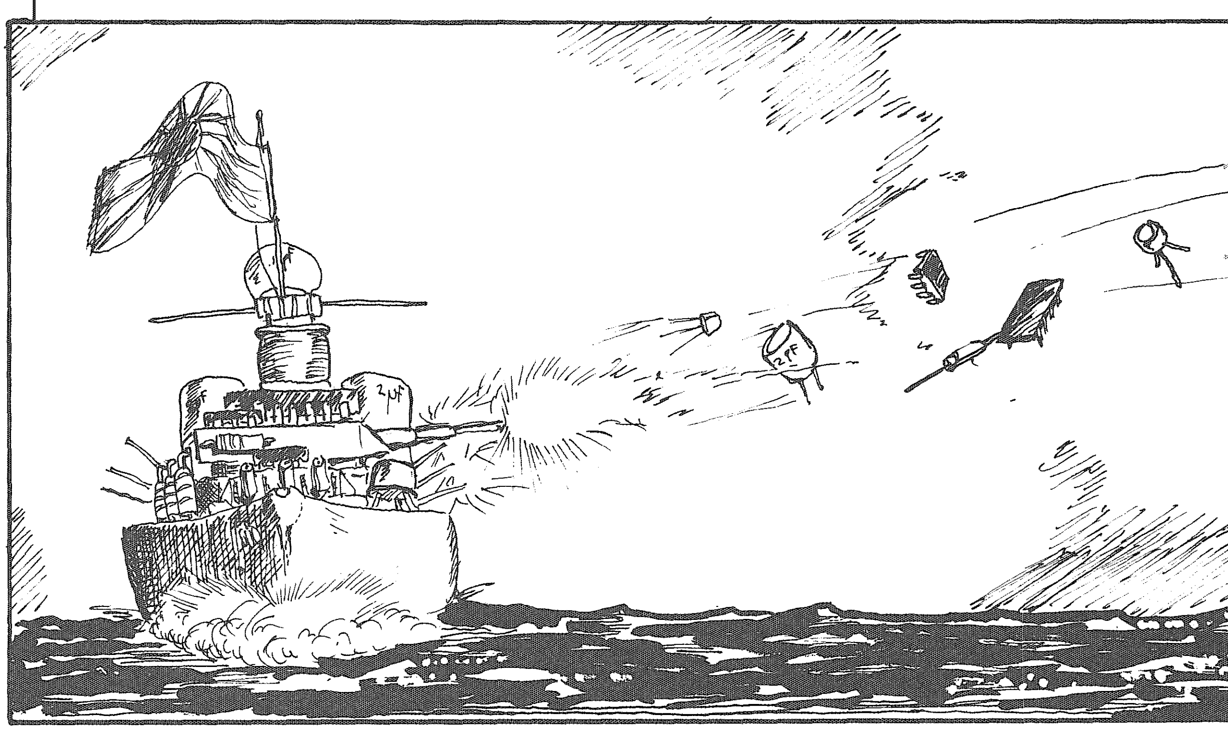
by Steve Kosier

After the invention of the transistor some 40 years ago, the semiconductor industry has evolved at a dizzying pace; steady and predictable improvements in device quality and miniaturization have revolutionized our society. The applications for microchips seem to be unlimited, and fantasies of today await only the seemingly inevitable technological advances of tomorrow.

The origins of these advances have shifted, however. The technology for producing microchips spread rapidly from its U.S. origins into Western Europe, the Pacific Rim countries (especially Japan and Korea), and many other areas. Today, many Japanese and European chip suppliers are subdivisions of large, usually government-supported, conglomerates. As such, they have vast internal markets; these markets are a steady source of demand for their products. This, among other things, enables them to weather fluctuations in market demand better than their U.S. counterparts. A case in point was the 1985 slump in worldwide semiconductor sales. This slump hit the U.S. semiconductor vendors particularly hard, and in the 1986 recovery, Japan, South Korea and other countries gained substantial ground on their U.S. companies. Anti-trust laws in the U.S. prohibited too much interaction between companies before the slump—interaction that some say would have been to the mutual benefit of the companies involved and to the U.S. economy.

Faced with a crisis, the U.S. corporations sought to protect their market shares. Following the examples set by Japan and Western Europe, mutual interest organizations such as Sematech, a manufacturing-research consortium of U.S. semiconductor vendors, have evolved. During the previous years of the semiconductor industry, cooperation in manufacturing (or any other phase of production) had been in violation of antitrust laws. The high cost and high risk of developing new technology have led our government to condone this collaboration, however.

The underlying shift in ideology, which Sematech symbolizes, is a need to boost U.S. competency in



technology transfer and manufacturing. All too often, fundamental technological breakthroughs are not pursued in the U.S. Before the 1985 slump, the U.S. typically did the cutting-edge research and let the other aforementioned countries develop the new concepts into salable products. More recently, these countries have begun to break fundamental technological ground themselves. Because of their manufacturing history, current and future advances in their countries have a structure ready to turn these advances into salable products. Due to this increasing independence from U.S. technology, these countries no longer require U.S. expertise. This translates directly into U.S. business failures and bankruptcy.

How can the U.S. regain its former stature in the semiconductor industry? The answer may lie with the United States' universities. Universities have traditionally been centers for basic research, far removed from the profit-minded business world (and often quite proud of it). Although this stance may seem idealogically pleasing, it is no longer practicable. A new era of interaction and cooperation between academia and industry is required. More of the breakthroughs that occur at our nation's universities need to find their way to the production lines of our nation's industry, particularly our semiconductor industry.

To accomplish this sweeping goal, new curriculum aimed at the needs of industry need to be made available. Manufacturing technology and processes, technical communication, engineering economics, and management skills need to be imparted to all of our nation's students, particularly the future technical professionals. Joint industry-university research teams need to increase. Organizations devoted to technology transfer (getting technology from the research labs to the production lines) need to be developed.

All these goals can be accomplished within U.S. governmental framework. Indeed, all the tools seem to be in place. The U.S. has outstanding research facilities in its universities and outstanding production facilities in its corporations. What is required is more interaction between the two areas, coupled with industrial cooperation to boost manufacturing proficiency. These changes will come partially out of necessity because U.S. corporations are not competing with themselves anymore; they compete with foreign conglomerates. Unlike the Olympics, the "medal count" of this contest has real significance for U.S. national security, prestige, and financial health. The U.S. cannot afford to fall behind its competition where these issues are concerned.

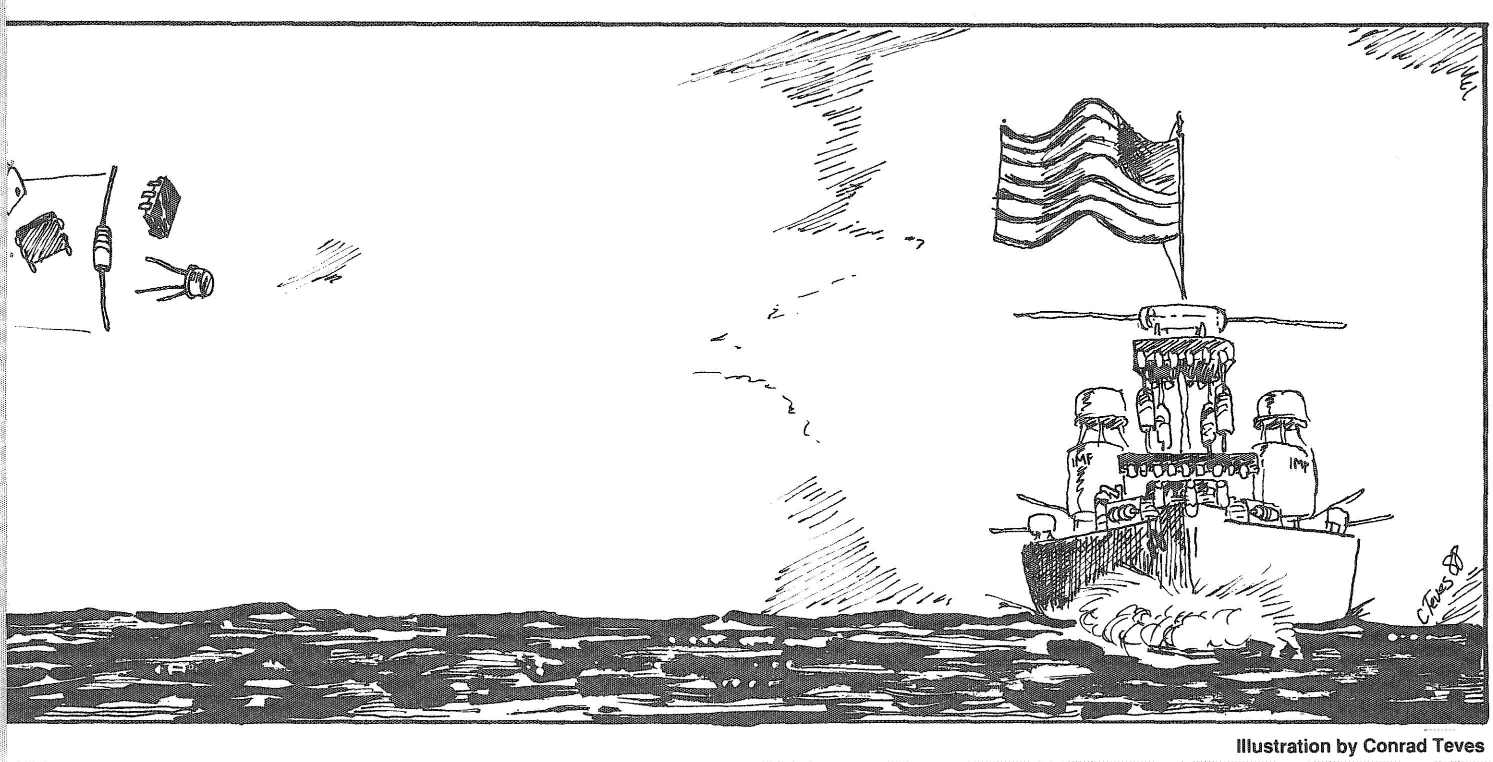


Illustration by Conrad Teves

Band-Gap Engineering

by Rob Hendrickson and Steve Kosier

When transistors were first integrated on a single chip, the world of electronics was revolutionized. Applications and inventions that could not have been imagined before integration, such as personal computers, became reality. The demand for faster and smaller computers and devices has prompted intense research into microchip fabrication techniques. This research has resulted in more precise methods that minimize semiconducter impurities and reduce the size of the transistor, allowing more and more devices to be placed on a chip.

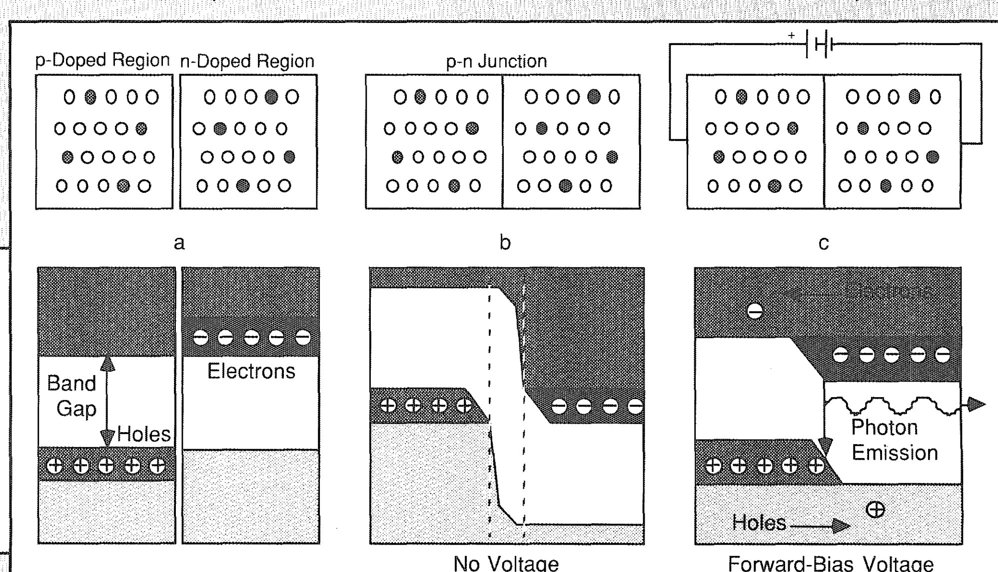
The latest fabrication techniques, known as molecular-beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD), represent a new path for semiconductor technology. These techniques enable individual layers of atoms, not necessarily the same kind, to be "spray painted" on top of one another when making a chip. This allows for nearly perfect crystalline structures to be built. Chips of this sort are governed by quantum physics; therefore devices fabricated on them behave very differently from traditional devices, which are governed by classical physics. These quantum-tailored devices have very useful and previously unattainable properties. For instance, many of these devices use light as the medium to transmit information.

The ability to quantum-tailor devices may be as revolutionary as the initial invention of the microchip. Powerful and efficient semiconductor lasers for communication systems, ultra-fast electric transistors for microchip applications, and even optically nonlinear materials are possible through quantum tailoring. The advanced lasers will help make it possible to transmit the entire Encyclopaedia Brittanica over vast distances in less than a second. On a more intriguing level, the inherent interconnectivity of optical circuits may greatly assist parallel processing computers to mimic the human brain.

This article looks at the devices that will bring these applications to fruition: quantum-tailored solid-state devices. Quantum tailoring, also known as band-gap engineering, refers to the process of precisely controlling the band gap, or amount of energy needed to free a valence electron, in a device. In particular, it refers to

Semiconductor primer

For those not familiar with basic semiconductor physics, or who have forgotten some of the key concepts, this should serve as a basis for understanding. Semiconductors are the materials from which microchips are made. These materials combine the properties of insulators, which resist electric current flow, and conductors, which allow electricity to flow.



P-doped and n-doped semiconductor samples (a) are combined to form a p-n junction (b), the building block of modern electronics. The junction can be made conductive by applying a forward-bias external voltage (c). If the voltage polarity were reversed, no current would flow.

Illustration by Jerry Fiala

the ability to vary the band gap of a device very precisely over very small distances. Recall that this is possible through the use of MBE and MOCVD.

The band-gap engineer has three basic methods for building quantum tailored devices: changing crystal composition during growth (alloying), juxtaposition of heterogeneous material, and built-in strain. The first two methods have existed for a long time, but produce different effects when crystal growth is controlled with atomic precision. The use of lattice strain is incumbent upon the ability to precisely control atomic layer thicknesses, and is thus a new technology. So far, gallium arsenide (GaAs) and other III-V compounds have been the materials of choice for all three methods because of their easily alterable band gap.

Alloying

In alloying, the atom that is being substituted in the lattice has the same number of

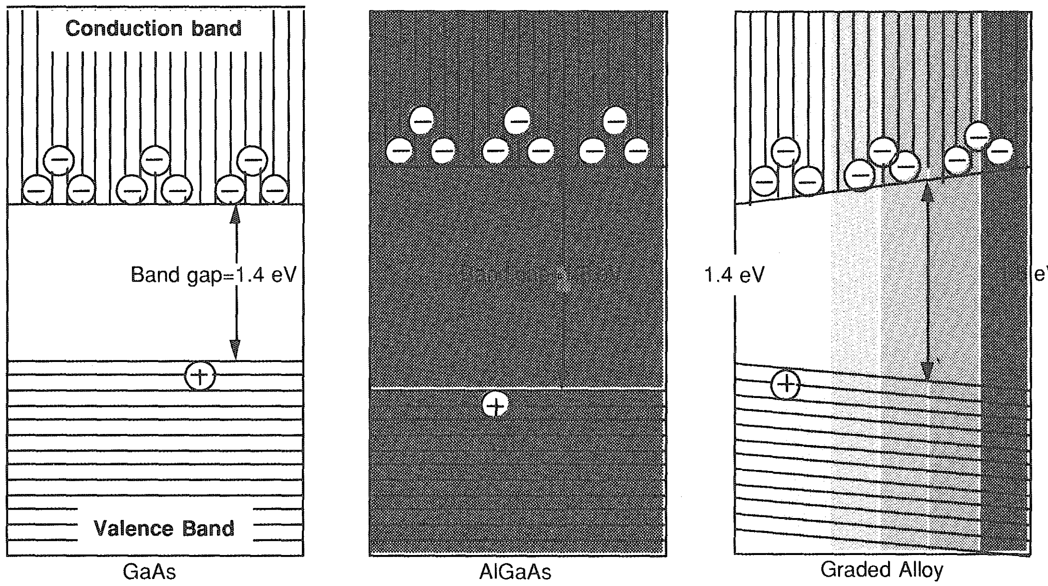


Illustration by Jerry Fiala

Alloying a semiconductor, or slowly varying its composition during crystal growth, allows for precise control of current carriers. GaAs has a band-gap of 1.4 eV, while AlGaAs has a band gap of 1.8 eV. Electrons in this structure will "roll downhill" to the narrower band-gap, while holes will "bob uphill" to the larger band-gap.

A more precise description of a semiconductor requires discussing band gaps. A material's band gap is the amount of energy required to free one of its valence, or outer shell, electrons. A freed electron is said to have gone from the valence band to the conduction band. For silicon, an elemental semiconductor, 1.13 electron-volts (eV) is required to promote an electron to the conduction band. For gallium arsenide (GaAs), a III-V semiconductor (after the columns in the periodic table), 1.40 eV is required. For comparison, the band gap in an insulator is extremely large; while the band gap in a good conductor does not exist in a normal sense, i.e., a good conductors always has free electrons.

Once an electron reaches the conduction band, it can be influenced by an applied electric field and can conduct electricity. By supplying different amounts of energy to a semiconductor, it is possible to precisely control the number of electrons promoted to the conduction band. This ability to control current flow by means of a separate current or voltage is what makes semiconductors so useful.

The number of available electrons or holes, the positive charge left by a missing electron, in a semiconductor can be precisely controlled as well. In an elemental semiconductor, impurities with either one more or one less valence electron are mixed with the semiconductor. This process is known as n-type and p-type doping, respectively. In a III-V semiconductor, doping is achieved by using unequal amounts of each element. For example, n-doped GaAs will have more arsenic than gallium. Almost all semiconductor devices, such as transistors and diodes, utilize doped semiconductors. The differently doped semiconductors are usually joined to form a p-n junction.

When a p-n junction is first formed, the free holes and electrons begin to migrate across the junction and neutralize each other, or recombine. That is, electrons in the conduction band of the n-type semiconductor fall across the band gap and fill holes in the p-type semiconductor. The charge separation that results from this recombination creates an electric field across the junction. The field bends the band-gap structure and prevents further migration and recombination. If a forward-bias voltage is applied to the junction, however, the junction is straightened out. This allows more holes and electrons to recombine, releasing energy equal to the energy across the band gap. This effect can be used to build lasers or light detectors for some semiconductors.

valence electrons as the atom it replaces. By contrast, doping, a traditional method of altering semiconductor properties, involves substituting an atom having a different number of valence electrons than the one being replaced. Some popular alloys of GaAs are created by adding either aluminum or indium. Atoms of these elements replace gallium atoms at random positions in the crystal lattice. Since both aluminum and indium have the same number of valence electrons as gallium, no excess charge carriers are introduced. However, gallium has a different number of electrons than the substitute atoms. This imbalance creates different band gaps for alloys of these elements. For instance, the alloy aluminum gallium arsenide (AlGaAs) has a larger band gap than GaAs does.

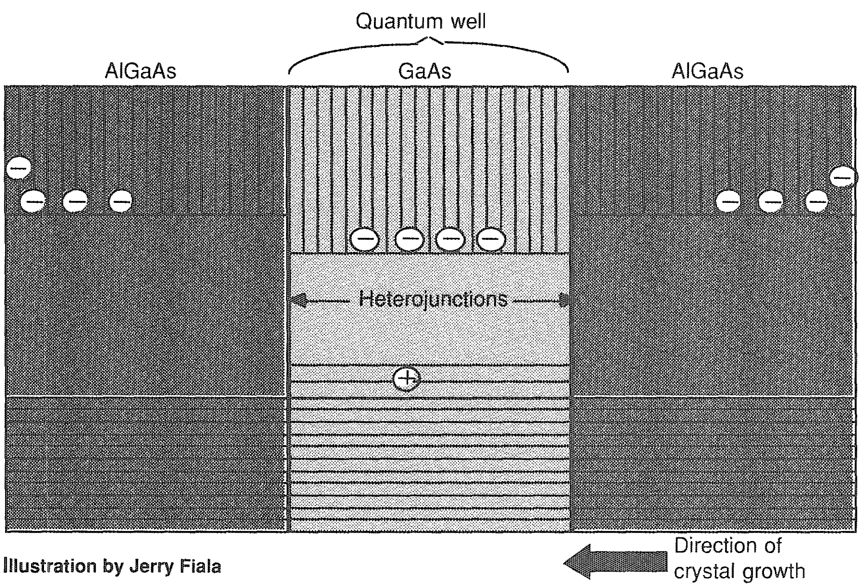


Illustration by Jerry Fiala

Heterojunctions are created by "sandwiching" a semiconductor with a narrower band-gap between materials with larger band gaps. Since excess electrons will tend to the material with the smaller band-gap, they accumulate there. The accumulated electrons encounter minimal electrical resistance in the plane of the heterojunction (into or out of the paper). Extremely fast electronic devices that exploit this fact have been built.

Heterogeneous Juxtaposition

Juxtaposition by alternating layers of semiconductors to form heterojunctions is the second major tool of the band-gap engineer. The two juxtaposed materials have different band gaps. The layer with the larger band gap is often doped, while the layer with the smaller band gap is not doped. The process of creating undoped quantum wells that separate charge carriers from their parent dopant atoms in the surrounding layers is called modulation doping and is at the heart of today's fastest semiconductor devices.

For example, if a thin layer of GaAs is sandwiched between two layers of n-doped AlGaAs, the two heterojunctions create a well of lower potential energy. The excess electrons from the AlGaAs are captured by the well and are unable to leave (unless they acquire sufficient energy from an external source.) Although the electrons cannot leave the well, their motion in the plane of the thin quantum-well layer is unrestricted. The carriers move much faster in the plane of the well than they do in any direction in a conventional doped lattice because they don't encounter the regional potentials left by ionized dopants.

Built-in Strain

The third and newest tool uses a built-in strain on an existing lattice to modify the hole transport characteristics of the device. Strain has been avoided as a band-gap engineering tool until recently because too much strain on a crystal lattice can cause defects in the crystal. Defects can trap excess charge carriers, reducing the efficiency of the device. The MBE and MBCVD thin layer technologies have rendered built-in strain a viable tool.

For example, when InGaAs is grown on a GaAs substrate, the GaAs substrate compresses the lattice constant of the InGaAs in the direction perpendicular to the interface between the two materials. This strain has the effect of separating the "heavy" holes and "light" holes in the conduction band. This enables the "light" holes to be accelerated in an electric field almost as easily as electrons are.

Applications

These techniques enable the engineer to design unique devices. Nonetheless, they have not overtaken the traditional silicon integrated circuit. The cost of producing quantum-tailored devices is far greater than the cost of producing devices by conventional methods, as quantum-tailoring does not yet lend itself to mass production. The advantage to quantum tailored devices is that they often exhibit qualities that are unattainable through other fabrication techniques. In applications where cost is not as important as performance, such as niche technologies and military components, band-gap engineered devices are the only tool for the job.

For instance, by using the technique of alloying, one can build a high-gain avalanche photodetector. This is a device used to amplify an incoming light signal for re-transmission or processing. Conventional avalanche photodetectors have a lot of electrical noise, as the ionization of individual atoms is a random event subject to statistical fluctuations. By alloying individual layers linearly from a low band gap, such as AlGaAs, to a high band gap, such as GaAs, and stacking the layers, a very high quality photodetector can be constructed.

When a bias voltage is applied to the device, an incoming photon with sufficient energy will free an electron in the outermost layer, which will be accelerated by the electric field. As the electron proceeds to the next layer it gains energy under the influence of the field. At the valence-band discontinuity between layers, the electron acquires still more energy. The electron now has enough energy to dislodge several other electrons. These newly dislodged electrons proceed to the next valence band discontinuity just as the first one did. Since the process is no longer random, the gain of the detector can be precisely controlled with minimal fluctuation.

The use of heterojunctions makes an optical-interference filter possible. Such filters transmit or receive light at a single wavelength. The filter is constructed by alternating materials which are lattice matched, but have different indices of refraction. Each layer is made to have an optical thickness (the physical thickness of the layer times the refractive index) of one-quarter wavelength of the light to be tuned. A popular choice of filter materials is GaAs and AlAs, as they have very closely matched lattices, a fairly large difference in their refractive indices, and are easy to grow to any thickness. An anti-reflector can be built by having the material with the lower index of refraction on the outside; a high reflector can be built by having the material with the higher index of refraction on the outside.

This filter has direct application to semiconductor lasers. All lasers employ a Fabry-Perot cavity, which is a cavity with two plane-parallel partially reflective mirrors, one at each end. By using the high reflector structure described above, the high reflectors can be included with the laser at the time of fabrication. Previously, a separate processing step had been required to insert a highly reflective material to act as a mirror. The high reflectors reinforce only the desired wavelength, which enables the laser to produce light of only one frequency. This is a very desirable property for fiber optic communication systems because different wavelengths of light travel at different speeds in a fiber optic cable, which causes distortion.

By using built-in strain, one can build a GaAs p-type Field Effect Transistor (FET). Until this discovery, p-type GaAs devices were only 1/15 as fast as n-type GaAs devices, making a complementary logic family of GaAs devices impossible. Complementary logic families are very desirable for implementing logic functions due to their versatility and low power consumption.

An additional application of quantum-well structures is the reflection modulator. The device is constructed by placing a thin layer of superlattice above a highly reflective mirror. The superlattice is engineered so its band gap energy is just above the energy of the incoming photon. Light then applied to the surface will be unaffected by the superlattice and will be directly reflected by the mirror. When the correct bias is applied, the quantum-confined Stark effect [see sidebar] decreases the bandgap to the energy of the photons so they are absorbed. The device reflects very little light under these conditions.

The demands of tomorrow's technology will require fundamental advances on many fronts. Without question, a major front in this battle will consist of new materials and processes for microchip fabrication, such

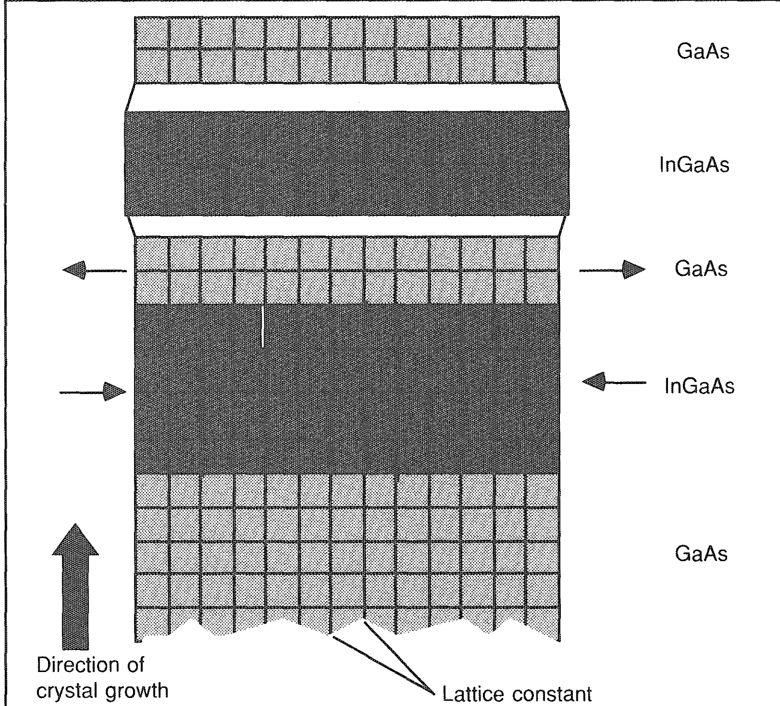
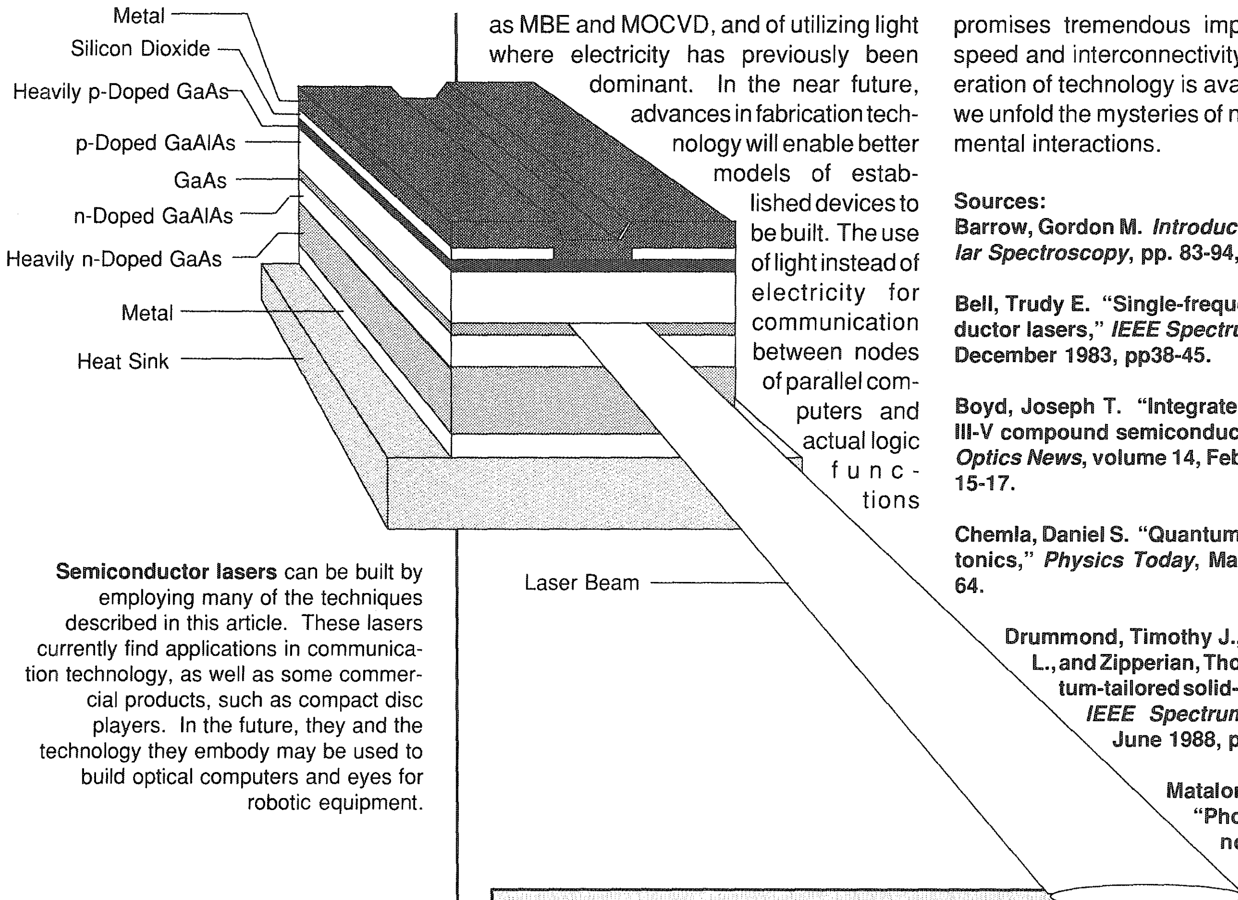


Illustration by Jerry Fiala

Mechanical strain can be introduced by alternating very thin layers of material, such as GaAs and InGaAs, with different lattice constants. If the layers are kept thin, the strain will not cause defects in the material with the larger lattice constant.



Semiconductor lasers can be built by employing many of the techniques described in this article. These lasers currently find applications in communication technology, as well as some commercial products, such as compact disc players. In the future, they and the technology they embody may be used to build optical computers and eyes for robotic equipment.

as MBE and MOCVD, and of utilizing light where electricity has previously been dominant. In the near future, advances in fabrication technology will enable better models of established devices to be built. The use of light instead of electricity for communication between nodes of parallel computers and actual logic functions promises tremendous improvements in speed and interconnectivity. A new generation of technology is available to us as we unfold the mysteries of nature's fundamental interactions.

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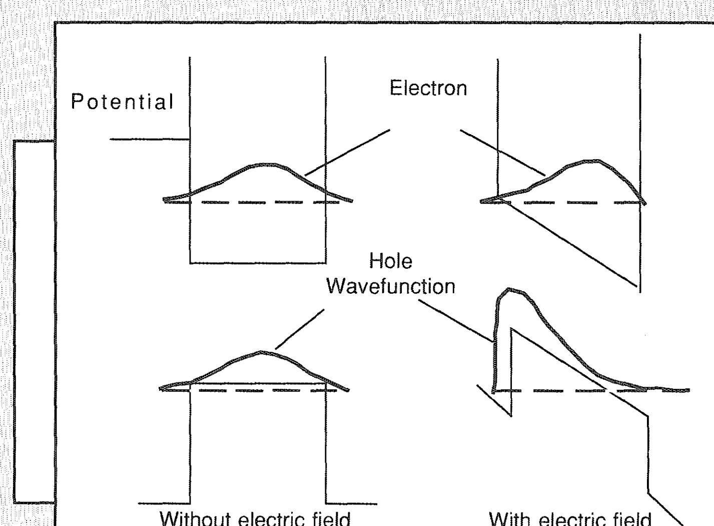
Quantum-confined Stark effect

The quantum-confined Stark effect is a particular case of a more general phenomenon called, simply, the Stark effect. The Stark effect is just one of the many ways in which the energy levels of a molecule can be disturbed. Another more recognizable method, called the Zeeman effect, uses a magnetic field to remove the m_l-orbital degeneracies in molecules. That is, the field interacts with the magnetic moments of the electrons to create energy differences among orbitals with differing moments. The stronger the magnetic field, the larger the energy differential.

The Stark effect involves an electric field



The quantum-confined Stark effect allows for altering a material's absorption spectra via an applied electric field. The quantum well confines the electron-hole pair despite the repulsive force the field introduces.

Illustration by Jerry Fiala

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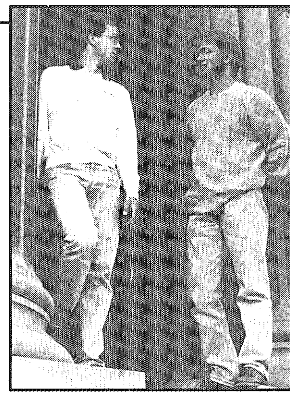


R. Hendrickson and S. Kosier may someday earn Ph.D. degrees, so they figured they would start using the initials of their first names now and avoid the rush. R. is a physics senior and S. is a EE senior and this year's *Technolog* editor. Their former names were Rob and Steve.

interacting with the electric dipole moment of an electron in orbit. The field removes the m-orbital degeneracies by spreading the energy lines corresponding to the different m-orbits. This is useful for quantum tailoring, as it enables one to shift photon emission energy and edges of absorption. Analogous to the Zeeman effect, a stronger electric field will further spread the energy levels. However, there is a limit to the amount that energy levels can be adjusted. If an electric field becomes too great it will ionize the electron. This is where quantum well structures and the quantum-confined Stark effect help.

When an electron breaks free in the quantum well of the superlattice, it can form a pseudo-molecule, called an exciton, with the hole it left behind. Like a molecule, the exciton can absorb and emit photons. However, the exciton in the well is different from a molecule outside the well in at least two significant ways. First, the electron and hole are confined to a narrow plane, so they are forced to orbit each other in an elliptical path. Since the pair is forced to spend more time together, the binding energy rises. Second, when the electric field is applied, it not only affects the enegy levels of the exciton, it affects the potential 'walls' of the quantum well. The field bends the profile of the potential barrier to keep the hole and electron closely bound.

Because of the unique features of the quantum well, the strength of the field may now be increased up to fifty times what is used outside the well, without the risk of ionization. This increase in ionization energy means much greater flexibility in changing the optical properties of superlattices. In the particular case of the reflection modulator, the quantum-confined Stark effect allows one to shift the absorbing edge from full transmission to absorption with great efficiency.

Finer and Finer

by Bill Dachelet
researched by Chi-Hum Paik and Erik R. Scott

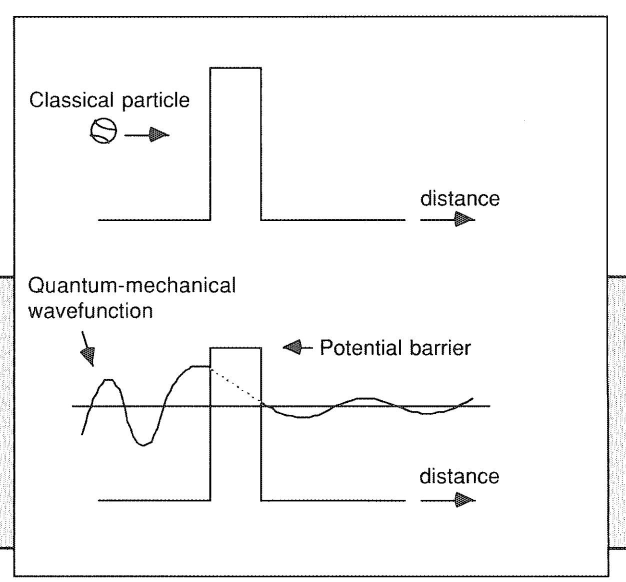
The picture you are looking at is the surface of mica which has been covered with platinum. The incredible clarity allows you to see distinct crystallite grains only 50 Å (1 Angstrom=10^{-10} meters) in diameter. In the six years since the invention of the Scanning Tunneling Microscope (STM) by G. Binnig and H Rohrer of the IBM Zurich Research Laboraties, for which they won a Nobel Prize, such precise imaging of materials has become commonplace.

Obviously, the closer we can look at a material, the better we can understand how it works. With the resolving power of the STM we are beginning to look at processes never seen with conventional microscopes. For example, the STM has allowed us to look at the ultrafine rippled nature of phosolipid membranes in the lung that may allow it to expand when we breathe. Researchers at the University of California, Santa Barbara, have imaged the pitting of stainless steel which has been immersed in sea water for as little as fifteen minutes. Another type of tunneling electron microscope can map the Shottky energy barrier of interfaces between metals and semiconductors. Applications for STMs are being found in fields ranging from biomedicine to space science. The scanning tunneling microscope can be used not only to look at the surface topography of a material, but may also be used to investigate surface, magnetic, electrostatic, and interatomic Van Der Waals forces.

The STM has become one of the most important new tools in the science of surface analysis because of its ability to see down to scales never before possible. It can create a three-dimensional image that has vertical resolution in the sub-angstrom range (resolution as good as 10^{-12} meters) and lateral resolution to nanometers (1 nanometer =10^{-9} meter). The STM has imaged a variety of semiconductors including graphite, silicon, and 2H-NbSe2. It has also imaged insulating materials that have been coated with a conducting layer, such as the DNA molecule. Another important example of the versatility of the STM is its ability to image samples in air, water, and even insulating materials such as paraffin oil and liquid nitrogen. This is important because many other scanning methods require the sample to be in an ultra-high vacuum.

The STM operates using the quantum mechanical phenomenon of tunneling. In classical physical theory, if an object does not possess enough energy to overcome a potential barrier, it simply will not cross the barrier. However, in the realm of very small measurements classical theory gives way to quantum theory, which states that there is a finite probability that the particle, due to its wave-like nature, will actually penetrate the potential barrier.

The quantum mechanical way of looking at an electron is as a probability curve (wave). Classically you can find the electron where the curve has its peak, but quantum mechanics says that the electron may actually be found anywhere under the curve. When the electron probability curve encounters a potential wall, the shape of the curve rapidly tries to approach zero—the electron "knows" it isn't supposed to be there! But if the wall is small enough there will be some of the curve left on the other side of the wall. This corresponds to the small probability that the electron will actually "tunnel" through the barrier and reach the other side.

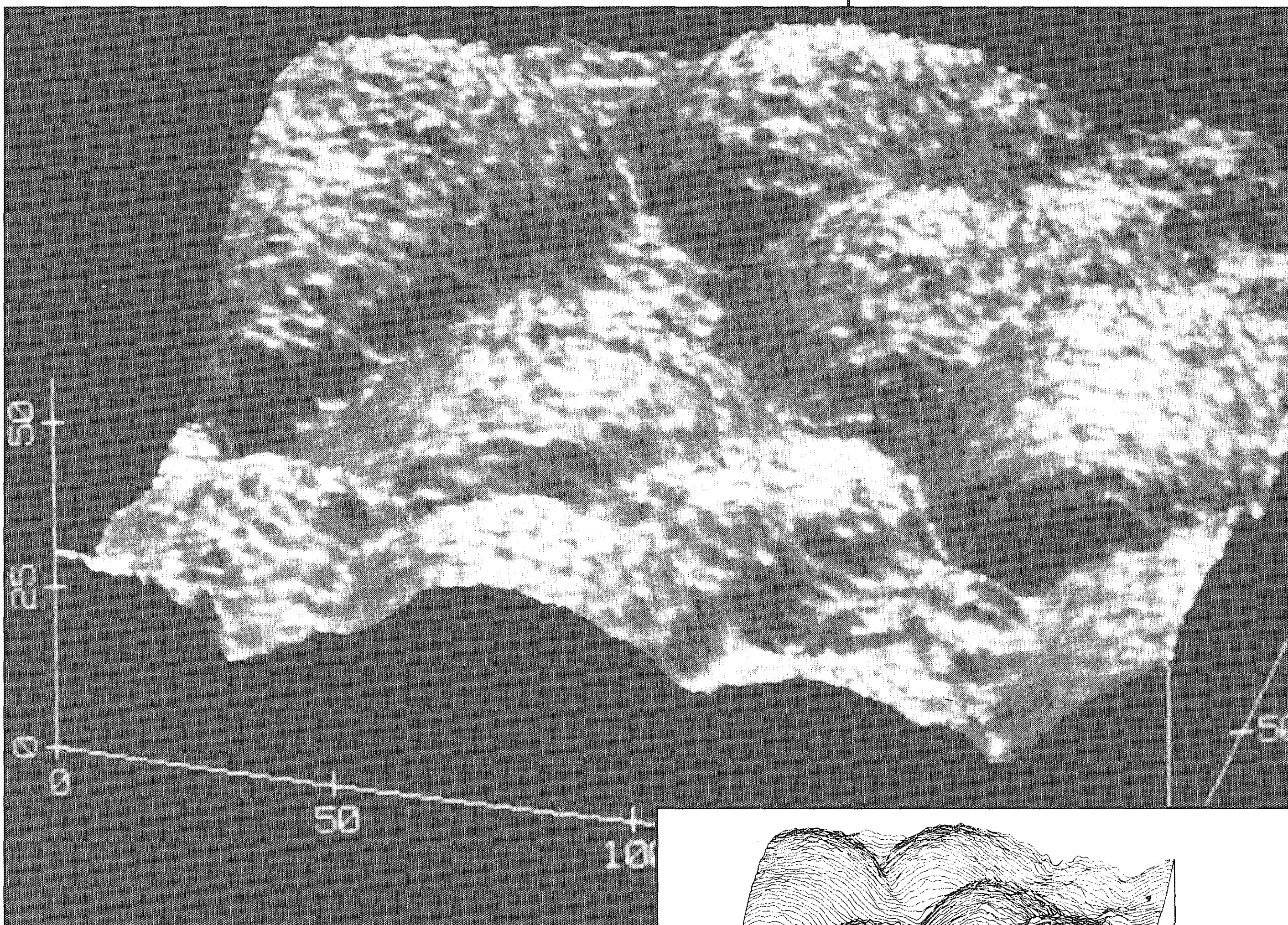


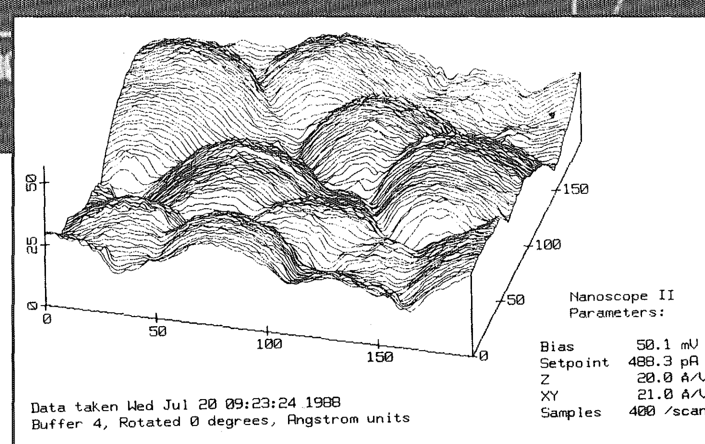
Classical mechanics says a particle will bounce off a barier. Quantum mechanics says a particle's wavefunction may "tunnel" through the barrier and appear on the other side.

Illustration by Jerry Fiala

To see how the STM works, imagine two conducting particles placed in a vacuum with a potential gradient between them. The activation step for an electron, which is the magnitude of the potential barrier, is too large to allow tunneling unless the distance between the two particles is very small. When the particles are within a few angstroms of each other, however, there is a measurable current, called the tunneling current. An STM measures the size of the tunneling current to figure out how far the STM tip probe is from the surface of the metal being scanned. The probe then moves back and forth over the sample to create a relief map.

A precise mathermatical characterization of the tunneling current J between the tip





Platinum film sputtered onto mica surface with 50 Å crystalline grains is revealed by STM. Since electricity is used to operate the STM, computer generated graphics of the image are possible with relative ease.

and the sample in an STM is described by first-order pertubation theory. However, most non-theoretical papers on STM will quote a simplified expression:

$$J \sim \exp [-A (\varnothing)^{1/2} z]$$

where Ø is the average barrier height (work function), and A is an agglomeration of constant terms, approximately equal to unity if Ø and z are measured in electron volts and angstroms, respectively. At conventional operating voltages, usually between two millivolts to two volts, the typical tunneling currents are on the order of nanoamperes (one nanoampere=10^{-9} amperes).

The probe tip of the STM raster-scans the surface plane of the sample by scanning linearly in the x-direction and then moving a small increment in the y-direction between successive x-scans. Images are created in either of two operating modes: constant-current or constant-height.

In the constant-current imaging mode, a negative feedback loop between a current amplifier and tip-height controller varies the tip-sample separation to maintain the tunneling current at a desired fixed value. A three-dimensional image of the sample surface is produced by plotting the tip's height z versus its position in the x-y plane. Alternatively, the STM can be operated in the constant-height mode, in which the tip scans the surface at a fixed height while the tunneling current is monitored. A constant height image consists of a plot of tunneling current on the vertical axis versus lateral tip position.

The STM apparatus includes four elements: the tunneling probe tip, drives and sensors to position the tip, an air table to control vibrations, and a computer control system. Below, the principles underlying each function or part as well as the way they are used in an STM are outlined.

Tunneling Tip

The scanning tip is merely a sharpened piece of wire. The type of metal used is not crucial, although high strength is desired for very fine tip points. Tungsten and platinum are the most commonly used tip materials. Typical "bulk" point diameters are 1,000-10,000 angstroms, although, through electrochemical etching techniques, diameters as small as 50 angstroms have been produced. Regardless of whether the point diameter is 50 angstroms or 5,000 angstroms, these sizes are extremely large on an atomic scale, and one might question how lateral resolution on the order of a few angstroms can be achieved.

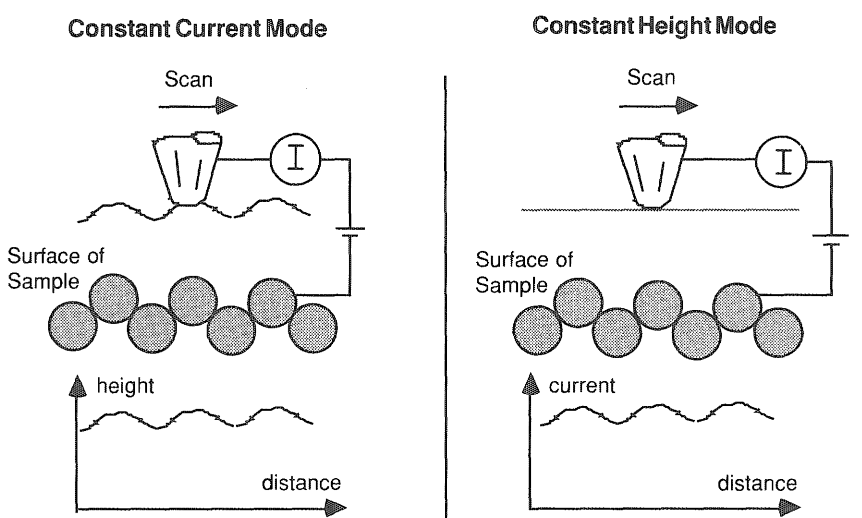


Illustration by Bill Swanson

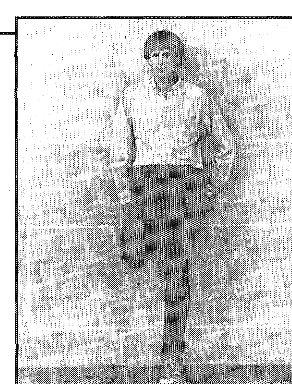
Two modes of operation are possible with the STM. In constant current mode, a constant tunneling current is maintained by adjusting tip height. In constant height mode, the changes in tunnelling current are recorded and processed.

An analogy of this seemingly impossible feat would be for a blind person holding an umbrella in a rain storm to use only his or her sense of feel on the umbrella handle to detect where each raindrop landed. How can such a large "umbrella" be made to detect a single raindrop at a time? The solution, in the case of the STM, is that the point of a tip is not smooth, but contains many tiny, unresolvable "nanotips" which protrude from its surface. These asperities come to a point, consisting ideally of a single atom. When the tip is brought within tunneling range of a sample, one nanotip will ideally be closer to the sample than all the others, and hence tunneling will occur only between the sample atoms and the single atom at the end of this tip. If the sample's surface is somewhat regular so that this nanotip remains closest to the sample as the tip is scanned across the hills and valleys of the sample, tunneling current will continue to flow through the same atom of the same nanotip throughout the scan. This achieves atomic resolution.

Tip Positioning

Obviously, a precise means of controlling the tip's position is required to provide high resolution images. STMs currently use piezoelectric ceramic devices to perform this task. Piezoelectrics have the property of elastically contracting or elongating by tiny amounts under applied electric fields. To precisely position and control the tip, three piezoelectric arms are used—an x-axis arm, a y-axis arm, and a z-axis arm. For small deformations, the change in the arms is proportional to the applied voltage, hence calibration of position is an easy task. Maximum tip scanning ranges

Author Bio



Bill Dachelet is the hero of this *Technolog* issue. Despite having just run the Twin Cities marathon, being the *Technolog's* circulation manager, tutoring math for the U, and taking five classes, this Physics senior agreed to do this article on semi-short notice. He is currently looking for a way to kill his free time.

generally vary from about 1,000 to 10,000 angstroms, which requires piezo-control voltages ranging from approximately -250 to +250 volts. The tip positioning features of an STM are known as the STM's actuator.

Scientists have made several improvements on the above positioning system but the general principles have remained the same. The aim of these improvements is two-fold: to minimize the operating voltage, and to stabilize the actuator system by minimizing vibrations and thermal drift. Since tunneling currents are on the order of nanoamperes, the less electrical noise emanated from the actuator, the better the image signal will be. Using a smaller operation voltage naturally reduces the actuator's electrical noise. Tip vibration and thermal drift of the actuator raise a problem because resolution of an object is limited by the magnitude of the uncontrolled displacements between probe-tip and sample.

Since the scanning range of the tip is limited on present devices to, at most, 10-5 meters, a means of positioning the tip on the sample is needed. This tip positioning is most often provided by a finely-threaded screw mechanism, which can be electronically controlled by a stepper motor. Lateral positioning of the sample is provided by a mobile support known as a "louse." A popular louse design involves resting a piezoelectric sample stage atop three piezoelectric feet. Appropriate sequences of voltage signals applied to the various piezo elements can make the louse "walk," caterpillar-style. These three feet enable both linear and rotational motion.

Control of Vibration and Thermal Drift

Various vibration dampening/isolation systems for the tunneling unit have been implemented. Most common is the use of ters has been achieved in the best cases, and resolution of 10 nanometers is routine. Given the explosiveness with which the STM has entered the field of surface science, as well as the impressive record of results and versatility of use, we can expect that both the number of applications and the quality of results will continue to grow in future years. Perhaps the STM will even, in the not too distant future, help us understand and unravel such mysteries as the conductor-semiconductor Shottky potential and exactly how saltwater pits stainless steel.

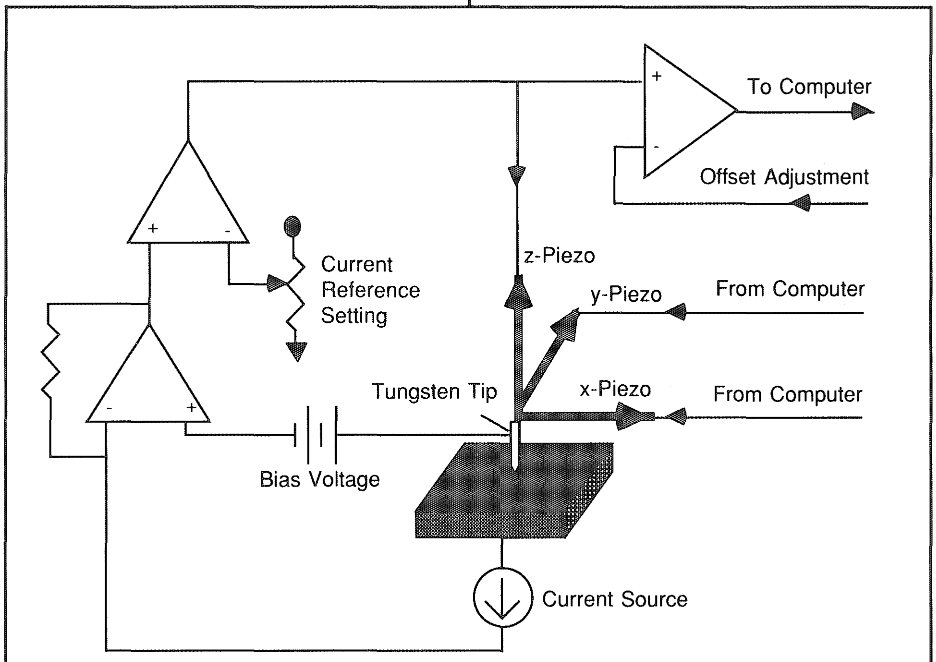


Illustration by Bill Swanson

Schematic diagram for the STM shows major functional blocks. The STM itself is controlled by analog circuits. In order for computer control to be possible, a digital-to analog or analog-to digital signal conversion process is required (not shown).

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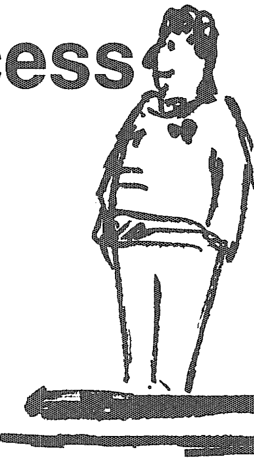
Student Production Process

by Steve Littig



When I let my mind drift back to my first day of school at the U, I remember walking up Church Street, nervously shifting my glance between my class schedule, a map of the U, and the maze of buildings lining the street. My first class that day was Physics 1271 in Physics 150. Having arrived late, I was forced to sit in the back of the room where I could neither see nor hear the lecture. Having nothing else to do, I began to daydream. I remember thinking with wide-eyed excitement that just four short years from now I would graduate as an engineer who would make over $30,000 a year working for a major corporation. I figured I would work for a couple of years before I quit my job and started my own company. Then after four of five more years of work, I figured I'd sell out to General Dynamics and retire at the age of thirty.

It amazing how your expectations can change over time, isn't it? Now as I begin my sixth (yes, that's sixth) year of college, still in search of that ever elusive undergraduate degree, I just hope that I can find my first job by the time I turn thirty. It's also quite interesting how your parents' expectations can change over time. I remember when I was leaving for college my father sat me down for a heart-to-heart chat. "Son," he said, "employers want to see that students can meet deadlines. You are getting a four-year degree, *get it in four years* " (his emphasis). I foolishly replied, "No problem Dad, I'll go to summer school and be done in three and a half years." Now whenever I broach the subject of college with my father and try to explain that five and a half years is the University average, his eyes bug out, his teeth grit, his hands clench and I leave the room. His expectations have also dropped a notch or two since I was in high school. At that time I think he was hoping that by now I would have received my doctorate from MIT, be completely self-supporting, and be a finalist for the Nobel prize for science (after all, Einstein won his by the time he was 22). Now he gets excited when I tell him I've got a job with McDonald's and he asks what kind of career advancement policies they have.

All kidding aside, now that I can see the light at the end of the tunnel, I wonder why it has taken so long to receive that all-important piece of paper. Why does it take the majority of us over five years to receive a four-year degree? The answer is simple. We have all entered into the undefineable amorphous mass of humanity and bureaucracy known as the University of Minnesota. It is similar to the black box production theory. The University is the black box; raw materials (freshmen) enter into the box on one side, some scrap is inevitably produced (dropouts), and the finished product (graduates) exit out the other side. However, what happens inside the black box is unknown. We don't know the direction, speed, acceleration, or defects of any of the materials when they are in the box. If the University is to reduce its current through-put time of five and a half years, it must do a better job of production tracking. It's time to open up the black box.

The problem starts with planning and training. If you'll allow me to continue with my analogy, the current method of planning a student's production simply consists of placing that student on the conveyor and assuming he or she will be channeled into a major, and from that major into a coherent elective program. The problems begin when that student finds he or she was channeled into the wrong line. This is where valuable time and money is lost. Students do change their minds, and this is unavoidable. But I think many students know what they want to do, but don't know what programs best suit their interests and abilities.

When I started school at the U I became a mechanical engineering major. I didn't know the first thing about what a mechanical engineer actually does, but I did know that the job paid well (not a good reason to enter into a major). Even when I was a freshman, my interests in engineering were on a macro scale; I didn't want to have to look through a microscope to see my work. This eliminated both electrical and

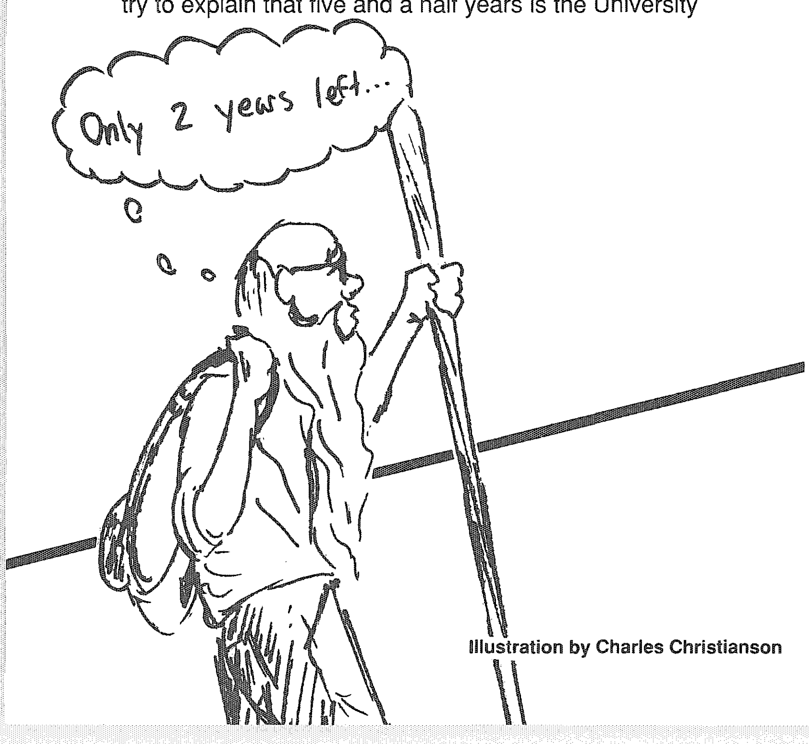
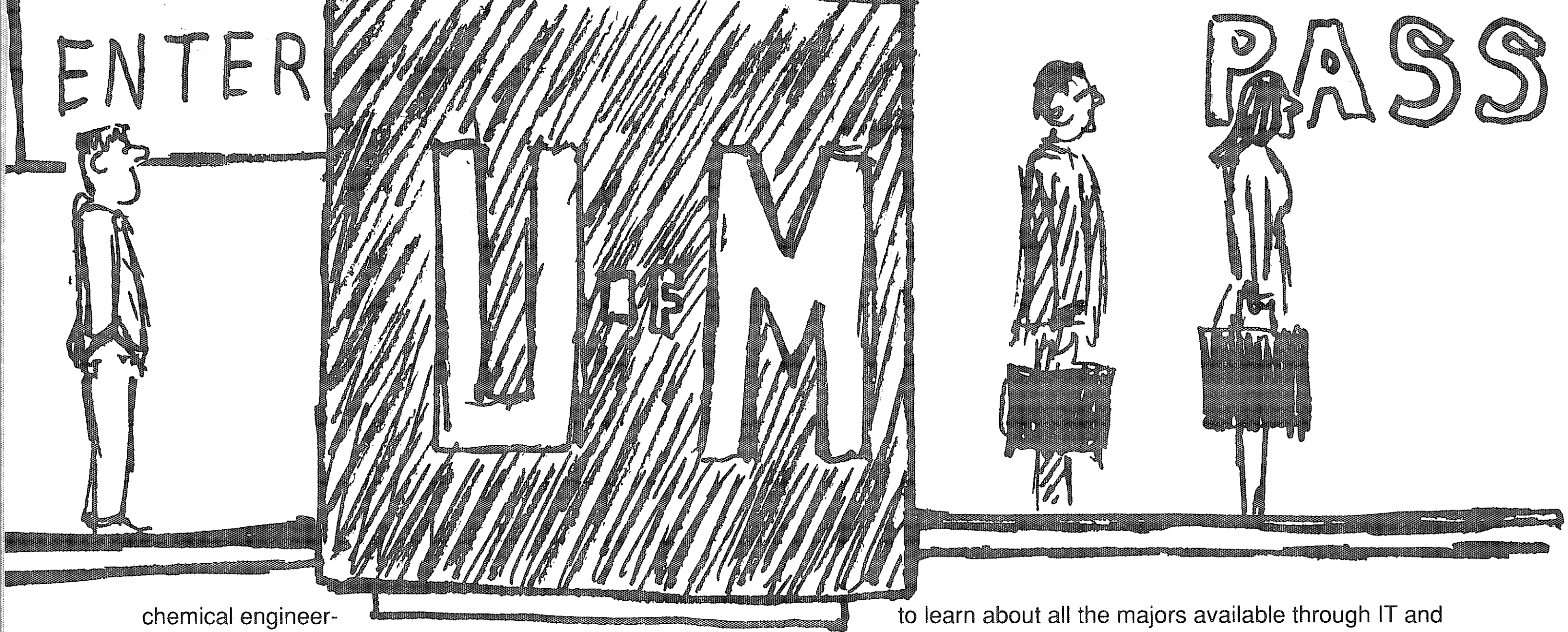


Illustration by Charles Christianson



chemical engineering. Mechanical engineering seemed to be a good fit, that is until my junior year when I came face to face with a hideous monster known as Heat Transfer. Because I could never understand the procedure (or purpose) for calculating the convective heat flux from a point source in three-dimensional space, I quickly bailed out and became an industrial engineering major.

In retrospect, I now realize that this was the major best suited to my interests and abilities all along. But during my freshman year I really didn't know anything about the industrial engineering program. My perception was that it was a program for people who couldn't hack the technical ME curriculum. Clearly, the University needs to do a better job of training students in what options are available to them. It's not fair to simply assign this responsibility to the advisors, because they are already overworked and don't have time to question each student about his or her true interests. Also, few advisors understand all the aspects of each major in IT.

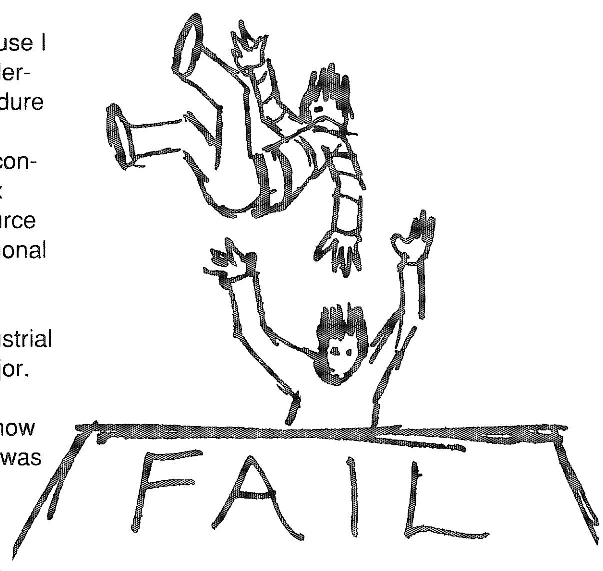


Illustration by Charles Christianson

Perhaps one answer would be to have some type of required class for all incoming freshman entitled "Understanding the Engineering Profession." The class could meet once a week and have guest professors lecture about their major on a rotating basis. This way students would have the opportunity to learn about all the majors available through IT and what types of jobs graduates can expect to receive. Even for those students who know what major they want, it would force them to learn a little bit about the other majors and other engineer's specialties. Inevitably, students will be required to work with all types of engineers and scientists in the real world so a better understanding of other fields would certainly help.

Continuing with the black box analogy, the University must assure that the students are on the right conveyor line (major) so they won't have to be sent back for re-work. To do this it must provide adequate tooling, resources, and facilities to ensure that the product (student) it produces is a high quality one (can you tell I'm an industrial engineer?).

Let's start with tools. Adequate tooling refers to generous computer access, up-to-date lab equipment, and a current curriculum. The importance of generous computer access and up-to-date lab equipment is obvious. Students need to know what is going on in industry today, not the "recent" innovations of World War II. A graduating student who can go into an interview and intelligently discuss with the interviewer the aspects of a computer program or machine currently in use in industry has a great advantage. Also, a current curriculum is important. A professor who uses his yellowed class notes written in the 1970's to teach a class today is doing neither himself nor his students justice.

As an example of this, allow me to draw on my personal experiencies once again. One quarter I sat in on, but did not register for, a quality control course in the evenings. During the six weeks that I attended the class the only subject we covered was inspection — methods for calculating inspection errors, methods of inspection, etc. I figured that having taken this class for six weeks, the course the following quarter would be a breeze. However, I was in for a shock the first day of class. The first thing my professor said was, "We won't be covering inspection in this class. Inspection is one of the biggest wastes of money in industry today. The wave of the future is Statistical Process Control." We covered that topic for the next ten weeks and after having interned last summer in industry, I now know that the second professor was correct.

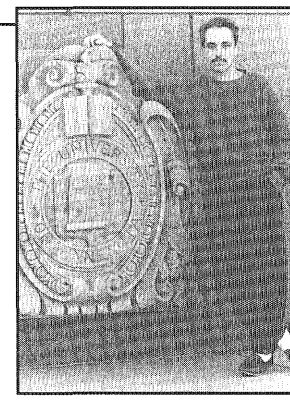
Adequate resources are also needed to produce a high-quality student. Students must have access to funds needed to pay for tuition and living expenses. Students who are forced to work thirty hours a week simply to pay bills are going to find it very difficult to complete their education in four years, much less five. And while the University has little control over the insult known as financial aid, it can surely do something about $50.00 textbooks and large annual bookstore profits.

As well, proper facilities must exist for the student to learn. This includes libraries, classrooms, and study space. The single largest improvement the University has instituted in this area since I have been going to school is the installation of LUMINA—the computer card catalog. This makes researching reference material much easier and the University deserves credit for a job well done. Also, the new buildings have improved the quality of the classrooms. Classrooms should contain adequate lighting, comfortable seating, and good acoustics. The new classrooms have this. Now it's time to work on the old classrooms. Where the University has failed is in the allocation of study space. There is very little 24-hour study space available on campus, and most students do their studying in the wee hours of the morning. Further investment is required here.

As students near the end of the conveyor line, hopefully the transformation from raw material to high quality finished product has taken place. Now it's time for the marketing people to take over. The most important goal of every industry is selling its products, not simply producing them. The University should feel the same way. More companies must be recruited to interview more students. The University must aggressively sell its "products."

So as I near the end of my production phase, I am thankful that I didn't end up in the scrap heap. I hope to find a market so that I can begin to pay for my production cost. And from the perspective of an industrial engineer, I look back at the production process, sneer at the inefficiencies, and wait for the reindustrialization of the U.

Author Bio



Steve Littig was President of the IT Board of Publications last year and *IT Connection* Editor the year before. He is currently a member of the Board. He has made many contributions to both organizations. Since he's so valuable, we tried to talk him into staying in school another year. We're still negotiating.

Jobs in Space

The recent launch of the space shuttle *Discovery* signals good news for engineers as the space program hopes to return to a program reminiscent of its glory days of the 1960's. Much of this recovery depends on the development of new technology to provide improved flexibility, safety, and a measure of economic viability for NASA.

It is commonly believed that current NASA projects, such as the space station and the Titan IV rockets, depend too heavily on aging technology, especially in the field of propulsion. To ensure future prosperity, NASA's launches must become several times more economically efficient, especially considering the pressure of an ever-tightening federal budget. These needs are opening the doors to improved relations with the engineering community.

Many of these relationships begin with engineering education and research programs at nationwide universities. Federally supported research aids NASA in meeting its goals and helps produce young engineers experienced in the aerospace field. The U.S. space program continues to need engineers from all disciplines to research, design, manufacture, and test its systems.

Space, as a commercial market, has attracted numerous participants, each with their own needs and desires. Military demands, however, have always dominated the space program. Space has supported few viable commercial enterprises, with the communications market being the notable exception. Materials manufacturers believe the microgravity of space to be the perfect environment for the creation of superior single crystals and biological materials, but critics remain skeptical of its practicality.

These industries depend on a variety of launchers for their payloads and this is where the United States finds itself lacking. Following the *Challenger* disaster, the space program discovered it had placed all of its research and development eggs, in one basket and quickly lost valuable customers for lack of an alternate launching system. NASA's recovery, with its emphasis on versatility and reliability, is providing a fertile field for design and propulsion engineers. The development of new engines is one of the space program's long-term priorities, since the current solid-propellent boosters are believed to be too complex, dangerous, and uncontrollable and the liquid-propellent rockets too bulky and limited in their potential.

This burgeoning future of the U.S. space program is opening up unlimited opportunities to young engineers experienced in areas as diverse as modern science, systems design, industrial manufacturing, and economics. In spite of a tight federal budget, "the final frontier" promises to provide a healthy job market and rewarding careers.

by Darin Warling

Source: "Engineering Education's Contribution to the Space Program," ***Engineering Education,*** **volume 78, October 1988, pp. 15-18.**

Letter to the Editor

To the Editor:

The word "bug," when used to mean error, could not have originated in the way the trivia test in the Fall One issue claims. While the story of the moth stuck in a relay of the ENIAC certainly has charm, the word bug was in use long before ENIAC was invented in 1945. In fact, it seems to have been first popularized by Thomas Edison. The first citation in *A Supplement to the Oxford English Dictionary* is dated 1889 and refers to Edison's phonograph. Moreover, I don't see how it is possible for a moth to be stuck in an ENIAC relay as ENIAC used vacuum tubes in place of relays.

Peter Kauffner
Computer Science Senior

Peter:

As was stated in the solution, there are many stories about the origin of the slang use of "bug." Since our copy of *A Supplement to the Oxford English Dictionary* has seen much use since 1889, we were missing that page and did not cite that possibility. We cordially thank you for sharing this alternative with us. We invite other readers to share their questions, comments, or insights about trivia or any other aspect of the *Technolog*.

The Editor

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Signature and Title of Editor, Publisher, Business Manager, or Owner: Steven L. Kosier - editor

PS Form 3526, Dec. 1987 *(See instructions on reverse)*

1. What is a Googol?

2. Which bounces higher: a steel ball or a rubber ball?

3. Which office complex has the largest telephone system and how many calls does it handle each day?

4. If you could take any one point in an electric circuit and count the electrons that pass through it in one second, what number would you come up with?

5. What is a Gregorian telescope?

6. What nuclear power plant has just recently been slated to be demolished?

7. What does the acronym LASER stand for?

8. How fast do radio waves travel?

9. What does the Focault Pendulum prove?

10. What is a Rochelle Salt?

Scoring

0-3 Are you sure you're in IT?
4-6 The 40 to 60 percent range is a 'C' at best in most IT classes.
7-10 Impressive. Truly impressive

Answers

1. A googol is the largest number with a name. It is a 1 with 100 zeroes following it.

2. A steel ball bounces higher. When it hits a hard surface, like the ground, it dents, just like a rubber ball. But the steel ball snaps back into shape much more quickly than a rubber ball. This snapping back into shape makes any ball bounce, so since the steel ball snaps back into shape faster, it bounces higher.

3. The Pentagon has the worlds largest telephone system, handling up to 280,000 calls every day.

4. 6,242,000,000,000,000,000.

5. A Gregorian Telescope is a reflecting telescope with a concave secondary mirror, located extrafocally, that reflects the light through an opening in the primary mirror and forms a real image behind the primary mirror.

6. Chernobyl.

7. The acronym LASER stands for Light Amplification through Stimulated Emission of Radiation.

8. At the speed of light—186,282 miles per second.

9. That the earth is in rotation about an axis.

10. A crystal of quartz, which, when compressed, generates an electrostatic voltage.

The Near Side

by Steve Littig and Conrad Teves

In the late 1990's, with an acute shortage of both classroom and parking space, the U reached a controversial compromise.

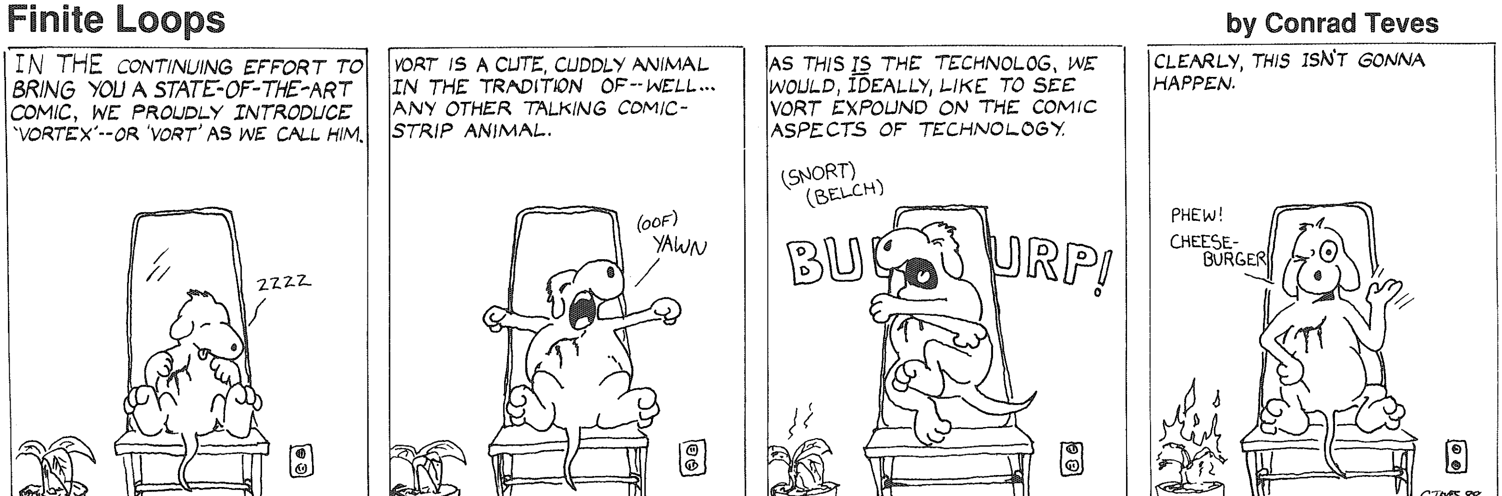
The Flip Side

by Jim Willenbring and Tom Rucci

When faced with the grades he received on his first round of midquarters this quarter, Denis decided to pursue the popular University route and call himself an "interim" student.

Finite Loops

by Conrad Teves



minnesota TECHNOLOG

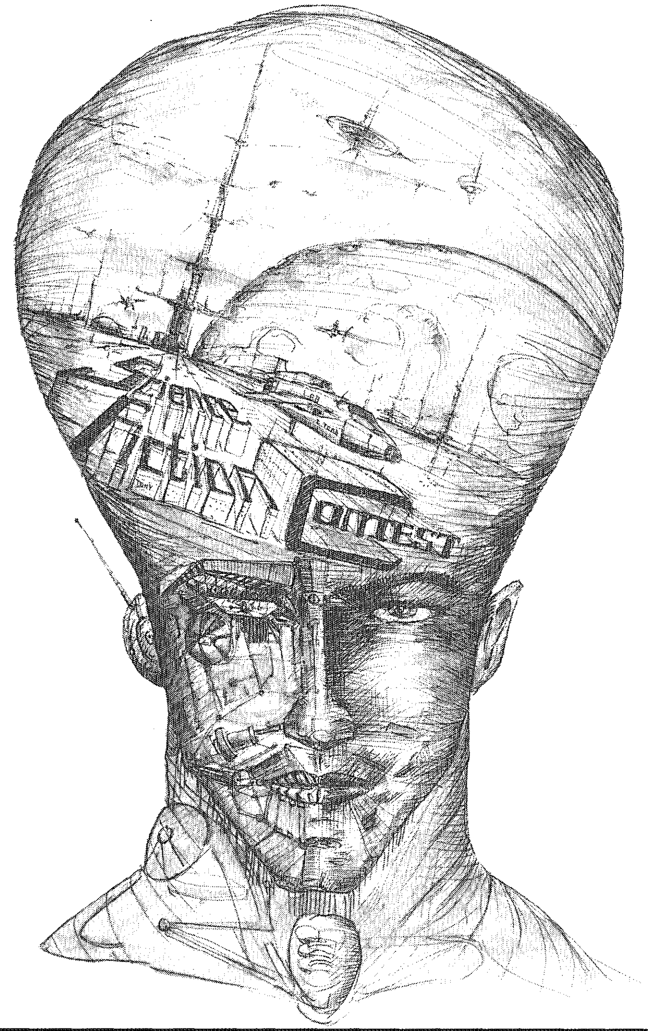
Winter One, 1989

Communication

- Presentation Principles
- Fiber Optic Communication
- Classroom Amusements

How's your communication hand?

The Annual Science Fiction Writing Contest



As alluded to in a previous issue, this gala event is underway. As promised in said issue, here are the guidelines.

Entries are to be typed, double-spaced, and no more than 4,000 words. Macintosh disk is preferred. Three copies of your entry, along with a cover page stating your name, address, and phone number are to be included as well. Please don't include your name anywhere else. The *Minnesota Technolog* retains the first publication rights to your winning manuscript. *Technolog* staff and IT Board of Publication members, whether past or present, are not eligible.

Deadline is 8 February 89 at 12:00 noon.

Awards	**1st**	**$100.00**
	2nd	**$ 60.00**
	3rd	**$ 40.00**

For clarification on any of these guidelines, call 624-9816 or stop by Room 2 Mechanical Engineering. Good luck, and start writing!

The Annual "Anything Goes" Photography Contest

The *Minnesota Technolog* is once again holding its "anything goes" photography contest. Winning entries will appear in the Science Fiction issue of the *Technolog.*

Guidelines
The only real guideline is that submitted photos must be black and white. Otherwise, we're after the most eye-catching and interesting photos around. "Doctoring" of photos is permitted, but certainly not required.

Prizes will be awarded, to the tune of

1st	**$50.00**
2nd	**$30.00**
3rd	**$20.00**

not to mention the incredible prestige that accompanies having your photo appear in print.

No limit to the number of entries per person. Please include your name, address, and phone number on the back of all your photos.

For clarification of these guidelines, call 624-9816 and ask for Paula Zoromski, or stop by Room 2, Mechanical Engineering.

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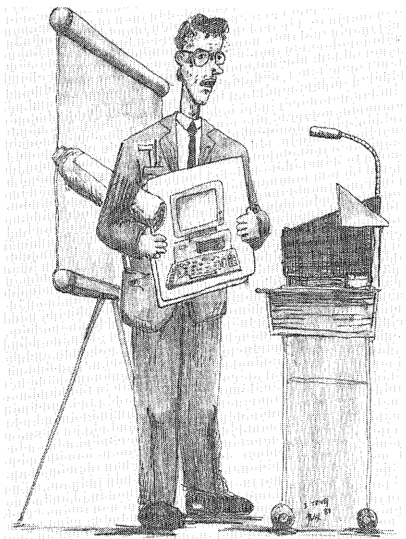
The official undergraduate publication of the Institute of Technology, University of Minnesota



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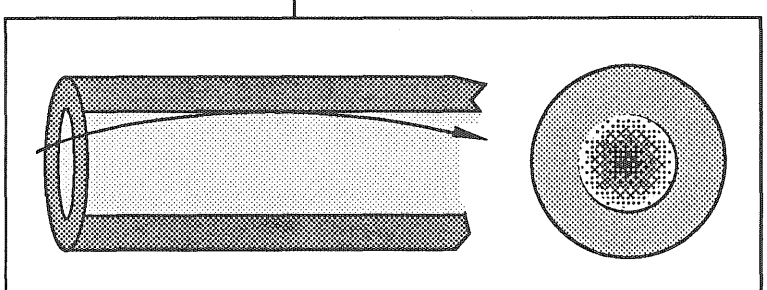

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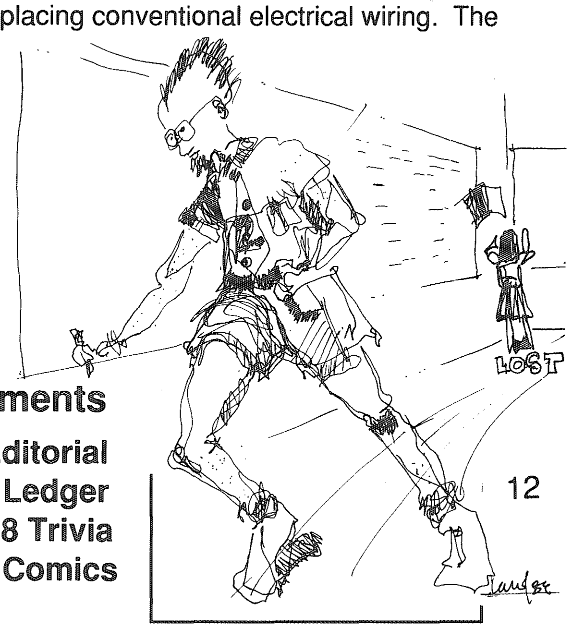

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On the cover

The cards in this high stakes poker game represent the communication skills available to engineers and scientists. Those with the best hands are most successful, if they play their cards right.

Photo by Paula Zoromski

Flip-flop TTL Vector Banana

by Steve Kosier

Engineers and scientists are a much maligned lot when it comes to interpersonal communication skills. It seems that many non-technical co-workers find their technical counterparts to be either uncommunicative, cold, or just plain weird. Phrases like "why can't he just talk in plain English" or "she doesn't like any of us" are often heard at the workplace. Their opinions cannot be dismissed, either. For it is said of engineers and scientists that if we communicate well with our co-workers, we will be successful. Poor communication, it is emphasized, may be our downfall.

Why do technical people have such a difficult time with interpersonal communication?

At least part of the answer lies in the preparation required for the profession we have chosen. To obtain a technical degree, we have to take four or five years of classes, only relatively few of which are non-technical. Assuming we want a "good" job when we graduate, we need to do well in our technical classes. For most of us, this means we have to study. Effective studying generally involves working many problems, understanding derivations, and being able to apply what we've learned from our examples to unfamiliar problems. Our grade, and thus our future employment possibilities, are based on how effective we are at solving problems posed to us on exams.

In solving exam problems, only the facts are relevant. The person who uses the facts most correctly on exams gets the highest grade. Things like the mood of the person sitting next to you or the clothes you are wearing at the time are not important. On a typical technical exam, no credit is given for nice handwriting, lucid restatement and clarification of the problem, putting the problem into simpler terms, witty comments about the problem, observations or stories about similar problems, useful analogies to the problem, or even documentation of solution steps. It seems, however, that credit is given for these things on the job.

It is safe to say that being effective at problem solving on exams requires a different set of skills, or at least a subset of the skills it takes to, say, effectively run a meeting, chat with co-workers, or give an oral presentation. It is quite a challenge to shift back and forth between "problem solving mode" and "chit-chat mode," a challenge people without technical backgrounds have difficulty appreciating. Mastering this skill may be, however, the only thing standing in the way of a rewarding career for a technical professional.

How can future engineers and scientists acquire these skills?

Like anything else, it requires practice. The best way to practice is to talk to a wide variety of people about a wide variety of topics on a regular basis. At your future place of employment, you will be required to do this. The thing to remember is that this is learned behavior; it doesn't come naturally for most people.

How does one get experience in this area? The best way is to join a student organization. There are many of them out there, and most are looking for new members. Think of the time you devote to the student organization not as time you could spend studying, but as an investment in your future. From this perspective, how can you afford not to join one or more?

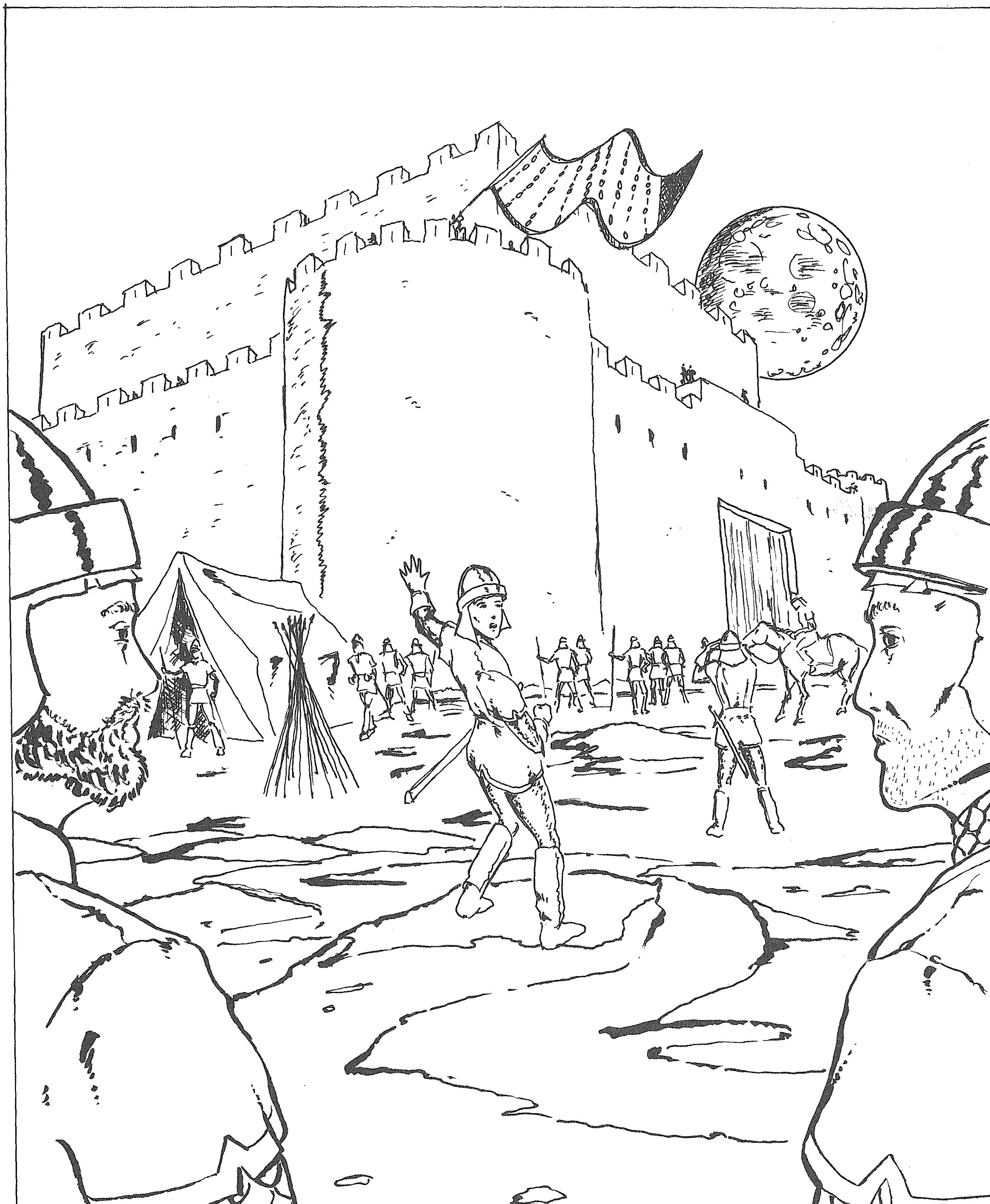


Illustration by Conrad Teves

Presentation Principles

by Darin Warling

Communication, n. 1. the act or process of communication. 2. the imparting or interchange of thoughts, opinions, or information by speech, writing, or signs. [< L *communication* — (s. of *communicatio*), equiv. to *communicat(us)* + —ion— —ION; r. ME comynycacioun < AF]
— from the Random House Unabridged Dictionary

Since time immemorial people have been trying to express their thoughts and ideas to each other through the various languages and alphabets that have evolved, and it hasn't always been easy. Because no common, all-encompassing dialect has yet been developed to link every culture with every other, a person from one area still has to translate his or her language into that of the other person in order to be understood. And, unfortunately, this doesn't just apply to different geographical regions. People who supposedly speak the same language still have problems with coherent communication. Take a computer science major and an economics student, for example. How many economists know, or care, what an n-doped GaAs chip is or what a 9600 baud modem can do? By the same token, how many computer scientists could discuss the finer aspects of Cobb-Douglas production functions? When people have to convey specific, precise, and complex things to one another, the field of technical communications is there to help.

According to Professor Victoria Mikelonis, director of the Department of Rhetoric's technical communications undergraduate program, the field of technical communication encompasses over 73,000 people in jobs ranging from writing those malevolent foot-thick installation guides that were shipped with your computer to presenting grant proposals before review committees. Nearly every scientific and professional field utilizes them to some extent, and as high tech industries have ballooned, so has the need for men and women skilled in the art of communication.

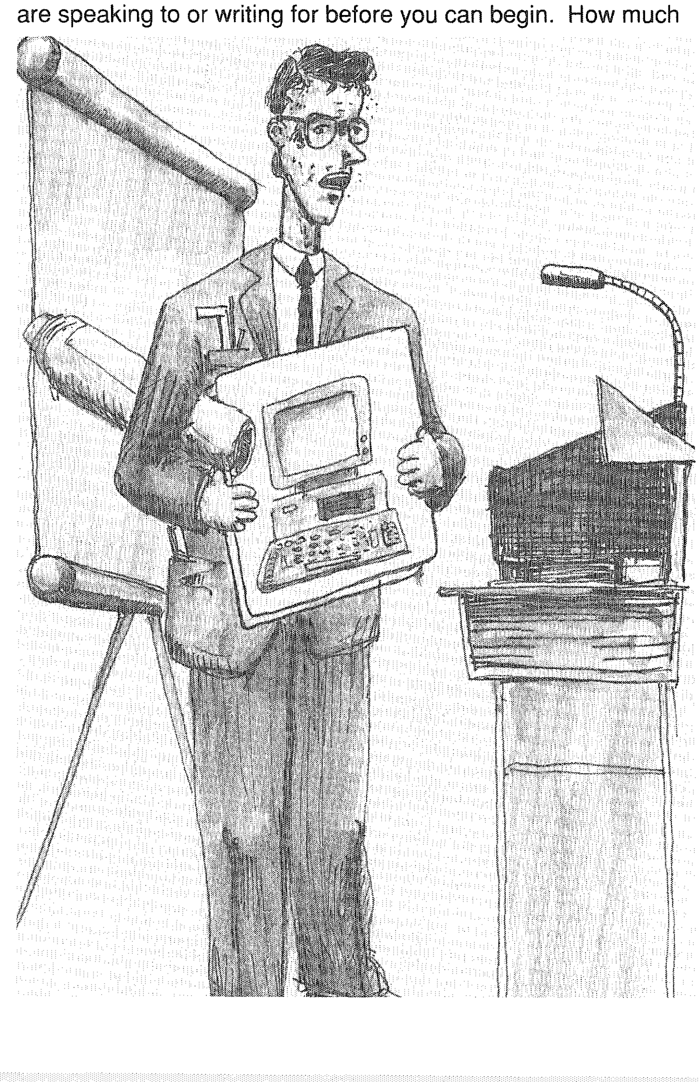
Technical communication generally falls into one of two basic categories, written and oral. Presentations, which can incorporate either or both of these categories, are further broken down into ones for informational purposes only, and those geared towards accomplishing a specific goal. The phrase "technical communication" connotes an image of very formal, structured speeches and literary works and presentations, but that sort of thing is probably the least common area of the field. Technical communication is not necessarily rigid standup public-address presentations or full-blown technical papers, but is more often meetings, briefings, reports, memos, and even informal person-to-person gossip at the water fountain. Technical communication completely permeates the corporate and academic worlds, though we rarely recognize it as such.

According to Mikelonis, there are several key ideas to keep in mind when forming an organized presentation. Most of these apply to both oral and written communication, although some, such as dressing, only apply to one or the other (obviously there's no need to get gussied up in your Sunday-go-to-meetin' best to write great literature; pizza-stained sweatpants, bare feet, and an old t-shirt will probably suffice).

So, without further ado and with Professsor Mikelonis' help, here is the Top Ten List of Technical Tips for Budding Communicators:

1. Know your audience

There are several things you have to know about the people you are speaking to or writing for before you can begin. How much



Keep in mind that the things that are most significant to you are not always the things that are most significant to the audience. It's a simple task to lose perspective and forget that you are presenting your information to an outsider's point of view.

do they already know? How large is the audience? Are they top-level management or ground-level wrokers? Are they hostile to your ideas or not?

Adapt to your audience's level and tailor your presentation. If they are already experts in the field you are talking about, you can assume they know all the asssociated jargon and you are free to use as much as you like. If you are addressing General Motors' board of directors you'll want to translate much of what you say into terms of cost-benefit analysis, while if you are talking directly to the assembly line workers who will actually use what you say, your presentation might be more effectively organized into detailed step-by-step procedures. Keep in mind that the things that are most significant to you are not always the things that are most significant to the audience. It's a simple task to lose perspective and forget that you are presenting your information to an outsider's point of view—they don't know everything you do.

2. Know the purpose of your presentation

Is your lecture or article solely to inform or are you trying to spur the troops to action? State your purpose in the introduction so your audience will know what they're supposed to look for. They'll be able to read or listen more effectively, concentrating on the information they need to know, and filtering out what they don't.

3. Make it interesting

Use scenarios and examples that your audience is already familiar with, throw in a touch of humor, and make effective use of pictures, models, and diagrams. Visual aids are one of the best ways to convey large amounts of information quickly, attested to by the old adage that a picture is worth a thousand words. Try not to just tell your audience, but show them. Progress from familiar examples to the idea you want to discuss.

Keep your audience alert, so they can concentrate on what you are saying. Consider giving up half a minute or forty-five seconds of your time to allow the audience to stretch and wake up. This will put you on their good list right away. Other details include making sure the lights are up when you turn the overhead off and varying the pace of your presentation. Do everything you can to keep them alert, within reason of course (do not, for example, have the distinguished scholars reviewing your grad project get up and do the shuffle for a minute of two; decorum's limits will stretch only so far). I can personally attest to the ease of nodding off in a warm, dark room in the company of fellow collegians with a long-winded lecturer droning on down in front, the soporic hum of the overhead projector purring along...

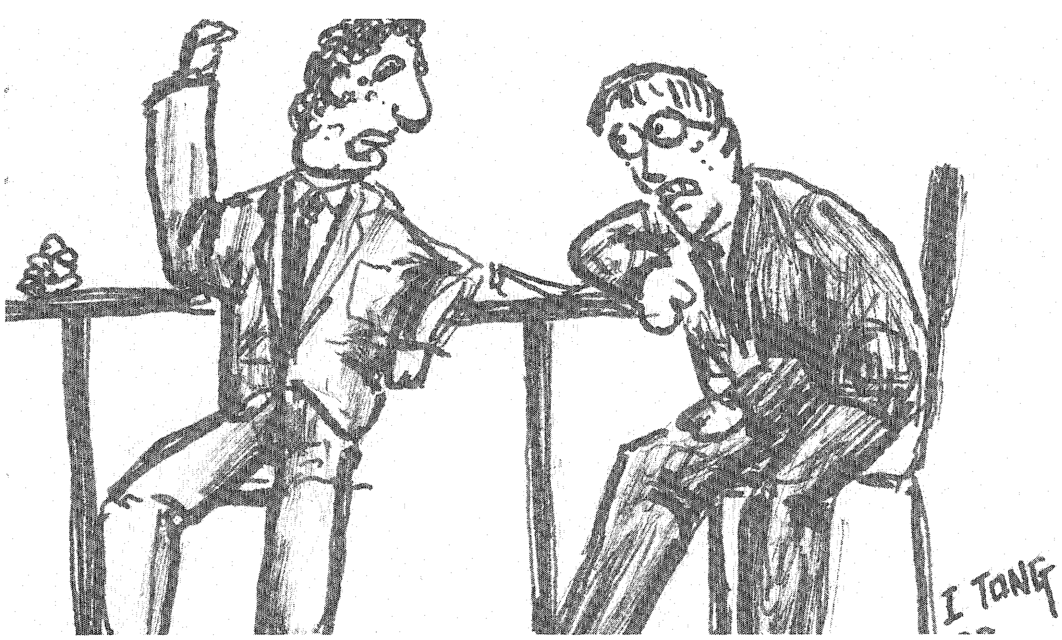


Illustration by Tony Tong

Another key to holding people's attention is humor. It can make for an outstanding presentation or it can just as easily detract from what you are trying to say, so use it with caution. Some people are under the impression that the first thing one must do when one gets to the podium is to tell a bad joke ("...so the guy says to the bartender, that was no duck, that was my wife!"). I must emphasize that this is not the case! Those of us who have a subtle, dry wit with excellent timing employ it to its fullest, but for the rest of you groveling among the masses, don't go out of our your way to find a joke or force one in somewhere; let the humor show through and stand on its own merit and mesh it with the rest of the presentation. Please. And if in doubt, don't use it.

Finally, have the audience think along with you ko keep them alert—a deductive approach lends itself to better recall. Show them how you solved the problem, but don't lead them by the hand down the golden path of enlightenment. You don't have to shove them step by step down the same route you took for them to come to the same conclusion you did. You are better off to tell them what the problem is, how you went about solving it, and what your conclusion was. Imagine a roadmap: in one glance you yourself can more easily get an idea of the area and the general direction you have to go to get from point A to point B than if you have a copilot next to you telling you where to go at each intersection.

4. Use the right language

Find your audience's level of expertise and scale the amount of jargon you use accordingly. While your average music student probably isn't going to know what a CAD/CAM system is, your average engineering student will. It would have to be explained to one but not to the other. Use analogies, synonyms, and examples to describe terms and ideas; a good example of this is the analogy of a computer's memory being like tiny post-office boxes that each hold a single bit of information. These little blurbs make it easier for the layperson to grasp your ideas.

5. Use standard formats

If forms and templates for routine presentations have already been determined, use them, but know when to break the rules if there is a good reason to. For example, business letters will usually fit into one of a couple of different catagories and formatting rules have been developed for each of them. These rules save time and increase efficiency, serve as guidelines, and act as checklists to make sure nothing has been forgotten.

6. Don't be confrontational

Build on other's viewpoints and ideas. If the audience is hostile (here hostile means having a different viewpoint rather than craving to draw and quarter you), build gently. Start by outlining their position first rather than your own, making sure you have it correct and allowing for feedback. Next, present the strengths and weaknesses of their position ("...this is a sound idea. It structurally looks very good, but this is where I feel it may fail...") and finally present your position ("...just for the sake of argument, let's look at it from another perspective..."). Point out the advantages of your ideas and show how they build on the strengths of their ideas.

7. Be prepared

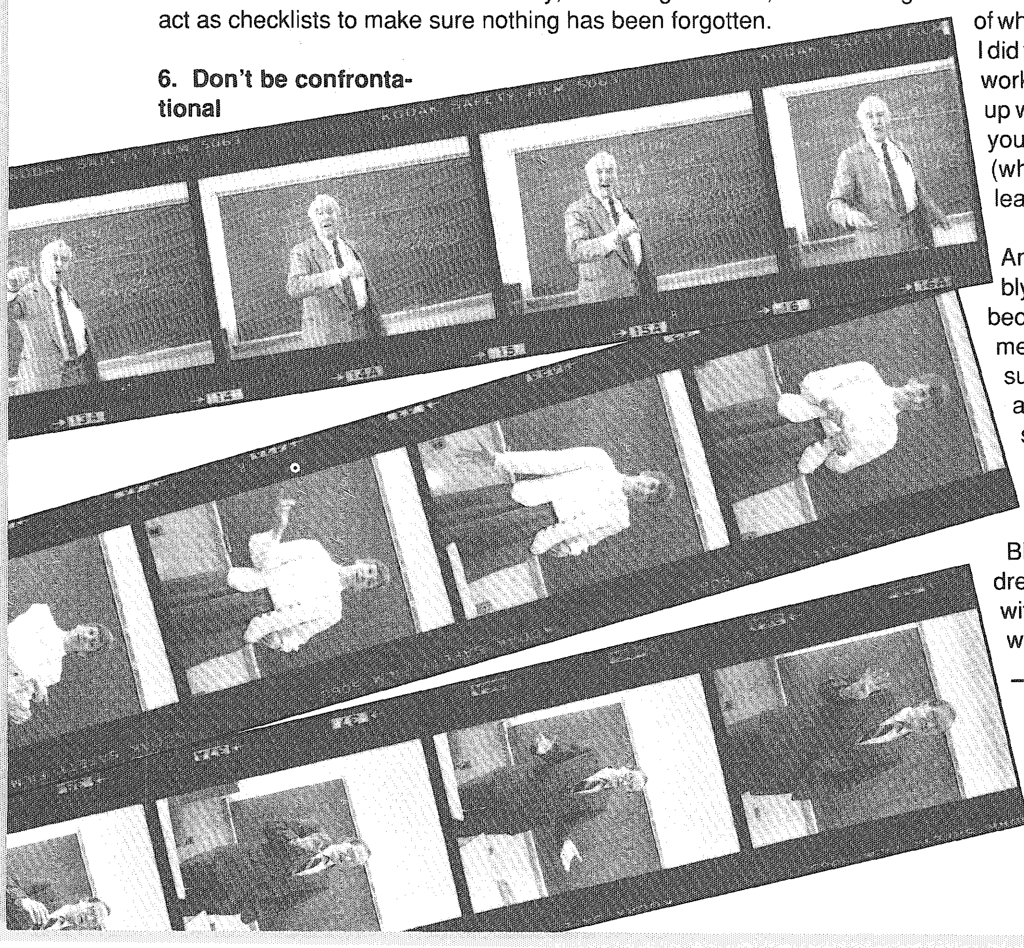
That's the old Boy Scout motto. Whether it's an oral presentation or a literary article, preparation and organization are two of the most important elements in any communication. Extemporaneous speaking just ain't gonna cut it. Rehearse your lecture and make sure it isn't too long. A detailed fifty-page report is NOT going to fit into a five-minute oral slot, no matter how fast you talk. You can only skim the surface and highlight the main points. Make sure your article is well-organized so the audience can search through it easily to find what they are interested in. Make effective use of headings, groupings, and white space. Let's face it. Joe Executive probably isn't going to read your report from cover to cover and grade it for grammar and spelling. He's going to pick it up, flip through it, skim right past the stuff he couldn't care less about and look for what pertains to him. If he can find it easily, he'll be more favorably disposed to what you've written. If he has to wade through three pages of single-spaced prose only to find out it doesn't apply to him, he won't be favorably disposed to what you've written.

According to Mikelonis, any presentation, oral or written, should be organized along the following lines: Start with a brief overview of what you've done ("This is the problem, this is what I did to solve it, and these are my conclusions."), then work backwards, showing how you actually came up with your results. Limit the number of points that you make, and arrange them from most important (when you still have the audience's attention) to least important (when they begin to nod off).

And finish with a bang-up ending. This is probably the most important part of any presentation, because although a strong ending doesn't always mean a strong presentation, a weak ending almost surely makes for a weak presentation. Close with a summary of your key points, a high-impact statement that will provoke questions, or both if the two can be easily meshed.

8. Dress appropriately

Blend, don't clash, with the people you're addressing. Appear professional. If you're dealing with upper management and they all come to work wearing navy blue pinstripes, white shirts, and



Professors from the Rhetoric Department demonstrate how gesturing can enhance effective communication.

black shoes, you may want to consider wearing navy blue prinstripes, a white shirt, and black shoes. If it's a loose-tie, rolled-up-shirtsleeves type of organization, dress accordingly. If you want to appear academic, wear a tweed blazer or courdoroy jacket with elbow patches and a turtleneck.

> Tell them what you're gonna tell them, tell them, then tell them what you just told 'em

Women do NOT want to call attention to their bodies; the audience should pay attention only from the neck up. This doesn't mean you have to wear a suit and tie, but don't wear dangling earrings, jangly bracelets, or stiletto heels.

In short, peg the organization you're addresing. Look as though you're one of them. It will increase both your level of confidence and your level of credibility.

9. Forecast what's to come and summarize what you've said

Follow the old preacher's saw: "Tell them what you're gonna tell them, tell them, then tell them what you just told 'em." It works. The audience will know what to expect and what to look for, and the summation and repetition of you main points will reinforce what you're trying to get across.

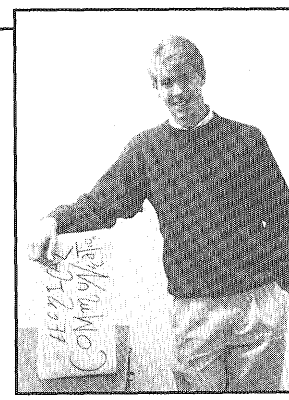
10. Keep it short

'Nuff said.

The above list is by no means contains everything needed to organize a technical presentation, but it should provide some guidelines when the time comes. As everything is relative, each presentation will have to be different from the last. Each will have to be tailored for its specific audience, and each will have to be organized a little differently to reflect varying emphases. And above all, the purpose of each is to clearly convey its meaning in the most effective way possible.

Editor's note: Darin would like to thank Professor Victoria Mikelonis and senior Rhetoric student and former *Technolog* editor Mark Werner for their help with this article.

Author Bio



Darin Warling is a sophomore who is double majoring in Mechanical Engineering and Computer Science. This is his first feature for the *Technolog*. The editors were all impressed with Darin's phraseology, as well as the fact that his article incorporates the guidelines he delineates.

Fiber Optic Communication

by Chadburn A. Blomquist

Fiber optics has become a household word to many of us. But how does this new technology work, and why is it better than the paper cups and string we all used as children? Fiber optics is a small part of a new field called photonics. Photonics is essentially the process of using photons to transfer information instead of electrons. This new technology is being applied in areas such as communications, laser printing, compact video/audio discs, and video conferencing. One of the most widely used products of this new technology, fiber optic cable transmission, has already proven its worth to the communication community.

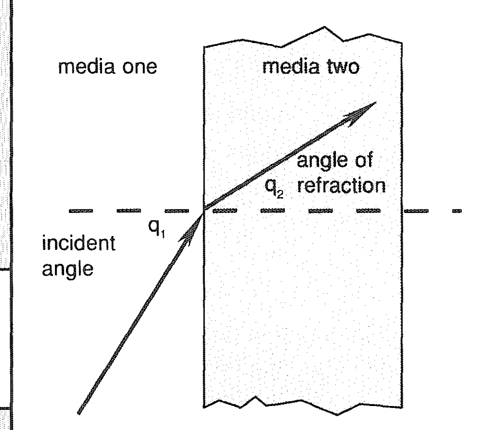
Because of the advantages of photonics, many countries around the world are investing large amounts of time and money for its development. The top seven include Japan, the U.K., Canada, West Germany, the People's Republic of China, the Soviet Union, and the United States. All of these countries have major investments into research and development of the new field. With a national commitment of four to ten times that of the United States, the Soviet Union is the leader in national commitment to photonics.

Why is photonics better for communications than the traditional methods that employ electronics? The major reason is the physical characteristic advantages of photons over electrons. Electrons are charged atomic particles. They can interact with other electrons and cause interferences. These interferences can inhibit clean transmission of signals through a medium. Electronic signals are also limited because the speed of propagation through a medium is restricted by the resistance-capacitance time constant of the medium.

Conversely, photons have no charge and do not interact with each other readily. In other words, light

Total Internal Reflection

In order to explain total internal reflection, refraction must be discussed. Refraction is the bending of light at the interface between the two media the light beam is passing through. The angle of refraction is the angle the ray of light makes in the second medium with respect to the normal to the original media boundary. Refraction occurs because light travels at different speeds in different materials. The ratio of this difference is called the index of refraction. If we denote the speed of light in a material as c_m and the speed of light in a vacuum (such as space) as c (= 3.00×10^8 m/s), the index of refraction is the ratio of the speed of light in a vacuum to the speed



Refraction of light rays at the interface of two media makes it possible to send light through fiber optic cables.

Illustration by Chadburn A. Blomquist

beams can cross each other with no adverse effects. Therefore, light can travel in optic fibers with no worry of data transmission errors caused by interference. Also, photons have a much higher frequency than electrons, which allows them to carry more information (they are faster).

Although it may seem that optical technology has advantages over electronics, the two technologies are complements of each other. Viewing the limitations of each, there is a definite advantage to combine the two into one system. For example, it is possible to set up a network using photonics to connect personal computers over long distances. This enhances the electronic technology of the personal computer by enabling it to communicate with other PCs or even mainframe computers. The photonic part of this system has the advantage of clear long distance signal transmission using fiber optics, whereas the electronic PC has low cost electronic microcircuitry.

Fiber optic technology is already used by the phone companies, local area computer networks (LANs), as well as applications like medical surgery and orthoscopics. Photonics will soon have a major impact on robotics, machine vision, and artificial intelligence as well as general computing and telecommunications.

So how do fiber optic cables work?

The idea behind fiber optic cable communication is to pass a beam of light through a long glass "rod." The light is sent through the glass by a laser on one end and "sensed"

of light in the material.

index of refraction = n = speed of light in vacuum ÷ speed of light in material = c/c_m

In order to fully explain total internal reflection, it is necessary to understand how the index of refraction affects light as it passes from one medium, such as glass, to another medium, such as air. Using Snell's law of refraction, (discovered by Willebrord Snell in 1621),

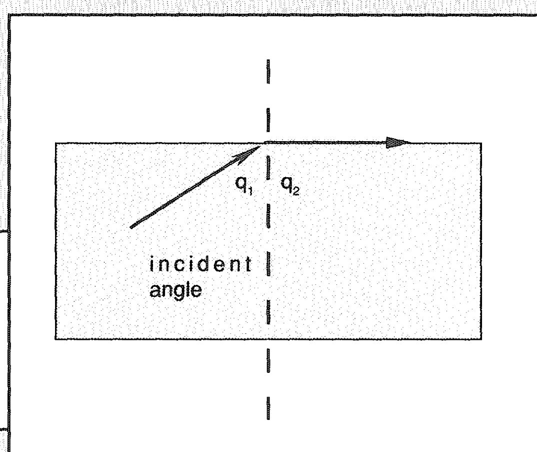
$$n_1 \sin(q_1) = n_2 \sin(q_2),$$

q_2 (the angle of refraction, or escape angle) is defined as:

$$q_2 = \sin^{-1}((n_2/n_1) \sin(q_1))$$

for $(n_2/n_1)\sin(q_1) \leq 1$.

This fact is important because if the light source originates inside the first material, and the incident angle (q_1) is greater than the angle needed to prevent light from escaping, (the critical cngle), the "light" pipeline is defined. This is the concept of total internal reflection.



Light does not escape from the cable when the incident angle is greater than the critical angle. In this illustration, the incident angle is also the critical angle.

Illustration by Chadburn A. Blomquist

at the other end of the cable. How does a computer or telephone use this new technology for transfer of information? The fiber optic system is composed of three parts: an electrical-optical translation device, the cable itself, and an optical-electric translation device. The electrical-optical translation unit converts electrical impulses into optical information to be transferred over the fiber optic cable. On the other end of the cable, a translation device is waiting to receive data to be re-converted to electrical impulses. Short on/off sequences of light define the digital information required to transfer data. This is analogous to the high voltage/low voltage sensing in a digital computer.

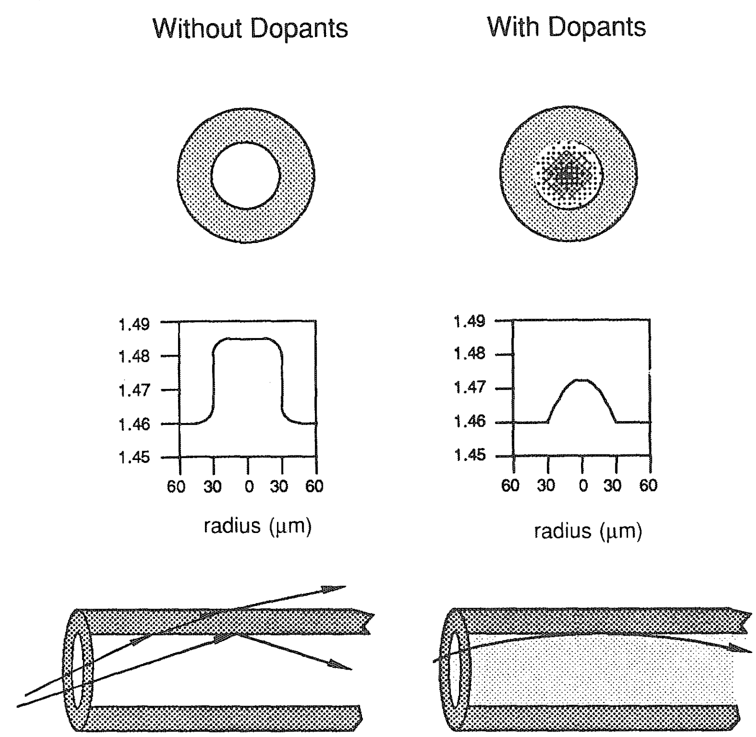


Illustration by Chadburn A. Blomquist

Varying a fiber's index of refraction with distance allows for signals to be propagated further without needing amplification than would otherwise be possible.

In a sense, sending the light through the glass cable is like passing a liquid through a pipeline. The light passes through a fiber optic cable in the same manner water travels through a plumbing system to a sink faucet. What keeps the light from leaving the pipe and going in the wrong direction? A concept called "total internal reflection."

The typical fiber optic cable has three main components: the core, the cladding, and the jacket. The core is the innermost part of the optic cable that the light will be moving through. The core is made of a glass or plastic medium. These materials are amazingly clear. Three miles of glass fiber optic cable is as transparent as a normal window pane.

The cladding, which is another layer of fiber, encompasses the glass fiber core. The cladding is also made of glass or plastic; however, the material properties are different. The difference provides for an interface between two mediums that introduces an efficient total internal reflection to the cable. These two materials form the "light" pipeline that will keep the light beam within the core.

Because the light that initially enters the cable will be traveling in many directions, some will try to escape the core. Any of the light rays that try to escape will be reflected back into the core by the reflection characteristic of the cladding. In this way, all of the light that enters the "light" pipeline will exit.

Finally, the jacket surrounds the cladding. The jacket basically protects the cladding from becoming scratched, crushed, or wet.

Fiber Optics to page19

Author Bio

Chadburn A. Blomquist is a senior in Mechanical Engineering who plans to graduate this spring, whereupon he will pursue an MBA. A veteran of the *Technolog* writing corps, Chad is also a systems programmer for Mincad Systems, Inc.

Classes and Profs

by Linda Urich

When we leave this university, each of us will have a few lasting images of the Institute of Technology and the rest of the University of Minnesota. One that will be prominently ingrained in my mind is the stereotypical IT professor. This impression was first given to me by my freshman orientation leaders, all in good-humored fun of course. But when you become a senior and have not been given any radical incentive to doubt the stereotypes, it can be very amusing to recall more than three years worth of professors, determining how each has contributed to the stereotype.

It is unfair to make fun of professors without giving them a chance to defend themselves. (See editor's note at the end of this article.) In order to be up front and honest about the situation, I will reveal the mannerisms of the stereotypical professor, the same one every student has experienced at least once in one form or another. Unfortunately, the one female professor I've had did not contribute to this IT professor stereotype, so I will use "he" as my pronoun instead of "he/she."

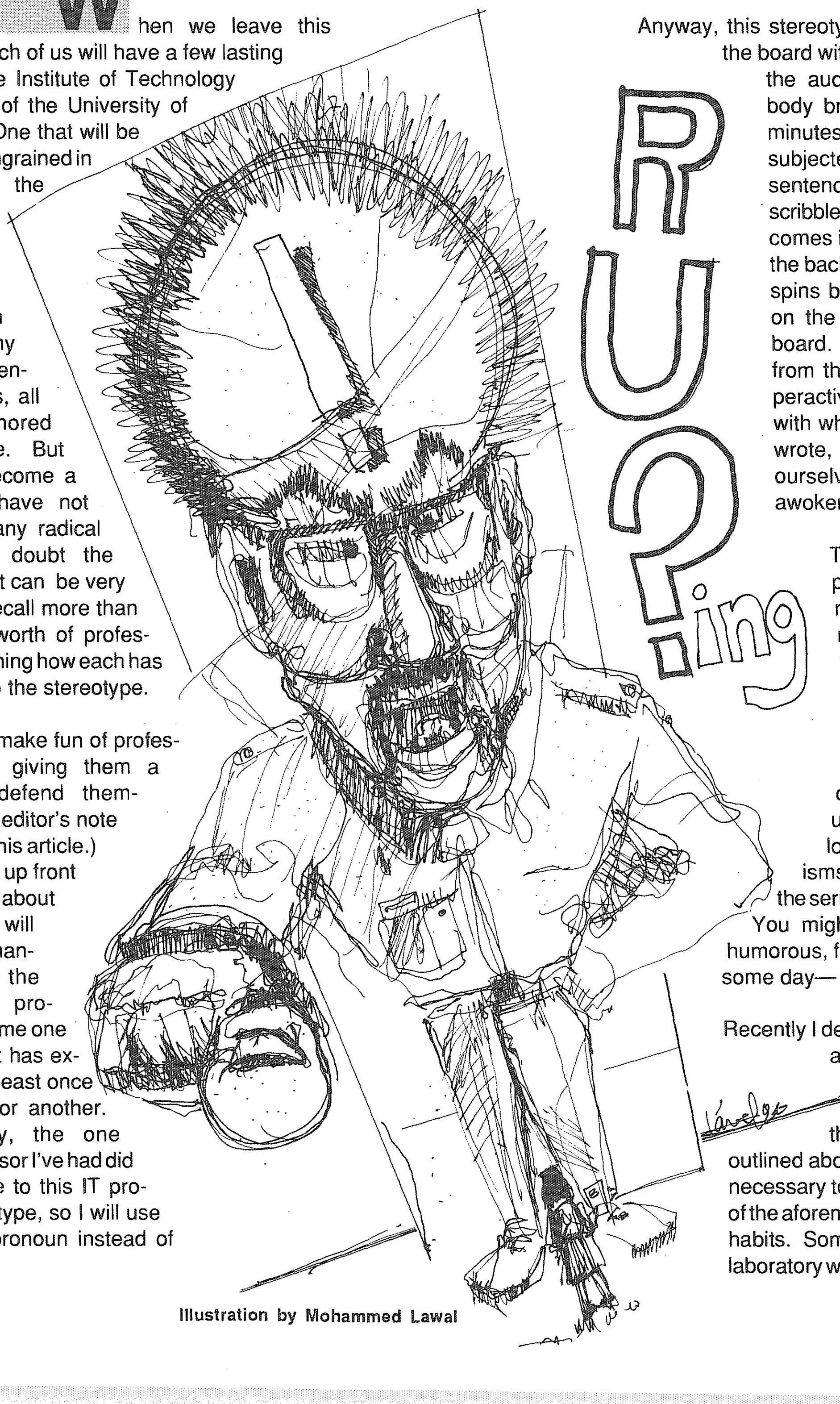


Illustration by Mohammed Lawal

Anyway, this stereotypical professor stands at the board with his back turned towards the audience, chalk poised and body braced for action. For 45 minutes at a crack the classroom is subjected to a concert of mumbled sentence fragments and madly scribbled equations. His face never comes into full view. All we see is the back and top of his head as he spins between reading his notes on the lectern and marking the board. We, the students, emerge from this performance either hyperactive from trying to keep up with what the professor said and wrote, or in a stupor, reassuring ourselves that we have just awoken from a bad dream.

To all my past and present professors who might be reading this out there, I do not specifically mean you when I speak of this stereotype. Fortunately for both of us, no professor of any class I have attended truly embodies every element of this stereotype. But for us students, it is difficult to look past teaching mannerisms that amuse us and on to the serious subject matter at hand. You might find my career choice humorous, for I too would like to teach some day— as a college professor.

Recently I decided that if I wanted to be a professor, I needed to do a little research on how not to perpetuate the IT professor stereotype outlined above. In doing this, I found it necessary to pinpoint and clarify some of the aforementioned mannerisms and habits. Sometime between a grueling laboratory write-up and a post-midnight cookie binge during midquarters, I found time to collect my thoughts for this non-homework exercise. What follows is a list of my findings: all of the obvious professor classifications that I have resolved not be a part of when I begin to teach. Its purpose is to enlighten myself and others interested in the same profession, hopefully aiding our preparations for careers in acadamia.

The "Wake Me Up When It Is Over" Professor

Some of my friends are affected most by the charisma of a professor, or more specifically, lack of it. They secretly scheme to send electric shock waves to the professor in hopes of eliciting *any* kind of response, good or bad. After all, they just want a little variety added to the regular, predictable lecture fare. This type of professor also lacks any inflection in his voice, forcing me to scramble for my thermodynamics textbook as a last resort for excitement when the drone of his voice makes my eyelids heavy.

The Marathon Man Professor

The opposite of the uncharismatic professor is the professor who throws his students into a major frenzy as they try to keep pace with his lecture and blackboard notes. Sometimes I feel like a human Xerox machine, transferring page after page of notes from chalkboard to notebook, lecture after lecture. I am not really listening to the professor, just trying to copy as fast as my mechanical pencil allows without the lead reaching its melting point. Inevitably, what happens is the professor descends on the board and erases everything on it before I even get a chance to copy it all down. When class is over I have to pry my cramped fingers loose from the pencil and hope I have enough energy to walk out of the classroom. Naturally, then, when test time rolls around I have a notebook filled with a lot of fragmented information that I am unable to combine in a comprehensible form.

The Zoned-Out Professor

A pet peeve of mine is a professor who habitually leaves his lecture speech incomplete. He typically starts out a new train of thought by writing the name of the topic on the board and then verbalizing a few introductory ideas to the class. Then comes the inevitable question: "So then, what does all of this mean?" As if he expects us to know the answer, he pauses for a very long time. What a waste! He answers his own question anyway by saying "Let me explain this one of two ways. Method number one goes like this..." Three class periods later I am still waiting for method number two, and surprise, it never comes. The professor is off

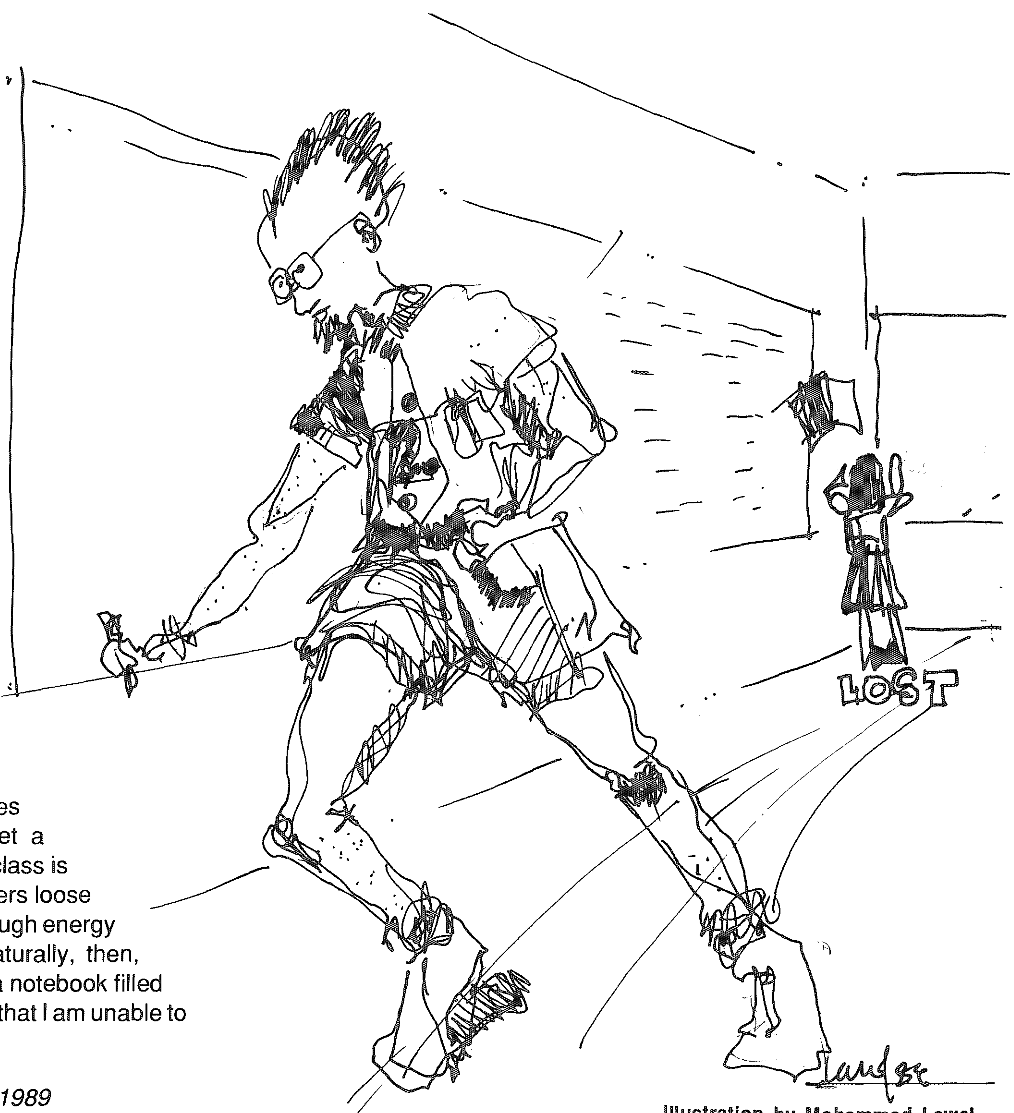


Illustration by Mohammed Lawal

following a totally unrelated tangent. Of course, he does throw that inevitable test question at us, solvable only by method number two.

The "Everything is Relevant" Professor
An all too common occurance are those professors who take time out to thoroughly explore and exhaust a totally unrelated subject, i.e. the inevitable tangent. I hope and pray at these times that I am sucessfully distinguishing the tangent material from the real subject matter. But then again, what about the times I cannot read the professor's mind?

It could be a scary scenario: a question about the professor's vacation in Aruba last winter unexpectedly appearing on my calculus test. No partial credit for me there; I can't even fake an answer. Later I approach the professor, stammering "I did not actually think you were *serious* about it appearing on the test." His reply to the naive, unsuspecting student: "Everything is fair game on one of my tests, and I mentioned it in class, didn't I?" (This is followed by a sinister laugh.) Even though I hate to admit it, I concede with, "Yes sir, you certainly did."

The Professor Who Writes in Code
I have also noted that the absent-minded professors are the ones with the cryptic handwriting. Since when did a course on hieroglyphics become a requirement for my major? Or maybe deciphering an assortment of unrecognizable variables in six simultaneous equations is one of the requirements for passing the course set down by the department.

The Tight Fisted Professor
Now we come to probably the most common gripe among students, that touchy subject of grading policy. There is a great conflict of interest between professor and student when a professor says "getting a B in my class is like getting an A elsewhere." My response? "Just give me that A, buddy!"

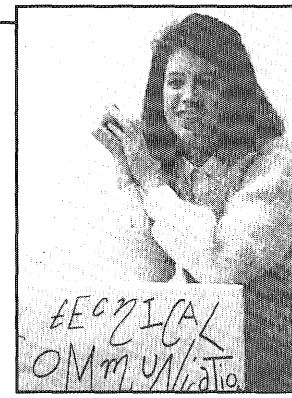
The "Theory is Good For You" Professor
This professor simply loves to derive and prove theories; whether or not the theory is applicable to the course material is irrelevant, and any theory conjured up in the last 30,000 years seems to be fair game. The professor will begin with a little history of the proof, usually discovered by some obscure scientist with an abnormal childhood. The theory-proof will occupy several class peoiods, inevitably one more class than I have patience for. Usually I get lucky, however, because after the professor is done proving the theory's validity he will casually remark "you won't have to know how to prove this; just how to use it and apply it."

Do not think that my perspective on professor behavior is too narrow; there are certainly other types of professors besides the ones mentioned above. For example, I have been thoroughly engrossed by professors who exhibite boundless enthusiasm for reinventing the world. On the other hand, I have been ready to scrap my college education entirely and just read the textbooks when professors make the subject matter seem trivial.

If all goes as planned, someday you will find me lecturing in the front of a college classroom. After class I will doubtless overhear my students classifying me into one of the groups I have mentioned. Which kind of professor will I be? Only time will tell. Whatever one I become, at least it will make me memorable. And I suspect revenge will be sweet when I am on the other side of the podium.

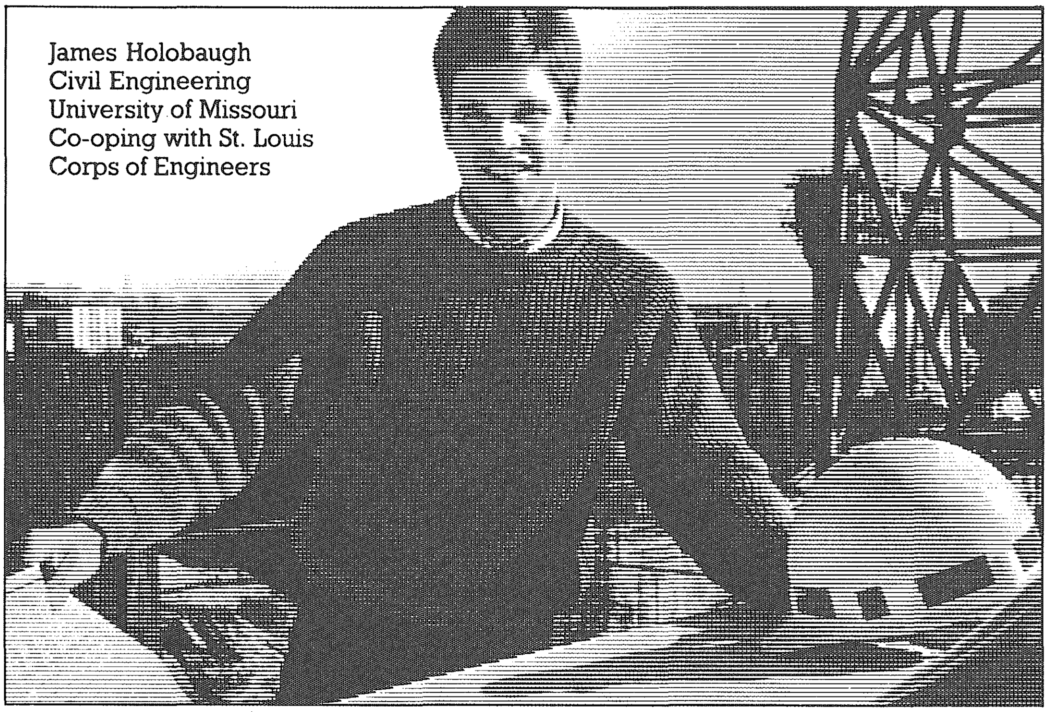
Editor's note: In the spirit of fairness, any IT professor who would like to write a similar article characterizing some typical IT students should stop by the *Technolog* office and see me by 10 January 89.

Author Bio



Linda Urich is an ME senior and Treasurer of the IT Board of Publications. Upon graduation, she hopes to attend graduate school to pursue her scholarly interests. We're confident she will create a new classification of professors when she begins teaching.

RESERVE OFFICERS' TRAINING CORPS



"THE DASE CO-OP PROGRAM IS LIKE A COURSE IN REAL LIFE."

"The big thing it offers is experience, and that's what companies look for. There are things I've learned on the job that I couldn't learn in school."

The Department of the Army Scientific and Engineering (DASE) Co-op Program provides ROTC students the opportunity to work in a Department of the Army facility while still in college. Each is paid while getting practical work experience in a high-tech facility. Selected students also receive up to $5,000 tuition assistance per year and the opportunity for continued employment after graduation.

To be eligible, you must be a freshman in a baccalaureate program leading to a degree in science or engineering. For more information on application procedures, contact the Chairman of the Co-op Department or Larry Springer at 624-1685. Or stop by the Armory, Room 108.

Students are selected on a competitive basis.

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Space Debris

Space travel has always been risky. Now the hazards have been increased by the 'littering' of space. According to NASA estimates, approximately 7000 pieces of debris large enough to detect by ground-based radar orbit the earth. However, the most deadly debris are the many smaller undetectable fragments of titanium, ceramic, Mylar, and paint. These particles approach speeds of seven miles per second. In a 1983 space shuttle flight a particle of white paint 0.008 inches in diameter struck the shuttle's window, leaving a pit in the glass. Larger fragments could have ripped holes in the shuttle's outer covering.

The tiny particles cannot be cleaned up, but Kumar Ramohalli, a University of Arizona engineer, hopes to reduce new amounts of debris with a robotic janitor. Ramohalli's device, called the Autonomous Space Processor for Orbital Debris, will hopefully dispose of larger objects before they disintegrate into smaller particles. A small version of the space janitor is tentatively scheduled on a shuttle flight in 1991 or 1992. At first it will be controlled from earth, but later versions will be totally automatic. The janitor has robotic arms and a solar-powered torch to cut debris into manageable pieces that can be placed in a storage bin on the craft. To avoid becoming debris itself, the space janitor can be destroyed by putting it on a reentry path to burn up or it can store its own arms and torch and land in the ocean.

Source: *Discover*, December 1988, page 22.

Meanwhile, back on Earth

The clean-up of hazardous waste on the planet's surface is a pressing concern. Theoretically, any waste site can be safely restored, but the prohibitive cost of the operation has hampered efforts. With approximately 1,000 sites on the Environmental Protection Agency's Superfund priority list, the price tag for clean-up could exceed $300 billion. Even if the money were available, current methods of disposal are inadequate. The hazardous waste must be dug up and transported to a landfill certified to receive it. Present sites are limited and rapidly decreasing.

Another solution, which could significantly reduce costs, underwent EPA testing this past spring. The process, developed by Kansas-based International Waste Technologies, uses an auger to mix cement, clay and neutralizing agents with contaminated soil. The clay is combined with other compounds that allow its normally tight molecular structure to expand and react with toxic organic wastes, making them chemically inactive. The cement then holds the whole mess tightly. Not every site qualifies for this type of clean-up because the soil is left hardened and useless, but the waste is neutralized and prevented from possibly contaminating ground water. The process passed its first test by neutralizing PCBs in Hialeah, Florida. Experts seem to agree that the process will keep the deadly waste confined for a long period of time, but testing will continue. Future uses include neutralizing toxic waste as it is created, currently a $12 billion to $15 billion job.

Source: *Discover*, November, 1988.

Ultrafast Transistor

Faster supercomputers and ultra-high-speed lightwave communication systems may result from a new bipolar transistor developed at AT&T Bell Laboratories.

Using indium phosphide and gallium indium arsenide, and a process known as gas-source molecular beam epitaxy (GSMBE, see "Band-gap Engineering," *Minnesota Technolog,* Fall two, 1988) researchers have obtained switching rates of 140 gigahertz. Current silicon bipolar technology operates at only 12 gigahertz.

The GSMBE process allows the researchers to precisely control the thickness and electrical properties of the semiconductor layers. A path for high-speed electrons can be custom made, thus reducing the number of collisions with other atoms. In traditional electron devices, a traveling electron will collide with many contaminants, slowing them down.

Development engineers are evaluating the transistor's potential. Future uses may be found in gigabit lightwave communication systems integrated on the same chip with present devices, such as lasers.

Source: At&T News Release, December 13, 1988.

Letter to the Editor

Dear *Technolog*:

We like your magazine. You do a good job.

In the Trivia section of your Fall Two issue, your problem #4 has us confused. Certainly, there is no net current in the absence of an applied voltage. Since you do not specify that there is a voltage, we must consider the electron motion in the unperturbed ground state. In that case, the answer depends on the material under examination. For a metal, the solution involves the total density of valence band states, since all electrons are delocalized. For a simple metal with a spherical Fermi surface, the answer is easy. For an undoped semiconductor, the answer depends on the temperature and the bandgap. For a large gap semiconductor, the answer is zero.

Your answer is unit specific (1.6 x 1019 coul)-1, is independent of material, and makes no sense to us.

Sincerely yours,

John H. Weaver and James R. Chelikowksy
Professors of Chemical Engineering and Materials Science

Professors Weaver and Chelikowksy:

It is very gratifying to learn that professors read the *Technolog,* or at least the trivia section, and thank you for the compliment. Concerning the incorrect answer to the trivia question, which was "If you could take any one point in an electric circuit and count the electrons that pass through it in one second, what number would you come up with?" my reply is this: you are right.

The Editor

1. What are the highest and lowest places on Earth?

2. What is the longest length of a year in our solar system?

3. What is a quasi-bistable circuit?

4. At age ten, a certain famous mathematician supposedly figured out a quick way to find the sum of the first 100 positive integers when his teacher gave him the assignment to keep him busy. Who was this person and what was the sum? (Was he right?)

5. What galaxy are you from, anyway?

6. Exactly how many seconds are in a year? You have 5 seconds to do this one.

7. What is a xiphosura? Clue: it's nickname is "horseshoe."

8. When you change altitude, you can feel pressure in your ears. Why is it that you can relieve this pressure by yawning or chewing gum?

9. What is the "poor man's weatherglass" and what does it do?

10. What is so spectacular about the kangaroo-rat and how did it get it's name?

Scoring

0-1 Come on. A newborn baby could do better than that.
2-3 How in the world did you ever get into college?
4-5 You might catch up in another 30 years.
6-7 You made sure you'd just beat the average, huh?
8-9 Please let me know your schedule so I can come for tutoring.
10 Are you certain that you have a human brain in your head and not a computer?

by Bunmi Odumade

Answers

1. The highest place is the top of Mount Everest, 29,028 feet above sea level. The lowest point on land is the shore surrounding the Dead Sea in the Middle East between Israel and Jordan, which is 1299 feet below sea level, but the lowest place anywhere on earth is a spot in the Western Pacific Ocean near the Mariana Islands. The ocean floor in this area is at a depth of 36,198 feet.

2. The length of a year on the planet Pluto is about 273 of our earth years. The lucky people in this world hardly live half that long.

3. This is an astable circuit that is triggered at a higher rate than its own natural frequency.

4. Carl Gauss, and the sum was 5050. (He was right of course. No credit for knowing he was right.)

5. Most humans are from the Milky Way galaxy, but you never know...

6. 31,557,600. If you got 31,536,000 you must have used 365 days instead of 365.25 days. If you got 31,449,600 you must have used 52 weeks instead of 365.25/7 weeks.

7. It is a class of the phylum Arthropoda containing only a single genus (Limulus) with five species. They are animals of ancient lineage, showing no important change from fossils of the Triassic Period.

8. Yawning or chewing gum stimulates muscle movement that opens the eustachian tubes running from the middle ear to the nose. When these tubes open, the pressure in the middle ear becomes equal to the prevailing atmospheric pressure, relieving the pressure.

9. The scarlet pimpernel. The small scarlet, white or purple flowers on this plant can give a very accurate weather prediction. If the flowers of the herb close up, it means that rainy or cloudy weather is coming. But if the petals are opened up, the day will be sunny and fair.

10. The tiny kangaroo-rat, a native of the southwestern deserts of the United States, never takes a drink of water in its lifetime. The little moisture it needs it gets from eating roots and desert plants, yet this is enough to keep it alive. It got its name because it has the same long powerful legs as the Australian kangaroo.

Fiber Optics from page 10

Even with the cable's amazing clarity, the light signal may only propagate for so long before it needs to be amplified. In order to help alleviate this problem, selected impurities have been introduced into the glass of some cables. The impurities, such as boron oxide (B_2O_3) or germanium dioxide (GeO_2), improve the refractive index interface between the cable and the cladding. If the interface change in refraction index is smoothed to a parabolic curve instead of the typical "step" curve, the speed of light in the cable increases with the radial distance of the light ray from the center of the fiber. This provides a means for the light to travel in a shorter path than if the material had a constant index of refraction. The shorter path increases the total range of the fiber optic cable without amplification.

It is clear that fiber optics and photonics have made an incredible contribution to the communication industry. With time the field of photonics will contribute more advances that will enable us to communicate over greater distances more effectively and efficiently. The fiber optic cable has indeed opened the gateway to a bright future in communications.

Sources:

Bowcutt, Roy. "Turning fiber optics inside out," *LAN Times*, October 1988, pp. 130-133.

Mataloni, Raymond J. "Photonics: Technology of the Future", *Singal*, August 1988, pp. 67-72.

Rowell, J. M. "Photonic Materials", *Scientific American*, October 1986, pp. 147-157.

Tiper, Paul A. *Physics*, Worth Publishing Inc., 1982.

Favorite textbook shortcut sayings

solving by iteration, we get...

after much algebra...

using obscure trigonometric identities...

this proof is left as an exercise to the reader...

the proof is way beyond the scope of this text...

by inspection...

these equations are easily solved by computer...

the details are left to the interested reader...

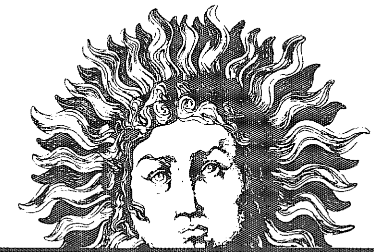
rearranging, we get...

...we omit the details...

-the Room 2 gang

Candidate Quiz

1. Would you like to be on the fast track to success, power, and the good life?
2. Are you able to juggle responsibilities with the skill of a circus perfomer?
3. Do you value sleep?



If you answered yes, yes, and no, the IT Board of Publications would like to do business with you. Applications are now being taken for *Minnesota Technolog* Editor and Business Manager for the 1989-90 school year.

Candidates should be well organized, be able to articulate their views, accept constructive criticism, and be hard-working. It would also help to be fun-loving and slightly off your rocker.

Applicants must be full-time University of Minnesota students, preferably in IT. The chosen applicants will be trained in by working with this year's editor and business manager on the Spring One and Spring Two issues.

Stipends are provided. Next year's editor will earn $400.00 per issue. Next year's business manager will earn $110.00 per issue.

To apply, submit a resume, unofficial transcripts from all colleges attended, writing samples (if applying for the editor position), and cover letter stating the position(s) for which you are applying.

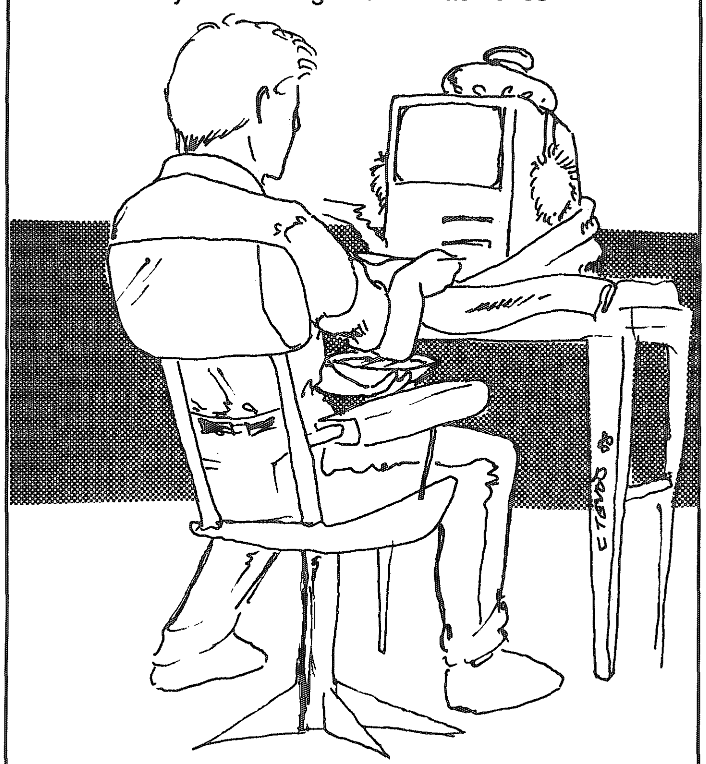
For more information about the editor position, please contact either Steve Kosier or Jim Willenbring at 624-9816. For more information about the Business Manager Position, contact either Vicki Bryner or Jim at the same number. Deadline for receipt of applications is 22 February 89. Interviews will be held the week of 27 February 89.

By the way, even if you didn't ace the candidate quiz, we still encourage you to apply.

Send resumes to:
Jim Willenbring, President, IT Board of Publications, Room 2, ME Building, 111 Church Street SE, Minneapolis, MN 55455

The Near Side

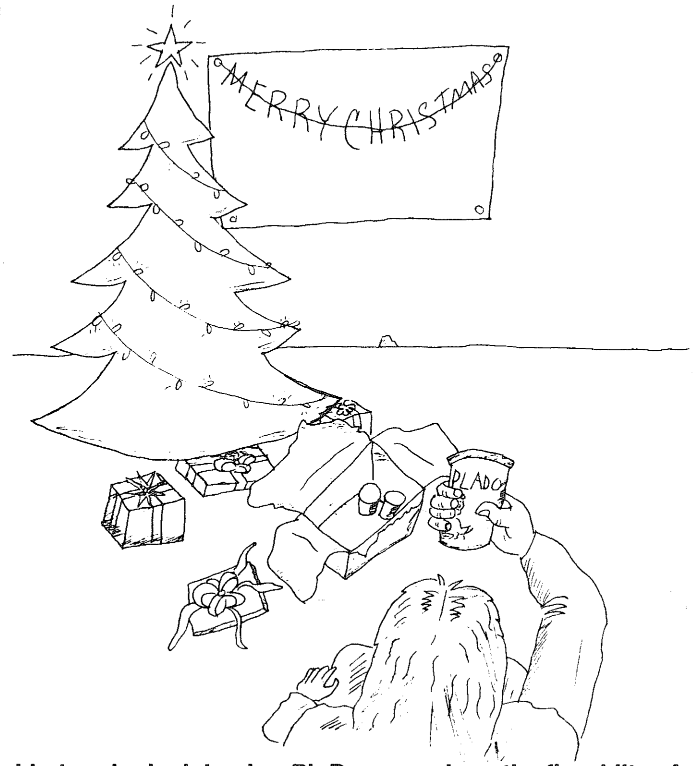
by Steve Littig and Conrad Teves



After discovering that his computer had been exposed to a virus, Bill's actions were heartwarming—but ineffective.

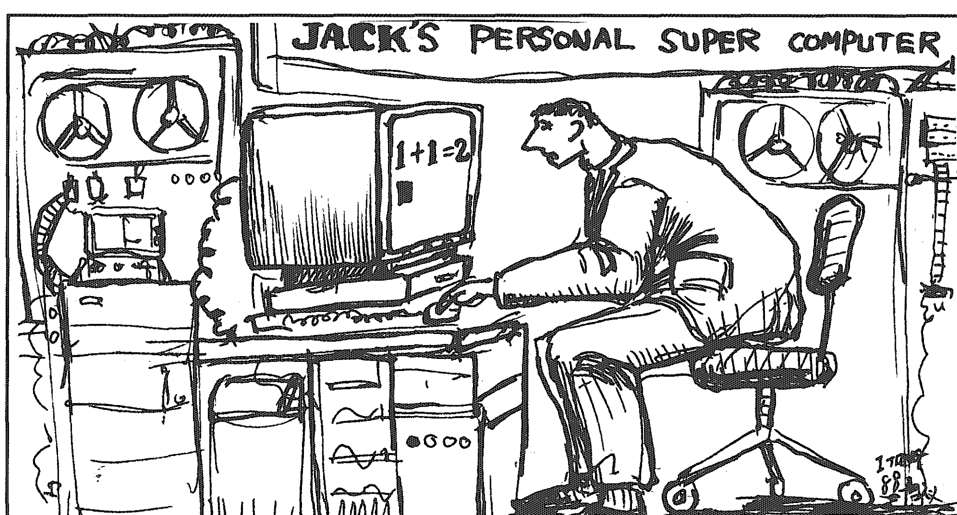
The Flip Side

by Jim Willenbring and Tom Rucci



Linda, who is doing her Ph.D. research on the flaccidity of malleable materials, found that Santa left an appropriate present for her under the tree.

Possible consequences of overdeveloping computers...



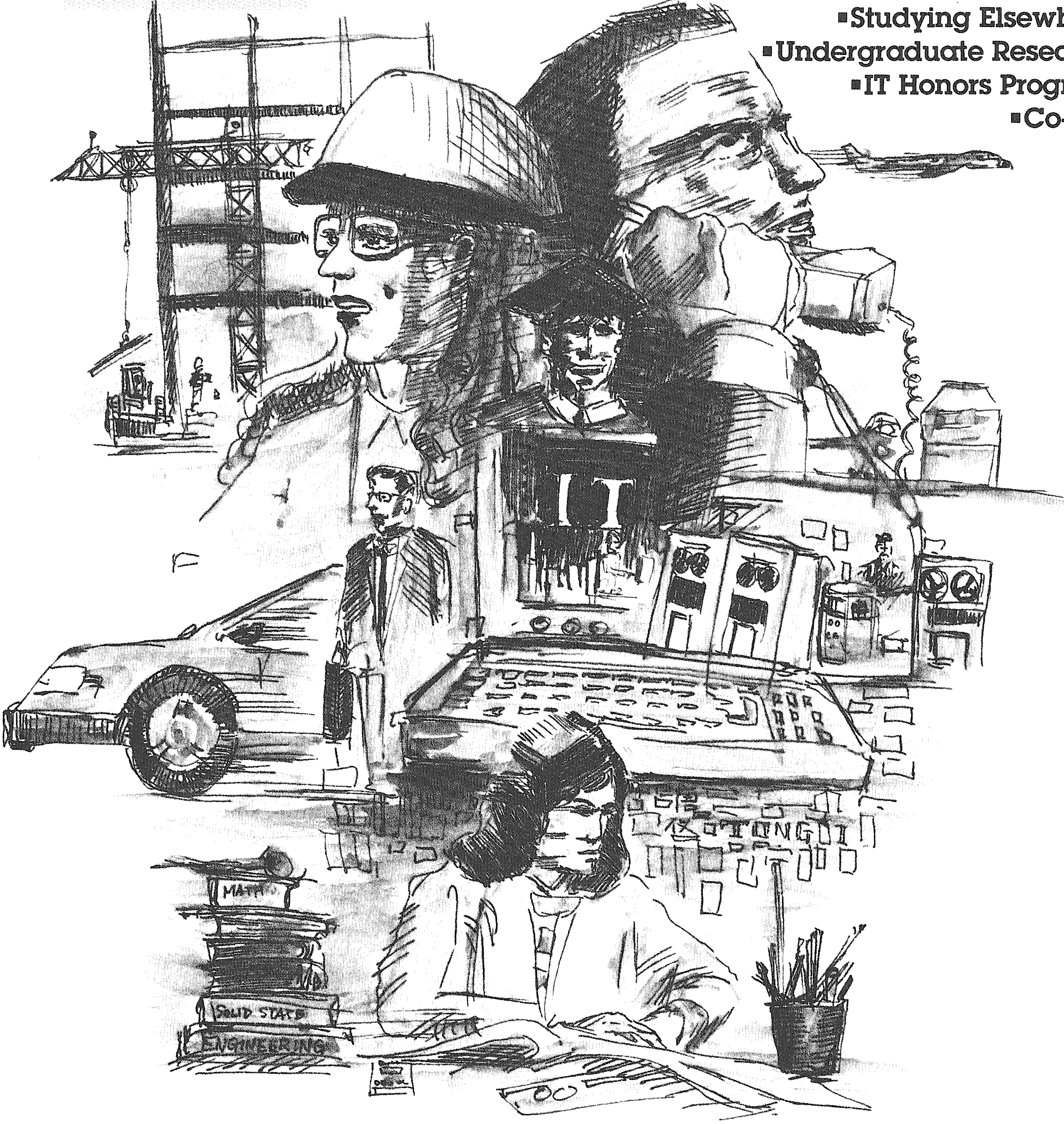
by Tony Tong

minnesota TECHNOLOG

Winter Two, 1989

Opportunities at the U

- IT/Business Curriculum
- Semiconductor Manufacturing Program
- Lower Division Programs Office
- Studying Elsewhere
- Undergraduate Research
- IT Honors Program
- Co-ops



Don't Get Involved in Anything!

Don't get involved in anything! Editors from other college magazines and newspapers, students in honorary socoieties, and university administrators often encourage students to join some of the many organizations available to them on a college campus, but don't pay any attention to them! There are a good many reasons not to get involved, which I will now relate to you.

1) *Joining an organization will keep you from doing other vitally important things.* For example, some people would have become involved with an organization, but the meetings are usually at the same time as the Cosby show. Well, clearly you should not miss Cosby! Many top industry recruiters will be very impressed when they see "Never missed an episode of Cosby in four years..." on your resume.

2) *You will probably meet new people and work together with them.* You might even make new friends, which is obviously dangerous, since friends take time—time which could be devoted to your valuable studies. Talking to your lab partner is probably the most contact any normal engineer should have with other people.

3) *You might learn something not related to your field of study.* UGH! This is clearly taboo. Brains operate much like computers, and there is only so much memory space up there. You need all of it for those final exams coming up, so don't waste any brain cells on non-engineering knowledge. Such knowledge and extra commitment have exposed people (on the *Minnesota Technolog* staff, for example) to opportunities for employment that their studies did not. This versatility may cause cancer.

4) *Many organizations do fun things like sponsor Career Fairs, have parties, put together IT Week events, and provide free pizza at some of their meetings.* Not good, not good. Such petty activities take away from valuable study time, or the Cosby show. Besides, all that pizza will surely bombard your face with zits. Don't do it.

5) *You might become an officer and have real responsibility; you might have a say in what actually happens in your organization; you might have control over funds.* How horrid! Remember that only the great achievements of engineers are to be admired—the engineers themselves are never to be seen or heard. Management should make all the decisions, like whether or not to launch the the space shuttle, or whether to build SDI. Don't have an opinion, and certainly don't express one—you could have your brains melted with a high powered laser!

There are many other reasons not to join any college organizations or societies. Don't even try one—they tend to be addictive, and many students who become too curious are still involved. The safest thing to do is go to your classes, go back to your room, and study. This will surely lead to the most successful, rewarding college career

by Ian McIwen. A reprint from the *Colorado Engineer*, used with permission.

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TECHNOLOG

Winter Two, 1989 **Volume 69, Number 4**

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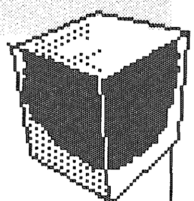
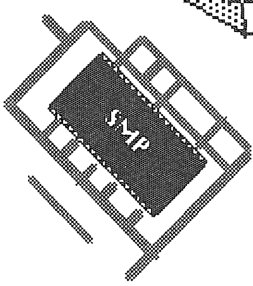
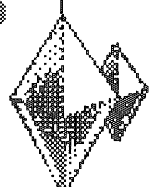


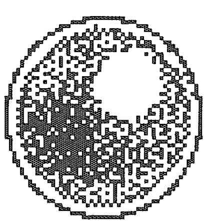
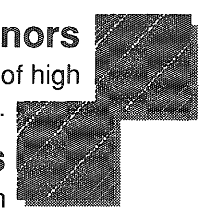
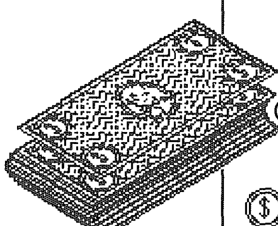

Departments

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Cover illustration by Tony Tong

Departure

by Steve Kosier

This issue of the *Technolog* is a departure from the usual fare. It contains no technical articles except in the Log Ledger. Instead, you'll find articles and information of a non-technical yet very practical nature.

We've taken a look at two new programs available to IT students, the Semiconductor Manufacturing Program (SMP) and the programs offered through the Center for Development of Technological Leadership (CDTL). These programs, like existing specialties within degree programs, are open to junior and senior IT students. Both programs are highly visible, very attractive to industry, and enhance the quality of undergraduate education at the University.

The quality of undergraduate education in the Institute of Technology has improved dramatically in the last two decades, and has made great strides even recently. A primary mover in this improvement has been the IT Lower Division Programs Office. The services provided out of this office are exceptional and can polish a student's experience in IT. They offer opportunities that most engineering and science students around the country can't take advantage of. We take a look at the past accomplishments and present endeavors of this office. All IT students should make use of the services provided here.

There are tremendous opportunities for IT students at this University if you know where to look and whom to contact. Unfortunately, many IT students don't take the time to look, thus missing out on opportunities. Two of the most common notions that students don't follow up on are the opportunities to do research and the chance to study in a foreign country. In this issue, we take a look at the Undergraduate Research Opportunities Program (UROP) and the opportunities for studying abroad. Each story provides helpful facts and step-by-step instructions for those with an interest in these areas.

Finally, we overview two programs that have been in place for several years, mainly for the benefit of underclassmen, who may already be involved in one or more of them. The co-op programs and the IT Honors program each contribute to make an IT education more valuable.

It is the hope of the *Technolog* staff that each student, staff, and faculty member reads and benefits from the information in this issue. We also hope that spring comes soon.

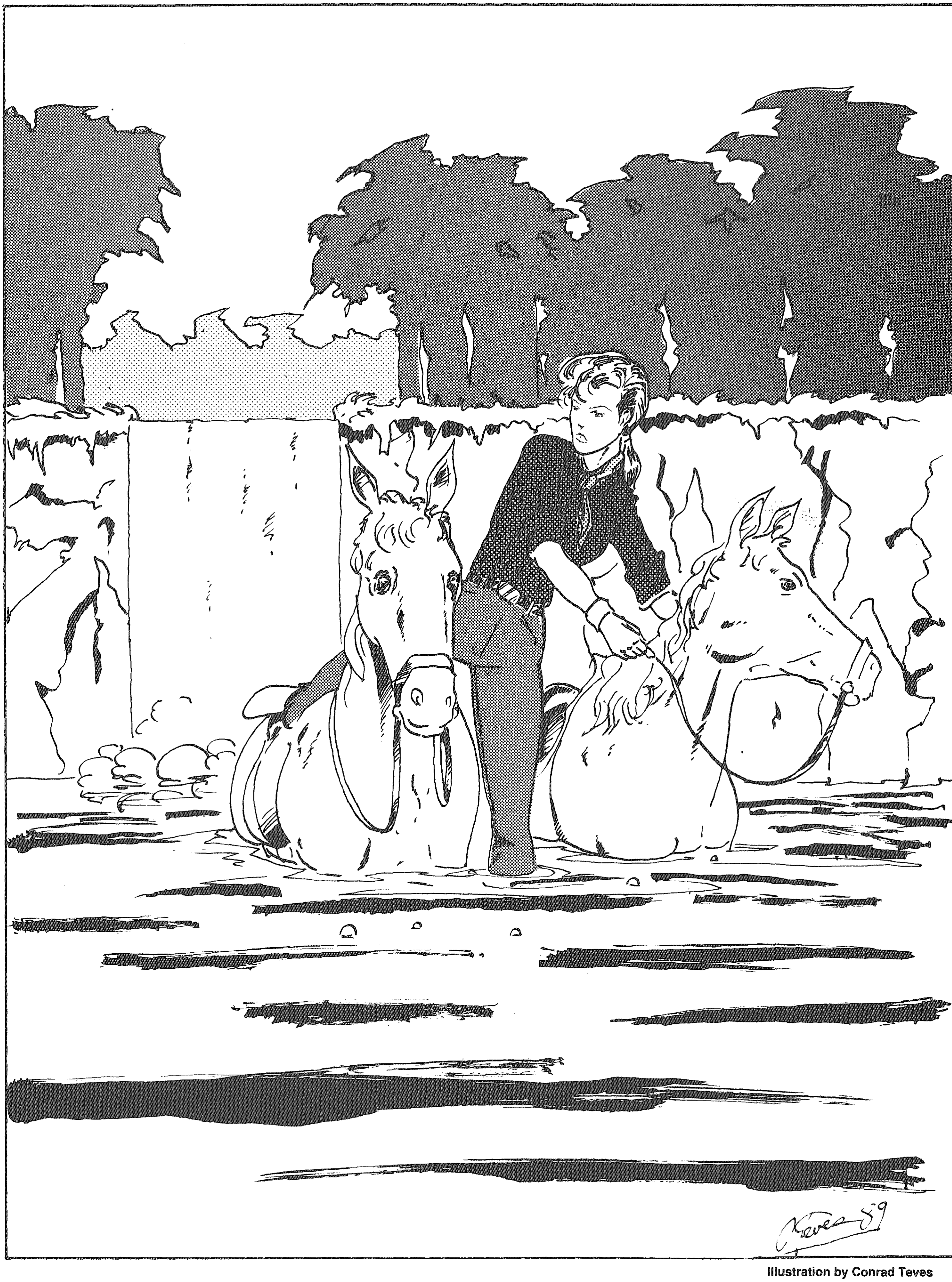


Illustration by Conrad Teves

IT Business Leaders

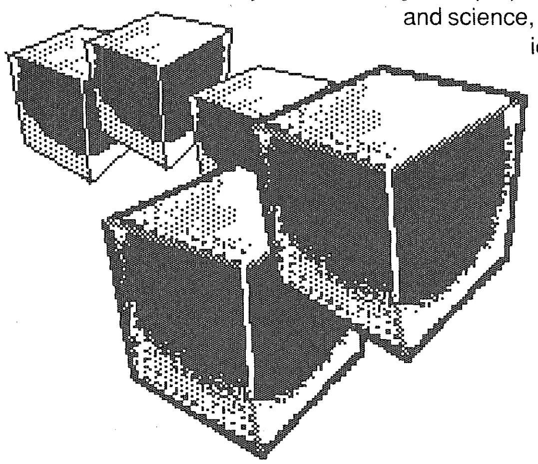
by Tony Veerkamp

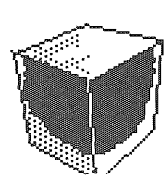
Many IT students wish they could take more business and communication courses to better prepare themselves for their careers. Critics and observers in business and industry have repeatedly expressed concern over the increasing specialization of undergraduate studies. In particular, recent technical graduates frequently find they lack the skills and perspectives required for promotion in the rapidly changing environment of high-tech industry.

The University of Minnesota has responded to these needs by creating the Center for the Development of Technological Leadership (CDTL). CDTL is designed to broaden the educational background of students in engineering and science, thereby preparing them for promotion to leadership positions. Although administered by the Institute of Technology (IT), CDTL involves the cooperative efforts of the Carlson School of Management (CSOM), the College of Liberal Arts (CLA), and IT.

CDTL was initially funded by the Honeywell Corporation with a donation of $2.7 million. The Honeywell gift was matched by $2.5 million from other University funds. This initial money has provided for a professional program director, two endowed chairs for permanent faculty members, one chair for visiting faculty members, and a rotating chair for visiting professionals from industry. In addition, CDTL will have an advisory board drawn from the University, business and industry. This board will provide guidance for programs offered by the Center. Also, the business courses offered to IT students are reviewed by a committee of professionals from business and industry to ensure their applicability. This system has been favorably received by both academic and corporate advisers.

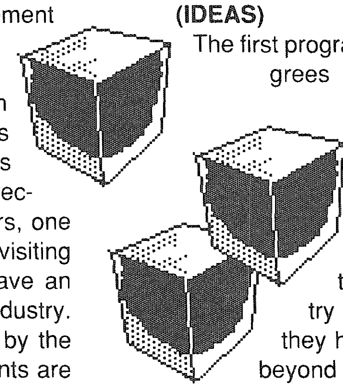
Currently, CDTL is developing four interrelated programs. Two of these programs deal directly with curricular enhancement. They will retain a rigorous preparation in engineering and science, but provide for studies in business management, communications, and other areas in the liberal arts. The first program of these two is a joint degree offered by IT and CLA leading to undergraduate degrees from both colleges in five years. Another program consists of a business enrichment curriculum. It will result in a business certificate, business minor, or a master of science in technology management.





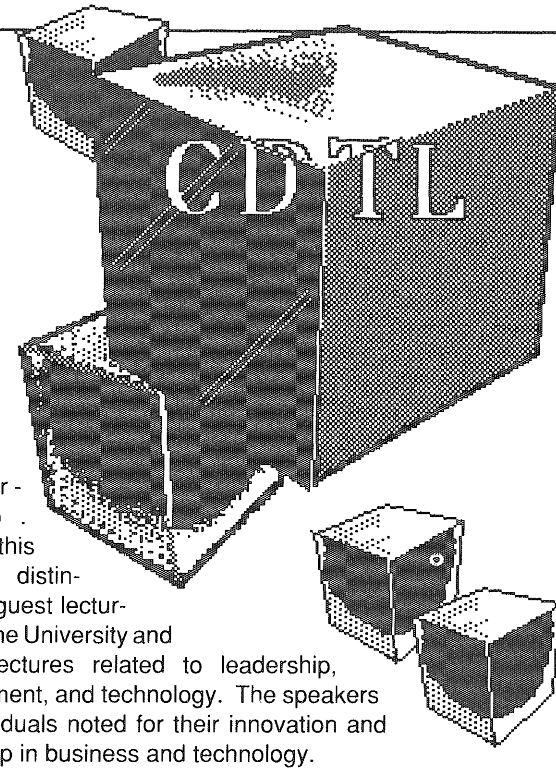
The third program comprises a series of lectures given by nationally distinguished guest speakers from both industry and universities. The fourth program will conduct research and experimentation in technology transfer from universities to industry. Through these programs, CDTL hopes to broaden educational opportunities in undergraduate and graduate programs for engineering and science majors. Below, these four individual programs are examined in more depth.

Integrated Degrees in Engineering, Arts, and Sciences (IDEAS)



The first program offered by CDTL, the "Integrated Degrees in Engineering, Arts, and Sciences" (IDEAS) program, will augment B.S. degrees in engineering and science with study from nontechnical fields. Martha Russell, associate to the dean of IT, in the September 1988 issue of *Minnesota* (the official publication of the IT Alumni Society) said "Many industry leaders have become leaders because they have a breadth of perspective that goes beyond a specific field of knowledge." The IDEAS program hopes to provide IT students with that breadth of perspective the corporate world currently demands. Flexibility is emphasized throughout the program. Students are encouraged to plan additional studies that will expand their technical education. Examples of additional studies could include marketing, international relations, or language. The IDEAS program is intended to be a rigorous, five-year course of study leading to a B.S. degree from IT and a B.A. degree from CLA. Students are encouraged to select this option during their sophomore or junior year.

In addition to the combined degrees, the IDEAS program includes seminars conducted by an interdisciplinary group of faculty and students from CSOM, CLA, and IT. These seminars were first offered in 1988 as a way to introduce students to a variety of viewpoints. The interdisciplinary seminar will be offered again during Spring Quarter 1989; the focus will be the structure of scientific revolutions.



Business Enrichment
The second program of CDTL is intended to enrich technical education with fundamentals of business and management. These fundamentals include the leadership, interpersonal, and business skills needed in engineering supervision and higher levels of technical management. "The program follows a business enrichment curriculum with course offerings that assume a technical background," says Dr. W. T. Sackett, Associate Dean of IT. The program could also provide training in certain new areas of technology such as semiconductor materials or composites engineering.

Three business enrichment options are currently being planned—all include the same core courses. These options will be available starting Fall Quarter 1989. The first option consists of sixteen credits in business, and will lead to a business certificate for students in IT. The second option results in a business minor with thirty-two business credits required. The third option will result in a M.S. in Technology Management. Referring to the advantages of this new M.S. degree, E. F. Infante, Dean of IT, stated, "A B.S. degree in engineering or science combined with a business enrichment option provides students with a firm technical foundation and the business tools needed to step into leadership roles in industry." The M.S. degree is based on a curriculum similar to an MBA degree, but is intended for students with a technical background. This option will require forty-five credits and is designed for graduates with three or more years experience in business and industry.

Currently, two courses are being offered by CDTL. They are: Manufacturing for Competitive Advantage (in cooperation with the Department of Operation and Management Sciences) and Communications in Human Organizations (in cooperation with the Department of Speech and Communications). The final course offered this year, Business Plans for Innovative Technologies, will be taught Spring Quarter (in cooperation with the Department of Marketing). Registration information may be obtained by calling (612) 624-5747.

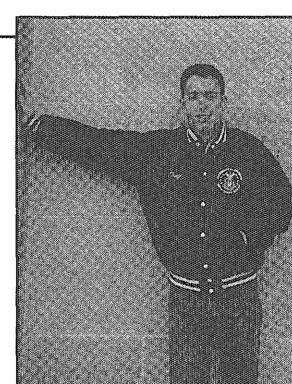
Honeywell W. R. Sweatt Lecture Series
A third program is the Honeywell W. R. Sweatt Lecture Series in Technology Leadership. Through this program, distinguished guest lecturers visit the University and deliver lectures related to leadership, management, and technology. The speakers are individuals noted for their innovation and leadership in business and technology.

Past guest speakers have included Lester C. Thurow, author of *The Zero-Sum Game* and dean of the Sloan School of Management at MIT, and Richard Cyert, president of Carnegie-Mellon University. There are three speakers scheduled for the remainder of the school year.

Technology Transfer
CDTL's research and experimentation in technology transfer is expected to evolve in conjunction with the other programs. This program will contribute to effective exchange of knowledge between research institutions and industry. Initial research topics will be developed to gain comparative information.

Although the CDTL has only been operating for a short time, its programs are sure to have a lasting impact at the University. The Center will provide broader educational opportunities for students in engineering and science. The lecture series and innovative class offerings will bring new perspectives to IT students and industrial professionals alike.

Author Bio



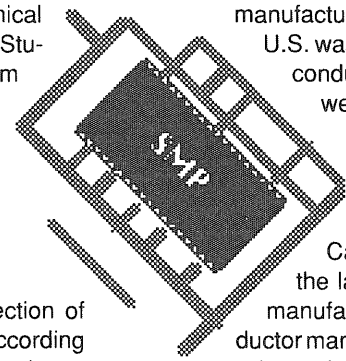
Tony Veerkamp is a junior in Electrical Engineering and is a new face in the *Technolog*. Between school, ROTC, and this article, he has had little free time. He is currently taking a class through the CDTL program.

Microchip Manufacturing

by Steven Subera

Developing an integrated circuit is an intricate process that requires expertise from many engineering disciplines. Semiconductor manufacturing engineers must be able to work effectively in teams comprised of process engineers, equipment engineers, integrated circuit designers, device architects, and facilities engineers. The Semiconductor Manufacturing Program (SMP) at the University of Minnesota was initiated to provide students with this necessary cross-disciplinary background.

Three departments in the Institute of Technology have collaborated to form a combined curriculum in semiconductor manufacturing. They are: Electrical Engineering (EE), Mechanical and Industrial Engineering (MechE/IEOR), and Chemical Engineering and Materials Science (ChemE/MatSci) . Students in these departments may participate in the program and choose courses ranging from basic microelectronics to clean room technology. Upon graduation from one of the departments, a student also receives a certificate of completion in the Semiconductor Manufacturing Program and a notification of participation on his or her transcript.



Depending on a student's interests, a good cross section of material from the three departments may be studied, according to John Weaver, chemical engineering and materials science professor. "You're not likely to switch from chemical engineering to mechanical engineering based on this curriculum. You are likely to know more about what the other person does," he said.

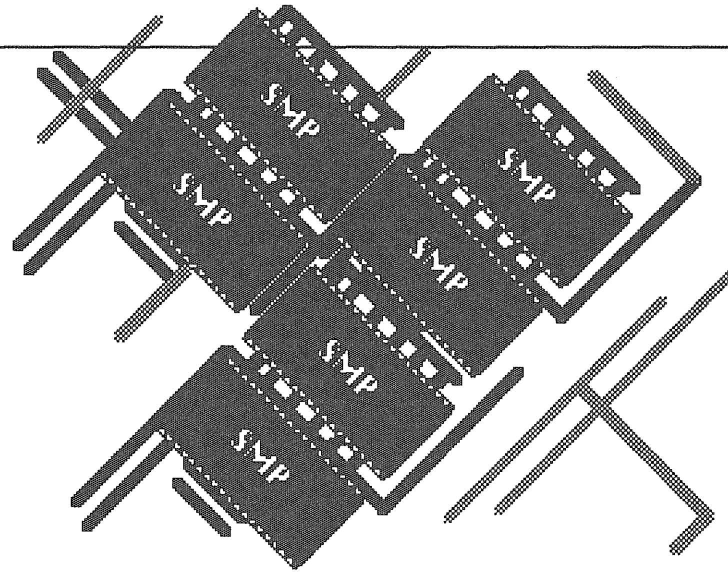
Funding for the semiconductor manufacturing program is provided by the Semiconductor Research Corporation (SRC), a national consortium of companies in the semiconductor industry. SRC sent out requests to universities across the nation asking them to submit proposals for programs in semiconductor manufacturing, according to Stephen Campbell, electrical engineering professor. Campbell authored the proposal to SRC and currently coordinates the program with MechE/IEOR and ChemE/MatSci. The program is also sponsored locally by the Microelectronic and Information Sciences Center (MEIS) at the University of Minnesota.

Florida State University was the first school to receive funding from SRC to develop a semiconductor manufacturing program. Their program began in January of 1987, was successful, and is still active, Campbell said. SRC sent out a second request, that sought four additional schools, and the University of Minnesota was selected along with the University of Texas, Rensselaer Polytechnic Institute, and the Rochester Institute of Technology. Funding at Minnesota began in January 1988 and the program officially started in September of 1988. It is scheduled for three years of funding at which time Campbell said he hopes to have most of the program installed. Part of the money from SRC will be used to maintain the old microelectronics laboratory. The EE/CSci building has a brand new facility, freeing up the old one located on the fourth floor of the old EE building for use as a teaching laboratory, Campbell said.

SRC provided money because they saw that there was an insufficient number of trained and experienced semiconductor manufacturing engineers. "They recognized that the U.S. was getting beaten badly in the area of semiconductor manufacturing. Mainly, we [the U.S.] were able to develop technologies and develop products, but we weren't able to manufacture them as competitively as other countries," Campbell said.

Campbell identified two possible reasons for the lack of adequately trained semiconductor manufacturing engineers. First, he said, semiconductor manufacturing suffers from low esteem. "Most people coming out [of college] feel the best position they can get is in research, next is development, and if they can't get a job in either, they go into manufacturing. Unfortunately, that sort of attitude has eroded the capability of the U.S. to manufacture semiconductors. In this particular industry the cost of developing new products is prohibitive unless you can manufacture them as well."

Secondly, he cited the rapid advances in technology and the narrow focus of study by today's engineer. Presently, Campbell said, microchips have approximately 1 to 4 million transistors on them. "By the time the people we are currently educating are out in the work force that number will be up by almost a factor of ten. If you look at a digital system, a supercomputer is something like 5 to 10 million transistors for the central processing unit so you're really talking about putting a supercomputer on a chip," he said. Developing this future technology requires cooperation among many different disciplines, such as computer architecture, VLSI design, semiconductor physics, chemical processing, and thermal properties. "In the U.S. we have a compartmentalized educational system so that we make computer engineers, we make material science engineers, we make electrical engineers.



The way we structure our programs, you don't get much overlap. The overlap is almost accidental," Campbell said. The semiconductor manufacturing program is designed to overcome today's high degree of specialization and provide engineering experience in all integrated circuit technologies.

Currently, eighteen students are participating in the program. Campbell expects the number to increase as more students are made aware of the option. Department coordinators (see editor's note) are actively seeking students at the junior level and beginning in the fall of 1989, six $1000 scholarships will be awarded to two students from each department. Campbell said the job outlook for semiconductor manufacturing engineers is very good and that the pay is the highest among the engineering professions.

Greg Swanson, electrical engineering senior, was introduced to the program by Campbell in the spring of 1988. He said he believes the program has great potential. "The classes I have taken and the seminars I have attended have been very interesting. They incorporate the latest in CMOS technology."

Integrated circuits are often thought to be the exclusive domain of the electrical engineer, working in areas such as semiconductor device engineering, VLSI design, and product engineering. However, designing a circuit also involves an understanding of the properties of materials (such as silicon and aluminum gallium arsenide), and creating a 'dust-free' environment for their production.

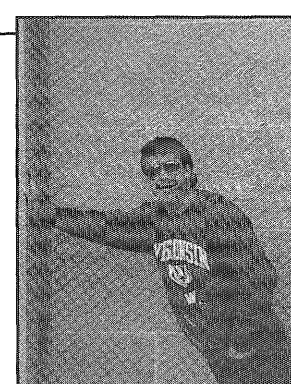
Current technology is producing devices with features of less than 1 micron (a human hair is approximately 70 microns thick) and a single mote of dust settling on the device could ruin it. This fact explains the need for clean rooms that have precisely controlled environments. Professors Benjamin Liu and David Pui in MechE/IEOR have created a class in clean room technology for the semiconductor manufacturing program. The class focuses on how to measure and control particulate contamination in clean rooms. Liu also stresses the importance of clean room efficiency. "One of the attributes of a clean room is it's very energy intensive," Liu said. Keeping a clean room free of airborne particles requires continuous filtering of large volumes of air, which can typically cost $500,000 per year, Liu said. With approximately 2000 clean rooms in existence today, clean room energy costs amount to $1 billion a year. Minimizing these costs is another one of the responsibilities of the mechanical engineer. Mechanical engineers can also apply their talents to studying heat transfer and CAD/CAM in semiconductor manufacturing.

Typically ChemE/MatSci students will have a background in processing through their traditional coursework, according to Weaver. He said the region where two materials come in contact, known as an interface, is currently being studied by both ChemE/MatSci and EE departments. "Manufacturing or processing means that you heat them [semiconductors] up. Things not at thermodynamic equilibrium tend to diffuse, however, and you bring up all kinds of complex issues. That interface ultimately determines a great many properties of the composite," he added.

Although the Semiconductor Manufacturing Program currently has a small number of students, all three professors are confident of continued expansion. Liu said he believes the program can easily hold 20-30 MechE/IEOR students. Weaver added, "We expect it to go up [the number of students]. The interdisciplinary character means that the students will have opportunities and exposure to programs they couldn't have elsewhere."

Semiconductors to page17

Author Bio



Steven Subera, an electrical engineering senior, enjoys writing for the *Technolog* because of the many interesting professors and administrators he meets. This quarter Steve is keeping in shape by emulating the Gopher basketball team by participating in intramurals.

Sound Advising

by Jim Willenbring

Picture yourself as a freshman newly enrolled in an engineering college. Facing you right now are some very frightening facts about this school:

- You have less than a 40% chance of getting good enough grades to stay in the college after your first year.
- Very little tutoring help is available.
- You are required to choose a major as a freshman before learning much about any of the fields.

Sound intimidating? Students in the Institute of Technology actually faced these conditions in the early 1960s. This situation doesn't exist currently because the IT Lower Division Programs office was established to help solve these problems.

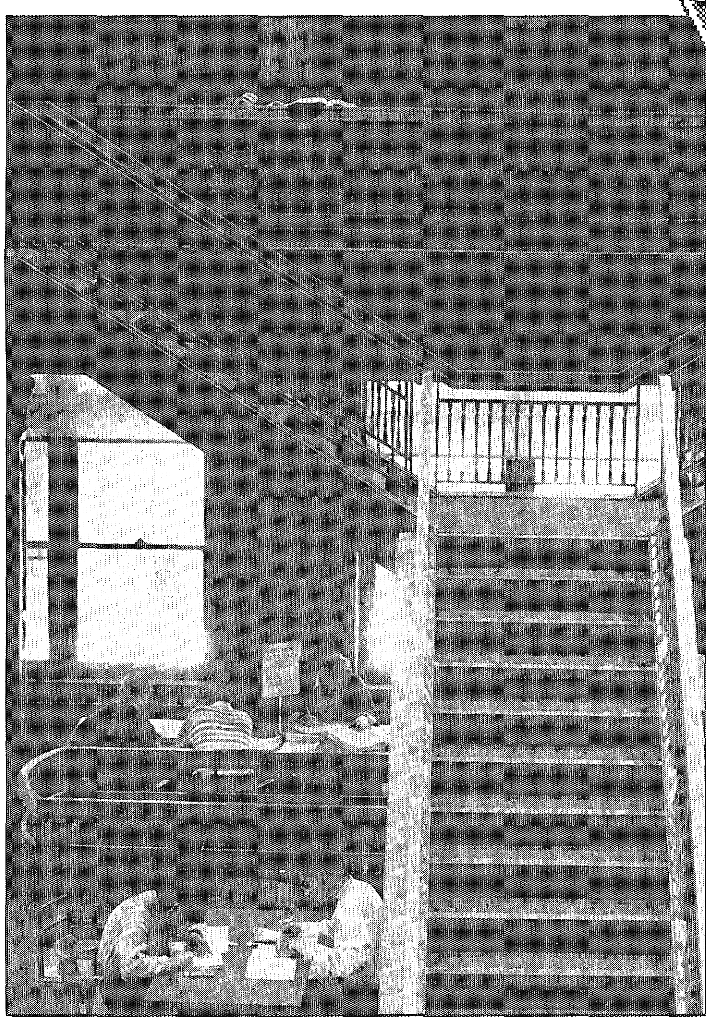


Photo by Paula Zoromski

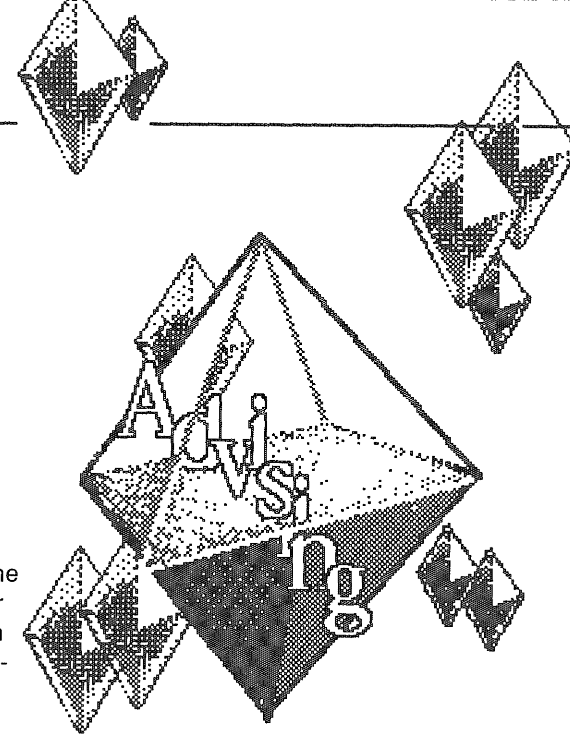
The IT Lower Division Programs office and what it does all originated from a 1963 task force of administrators, students, and faculty that was formed to look into problems that students were facing. Paul Cartwright, assistant dean of IT in 1963, did some research and found that more than 60% of freshmen students in IT dropped out or were doing less than C work after their first year. The task force was set up to investigate the reasons behind this retention problem. They found several basic causes:

- The quality of instruction could have been better.
- Little help was available to students who were having difficulty. Professors and teaching assistants offered help only during office hours. No tutorial service existed. The prevailing idea was that you had to make it on your own.
- Students had to declare a major before they could register for their first quarter of college. Back in the 1960s, students fresh out of high school knew much less about science and engineering fields than students today.

The task force recommended solutions to each of these problems: the quality of instruction would be improved through more emphasis on teaching and by hiring good instructors; teaching assistants would be hired as tutors so students could receive help with their courses; and students would be allowed to enter IT as 'unclassified,' or no major declared.

The administration, to implement these programs, asked mechanical engineering Professor John Clausen to start the IT Lower Division Programs office. Clausen was the one who originally brought many of these student problems to the administration's attention.

This department, established in 1968 in small quarters and on a small budget, has grown greatly in size and importance. It offers students many opportunities to help their education in IT. It also is one of the main reasons that now more than 80% of IT freshmen are able to stay in the Institute of Technology for their second year (see graph). Four of the most important programs that the IT Lower Division Programs office offers are:



- Tutorial services
- Unclassified student advising
- Industry adviser program
- Mentor program.

Tutorial services

Tutorial services started out small because of modest funding; the first tutors were graduate students who put in a few hours each week in a classroom in Lind Hall. In the evenings, one tutor worked at a residence hall while others worked at a high schools or community colleges in the suburbs to service the large number of commuter students. Then, as high-tech companies like 3M, Honeywell, Control Data, and others donated money to help support these services, it was possible to hire more tutors.

Several years later Clausen hired undergraduate honor students as undergraduate teaching assistants (tutors). Volunteer tutors, many of them Tau Beta Pi (an IT honor society) members, also joined the program. In recent years, math and physics graduate teaching assistants have been employed to help in their specific areas.

The current state (figures from spring quarter, 1988) of the tutorial program has these impressive statistics:

Number of tutors:	
undergraduate	73
graduate	50
total	123
Total number of hours: (spring quarter, 1988)	2,942.5
Total number of contacts: (spring quarter, 1988)	7,916

To illustrate how much the program has grown since it started, the number of contacts recorded in spring quarter of 1973 was 1,166.

One of the most recent improvements in the tutorial program has been the remodeling of 150 Lind Hall. Formerly the Engineering Library, it was adapted for tutoring use when the library moved to Walter Library. Renamed the Mr. & Mrs. George W. Taylor Undergraduate Academic Center, the facility reopened in January of this quarter and has been beautifully refinished and redesigned. Mrs. George W. Taylor and the Taylor Foundation provided the funding for this much needed improvement.

Tutorial services are not just located in 150 Lind Hall. Every dorm has at least one tutor. The dorms with a high concentration of IT students even have two to help out in the evenings. Other tutoring locations include Walter Library, the Armory, and six metropolitan area high schools to serve the commuter students.

One of the primary outcomes of the tutorial program has been to increase the quality of instruction in IT. Many tutors hear comments from students while helping them with their problems. Students talk more freely with the them about problems because they know that the tutor is not directly involved with the class or department. The tutors are instructed to relay the messages to Clausen who will try to make amends. Clausen said, "I have not hesitated in calling up faculty, TAs, or department heads when I get a substantive complaint about a professor or teaching assistant. They are usually very receptive and responsive. Many of them are not even aware of the problem and are happy to help. Sometimes the solution is as simple as the student switching sections."

"To sum it up," added Clausen, "The tutorial program's goal is to help students achieve their potential and at the same time have them enjoy the experience."

Unclassified advising

This program was started in direct response to the need for students to enter IT without declaring a major. The IT Lower Division Programs office can help all IT students, but caters especially to unclassified students by encouraging them to take part in the special industry and mentor advising programs. The unclassified students also meet regularly with a peer adviser. A peer adviser is an upper division honor student who helps uclassified students with academic planning, career information, and any other questions that the students may have. These meetings are in addition to meetings with a faculty adviser about their academic schedules.

Clausen believes that one of the problems IT has is that students are being short-changed in the faculty advising area, especially in the lower division. He believes that most students should enter

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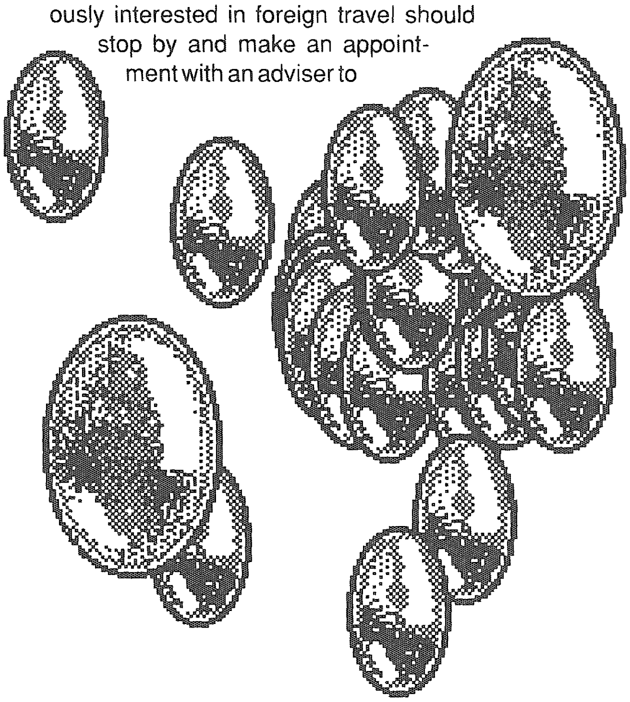
Engineering Elsewhere

by Angie Miller

"Literature in London."
"German in Graz."

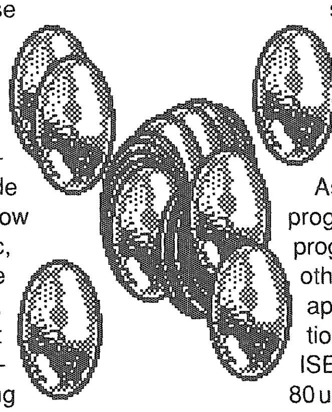
These are the slogans on just a few of the highly-visible posters all over campus that advertise various study abroad programs. However, most seem geared toward the CLA crowds, especially those who speak a foreign language. It seems that the technical fields are being ignored, glossed-over, even forgotten. Where are the programs with catchy names like "Mechanical Engineering in Mexico", or "Aerospace in Australia?" Although these may not be actual programs, study abroad opportunities abound for IT students, and you don't have to search too hard to find them.

If the idea of traveling to another country to expand your educational horizons appeals to you, your first step will be to decide what type of studying you want to do. Being in IT does not narrow travel possibilities since students aren't limited to only specific, major-related fields of study programs. Culture and language programs are definite options as well as engineering, math, and science courses. One of the best places on campus to get ideas is the International Study and Travel Center (ISTC) located in the basement of Coffman Memorial Union. Advising services coordinator Margaret Warpeha suggests anyone seriously interested in foreign travel should stop by and make an appointment with an adviser to discuss the type of program that interests them. Programs can vary from a quarter or semester to a full year in length. Most ask that participants be at least a junior. It's a good idea to begin planning about a year ahead of time so you can meet application deadlines and have time to organize the trip.



According to Warpeha, there are at least three different options for an education-related trip to a foreign country. These are:

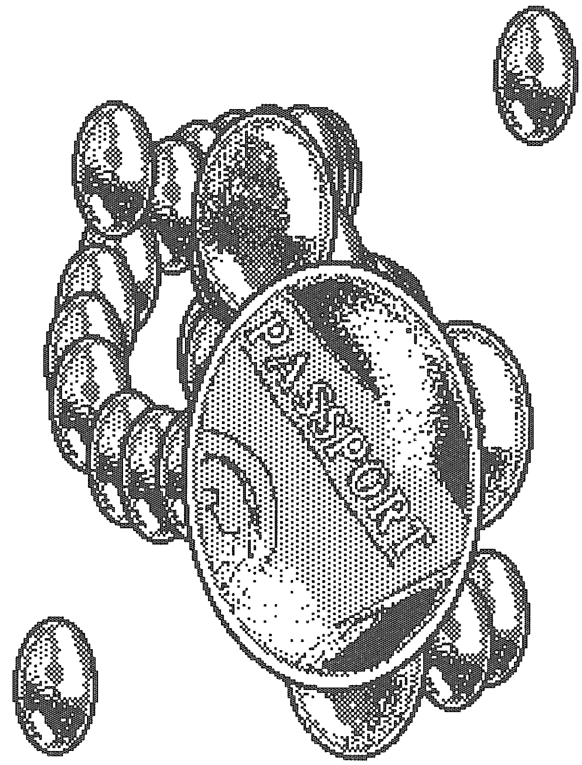
- Apply to a program sponsored by an American university of organization.
- Directly apply to a foreign university.
- Apply for traineeships or internships for specific fields.



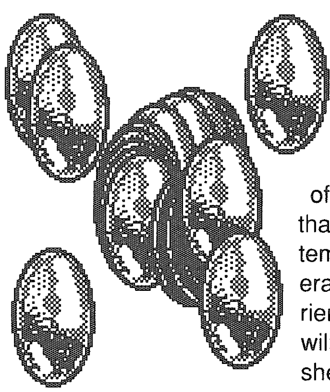
As far as she is aware, no specific U of M programs exist for IT students. However, programs do exist independently or through other universities to which students can apply. One such program is the International Student Exchange Program (ISEP). ISEP offers participants a choice of over 80 universities in various countries throughout the world. Courses offered through the program vary depending on the university, but Warpeha estimates "out of the about 80 universities participating, maybe twenty will have engineering courses." Many of the courses are taught in English, so knowledge of a foreign language is not a requirement. Of course, there will be more opportunities open to someone who speaks another language.

Directly enrolling at a foreign university is another option. This method won't be as limiting in the number and variety of courses available to you as a pre-designed program would be. The general idea is that just as most U of M courses are available to U of M students, most of the courses at a foreign university will be open to students directly enrolled at that institution, as you would be if you pursued the second option.

Paula Zoromski, a chemical engineering senior, combined these first two travel options by directly enrolling in a foreign university's program for international students. She spent last summer studying Spanish at The University of the Americas in Puebla, Mexico.



Although she took part in a program designed for non-natives of the country, she recommends direct enrollment at a university because you are then treated like the other students, not segregated from them. You are more directly involved and experience all aspects of the culture firsthand. She feels studying another language is a definite plus for all IT students because "learning a language forces you to speak in front of other people. It helps develop communication skills." These skills will be useful later on when entering the job market. Further, there are many job opportunities with companies overseas; studying abroad helps prepare you for adjusting to different cultures and different situations you may face.



Paula's advice to students who plan to study abroad is to keep an open mind about the culture and the different educational system you will be a part of. "Don't go in with the opinion that the American educational system is way above others. In general, those who had negative experiences were the ones who weren't willing to accept different methods," she said.

A few of the reasons some IT students may hesitate to journey abroad—such as a lack of funds, and/or the missing of sequential classes—can be overcome by a third travel option. Students in engineering, computer science, and architecture can obtain paid internships during the summer months. Examples of such programs are: International Association for the Exchange of Students for Technical Experience (IAESTE), and International Programs in Engineering (IPE). These types of programs are unique in that not only are most of the student's living expenses covered by what they earn, but also students are able to live in a different culture while gaining valuable work experience.

Looking toward the future, travel abroad opportunities for technical students are increasing. New programs and options are constantly being introduced. More IT students than ever are discovering the benefits of foreign study for themselves firsthand. With so many foreign study avenues open to the IT student, there's bound to be a program out there that's right for you.

Sources:

Warpeha, Margaret, interview: January 23, 1989, University of Minnesota.

Zoromski, Paula, interview: January 26, 1989, University of Minnesota.

Author Bio

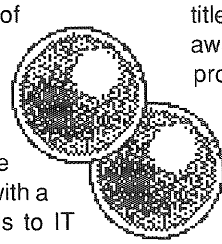
Angie Miller is a senior majoring in English and is a past contributer to the *Technolog*. She plans to graduate this spring and hopes to pursue a master's degree in Education. She is not unfamiliar with her subject, having spent some time last spring in England on the Literature in London program.

Undergraduate Research

by Bill Dachelet

Have you ever had an inkling to do some real research as an undergraduate? Does the thought of plodding through week after week of mundane lab writeups make you wonder why you're in IT? Maybe what you need is UROP, the University's Undergraduate Research Opportunities Program.

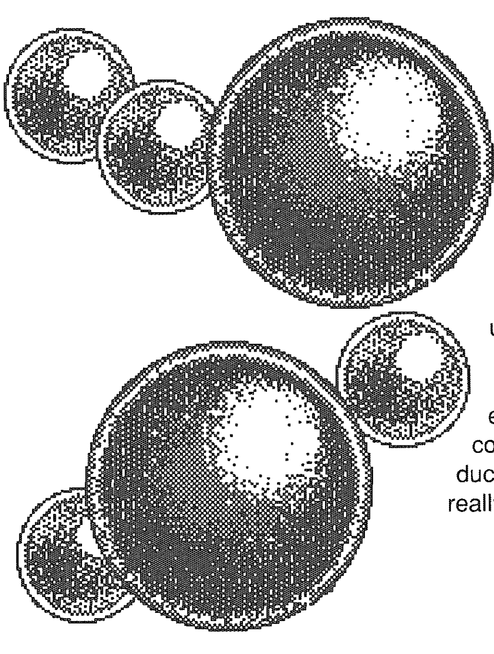
The purpose of UROP is to award money to undergraduates who would like to undertake a scholarly, creative, or research project. Done under the supervision of a faculty sponsor, the program is University-wide and has an annual budget of $200,000. IT's piece of the pie was just under $44,000 for the 1988-89 school year.



Who's eligible? Any student taking at least six credits who is not on academic probation is eligible for a UROP award. UROP isn't just for seniors with a 4.0 GPA. In April of 1988, 25% of the awards to IT students were given to freshmen, 25% to sophomores, 41% to juniors, and only 9% to seniors.

What does it pay? UROP awards a stipend of up to $750 and an expense allowance of up to $250.

How many credits is it? None, usually. However, if a student wishes to, he or she may register for a directed studies class while concurrently applying for a UROP award. Students undertaking a project for credit are only eligible for the $250 expense allowance.

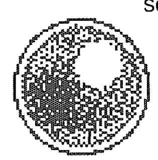


How do I apply? It's simple. Think of a project idea, find a faculty sponsor, and write a research proposal.

• Thinking of an idea. Ideally what happens is that the student wakes up one day and realizes, "you know, I'd really like to study annealing processes for yittrium barium copper oxide superconductors (or whatever), but I really don't know how to go about it. If only there were some sort of program. . . ." What happens more often than not, though, is that the student wants to do research in some field but doesn't really have a concrete idea on just what to study. Don't panic. The best way to get a workable idea is to go and talk to a few professors.

• Finding a faculty sponsor
UROP publishes a directory for people interested in their program. One useful item in the directory is a list of projects that have been given awards in the last two years. Reading the project titles gives you a rough idea of what kind of projects receive awards, but more importantly, the list will give you the names of professors that have already worked with students doing UROP projects. This is important because over half of the professors involved this year will be helping someone again next year—maybe you.

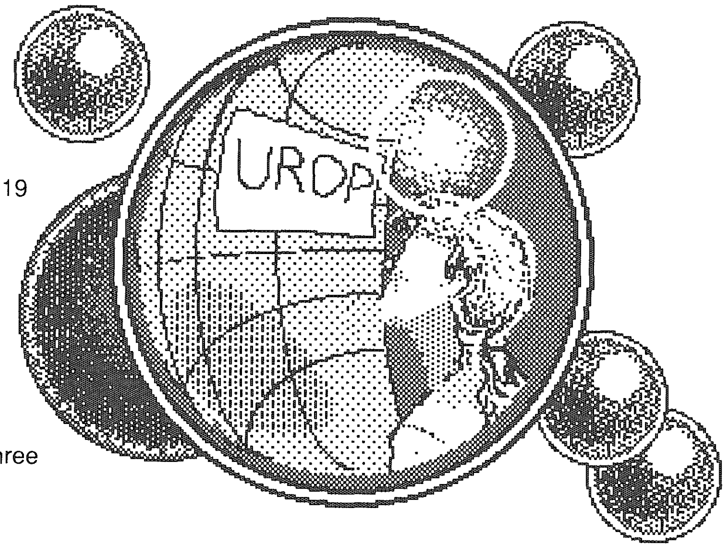
A second useful item in thedirectory is another list of professors. This list gives the names and areas of research interest of professors that have expressed an interest in the UROP programby filling out and returning a survey postcard. The entries in this\directory list are given by college and department.



The UROP directory lists are by no means complete. If you think a professor might want to be a UROP sponsor, you are doing both the professor and yourself a service by talking to him or her. Another place to look, besides the UROP directory, is in your department office. Remember, any University faculty member in any department or college may be a UROP sponsor.

What finding a faculty sponsor boils down to is this: pick a faculty member, talk to them, see what they have to say. It helps to know exactly what you would like to do. If you don't know precisely what you would like to do, identify an area of interest. The more precise you are, the easier it is for the professor. If you really don't have an idea, don't worry; a large percentage of UROP projects are suggested by the faculty sponsor. If one professor is unwilling or unable to sponsor you, don't give up—try another professor.

• Writing the research proposal
Details of the application procedure can be found in a booklet entitled *UROP Guidelines and Application Procedures*. Both the guidelines booklet and the directory mentioned previously can be found in Associate Dean Rusell K. Hobbie's Office, 106 Lind Hall,



or in the Office of Educational Development Programs, 419 Walter Library.

The main part of the application procedure, once you have found a project idea and a faculty sponsor, is writing a research proposal. The quality, feasibility, and completeness of your proposal chiefly determines whether your project is accepted by the UROP office.

The guidelines state that your proposal should be about three pages and that it *must* contain the following:

- A description of your project
- A timetable for completion of your project
- A budget
- A discussion of the relationship of your project to the research, scholarly, or creative work of your faculty sponsor
- A discussion of your educational objectives in under taking the project

In April of 1988, 32 out of 33 proposed projects were approved for IT students. In November of 1988, when there was only about 10% of the amount of the April funds available, 14 out of 20 IT proposals were approved.

How many hours of work a week is a project? That depends entirely upon your specific project. UROP projects can be tailored to the specific student.

Is there a final report? There is a very short report and evaluation due at the end of the project.

When is the application deadline? UROP has two "rounds" per year. The main round has an application deadline in April and the projects run from July 1 to June 15 of the following year. The secondary round has an application deadline in November, and the projects run from January 1 to June 15 of the same year. Most of the funds allocated for the year are awarded in the April round. This April's deadline is on the 10th. Plan ahead!

Where do I go for more information? The Office of Educational Development Programs in Room 419, Walter Library, or Dean Hobbie's office, Room 106, Lind Hall. Applications should be sent to Dean Hobbie's office.

Sources:

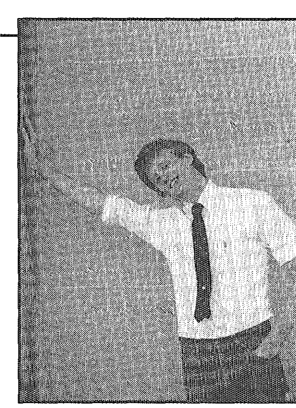
Hobbie, Rusell K., interview: January 20, 1989, University of Minnesota.

Munro-Bjorklund, Vicky, interview: January 20, 1989, University of Minnesota.

UROP 1988-90 Directory, Office of Educational Development Programs, University of Minnesota.

UROP Guidelines and Application Procedures, 1988-89 Awards, Office of Educational Development Programs, University of Minnesota.

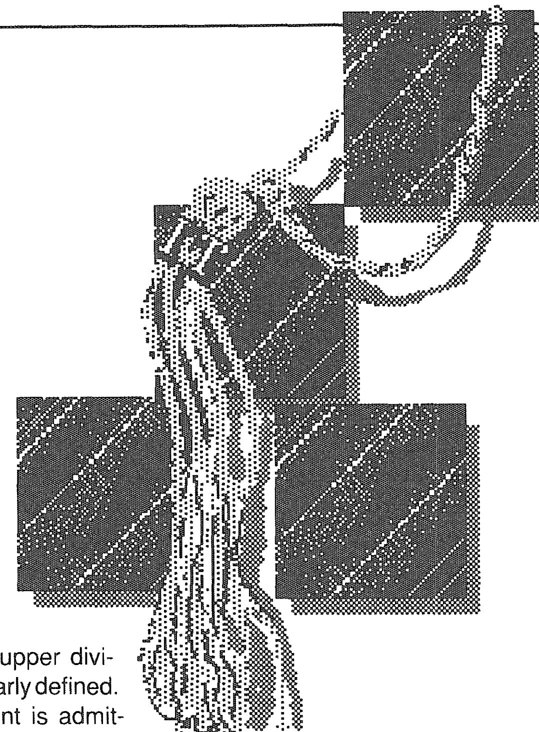
Author Bio



Bill Dachelet is a senior pursuing a double major in math and physics. He has been working for the *Technolog* since Fall,1987. When not reading in the *Technolog* office, Bill fills his time as a math tutor and works in the Nicholson Hall computer lab.

IT Honors

by Paul Kreemer



The IT Honors Program was created four years ago out of a perceived need for a more challenging curriculum for highly motivated, high ability students. This spring the first students to participate in the lower and upper division honors programs will graduate from the Institute of Technology.

The upper and lower divisions are distinctly separate programs that are only loosely related to each other. The lower division accepts only about one hundred students each year, with selections being made on the basis of standardized test scores, application essays, teacher recommendations, and other factors. Once accepted and enrolled, these students are together two to three hours a day for most of their freshman and sophomore years. The math, physics, and chemistry classes they are required to take as a group attempt to be more challenging and cover the material in more depth without rushing things too much.

The system of having one hundred students together taking the same classes for most of the day does more than simplify registration. It provides a cohesiveness the the first years of college that helps students to make friends and have a group with which they can identify. A greater attempt to integrate what is being taught in the classes is also made so that, for example, when vector math is needed to describe a force or motion in physics, the students will have just learned vectors in their mathematics course.

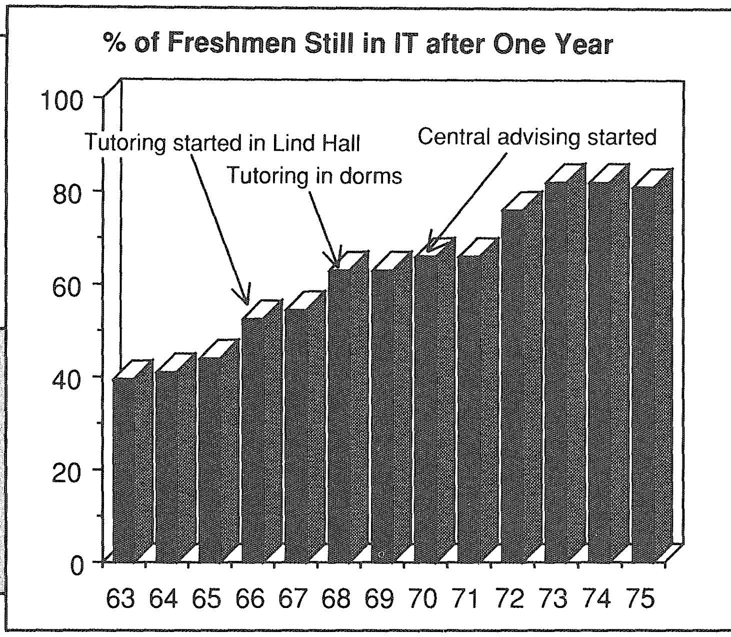
Unlike the lower division where a student is definitely in or not in the honors program, the upper division is less clearly defined. Once a student is admitted, he or she is expected to participate in a certain number of "honors experiences" such as honors sections of normal courses, special seminars, and maybe a thesis or design project (depending on the department requirements), but in general a student has much more freedom in choice of classes.

If the prospective honors graduate has acquired the necessary number of honors experiences and has a minimum GPA of 3.5 to 3.75 (depending on the degree), he or she will graduate cum laude, magna cum laude or summa cum laude with a thesis being required for the summa cum laude degree.

Other benefits of being in the IT Honors Program are special library privileges, honors seminars, a tutoring program, easy access to liberal arts honors classes and membership in the IT Student Honors Group. These are offered to supplement and aid a challenging and rewarding technical education.

Editor's note: Paul would like to thank Professor David Frank for his help with this article. Frank is the director of the lower division IT Honors program.

Paul Kreemer is a fifth year senior in Aerospace Engineering. He plans to graduate this fall and go right into the job market. His interests include sailboating and radio-controlled airplanes.



The retention rate for first-year IT students was very low in the early '60s. The IT Lower Division Programs Office has successfully helped to increase the percentage of students still enrolled in IT after one year. Since 1976 the retention rate has remained near 80 percent.

Source: IT Lower Division Programs Office

Illustration by Jim Willenbring

Advising from page 9

IT as unclassified. "I think that our office as a central advising staff for lower division students would be a great benefit for everyone because we can keep them better informed about regulations and opportunities," he said. "Most department advisers are professors who usually just teach upper division courses. Some don't follow very closely the lower division curriculum, books, courses, and requirements."

Industry adviser program

The industry adviser program was set up to provide the opportunity for IT students to meet with a professional in industry. From these volunteers, the students can learn much more about the specific field they are interested in, especially in what an engineer or scientist does in a normal day and how their education has helped them.

The first company to participate was 3M Company in 1984. They lined up about 70 volunteers. Currently several hundred engineers and scientists from 3M, Honeywell, and NSP help IT students better understand what their technical fields are about.

The way the program works is that interested students are assigned an engineer or scientist in their field of interest. The student contacts this person and a meeting is arranged. Students can sign up more than once to meet with other professionals who are doing different kinds of work. This one-time, on-the-job kind of contact is often the first glimpse of many students into what engineers and scientists actually do. The program is open to any student in IT.

Mentor program

Over the years, a few students expressed interest in having a more long-term relationship with a professional out in industry because of their own job experience or that they had heard of mentor programs in other schools.

3M Company was again the first company to help out with this advising-type program and they found about 30 people who were interested in meeting with students. The mentors act as a role model, adviser, and even as a friend to the students over a long time period. Honeywell was enlisted last fall to help in this program so more spots became available; the first openings offered by 3M filled up right away. Clausen is currently working with other high-tech Twin Cities companies to make this opportunity available to more students. The University is fortunate that the Twin Cities is the home for many technical companies so that programs like this are possible.

Today, the IT Lower Division Programs office has the same philosophy it had when it started: to help IT students in any way that it can. This office has made sure that students do not face alarming statistics when entering IT. Through the many programs and opportunities it offers, IT students today can graduate better prepared and with a better understanding of what it means to be an engineer or scientist.

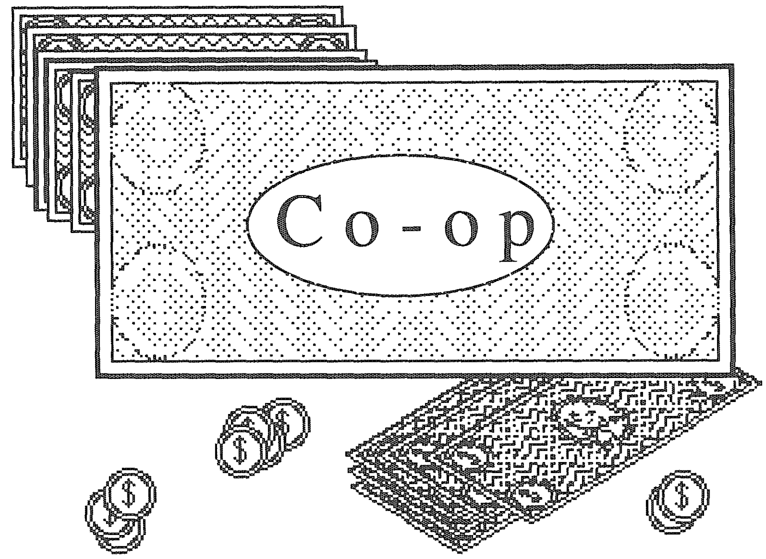
If you are interested in any of the above programs or would like further information, feel free to stop in at the IT Lower Division Programs office in 128 Lind Hall or call 624-2890.

Author Bio

Jim Willenbring is a senior in EE. He was *Technolog* Editor last year, and this year he is President of the IT Board of Publications. After he graduates, Jim plans to attend graduate school in Technical Communications to pursue his calling: translating engineering gibberish into English.

Co-op Programs

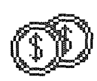
by Ann Jones



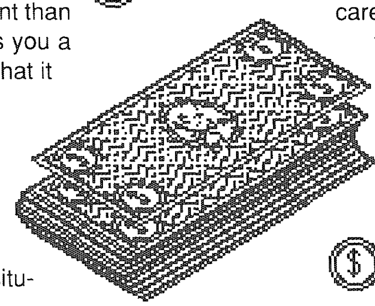
"A major complaint of the practicing sector is that engineering graduates are not equipped to practice. The University of Minnesota Intern Program makes a definite contribution to the development of a well rounded engineering graduate."

— American Society of Civil Engineers' Newsletter

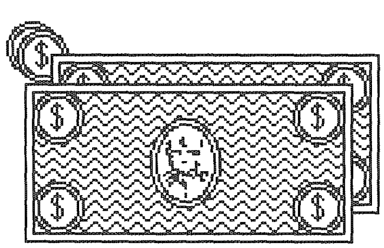
Many of the departments in IT offer co-op programs. The objective of these programs is to provide industrial experience during the last two or three years of a student's academic career. Starting after the sophomore year, a co-op student alternates each quarter between an assignment in industry and an academic quarter. There are many benefits available to an engineering student. You can:



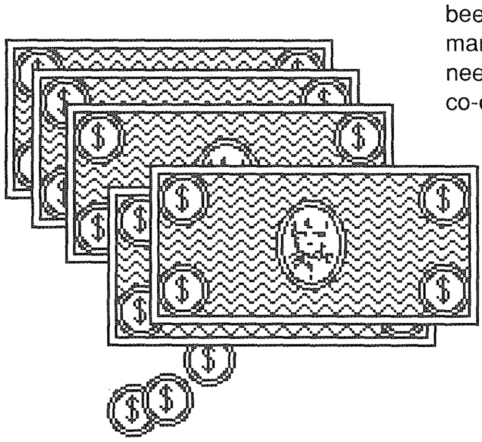
•*gain an understanding of an engineer's role in industry.* The life of a student is quite different than life in the technical world. A co-op job gives you a chance to get a feel for the real world and what it means to be an engineer on the job.



•*apply your knowledge of fundamental theory to practical problem solving.* Here is an opportunity to find out what you really can do. You can use what you've learned in the classroom and apply it to actual working situations.



•*build a base for making a decision about which direction to follow in your field of engineering.* What area do you want to concentrate on? As a sophomore or junior many people aren't sure because they haven't been exposed to the many branches of engineering. Students in the co-op programs have found that it has helped them to find direction in their studies and develop their interests.



•*begin a career.* Students who have taken advantage of the co-op programs have found that it set their engineering career off to a good start. In general, co-op students tend to receive better and more offers after graduation. Having done a co-op, students have more to offer hiring companies. Sometimes a co-op assignment can even lead directly to a job within the company of assignment.

•*earn money.* In the four quarters of assignment, a student can expect to earn a total of about $12,000.

Of course, co-op programs have their bad points, too. You might not be able to take all of the classes you want for your emphasis or minor due to your co-op assignment. The employer that you end up with may not have any work that you find interesting. Also, despite the fact that the money earned at a co-op job is nice to have, it is still far less than a beginning engineer makes. This means that you may be able to come out ahead moneywise by graduating early instead of being in a co-op program. Each situation is different, of course, and your faculty adviser should be able to help you asess yours.

Information about the co-op programs can be obtained in each department office. All of the programs are entered after completion of the sophomore year. And it is a pre-requisite that you have completed all of the required freshman and sophomore courses in your major. In general a minimum GPA of 2.5-3.0 is required.

Ann Jones is a junior in physics. She competed in the Olympic cross-country skiing tryouts last year, and plans to try again. Ann may never use the information in this article, as she says the physics department has no Co-op program.

Semiconductors from page 7

Editor's note: A brochure on the Semiconductor Manufacturing Program can be obtained from the MEIS office in 227 Lind Hall. For information from a specific department please contact the following people.

EE	Professor S. A. Campbell	625-5876.
MechE/IEOR	Professor David Pui	625-2573.
ChemE/MatSci	Professor J. H. Weaver	625-6548.

Sources:

Campbell, Stephen, interview: January 20, 1989, University of Minnesota.

Liu, Ben, interview: January 23, 1989, University of Minnesota.

Weaver, John, interview: January 24, 1989, University of Minnesota.

Time Travel

Black holes have been mentioned as possible time travel vehicles for many decades. However, a recent paper in *Physical Review Letters* suggests a unique approach to the problem of keeping a traveler alive while passing through a black hole. The three authors (Michael S. Morris, Kip S. Thorne and Ulvi Yurtsever) hail from the California Institute of Technology in Pasadena.

Black holes are believed to be one end of a "wormhole" that connects two different regions of spacetime. If a traveler ventures through the wormhole he would enter a different region of spacetime. Preventing this passage is a point of infinite gravitational and tidal force within the wormhole known as a singularity. Any commuter would be quickly destroyed by the singularity.

The Caltech researchers solved the singularity problem by suggesting that a future society might be able to create their own wormhole and expand it for transportation using a phenomenon known as the Casimir effect. The Casimir effect causes the violation of the "weak energy condition." This condition requires that the average energy density of a material be either zero or positive. The weak energy condition is the cause of a singularity in a black hole.

By putting one electrically charged conducting plate on each side of the wormhole's openings, one end of the wormhole may be accelerated away from the other by electrical or gravitational means to nearly the speed of light and then brought back. According to relativity, the moving mouth's clock is slower relative to the stationary mouth's clock. Hence a voyager traveling from the moving end to the stationary one would move backward in time.

Source: *Scientific American,* January, 1989, pp. 21-22.

Skin Grafts

Using a noninvasive blood flow monitoring system, Kenneth Waxman, professor of surgery at the University of California at Irvine has developed a method to determine whether or not burn victims need skin grafts. Choosing between a skin graft and the natural healing of a serious burn is difficult even for expert surgeons, who make the correct choice only 60 percent of the time. Studies have shown Waxman's technique to be correct approximately 95 percent of the time.

Waxman's method revolves around the hypothesis that burn wounds would heal themselves if a minimum blood supply was flowing. Anything less than this minimum and a skin graft is needed. Measuring blood flow in the capillaries, however, is a difficult task. The capillaries in the skin are tangled and blood flow is multi-directional. Most conventional methods work only on single direction flow. TSI Inc. of St. Paul, Minnesota makes a laser Doppler system called the Laserflow BPF (blood profusion monitor) 403, which he has used in his research with good results.

The laser has three optical fibers. One is used to emit a small amount of laser light and the others return the reflected light to a photodetector. Waxman measured the blood flow by statistically obtaining a value for the Doppler shift caused by red blood cells flowing past the probe. The velocity of the flow can then be calculated and multiplied by the red cell density, resulting in a value for the volume of blood flow.

Source: *IEEE Spectrum*, January 1989, p. 18.

Radioactive Pollution

Data released last fall by the federal government has provided more damaging evidence against nuclear plants. Apparently four plants used for the production of nuclear weapons had been releasing radioactive waste into the air and water for decades. One plant, the Hanford Reservation reactor in Washington State had been releasing radioactive gases into the air from the middle 1940's until well into the 1960's. The other three weapons plants are located near Aiken, South Carolina; Boulder, Colorado; and Fernald, Ohio.

The Center for Disease Control (CDC) has stepped in to study the effects of the radioactive emissions in the surrounding communities. As one might expect, there have been reports of increased cancer among the local inhabitants. However, James Ruttenber of the CDC is waiting for more evidence. He says that whenever there is information about possible radioactivity in a community the reports of cancer increase even though they may be totally unrelated.

The effects of Iodine 131, a radioactive pollutant released at the Hanford plant, are being studied by the CDC. Iodine 131 binds with proteins found in the thyroid and begins to accumulate. Researchers are unsure exactly how damaging the radioactive isotope is, but they admit that residents near the plant could face serious health risks.

It could take two more years before the CDC determines the effects of the radioactivity. Environmentalists are already arguing for the temporary closing of the weapons plants, but Department of Defense officials worry that tritium production will not keep up with scheduled bomb building.

Source: *Discover*, January, 1989, pp. 10-11.

Circulation Manager

The *Minnesota Technolog* has an opening for the position of Circulation Manager. Duties include distributing the *Technolog* both on campus and through the mail, and maintaining the *Technolog*'s magazine library. If interested, stop by Room 2, Mechanical Engineering and ask for Steve Kosier or Bill Dachelet, or give us a call at 624-9816.

1. What is dry ice and why is it called 'dry' ice?

2. What is the most frequent cause of epilepsy in humans?

3. About how much food does the average American eat in a year?

4. Why does your foot 'fall asleep' after sitting with your leg curled up in one position for a long time?

5. What is a zymolytic reaction?

6. If nothing sticks to Teflon, how does DuPont get Teflon to stick to the metal frying pan?

7. How do three-way light bulbs work?

8. What bridge received an Award of Merit in the 1988 Outstanding Civil Engineering Achievement Award Program of the American Society of Civil Engineers?

9. What is a zwitterion?

10. So far, who is the first and only president elected in a year ending in 0 (for example, 1970) who left office well and did not die of either a sickness or assassination?

Scoring

0-2 You should have humbled yourself and asked your little brother for help.
3-4 It's about time you woke up.
5-6 OK, you're tolerably intelligent.
7-9 Very impressive, if that was honest work.
10 Students who do nothing but study are bound to have a hard time when they leave the University.

by Bunmi Odumade

Answers

1. 'Dry ice' is carbon dioxide when it has frozen into its solid state. It is called 'dry' ice because when it melts, it doesn't melt into a liquid but into a gas. Remember high school chemistry?

2. It is frequently caused by a small piece of brain tissue that begins to produce abnormal electrical activity when stimulated. This activity spreads to neighboring pieces of tissue, gradually involving larger areas of the brain, causing loss of consciousness and often uncontrollable body movements.

3. The average American adult eats 525 pounds of food each year. Imagine what people would look like if it all stayed there.

4. Your blood usually flows through blood vessels in your leg, gathering poisonous wastes from various organs as it runs. When that flow is slowed down, these poisonous wastes accumulate and block the nerve cells that carry messages from your foot to your brain.

5. It is a chemical reaction catalyzed by an enzyme, especially a chemical reaction involving bond rupture or splitting.

6. First, the interior of the pan is grit blasted, then a primer coat is sprayed on and baked. Then a second layer of PTFE (polytetrafluoroethylene) is applied, baked and dried again, then a third coat is applied, baked and dried.

7. Each three-way light bulb contains two filaments. When you turn the switch the first time, the lower wattage filament lights. When you turn it again, the next one lights and the first one turns off. When you turn the switch again, both filaments light.

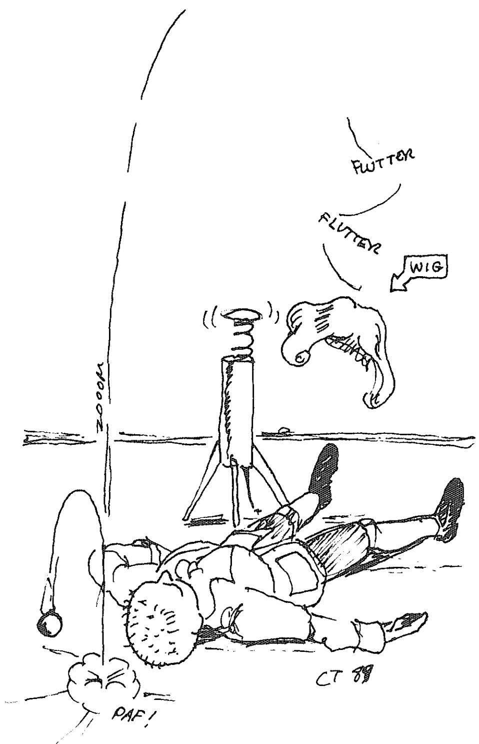
8. The Sunshine Skyway Bridge in St. Petersburg, Florida. It carries an interstate highway 175 feet above the Tampa Bay. If you are in Civil Engineering and did not know that, subtract one.

9. It is an ion carrying charges of opposite sign, which thus constitutes an electrically neutral molecule with a dipole movement.

10. Former President Ronald Reagan.

The Near Side

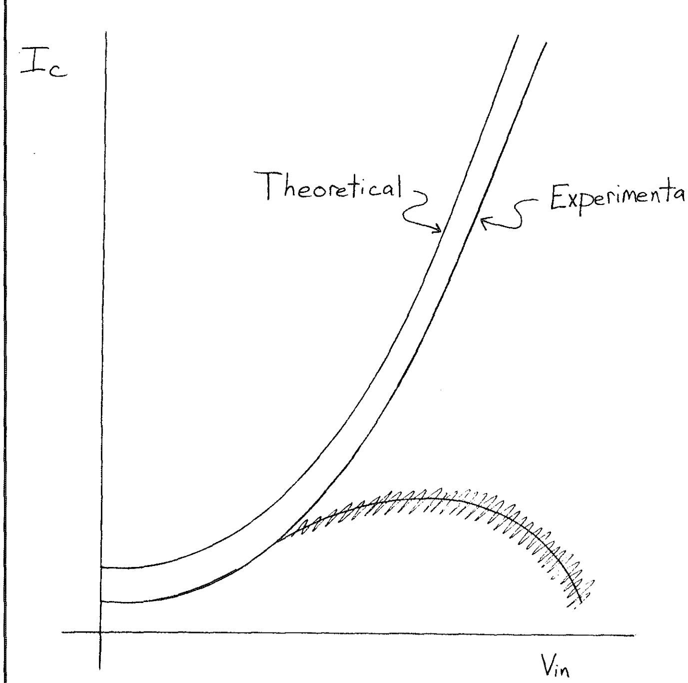
by Steve Littig and Conrad Teves



Newton experiences a quiet, thoughtful moment after an early gravitational experiment failed.

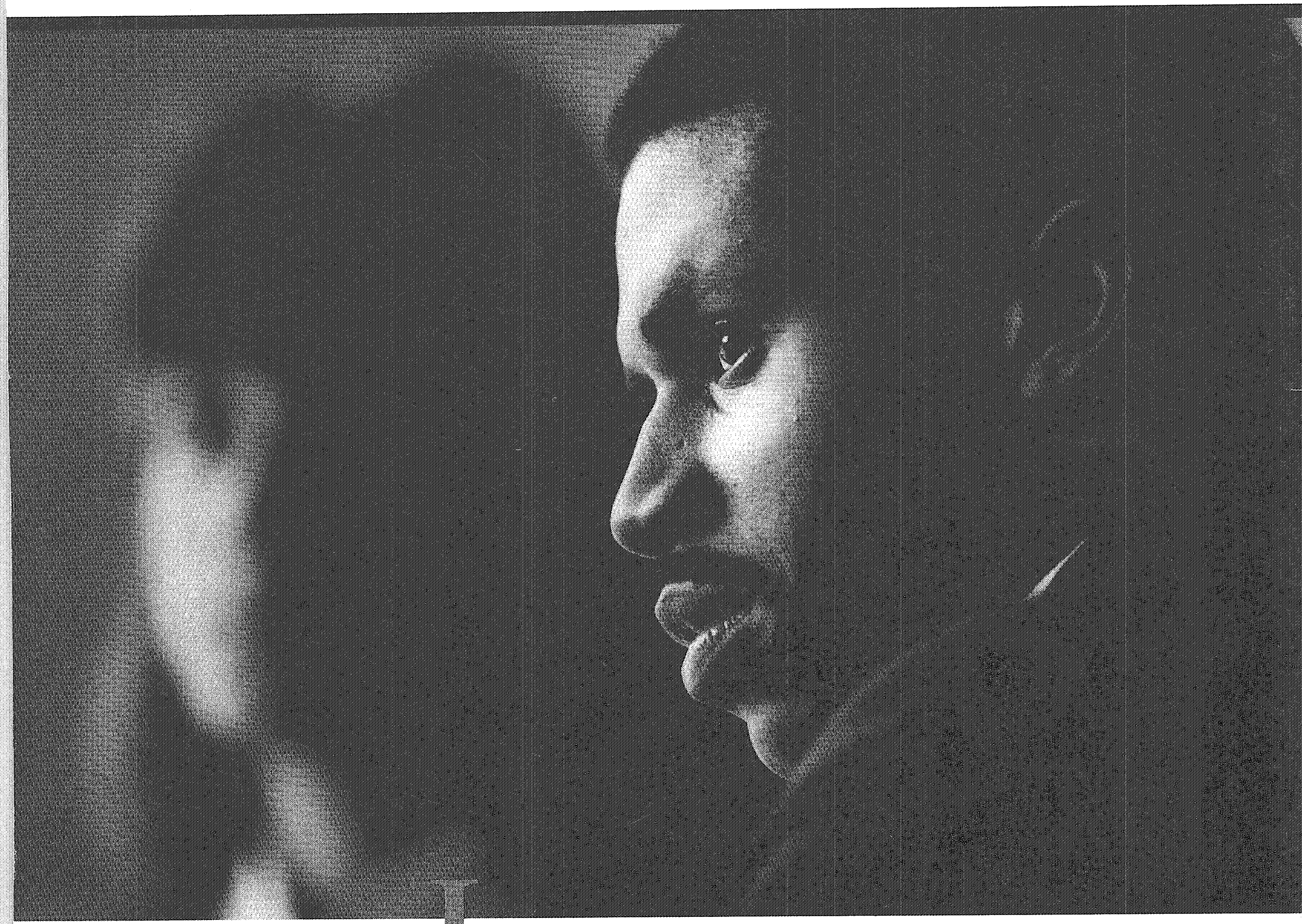
The Flip Side

by Jim Willenbring



Tom consulted Doctor Ed Data and his magic constant k when his experimental plot wouldn't fit.

Darryl Greene knows that teamwork is the key to winning.



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Spring One, 1989

Science Fiction/Future

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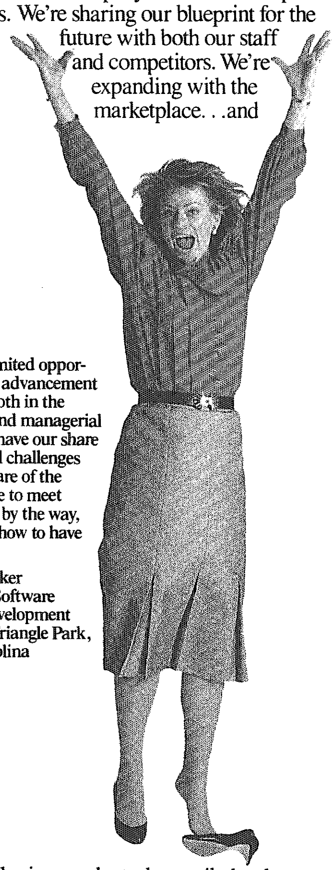

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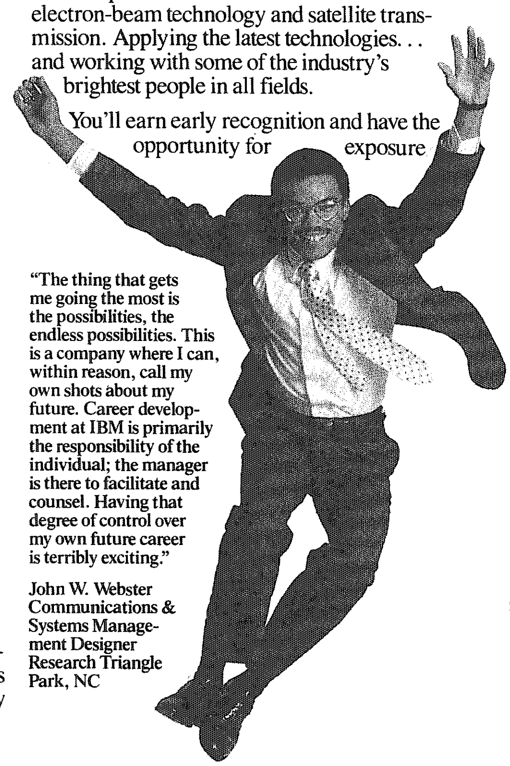

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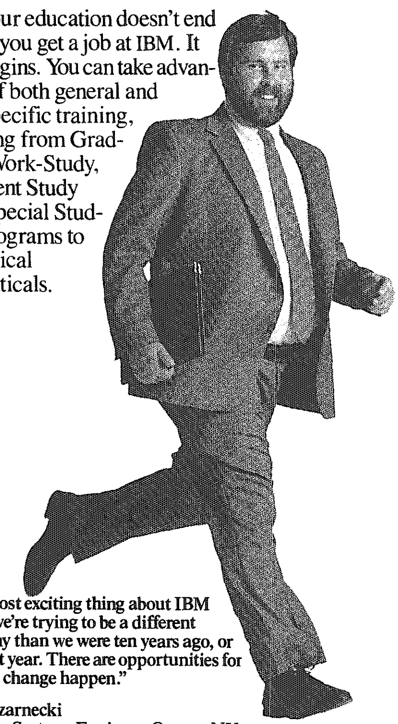

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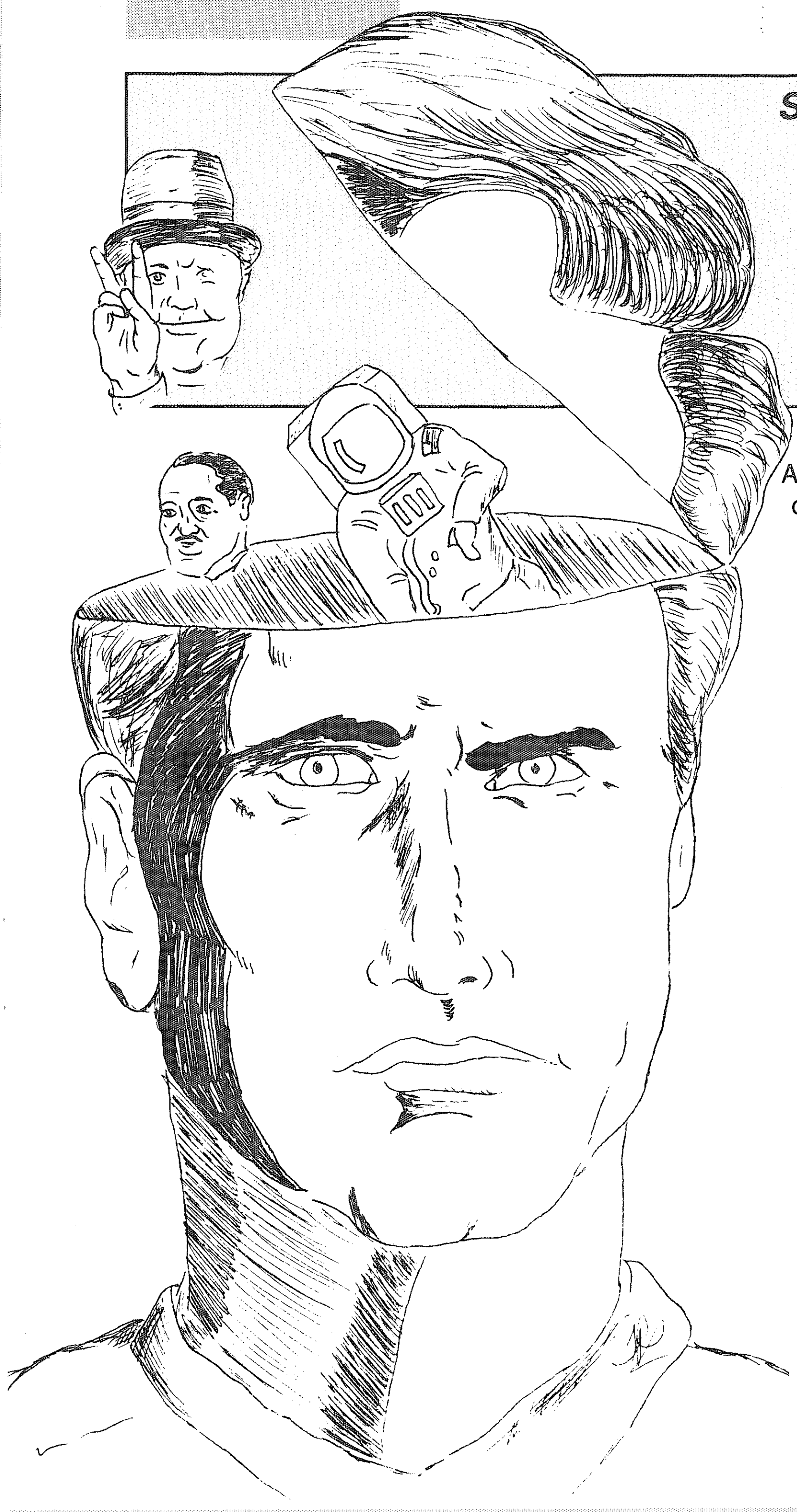

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Springtime Studying

by Steve Kosier

I have always thought it was a dirty trick to have school in the springtime. Who came up with this notion anyway? After a long Minnesota winter, all of us feel we deserve to spend time in the warm spring air. Not just some time, but a whole lot of it. It's such a novelty, it seems, to be able to expose your skin without fear of frostbite. I recommend not doing any homework or reading during these warm spring days unless absolutely necessary, since you will probably not be able to focus on your studies. After all, there may not be a day as nice as this one for a week or more, and it would be such a shame to waste it doing a problem set. And even if you do get some schoolwork done, you will wish you had spent the day playing golf, frisbee, softball, or just laying in the sun and soaking in the ultraviolet rays. This will create resentment and impair your productivity for many days.

Lest all the IT professors label me a heretic and a rabble-rouser for planting revolutionary thoughts in the minds of their students, I now offer some tactics for successful springtime studying.

Take your classes as early in the morning as you can. This will free up the warm spring afternoons for your favorite outdoor sport. After all, it is usually too cool to be outside without a jacket in spring, so a morning filled with classes doesn't cut into your valuable recreation time. Also, it is remarkably easier to get out of your warm, soft bed when the sun is already shining. Since the sun will rise earlier and earlier all quarter, it will become easier and easier to get up. By the time daylight savings time goes into effect, you will be a seasoned early-riser.

Even if you can't take your classes as early as you would like, or if you have some days without early classes, get up at the same time every day. Your body would probably welcome the regularity (or, if you're like me, it may be quite unprepared and not know what to do).

Try to fill a distribution requirement by taking a liberal arts course that requires outside reading. This requirement will force you to sit outside, read your book, and enjoy the warm weather.

Perhaps the best plan for faculty and students alike would be for the U to cancel classes on the first few days that the temperature gets into the mid 60s. This isn't as crazy as it sounds, because most everyone wishes they were outside on the first warm days of spring. Overall productivity might even rise because of the good spirits everyone would be in after such a break.

If I were you, however, I wouldn't count on this plan being implemented any time soon. A better bet would be to employ the springtime studying tips whenever you can.

Illustrations: ***Technolog*** **file**

Infinite Wisdom

by Thomas G. Jones

Blake stared blankly at the screen, the computer cord dangling motionlessly from the adapter connected permanently to his brain. Since he had successfully fused the neurons of a dog with copper wire, he could interface any living being's brain with a computer, combining artificial and natural intelligence and benefitting from the best of both. The problem with artificial intelligence had always been the system's inability to make decisions based on insight, past experience, or even intuition. This ability to reason was now given to the computer by the human brain. The electronics of the marriage between man and machine contributed its main strengths: speed, and the ability to organize and process vast amounts of information. The results were stunning: the human user could guide a system through a program solving problems of any kind, which previously had either been unsolvable, or which would have taken decades to solve. Blake had hooked up a friend who was a medical doctor doing research on the common cold. At the end of a thirty-minute session, he had discovered a cure.

But Blake had not yet marketed the system because it was not completely free of glitches. The biggest problem was unlinking the brain's functioning process from the computer system. It worked in the same way as a regular program, and a retreat from the system was only possible during a natural break in the program or at the end of it. Breaking in during the regular run of any program loop would instantly erase all the information contained in the human brain. It was for this reason that non-terminating equations had to be avoided at all costs during linkage. Hooking up and asking a simple math program the value of pi would lock the brain into eternal calculation of the figure. Any external attempt to break into the program during the calculation would result in the complete erasure of the brain's natural memory.

Blake had thought of this, as he always had, before he linked up on this particular day. He had run through the checklist, as always: no questions about pi. No philosophical or religious considerations. No questions about human emotion. He had it memorized. He knew what to avoid.

His wife, Andrea, was a little concerned. He had been hooked up for ten hours, longer than the usual four or five. She knew he was working on some standard physics equation, so there was nothing to worry about.

As she sat down to read some of her law texts, she muttered to herself, "I just wish I could talk to him while he's in there."

"So do I, Mommy," a high-pitched voice rang in. "He never says anything to me when he's working, even if I have a 'portant question."

"Billy, you know you're not supposed to talk to your father when he's working."

"I know, but this was really 'portant."

"Did you talk to him today, Billy?" Her voice grew a little louder.

"Yes. I asked him if outer space stops somewhere. And if it does, what's on the other side?"

"Oh Billy! ..." She was white. She jumped up, screaming ll the way to Blake's den. "You know you're not supposed to! ... You know you're not supposed to! ..."

She fainted when she looked at the screen. Billy was right behind. He stepped over her and looked at the words on the CRT, meaningless to him, repeating themselves from top to bottom:

"... but if that ends there's got to be something beyond that but if that ends there's got to be something beyond that but if that ends there's got to be something beyond that but if that ends ...."

Author Bio

Tom Jones is a senior double-majoring in international relations and French, but he still finds time to pick up the *Technolog*. He has had a number of opinion pieces published in the *Minnesota Daily*, and his dream is to be able to make a living writing political essays.

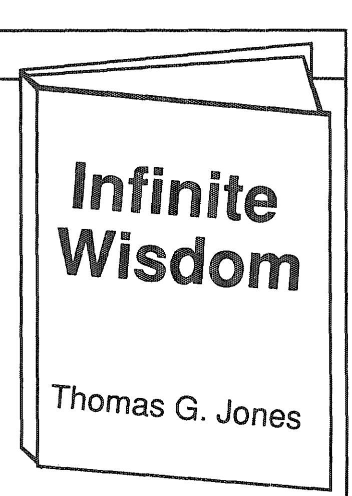


Illustration by Conrad Teves

SECOND PLACE

Caveat Vendor

by C. Ray Coleman

"For I am a Pirate King!"

"Hurrah for the Pirate King!"

"And it is, it is, a glorious thing, to be a pirate king!"

"It is! Hurrah for the Pirate King, hurrah for the Pirate King!"

Maxwell Sullivan let a whoop of sheer glee as he danced around the bridge of the Imperial Starship *Sao Paolo*. He grabbed the hands of his two partners in crime and waltzed them around the tiny chamber in dizzying circles while the deep black of the navigation 3-display turned to a brassy gold, indicating the successful translation to N-space.

"A coup for the history books!" Sullivan roared. He kissed Sheri-Ann Peters hard on the lips, and then tackled Desmond Flick with a flying bear hug. The three pirates collapsed in an exhausted heap in the center of the bridge and stared with increasing wonder as the navigation display showed them their progress toward wealth and freedom, and away from the Solar Empire.

"Translation to N-space is complete," announced the silvery voice of the ship's cognitor. "What are the Captain's instructions?"

Sullivan, Peters, and Flick looked at each other for just a moment, and then Sullivan proclaimed from his position on the deck, "Captain's directive."

"Proceed."

"The name of this vessel is to be changed. It will no longer be referred to as the Imperial Starship *Sao Paolo*, but rather, the Starship *Penzance*."

The cognitor digested this information in silence, and then responded: "This is highly irregular. You are not the captain, but I find myself constrained to accept your directives. It shall be as you order, but I must lodge a formal complaint."

Sullivan suppressed a smirk. "Acknowledged," he replied in his best command voice.

The *Penzance* was a small ship, as befitted its mission as long-range exploration vessel and part-time upholder of the dignity of the Solar Empire. It was barely one hundred meters in length, and only one-third that in width. From outside, had there existed any observer who could persist unsupported in N-space, it would have looked like a stubby cylinder, squared off at both ends, and polished by its film of space-normal into a perfect mirror. Since no one could exist independently without his own shielded region of four dimensional space-time, such a view was essentially impossible. However, an analogue of the ship in its inhospitable environment did appear in the navigation display on the bridge, where an imperfect interpretation of the vessel's external condition was projected for the delectation of the officers and crew.

Today (as such was measured by on-board chronometers) the crew of the Sao *Paolo* was missing, and in its stead the three pirates of the *Penzance* sat looking at the imitation marble and gilt of the bridge.

Sullivan, as befitted the captain, sat above the navigation display on a command chair that bore more than a passing resemblance to a throne. Sloping away below him was the navigation display, which was a rectangle some five meters by ten in length and width, and apparently infinite in depth. Below, looking up at the starfield of the display, and at the captain's throne, sat Flick and Peters, each occupying several of the stations usually filled by the Imperial officers.

Caveat Vendor to page 8

Author Bio

C. Ray Coleman, a graduate student studying sociology, is a long-time fan of science fiction. His personal goals in the genre are to publish the first truly hard-core social science fiction novel (Keep an eye out; its tentative title is *Social Wars*.) and to attend many conventions at the fans' expense.

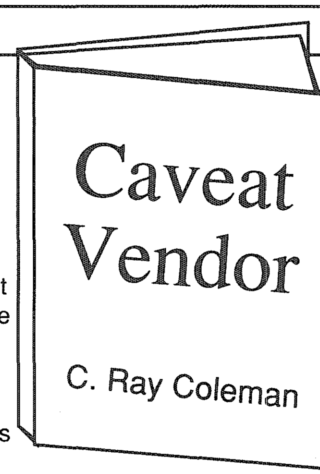


Illustration by Tony Tong


SOLA EMPIRE
2200
SOLA EMPIRE
SAO PAOLO

Caveat Vendor from page 6

Sullivan raised a goblet, filled with the most expensive officers' rum, and proposed a toast to his pirate crew. "I damned well didn't know that the Imperials lived so well. The hell with them— to us!"

"To us!"

Sheri-Ann, from her post as fire-control officer, frowned. It was not simply that she and Flick were not sharing in the purser's rum. She was worried about the future. The Solar Empire would surely not sit idly by while one of their exploration vessels was hijacked. The theft was infinitely more important than the worth of the ship itself. In the memory net of the ship's cognitor could be found the proprietary algorithms upon which Solar civilization was built.

"Max," she said, "the algorithms on board are worth a fortune in the colonies, and the Solarians know it. How the hell are we going to stay alive long enough to make a profit?"

Sullivan took another long draught off his rum (he was beginning to enjoy this captain business) before he spoke. "That's Flick's department." He fixed Flick with a baleful glare. "You said you could break the cognitor before we make it to New Minnesota. You'd damn well better, or we aren't going to survive this little adventure, let alone get rich."

Flick spat on the deck, a surprisingly disrespectful gesture. "I'll do my part Max. You just make sure that the Minnesotans will deal with us. Algorithms or not, if they turn us over to the Empire, we're history."

Sullivan got up from the captain's chair, and descended the long, marble stairway which passed along one side of the navigation 3-display. When he reached the bottom, he stopped to look into

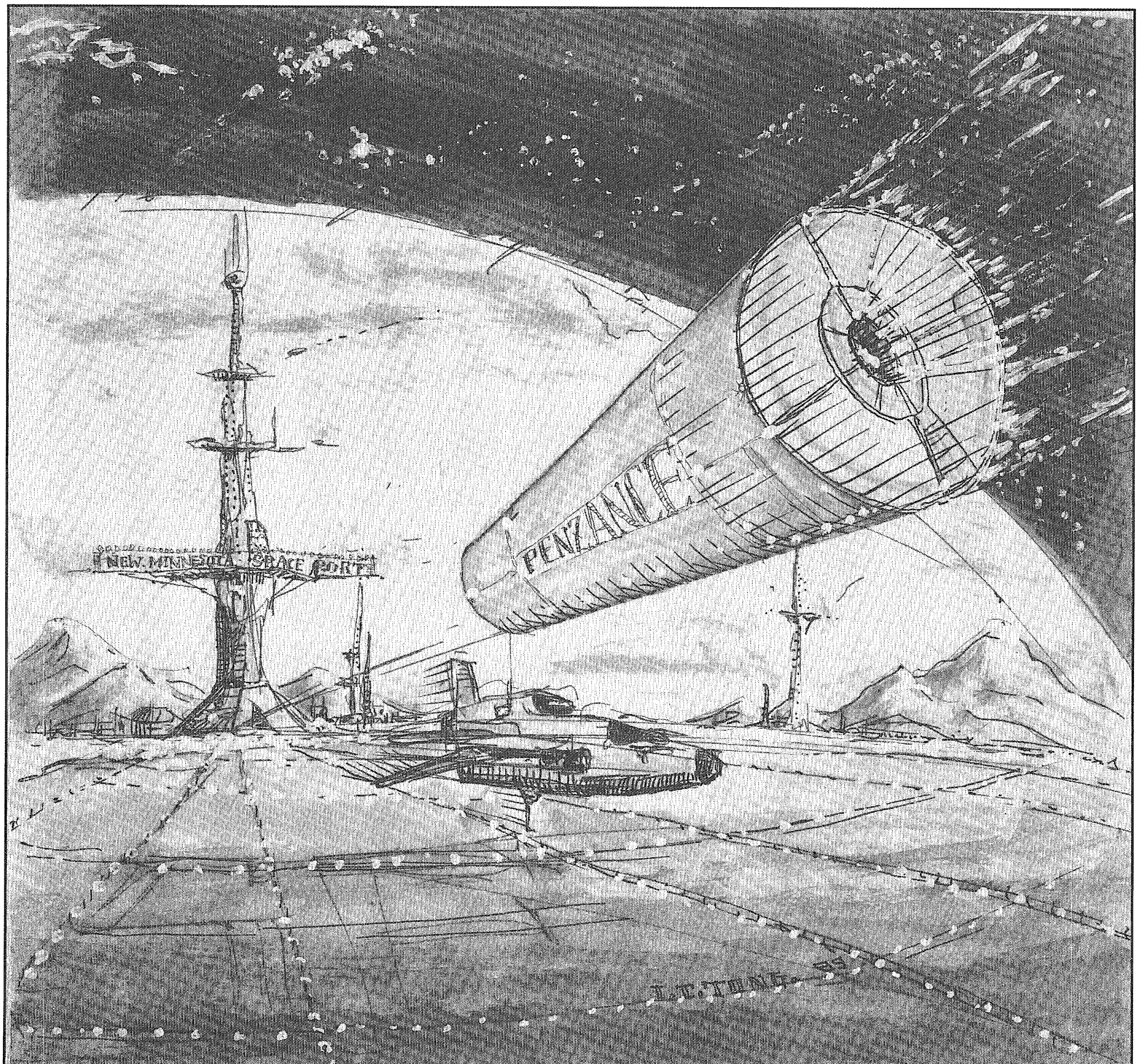


Illustration by Tony Tong

the depths of N-space as it appeared in the three dimensional tank. "Two problems," he muttered to himself. "Neither easily solved."

The nature of the Solar Empire was singular. As far back as the late 20th century it had become apparent that political economy was simply a way of handling, distributing, and manipulating information. With the achievement of Universal Constructors in the early 22nd century, this conceptual approach to economics became de facto, as well as de jure. With the ability to create anything which could be sufficiently described, the capitalistic energies of the Solar System shifted from the creation of goods to the creation of the algorithms which produced them.

Interstellar trade crawled along at light speed, while algorithmic advances on Earth paced on at the speed of thought.

With the launching of the first colony ships, in the wake of Universal Constructors in the form of Von Neuman probes, this information processing society transcended solar limitations and became interstellar. Sol kept a light hand on its colonies militarily, since warships did not produce algorithms. The empire ruled instead through its decades-long head start in algorithmic technology. Algorithms were beamed to the colony worlds via electromagnetic radiation in a successful attempt to preserve the Solar monopoly on economic power. Interstellar trade crawled along at light speed, while algorithmic advances on Earth paced on at the speed of thought.

Only New Minnesota had arisen among the colony worlds to challenge Solar domination, and a feeble challenge it was. Hierarchic and oligarchic as the empire itself, it represented the only immediate haven for the three fugitives from Solar justice. In effect, Sullivan and his crew were banking on trading their stock of Solar algorithms to the Minnesotans, years before the Solar data transmissions would reach the planet. The holds of the *Penzance* might be small, but the neural network of the ship's cognitor held the most modern in information. The pirates would physically bring to the colony worlds, at superluminal speeds, what the empire deigned to transmit at the speed of light.

"New Minnesota. Why is it called that?"

Maxwell called down from his captain's throne above the navigation display, "Because of its miserable climate. Just like Minnesota in the old United States."

Sheri-Ann looked deep into the 3-D display at the lovely planet of blue and white which *Penzance* currently orbited. "So where is this Minnesota?" she asked.

Sullivan laughed. "You damned Europeans. You don't know anything but your own history." He rubbed his hands across his face, and then through his thinning blond hair. "Minnesota is God's country, in the heart of North America."

Sheri-Ann couldn't help smiling. "I take it then that you're from Minnesota?"

"*Touche*."

Flick entered the bridge, coming up behind Sullivan from the long, curving passage that contained the crew's quarters. He stopped short, and put out hand on the back of Sullivan's chair. Flick's brown, lined face showed his unhappiness.

From down on the first level Sheri saw Flick's grave countenance before Maxwell did. "What's wrong," she asked.

Flick shook his head. His jumpsuit was unkempt, and his eyes had a reddened look. "I can't get into the neural net. I don't know what the hell is the problem. I just can't.."

"Captain," interrupted the ship's cognitor, "we are receiving a transmission from New Minnesota Port Authority. We are granted docking permission. Our orbital assignment puts us only seven hundred kilometers away from the Imperial Starship *Vengeful*."

Flick loosed a string of obscenities. They floated like a cloud in the chilled air of the bridge. The cognitor, adversary as well as servant of the pirates, asked, "Is that to be considered an official response?"

"Smart ass. Reply to the Port Authority, and leave the humor to us."

"Yes Mr. Flick."

Capitalism is an interesting phenomenon on the interstellar level. Finished goods are far too expensive to transport across the void. Furthermore, the presence of Universal Constructors on the colony worlds make the effort ridiculous. In the brave new world knowledge is power, and power is knowledge. The three pirates had gambled their survival on this equation. Now, sitting in a tight parking orbit over the frozen surface of New Minnesota, they pondered the sense behind their decisions. Flick was making no headway in breaking the iron conditioning of the ship's cognitor. Each twist and turn of his meta-logic brought only amused silence from the mind which ran the *Penzance*, while the tell-tale indicators recorded the clandestine communications between their own ship's brain, and the electronic mind which ran the *Vengeful*, only hundreds of kilometers away. Was this treason, a sort of mechanical mutiny? Of course not, replied the cognitor. Piracy conferred no sense of obligation or loyalty.

Sullivan stood before the captain's throne, rum in hand. The gilt and marble bridge of his stolen vessel mocked him with its vision of the luxury available to the elite of Solar society. He took a swallow from his drink and looked deep into the navigation display. Floating there, like a glittering sphere of ice, was New

Minnesota—a world too much like Earth to offer any hope of solace. Instead, it held out the slim chance of immediate survival, and freedom from Solar tyranny if success should crown the efforts of *Penzance*'s piratical crew. A communication had been received from the Minnesotan government, inviting the commander—not the captain, the Minnesotans were hedging their bets—of the *Sao Paolo* to a conference on the planet's surface. As an inconsequential afterthought, the message had informed Sullivan that an officer of the *Vengeful* would also be present. The meaning was clear: deliver the goods, or be turned over to the Solar authorities. Could the goods be delivered?

"Mr Flick, progress report."

Flick, who had come up behind Sullivan, made a disrespectful snort. "Don't take that military tone with me Max. It's not becoming in a pirate."

Sullivan grimaced. "Sorry, Flick." He assayed a smile. "Standing here on this damned bridge makes a man feel like he's some kind of aristocrat. Golden instrument panels. Can you believe it?"

Flick looked away for a moment. He took in the incredible luxury on what should have been a fighting vessel. When he looked back at his partner in crime he saw the bags under Sullivan's eyes, and the new wrinkles in his face, which hadn't been there when the adventure had been planned. "Jesus, Max, I'm sorry too. I can't make the damn machine respond to my logic probes. If I could break the thing, we could have gold carpeting and platinum fixtures in the washrooms. I'm stuck."

> In the brave new world knowledge is power, and power is knowledge. The three pirates had gambled their survival on this equation.

Max looked down into the navigation display, at the frozen world that hung beneath them. "I'm stuck too, Flick. Either I give the Minnesotans what they want, or we all go home in the *Vengeful*'s brig. *Vengeful*, there's coincidence for you. We won't last thirty minutes back in the Solar System."

"What are you going to do?"

"Bluff, Mr. Flick, bluff." The pirate king drained his golden cup of rum, and tossed the precious goblet to the deck. Without the algorithms stored in the ship's memory the gold was useless; with the algorithms, the gold was worthless. A fitting analysis. Sullivan gave Flick a sardonic Naval salute, and stalked off the bridge.

The wind was frigid on New Minnesota. It matched the temperature of the greeting Captain Maxwell Sullivan received from the Minnesotan authorities. They met him not in a warm and quiet transport station in their government precincts, but rather in an industrial facility at the space port. He had materialized unprepared for the dizzying bite of the winter wind, only to find himself faced with the icy countenances of the Minnesotan officials. In an unexpected maneuver of singular importance, the Minnesotan officials had brought crewmen from the *Vengeful* to meet him. It was clear that the failure of *Penzance* and her crew was a foregone conclusion.

"Gentlemen," Sullivan said. If the Minnesotans responded, it was lost in the bitter wind.

"Mr. Sullivan, I am Talcott Coleman. I have been detailed by the government of New Minnesota to adjudicate your claim to the vessel that is currently orbiting our world. With me are my assistants, whose names you need not know. Also with me is Commander Alex D'Artois, executive officer on board the Imperial Ship *Vengeful*. He claims you are a pirate. And that hanging is too good a death for you."

Sullivan stood and faced the Minnesotan official. He stood because he had been offered no chair. The meeting room was arrayed in those dark, somber tones that the natives seemed to prefer, and Mr. Coleman sat with his assistants behind a long, polished table of local wood. It was no doubt significant that the executive officer of the *Vengeful* also sat behind that table. Adjudicate, the Minnesotan had said. Coleman was to judge the pirates, not treat with them. Sullivan could not help wonder if the man was empowered with both the high and the low justice; a hanging would be a hanging, wherever it took place.

D'Artois tried to speak first. "Mr. Commissioner, I must protest the treatment given to this criminal, and I demand in the name of the Solar Empire that he be turned over to me for removal to the System in order . . . ."

"Please be silent, Commander," interrupted Mr. Coleman. "I am well aware of the position of the Empire, and of New Minnesota's position relative to it." He turned his attention to Sullivan. "We will dispense with the usual procedures, Mr. Sullivan. You have been accused of piracy. There is only one answer to this allegation. You are well aware of what that answer is. Are you prepared to give it?"

Sullivan took a deep breath. Play out the drama. Follow through to the bitter end. No other course was now available. "I am," he said. "But first I would like to address this panel."

"Is it germane?" Coleman asked.

"It is."

"Very well."

D'Artois, red in the face, objected. "Mr. Commissioner, I must protest!"

"Indeed?" Coleman commented. "Please continue Mr. Sullivan. I do not need to remind you of what is at stake here."

Maxwell Sullivan took a deep breath. He composed himself as best he could, and proceeded to plead for his life.

"Independence is the core of the matter here," he began. "With the Universal Constructor, anything that can be imagined can be built. But imagination must be couched in the proper terms. The Solar Empire keeps its control over known space not through force of arms, but rather through its stranglehold over the algorithms that create what we need to survive."

"Is this new?" interjected Talcott Coleman.

> We can break that stranglehold. ... Deal with us, and you can have those technologies years before the Imperials would deign to let you have them.

"We can break that stranglehold. In the memory of the *Sao Paolo* are the algorithms for untold technologies which the Solar misers are only now beaming to you at light speed. Deal with us, and you can have those technologies years before the Imperials would deign to let you have them."

Coleman seemed amused. To his left, Commander D'Artois was apparently undergoing a mild fit of apoplexy. The commissioner ignored the Naval officer's showy discomfort. Coleman stood, and his assistants stood with him. "You know what we need," he said to Sullivan. "Proof. We will not risk confrontation with the Empire without it." The commissioner turned his aggressive eyes on Sullivan—his attitude demanded a reply.

"Show me," the commissioner commanded.

"Open communications with the *Penzance*."

"*Penzance* here." The voice was Sheri-Ann's.

"Sullivan here. Do you receive me?"

"We do indeed. Proceed Captain Sullivan."

"They want proof, Sheri-Ann. Give it to them."

"Aye sir."

Sullivan took another of those deep breaths. Bluff had carried him this far. It was up to Flick and Sheri-Ann from here on. He looked at the men before him. D'Artois, with the sneer of the Solar aristocracy on his well-bred face. Coleman's assistants, the blank expressions of the career bureaucrats. Coleman himself; doubt, distrust, and hope. Hope? The chance to throw off the hegemony of the Solar Empire. The chance to make New Minnesota into an empire in miniature, with Coleman and his like firmly on top. Damn them!

"Captain Sullivan, we have your coordinates locked in, and we are ready to transmit on your signal."

"Miss Peters, you may transmit."

Time slows when life and empire is at stake. Coleman saw his future, and his world's, take shape on his assistant's cognitor screen. D'Artois jumped to his feet, and screamed, "Non!" in his native French. Sullivan fell forward, and caught himself on the edge of the fine table of native wood—his traitor knees had been rescued by quick hands. Over all the excitement could be heard the silvery voice of the cognitor: "Transmission of algorithms completed. This is *Penzance*, bidding you good day."

"Now what, Captain?" asked Sheri-Ann Peters.

Sullivan shifted in his captain's throne. In his hand he held a find crystal goblet full of the finest ship's rum. "Now we get rich," he said. "There are years' worth of algorithms crawling through space at light-speed. We put ourselves between Sol and the colonies, and we pick them up. Then we carry them to the inhabited worlds at FTL. The colonies get the new technology years ahead of schedule, the Solar Empire gets the shaft, and we get filthy rich. Almost everybody is happy!"

"Yes sir!"

"For he is a Pirate King!"

"Hurrah for the Pirate King!"

"And it is—It is!—a glorious thing to be a pirate king!"

"It is! Hurrah for the Pirate King, hurrah for the Pirate King!"

"This is *Penzance*, bidding you good day."

THIRD PLACE

#3309

by Robert Johnson

Alec awoke, as usual, stiff and unrested—but somehow sensing that today would not be the rat race as usual. As he stretched and helped himself to something to drink, he began to trace his own thought paths from the night before.

Tracing was Alec's talent, his vocation. In our society he would be considered a librarian or, more appropriately, a record keeper. The difference was that Alec didn't work with catalogs and microfiche; instead he worked with thought paths. He was to trace the thoughts of the great minds of his race. Some of these thoughts were generated just moments before he traced them and others dated back to the very origins of his race. Each time a thought was traced the path became more established. Those thoughts that were most frequented Alec did not have to bother with, for over time these had become as permanent as the floor that Alec stood on. Alec's task was to trace those thoughts not used so often—thoughts either so bizarre that no one else could trace them or so mundane that no one else cared to. He enjoyed his work and learned much from the thoughts he traced. Over time Alec had even developed a few worthy theories of his own—not that it mattered. Alec was not one of those great minds of his race and he accepted that.

Alec could enter the massive thought highway system at any convenient point, but it was often easiest to enter at one of the main thoroughfares. These had been altered by specialized groups of tracers to allow passage of more than one mind at a time. Even though thought travel occurred at near light speed, congestion could still be present at some of the more common ideas if a lot of people were researching on the system. The advantage to entering the system on a common, though congested, thought path was that you didn't find yourself caught on a fleeting thought—some diversion from the overall train of thought that didn't lead anywhere. Billions of thoughts enter the system each second and not all of them are worth saving for posterity.

Today Alec had decided to enter the system on the topic of interspecies communication. He chose this because he knew that was where his dreams from the previous night would be, just as they had been for some time now. Alec passed through centuries of research on the topic and after very little searching found his own dreams from the previous night. Of course he could have simply traced his own thought path directly from the present to last night's dream, but having to go through all of the thoughts inbetween was time consuming. Besides, it was usually pretty easy to find one's own thoughts. For Alec, as it was for most of his race, he would be the only one to ever trace those thoughts. Tracing one's own thoughts did not enter them into the general system. Someone else, another tracer like Alec, would have to trace them and no one else would ever trace Alec's thoughts—it simply was not done. Alec was not born into the class of great minds and it was generally assumed that any thought of a lesser mind was probably already thought of by a great mind. Even if it wasn't, lesser thoughts were simply not worthy of preservation. Alec's dream would not be preserved for anyone other than himself.

This particular dream was one that Alec had traveled many times before. A dream of peace where the clash between ruling species would stop and be replaced by communication and cooperation. As Alec raced on, the dream now focused on this communication—not the interpretation and guesses from physical motions and incoherent sounds but real communication between the species.

Now the dream path began to take a new twist and Alec followed with new interest. What if the minds were not linked through conscious thought, but through subconscious thought instead, a no-man's land where both species proved equal? Suddenly

#3309 to page 14

Author Bio

Robert Johnson, a senior in aerospace engineering, plans to get a real job after he has graduated (i.e., he will join the rat race) next winter. After securing valuable work experience he intends to return to school for an MBA. He enjoys downhill sking, and, not surprisingly, would like to work in Colorado.

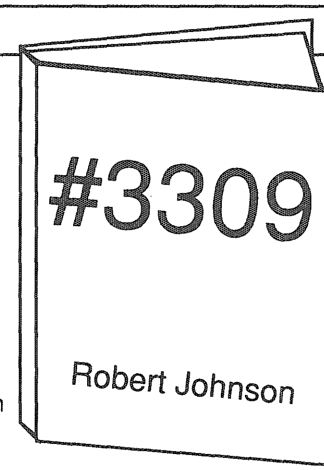
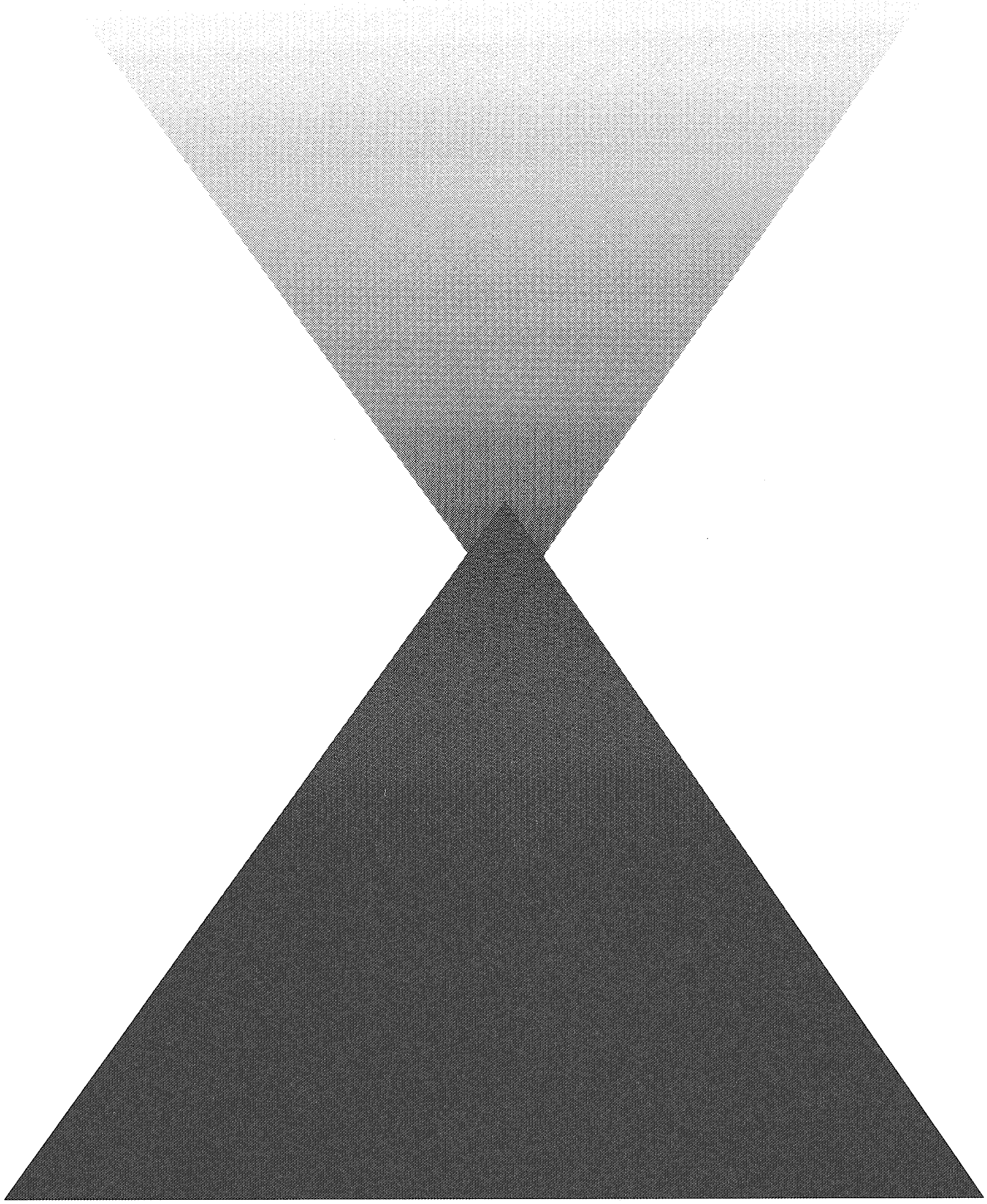


Illustration by Dave Jensen



#3309 from page 12

something was quite different. He was not the only person to have traveled this path. No, someone quite different had been this way. Two thought paths crossed here and they had arrived from two very different sources. One was his but the other was very different. When the two paths separated it was this new path that Alec now followed. His mind raced through a thought path so different, so unique, that Alec had to do all he could just to follow it.

Suddenly it clicked. Alec knew where he was. The connection had actually been made! All of the research he had traced had shown that the link between species would come only after single members of different species shared the same thought at the same time. Much had been done to try to induce this shared thought. Most great minds agreed that attacking or terrorizing the other species would induce fear that would somehow create a common thought. Some common members of Alec's race, however, saw this as only driving the two species apart. It was those people, like Alec, who thought the link would only come through cooperation. They went along with the apparent wishes of the other species and subjected themselves to their torturous will in hopes of increasing the chances of that shared thought. Yet here was the link, after centuries of interaction, not in the conscious mind at all, but in the subconscious.

Alec now raced along these new paths looking to find the current train of thought. This was it! He found it. Faster and faster he traced until—NO—it couldn't end like this. They had so much to teach each other. Alec had traced this new path only to find his own end and no one would follow his thoughts here—it simply wasn't done.

Sharyl opened the door and removed #3309 from the cage. Funny, it seemed as if both of them knew this would be the one to do it.

8:45 AM entry 1 Rat Specimen #3309
Death 1:03.5 after injection
0.010 A113 concentration

As Sharyl looked down at the dead animal in front of her, she could not help but remember the dream she had the night before. It was almost as if she really communicated with an animal just like this one. On the way to work she had thought of mentioning the dream to Dr. Green, but then thought better of it. She couldn't talk to someone like Dr. Green about her dreams—it simply wasn't done.

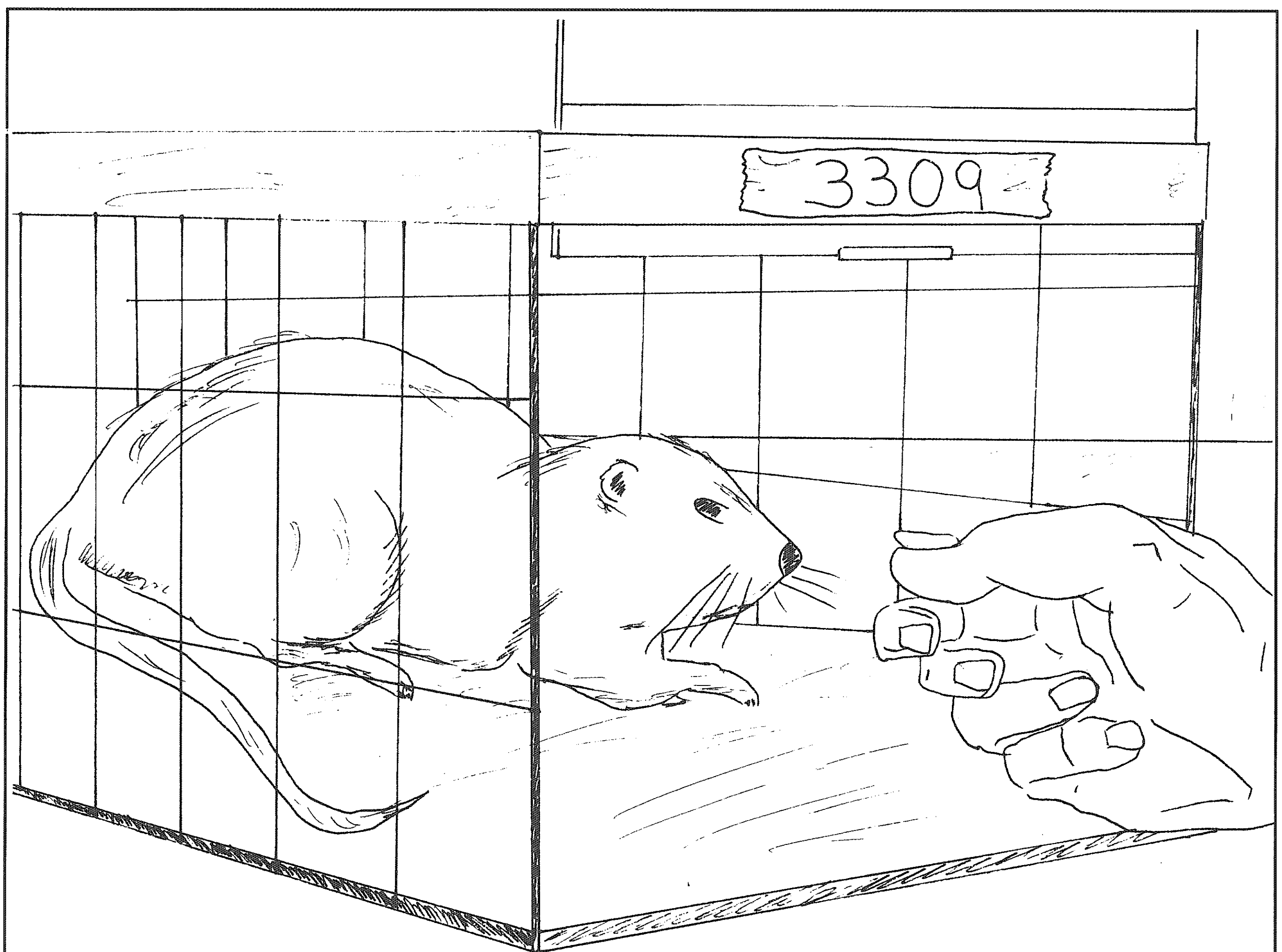


Illustration by Thomas J. Rucci

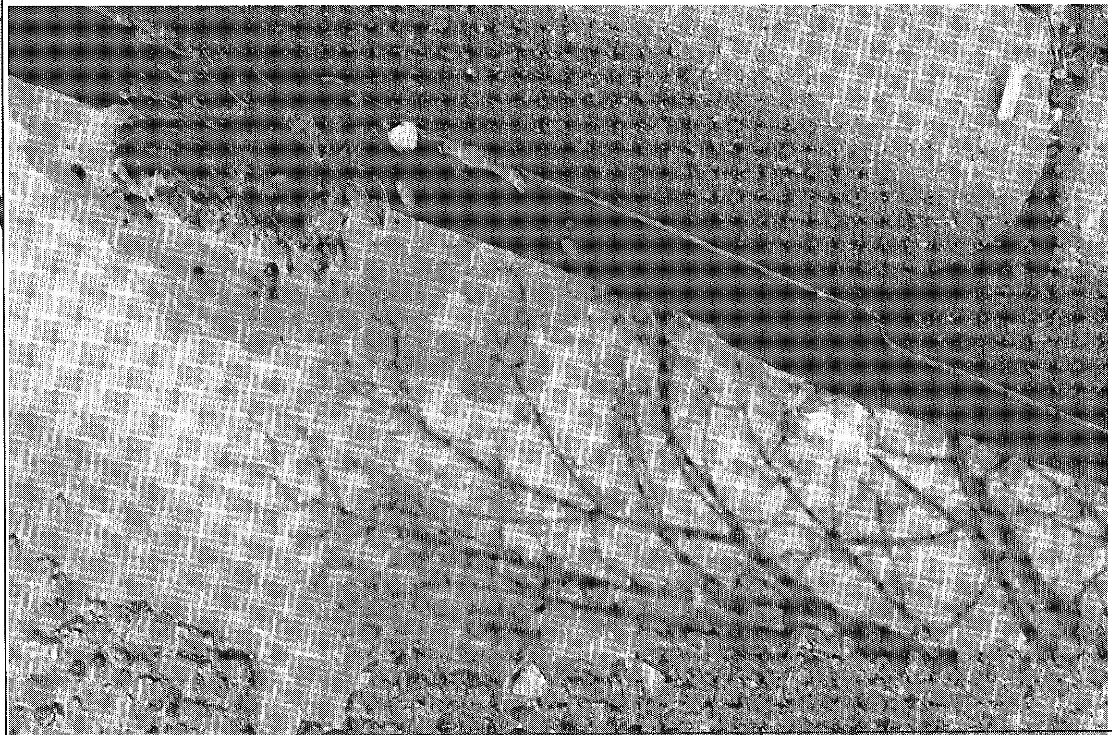
EYE of the CAMERA

Encouraging a fresh look at reality is certainly one of the missions of science fiction writers. Although their stories are often set in the future, a science fiction writer usually intends that his or her work illuminate an issue in the audience's current reality. Similarly, artists working in visual media aim to render refreshing or unexpected outlooks on the world around us.

The *Minnesota Technolog* is pleased to present the winning photos from the second annual "Anything Goes" Photography Contest. We would like to thank all the readers who submitted photos. We hope you enjoy the winning entries.

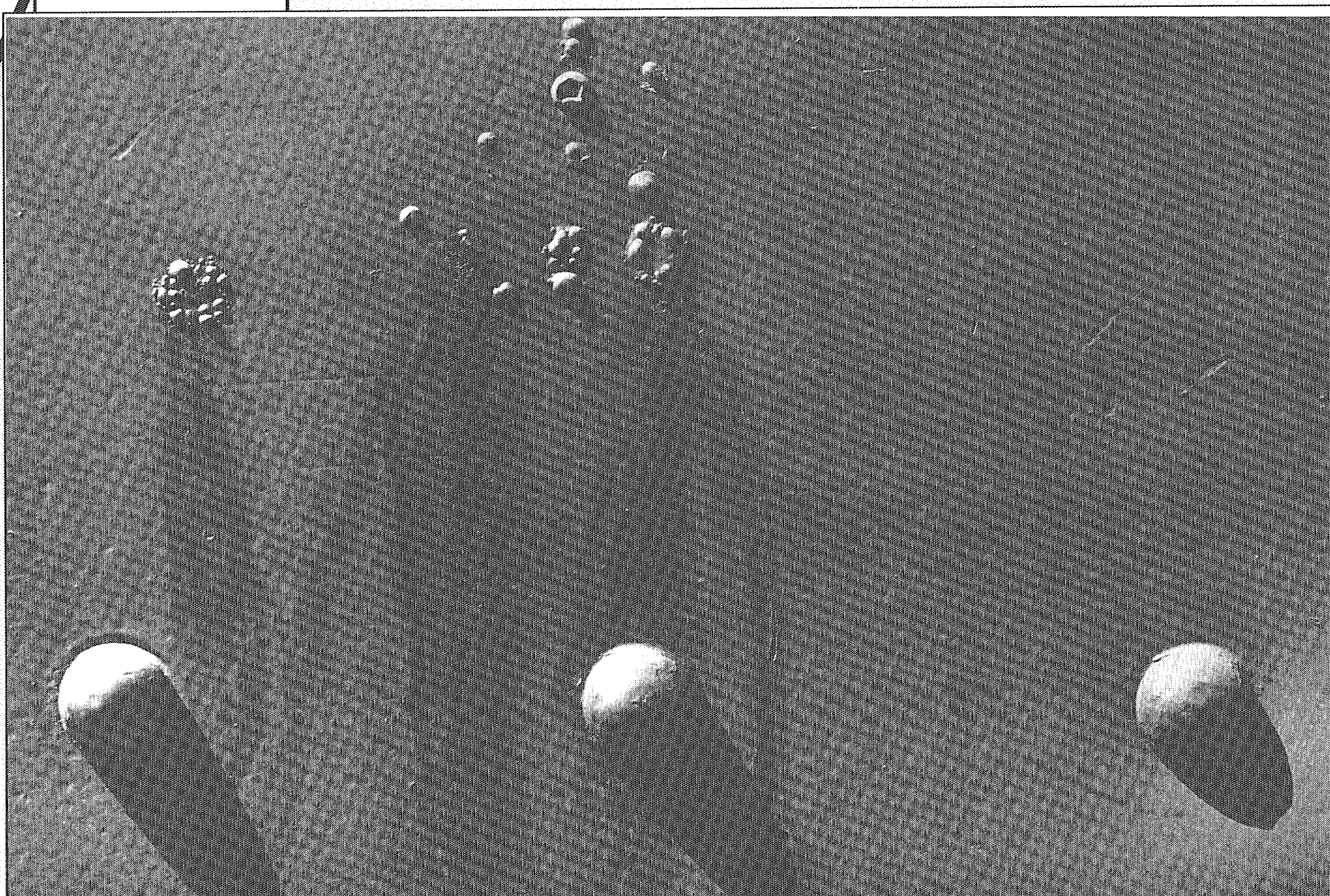
First Place

by youth DK



Second Place

by Eric Peterson



Third Place

by Eric Peterson

Hypertext

by Chadburn A. Blomquist

Remember the last time you were in the library researching material for your next paper?

Imagine yourself walking into the library, going to the card catalog, and looking up a book on J. S. Bach. You find numerous listings and head for the location in the stacks. You locate the books, and while paging through, you notice that he was born in 1685 in Eisenach, Thuringia.

Thuringia?

So you write this down and return to the card catalog for a book on historical geography. Back to the stacks you go looking for a reference to Thuringia. After a brief search, you find that Thuringia is now in East Germany. What did Thuringia look like in 1685, you wonder? Back to the catalog you go, looking for a book with images from that period.

You return to the reference on Bach and discover something extraordinary about his last piece of work: "The Art of the Fugue." Apparently he inserted his name coded into the notes as a theme. Strange, you say? Especially when you think back to the mnemonic learned in grade school music class—"Every Good Boy Does Fine." There is no "H" in the musical scale! How did he do this?

Back to the stacks you go to look for music from Germany in the mid-1700's. You find a reference to the music, locate it, and discover the secret to Bach's ingenuity. In most countries the musical scale ranges from "A" to "G," except in Germany, where there are two differences. What we call "B" they call "H" and what we call "B-flat" they call "B." So his theme was "B-flat - A - C - B, or B-A-C-H."

Lastly, you would like to hear this piece. You write down the name and head for the library record collection.

Time consuming process, don't you think?

Now imagine sitting at your personal computer with a Hypertext system. Hypertext (very basically) is a data base management system that allows you to connect ideas, facts, pictures, sounds, etc. through associative links. You ask the computer for information on J.S. Bach. It finds the reference and gives you a brief (encyclopedia style) description of him and a brief personal history. By highlighting his birth place (1685 in Eisenach, Thuringia), you request more information about Thuringia by either a mouse click or a few keystrokes. Perhaps a map with the city of Eisenach highlighted appears. You return to your original information, highlight "musical pieces," and immediately are given a list of all Bach's works. You select "The Art of the Fugue." You may either choose to read a history of the piece, or even have the computer play it while you learn more about the genius who composed it.

Sounds far out doesn't it? It may not be as far away as you think.

Perhaps a more descriptive definition of Hypertext comes from *Byte* magazine: "Hypertext is a software environment for collaborative work, communication, and knowledge acquisition." Hypertext effectively mimics the way our brain links pieces of information together, allowing for quick and intuitive access.

There are perhaps four categories of Hypertext systems: problem-resolution systems, on-line

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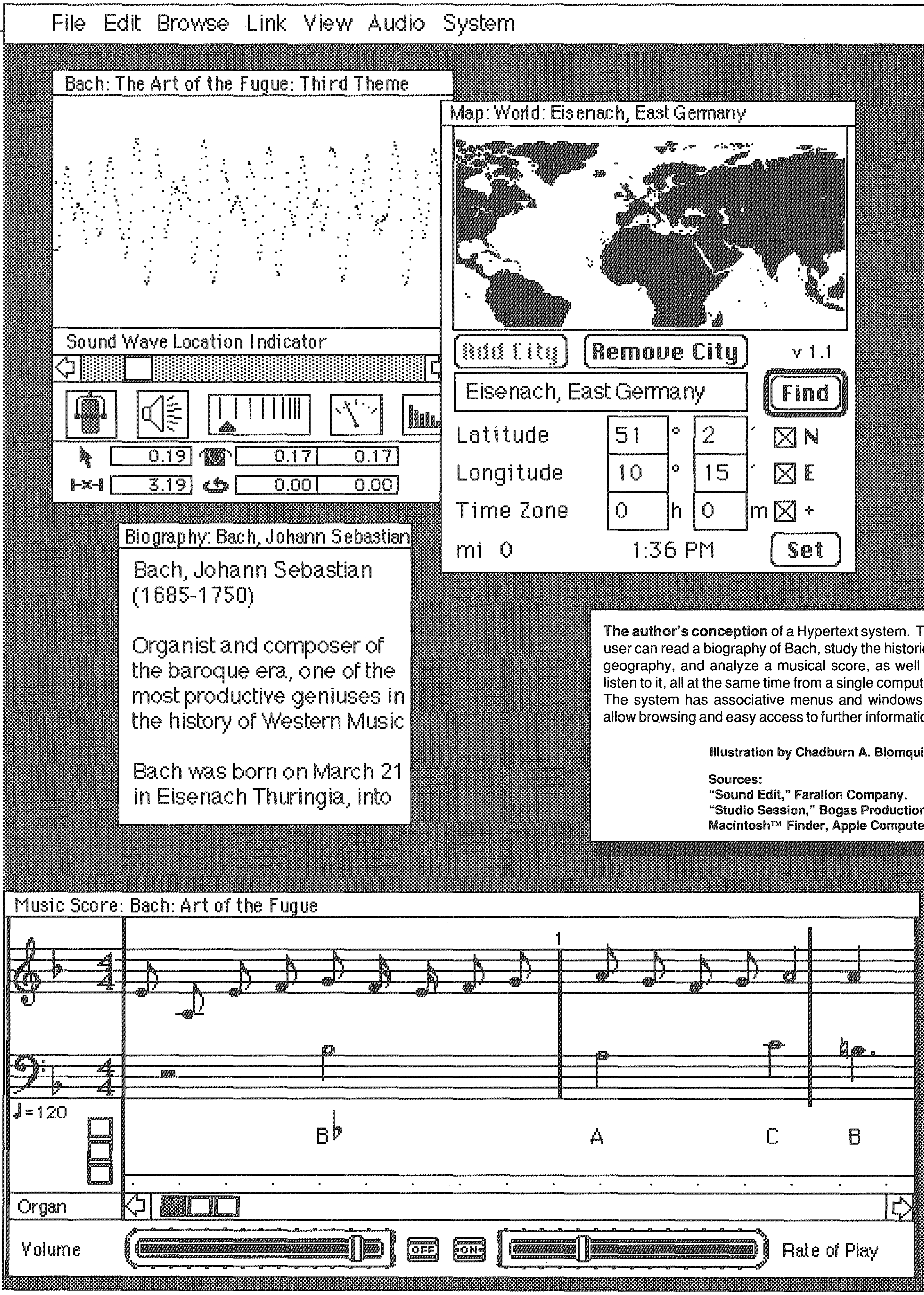

The author's conception of a Hypertext system. The user can read a biography of Bach, study the historical geography, and analyze a musical score, as well as listen to it, all at the same time from a single computer. The system has associative menus and windows to allow browsing and easy access to further information.

Illustration by Chadburn A. Blomquist

Sources:
"Sound Edit," Farallon Company.
"Studio Session," Bogas Productions.
Macintosh™ Finder, Apple Computer.

Hypertext History

The Hypertext concept has been around for about forty years. Vannevar Bush, President Roosevelt's science adviser, envisioned a machine called the "memex." This machine would serve as "an intimate supplement to man's memory." His machine would store—via microfilm—every bit of information useful to the owner. This includes books, notes, pictures, newspaper articles, and documents. Bush said, "The human mind snaps instantly from one related thought to another, following an intricate web of associative trials. The speed of the action, the intricacy of the trails, the detail of mental pictures is awe inspiring. Man cannot hope to fully duplicate this mental process artificially, but he certainly ought to be able to learn from it." Although never created, his machine became the inspiration for some of the current research in the Hypertext (artificial intelligence) field.

Douglas Engelhart (inventor of the mouse input device), for example, was influenced by Bush's vision. At Stanford University in the 1960s, Engelhart performed research

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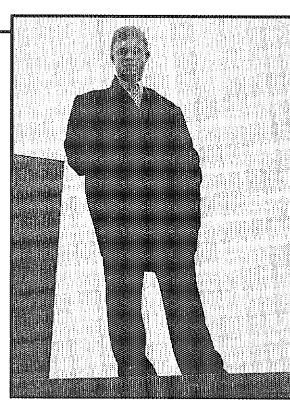
browsing systems, library or literary-exchange systems, and multipurpose systems. Systems for problem-resolution deal with organizing elements of unstructured problems, providing links to key concepts and facts. On-line browsing systems incorporate large data base scanning with associative linking. Library or literary-exchange systems help link literary material together under a network of discrete associations. Finally, multipurpose systems integrate hypermedia of all sorts including video and audio compact discs, and computer graphics.

Recently a number of microcomputer Hypertext systems have entered the software market. One of the most popular micro-based Hypertext systems is Apple™ Computer's HyperCard™.

HyperCard is a "personal tool kit for managing information." HyperCard lets you merge different media—text, pictures, graphics, video, voice, sound, and animation. The beauty of this product is it simplicity. To use it you only need to understand three simple tools: cards, stacks, and buttons. Cards are analogous to index cards. Cards appear on the screen and allow you to place information on them (text or graphics.) By organizing many cards together you form stacks. Stacks of cards can then be linked together with buttons. Buttons are placed on cards with instructions for what to do when pressed. For instance, a button may be given the instruction to go to another card on a different stack when pressed. Once these stacks are created, they can used by many people under the description "stackware." Stackware can be further modified by the particular user for his or her own purposes.

A number of HyperCard applications have been used commercially as well as academically. For instance, ABC News used a stackware application called "Magna System: The '88 Vote" to assist with live conventions and election coverage. The elaborate system (containing 200 stacks and thousands of cards) gave Peter Jennings information about background, views on major topics, status, past conventions, convention seating arrangements, as well as a photo of each candidate at the touch of an on-screen button.

Author Bio



Chad Blomquist is a senior in mechanical engineering who plans to graduate next spring. To fill his time he has started taking Japenese, important for his goal of someday being a manager for an international firm. Chad reads a little science fiction, and right now would like to have the time to read *Dune.*

that centered around using computers to mimic human intellect. The result was a computer system initially called On-Line System. The system's name was later changed to Augment and is now used by McDonnell-Douglas for internal project development. The Augment system serves as a large storage receptacle for memos, research notes, and documentation. The advantage to having this on a Hypertext system is that, at all times, the information from any group is on line to any of the other project departments. This made on-line conferencing possible.

Another Hypertext visionary, Ted Nelson, focused on one system that would house all of the world's literary treasures under one roof. Nelson coined the word "Hypertext" twenty-four years ago to mean non-sequential writing. His Hypertext creation, Xanadu, is a look into the future of publishing and is perhaps the most widely known Hypertext system.

In 1968, Alan C. Kay coined the term "personal computer" and forever changed the way we looked at computers. He conceived of a portable computer that could be "tucked under an arm." Kay called it the Dynabook. Although never produced, the Dynabook sparked the creation of today's personal computers (PCs). Kay also was the pioneer of icon-based computer systems. His ideas for using pictures instead of words to tell computers what to do has triggered a revolution in the computer industry.

At Stanford University, English professor Larry Friedlander developed a stackware application designed to introduce two versions of Shakespeare's Hamlet, Macbeth, and King Lear to students. HyperCard was used to control a video laser disc that contains filmed performances of contemporary theater on one side, and scenes from Shakespeare's plays on the other. The student using the system, called "The Shakespeare Project," is allowed to watch any portion of a particular play at the touch of a button. As if this weren't enough, after the portion has been viewed, a different version of the same scene can be observed instantly. Another fascinating feature: If the student so desires, she or he can listen not to the dialogue of the scene, but to the thoughts of the actors as they perform, providing insight into what motivates their words and actions.

Steve Jobs (co-founder of Apple Computer) gives an excellent analogy of how computers and Hypertext can expand the possibilities of the human mind. He said,

> A study was done recently by the scientific community to determine which species of animal (including man) was the most efficient at locomotion. The study centered on which species was most efficient in terms of getting from point A to point B with the least amount of energy exerted. The condor won. Man made a rather unimpressive showing, about one-third of the way down the list. But someone had the insight to test man riding the bicycle. Man was twice as efficient as the condor.
>
> This illustrates man's ability as a tool maker. When man created the bicycle, he created a tool that amplified an inherent ability. That's why I like to compare the personal computer to the bicycle.
>
> The computer is a tool that can amplify a certain part of our inherent intelligence. There's a special relationship that develops between one person and one computer that ultimately improves productivity on a personal level.

With the help of the personal computer, Hypertext is becoming more than just an idea. With products such as HyperCard, people are beginning to touch the surface of how Hypertext will enhance the incredible abilities of the mind.

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A Space Odd-Essay

by Steven Subera

Writing this science fiction essay was going to be easy. I had volunteered my services to the Great One (my editor, not Gretzky) because science fiction had been an important ingredient in my life. Yup, easy essay. I could just quickly compile my vast knowledge about science fiction into a definitive and monumental article.

Wrong. Wrong. Wrong.

All of my aforementioned glee quickly disappeared as I attempted to compile an original opinion piece concerning what I thought was the definition and purpose of science fiction. I needed help. Quickly. Before my editor had me vaporized for being later than usual with this article.

Which brings me to my current situation. Hurtling through space at a considerable fraction of the speed of light, I have enlisted one of my drinking buddies to assist me in writing this essay. Glorb he has few intellectual peers. He also writes science fiction. Actually, he is quite prolific, since his brain is segmented and is capable of three separate simultaneous activities. When I mentioned this essay to him he was enthusiastic about the possibilities and wondered why I was having difficulty writing about one of my favorite subjects.

"Please read what you have written," Glorb said. "And then we'll see what needs to be added."

I paused a moment and began reading from my notes: "The story should contain plausible science. No middle earth or mystical swords allowed. Ruby slippers are definitely out. Obviously, a writer may use science and technology that doesn't currently exist. However it is the responsibility of the writer to make the science believable. Suppose the following: Our futuristic hero Vance Astro finds himself surrounded by three legions of Loaken space warriors on the planet Goth. Unknown to the warriors, Vance has developed an instant space ship pellet. He quickly drops the pellet on the ground, spits on it, and rides away to safety. Probably not too many readers would tolerate such a distortion of science.

"Of course the story need not be confined to the earth's future. Many excellent science fiction stories have taken place in earth's past. A writer may simply decide to explore the possibilities of alternate realities. Maybe Napoleon wasn't defeated at Waterloo or Kennedy wasn't assassinated. Also, our future may not contain many more technological advances. Disasters or simple complacency may reverse our society's technological movement."

I stopped. "That's the only real material I've got so far," I said.

"You're going to include something about the labeling of science fiction as predictive or futuristic, I trust," Glorb suggested.

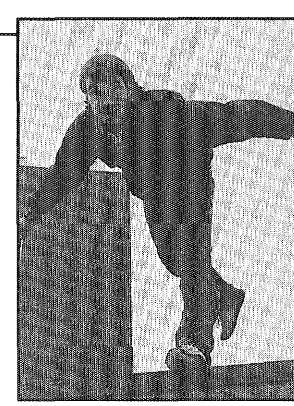
"Yes, you know those labels irritate me. Unfortunately, many people outside the science fiction community view the literature solely as an avenue to the future. True, the technology aspect involved lends itself to 'predictions.' But why do people think science fiction writers have a prophetic view of the future? Anytime a journalistic piece concerning life in the year 2000 is written, a noteworthy science fiction author is polled for his or her opinion."

"That has puzzled me also," Glorb offered. "Jules Verne, possibly the first science fiction writer, is noted as a visionary. Verne wrote in the late 1800s and some of his ideas surfaced decades later."

"Sure, but those technologies took decades to develop. His predictions might be similar to predicting today's technologies one year in advance."

Essay to page 24

Author Bio



Steven Subera, a senior in electrical engineering, has been a regular contributor to the *Technolog* since his junior year, when he calmly walked into the *Technolog* office and demanded a job. He enjoys science fiction immensely; indeed, he would rather earn his pay writing than designing circuits.

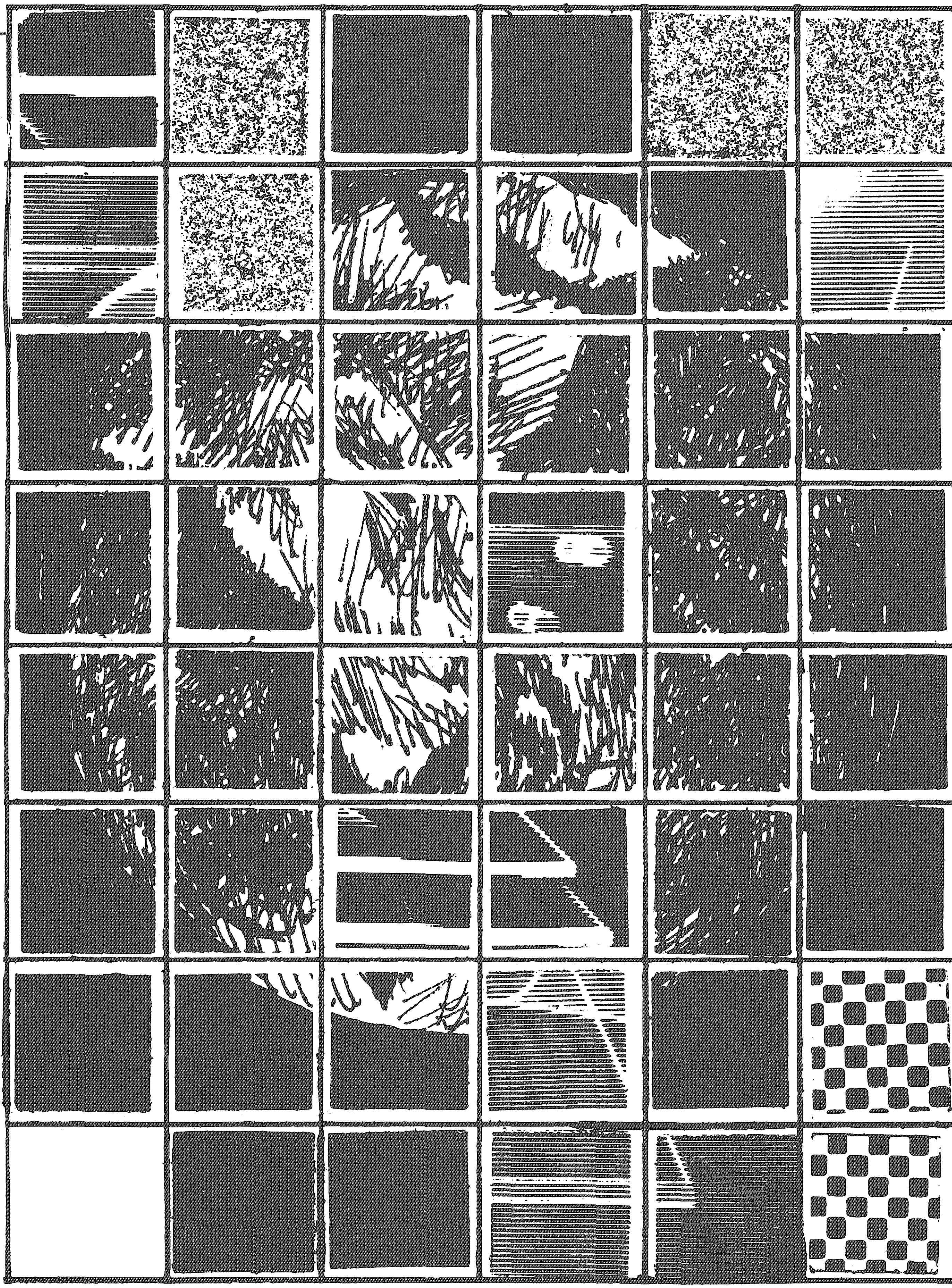


Illustration: *Technolog* file

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Glorb agreed with a nod. "So what do you like best about science fiction? Obviously it isn't the futuristic technology."

"I guess what is important is that science fiction writers often use the future to give us a glimpse of the present. Arthur C. Clarke's penchant for putting humankind in its place with novels such as *Rendezvous with Rama*, *Childhood's End*, and *2001: A Space Odyssey* is an example of this. Isaac Asimov's robot novels are intriguing, not because they predict robots will become ingrained in society, but because he deals with how society handles the problems intelligent robots would pose. Racism against robots and the treatment of them as second class citizens in his novel *The Caves of Steel* mirrors problems that have plagued contemporary societies.

"I thought Heinlein's *Stranger in a Strange Land* presented an interesting study of the Christian religion," Glorb added.

I noticed on the monitors that our speed had decreased considerably. We must be approaching my solar system, I thought, and a yawn reminded me of my lack of sleep. I was going to have a mean case of space lag when I arrived home. "Well, I think I can sum up my feelings since I'm almost home," I said.

"I hope you enjoyed your journey." Glorb's fiery red eyes danced in the artificial light.

"Glorb, your help has been crucial. I don't think the science fiction's emphasis should be placed on its ability to predict future technology. It is merely an area of literature that utilizes science and a writer's imagination. The writer then proceeds to try to convince (or con) the reader into believing there are little green bug men on Mars and we should invite them over for tea."

Glorb winked. "Actually, on Mars I believe they are amber."

"Whatever," I grimaced and reclined for a nap until journey's end.

Hypertext from page 21

Sources:

Young, Jeffrey S. and Jobs, Steve. *The Journey is the Reward*, pp. 188-189.

Sculley, John and Byrne, John A. *Odyssey; Pepsi to Apple...A journey of adventure, ideas and the future*, p. 201.

Hofstadter, Douglas R. *Gödel, Escher, Bach: An Eternal Golden Braid*, pp. 80-81.

"Bach, Johann Sebastian," *Funk and Wagnalls Encyclopedia*, volume 3, p. 179.

Tazelaar, Jane M. "Hypertext," *Byte*, volume 13, October 1988, p. 235.

Fiderio, Janet. "A Grand Vision," *Byte*, volume 13, October 1988, pp. 237-244.

Dunn, Nancy E. "SuperStacks," *MacWorld*, November 1988,

Heredity vs. Environment

Debate continues over the role genetics plays in forming a person's intelligence. Data amassed over the past 60 years and a recent study suggest there is a genetic component to intelligence. Researchers David W. Fulker and John C. DeFries of the University of Colorado at Boulder and Robert Plomin of Pennsylvania State University conducted tests on 245 adopted children and their biological and adoptive parents.

The tests scrutinized various intellectual capabilities like perceptual skills and abstract reasoning. The children underwent testing at ages one, two, three, four, and after completing the first grade. The test results revealed a close correlation in scores between the adopted children and their biological parents. As the children grew up, the correlations between adopted children and biological parents increased from 0.15 at age three to 0.28 at age seven. Conversely, during the same period correlation scores between the children and their adoptive parents dropped from 0.16 to 0.06. Typically, children in non-adoptive homes achieve a .40 correlation with their natural parents.

The study is not without its detractors. Many critics say that the test results show nothing significant. Leon J. Kamin of Northeastern University believes different correlations could have been extracted from the test data and that the bias of the researchers played a part in the results.

Source: *Scientific American*, March, 1989, pp. 27-28.

Plastics Everywhere

Plastic packaging may be cheap and convenient, but it is also causing a problem for the nation's landfills. Although only seven percent of an average city's landfill is comprised of plastics, the material doesn't decompose like paper or food and it isn't easily recycled. Only one percent of plastic packaging is being recycled compared with 27 percent of aluminum and 21 percent of paper products.

Plastics can be melted down and reused; however, most current products contain different types of plastic like polyethylene terephthalate and high density polyethylene. Melting them down yields a low quality product that has uses as a wood substitute, but manufacturers must still produce new plastic for bottles and bags, thereby increasing the total amount in the environment. Processes for separating the different types of plastics from a mountain of plastic trash are usually complex and costly. Another possible solution is to produce biodegradable plastics. Adding natural polymers like corn starch to some plastic products during manufacturing makes the material degradable, although scientists do not actually understand why it works. A small number of companies now produce degradable plastic products.

Degradable plastics have caused some concern because of potential ground water pollution from decomposing plastics. Also, degradable plastics may hamper recycling efforts because they could not be used in products requiring a long life. Initially, biodegradable plastic will probably be used in products that have high littering rates like six-pack loops. Although new ways to decrease the amount of plastic produced are being sought, many contend that the best possible solution is to just use less plastic.

Source: *Discover*, February, 1989, pp. 22-23.

Computer Enhanced Mathematics

Mathematicians have traditionally relied on pencil and paper when conjuring up their elegant proofs. Computers have been used to assist in solving many problems, but the results had always been verifiable by hand. Last November, however, a team of mathematicians and computer scientists proved one example of a conjecture first posed by Carl Friedrich Gauss.

The team, led by Clement W. H. Lam of Concordia University in Montreal employed a Cray-1 supercomputer to prove that there are no finite projective planes of order 10. According to Scientific American, "Such a finite projective plane, if it existed, could be thought of as a matrix of 111 rows and columns, in which each row has exactly 11 positions filled and any two rows have only a single filled position in common." The Cray was used to prove the negative result by examining over 100 trillion possibilities over a two year period. The program was executed during the computer's idle moments. There is no way to actually check the results by human computation, but Lam's procedures have been generally accepted.

Although purists may object to the intervention of computer proofs into mathematics, many areas of study such as chaos and fractals are quite dependent on computers. According to Ronald L. Graham of AT&T Bell Laboratories, computer-based exploration can point out promising avenues for formal analysis.

Source: *Scientific American*, March, 1989, p. 24.

Correction

In the Fall Two issue of the *Technolog*, the byline for the feature "Finer and Finer" should have been as follows: by Erik R. Scott, Chi Hum-Paik, and Bill Dachelet. In addition, the illustration on page 12 should have carried the following source: *Journal of Applied Physics*, January 15, 1988, p. R1, while the illustration on page 13 should have carried the following source: *Surface Science*, vol. 181, p. 394. The *Technolog* apoligizes for these oversights and for any inconveniences or misunderstandings they may have caused.

1. What was the name of the planet where rebel soldiers took refuge at the opening of *The Empire Strikes Back*?

2. In Ray Bradbury's novel *The Illustrated Man* , what did the "illustrated man" do for a living?

3. In the Stanley Kubrick film *A Clockwork Orange*, the main character, Alex, was treated with an experimental drug called Serum 114. In which other films did this same cryptic numeral appear?

4. True or false: Leonard Nimoy, who played Spock on "Star Trek" has the largest nose hair collection in the nation.

5. In Larry Niven's *Ringworld*, the character Nessus had 2 flat heads mounted on flexible and slender necks, white skin, 3 legs, and a coarse brown mane. Of what race was Nessus?

6. What year was "Star Trek" first televised?

7. How many "doctors" have acted on the science fiction TV series "Doctor Who" so far?

8. Name both the writer and the illustrator of the science fiction book *The Trouble With Tribbles*.

9. The landmark science fiction film *2001: A Space Odyssey* was based on what short story by Arthur C. Clarke?

10. In the 1963 book *Planet of the Apes*, journalist Ulysse Merou, scientist P. Antelle, and physician Arthur Levain discover the second planet of the giant red star Betelgeuse. The planet has the same characteristics as earth, except that on this planet, the apes rule and the humans are beasts. What is the name of this planet, and what year did the 3 humans discover it?

by Bunmi Odumade

Answers

1. It was the ice planet Hoth.

2. He was a carnival worker. He had received his "skin illustrations" from a woman who claimed she could travel in time. Since the illustrations turned out to be a curse, he spent 50 summers trying to find and kill her.

3. The other film was Dr. Strangelove.

4. This is false. However, his earwax collection is unrivaled in the Western Hemisphere.

5. He was a "Pierson's puppeteer." Puppeteers were a shy, nonviolent race with an extensive commercial empire.

6. 1966.

7. Currently, the TV series is featuring the 8th "doctor."

8. The writer was David Gerrold and the illustrator was Tim Kirk.

9. It was based on the short story The Sentinel.

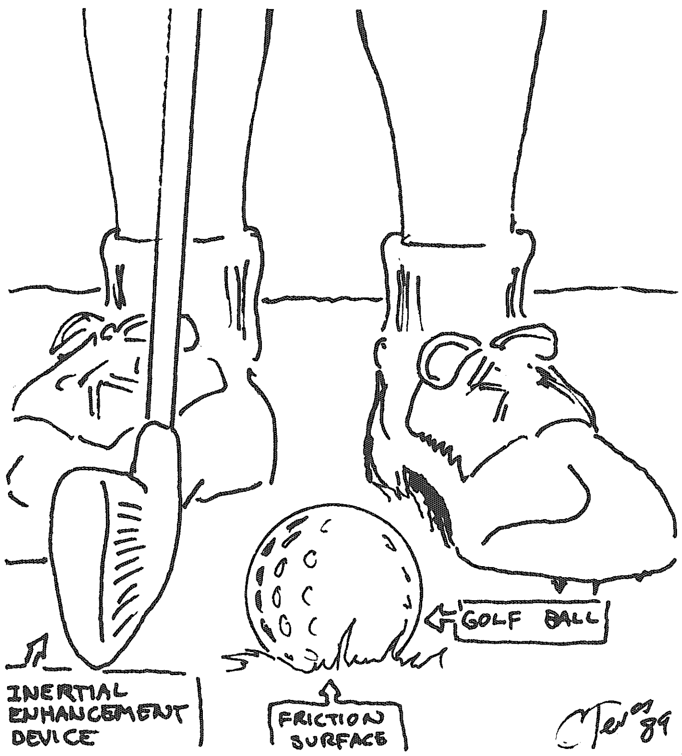
10. The name of the planet was Soror which means "sister" in Latin, and it was discovered in the year 2500.

Scoring

0-1: Chances are you live in the library.
2-3: Well, at least you have heard about such things as "television" and "science fiction books."
4-6: It is good to know that you take an occasional break from studying.
7-10: I really hope that your GPA does not suffer.

The Near Side

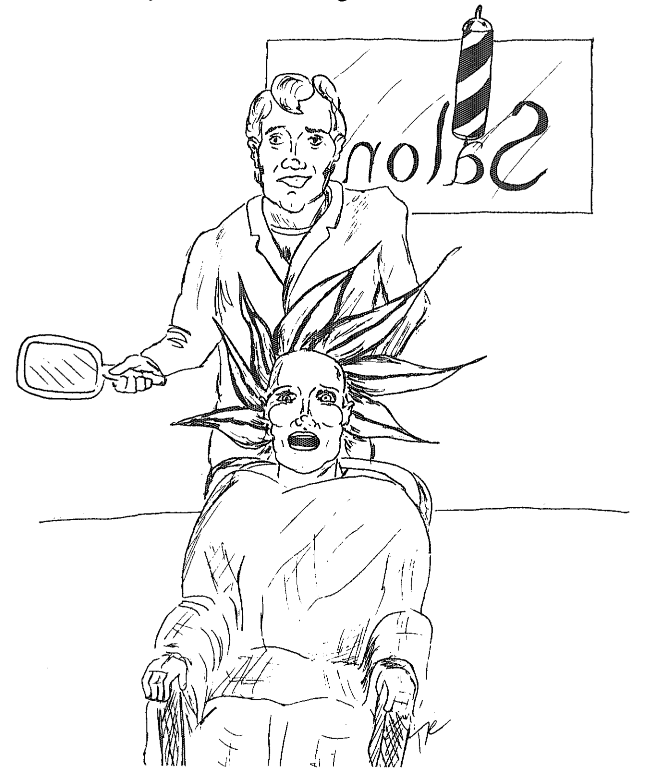
by Steve Littig and Conrad Teves



With temperatures in the 60s, Linda decided to study the physical principles of trajectory, gravity, force, and friction firsthand.

The Flip Side

by Jim Willenbring and Tom Rucci



Mark's winning hair design in the IT hairdresser competition reflected his research in random fractal sets.

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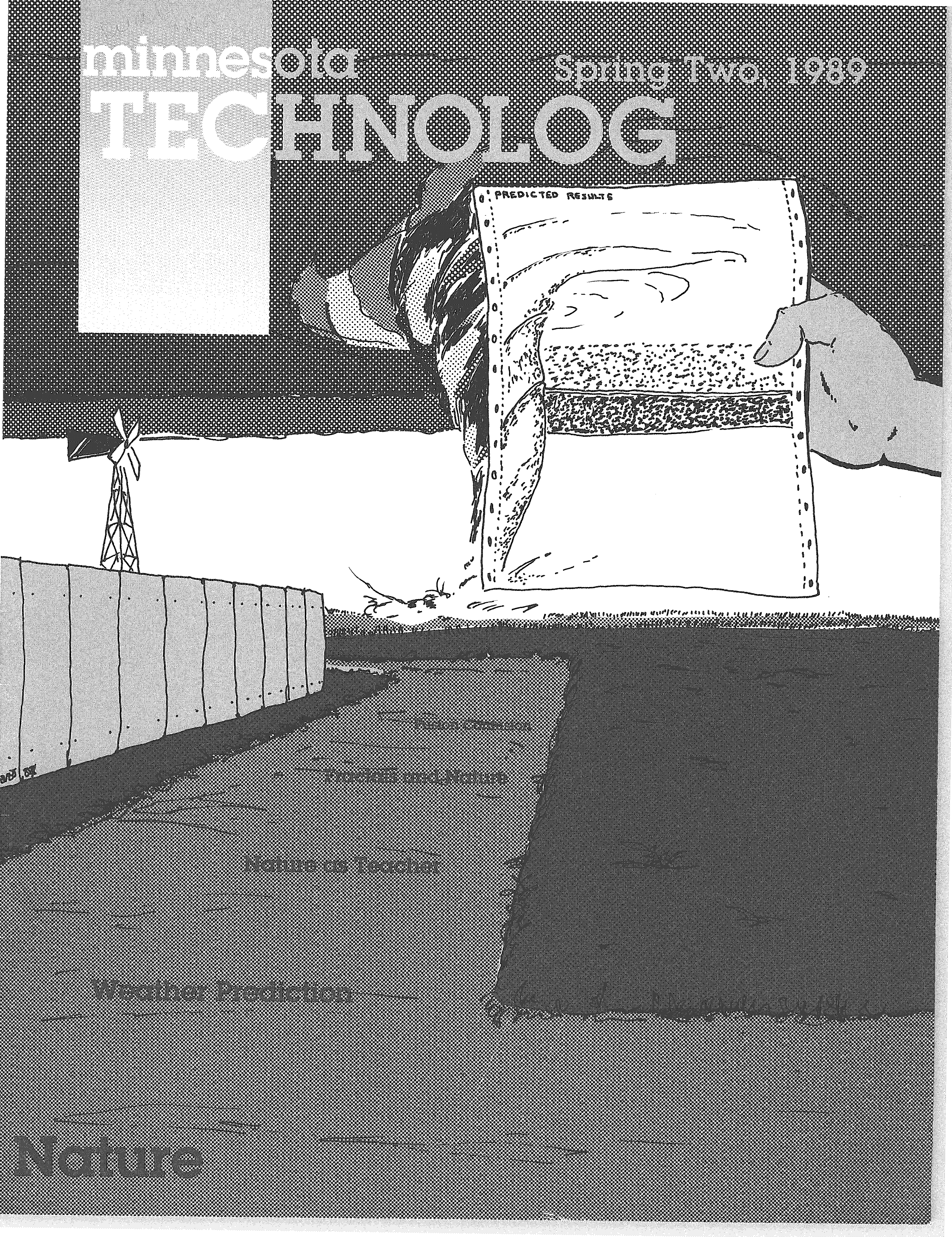

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Fractals and Nature

Nature as Teacher

Weather Prediction

Nature

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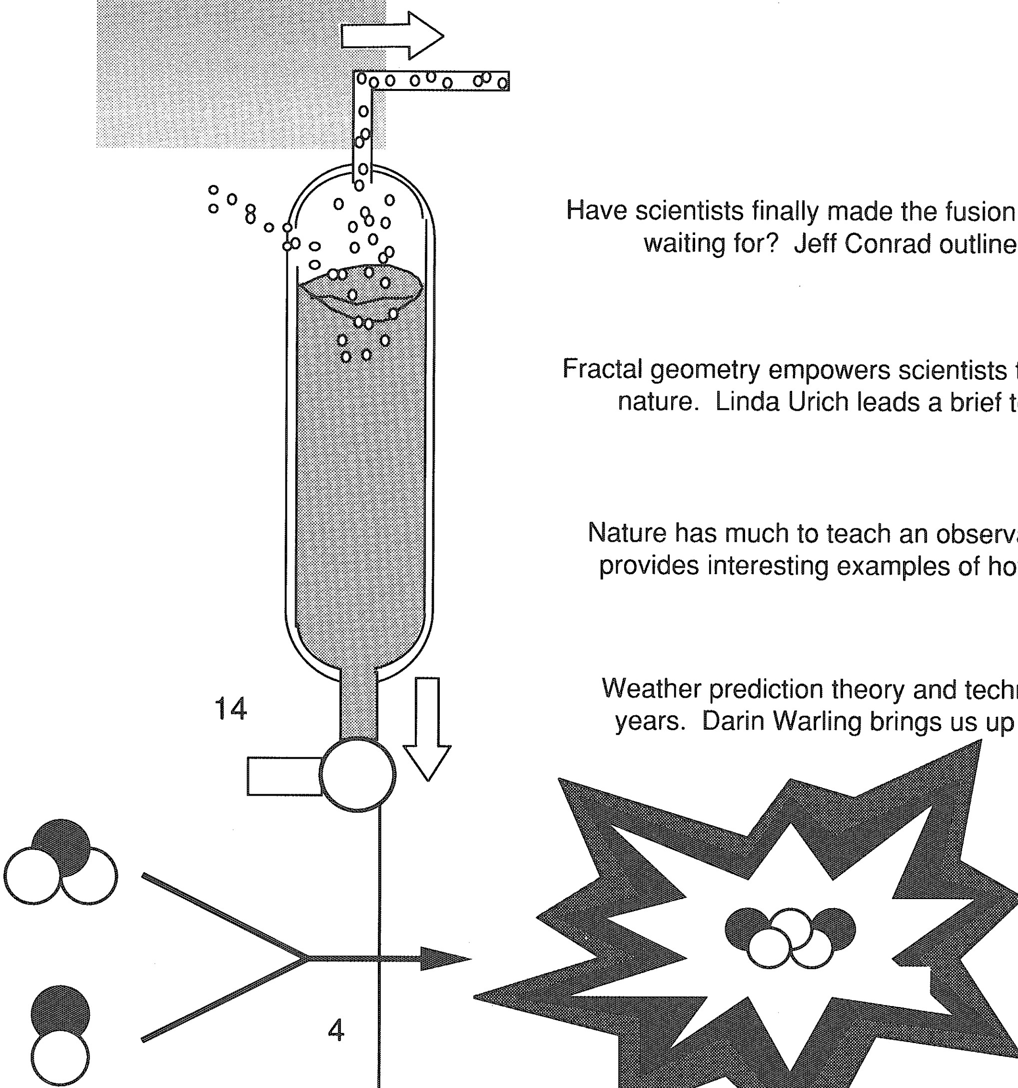
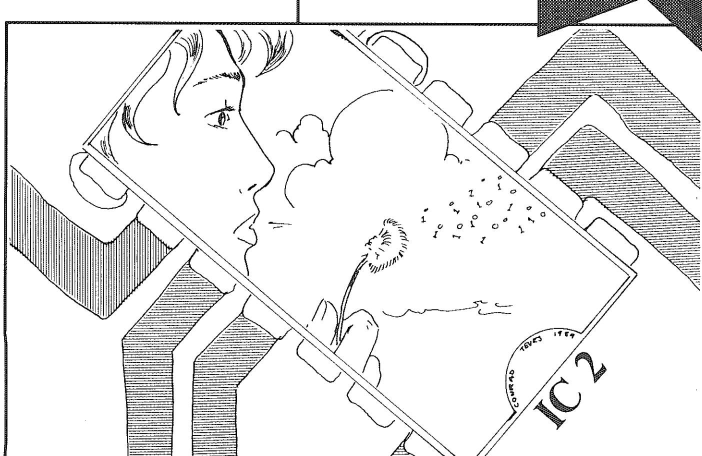


Departments



Cover Illustration by Conrad Teves

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Tradeoffs

by Steve Kosier

What are you going to do with your IT background? Pursue a graduate degree in science? Enter the job market? Go for an MBA? Join the circus as a fire-eater? A more appropriate question may be the following: Where do you want to be in ten years?

Read the following scenario, and put yourself in the shoes of the protagonist. You will be tested at the end, so pay attention.

You have been selected by management to be the project leader for a new in-house project. Your outstanding service to your company has earned you this high-visibility and high-responsibility position. Your charge: supervise the development of a scrubbing system for a chemical plant your company is building. Being an ambitious and career-minded soul, you want to rise through the ranks of the company and are honored to be given this new responsibility. Friends congratulate you with a barbeque party. Things are looking up.

After starting to lay the framework for your project, however, you discover some disturbing tradeoffs. Your roots are in engineering. Therefore you would like to develop an original and sound design that will allow your technical group some interesting design and research work. But now you're a manager too. As such, you are faced with the reality of meeting deadlines and trimming costs.

As if these tradeoffs weren't enough, you are aware of the environmental damage that your company's chemicals can cause. Current legislation allows for emissions that you believe are dangerous. The company would profit most, however, with a design that barely meets the current emissions standards. Local residents are mobilizing to protest the chemical plant, and the possibilities of negative publicity for you and your company are a growing concern.

Through the application of your communication skills and common sense, you learn that upper management is watching you very carefully. You recognize that your perfomance in this position may well determine the course of your career within the company. Obviously, you want to perform well, but you are overwhelmed. You have never had to consider such diverse influences. "There were no classes like this in college," you moan.

Advice must be sought, you decide.

You go to see your immediate supervisor, a dyed-in-the-wool manager. "In your opinion, what should be the focus of this project?" you ask.

"Money. Money and time. You've got to complete the project ahead of time and under budget. If your design doesn't work, you can always blame it on R & D. Believe me, it's in your best interest to demonstrate the ability to find profitable solutions to the company's problems," he says. You thank your supervisor and promise to attend the next party he throws. But you are concerned. Surely there is more to the issue than this.

You pose the same question to the engineering project manager who will be in charge of the design team. You and she worked on a project a few years back. "I think we can break real ground here," she says with enthusiasm. "With a little investment in lab equipment, we could very possibly usher in a new era of scrubbing systems. The potential is there. We're really excited about the prospects. I'm glad you're overseeing this project. Management has no idea what is really needed."

"Could existing technology do the job?" you ask.

"Not nearly as well as the system we've got in mind," she says, puzzled. "This new technology could provide more efficient scrubbing than is currently possible at a comparable cost. We could present our findings at next year's conference. It would be good publicity for our company, and be a big aid in recruiting new engineers."

You go back to your office to ponder what you've learned. Existing technology will suffice, and will meet budget and time constraints, but it would be less exciting for the engineers and may harm the environment. Future advances may yield good results, but will probably cost more and take longer to develop than existing technology. Management is getting restless; they want to see a thirty-page proposal by the end of the week.

"Well," you say to yourself (you talk to yourself more and more these days), "the facts are in, and they are inconclusive. A decision has to be made, and I have to make it. I have to go with my gut feeling and personal values." You regret not exploring your beliefs earlier. You recognize that the pressure of the situation will influence your opinion. You also know that upper management will probably do whatever you suggest.

What does your thirty-page proposal suggest to management?

a. Build the scrubber with existing technology.
b. Allocate research funds to develop a new scrubber.
c. Reexamine the environmental issues surrounding the chemical plant before taking action.
d. A combination of a, b, and c. This effectively lets management do whatever it wants to, as you have given them no clear direction.

There is no "right" answer; the issue is not black and white.

Think about your answer. What does it say about you and your beliefs? Where would you be most likely to "fit in" with these beliefs?

Thinking about tradeoff issues like the one above is new to most technical students. It is very important that you think about such scenarios, because sooner or later you will be tested for real. You will find yourself in a situation in which there is no clearly right or wrong response. At that time, the stakes will be high. Putting yourself through scenarios like the one above will prepare you to act in accordance with your beliefs. And that is all anyone can expect of you.

To sum up, our actions in situations where there is no clear solution are what define our character. When analysis fails, we have to go with our instincts. That is a scary thought if our instincts are dull. Fortunately, our instincts can be sharpened by grappling with moral dilemmas before they occur. We should all do so.

Fusion Confusion

by Jeff Conrad

Does cold fusion make you think of jazz music on a chilly winter night? Or does it prompt wishful thoughts of a cheap, clean, and abundant energy source? As of today, both of these answers are incorrect, but results from recent experiments in fusion have generated incredible interest in this nuclear process from the scientific community, the general public, and even Congress. But just what is fusion and what is this current experiment in cold fusion all about?

It all starts with a simple nuclear reaction of two hydrogen atoms combining to form helium, and in the process, giving off excess energy. It is this excess energy that could become our society's energy source for the future.

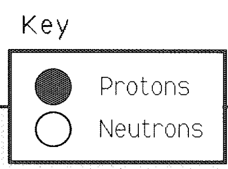
The fundamental obstacle to harnessing the enormous energies generated by fusion reactions is getting the hydrogen nuclei so close together that short-range nuclear forces will produce nuclear binding. This is difficult to achieve because the positively-charged hydrogen nuclei exert enormous repulsive forces on each other, due to their like electrostatic charges. Nonetheless, if the hydrogen nuclei can be forced to fuse, the mass of the fused nucleus will be less than the sum of the masses of the original nuclei. The missing mass is released as energy according to $E=mc^2$.

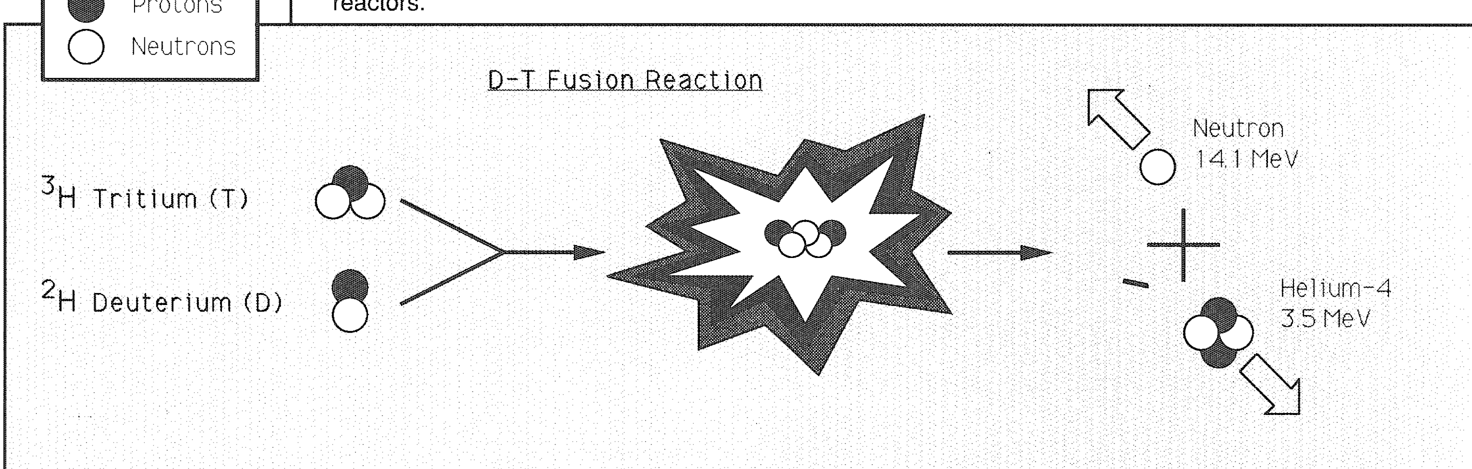
Brute Force Fusion

The simplest way to prompt a fusion reaction is to heat hydrogen to an extraordinarily high temperature. Fusion of this type occurs in stars. Average stars like our sun fuse hydrogen into helium at enormous rates. Gravitational forces of the sun's huge mass produce intense pressures at the core, which in turn produce temperatures that can reach 100 million K. If a pinhead could be raised to that temperature and kept there, it would generate enough heat to boil water 10,000 miles away.

Obviously, the Earth's gravity cannot be used to generate such high pressures and temperatures in a laboratory. Instead, researchers must electrically heat the fuel to a plasma state. A plasma is a gas at such a high temperature that the electrons are stripped from their respective atoms. Strong magnetic fields suspend the plasma long enough for the nuclear fuel to thoroughly undergo fusion. If the plasma touches the wall of its container, it will cool rapidly and the fusion process will stop. Costly electromagnets and their support equipment are the main components of typical fusion reactors.

D-T fusion occurs at very high temperatures and densities. In inertial confinement fusion, the D-T pellet is superheated by lasers or particle beams to achieve the necessary fusion environment.





Another brute force method is termed "inertial confinement" fusion (ICF), or "laser-induced" fusion. After injection into a vacuum, a hydrogen fuel pellet is bombarded with a high-energy laser or ion particle beam. After the bombardment, the pellet heats up in less than a billionth of a second, becoming a plasma. The density achieved in this situation is 10 billion times greater than that of magnetically-confined plasmas. The pellet's own inertia holds it together long enough for it to fuse before blowing apart. Therefore, ICF avoids the high cost of containment electromagnets.

Each micro-explosion induced by a laser pulse has the explosive force of one-tenth of a ton of TNT. Significant power could be generated if many micro-explosions occurred per second.

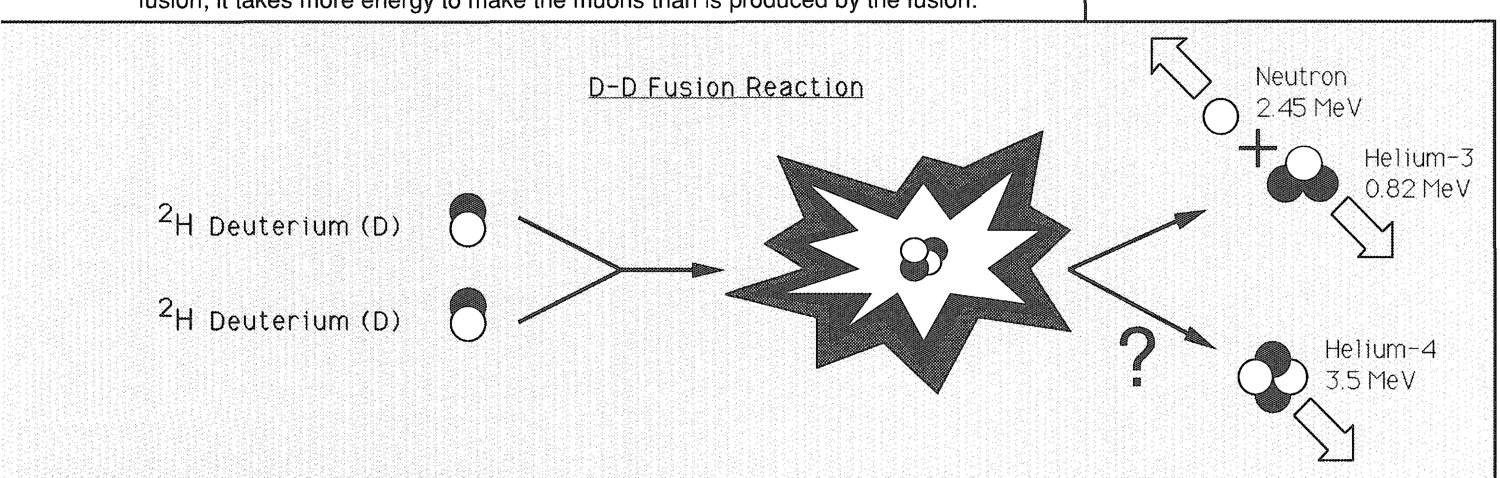
Incidentally, inertial confinement is the process by which thermonuclear warheads are detonated. In this case a fission bomb heats the fuel, while the inertia of the warhead provides the containment time necessary for the hydrogen to fuse. Because of its military nature, much inertial confinement research is classified.

Cold Fusion

The alternative to these brute force methods is called "cold" fusion, meaning that the fusion reaction occurs near room temperature. Instead of trying to re-create pressures and temperature conditions like those found in the sun, the objective of cold fusion processes is to prevent the fuel nuclei from repelling each other so fiercely. There are possibly two ways this can occur: with muons, and without muons.

The muon is a synthetic subatomic particle with negative charge like the electron, but 200 times more massive. Unlike an electron, a muon bonds so tightly to a hydrogen nucleus that its positive nuclear charge is shielded to a level where fusion can take place. Unfortunately, muons only have a 2.2 microsecond lifetime. On average, each muon must generate enough fusion energy during its short lifetime to replace itself. Although muon-catalyzed fusion takes place at much lower temperatures than magnetic confinement fusion, it takes more energy to make the muons than is produced by the fusion.

D-D reactions usually produce neutrons. The Utah researchers, however, reported low amounts of neutron radiation. This has led some scientists to theorize that the Utah experiment's D-D reaction produces Helium-4, which would account for the low neutron count.



tists claiming the discovery of the bench-top method are Martin Fleischmann (professor of electrochemistry at the University of Southhampton in England), and B. Stanley Pons (Chairman of the Department of Chemistry at the University of Utah), both well-respected researchers.

Their experiment involved the electrolysis of heavy water. In heavy water, hydrogen is replaced by deuterium (an isotope of hydrogen), resulting in D_2O. A special solution (containing heavy water and a special type of lithium hydroxide) was used to conduct electricity from a palladium cathode to a platinum anode. Deuterium collects at the palladium electrode, and oxygen collects at the platinum electrode, similar to the normal hydrolysis of water. In fact, deuterium builds up inside the palladium electrode until saturation is reached (although most of the deuterium bubbles away as a gas).

Palladium is uniquely permeable to hydrogen, due to its crystal lattice structure. To be exact, palladium is a face-centered, cubic metal. Within its lattice structure there are many small gaps (called octahedral sites) where small atoms such as deuterium can enter. At first, only the outer layers of the palladium's holes are filled up. As time goes on, however, the deuterium atoms find their way into all regions of the palladium electrode, reaching high concentration levels. Furthermore, once inside the crystal lattice, the "sea" of electrons in the palladium metal lessens the repulsive force between the positively-charged deuterium nuclei. Under these conditions, some scientists theorize that fusion can occur when two deuterium nuclei try to simultaneously fill the same gap in the crystal lattice.

Obviously, if the theorized fusion reactions were really taking place, researchers would observe significant heating of the palladium electrode. Indeed, in an early experiment, Fleischmann reported that "a substantial portion of the cathode fused (melting point 1554° C), part of it vaporized, and the cell and contents and a part of the fume cupboard housing the experiment were destroyed." Increased levels of tritium (a radioactive isotope of hydrogen), and neutron radiation provided further evidence that a genuine fusion reaction was occurring within the palladium electrode.

Prompted by the remarkable results of the Utah experiment, over 1,000 researchers in the U.S. and abroad have entered the cold-fusion race. Pons claims that 60 laboratories worldwide have duplicated parts of his experiment.

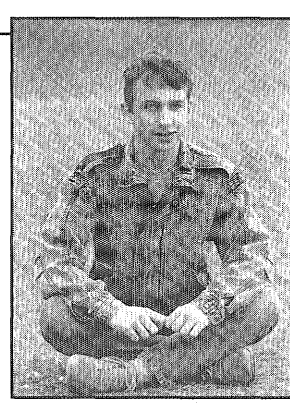
Meanwhile, the University of Utah has applied for a patent on the fusion process. "Our indications are that the discovery will be relatively easy to make into a usable power technology for generating heat and power," claims Martin Fleischmann, "but continued work is needed; first, to further understand the science and secondly, to determine its value to energy economics."

University of Minnesota Experiment

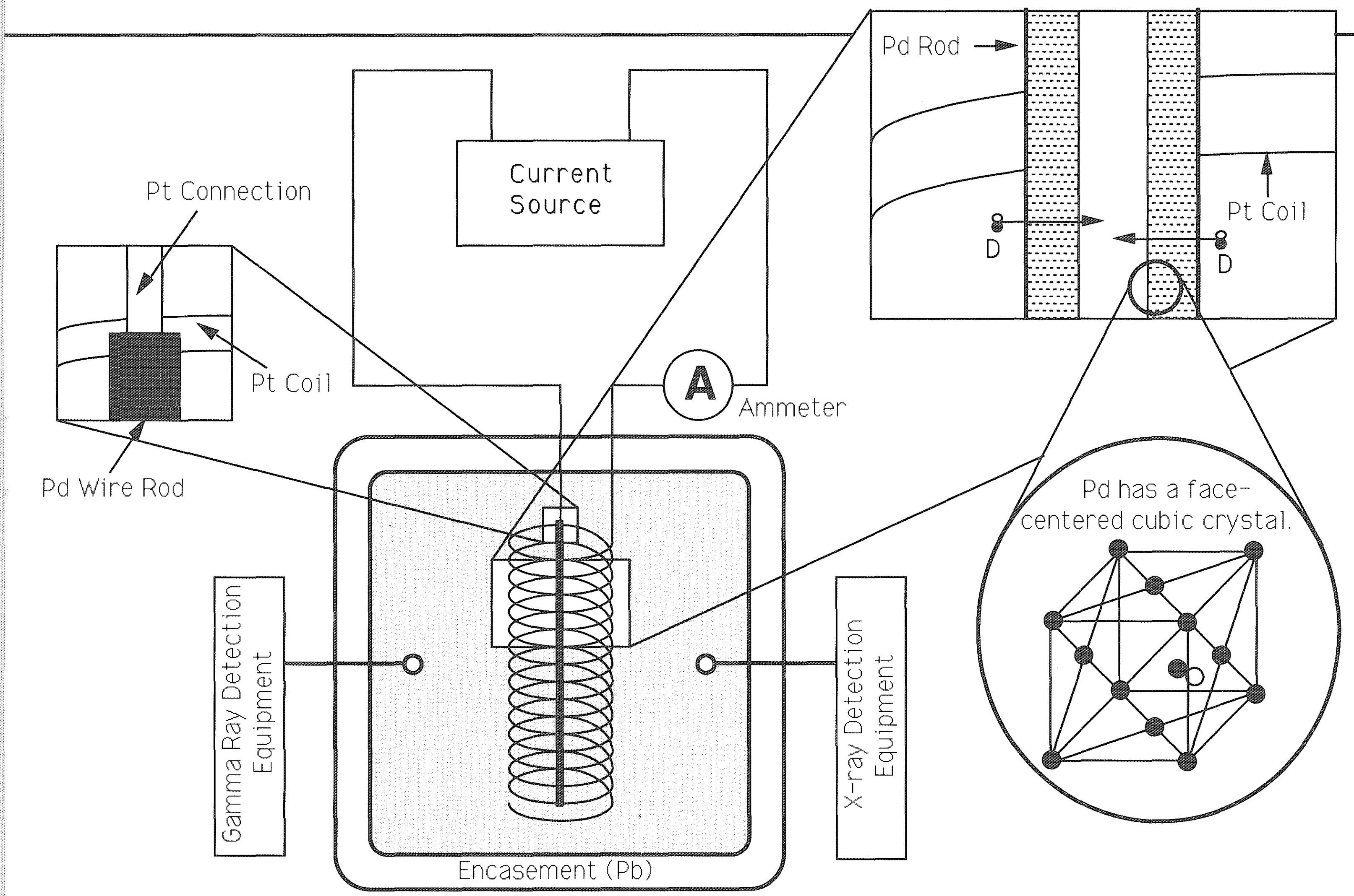
In spite of all the excitement they've generated, the results of the Utah experiment are open to skepticism. Few scientists believe that deuterium atoms can be persuaded to sneak up on each other in the manner described by Pons and Fleischmann. For instance, some researchers believe that the the experiment's enormous heat release was merely caused by a chemical reaction between deuterium and oxygen, not a genuine nuclear reaction between deuterium atoms.

A local attempt to refute or confirm the Utah experiment began April 26 at the University of Minnesota. Research team members include professors Richard Oriani, John Broadhurst, J. Woods Halley,

Author Bio



Jeff Conrad is an IT freshman who plans to major in mechanical engineering. He has been involved with the IT Board of Publications since last fall, and will be editor of the *IT Connection* next year. Right now, he wants to be a flyboy; he is working toward his pilot's license.



and graduate student John C. Nelson. They are conducting their particular cold fusion experiment at the Williams Laboratory for Nuclear Research, located in the Tandem Accelerator Building.

The main objective of the University experiment is to determine exactly what kind of radiation is emitted. The researchers are using multiple detectors to test for neutron and gamma ray radiation. X-ray detectors are also being used, since the palladium crystal structure may transform gamma rays into x-rays. Oriani's team wants to make sure that all possible types of radiation are detected, since radiation data can provide valuable clues concerning what is actually occurring during the experiment. In particular, if their sensors detect x-ray radiation from the experiment, fusion may indeed be occurring.

Although of secondary interest, the University team also plans to measure the heat generated in the palladium electrode during a later calorimetry experiment. In fact, calorimetry is one of Professor Oriani's past specialities. According to Oriani, "The setting up of the experiment was easy—the discrimination of the radiation data and the calorimetry are the difficult parts of the experiment."

Oriani emphasizes that "We want to make it very clear to people that we are very skeptical about this. We just want to find out what is the case." Furthermore, Oriani asserts that "This sort of thing cannot be answered just like that. We will not believe the results of one test—it will have to be replicated many times."

When the findings of the University experiment are definitive, the researchers plan to hold a news conference to disclose their findings. As of the end of April, preliminary findings indicated that the experiment was not generating significant amounts of radiation. In other

The University of Minnesota, like many research institutions worldwide, has tried to duplicate the Utah experiment. A simple block diagram for the initial U of M experiment is shown above.

Fusion Research History

A long history of research and engineering has provided the foundation upon which current fusion efforts stand. Fusion energy itself was first discovered during the 1920s when protons and deuterons were used to bombard small atoms. However, the first earnest effort to harness fusion power didn't begin until the Manhattan Project during World War II. The Manhattan Project did successfully design the first atomic bomb, but it was based on fission, not fusion. Nonetheless, by 1952, a government weapon development program had produced the world's first fusion-powered explosive, commonly referred to as the H-bomb.

During the early 1960s it became apparent that finding a practical way to exploit fusion power was going to take longer than originally expected. Fusion's theoretical framework advanced, but many large discrepancies between theory and reality persisted. However, in 1968, Soviet researchers had reported significant advances in the technology used to magnetically contain hot fusion reactions. Their device was named the *tokamak*, a Russian acronym taken from the words for "toroidal chamber with magnetic coil" (toroidal means doughnut shaped). The announcement caused much controversy until 1969 when a team of British scientists verified the Soviet research. In fact, they found even higher energies than the Soviets had reported. The U.S. responded by constructing some experimental tokamaks of its own.

During the 1970s, fusion research grew rapidly because of the public's growing dissatisfaction with fossil fuels and nuclear power. In response to the expense, pollution, and safety hazards associated with traditional energy sources, federal funding for fusion research increased tenfold between 1972 and 1979.

Recent fusion research and development is diverse and innovative, compared with the earlier fixation on hot fusion reactors. If verified, the "cold" fusion experiment at the University of Utah will lead to even further innovation.

words, the University experiment was tending to refute the Utah experiment, not confirm it.

Whether this Utah experiment is proved or disproved, fusion has been acknowledged as one of the leading alternative energy sources that is under research and development today. The effects that our current energy resources have in polluting the environment and generating hazardous waste only provide more reason to research any other possible energy source. Fusion seems to be in the forefront these days and hopefully these experiments will cast further light on the solution to our society's energy problem.

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Nature's Fractal Nature

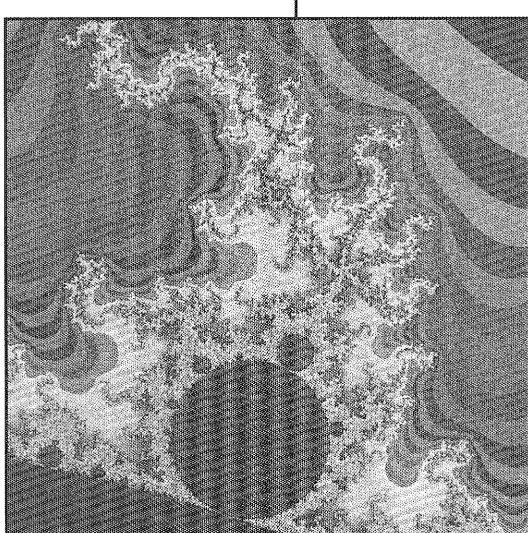
by Linda Urich

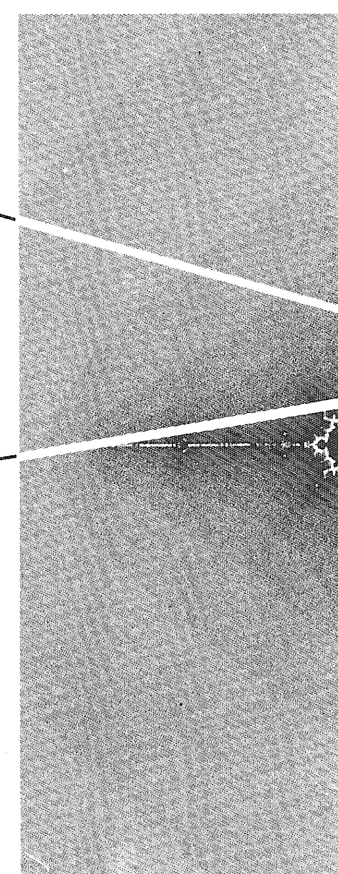
How would you describe the shape of the moon? Although it appears round, a simple circle only approximates its shape. What is the length of Lake Superior's coastline? Would you believe it could be considered infinite? In these examples, the actual shapes are really rough, warped, and hard to measure. Fractal geometry provides the tools to describe and recreate these difficult shapes.

The idea of fractals has been around since the late 1800s when a group of mathematicians abandoned classical, Euclidean geometry in favor of irregular, geometric structures. In the 1950s Benoit Mandelbrot, then a research fellow at the IBM Thomas J. Watson Research Center, started developing fractal equations based on this early research. He used them to better approximate the apparent randomness and irregularity of patterns found in nature. After all, nothing in nature can be accurately represented by traditional shapes, such as cubes and spheres.

Properties of Fractal Shapes

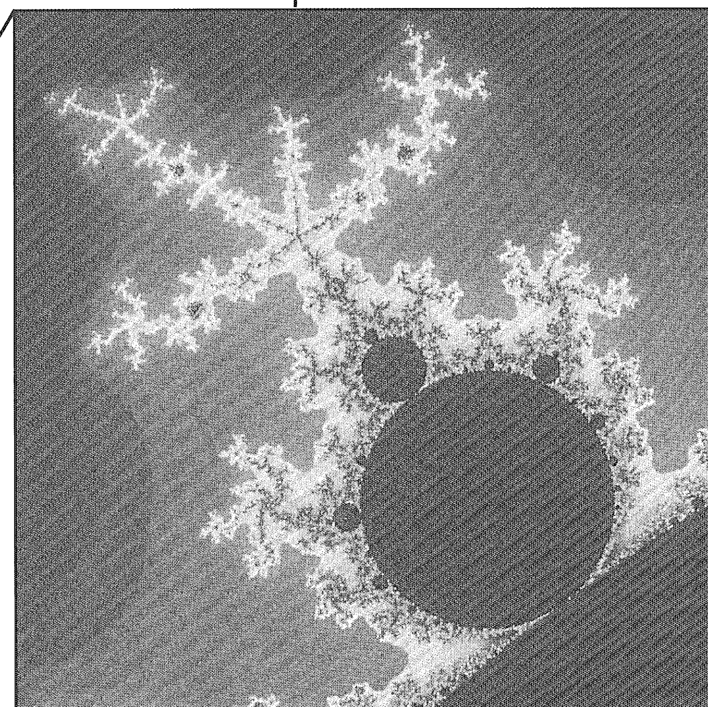
Fractal shapes have several unique properties. One property is that they contain patterns that are self-repeating. For example, the trunk of a tree divides into several limbs. From each limb grows branches, and from each one grows smaller branches. Even the twigs, once examined under a microscope, reveal minute offshoots, following the same pattern of the trunk, limb, and branches, but only on a different scale. This self-symmetry property is also observed in ferns, root systems, tree bark, the lining of lungs, and so on.





Fractal shapes are also infinite in detail. At any magnification a fractal image will exhibit the same patterns as it would at any other magnification. In contrast, the surface of a sphere will appear flatter and flatter the closer it is scrutinized.

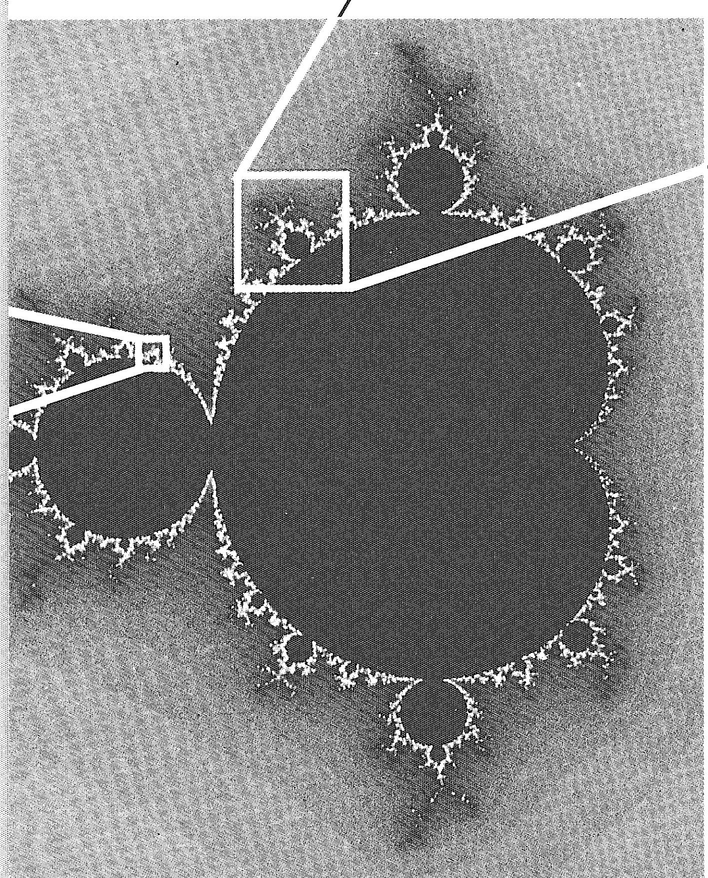
Fractal dimensions quantify a shape's degree of roughness and irregularity. Conventionally, we assign whole numbers to dimensions: a line has one dimension, a plane has two dimensions, and a volume has three dimensions. Fractal dimensions can be real numbers, describing the degree to which a fractal covers up a space. For example, a crumpled paper ball has about 2.5 dimensions. The coastline of Great Britain has approximately 1.25 dimensions. If the coastline was more crinkly, it would be defined over more surface



area and have a higher fractal dimension. Some fractals are so curvy they fill up most of the surface or space they are in. In this case, their fractal dimension could be 1.99 or 2.99, respectively.

Applications of Fractal Geometry

Euclidean geometry describes the regular shape of some objects well, such as buildings or books. But as mentioned earlier, it falls short of describing the shapes that occur in nature. For example, the length of a coastline can only be approximated by Euclidean geometry. But if the coastline was treated as a fractal set of curves, the length is considered infinite. By measuring the length of a coastline using a yardstick, then again with a ruler, and then again with calipers, the length is measured down to infinite detail and with infinite accuracy. This implies infinite length, since the length of the coastline could be measured on an atomic and then subatomic level. For practical purposes, of course, geographers set an arbitrary limit on the fineness of the measurement so they can determine a finite coastline length.



To futher illustrate the applications of fractals, consider the structure of the nighttime sky. The universe consists of galax-

Similar patterns appear in fractals at any magnification. Note how the close-up views (above, and far right) resemble the image at smaller magnification (center).

Source: Peitgen, H.-O. and Richter, P. H. *The Beauty of Fractals*, p.79.

Chaos

Chaos is a cousin to fractal geometry. Chaos recognizes that the most predictable mathematical model is subject to fluctuations and seemingly random results. For example, the population of an animal species for one season is dependent on the previous season's population. Theoretically, then, the population can be determined from a mathematical formula. But despite the laws of nature, the population may fluctuate dramatically and for a time be irregular and unpredictable.

The study of chaos began in the 1960s when an MIT meteorologist changed one small parameter of a weather forecasting program. The result was an entirely different outcome in the weather prediction. This is classically known as the Butterfly Effect: a butterfly flutters its wings in Brazil and causes a tornado in Texas.

Fractals from page 9

ies, stars, and planets with vast space in between them. The distribution of matter in the universe has been assigned a fractal dimension of 1.2. Assuming that the distribution is fractal, the empty spaces are considered void of matter, and therefore void of stars and sources of light. This is consistent with the observation that the night sky is dark even though it contains an infinite number of stars.

Rainfall can also be understood in terms of fractals. Rainfall usually occurs in short, small bursts in random locations, making a rainfall map fractal. A rainfall map consists of patches made up of patches of rainfall amounts. A long-term rainfall map will differ very little from a short term rainfall map for a week, month, or year. The length of each rainfall occurrence can also be represented by a fractal map.

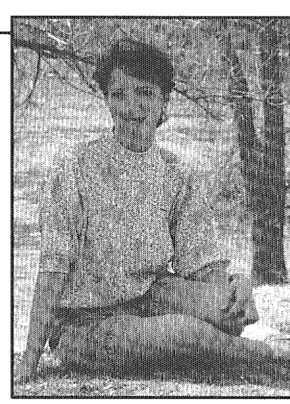
Describing a surface or space with fractals has many significant applications because fractals have the right combination of structure and irregularity. For example, a UCLA researcher discovered that surfaces of protein molecules are fractal. He determined that the fractal dimension averaged around 2.4 by analyzing the way x-rays scattered after they hit hemoglobin molecules. Some of the surfaces were smoother (i.e. a lower fractal dimension) than others. They could be sorted from the rough surfaces by analyzing the fractal dimension of each surface.

Fractals and Computers

The interest in fractals has grown with the increasing sophistication of computers and computer graphics. The fractal made the transition from a mathematical formulation to a computer generated image in the early 1980s. Fractal equations are relatively simple, but the equations must be iterated millions of times before they converge to a consistent solution. The final "picture" of a fractal equation is also difficult to visualize. Furthermore, the amount of memory required to reconstruct something like a detailed surface image of the moon is incredibly large.

A computer program that produces a fractal image uses a procedure called recursion. This process consists of a sequence of instructions that repeats itself, building successively on its preceding output. To illustrate, a wall of bricks may be built recursively. First, the bottom layer is put down, or in computer terms, the command lay a row of bricks is executed. The computer can then build a wall by repeating the

Author Bio



This is Linda Urich's final article for the *Technolog*. Following graduation this spring, she is leaving the U to pursue a graduate degree in industrial engineering at the University of Michigan. Her present activities include learning to play golf and working hard in her classes.

Other complex systems also have hidden order. Computer printouts of patterns modeling the spin of water wheels and the rise of heat currents closely resemble patterns represented by fractal equations.

Mitchell Feigenbaum, a researcher at Cornell University, developed most of what is known about chaos. For instance, the ratio of the coefficients in an equation that models a chaotic process is 4.5592016..., also known as the Feigenbaum constant. Feigenbaum discovered the constant empirically from his studies of turbulent flow. The constant has also been proven theoretically, giving chaos a universal flavor.

Because chaotic behavior explains such a wide range of phenomena, chaologists look for it everywhere. For example, the beat of the human heart is chaotic rather than a steady pulse. The eye movement of a schizophrenic is chaotic as is the distribution of large and small earthquakes around the world. Although chaos can not predict the path of a roulette ball, the closing price of a stock, or tomorrow's weather, it can anticipate the pattern in its behavior.

initial *lay* a *row of bricks* command. Thus, a wall is built using only one command. To finish the wall, one only has to stop the recursive process.

Fractal images can also be created from a mathematical operation called affine transformations. The idea is to take any basic shape and copy it in smaller, distorted sizes. By overlapping the shapes together with respect to a fixed origin, the resulting collage will represent the original shape but in a more complex form, called a contractive map. When the image is complete, the original shape can be thrown away with only the affine transformations left behind.

With a fractal program, fractal images copy themselves and "grow," creating natural looking forms. If a few random numbers are added, then the forms become even more natural looking, as they now have a few irregular features. For instance, designating the fractal dimension variable as random will change the surface texture from smooth to rough and back again. The fractal dimensions of clouds range over seven orders of magnitude, from millimeters to kilometers and beyond. Therefore, a picture of a cloud will look the same if its scale is one meter or one kilometer.

Instead of creating a fractal equation and seeing what image it produces, scientists at the Georgia Institute of Technology are experimenting with fractal equations (in the form of affine transformations) that describe things already occurring in nature. They hope it will play an important role in the transmission of images over telephone and data lines. For instance, if a picture of a tree is divided into a 1,000 by 1,000 grid of dots, or pixels, eight bits of data are assigned to each pixel. Each eight bits represents one of 2^8=256 shades of gray or color, resulting in a string of eight million ones and zeroes just to represent the foliage of a single tree. In order to compress this signal, a few fractal equations could reproduce the same image of repeated patterns in a more compact way and need only 10,000 bits of data or less.

As scientists are discovering more applications for fractals in all areas of science as well as in nature, the only limit for the use of fractals seems to be our imagination.

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Natural Models

by Jayne Ojarood

Cat whiskers, fish blood, dragonfly wings, moth-eyes, squid muscles, reptilian hearts...

Ingredients for a witch's brew? No, these are just some of Mother Nature's many marvels being imitated in technology. Instead of creating complex new systems, some engineers and scientists have based their designs on processes and systems that occur in nature.

Fish Blood

Analogous to an animal's circulatory system is technology's creation of an artificial gill utilizing a carrier fluid that mimics fish blood; that is, the fluid extracts oxygen from seawater. The artificial gill has three primary components: a carrier fluid, analogous to blood; a membrane that allows oxygen to diffuse from seawater into the carrier fluid; and an electrochemical cell, which is used to turn the carrier fluid's affinity to oxygen on and off.

The carrier fluid is the most important component of the artificial gill. It consists of a solution of synthetic carrier molecules that bind to oxygen. Besides binding to oxygen, these carrier molecules may be induced to release oxygen at another location. The gill's membrane, which is nothing more than a cartridge used for oxygenating blood in hospitals during cardiac bypass surgery, has the appearance of a bundle of spaghetti. The gill's final component, the electrochemical cell, removes an electron from a carrier molecule entering its anode, causing the molecule to release oxygen by lowering its electron affinity. When the carrier fluid re-enters the electrochemical cell's cathode, each carrier molecule regains an electron and once again has a high-affinity state.

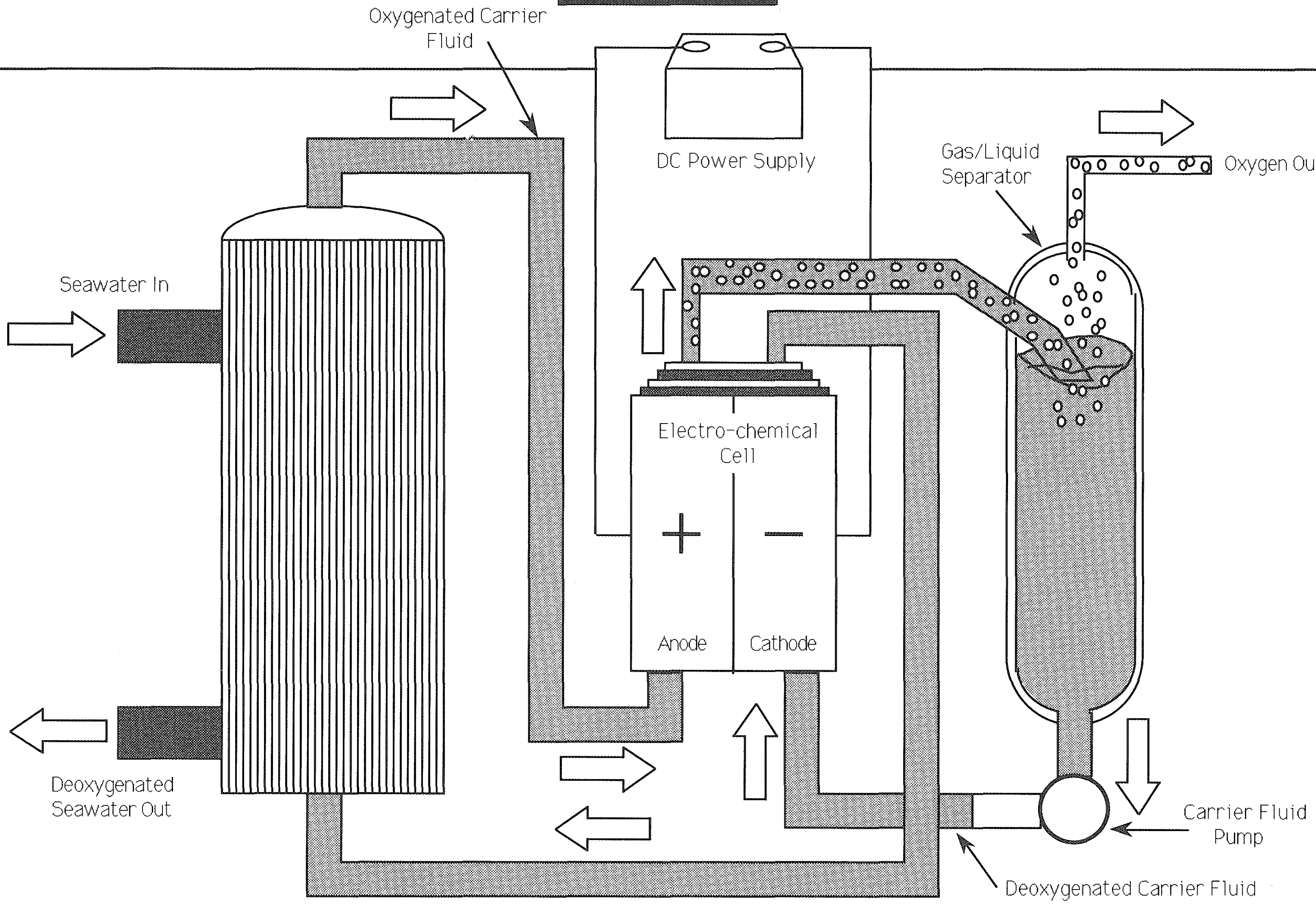
Some not-so-obvious applications for this new oxygen extraction system include keeping beer fresh and preventing spoilage of packaged foods by filtering oxygen from them. Another use of the gill is in life support systems, where it could provide oxygen for breathing in unusual environments (e.g. during chemical warfare, inside a submarine, or on board an aircraft at high altitudes). An underwater vehicle, for example, could use the gill to breathe water and extract oxygen to propel itself.

Snake Hearts

Why mimic the hearts of snakes, lizards, and turtles? The hearts of these animals lack arteries, which makes them quite different from human hearts. In particular, they never suffer from clogged arteries. This difference inspired a revolutionary medical technique known as laser revascularization. In this open-heart operation, a cardiovascular surgeon uses a laser to bore eight to fourteen holes though the left ventricle of a diseased human heart. As a result, the starving myocardium, or muscle tissue of the heart, no longer has to rely on a blocked coronary artery to nourish it with blood. Rather, like a reptilian heart, most of the heart wall will be fed by blood from the ventricle chamber seeping through the newly made canals. This new supply of blood greatly reduces the threat of heart damage. Laser vascularization is expected to supplant the traditional coronary bypass

Author Bio

This is Jayne Ojarood's first *Technolog* article. A senior in computer science, she will be graduating at the end of this quarter. She is presently looking for a job in software engineering, but she hopes to someday earn an advanced computer science degree.



This artificial gill is capable of extracting oxygen from seawater. A special carrier fluid (analogous to blood) interacts with seawater within the membrane apparatus (see page 16) to obtain oxygen. An electrochemical cell releases the captured oxygen molecules from the carrier fluid. Submarines may someday use the oxygen in life-support systems or fuel cells.

Illustration by Tony Veerkamp

Source: "Artificial Gill," *Popular Science*, volume 234, April 1989, p. 122.

operation since it is not as dangerous nor as complicated, and takes only minutes instead of hours to perform.

Squid Muscles

By studying squid muscles, scientists have discovered a new way for muscles to work. Squid have a kind of muscular action that works without bones, cavities filled with incompressible fluids, or any other kinds of skeletal supports. According to traditional teachings, the muscles of these animals shouldn't be able to function, but they do–very well, in fact.

Besides powering motion, the squid's muscles serve as skeletal support. Their unique arrangement enables the animal's appendages to be lengthened, shortened, bent, or twisted with great dexterity. Consequently, (like tongues and elephant trunks), squids, octopi, and other cephalopods posess many capabilities that animals with other muscle-skeleton systems lack. Without the constraint of joints, for instance, a squid is able to scratch its right "elbow" with its right "hand."

The increased flexibility, finer control, and more precise bending and manipulative movements of squid intrigue scientists involved with robotics. Duke University's James F. Wilson and colleagues built a robot arm modeled after an elephant's trunk. The arm expands and bends when air is pumped into its partly corrugated polyurethane tubes. The design is intended to enable the robot to maneuver in tighter, more awkward work spaces than its conventional counterparts.

Cat Whiskers

Another one of Mother Nature's ingenuities that has been implemented in robotics is cat whiskers. In nature, insects, cats, and many nocturnal animals use antennae and whisker sensors to avoid obstacles and gauge clearances in tight situations. Naturally, whiskers seemed to be the obvious model for a robotic sensor designed to locate the presence of objects.

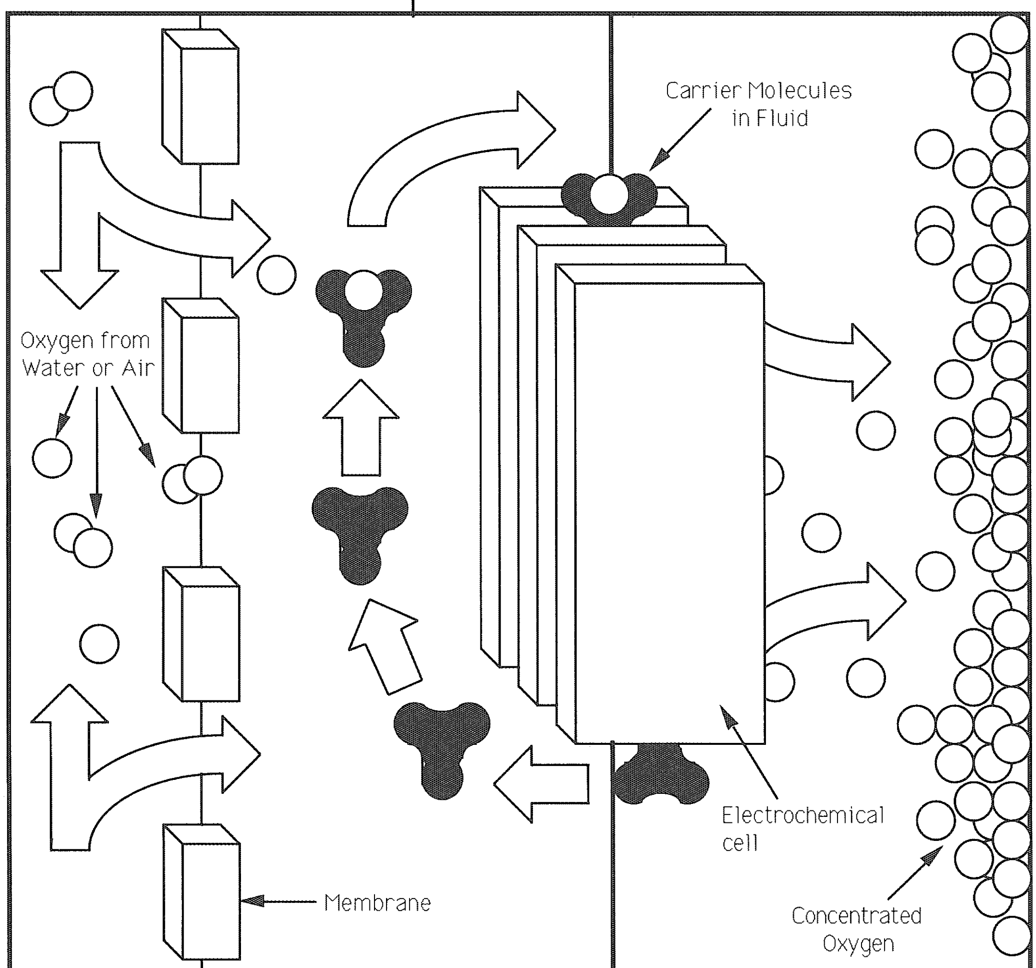
Simulated whisker sensors have been constructed using a short piece of flexible wire protruding through a small hole in a copper sheet. When an object touches the wire and pushes it against the edge of the hole in the copper sheet, an electrical connection is completed, changing the logic level on a computer input line.

Moth Eyes

One insect-inspired technology involves moth-eye magic. The moth's eye is one of nature's best light absorbers. Because its surface has a very low reflectance, most of the light that hits the eye is absorbed by the eye. The moth's intricate eye structure includes a thin film covering its cornea etched with a three-dimensional hexagonal grid. This corneal pattern, when magnified under a scanning electron microscope becomes an array of peaks and valleys that captures and absorbs light. Smaller than the wavelength of light, these tiny bumps are able to trap incoming light with only a small percentage being reflected.

Recently, this moth-eye magic has been applied to new technologies by duplicating the moth eye's texture on film and surfaces. The honeycomb-like pattern is first etched onto a glass plate using laser beams and then vacuum-coated with a metal that retains the pattern.

Various applications of this "no glint" film include such things as anti-glare glass, optical data-storage discs, test strips for instant blood-typing, and heads-up instrument-display systems.



An artificial gill has three primary components: a membrane, a carrier fluid, and an electrochemical cell. The Oxygen molecules diffuse through the membrane, where they bond with the circulating electrolytes. The Oxygen is extracted from the electrolytes by the electrochemical cell, and the electrolytes are sent back through the cycle.

Illustration by Tony Veerkamp

Source: "Artificial Gill," *Popular Science*, volume 234, April 1989, pp. 122.

In conclusion, a lot of interesting ideas for engineering have resulted from following nature's lead. With more imagination and investigation, who knows what high-technology breakthrough Mother Nature will inspire next?

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Would you like to become involved with *Minnesota Technolog* or *IT Connection*? More specifically, would you like to participate in the management, financing, and publication of these periodicals? The IT Board of Publications has two openings for the 1989-90 school year. One opening is reserved for an entering freshman, and the other opening may be filled by any student currently enrolled in IT. If interested, please drop by Room 2, ME Building, or call the Board office at 624-9816.

Weather Prediction

by Darin Warling

Summer, 1933

Iron-horse winds hurtle across the desolate prairie, turning up dirt and dead corn stalks, rippling across the vast open wheat fields under an ugly black sky. A few fat drops of rain fall to the bare earth, splashing into the dry dust on the edge of the field. A barn door groans under the force of the wind and a lone car is seen in the distance, kicking a choking haze of dust off the road. No sound is heard except the rise and fall of the rolling wind. Three and a half miles up, the winds begin to churn, driven by a warm bubble of air pushing its way northward from the Gulf of Mexico, and a hard-edged cold air mass fresh from the flatlands of Alberta. Within a few minutes it has begun to circulate, twisting itself into a swirling black vortex. Ten minutes later the vortex drops from the clouds, unleashing one of nature's most powerful phenomena. Within five minutes it has ****laid out a path of destruction half a mile wide and two miles long, overturning trucks, toppling barns and flattening houses, leaving three dead and four injured.

Summer, 1989

On a dark computer screen somewhere in Maryland, a sluggish mass of brilliant colors begins to shift and move. A glowing blue appendage starts to shake free from the slowly revolving mass, pushed by unseen winds simultaneously moving north from the Gulf of Mexico and south from Canada. The appendage snakes away from the splash of color and begins to move with a life of its own, swirling and dancing away from the rest of the enormous storm system. A weather service technician blows the new radar image up on another screen and starts tracking it closely. As soon as the arm begins to circulate, the technician picks up a phone and alerts the Minnesota bureau of the possibility of some ugly weather ahead for the southern third of the state. The warning goes out on local Minnesota radio and TV networks, and tornado spotters fan out across the silent prairie. Half an hour later a full-blown twister spins to life three miles south of Mankato, causing thousands of dollars worth of damage. No injuries were reported.

> "... weather forecasting has joined the realm of the high tech, employing supercomputers, Doppler radar, and statistical analysis...

Modern weather forecasting has indeed moved beyond the scope of Elmo's brilliant description of the *Daily* weather. Indeed, weather forecasting has joined the realm of the high-tech, employing supercomputers, Doppler radar, and statistical analysis right alongside the traditional tools: barometers, rain gauges, thermometers, weatherpeople, and flashy weather maps. These new methods are supplementing the well-established prediction practices with the numerical number-crunching capabilities of Cray supercomputers, turning what was once largely unfocused guesswork into, well, focused guesswork.

Nowcasting

One of the newest developments in the field of weather analysis is called nowcasting. While forecasting involves the prediction of weather developments anywhere from six hours to a week in advance, nowcasting is used to predict the weather two to twelve hours ahead by collecting information about current conditions and statistically extrapolating ahead. Because such detailed data is needed, nowcasting relies on very frequent, very exact observations from a large number of remote sensors. Unfortunately, while the results are highly accurate for extremely short-range forecasts (two to eight hours ahead), its accuracy decays rapidly. It's virtually useless after twelve hours because the original weather patterns have degenerated so far from their initial state that meaningful statistical analysis is nearly impossible. It is here that the emerging field of mesometeorology is able to take over some of the forecasting burden.

Mesometeorology vs Macrometeorology vs. Nowcasting

Mesoscale weather refers to a wide variety of air disturbances, ranging in severity between ordinary air turbulence and cyclone weather systems. Mesoscale weather may occur over areas as small as a few square miles, or as large as a few hundred square miles. Mesoscale air flows combine to make up the larger weather systems (synoptic-scale or macroscale) that the National Weather Service generally deals with.

Like nowcasting, mesoscale modeling is used for short-range, detailed forecasting at a given location. Unlike nowcasting, it employs fluid mechanics to make predictions rather than pure statistical analysis. Mesoscale forecasting tends to be much more accurate for a longer period of time, but its predictions are not as good as those predictions obtained through nowcasting.

Mesoscale predictions take into account the effects of things like topography, vegetation, and water bodies. They also are able to simulate such things as sea breezes, mountain valley winds, and

Weather Prediction to page 20

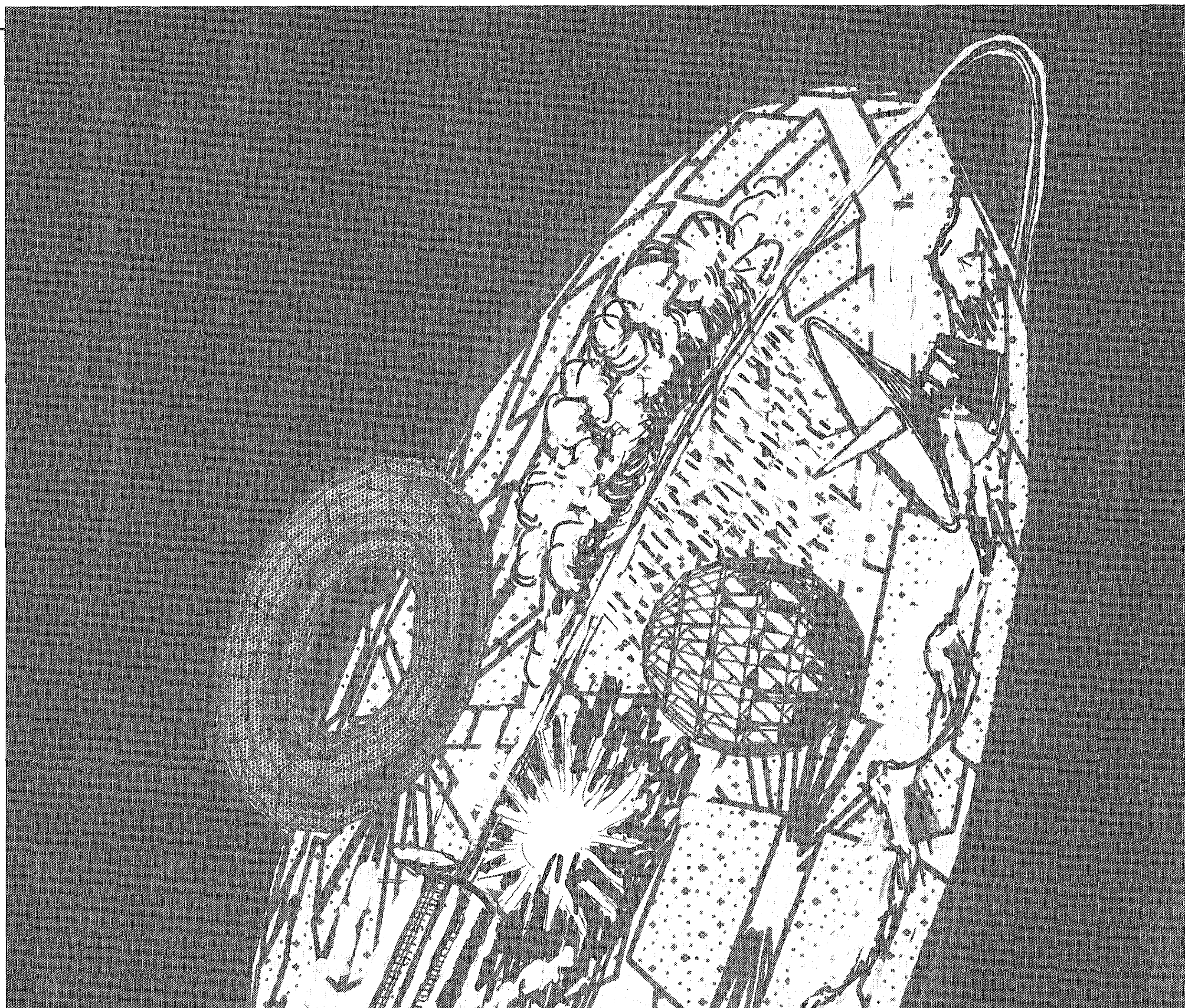

Illustration by Tony Tong

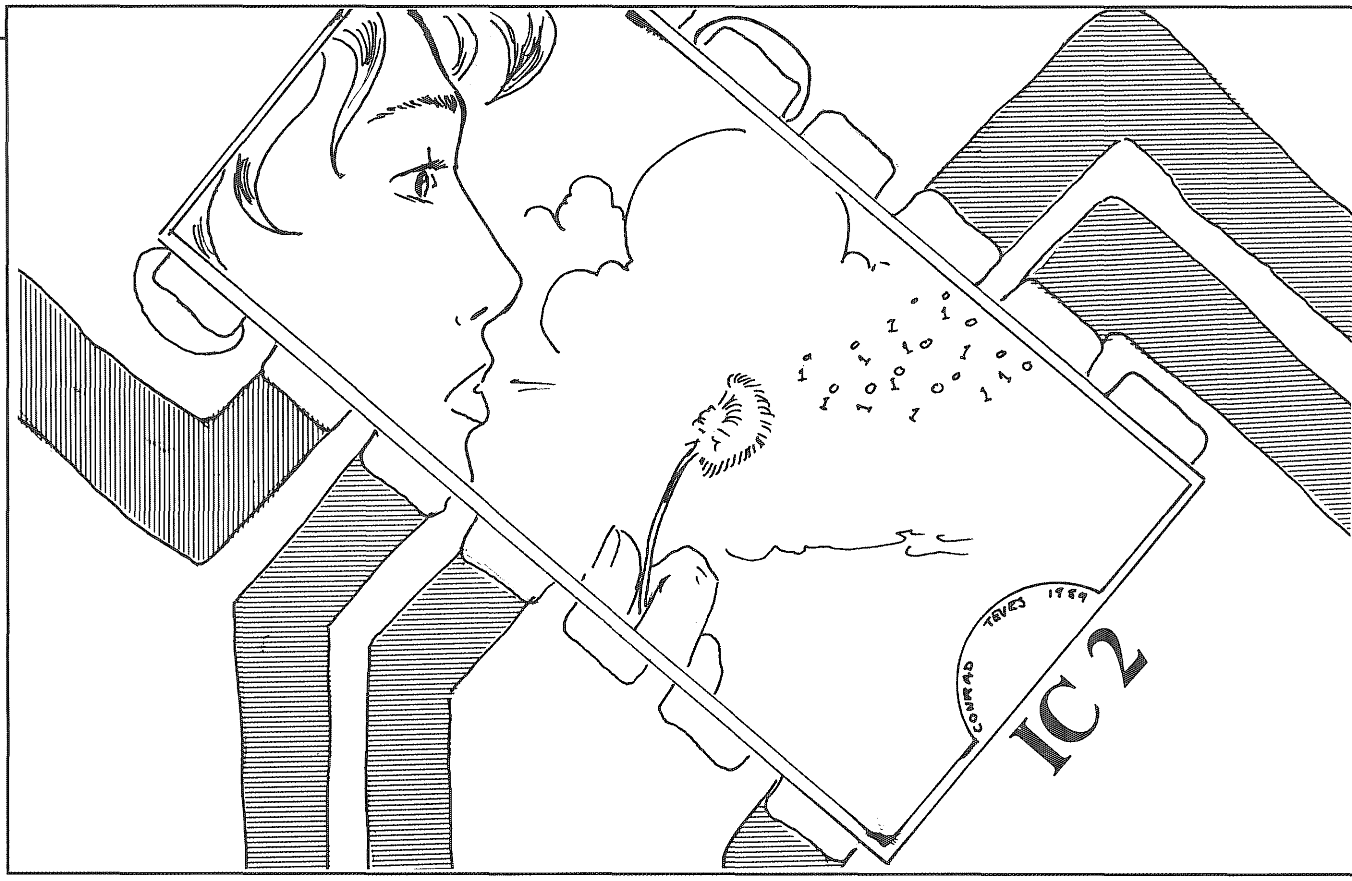

Illustration by Conrad Teves

Weather Prediction from page 18

squall lines. Macrometeorology, on the other hand, deals with a slightly larger picture, such as the weather over all of North or South America.

Mesometeorology is an extension of the traditional methods of meteorology; a further refinement of the older numerical models. It is meant to complement and "fine tune" rather than replace what has already been learned. Both mesometeorology and macrometeorology employ supercomputers to handle the enormous amounts of weather data involved, freeing the forecasters for the numerous judgement calls needed to correctly interpret the forecasts the models generate.

The approach the National Weather Service takes to weather prediction involves many model simulations running on a number of different computers, all based in Maryland. After feeding in the necessary data, the results of each model are sent into a model output statistics (MOS) program that analyzes the chances for each type of weather occurrence in each area of the country. Next, weatherpeople weigh the results of each model, using the statistical analysis to draw up their best guess for each area's hour forecast. Of course, the process is a hair more complicated in reality, but the above describes the basic idea.

Mesoscale modeling is based on the same technique, but on a smaller scale. Instead of covering, say, all of North America, it may cover only the southern half of the Florida peninsula, which happens to conveniently lead me to the next subject...

R-Scan Corporation's Experience in Mesoscale Modeling

R-Scan, a company based in the Minnesota Supercomputer Center, is mainly involved in the nationwide, real-time detection of lightning strikes. However, under the direction of Dr. Dennis Moon, Dr. Walt Lyons, and Joe Eastman, it is also involved in mesoscale weather modeling, some of which it did experimentally for NASA's Kennedy Space Center in Florida. It is currently doing this modeling for a number of nuclear power facilities and pollution control agencies.

R-Scan's model began as a research project at Colorado State in 1974. Originally, it was an attempt at creating a primitive atmospheric fluid simulation, and over the course of the last fifteen years, it has evolved into a full-blown mesoscale weather model. While most academic research and (re)development is done in Colorado, it is being put to practical use in the Twin Cities.

The model, as it now stands, consists of over 50,000 lines of Fortran code running on a Cyber 205 and Cray 2. It uses differential fluid equations involving a large number of parameters for various situations, and since the equations it uses lack a closed-form solution, it approximates a solution using a finite-difference scheme.

After the needed state variables are entered, the computer will toil at the solution, which can take as little as two minutes for a highly-simplified 2-D model to as long as two and a half hours for a highly-simplified 3-D model. The parameter list for each model is kept short because the problem tends to become exponentially more complicated as new parameters are added. Ironically, it takes less effort for the computer to approximate a solution for a larger geographic area than a smaller one, because any given location is first divided up into equal-area sections and then each section is solved for individually. Larger areas tend to be less finely sectioned, and therefore more quickly solved.

The two largest uses of the R-scan model thus far have been the prediction of weather and the simulation of pollutant trajectories. NASA put the model through its first extensive test, using it for the prediction of highly-localized weather, such as the area surrounding the space shuttle launch pad. When the NASA test was completed last summer, they found that the model was accurate, agreeing with actual wind velocities for twelve to twenty-four hours before the results began to decay. They also found that even simplified parameters gave fairly good results.

The R-Scan model is also being used by a number of nuclear power plants in the eastern U.S. They use it to predict the trajectory of radioactive particles in the event of an accidental release into the atmosphere. One other user of the model is the San Francisco air quality board, which uses it to predict the movement of smog and other airborne pollution around the Bay area.

Doppler Radar

One method for tracking the trajectory of particles in real time rather merely than predicting their path is to use Doppler radar. Doppler radar measures the relative velocity of the radar transmitter and its target based on the Doppler frequency shift of the target's radar echo. Doppler radar is able to map any type of air disturbance that causes the radar wave to echo back to the receiver, whether it is pollution particles, air turbulence, or, more normally, rain.

Doppler radar has been around for many years, mainly for use in aircraft navigation. It is seeing widespread use among weather agencies due to basic technological advances. Because the "pulse" Doppler measures is the very small motion of particles, and because the corresponding change in the echo's returning frequency is so small (less than one-millionth of the radar's propagation frequency), extremely good frequency stability is required. This has only been possible in recent years.

This technology may prove to be the most useful ever for the meteorology field. Doppler radar is able to map out tornadoes, thunderstorms, hurricanes, severe air turbulence, windshear, and microbursts (intense, small-scale downdrafts, usually carrying rain with them; they are extremely dangerous and are able to literally knock aircraft out of the sky). Extensive radar networks can map out complete wind fields associated with showers and thunderstorms. The extremely sensitive radars are able to detect ordinary air turbulences in clear air by measuring the drift velocity of scattered particles carried by the wind, from which the wind's velocity can be accurately calculated.

Doppler radar is also able to detect circulating winds hidden in the midst of a storm several miles above the ground. These winds, called mesocyclones, often produce tornadoes within twenty to thirty minutes after beginning to circulate. Because of this, Doppler systems are an important element in tornado early-warning networks.

The use of ever-improving radar systems combined with mesometeorology, macrometeorology, and nowcasting will eventually result in more accurate forecasts covering time periods from an hour away through the next week. Doppler systems take care of immediate, on-the-spot weather imaging; nowcasting covers the next two to twelve hours; and mesoscale modeling takes over just as the nowcasting-based forecasts begin to decay. Finally, the synoptic-scale predictions will cover from a day to a week or more into the future. While it will still be many years before the National Weather Service puts all of these methods to full-scale use (as it stands, the cost, complexity, and the amount of computer time needed are enormously prohibitive), the benefits are already being reaped in the forms of improved tornado detection, safer air travel and space shuttle launches, and better pollution tracking.

The next time you and your sweety are laying on a grassy hilltop and staring at the sky with a warm summer breeze blowing through your toes, just remember that those clouds are really just huge strings of ones and zeros on a chip in the depths of some Cray's memory somewhere in a dark building in Maryland. It'll ruin a romantic moment every time.

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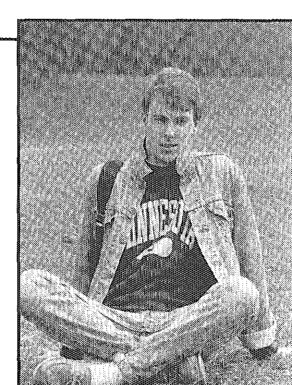
Dr. Dennis Moon, R-Scan Corporation, Minnesota Supercomputer Institute.

Dr. Walt Lyons, R-Scan Corporation, Minnesota Supercomputer Institute.

Joe Eastman, R-Scan Corporation, Minnesota Supercomputer Institute.

Author Bio



Darin Warling is a sophomore double-majoring in computer science and mechanical engineering. This is his second article for the *Technolog*, but Darin enjoys writing in his spare time as well. He is working on his second novel.

Storing Nuclear Waste

Transporting nuclear waste is a hazardous procedure requiring special containers that can withstand the most perilous accidents. Department of Energy officials are currently testing the Trupact II nuclear waste container by dropping it onto solid concrete, subjecting it to 2000° F infernos, and smashing it against steel spikes. If the trash container passes its tests, the Trupact II will be used to transport radioactive waste and other contaminated materials from weapons plants across the country to a waste isolation plant in New Mexico.

The Trupact II is a stainless steel container with a two-inch airspace separating the inner containment vessel from the outer vessel. Protection from the outside is provided by ten inches of dense shock-absorbing foam and a fire-resistant material called lytherm. Inside the container are drums and two large metal boxes capable of storing 7,000 pounds of contaminated materials.

Initial tests have revealed defects that allow dust particles from inside the container to escape. Designers are now working on a dust seal that can withstand extreme conditions. Detractors contend that the testing being performed is not worst-case. For example, a gas tanker in Oakland, California caught fire and burned at temperatures greater than those used to test the Trupact II.

Source: *Discover*, May, 1989, p. 18.

Mapping the Sun's Interior

The differential rotation of the sun is one of solar physics' longest unsolved mysteries, but work by Kenneth G. Libbrecht of the California Institute of Technology may provide some clues.

Because the sun is a hot ball of gas it is not constrained to a rigid rotation like the planets, hence the name differential. The sun's rotation rate decreases steadily from the equator where the period is 25 days to the poles with a period of 36 days. Libbrecht says he believes that this surface pattern is the result of some deeper pattern that would explain the differential rotation if it could be found.

Physicists have known for years that the sun produces approximately 10 million sound waves in its interior. Although they do not understand the origin, these waves serve as an important observational tool because the longer their wavelength, the deeper they originated within the sun. In addition, the difference in the frequency between the waves moving east and the waves moving west is directly related to the rotation rate. By studying the surface waves, information about the sun's interior can be obtained.

Libbrecht and his students undertook the daunting task of analyzing the data from the surface waves. Their results yielded the highest resolution images of the sun's interior yet attained.

However, their efforts required four months at a solar observatory taking over 60,000 images of the sun, and consumed large amounts of time on a Cray Research supercomputer.

Unfortunately, the results were not good enough to say anything about the inner 40 percent of the sun's core. However, they do show that the rotation rates extend 30 percent inward to the "convection zone," a region where gaseous plasma is violently excited as it changes in temperature.

Source: *Science*, April 7, 1989, p. 31.

Technolog *Takes Top National Award*

The annual Engineering College Magazines Associated (ECMA) convention was held April 14 and 15 in Washington, D.C., hosted by Howard University. Five IT students and a faculty advisor attended the convention representing *Minnesota Technolog*. Convention activities included seminars on magazine layout, editing, and printing. Additionally, speakers addressed the convention on general topics concerning student engineering publications, with particular emphasis on the social context of engineering.

In keeping with its charter to promote excellence among member publications (over 40 magazines nationwide), ECMA annually presents awards recognizing noteworthy achievements in writing, layout, and artwork. Of the fifteen award categories, *California Engineer* took five first-place awards, *Minnesota Technolog* took three, and *Cornell Engineer* took two. *Minnesota Technolog* won awards in the following categories:

Third Place	Best Art/Photography (All Issues)
	Best Single Issue (Four or More Issues)
	Best Editorial (All Issues)
Second Place	Best Layout (Single Issue)
	Best Layout (All Issues)
First Place	Best Non-Technical Article
	Best Editorial (Single Issue)
	Best All-Around Magazine

Including this year, *Technolog* has won the first-place award for Best All-Around Magazine three of the past six years. Jim Willenbring, editor during the 1987-88 school year, credits *Technolog*'s success "to the students who are involved with *Technolog*—the writers, editors, illustrators, and IT Board of Publications members. Everyone is really committed, even with all of their school work and other activities." Steve Kosier, 1989-89 editor, echoed Willenbring's observations, adding that "the desire to put out a superior product, creative thinking, a small dose of craziness, and the belief that nothing should be taken too seriously" have been instrumental to the *Technolog*'s success.

NATURE TRIVIA

1. What is the world's longest bridge and where is it?

2. What is eugonol and how is it used? (Clue: You've probably smelt it a number of times at the same place.)

3. What is it that makes a skunk smell?

4. What is a proustite and how did it get it's name?

5. How many and what kind of bones are in an elephant's trunk?

6. What is a tintometer? Since the name gives a hint, say briefly how it works.

7. About how many times do you think you change your body position when you sleep, and how many dreams do you think you have?

8. Just how does a firefly make it's light?

9. Why is it that sugar, unlike other kitchen staples, does not spoil or get moldy?

10. Which is thicker: city fogs or country fogs?

Scoring

0-1: Next time, do the trivia when you are awake.

2-4: How did you ever get into IT?

5-6: Well, you are normal (or at least average).

7-8: Be proud of yourself—if it was honest work.

9-10: You had better seek professional psychiatric help—immediately!

by Bunmi Odumade

Answers

1. The Humber bridge in England is the world's longest.

2. It is a colorless or pale liquid that is the essential chemical constituent of clove oil. It is the most prominent smell in a dentist's office and the reason why they all smell alike. Dentists combine solutions of it with a mixture of rosin and zinc oxide to prepare a protective pack after gum surgery or as a temporary cement.

3. It's bad smell is contained in a liquid, called musk, which it produces and then discharges if it is afraid. It sprays only a few drops at a time, but this is plenty.

4. It is a silver, arsenic sulphide with adamantine luster that crystallizes in the hexagonal system. It got its name because of its scarlet-to-vermilion color.

5. None at all, but it does have 40,000 different muscles.

6. It is a type of colorimeter, in which the intensity of color and the concentration of the colored substance is determined by comparison with colored glass or standard solutions.

7. During an average 8-hour sleep period, which is probably not typical with most non Technolog staffers, most people change their body position at least 12 times, and have from 3-5 dreams, each lasting from 10 to 30 minutes.

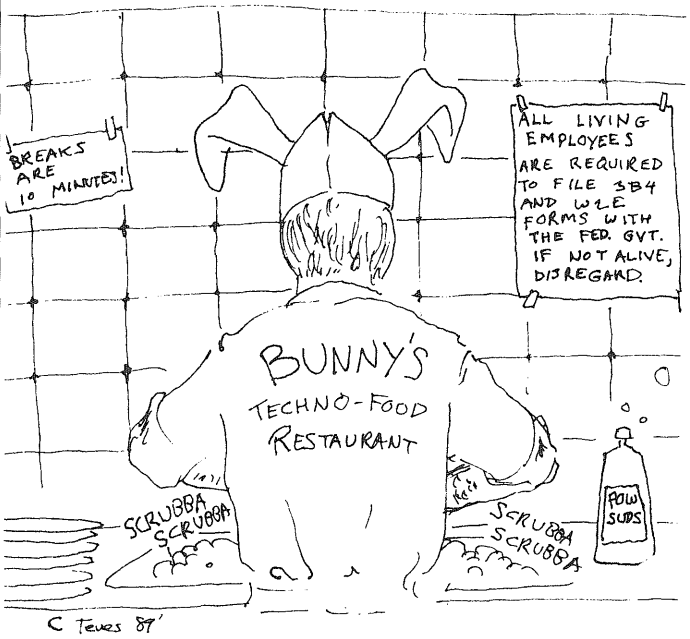
8. The firefly, which is really a beetle, has 5 chemicals in its stomach. When oxygen enters the body, it stimulates a nerve reaction which causes them to combine, turning the light on. Later on, another chemical combines to stop the reaction, turning off the light.

9. Since sugar has an extremely low moisture content, it dehydrates micro-organisms that might cause mold. This also impedes chemical changes that could spoil it.

10. Since city air has more dust and soot from factories, chimneys and traffic, city fog is thicker than country fog.

The Near Side

by Steve Littig and Conrad Teves



After six years and $50,000, Steve graduated and found a job in the field of ceramic and silver purification.

The Flip Side

by Jim Willenbring and Tom Rucci

The aftermath of the lunch meeting between Professor Jones, who researches anti-matter, and Professor Smith, a leading condensed matter physicist, was not pretty.

1988-89 Room 2 Gang

Back row, left to right: Jim Willenbring, Jeff Conrad, Steve Subera, Denis Zilmer, Jeff Rud, Tim Hartley, Steve Littig. Middle row (being held), left to right: Steve Kosier, Loren Thomsen. Front Row, left to right: Cathy Bekavac, Jayne Ojarood, Linda Urich.