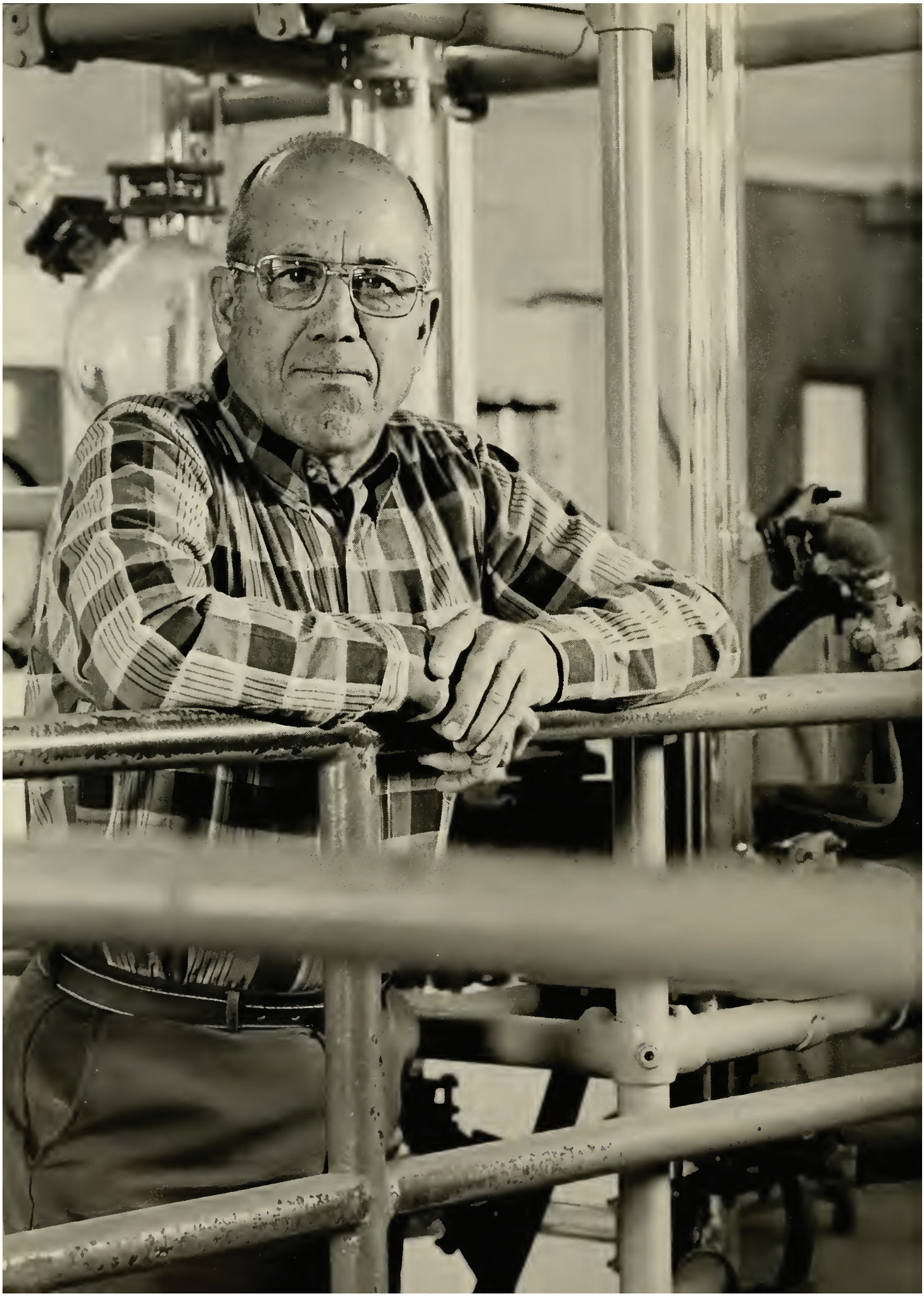
Inside Chemical Engineering • London Project Center

WPI Journal

WORCESTER POLYTECHNIC INSTITUTE

SUMMER 1987



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Cover: June skies behind Boynton Hall. Photo by Jon Reis.
Opposite: Prof. Robert E. Wagner joined the Chemical Engineering Department in 1949. Nearly four decades later, the Department carries on its pioneering spirit. Photo by Michael Carroll.

THE PRESIDENT'S MESSAGE

Independent Technological Universities: Aiming at the 21st Century

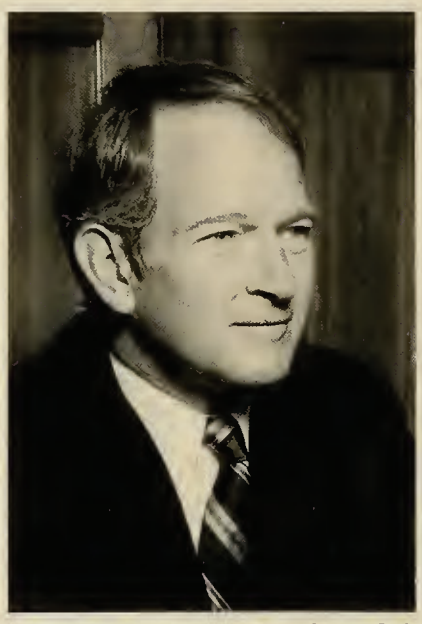
By Jon C. Strauss

Beginning 120 years ago with its original colonial colleges, American higher education has evolved to the land grant universities, the independent "polytechnic" schools (of which WPI was the third to be chartered), the liberal arts colleges, the comprehensive universities, and now to the modern research universities. Given the needs of contemporary and future society, the breadth of mission of these various types of institutions, and the changing character of contemporary "polytechnic" schools, a question needs to be addressed: What is the best course for WPI—a polytechnic now being transformed into a technological university—as it approaches its 125th year and prepares for a new century of progress?

Charting a course for the next decade is a particularly timely issue as American higher education is being subject to intense criticism. William Bennett, secretary of education, recently stated that colleges and universities are in danger of losing public support because of their failings in undergraduate education. A great deal of scrutiny has also focused on the proper role for technical subjects in engineering, business, and science in a four-year college education. R.J. Franke, president of a major investment banking firm, joins a common refrain in saying: "Humanities educate us to live, and vocational training teaches us to earn."

Moreover, the recent Carnegie Foundation Report on Higher Education cites a conflict between "careerism and the liberal arts," stating that "narrow vocationalism, with its emphasis on skills training, dominates campuses.

As if these indictments of higher education weren't enough, Allan Bloom, in his book *The Closing of the American Mind*, states that students who use the university as training grounds for professions merely go through the college experience with "blinders on, studying what the chosen discipline imposes." Bloom further alleges that such a student



is generally motivated not by love of his field of interest, but by love of money from the career that will follow. Similar concerns have been voiced by many in business, in higher education, and in government.

How should institutes of technology respond to these concerns? The value of the applied sciences in the undergraduate curriculum is under attack. Interestingly, this situation is not new; its history is both revealing and humorous. The applied sciences have long struggled against accusations of being vocational and secondary. As long ago as ancient Greece, for example, Xenophon spoke for many of his fellow citizens in Athens when he proclaimed that "the mechanical arts carry a social stigma and are rightly dishonored in our city." Technologists, he maintained, "simply have not the time to perform the offices of friendship or citizenship. Consequently they are . . . bad friends and bad patriots."

In the 1630s, the Marquis of Worcester proposed that England's great universities present instruction in the various national industries. The Marquis argued that men with talent in invention and industry were men of great genius and should be considered scholars. Himself an amateur inventor and scholar, the Marquis fought to promote this "new education." But he had come upon his idea at the wrong time: With Oliver Cromwell on one side and Archbishop Laud on the other, and England's civil war brewing in between, the Marquis' thoughts fell on deaf ears. He died bankrupt, and for two centuries more, England's universities refrained from instruction in anything but the classics.

The industrial revolution provided the catalyst that ultimately changed curricula. After centuries of intellectual prejudice hampering studies in the applied sciences by the world's scholarly community, the needs of growing industrial nations finally created an undeniable demand for their acceptance. But this societal need did not always enhance these areas of inquiry to equal status among the more classical disciplines.

For instance, Yale and Harvard universities took bold steps in the late 19th century by creating "scientific schools" that incorporated studies bearing on modern industries. But these scientific schools had a severe drawback. Their new studies were not presented on a par with more classical studies. Both institutions kept their scientific schools separate, even physically isolating them from the rest of campus, and giving their graduates certificates instead of diplomas.

Eventually, two types of colleges evolved with specific instruction in the mechanical and industrial arts. The land grant universities had, and continue to have, strong ties to agriculture, animal husbandry, and mechanical arts—the skills necessary to support the economy of a rapidly expanding nation. The same economic needs that motivated the land grant universities prompted the development of the polytechnic schools. WPI—founded in 1865—and its predecessors—RPI in 1834 and MIT in 1864—were established to satisfy the technological

needs of their communities of origin. In the case of WPI, those needs focused on preparing young men from the immediate locale to staff the burgeoning industries and factories of Worcester. WPI was successful in this enterprise, as were over a dozen other similar institutions.

Harold Shapiro, Princeton University's new president, has noted that the primary concern of early American colleges was the preservation and the promotion of morality. Little emphasis was placed on the development of new ideas. But as the world changed dramatically in the 19th and 20th centuries, so did the mission of its academic institutions. Just as the industrial revolution created a need for technical education in engineering, science, and business, World War II served as a similar agent of change for altering higher education's technical emphasis. This conflict established that basic scientific research was essential for a nation to maintain its military and economic strengths.

The modern research university is the direct result of this interpretation, and has become the major factor in American higher education in the relatively brief 40-year period since. These institutions grew out of some of the land grant universities, comprehensive universities, and polytechnics. They are characterized not only by the scope and breadth of their faculty scholarship, but also by the intensity and success of their faculties at obtaining external sponsorship for their research, largely from various federal agencies. CalTech, MIT, and Carnegie-Mellon University (formerly Carnegie Tech) are good examples of polytechnic colleges that have transformed themselves into research universities.

These four decades that saw the emergence and growth of the modern research university also saw tremendous changes in the polytechnics. Some, like CalTech and MIT, did more of the same, but better, while others, like Carnegie Tech and Case Tech, achieved recognized research university status by affiliation with other institutions. But key to the change in all of the former polytechnic institutions (including WPI and the other members of the Association of Independent Technological Universities) in the last half of this century is a new emphasis on scientific research.

WPI is a good example of this change in the breadth of the polytechnics. Following founder John Boynton's emphasis on academic instruction and mindful of founder Ichabod Washburn's concern for practical, shops-oriented education, WPI continues to emphasize both theory and practice. This is the "Two Towers" tradition captured in the WPI motto *Lehr und Kunst* (learning and skilled arts) and is embodied in the original two towers (Boynton for academics and Washburn for shops). Today, this approach to higher education is also embodied in the WPI Plan—outcome-oriented education that blends theoretical studies and practical application through project work.

WPI must devote significant resources toward faculty development.

While the scope of both the origins and employers of WPI students has broadened considerably in the past 120 years, WPI remains closely tied to this nation's industries. Yet now, through active programs of research, WPI is also initiating new developments, processes, and directions for industry as well as responding directly to its needs for trained engineers, scientists, and managers. In this, WPI remains true to its founders' directive to create or discover and to convey knowledge at the frontiers of academic inquiry for the betterment of society, while responding to the very different world today.

The evolution of engineering in higher education and the recent recognition of the polytechnics as technological universities help bring focus to my question above regarding the best course for WPI in preparation for the 21st century.

The recent report on "Engineering Education and Practice in the United States" predicts an evolving future. It foresees likely characteristics of the engineering environment in the year 2000 to include longer time horizons for profit-taking, shortages of capital and resources (both energy and materials), a global economy with increased intra- and interindustry competition, increased government demand for engineering goods and services, continued high rate of scientific discovery and technological development, and an increased requirement for nonadvanced engineering tasks.

Reports such as this and the Carnegie Report must be considered when determining a future course. Fortunately, WPI is healthier than many peer technological universities with respect to the reports' recommendations. For example, the Carnegie Report raises one question above all others: "Can the liberal and useful arts be blended during college, as they must inevitably be blended during life?" To accomplish this and other objectives, the Carnegie investigators propose several criteria:

- The student's field of study should include a written thesis that relates some aspect of the major to historical, social, or ethical concerns.
- Every student should write a senior thesis, and present this report in an oral defense to colleagues and fellow students.
- Students should be measured by the outcome of their education, not by curriculum requirements fulfilled.
- While not all professors need be publishing researchers, they nonetheless should be first-rate scholars.

These specifications are well met by the "outcome"-oriented WPI Plan, which has been evolving at WPI over the

Continued on inside back cover

WPI's excellence in chemical engineering continues—in traditional and emerging fields.

In the Labs of Goddard Hall

By Leslie Brunetta

"THE EXTRAORDINARY THING about WPI's chemical engineering department," says Associate Professor Robert Thompson, "is that we rank among the top universities in at least three areas of research—zeolites, biochemical engineering, and catalysis. Considering how small the department and the college are, that's pretty remarkable."

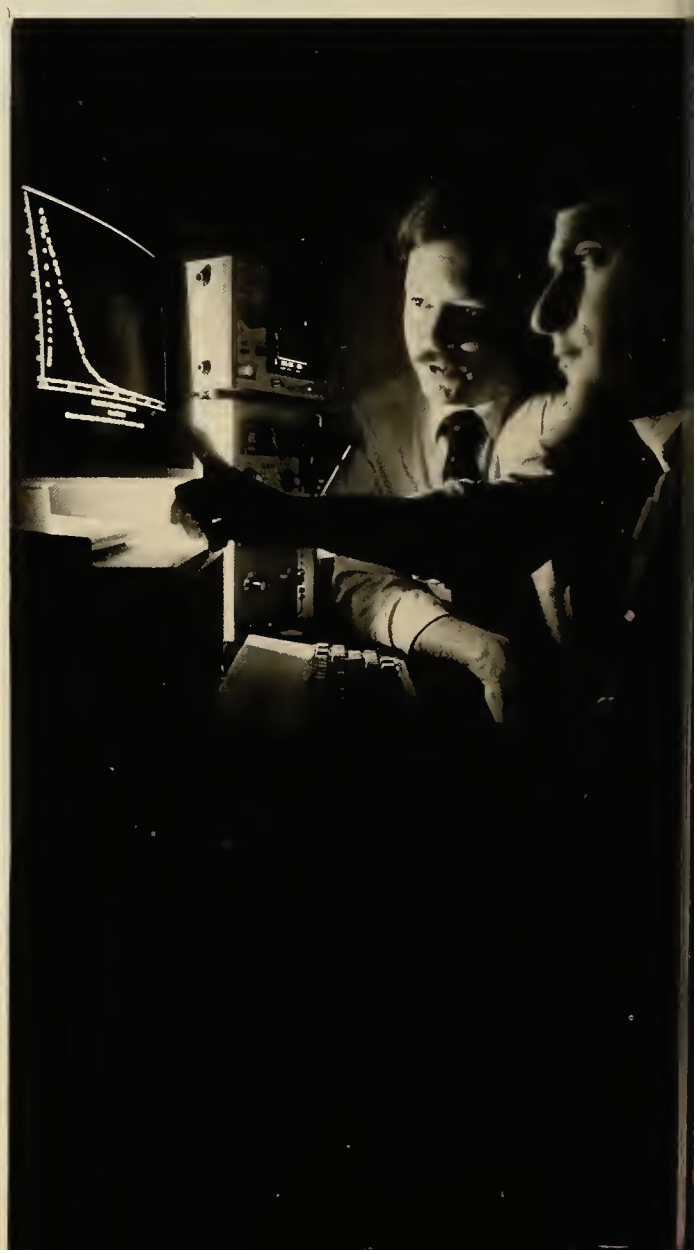
While the MITs, CalTechs, and Purdues of this country can boast chemical engineering faculties of 30 or more, WPI's department supports a staff of just 10 active faculty members. But, as David proved to Goliath, strength doesn't always depend on size: sometimes commitment, clear aim, and focused energy can put you on top.

FOR MORE than a decade, WPI has been an internationally known center for zeolite research. When the inferno of molten magma at the center of the earth breaks its bounds, igneous rock is formed as lava belches up to the earth's surface and meets cooling air or water. In the cavities of these rocks can be found about 40 varieties of zeolites—minerals consisting of hydrous silicates. Like all other minerals, zeolites are crystals, and so their atoms are arranged in regularly repeating patterns.

Fortunately for chemical engineers, and for the rest of us who rely on a variety of chemical products in our daily lives, these patterns have been found to be extremely useful tools in a number of chemical processes, particularly in the production of liquid fuels and new chemicals. So useful, in fact, that over the years chemical engineers have gone to the trouble to synthesize an additional 150 or so zeolites.

"I was recently at a conference in Tokyo," says Thompson, "and someone came up to me and said, 'Oh, you're from the WPI zeolite group. You're the only ones in the country who are doing any reasonable work.' We get comments like that frequently, and it's a good feeling."

Thompson's acquaintance may have been exaggerating WPI's standing a bit, but the fact that WPI has a larger zeolite research program than any other academic institution



in the country and that the department can be counted on to be a star participant in virtually every major zeolite conference is taken for granted by the rest of the chemical engineering world community.

WPI owes this fame in part to the pioneering work of Professor Leonard Sand, who died in September 1985. Sand joined the department in 1967 after spending eight years as head of a Norton Company research unit developing synthetic zeolites. During his nearly 20 years at WPI, Sand's enthusiasm for the promises zeolites held out for industry and research rubbed off on the department's other members, with the result that now nearly half of them are involved in some aspect of zeolite research.

Because of the properties of their crystalline structures, many zeolites act as molecular sieves—they allow some molecules to pass through them but not others. This chemical gate-keeping activity is essential to the zeolites' role in catalysis, a process central to the workings of the whole chemical industry.

A catalyst, such as a zeolite, either kicks off or affects the rate of a chemical reaction without itself being chemically changed by the reaction. That's important: The reaction might take place in nature anyway, but so slowly as to be of little use.

Two ways in which zeolites act as catalysts are department research specialties: adsorption—in which a thin layer of the reacting molecules sticks to the zeolite surface—and diffusion—in which gas or liquid molecules pass through a zeolite.

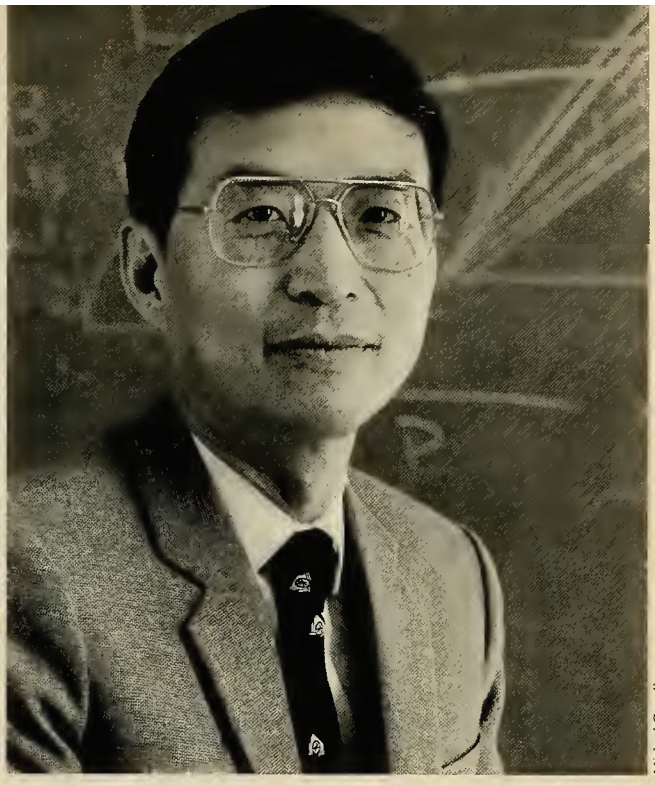
Department Head Professor Yi Hua "Ed" Ma's primary research interests are in the adsorption and transport properties of reactants as they diffuse through porous materials, including molecular sieve zeolites. This research is of fundamental importance to catalysis because how—and how quickly—a reactant travels through and around a catalytic site on its way to the reaction site determines how efficient a reaction will be. Ma studies both intercrystalline diffusion (how a reactant gets from one crystal to another) and intracrystalline diffusion (how a reactant gets through a single crystal) with the goal of helping industry better predict the most efficient sizes for reactors and flow patterns for reactants.

Ma is also trying to help scientists and industry by reconciling seemingly contradictory results that have appeared in research literature. Over the years, many people have tried to measure zeolites' adsorptive and diffusive properties by using nuclear magnetic resonance techniques and gravimetric analysis.

But the two techniques often produce extremely different measurements. Ma hopes that, through a more rigorous approach, he'll be able to resolve these different measurements and come to an understanding of the two properties that will make catalytic use of zeolites more predictable.

Ma's work in this area is an NSF-sponsored, cooperative effort with WPI colleague Associate Professor Anthony Dixon and Clark University Professors Alan Jones and Paul Inglefield.

A new area of Ma's research is inorganic membranes—materials (including aluminas and zeolites) that may find applications in many industrial processes. Almost without his expecting it, Ma's work in zeolites has propelled him to leadership in the field. In fact, Alcoa has given him $100,000 to establish the country's only academic center for inorganic membrane research.



Michael Carroll

Opposite: Associate Professor Robert W. Thompson (l.) works with M.S. student Richard Correia on a partial size analyzer for measuring zeolite crystal size distribution. Above: Professor Yi Hua "Ed" Ma heads a department that has long been one of the Institute's most distinguished.

These membranes would be made up of inorganic materials (oxides) through which a fluid would pass. As the fluid passed through it, the fluid's diffusion properties would cause some of the fluid's components to separate out. The successful use of inorganic membranes could provide industry with an extremely efficient way to cull valuable products.

In 1986 Ma was elected to a six-year term as a member of the governing council of the International Zeolite Association.

Department ambassador Professor Alvin Weiss is also a long-time student of zeolite catalysis, and is widely recognized as a world-class expert. He has traveled all over the globe to share his expertise in catalysis, helping to set up projects or analyze results in Argentina, Israel, the USSR, and Viet Nam, among other countries.

Weiss's research projects in this area have been many. He has defined how ethylene glycol—the thick liquid alcohol used in antifreezes—can be produced as formaldehyde reacts over basic zeolites. He

also has been studying adsorption in natural zeolites.

A project that falls under the biochemical engineering umbrella involves using zeolites as one of a number of catalysts in the synthesis of edible sugars from non-edible chemicals such as formaldehyde. The sugars might also be synthesized from water and waste carbon dioxide—one small step toward making long space voyages more feasible.

One type of zeolites, the H-ZSM-5 synthetic, is a big player in the fuel industry, and Professor William Moser has been trying to find out more about it. Mobil has already used it to convert methanol to unleaded gasoline. It is used in South Africa in a process for converting coal first to synthetic gasoline and then to a readily usable gasoline. What Moser has found is that it can also be used to convert dilute aqueous ethanol to high quality ethylene.

"That means," Moser says, "using anything that can be fermented, you can take the alcohol from that fermentation and convert it to ethylene, which is probably the single largest commercial chemical used in the world. It's used for making everything from fuel to plastics." And since ethylene is usually obtained from either coal gas or petroleum hydrocarbons—finite resources—the option to take it instead from renewable sources like plants is a remarkable one.

Moser is joined in the study of zeolite synthesis by Ma and Thompson. Thompson devotes most of his research time to trying to understand how and under what circumstances zeolites crystallize. At present, a lot is known about what different zeolite crystals can do, but not enough about how they get that way, and without that understanding much of zeolite technology remains a dream rather than a reality.

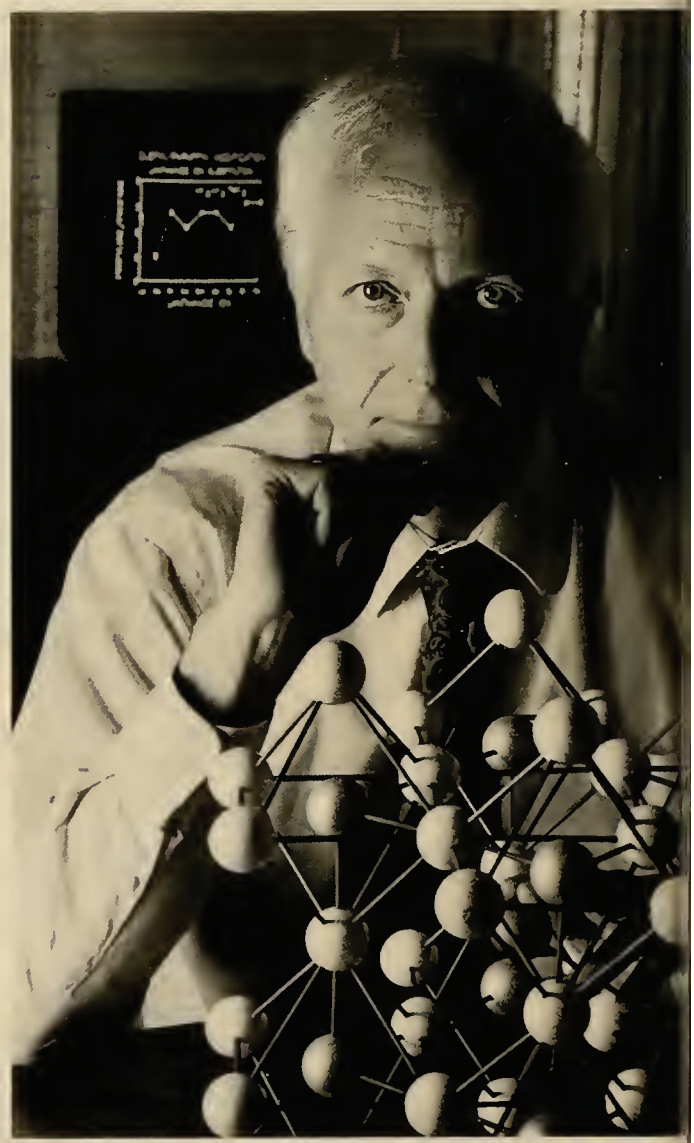
"Once we understand zeolite crystallization," Thompson says, "we can control it. Many of the natural zeolites come contaminated, and some of the synthetic ones are inefficient. Once we can control the crystallization process, zeolites should become much more cost effective."

Another problem Thompson is working on concerns zeolite stability—or lack thereof. Most of the useful zeolites are chemically unstable and tend toward more stable, but less useful, phases. Some zeolites can be stabilized in their useful phases, but the very substances that aid the stabilization have other side effects that botch reactions. Thompson hopes that, through both experimental and theoretical work, he'll soon be able to crack the mysteries of the transformation from one phase to the next and so, eventually, be able to control the change.

The project that the zeolite team is perhaps most excited about is the NASA space shuttle zeolite experiment. Thompson, Tony Dixon, and Associate Professor Albert Sacco have been awarded a $325,000 grant from NASA's Centers for Space Commercialization program. The team will study microgravity zeolite crystal growth—specifically, how to grow zeolite crystals in space that are larger than those that can be grown in earth's gravity.

On earth, Sacco explains, zeolite crystals of industrial interest typically grow to have sides two to eight microns (one micron is one millionth of a meter) in length. In space, where gravity becomes a secondary consideration and surface tension a primary one, the crystals may grow to have sides in excess of 100 microns in length.

Growing large zeolite crystals will have tremendous implications for the commercial use of zeolites. Such large zeolite crystals should



Prof. William R. Moser works on developing methods for using the alcohol from anything that can be fermented to make ethylene, the world's largest commercial chemical.

be excellent selective molecular membranes as well as useful ionic exchange materials. "NASA seems to think that this process may be commercialized in a short time," says Thompson. "But even if it isn't, we stand to learn a great deal about processing both in microgravity and on earth."

"We are one of probably only three or four schools in the country who know how to process in space," Sacco says. "In fact, we are perhaps the only school given priority flight time in the shuttle flight schedule." After the explosion of the *Challenger* delayed all subsequent shuttle launches, many experiments scheduled for the flights were bounced in favor of Department of Defense projects. But NASA thinks so highly of the WPI project that not only was a slot saved for it, but it was also actually bumped farther ahead of its original position on the experiment list.

While the NASA zeolite project's results should mainly benefit earthbound industry, Sacco's other NASA project may solve one of the major obstacles to extended space missions: the effort and cost of transporting oxygen from the earth. "Basically, we'll be mining the moon for oxygen," Sacco says, "and if it works, it should cost only about 20 percent of what it costs to transport oxygen from earth."

What Sacco is proposing is to mine ilmenite, a mineral composed of iron, titanium, and oxygen that's found in great quantities on the moon's surface. A fixed amount of hydrogen would be brought to the moon from earth and reacted with the ilmenite. As the hydrogen bonded with the oxygen in the ilmenite, water would be formed. The water then could be separated back into hydrogen and oxygen by electrolysis and the hydrogen recycled while the oxygen is used on a space station or for deep space missions. "Obviously, there are a lot of technical difficulties," says Sacco, "but we have a four-year contract to try to develop the kinetics of the process."

One of Sacco's graduate students, Randall Briggs '86, is continuing ilmenite-related

Michael Carroll

Current research of Assoc. Prof. Albert Sacco includes a NASA-sponsored study on the growing of zeolites in space.

Bob Wagner: Still Climbing All Kinds of Mountains

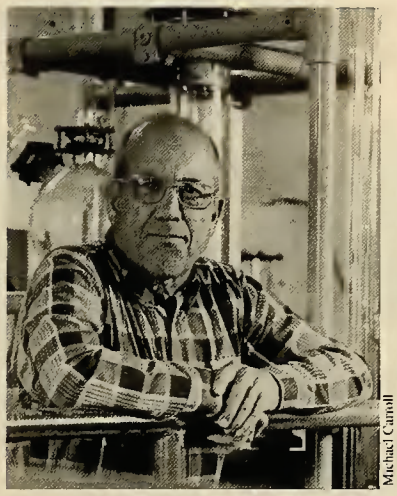
Before Prof. Robert Wagner and his wife, Ruth, set off on a cross-country retirement celebration last year, Wagner telephoned a few old students. By the time the couple returned to Shrewsbury, they had been welcomed into the homes of over 40 alums.

"It's funny," Wagner says, "but I remembered each of their voices the moment I heard it on the phone—even if I hadn't spoken to them since class 30 years ago."

Wagner has always had this instant rapport with his students, and it's a prime reason he has long been one of the best-loved professors on the Hill. Another is his ability to inspire his students with imaginative and practical approaches to problems that might at first seem outside the usual realm of the chemical engineer.

Wagner regularly used to supervise more than 30 MQP and IQP students a year, a measure of both his dedication and his popularity among the students. "I became a nature freak when I started mountain-climbing," says Wagner. "Since then, most of the MQPs and IQPs I've handled have centered around problems with the contamination of nature."

Solar composters at trailside toilets in the White Mountains posed a memorable puzzle for Wagner. Because they worked too slowly, the Appalachian Mountain Club, which supervises them, faced the costly prospect of hauling wastes by helicopter. But Wagner's students found a way to enhance the composters' work by forcing warm moist air through their reaction chambers.



Michael Carroll

A paradox involving acid rain also riveted Wagner: Red spruce in valleys were healthy, but dying on mountaintops. His students designed a device separating clouds' particles of fine fog and rain. They solved the mystery: Analysis showed the fog particles to be 50 times more acidic than rain, and rain fell in the valleys while fog shrouded the peaks. The students next installed separators in Alaska and the Rockies under government contract.

"Chemical engineers are in the best shape to do this kind of environmental work," says Wagner. Thanks to his dedication, many WPI alums can now see why. —LB

research, which he began as an undergraduate while completing his Interactive Qualifying Project.

WPI'S NEWEST ADDITION to the chemical engineering team is Assistant Professor William M. Clark. Clark gained his Ph.D. from Rice University in 1984, then studied in Denmark for nine months on an NSF-NATO postdoctoral fellowship. Following further postdoctoral experience at the University of Delaware, he came to WPI last fall.

"Besides the high quality of WPI research and its students, I was attracted by the idea of working with DiBiasio and Rollings," says Clark. Associate Professors David DiBiasio and James Rollings form the backbone of WPI's biochemical engineering effort. The fact that WPI now has three researchers not only specializing in the field but also in different aspects of the field puts the college in a class by itself.

"There are probably not more than 80 biochemical engineers distributed throughout the nation's universities," explains Rollings. "Not more than 15 deparments have more than two people. We have three, which puts us among the, say, top five schools. And most of those have all their people working in the same area—fermentation, for example. Whereas at WPI, we have someone specializing in fermentation, in biothermodynamics, and in biopolymers."

DiBiasio is the department's point man in fermentation and process control of biochemical systems. Currently, his main area of concentration is in studying biochemical reactors, with an aim toward eventually controlling and optimizing them. The reactors DiBiasio is studying use whole cells, such as microorganisms or tissue cultures, to convert some raw material into a useful product. That product may be a protein, a vaccine, a hormone, or some other biological substance.

DiBiasio has spent most of his recent efforts on a microbial system yielding a protein that may be used for animal food. "I'm trying to develop a methodology for mathematical modeling of these systems," he says. These models, he hopes, may eventually be used to better control multiple steady state and dynamic reactors.

Hollow fiber reactors are a second kind of bioreactor used to produce proteins, in this case, proteins that may be used for therapeutic purposes. The problem is that since live animal cells are used to produce the proteins, special consideration has to be given to their fragility and their sensitivity to outside influences if the very biological processes that make them promising are to be preserved. DiBiasio is engaged in theoretical and experimental work directed toward designing these reactors so that the cells are maintained in optimum condition.

Even though many systems used in biotechnology research make use of immobilized cell reactors, not much is yet understood about how pinning the cells down affects their behavior. And without this information, it's tremendously difficult to predict how best to scale reactors

Michael Carroll

Biochemist William M. Clark is working to understand how fundamental areas of chemical engineering like thermodynamics and transport properties apply to new biochemical systems.

up to the sizes needed to make biotechnology a thriving industry.

So DiBiasio has formed a partnership with Judith Miller, associate professor of biology and biotechnology, to discover what effect immobilizing microbial cells in reactors has on a system. Miller and DiBiasio are studying a recombinant strain of *E. coli* to see how immobilization affects the cells' use of the input substance, distribution of by-products, and gene expression.

Two years ago, the National Science Foundation and the White House flagged Jim Rollings' exceptional work on biopolymers with a Presidential Young Investigator award. Proteins, polynucleic acids, and polysaccharides (carbohydrates such as starch or cellulose) are all biopolymers—biological substances whose molecules are constructed of chains of smaller molecules.

A polysaccharide, for instance, is a large molecule that can be broken down into component molecules such as fructose or glucose by breaking the hydrogen-oxygen bonds between these molecules. Rollings' work aims to build up an understanding of the fundamental physical and chemical properties of biopolymers and how these properties affect a variety of biochemical processes.

"Rice isn't corn isn't wheat isn't cassava, even though they're all polysaccharide starches," says Rollings, stating an observation that anyone who has either cooked with or eaten those foods will have made. "But why they're different, we don't know."

Not knowing why cassava starch was different from wheat starch didn't matter in the days when all that rode on that knowledge was a bowl of tapioca or a loaf of bread. But in the age of biotechnology, when these abundant, renewable sources of food may hold the keys to more plentiful supplies of fuel, industrial chemicals, or nutrition for people in food-poor areas, this knowledge becomes more valuable with every passing year.

One of the main facets of Rollings' research is the development of an analytical technique for characterizing biopolymers and their properties. Rollings has found that currently available tools for analyzing molecular characteristics aren't up to the task of studying biopolymer systems, so he's trying to come up with something designed specifically for them—a size exclusion chromatograph coupled to an on-line detector.

Another Rollings project is the study of depolymerization kinetics—what happens when biopolymers break down into their component molecules. "In industry, you want to process polymers so that they have more desirable end products," says Rollings. "For instance, you might want to take corn, which is abundant and cheap, and process it to come up with a sweetener that's cheaper than sugar cane."

What happens when a polysaccharide, for instance, is depolymerized is well known; it's hit with an enzyme and chewed down to its individual sugars. How that process works isn't understood, though. The practical problem of this lack of knowledge is that effective depolymerization usually boils down to a matter of trial and error attempts to break down some particular polymer. "So if we know how to get an alternative sweetener out of corn, that's great for places that have plenty of corn," says Rollings. "But what about Thailand, where cassava is the main starch crop? If we don't really understand depolymerization, the applications are limited."

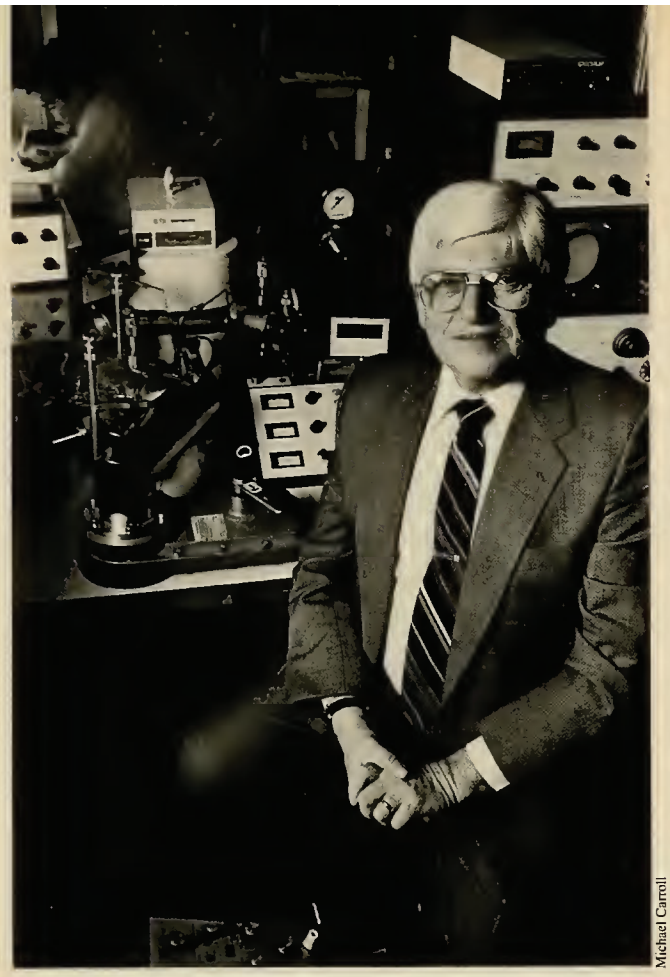
Michael Carroll

Assoc. Prof. David DiBiasio's research in biochemical systems centers on reactors that convert raw materials into products like proteins, vaccines, and hormones.

As the new kid on the block, Clark is still in the early stages of his research projects. But with a strong background in thermodynamics and transport properties, he is already in the thick of work geared toward an understanding of how these fundamental areas of chemical engineering apply to newly recognized biochemical systems.

One of the most important factors in the eventual survival and success of biotechnology as an industry is the development of reliable, large-scale recovery processes. It's all very well, after all, to be able to produce proteins or hormones or vaccines in the lab, but if you can't manage to extract them efficiently from the system they're in, they're not much use for anything except, perhaps, scientific study. So Clark is experimenting and using mathematical modeling to gain insight into some basic separation problems.

Clark's two main projects at the moment involve two-phase solutions. In the first project, he is studying the



Michael Carroll

Above: A founding member of WPI's zeolite team, Prof. Alvin H. Weiss also studies catalysis related to petrochemicals, ceramics, pollution control, and fire protection. Opposite: Assoc. Prof. Anthony Dixon (left) and graduate student Chue-San Yoo examine a semiconductor wafer.

thermodynamics of a separation process in which a bacterial cell pulls an antibiotic from one phase into the next, thereby separating it from the other components of its original solution phase. A kind of affinity partitioning, this process seems to have the potential to be very selective, even in a large-scale operation.

His second project is a collaboration with DiBiasio. They are trying to incorporate a two-phase system into a bioreactor with the hope that they can come up with an extremely efficient process—simultaneous biochemical reaction and extraction. (The experiment is similar to Rolling's reactor-separator experiments in concept, although the chemistry is different.) The idea is that, while recirculating the reactor cells and continuously removing reaction inhibitors and the end products, production of such things as antibiotics and recombinant proteins can be markedly enhanced.

WHILE WPI is at the leading edge of the two "new" specialty areas of zeolites and biochemical engineering, the department also claims honors as a leader in one of the field's most fundamental studies—catalysis. Most of the zeolite research actually falls into the catalysis category, but zeolites are just one in a myriad of catalyst types.

Weiss, a founding member of the zeolite team, together with Ed Ma, is also heavily involved in researching petrochemical catalysis, as well as catalysts for use with ceramics and in pollution abatement and fire protection.

He has been able to break down methane at high temperatures to produce acetylene and ethylene, immensely valuable chemicals which are usually taken from fossil fuels. Weiss has also invented a technique to fluidize silicon so that it can react with atmospheric nitrogen—a new way of manufacturing silicon nitride, a tough ceramic that is bound to be integral to new mechanical and electrical engineering design. And he has found catalysts that adsorb and react with toxic materials in ways that promise to save people from death by smoke inhalation—the primary cause of fatalities.

Catalysis falls into two main categories: heterogeneous (in which the catalyst is a solid and a gas or liquid reactant is passed over it) and homogeneous (in which the catalyst is dissolved in a solution and the reactant is passed through it). Over the last few years, chemical engineers have enormously increased their knowledge of how these two types of catalysis function, in large part thanks to scientists like Moser who have designed microscopic techniques for their study.

Over the past four years, Moser has developed a highly sensitive infrared spectroscopic exam that enables him to see what happens under typical industrial conditions. Using the exam, he has been able to determine exactly what happens—in real time and under real conditions—in the Monsanto acetic acid process (producing vinyl acetate, one of the top 10 industrial chemicals), the Union Carbide hydroformylation process (producing plastics and detergents), and the Dow organic halide carbonylation process (producing monomers for polymerization). "I'm providing the fundamental information needed to make these processes better," says Moser. "And if you make the processes better, you can make the products cheaper."

Moser's catalytic explorations have also led him into the development of a new method to synthesize simple and mixed metal oxides. This new method was meant to give the metal oxides unusual properties that would make them super-effective catalysts. But, unexpectedly, they also seem to be exceptional candidates for new leaders in superconductivity, the most recent area of engineering research to make the front pages. Moser is now doing the research necessary to determine if the materials' reality lives up to their potential.

In another case of near-serendipity, Al Sacco is now trying to encourage a stage of catalysis that he had previously spent years trying to eliminate. For decades, chemical engineers tried to stop the growth of the carbon filaments that tend to sprout whenever a catalytic process involves transition metals and high-temperature gases. As the filaments grow, they deactivate the catalyst, slowing down the process and

making it more expensive. But it turns out that if the filaments can be grown long enough and fat enough, they can be woven to make carbon-carbon composites that approach the strength of steel but are much lighter. Many supersonic fighter aircraft already use other types of carbon-carbon composites in their skins, and the material has many other potential uses in space and industrial design.

Tony Dixon takes information about catalysts and uses it to analyze and design catalytic reactors, in particular, the fixed bed reactor. "The fixed bed reactor is the work horse of the entire chemical industry," according to Dixon. "The bulk of all chemical processes comes through these reactors, and the efficient operation of the reactor is dependent upon an understanding of the heat transfer process within it. That's what I'm working on."

One way to think of a fixed bed reactor is to think of a tube filled with catalytic particles and perhaps other reactants. The primary reactant is passed through the tube. As it comes through, the reaction produces a lot of heat, usually enough to burn up some of the products that are supposed to emerge at the other end of the tube. The goal is to get as many of those products to come through the tube unscathed as possible.

What Dixon is studying is the relationship between the rates of heat transfer and the flow of gas through the tube, with the ultimate aim of being to be able to control the amount of damage done by the heat. Dixon is experimenting with how different catalyst particle shapes and methods of packing the tube come into play.

THE PAST FEW YEARS have been eventful ones for the Chemical Engineering Department. In addition to the many honors collected by individual team members, the department and the college have garnered attention as home of the New England Biotechnology Association (NEBA), organized by DiBiasio, Rollings, and Judy Miller to promote dialogue between people specializing in biotechnology, biochemistry, and chemical engineering. This year saw the fourth annual NEBA conference held at WPI, with more than 200 university and industry scientists and engineers in attendance.

In addition, Sacco and Weiss were chosen as this year's co-chairmen for the 18th Biennial Conference on Carbon which took place at WPI in July. This is the largest U.S. conference of its kind. More than 600 carbon specialists from around the world attended and presented over 300 papers.

WPI has traditionally been known as a leading center for the study and teaching of chemical engineering's fundamental disciplines—thermodynamics, fluid mechanics, process engineering, and the like. Even though the department has established itself as a leader in novel areas, that hasn't changed.

Anthony Dixon's advice to young chemical engineers hasn't changed with the opening of new frontiers: "We need the specialty areas, but we still need what we think of as a chemical engineer's basic knowledge. That's where we come from, and that's what enables us to make our unique contributions in new areas."

Leslie Brunetta is a case writer at Harvard's Kennedy School of Government and a freelance writer and editor.

Michael Carroll

Michael Carroll

The Entrepreneurial Spirit
Seventh in a Series

Room with a View

From his office overlooking the nation's premier hi-tech highway, Fred Molinari '63 looks at the past and, especially, the future.

By Michael Shanley

Fred Molinari fits the classic profile of an entrepreneur, but don't tell him that.

The founder and president of the computer product firm Data Translation considers such profiles to be largely irrelevant.

"People try to find similar characteristics among entrepreneurs," says Molinari from his company's modern all-purpose headquarters on Interstate 495 in Marlboro, MA. "And they do find some things. They find that entrepreneurs are likely to be 30 to 35 when they start businesses, that they probably were firstborn of the family. But you could get together a lot of people who are 30 to 35 and firstborn in the family, and there probably wouldn't be an entrepreneur in the bunch. And if you got together 50 entrepreneurs, you'd find 50 different stories."

Molinari's story, however, has at least some familiar elements. Like other of the industry's success stories, Molinari found himself a niche in the growing computer industry of the early 1970s and rode the wave as the world embraced low-cost computing power.

Molinari's niche was—and is—data acquisition products, devices that take information from electronic sensors (which measure such things as temperature, pressure, and voltage) and translate them into digital form for storage or processing by computer.

"There's a fundamental need to convert analog to digital," Molinari explains. "Some companies do it with an integrated circuit, or chip, and others, like us, do it in a modular sense."

Molinari cites the common industrial application of a process control loop, where precise temperature measurements are crucial.

But Data's devices are also used in a variety of other settings. In medicine, for example, the company's products are used as a go-between for Jarvik artificial heart patients and their computer monitors, and as part of the process for "cell sorting," a noninvasive technique for studying the human fetus. Another company uses one of Data's boards as part of a noise cancellation system that makes factories and vehicles quieter and more vibration-free.

Most of Data Translation's products, which generally range in price from $500 to $1,500, are made for Digital Equipment Corp. computers, but the company is also the principal supplier of data acquisition products for the IBM PC.

In recent years, Molinari has overseen the company's expansion into the field of image processing, which converts a regular picture into digitized form and stores it in the computer. One of Data's image processing boards allows an image from a camera or VCR to be stored as data in a computer's memory, then displayed on a computer monitor.

A new generation of boards and software that offers sharp resolution and extremely fast flexible processing has doubled and tripled the company's growth in the last year or two. Data's products are being used to solve problems in research installations, factories, X-ray equipment, and CAT scanners.

CSD International Inc. is using one of Data's image processing boards as part of an automated system that inspects toothbrushes. A video camera takes a picture of the toothbrush, then the digitized picture is examined for defects such as missing tufts or dirt.

All this pushed Data's net sales over the $23 million mark last year, a 37 percent increase over the previous year. Net income was $2.1 million, an increase of 30 percent. Stock originally priced at $7.50 when the company went public in 1985 was selling this summer at $17 to $18 per share.

The company's sleek 47,000-square-foot Marlboro headquarters has been expanded four times. Construction on another 30,000-square-foot expansion will soon be under way. Data currently employs about 175 workers. Included among the 25 engineers are several WPI graduates, including Stephen G. LaVeuenesse '84 and Robert F. White '64.

But, of course, it wasn't always so rosy for him. Like most who have built companies from scratch, he's been through some hard times. Foremost among them was a devastating trade secrets suit that nearly destroyed Data Translation in its first months of operation.

That's why when you ask Molinari today what the one crucial ingredient in the entrepreneurial soup is, he'll say "perseverance."

"Almost anyone can make it, given the time," he says. "You just have to have enough determination to make it through the difficult years. That's assuming that you know what you're doing, and that you're going to pick up on opportunities and keep going.

"Luck plays a big part, too—you can get there earlier if you have some lucky breaks. But even without the breaks, it's just a matter of being solid in your commitment to what you're trying to do. Of course you've also got to be smart enough to figure out something that really makes sense to do, and perceptive enough to know when it's time to move in another direction.

"Each venture has its own fingerprints. But I think the overriding element is perseverance." Molinari's own perseverance was severely tested early in his career.

After working for a few years as a manager for Pacific Telephone and Telegraph in San Jose, Calif., and as a design engineer for EG&G at a nuclear test site in Nevada, Molinari returned to New England. He took a job as an electronics engineer while earning a master's degree in electrical engineering from Northeastern University. A number of business course electives there fueled his interest in marketing.

He was accepted into Harvard Business School, and studied full time for a couple of years, earning an M.B.A. in 1970. To help pay his way, he took consulting jobs with a company called Analog Devices.

After graduation, he went to work for Analog as an integrated circuit/converter product marketing manager. Two years later, he accepted a vice presidency at a similarly named company, Analogic Corp. Both companies were involved in translating analog into digital.

"I ended up having some fundamental differences of opinion with my boss," Molinari says of his one-year stint with Analogic. "And of course I was the one who had to go."

So, in 1973, Molinari—with a wife and three children, little in the way of savings, and lots in the way of expenses—found himself out of work.

"I did what many out-of-work people do," he says with a smile, "I called myself a consultant."

On a more serious note, Molinari says, "So much of life is determined by how you deal with unforeseen events. I think people get the mistaken impression that every entrepreneur has a master plan to start his or her own business and be successful. Perhaps that's true in some cases, but it wasn't in mine." In fact, Molinari says, he was quite happy working for somebody else.

Over the course of his time at Analogic, Molinari had established enough contacts to make a decent living as a consultant after parting ways with the company. "I never really liked consulting, though," Molinari recalls. "Because you're always trying to sell yourself—it's 25 percent doing your job and 75 percent selling yourself. And you're always looking for the next job."

Michael Carroll

Assembling advanced computer hardware is still a labor-intensive task. But automation, says Fred Molinari '63, is replacing much of the painstaking effort involved.

While on the consulting circuit, Molinari met two others with similar situations. "We had different skills," he says of the men who would become his partners, "and we were able to put something together."

All three had an understanding of the data acquisition field, so they each tossed $700 into the pot and, in November of 1973, formed Data Translation.

After a few weeks of working out of the basement in Molinari's Framingham home, they found a low-rent, 9-by-12 office in town. There—below a bowling alley and above a restaurant—they developed their first product, a data acquisition module similar to products sold by Analogic.

"We succeeded in the most important step in any venture: we started," says Molinari. It's like the answer to the question 'How does one begin running?' 'You open the front door, and you put one foot in front of the other and you keep going.' That's what we did."

The first months were spent writing data sheets, buying printed circuit boards and components, and preparing a business plan that could be shown to venture capitalists. The trio supported themselves by consulting for other companies.

Just four months into the venture,

catastrophe struck. Before the product was even on the market, Analogic slapped the new company with a lawsuit, claiming, on the basis of a data sheet, that Data was unfairly using Analogic's trade secrets.

"Here we were without any income, without a product and without any funding, and a court suit we were totally unprepared to fight. None of us had even been in a courtroom before."

Worst of all, Molinari explains, was what happened to their fund-raising efforts: Lawsuits are the kiss of death for start-up companies seeking venture capital. "Venture capitalists won't invest their money in a business whose time and energy are tied up with legal troubles."

In fact, Molinari says lawsuits are a routine weapon used by established companies like Analogic to squash new competition.

"They said we took trade secrets," begins Molinari, warming up to a heartfelt indictment of the legal system. "But they wouldn't say what the secrets were. How were we supposed to fight that? The more nebulous a lawsuit is, the tougher it is to defend yourself, because there's nothing to take issue with."

One major software maker, he notes, is now suing other software developers, saying the new software "has the look and feel" of its popular spreadsheet program. "What does that mean? How can you defend against that?

"As every American knows, if you've got enough money and enough clout, you can tie things up in the court system forever. In some cases, the little guy ends up winning, but he's injured himself so badly in the process he can't recover. As the case drags on and on, there's no money coming in for the little guy—it's the quickest way to put him out of business.

"It happens every day in technology cases. That's one of the ways that this country discourages entrepreneurship. People think it's encouraged, but it's not. The whole legal system is against the entrepreneur—the entrepreneur succeeds in spite of it, because of commitment and perseverance."

Molinari sweeps his hand to take in some of the other hi-tech giants in Marlboro's industrial park. "They've all got lawsuits going against small companies. A judge doesn't know anything about these technical matters, so the only way to proceed is to hear deliberations. That can take years. And the big companies are never penalized for frivolous lawsuits.

"In Japan, this doesn't exist. They have 15,000 lawyers versus something like 700,000 in the United States. That means they have a legal establishment equal to just 2 percent of ours."

Molinari believes that trade secret suits should be virtually eliminated in this country, since only a tiny percentage, he says, are valid.

> "We succeeded in the most important step in any venture: We started."

When, after two and a half years, Data Translation finally lost its case to Analogic, Molinari considered it a victory. "We finally had them off our backs and could get going. We never even knew what the trade secret was—it was the 'look and feel' issue again."

In the early days of the lawsuit, one of Molinari's partners bailed out. "Interestingly, he was studying to be a lawyer at the time," says Molinari with a smile. "Maybe he knew things we didn't know."

By the end of the legal proceedings, Molinari and his partner had slowly built up enough of a business to pay off the $56,000 judgment against them. Their legal fees exceeded the settlement, however. "Luckily, the owner of the law firm had a hunch that we'd be successful, so he took stock instead of cash." Today, the lawyer is one of Data Translation's largest stockholders.

"There are times to cut everything to the bone," says Molinari, "times to just do the best job you can with what's available. That's what we did through those first couple of years.

"But you've also got to know when it's time to really spend money, when the market is ready for the right product. For us, that time came in 1976, when a few large computer companies started bringing out single printed circuit board microcomputers. This was one of the turning points in the computer industry. It brought the costs way down and made more people aware of computing capability. We quickly came out with a line of data acquisition boards that fit nicely with these computers."

Sales built dramatically.

And when the next computer revolution, the personal computer, arrived, Data Translation was ready for that, too.

The rest, of course, is simple history. It's as simple as the sleek new buildings that line Routes 128 and 495 in Massachusetts and Silicon Valley in California. As simple as the millions of computers that are now so much a part of our lives. Fred Molinari's boards are housed in a good chunk of those computers, and that's a lot of merchandise.

Over the years, the company, searching for a new and bigger home, moved to Natick and, finally, to Marlboro.

But, as the company grew, Molinari's own focus narrowed. No longer required to be a jack-of-all-trades, he was free for a little crystal ball gazing.

"The job of any head guy," he says, "is to figure out what the company is going to be doing two or three years from now. You always have to be living in the future. So what you have to do is unload the day-to-day operational responsibilities and keep looking farther and farther into the future."

What he sees is bright enough to require shades.

You may think we must be close to reaching the saturation point with computers, but Molinari doesn't. "We're nowhere near the end. Computers are going to be used more and more. And everywhere automation takes place, they'll be using our products."

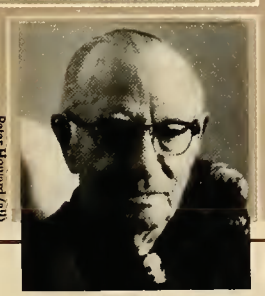
International economics are such these days that to ensure the quality that consumers demand, industry can't rely on the human eye and hand anymore, Molinari says. "You've got to have computers bringing things together now, you've got to have robots. And our image processing boards are eyes for robots."

Molinari ticks off the examples, from automobiles to dental systems to soft drink manufacturing. The message is clear: Data has only just begun.

Yet Molinari knows that future business won't be delivered to him on a silver platter. Past successes are worth little in a world full of hungry young companies such as Data once was.

"You have to stay ahead of the mar-

Continued on inside back cover



Peter Howard (all)

An Album on Aging

Essays, portraits, plain facts, demographics, and even the quirks and quackery of growing older. Here's a summer anthology on the passage of time in our lives, from middle age onward.

A mirror on the middle years

Reflections on remapping life 25 years after graduation

By John T. Bethell

"MIDDLE AGE," wrote Ogden Nash, "is when you've met so many people that every new person you meet reminds you of someone else." A contemporary greeting card pilfers Nash's line and tacks on, "Old age is when no one you meet seems familiar!"

Or words to that effect. I'd check it, but I can't remember where I saw that card.

Certain departments of my brain, alas, have elected not to wait for old age to begin forgetting things I could always remember: people's names, the second law of thermodynamics, what Mike Andrews hit in the '67 World Series, and high-impact intellectual words like *heuristic* and *teleology*.

And that isn't the only dismaying aspect of middle-aging.

In the country of the middle-aged, our circle of professional retainers inexorably expands to include endodontists and periodontists as prominent members of the support team. Peering into a store window we see reflected an ample forehead and deeply etched crow's-feet that must be someone else's. They are ours. We can't stay up as late as we used to, and we need more recovery time after going running. In fact we need more recovery time after *everything*. When we dine out we begin with Perrier, and after the meal we order decaf. With increasing frequency we discover the names of classmates in the obituary column of our college magazine. Many of us have lost one or both of our parents. Some have lost children.

So much for the bad news. The better news is that, despite our declining physical prowess, most of us still have energy in abundance. Experience has endowed us with an understanding of the complex dynamics of change and a sense of How Things Get Done. Under the lengthening shadow of mortality we have learned to use time better, to be more purposeful. ("As we advance in life, we acquire a keener sense of the value of time," wrote William Hazlitt in 1827. "Nothing else, indeed, seems of any consequence; and we become misers in this respect.") But we also derive satisfaction from sharing our knowledge and skills—with our children, who may not appreciate what we have to offer, and with younger coworkers, who may. As the children leave home we rearrange the furniture of our lives to create more space for intimate relationships and for social concerns. We grow more generous and accepting of people's shortcomings, including our own. We learn to read from our own biographies, and to put what we read to use as we remap the balance of our lives. Middle age is by no means all bad. As Daniel Levinson writes in *The Seasons of a Man's Life* (1982), "The concrete character of adult life is one of the best-kept secrets in our society, and probably in human history generally."

For those of us who are 25 or 30 years out of college, a class reunion provides a panoramic grand tour of the country of the middle-aged. This summer at my own university's commencement, I mixed for a while with returning members of the Class of 1962 (which describes itself retrospectively as "The Last Polite Class" in the history of the institution). I am not a member of the class—I was born eight years too soon for that—but my brother is, and so are a number of friends. In the course of their five-day reunion I went to a thoughtful symposium titled "Safe at Last (?!) in the Middle Years," compared notes on aging with a variety of experienced hands, and skimmed through the buckram-bound *25th Anniversary Report*, which at 999 pages is longer than John Barth's longest novel. It teems with raw data, case histories, and apercus served up by members of this 1,160-man class, and like previous 25th reunion reports, it may constitute an invaluable resource for future contributors to the growing scholarly literature on the nature of mid-life. (It's unfortunate that most of the existing literature is male oriented, but that is starting to change.)

"What amazes me is the way we all seem to be aging in lockstep," one reunioner told me. Leafing through autobiographies in the *Report*, you are struck by the reiteration of shared concerns, of common perspectives derived from diverse experience.

The theme of mortality overarches everything. "I'm getting paid to have fun," writes a Boston investment banker, but:

> All is not joy and computers. My father died four years ago; my mother died this month. A close friend drowned recently. Death is no longer impossible. I had bleeding ulcers six years ago. I don't take alcohol, nicotine, aspirin, or coffee. I also know a lot more about stress and how to handle it. Mid-life crises are not just a psychologist's invention; we all have them. Some have better ones than others. I'm not through with mine yet.

A Chicago lawyer writes:

> My father died [in] January in his eightieth year. It made me see things differently. Whereas I had always

JOHN GARTLAND, AGE 47

"You never know what's going to happen. There is no career path."

"Hubert Humphrey once said that the longer he stayed in the Senate, the better seniority looked. As you get older, the older people are, the better they look. Once you'd think, 'Oh my gosh, 60, that's over the hill.' Now you say, 'No, I'm just ready for another career.' "

John Gartland's career has taken unexpected turns, thanks to the success of Republican candidates. When he graduated from Villanova University in 1963, he expected to go into business, but was swept up in a victorious Nixon campaign. At 47, he is content to be a corporate lobbyist and volunteer "advance man" for President Reagan, arranging details for his trips abroad. But he delights in the thought that his future may turn on an election, a phone call, or a chance meeting: "You never know what's going to happen. There is no career path."

Age is no disadvantage in a city where contacts determine power. "The lobbyist's point of view is the older you are, the longer you've been in it, the more influence you have," he notes. Gartland's office, filled with official thank-yous, certificates, and photographs of presidents, is a memorial to two decades of work in Washington.

He believes that fewer Americans consider 65 the "magic year" when careers end and carefree days begin.

"I think the bloom has really come off the rose. I think my parents, and people in their age bracket, were taught, 'You're going to retire at 59 or 60, you're not going to do anything, and you're going to go off to this great, wonderful life.' But we have seen, taking care of our parents, that it's not that great.

"I am not looking for that day of retirement. Yes, when I reach 60, and my last child is in the class of 2000, then I will be a lot freer to do more of what I want to do. It may be what I'm doing right now. But I'm not looking for retirement, I'm looking for doing a different career."

Profiles by Julia Ridgely

Photographs by Peter Howard

CAROLYN SCOTT, AGE 41

"For me, the best age is the age that I'm at."

"Who would want to stay 22 all their lives? To stay in any one area would be boring, like living in a climate where there's no change of season."

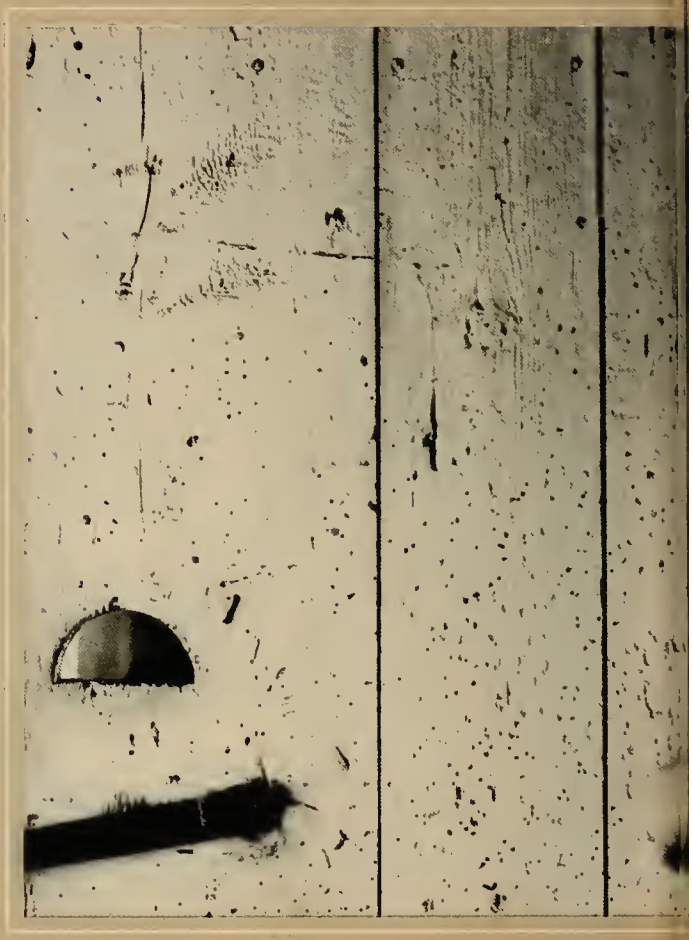
Carolyn Scott tends her garden in the farmlands outside Westminster, Md., few miles from her alma mater, Western Maryland College. One of her recent large-scale projects was advising the College on the renovation of the McDaniel Lounge and its gardens.

The seasons of life are longer than of those in her backyard, and her summer longest of all. "I see life as proceeding in double decades. I see 40 to 60 as really getting in the beat of life. Even 60 to 80 I think is really just getting into the swing of things. Eighty may be old, but ask me again when I'm 80."

For ease of living, she gives a slight edge to the post-30 years: "It is a more comfortable time materially." But she adds, "For me, the best age is the age that I'm at. I hope I change my mind next year when I'm 42."

She is looking forward to the empty nest syndrome and the time to pursue less earthy interests like writing and photography, and she will probably not stop there.

"It takes me so long to learn so little. I'll be old when I stop learning and stop growing."



looked forwards in my life, and up, suddenly I stood at the end and looked backwards, to where I am now, and towards the beginnings. . . . Although it should undoubtedly have been old news, it came as a shock to me to realize there are perhaps 25 more good years—if I'm as lucky as he was. Twenty-five years back, and 25 years forward; a good time for a reunion report. Mid-life, mid-career, mid-kids, mid-everything.

And this from the attorney general of a Pacific Northwest state:

The unabated joys of parenthood were shattered three years ago when [my wife] and I learned that our two beautiful, bright and cheerful daughters both are hostage to a biological time bomb. Fanconi anemia, a lethal disorder characterized by bone marrow failure, strikes most often (in our case totally by surprise) in the first decade of a child's life. . . .We are told that only a bone marrow transplant, for which we have no suitable family donor, can really promise significant life-extending possibilities.

The authors of these accounts are resilient survivors, capable of extraordinary forthrightness and humility. "I have been drowned, poisoned, and rearranged my face on a post, which I met at full sprint," writes a California designer and environmentalist who comes from an old Boston family. He adds, "The truth of Zen lies somewhere within that space between utter joy and excruciating pain, and I shall be the better for it. . . ."

The current life of a New York state attorney reflects what Alfred North Whitehead called the disorderly character of experience. The lawyer writes:

I am in at least four "stages of development" at once. My children from a previous marriage are 21, 19, 17, and 15. Barbara and I now have our own baby, born October 1, 1985. My oldest son . . . has just announced that I will be a grandfather. . . . Finally, my 80-year-old father, having retired as a judge, practices law in my office and, when I sometimes find him napping in the afternoon, I feel more like a father than a son. Am I young? Am I old? Or am I just right? . . . I feel that life, although seldom easy, has given me an unexpected second chance for personal happiness.

"Sometimes I wish life would relent," admits a visiting professor of education at a major private university. "Then I look around at us in wonder: If this is the price of admission, I'll gladly pay." His concluding sentence is: "As I get older, I'm more patient about everything but complacency."

This *Bildungsroman* of middle life contains few signs of complacency. There are many expressions of willingness to acknowledge and accept failure, but that is not the same thing. Here is one, from a geophysicist:

> I work largely on the physics of the terrestrial and Venusian stratospheres, my latest effort being a speculation on the origin of the great Antarctic ozone hole. At this writing, it appears to be wrong.

A Massachusetts teacher rejoices in "the giddy happiness of my second marriage," but goes on:

> I consider my life in nearly every other respect a failure. It is pretty clear now—even I can see it—that I'll never pitch in a World Series. . . . What remains and matters are several friends . . . and this bewildering 10-year ecstasy with Sandy.

Many accounts illuminate a process that Levinson calls "reworking the dream." Henry Thoreau, an early student of life cycles, described it in this way: "The youth gets together his materials to build a bridge to the moon, or, perchance, a bridge or temple on the earth, and, at length, the middle-aged man concludes to build a woodshed with them." An upstate New York university English teacher—another who resorts to baseball for a metaphor—writes:

> Here I do everything but lit . . . which is my chosen career. But they have to play me because I am tenured, through a series of misadventures illustrating that justice gets out of town as often as possible on weekends; and so I am a lifetime utility infielder in a department needing a .320 Shakespearean and a good southpaw deconstructionist.

For some, processes of self-renewal have become continual. Writes a Massachusetts consultant:

> In a way there's a pattern—do things that are interesting and new. . . . The problems or opportunities [of management consulting] keep changing as do the groups. Rarely dull. The rest just sort of happens, gets intense, and then integrates and finds its place. There was a time of running and marathons, a time of yoga and reflection. Now it's a plane and flying.

We could go on and on. But let a California writer and actor have the last word:

> Currently, I am happily married. But I haven't found God or mastered the PC. However, I feel that Jesus and IBM are coming soon.
>
> Suffice it to say that I've spent the past 25 years "finding myself." Now, I plan to spend the next 25 playing with what I've found.
>
> So much for life. I congratulate the survivors. Now, where's the party?!

When I finished this *omnium-gatherum* of confessional literature, I reread my own submissions to the 25th and 30th reunion reports of the Class of 1954. Because I was not at ease in first-person writing, I had adopted a parodic self-interview format for these reports. "What, another reunion?" I began rhetorically when I wrote in 1984.

> *Time marches on, old sport.*
> Indeed. And the fractile effects of its passage seem more evident now than they did five years ago.
>
> *How would you characterize yourself at this point?*
> On the sill of age.
>
> *A phrase you pinched from Robert Fitzgerald's translation of* The Odyssey, *did you not?*
> I might have.
>
> *What preoccupies you at present?*
> Mourning lost innocence. Not mine. Everybody's.
>
> *Can you think of anything to be bullish about?*
> Word processing! Bach, Haydn, Mozart, Schubert, Brahms. My wife's smile. In point of fact I've been lucky.
>
> *Say something about the future.*
> Come the next reunion, I hope to have seen two of my three offspring into and out of college, run a few more marathons, and read all the novels of Dickens.
>
> *And after that?*
> A happy retirement, in Cloud-Cuckoo Land.

I regret writing "fractile" and that mawkish bit about innocence. As to the rest, the college projections are on target. The marathons are behind schedule, but there is time yet. Halfway through *Little Dorrit* as I write this, I still have *Great Expectations*, *A Tale of Two Cities*, *Our Mutual Friend*, and *The Mystery of Edwin Drood* to savor before starting all over with *The Pickwick Papers*. A wonderful novel, by a very young author, about a middle-aged man and his friends.

John T. Bethell is editor of Harvard Magazine. *He took up competitive running at the age of 45 and has since completed 127 road races, including six marathons.*

Lifestyle, illness,

'Use it or lose it' often turns out to be good advice for both body and mind. Many physical changes are simply a part of aging, but others may signal disease.

By Peggy Eastman
Photos by
William Denison

The alert mind can be honed well into old age. What many call senility could be a temporary lapse in memory related to stress.

It starts with small things: a crinkly relief map at the outer corner of the eyes, a graying that spreads from the temples to the crown, an inability to remember just where those car keys went. We think to ourselves, "I must be getting old."

We all age, but at our own pace. People don't experience clockwork-timed changes that say now you're 50, now you're 60, now it's time to retire. One person might have the equivalent of a 70-year-old heart in a 50-year-old body. Conversely, Jane Fonda in her early 50s seems to maintain the physique of a woman of 40. "There are extraordinarily 'young' 80-year-olds, along with extraordinarily 'old' 40-year-olds," noted one study of 1,000 volunteers over a 23-year period. Known as the Baltimore Longitudinal Study of Aging (BLSA), this project began by looking at healthy men aged 17 to 96 (women were added to the study about a decade ago). So far, it has found far more physical, mental, and emotional differences among a group of randomly selected people over 65 than among a group of younger adults.

But in the field of gerontology, such studies are rather rare, for it is a specialty in its youth. The National Institute on Aging (NIA) was not even established until 1974.

"The state of research on aging is quite primitive—yet aging could turn out to be far more complex than cancer," notes Rene J. Herrera, a Worcester Polytechnic Institute (WPI) biotechnology professor who is attempting to unlock secrets of aging on a cellular level. Two factors spurring more basic research, he explains, are "the scientific realization that we know so little about aging, plus the political realization that the percentage of people in the aging brackets is increasing—and all of these people still will have the right to vote."

In recent years, this escalation in the numbers of elderly has prompted a far higher priority on treating age-related maladies. Health care professionals can, for instance, unblock or detour clogged arteries, replace arthritically crippled finger joints with synthetic implants, and train the incontinent to achieve better muscle control.

In sorting out what is normal aging and what is abnormal, medical professionals are shedding light on how the lifestyle choices we make affect our longevity. Wellness programs and preventive medicine emphasize personal decision making in balancing risks, although there is plenty of conflicting evidence to make such decisions bewildering at times.

In general, normal aging may be viewed as a loss of adaptation to the environment, suggests J. Grimley Evans, a physician specializing in geriatric medicine in Oxford, England. Men and women in their 70s, even when not suffering from disease, still will not be able to run as fast, see as clearly, or hear as acutely as they did at age 25. Reaction times and reflexes slow down. "You're not as likely to get your hand out, so you fall over and break your hip," he adds. He proposes setting up physical training programs to help the elderly improve their protective responses.

Many individuals later in life experience a sense of losing control of their lives, which all too often turns into learned helplessness, notes Dr. John Campbell, professor of psychology at Franklin and Marshall College. "They develop the expectancy that they cannot control outcomes, and so they don't even try." They will tell themselves that they did poorly at a task because they have a terrible memory, when the fault might be elsewhere. One approach to help overcome this is "giving people situations they can control" to build up their confidence.

Exercise and diet can modify—but not entirely block—the changes the body undergoes in aging. From BLSA data, for example, we know that the propor-

and longevity

tion of lean body mass (muscle tissue) to total body weight drops with age, while the percentage of fat increases. What other physiological changes are normal?

As we add on years, we often add on weight. But for the obese, it's better to be shaped like a pear than to have a pot belly.

Old bones and new tissue

In aging, the body's framework of 206 bones loses density, especially in postmenopausal women. Bone is far from dead: It is living tissue in a constant state of recycling. Breakdown cells called osteoclasts destroy old bone so that it can be reabsorbed into the body, while osteoblasts help to build new bone tissue. Bones no longer lengthen after the body has reached its full height, but the remodeling process must continue for bones to be strong, dense, and healthy. When more bone tissue is lost than replaced, osteoporosis—the brittle bone disease—results. Women with osteoporosis (often with the characteristic "dowager's hump") become stooped over as their weakened vertebrae collapse and their bones break easily. More than half of American women over age 45 will experience osteoporosis, as will 90 percent of those over age 75.

Heart and blood vessels

As changes occur in muscle mass and the skeletal framework, the heart and circulatory system gradually decline from their maximum aerobic potential. In practical terms, healthy, well-conditioned 65-year-olds may still be able to play a good game of singles tennis, but they may tire after one or two sets rather than the three in a row they had played 20 years before.

Chronological age doesn't predict heart function, but the cardiovascular system does exhibit age-related changes. Among them are a stiffening of arteries, hardening of the aorta, and impairment of the ventricles' capacity to relax after pumping blood, notes Nanette K. Wenger of the Emory University School of Medicine. Older people are more likely to experience severe atherosclerosis, ultimately leading to heart attacks and strokes. Both chronic high blood pressure and the low pressure that causes faintness (orthostatic hypotension) often become more severe in older people.

Older and wiser?

A sharp intellect can be honed and exercised well into old age. But the performance of older people on tests measuring verbal learning and memory tends to decline, especially if such tests are given at a fast pace, the Baltimore longitudinal study shows. Its authors theorize that each passing year may result in a slightly lowered performance, or that some threshold level of decline in the brain has to be reached, or that a milestone event must occur (such as worsening of atherosclerosis) before the lowered level of intellectual performance is noticed.

For those who continue to pursue intellectually stimulating activities, these changes in the brain's physiology may be so subtle that they are hardly recognized.

Forgetfulness and senility

Senility, far from inevitable, too often is a "wastebasket" diagnosis, in the words of Robert N. Butler, former director of the Washington, D.C.-based NIA. True senility is a disease resulting from a progressive loss of brain cells, which can never be replaced. What many call senility might more accurately be termed a temporary lapse in memory.

"We use the term 'benign senescent forgetfulness' to discriminate between ordinary forgetfulness and organic brain disease," says May L. Wykle, acting director of the Center on Aging and Health at Case Western Reserve University, where she's also professor of psychiatric mental health nursing at the Frances Payne Bolton School of Nursing. "Benign senescent forgetfulness is common after the late 40s, although peo-

Staying actively involved gives you an edge later on. Regular exercise can help to modify some physiological changes of aging.

ple complain of it earlier than that. It means forgetting where you put your glasses, forgetting the names of people you run into, parking your car and getting panicked because there are so many cars out there in the lot and you can't remember where yours is."

Those kinds of lapses may be a reaction to "life overload." Bit by bit, we seem to get too much information, too much complexity, too much responsibility, says Wykle. "This is part of normal stress. As you get older, you have many more things to do. People get panicky because they think it's Alzheimer's disease, but it probably isn't."

One of the most publicized forms of dementia, Alzheimer's disease now afflicts an estimated 1.5 million Americans severely, 1 to 5 million moderately. By the year 2000, the number of Alzheimer's patients is expected to jump 60 percent.

Physicians aren't sure of its causes, although evidence is mounting for an infectious virus and some kind of genetic trigger. One theory points to an abnormality on chromosome 21 as a cause of both Down's syndrome and Alzheimer's disease. In fact, almost all people with Down's syndrome who live past 40 develop Alzheimer's disease. Other theories blame as a key factor an injury to the blood-brain barrier, thus permitting harmful substances to enter the brain.

Another promising clue about the cause of Alzheimer's disease comes from research into amyloid, a "marker" protein found abundantly in the brains of Alzheimer's patients—and in those of aging monkeys, apes, dogs, and polar bears. Amyloid is linked to distinctive, abnormal clusters of nerve cells. While nonhuman mammals don't develop Alzheimer's disease, those with heavy concentrations of amyloid show memory loss and some behavioral changes (such as confusion) similar to those in human patients. "This similarity in amyloid levels provides a strong biochemical connection with which to investigate the biological basis for memory impairment," explains Donald L. Price, director of the Johns Hopkins University Alzheimer's Disease Research Center and a professor of pathology, neurology, and neuroscience at the Hopkins Medical Institutions. He is part of a team of researchers from the center and from Harvard University who recently reported on their findings.

Hormonal changes

Old age also modifies the body's endocrine system, including glands that secrete hormones, the complex compounds that act directly on or stimulate other organs to regulate physiological changes. These changes were once thought to be linked to a decline in the number of hormone receptors on the cell surface, making aging cells less responsive to hormones. But research during the past decade has shown that a hormone can penetrate a cell's surface.

Here again, some symptoms may indicate disease while others are evidence of normal aging. Older men and women are more susceptible to diabetes mellitus, a metabolic disorder related to the use of insulin. However, old age frequently brings higher blood sugar levels—older bodies tend to lose the ability to use sugar efficiently. Diabetes, in fact, has been described as accelerated aging because some of its complications—cataracts, stiffness in joints, and atherosclerosis—are common in the elderly. Recently, the official guidelines for determining diabetes were revised. As a result, fewer elderly are being incorrectly diagnosed as diabetic and needlessly put on insulin.

In women, the normal cessation of menstruation is related to a drop in estrogen, sometimes resulting in osteoporosis and a tightening and drying of vaginal tissues. Men don't go through a normal, hormonal change comparable to menopause, but they are subject to an age-related enlargement of the prostate gland, an endocrine disorder often requiring surgery. However, healthy older men maintain the same levels of testosterone as do healthy young men, studies from the NIA's Gerontology Research Center have shown.

Eyes and ears

A gradual decline in hearing is an expected part of aging: About half of Americans over 65 will suffer from presbycusis, according to the NIA. Distance vision, too, commonly decreases with age, yet elderly people with no eye disease can maintain reasonably good visual acuity (20/40 or better) into their 80s, according to the BLSA.

One example of an age-related eye disease is senile macular degeneration, a disorder of the ocular blood vessels that primarily afflicts people over 50. Until recently, this was the culprit in about 16,000 new cases of blindness every year, or 17 percent of all new cases of blindness among Americans. Today an estimated 90 percent of such cases can be treated with an argon laser beam that seals leaky blood vessels in the eye through photocoagulation, pioneered at Hopkins.

The cellular level

Overall, the incidence of such chronic diseases as osteoporosis, arthritis, cardiovascular disease, and cancer goes up with age. Some 80 percent of Americans

The graying of the globe

By the year 2030, some 17 to 20 percent of the American population will be over 65, compared to 4 percent in 1900. Those over 85 are the fastest growing population segment.

Until recently, problems of the oldest group of the elderly were thought of primarily as the province of women. But in the past few years the sex gap in longevity has fallen from eight to about seven years, according to the U.S. Department of Health and Human Services. The narrowing of the gap is attributed in part to escalating rates for lung cancer in women.

While the United States is experiencing an unprecedented explosion in the over-65 group, other industrialized nations are also facing the enormous medical, social, and economic implications of a graying society.

But the challenge is truly a global one. Until recently, this longevity explosion was considered to be mainly a phenomenon of industrialized countries. However, around 1980 the number of older people in developing nations began to catch up, according to a study at Flinders University of South Australia. By the year 2000, there will be 229 million people over age 65 in developing nations compared to 167 million in the industrialized world. This large population of older people in the Third World will strain the scarce medical and economic resources of struggling nations and the countries that lend them money.

By the year 2025, the world will have 1.1 billion people aged 60 or over. In China, the population in that age bracket alone will exceed the entire population of the United States. —Peggy Eastman

BILL EVITTS, AGE 44

"The more you know, the better you get."

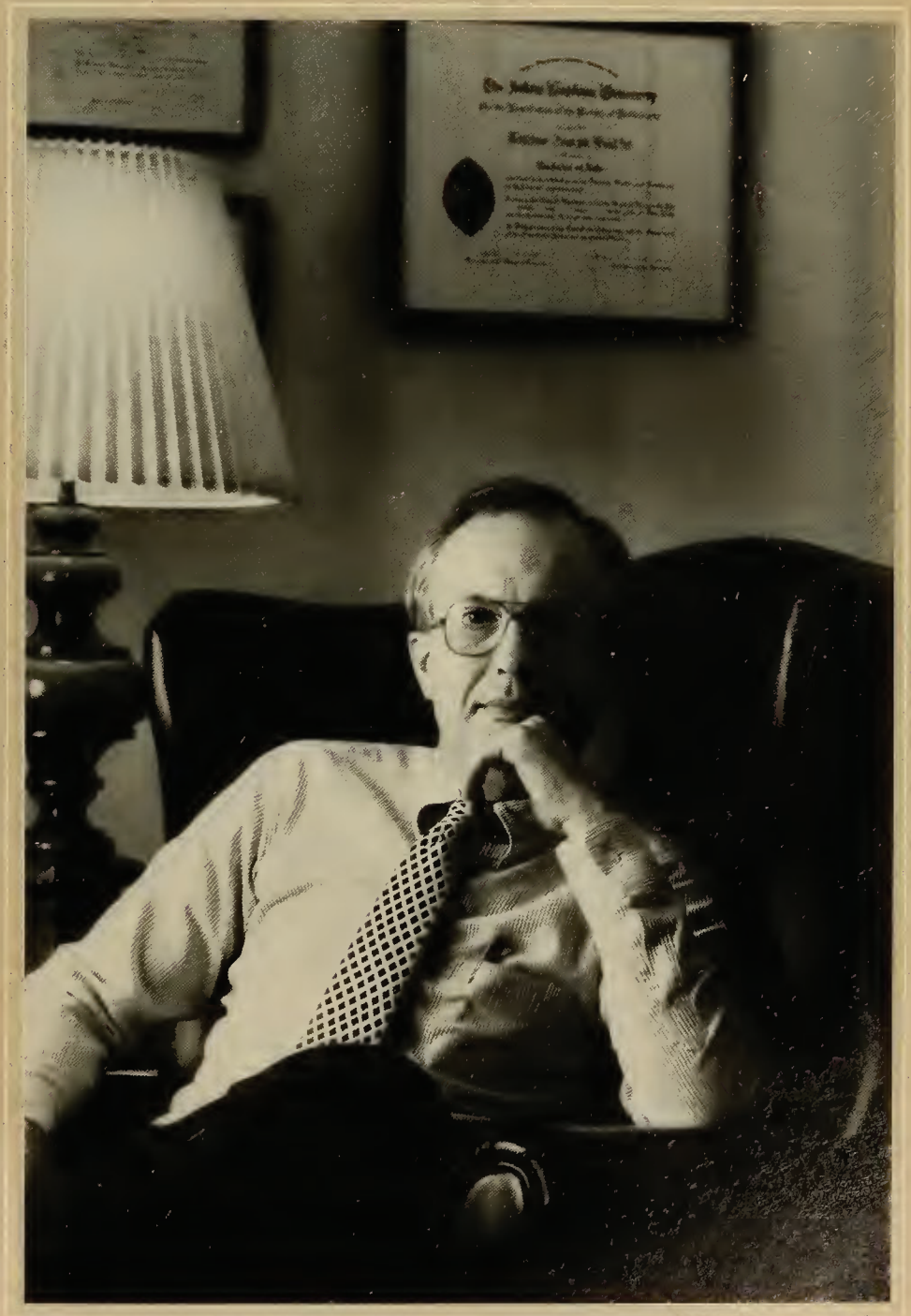
"Everything's got its moments," Bill Evitts says, "though I wouldn't consider much before college. High school is a vastly overrated phenomenon."

Evitts enjoyed every stage of his academic career, from college through graduate school and teaching college-level Southern history: "I liked it as much the day I walked away as the day I started."

But he had reached the point "where you either speed up and become a senior person, or you hit some kind of burnout and make some changes. I got lucky; something fell on me. I turned in a tenured professorship and, on very short notice, moved my family back to Baltimore."

As Johns Hopkins University's director of alumni relations, he sees a steady procession of stages in his life. He speaks fondly of the charms of college, a first job, a new family. Though the procession seems orderly, he warns, "Time seems to compress as you get older. This has been accelerated for me by the fact that my son is starting at Hopkins in the fall, and he's going through some experiences that I can vividly remember myself, except that now it's my own son.

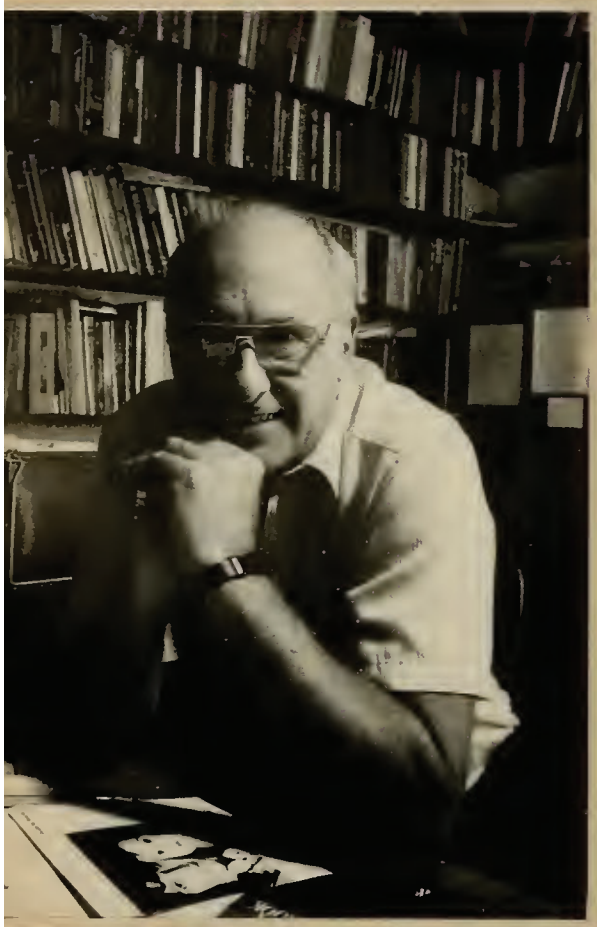
"It's sometimes less difficult to cope with the reality of being, say, 45 rather than 35, than it is to cope with your perceptions of yourself. You keep thinking of yourself as 26 or 18, and sometimes you get into trouble by trying to do things physically that you really should back off on, or being shattered by the realization that you don't look like you used to."



At the same time, he does not necessarily find a sense of perspective comforting: "It is a little scary to be able to look that far back and that far forward. I suspect that people in their 40s are more wired up and uptight about this than people in their 60s. Life's like the humanities: the more you know, the better you get. If you don't let yourself harden, you're going to in many senses get better and better and better."

DONALD TYRRELL, AGE 52

"Many of the people we canoe with are not much older than our kids."



Donald J. Tyrrell took up whitewater canoeing because "my wife made me sell my motorcycle, and I had some spare money, so I bought a canoe.

"The last hobby she and I both had was modern dancing, and before that it was jogging, and before that it was working, and youth." Long before that, it was kindergarten, where they met.

During the week, Tyrrell studies infant development in the psychology labs of Franklin and Marshall College. Every weekend that he and his wife can get away, they're on the Cheat, the Ocoee, the Nantahala, or one of a dozen other rivers within a day's drive from Lancaster, Pa.

"Many of the people whom we canoe with regularly are not that much older than our kids," Tyrrell says. He gets stares, offers of help, and eventually respect from them, and tries to make converts among their parents. "They say, 'Nah, I'm too old for that stuff'— but then they meet us and we're as old, if not older than, they are."

Tyrrell tries to fit in as much of his favorite sport as he can, recognizing that, at the age of 52, he may not be far from the time when he will no longer want to spend his weekends shooting over sharp rocks in a wet boat. But then, he estimates, he has about 20 years to go in his research on infant development.

"The hot, new stuff that I learned in graduate school is now no longer even covered in the intro psychology textbook," he says. "I am not as expert on the hot, new things as the kids coming out of graduate school are. But they don't have the context in which to embed that, they don't have the historical development, they don't know what's been tried and has not worked. The young kids think the new information is all there is."

over 65 years old have a chronic disability. About 27 percent have heart disease and 44 percent experience arthritis. This rising tide of disability may be at least partly due to an age-related decline in ability of some cells to reproduce, an impairment that also interferes with the healing of wounds and the functioning of the immune system.

Support for a "cellular rundown" theory of aging, based on the idea that cells have a limited lifespan and functional capacity, comes from the work of microbiologist Leonard Hayflick, now at the University of Florida. His earlier work at the Wistar Institute led to a widely accepted model, known as the Hayflick limit, to describe this finite number of doublings for normal cells cultured in a laboratory. Even if our age's major diseases were eliminated, a human would still have a life span of no more than about 115 years because of this cellular limit, he has written. Not only do normal cultured cells have a finite number of doublings, but they even "remember"— perhaps with a kind of molecular chronometer—that level, even when frozen for years. When thawed, they pick up where they left off in replicating until they reach this limit. Hayflick has found that occurring in human cells frozen for as long as 25 years.

Normal human cells cultured in a laboratory double about 50 times and then die, explains Rene Herrera, the WPI professor of biotechnology. Cells from an elderly person—approaching this Hayflick limit—undergo far fewer doublings than do those from a baby. There's an inverse relationship, in fact, between the age of the donor and the doubling potential of human lung and skin fibroblasts and certain other cells.

Cells as they age tend to accumulate excess or inaccurate genetic material. In seeking to code the genetic program for aging, Herrera studies the expression of certain types of ribonucleic acid (RNA) called small nuclear RNAs or snRNAs, which are known to edit this material. These molecules, which rid the gene of information not used in protein production and splice together the remaining message, play an important part in the normal functioning of the cell. Perhaps, Herrera theorizes, aging may be related to a loss, increase, or malfunction of these 10 or 20 types of snRNAs. Gene products must be spliced to produce proteins, essential for regulating metabolism. So in making even very small mod-

JUDY STRAUSS SCHWARTZ, AGE 35

"I had the best time of my life turning 30."

One summer Judy Strauss Schwartz decided she wanted to get a job with a program for blind children.

"My mother said to me, 'I think before you do that you should get a volunteer job; you've never worked with the blind.' " So Schwartz made her case to a placement counselor at the Westchester Volunteer Bureau:

"I went through my whole list of why I wanted to work with blind children, and she said 'How old are you?' I said, '16.' " Unfortunately, volunteers had to be of college age. "I told her, 'You have to give me a chance.' I talked myself into it. She hired me, and I loved it. I worked with kids from ages 6 to 16—some were my age, but they thought I was one of the college students. The next year, I headed all their college volunteers."

After years of teaching blind students mobility—the art of being able to cross streets or take train trips unassisted—she became development and community relations coordinator for the New York Institute for Special Education. As head of Case Western Reserve University's New York alumni chapter, she organizes events like the annual get-together when the Cleveland Symphony comes to Carnegie Hall.

"The only birthday I remember being really terrible was 19. I didn't like being 19. But since then, life has been very good. I think the only thing that's gone by very fast is our marriage. It's hard to believe it's seven years.

"People always told me that turning 30 would be traumatic, but I had the best time of my life turning 30. I spent two weeks partying. Thirty-five sort of came and went. Ed gave me a bicycle, and bought himself one. People say, 'What will you feel like when you're 40?' and I say, 'I'll probably party like I did when I was 30.' "

JOHN SCALVI, AGE 71

"The old adage still holds—so little time, so much to do."

The wing of the Flying Tiger aircraft that hangs in the National Air and Space Museum, the steel structure of Washington's RFK stadium, and bridges and buildings across the country are the visible trail left by John Scalvi. Now 71, the civil engineer has alighted in the earthquakes and volcanoes division of the National Science Foundation. It was the latest in a series of career moves that seem less abrupt for being spread between the Depression, when Scalvi graduated from Worcester Polytechnic Institute, and the present.

"I came to government with the idea that I was getting into a new area, although at that time I was pretty well along in years. And you might ask, was I afraid? I didn't really give it a thought. I took the opportunity as it came.

"Fifteen years is long enough in a given area," he has decided. "When I look back now, my teaching career was about 15 years, my industry career was about 12, and now I'm in government, and I'm in my 16th year here."

It's understandably hard for Scalvi to pick a high point, but he says his favorite years may have been those he spent in the steel industry.

"The nice part was that my wife was able to accompany me and we had the opportunity to visit almost every state in the country. Plus, we were at the peak of our health. The kids were off, and then they were married, so we didn't have to worry. I'm only 12 hours older than my wife. We were born in two small towns in Massachusetts. I was born before midnight, she was born after midnight."

He spends a lot of time now trying to convince faculty and students who specialize in narrow fields and who are infatuated with computers that great opportunities exist in civil engineering.

"Oddly enough, I have to suggest new things to some of these young people. They want to do what they've been doing, and they don't see the broad picture or the need.

"I hate to use the word challenging, because everyone says 'challenging,' but it's something that has to be done," Scalvi says of his mission. "The nation needs it, and people should be getting into it. So it's as though I just graduated with a B.S. degree.

"The old adage still holds—so much to be done, so little time."

ifications in cellular functioning and reproduction, these molecules could have a rather large impact on metabolism. While that would seem to point to a genetic cause of aging, he cautions, "It's impossible to tackle the question of whether it's environmental or genetic."

Of course it is not yet possible to alter the genetic code to extend life. But even common sense tells us that toxic wastes, spoiled food, and cigarette smoke could have similar effects. For someone whose genes are particularly susceptible, such environmental factors can hasten certain diseases linked to aging.

New evidence for an environmental and genetic linkage comes from the field of rheumatology, the study of arthritic diseases. Following a 1985 spring outbreak of food poisoning in Chicago caused by *Salmonella* bacteria borne in

milk, researchers at the University of Michigan identified a type of arthritis they call reactive arthritis syndrome. About 5 percent of the approximately six million people each year who get *Salmonella* food poisoning will later develop arthritis—often within the year, says Michigan's Robert W. Ike. Other studies on reactive arthritis have shown that those 5 percent all seem to have the same tissue type (called HLA-B27 to describe its genetic arrangement of proteins). "Our hypothesis is that B27 proteins may interact with a similar protein in bacteria to cause reactive arthritis syndrome," explains David T.Y. Yu, an associate professor at the University of California at Los Angeles.

Stay active and alert

If aging is due to a cellular limit, then wouldn't a decrease in activity help to save wear-and-tear and give cells their best chance to multiply and thrive? Not so, according to many studies on physical activity and aging. Doctors know, from studies of bed-bound invalids and astronauts in weightless conditions, that forced inactivity is the fastest route to premature aging. The advice to "use it or lose it" seems to be valuable for just about every part of the body and mind.

Regular, vigorous exercise, along with boosting the efficiency of the heart and lungs, can increase high-density lipoprotein cholesterol, known as the "good" cholesterol because it offers some protection against heart attacks. Exercise can also lower the concentration of triglycerides, the fatty substances that are the culprits in atherosclerosis, note Andrew P. Goldberg and co-workers at

Myths and facts about life-lengthening fads

Potions and incantations, rituals and exotic remedies, used to be mainstays of trying to stave off old age. Legends and literature told of fabled fountains of youth and lands promising a detour around death and debilitation. While an elixir still eludes us, science has taken up where the alchemists left off.

In many an age past, the gullible could take their choice from an enticing array of quackery and quirky promises. For instance James Graham earned a fortune in London in the 1780s by purveying a dozen quite costly medicines at his Temple of Health.

His "Aetherial Ambrosial Quintessence" was guaranteed to have been manufactured in the "Adepti-Alchyrical Medico-Electrical and Philosophic Apparatus." This marvelous metallic, glass, and magnetic contraption, pronounced Graham, was "infinitely superior to anything that now is or ever was in the world."

At his temple, those so inclined could sleep on the "Grand Celestial or Magnetic-Electrico Bed." Forty pillars of glass supported the 12-by-9-foot frame and its dome, fragrant with spices and essences. Groups of figures on the dome held aloft flutes, kettledrums, oboes, and other instruments that "by the most expensive mechanism, breath(ed) forth sound," the advertisement assured the public. Such a rejuvenation cost the astronomical sum of 50 British pounds a night. "It may even have been worth it," muses David P. Barash in *Aging: An Exploration*, his engaging book melding mythology and biology.

In our own age, the yearning for a magic potion to slow down aging remains strong, though the strategies and substances have changed dramatically. The trouble is, no one has yet found a way to circumvent the fate nature intends. But research is uncovering some fascinating avenues along with the dead end streets.

• *Dietary antioxidants.* Proponents of the "free-radical" theory of aging suggest that by-products of chemical reactions damage cells beyond repair during normal metabolism. To block "free radicals," those short-lived oxygen molecules, they are looking into certain antioxidant substances—among them vitamins A, C, and E and the mineral selenium.

To date, there's no agreement on how much of a role free radicals play in aging, though it's a promising area in research. Nor is there agreement on whether an antioxidant regimen can extend life, or, if it can, what the daily dosage should be. In fact, large quantities of vitamin A and selenium can be highly toxic.

• *Superoxide dismutase (SOD).* SOD, present in most cells, is the scavenger that mops up the free radicals. This naturally occurring enzyme, which seems to protect cells from damage, is more active in long-lived species than in those with shorter life spans. Could SOD extend life? Proof has yet to emerge. SOD supplements, sold over-the-counter, are of little use since the protein in SOD breaks down during digestion and the cells can't reassemble it.

However, scavenger drugs that block free radicals are being tested for use in human organ transplants, where the rush of blood back into an organ after surgery overwhelms the cell's scavenger system.

• *Calorie-restricted diets.* In the 1930s, Clive M. McCay reported that undernutrition (30 to 50 percent fewer calories than normal) could extend the life span of rats, leading to speculation that it might do the same in humans. The rats, fed such a diet since infancy, showed stunted growth but stronger immune systems. Naturally, there's been no interest in producing a nation of hungry, growth-retarded children in the uncertain hope that they might live longer.

• *Gerovital-H_3.* This is a salt solution of the pain killer procaine (Novocain) and stabilizing agents. Ana Aslan of Romania has heavily promoted Gerovital-H_3 to slow down the bodily changes accompanying aging. She runs a state-supported rejuvenation clinic visited by Charles de Gaulle and Marlene Dietrich, among other hopefuls. But the procaine hydrochloride is primarily an anti-depressant and an anesthetic. If you're glum, it may make you cheerier. But younger?

• *Dehydroepiandrosterone (DHEA).* Produced in the adrenal gland, this hormone is found in higher concentrations in the blood of younger people than of elderly ones. DHEA is hardly detectable in those age 70. In studies, rats given DHEA supplements tend to live longer, but there is no convincing evidence to suggest that taking DHEA supplements can extend human life.

—Peggy Eastman and
Donna Shoemaker

the Francis Scott Key Medical Center at Hopkins. They have shown that the normal age-related decline in maximum aerobic performance can vary. Armchair sitters may lose up to 10 percent per decade, while highly trained master athletes might show only a 5 percent loss over the same period. Exercise also stimulates glucose receptors in the muscles, thereby cutting down on the amount of sugar in the blood stream and on the chance of developing diabetes.

But exercise has to be continued over a lifetime to keep its protective edge. Middle-aged and older athletes who continue to train as competitive runners have an oxygen intake capacity 50 percent or more higher than that of ex-athletes of the same age who have stopped training, says Claude J.M. L'Enfant, director of the National Heart, Lung, and Blood Institute.

Calcium and estrogen are frequently prescribed to strengthen bone mass in women. But might exercise also protect against osteoporosis by stimulating bone tissue turnover and building up bone density? To study that question, Christopher Ruff, a Hopkins anatomist at Key, is comparing the bones of aging female beagles who run five hours a week on a treadmill with a control group of age-matched sedentary beagles. In human years, the dogs are between 65 and 80. The bones of beagles are almost identical to human bones in histological structure and mechanical properties, says Ruff, assistant professor of cell biology and anatomy and an orthopedic surgeon. In earlier studies (using younger animals), exercise led to a 20 to 30 percent increase in localized bone mass.

In this second phase of the study, every five months the researchers take computer-assisted measurements on the loads and stresses on the beagle bones to determine changes in shape and density. The study is also testing other potential causes of osteoporosis, including lower levels of estrogen, calcium, and parathyroid hormone.The results might help to provide the answer to whether regular, load-bearing exercise strengthens the structure of bones and aids in preventing hip fractures.

Weighing in for life

Proper diet, along with exercise, can slow some age-related changes in the body. Eating too much of the wrong foods—a common American habit—puts fat on the frame and fat in the blood stream. But the concept of ideal weight has been shaken of late. No one can say for sure what obesity is, although the American Heart Association and the National Cancer Institute do agree that the obese are at risk for heart disease and cancer.

The controversy heated up when Reubin Andres, a Hopkins professor of medicine, analyzed data on the relationship between body weight and life span. In general, he found that healthy people who weigh 10 to 15 percent more than the previously set "ideal weight" (as defined by the widely used 1959 Metropolitan Life Insurance Company charts) tend to outlive other underweight or average adults. In 1983, Metropolitan Life revised its "ideal weight" charts upward, a step criticized by some physicians who remain convinced that thinner is healthier.

"The basic contention of my 'contentious concept' is that it seems to be appropriate to gain weight as you grow older," says Andres, who also is clinical director of the NIA Gerontology Research Center at Key. "The question is, is it more important what your cholesterol is or whether you live or die? Would you rather be alive with a high cholesterol or dead with a low cholesterol?"

Andres takes a philosophical view of

Tanning: Is it a fading trend?

What prompts the desire for a glorious tan? The social pressure to look young. What makes skin look old? Too much exposure to the sun. Hmmm. There's a Catch-22 to catching some rays.

For an office-bound worker, a tan conjures up looking healthy, feeling relaxed, and managing well enough to have jetted off to Jamaica. Another often cited justification for tanning is to pump up production of vitamin D, though low levels of sunshine will do that nicely.

Even in summer, fans flock to tanning booths. Why? "Before they go on vacation, they like to build up a tan in a controlled fashion," suggests Paul Strickland. But the Johns Hopkins School of Public Health assistant professor and environmental health researcher would prefer that tanners seek some cover instead.

Tanning is the skin's attempt to shield itself from ultraviolet radiation (UV); sun screens serve the same function. Tanning results when the epidermis steps up production of melanin, the brown or black pigment designed to absorb harmful rays. But overexposure to UV rays can be carcinogenic. "The majority of non-melanoma skin cancers are associated with sun exposure," Strickland says. And, he adds, epidemiological evidence seems to be mounting to indict the sun as an agent in melanoma as well.

He believes there's a new culprit indoors: the ultraviolet light bulbs used in tanning lamps, which produce UVA radiation. Thus he suggests more regulation of tanning studios, many of which, ironically, are located in health spas.

Five or 10 years ago, UVB bulbs were used in most tanning lamps, but have been replaced by UVAs, thought to be safer. "It takes a much higher exposure to UVA to induce suntan and tissue damage," Strickland says. But in his tests on albino mice (which are not susceptible to melanoma), UVA rays produced cancerous lesions.

UVA rays are the long-wave-length rays closest to the visible light spectrum; they range from 320 to 400 nanometers (nm). At the Earth's surface, 95 percent of UV rays are type A, while only 5 percent are mid-length B type, 280 to 320 nm. UVC rays, the third kind at 200 to 280 nm, are the shortest and most hazardous ultraviolet ray. But UVC rays don't pass through the protective ozone layer to reach the beach. "This is the reason why the ozone layer is so important—it's absorbing everything below 290 nm," he explains.

UV rays destroy certain proteins in the skin that give it elasticity. When the protein breaks down, the skin begins to look like leather. "The appearance of the skin is the major factor we use to visually assess the age of an adult. An individual who works outdoors in a hot, dry climate can look 20 years older," Strickland notes.

But the paler look may be having a revival. Says Strickland, "the impression I have is that the trend might be swinging back. A lot of people are beginning to realize the dangers."

—Donna Shoemaker

MILLARD MILBURN RICE, AGE 93

"I don't use a cane and I don't feel old."

Many people have asked Millard Milburn Rice how he has lived to be almost 93. Though he respectfully credits his ancestors, he puts more faith in a lesson he learned years ago.

"I spent 13 years in a little mining town 7,000 feet up in the Colorado Rockies, recovering from an ailment resulting from my service in World War I. He had been a student at Western Maryland College when the war broke out.

"I knew that my chance of recovery was about 50-50, and somehow I adopted a fatalistic attitude. I followed a careful regimen and resolved to keep my mind active and to push all worry as far into the background as possible."

He follows the same rules now that he is retired from a job as a bank vice-president and semi-retired from an avocation as a local historian. "To avoid boredom," he says, he fully indulgences passions for reading, baseball, and walking. "I don't use a cane, and I don't feel old."

Most of the changes in his lifestyle he cheerfully accepts. But the move to his single room in Frederick, Md., was trying even for one with a long education in patience.

"For 10 years following my wife's death I had continued to live in a spacious apartment surrounded by lawns and trees. In the retirement center I knew that I would live in a very small room overlooking roof tops. That knowledge alone generated a reluctance to move, and combined with the knowledge that I should be forever separated from most of my possessions, the decision became traumatic.

"The separation leaves a sense of loss almost impossible to express. I have been asked how to adjust."

On approaching death and dying

"One advantage of old age is the clarity of vision. Not everyone has it, and it would be wrong to romanticize old age. But those who do have a much sounder sense of values, which comes of looking death in the eye."

The thoughts are those of John Caputo, professor of philosophy at Villanova University. He likes the word mortal. "It's a good word; it describes our condition as humans. We are the only beings who die—other beings perish. We're the only ones who experience mortality, because we are projected ahead of ourselves. We have what Heidegger called 'being toward death.' We tend to say death is something off in the future that's not going to happen, not to me, not yet. So we turn ourselves over to present distractions." He adds that ours is "a culture of youth, a culture of erasing the time process. People in their 60s want to look like people in their 30s."

Through his interest in existentialism, he thinks of time in two guises, human temporality and objective time. The time of objects, he explains, "is homogeneous. What you have is only units of the present. The future is what didn't happen yet, the past is what is over."

But in human temporality, "the focus on the now is diminished. You're oriented toward the future. You're always moving ahead of yourself. You also have your past in the back of your head. The movement of the present seems to vanish. You become literally ecstatic, extended out of yourself."

Often, the young are the ones most entranced by "now" time, by immediate gratification, into idling the present away. What's it like to talk with a class of freshmen about death? Says Caputo, 46, "It's practically impossible. 'Death' tends to just bounce off an 18 year old. They are so vitally throbbing. But as you get older, you hear it."

What we hear is that death is coming, sooner or later. But, says Caputo, "the projection upon death is salutary, a constructive thing. If confronted squarely, it's not a morbidity or moroseness, but it's seeing yourself in a cold, white light. And that's liberating."

—Donna Shoemaker

the controversy on fatness and longevity. "In my talks and writings, I have compared obesity to a Jekyll and Hyde sort of variable. We need quite a bit of body fat, but what's it there for? We certainly don't need it to survive an overnight fast. And we certainly don't need it to survive weeks of fasting—at least not anymore. Any advantage that the plump cave man had certainly should not apply to modern people."

Part of the paradox of extra pounds—that they are associated with disease but may aid longevity—may be explained by the fact that there are different kinds of fat. In terms of the chronic diseases of aging, it's better to be shaped like a pear—known as female-pattern obesity—than like a pot—known as male-pattern obesity. The pot-bellied are worse off because "adipose tissue inside the abdomen drains directly into the liver," says Andres, "so the blood leaving that tissue is heavily laden with harmful fat. Whereas the fat around the hips and thighs doesn't go to the liver, it goes generally everywhere."

Diet and a long life

Although the medical profession may not agree on what ideal body weight is, it is reaching some common ground on what kind of diet helps people live longer.

New evidence that diet can help to reverse artherosclerosis comes from a study of men aged 40 to 59, conducted by the National Heart, Lung, and Blood Institute. A stringent low-fat diet, coupled with a cholesterol-lowering drug and niacin, actually helped to widen portions of narrowed blood vessels in men who had previously had coronary bypass surgery. Of those following the test regimen, 16 percent showed actual arterial widening, compared with only 2.4 percent in the control group on a more normal diet.

The American Heart Association's low-fat, low-cholesterol diet recommended to prevent heart disease and the National Cancer Institute's diet to prevent cancer are almost the same. Both say to avoid foods high in saturated fat (such as marbled steak and butter), cholesterol (such as organ meats), and sugar and salt. Not surprisingly, they recommend eating more fresh fruits, vegetables, and whole-grain cereal and breads.

Recently the heart association revised its dietary guidelines to focus more on the link between calorie intake and cholesterol. "Calories do make a difference—that's one of the major messages," says W. Virgil Brown, professor of medicine at Mt. Sinai School of Medicine in New York.

Along with its recommendation that fat should make up less than 30 percent of what we eat, the heart association now advises that cholesterol should be no more than 100 mg per 1,000 calories consumed, not to exceed 300 mg a day. Sample menus show how substitution can reduce calories and thus cholesterol, for example, munching an apple instead of six chocolate sandwich cookies or substituting an eight-ounce glass of skim milk for a deviled egg and cheese sauce.

Skim milk also rates high with doctors treating older women because it's low in fat but high in calcium (an eight-ounce glass contains about 300 mg). While calcium can't compensate for the drop in estrogen accompanying menopause, the often-prescribed daily dose of estrogen could be reduced if women would take in 1,500 mg of calcium every day, concluded panelists at a recent NIH workshop on osteoporosis.

The attitude factor

Research into the intricate connections between the brain, the central nervous system, and the immune system—a field called psychoneuroimmunology—is confirming that how we think may affect our susceptibility to disease.

In the absence of illness, personality remains fairly constant over a lifetime, the BLSA reveals. Thus the stereotype of an older person becoming cranky and difficult is false. It's unlikely, unless he or she was cranky in youth and middle age.

In studies of how older people perceive their health and well-being, those who say they feel pretty good are, in fact, relatively healthy. Do they feel good simply because they think they do, perhaps ignoring aches and pains that may be present? That's hard to sort out, but it is clear that attitude exerts a strong influence on healthful aging.

While aging is inevitable and the cellular clock continues to tick even as you read this, practicing a healthy lifestyle throughout your life does give you an edge on old age. No one can change inherited genes, but changing habits is within anyone's grasp.

Peggy Eastman is a free-lance writer specializing in gerontology and living in Chevy Chase, Md.

London Bridges Building Up

With pageantry and grace, Great Britain welcomed 12 undergraduates whose seven weeks of hard work christened WPI's new London Project Center.

By Kenneth McDonnell

It's over now. The reports have been written and polished. The final presentations have been given and good-byes exchanged, along with mementos of thanks and new-found friendships.

The student teams have disbanded and gone their separate ways—most of their members off to the playground that is Europe in the summer, others back to the States for summer jobs. They will regroup in September, no doubt, for debriefing and reminiscing, and then on to their junior or senior years—one more episode in their education.

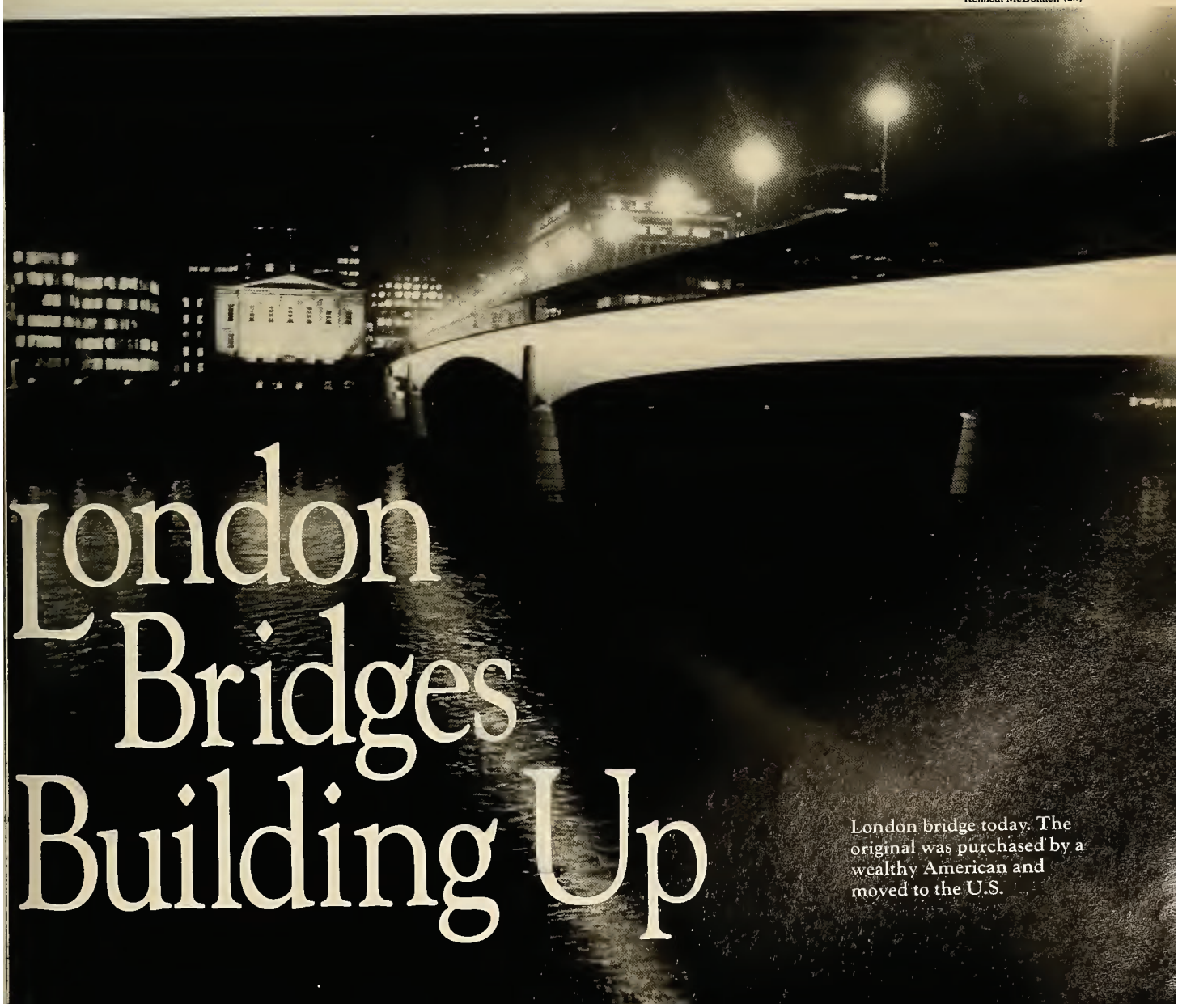
In completing their Interactive Qualifying Projects (IQPs), these 12 undergraduates, the first to represent the college at its new London Project Center (LPC), have established WPI as a significant presence in Great Britain—a presence that is certain to increase in the years ahead.

"Frankly, I was surprised by how happy each of the four agencies was with what our students achieved," says humanities Professor John Zeugner, co-advisor at the LPC this year. "The kids had their hands full—seven weeks is little time to deal with a new culture and professional-level expectations—and I pushed them pretty hard throughout the term.

"Still, the amount of time the agency liaisons spent with each group and the close relevance of each project to the mission of the sponsoring group are marvelous indications that all the hard work will find receptive ears in this year's sponsor organizations—and has already opened more doors in Britain."

MODELED AFTER WPI's Washington, D.C., Project Center, established in 1974, the LPC is largely the culmination of the 14-year student exchange program

Kenneth McDonnell (all)



London bridge today. The original was purchased by a wealthy American and moved to the U.S.

"The kids had their hands full.
Seven weeks is little time to deal with a new culture and professional-level expectations."

between WPI and The City University of London. In Washington alone, some 500 students and 40 faculty members have completed more than 200 IQPs with 50 government agencies and private organizations.

Now, the LPC adds a cross-cultural element to WPI's residential projects program. And it is the cultural exchange—even in a nation as socially similar to the U.S. as Britain—that is one of the major benefits and challenges of participation in the LPC.

"I think our students were surprised by just how *different* things are in the U.K.," says Zeugner, whose desire to serve in London derives from his interest in both teaching through projects and investigating how other cultures handle higher education.

It's the little things that matter, he says, such as dealing with differences in technical terminology and regular working hours, together with new social norms—proper silence on the Underground, London's exceptional subway network, and etiquette in England's fabled pubs. All told, it creates not only a challenging working environment for students but also the need to demonstrate, often for the first time, a sense of collegiate and even national ambassadorship.

And in every project, the proposals so meticulously conceived and presented prior to the students' departure in March needed altering once they got to London, due to normal progress achieved by the agencies themselves and changing conditions of the problems being addressed.

"It's all very exciting," Zeugner says, "but being in a place where you absolutely must carry a 300-page book of maps to get anywhere—well, you have to budget a little extra time for these things."

In London, there are, for example, 65 streets whose names contain the word queen. And it's said that to win an operator's licence, London's cabbies must pass an exhaustive, three-day examination testing their ability to get you to anywhere in London via the fastest, most economical route—and always in a clean, comfortable fashion with a courteous "Thanks, mate" at your destination.

"*Very* civilized," Zeugner says.

During a review session with advisor John F. Zeugner, professor of history at WPI, U.K. Patent Office project members pose for a photograph. Left to right: Robert A. Petrin '88, Andrew J. Scholand '89, and Sergio E. Levi '88.

Junior Paul R. Mancini, an LPC student, adds, "It's so different here. At home, we go to class, crank out homework, go to project meetings, take exams, start again. Here, we have a problem to solve in a limited time within set parameters. We've got to develop resource networks quickly, building something from nothing in a strange place."

Considering the demands on their time, is there much left over for exploring this enchanting, non-stop city? "Weekends," says the mechanical engineering major.

In London, Mancini and teammates Jodi-Ann Medeiros and William F. Noel, juniors as well, worked on a project for the Worshipful Company of Scientific Instrument Makers. The Company, Noel explains, is one of England's many modern-day guilds, or liveries. These organizations were established in the Middle Ages by craftspeople in particular trades to regulate the activities of the

"It's all very exciting," Zeugner says, "but being in a place where you absolutely must carry a 300-page book of maps to get anywhere—well, you have to budget a little extra time for these things."

industry—by governing apprenticeships, setting prices, and playing a vital role in the lives of their members. Today, these fraternal groups continue to promote the welfare of their industries, but normally through channels similar to those of manufacturing associations.

Each year, for example, the Company gives an achievement award for the best commercially innovative technological instrument. The award, Medeiros notes, has always been well received, but until now the Company lacked a formal structure for selecting award nominees and winners. Past winners have included the scanning electron microscope and the EMI whole body scanner.

By studying the selection systems of similar awards and sources of new product information, such as trade publications, university research, patent office documents, and word-of-mouth resources, the team was able to recommend not only a more formal award format, but also a leading nominee for the 1987 award.

In addition, the team's final recommendations included showcasing the current year's winner at the guildhall and at British libraries and museums, providing the winning organization with an award crest for display, and perhaps changing the name of the prize as well. Their efforts should go far in promoting the prestige of the award.

The building in which the Company resides houses several other liveries like the launderers' and the glaziers' guilds. Located on the river Thames and abutting London Bridge—making the hall itself part of the historic City of London—Glaziers Hall was the site of the LPC inaugural banquet on April 13.

For the 80 guests assembled, it was an evening to exchange best wishes for the work ahead, to express appreciation for the close relationships that had already sprung up between WPI and British project sponsors, and, of course, to toast the queen—and the president.

Not only were the 12 project students on hand for all the introductions, the feasting, the speechmaking, and the classical music, but so were WPI representatives who journeyed to London for the inaugural event and to make plans for subsequent LPC projects in the spring of 1988. Those in attendance included Dean William R. Grogan '46; Dean John P. van Alstyne; Dean Frank Lutz and his wife, Evelyn; Professor Lance Schachterle, co-director of the LPC and director of the Division of Interdisciplinary Affairs (DIA), which oversees all IQPs; and freshmen Nancy A. McLaughlin and Jeffrey A. Yoder, who delivered greetings from the Class of 1990.

Also in attendance were alumni George H. Long '57 and his wife, Linda; Henry M. Strage '54; and Robert Wolff '51 and his wife, Millicent.

The LPC had been in the planning

Juniors Henry J. Clark III, Michelle A. Pence, and David A. Burrage catalogued the papers and wrote a biographical sketch of the British inventor Albert H. Midgley for the Institution of Electrical Engineers.

In completing their IQPs, these 12 undergraduates have established WPI as a significant presence in Great Britain—a presence that is certain to increase in the years ahead.

At the conclusion of the inaugural banquet of the London Project Center, 10 of the dozen WPI students, together with the British advisor to one project, Peter M. Back, second from left, offer a most American rendition of the song whose chorus begins, "Do wah ditty ditty . . ."

stages for several years, thanks in part to the untiring efforts of Maria L. Watkins, co-director of the Center, co-advisor with Zeugner, and an adjunct associate professor in the DIA. A retired professor of electrical engineering at The City University and the first woman in England to teach EE, she has also established and managed nearly a dozen university exchange programs, including those of Clarkson and Syracuse universities.

She is also an active committee member of the Institution of Electrical Engineers, a member of the Worshipful Company of Scientific Instrument Makers, and one of just 50 female freemen, out of more than 1,000, of the City of London, which entitles her to vote for—or even become—the Lord Mayor of London.

And for WPI, she is a vital asset to the LPC, opening doors at high levels.

THE BANQUET seemed to lend a sense of British grace and style to the entire LPC venture with guildmasters in full regalia, the keynote address by Baroness Platt of Writtle, chairperson of the U.K. Equal Opportunities Commission, entitled "A Woman's Place Is in Industry," and the Thames just outside the window.

For the project students, the banquet was one of several testaments they would experience to the value of their work to their sponsor agencies. It was also, though, but an evening's respite from a commitment that demanded sometimes 60–70 hours of toil each week.

At the U.K. Patent Office (UKPO), for example, a typical week might find Sergio E. Levy '88, Robert A. Petrin '88, or Andrew J. Scholand '89 jetting off to The Hague to discuss elements of their project with representatives of the European Patent Office (EPO).

The project centered on the UKPO's concern over criticism of its patent searches uncovered in a survey conducted by an independent research group. The outside study examined the perceived satisfaction of the agency's users—patent agents, similar to U.S. patent attorneys—with UKPO searchers compared with those of the EPO.

Created in 1978 because of the desire of European national patent offices to ease the procedure for multinational patent protection, the EPO is today most attractive to that sector of industry interested in marketing its products throughout Europe. The UKPO, on the other hand, is used mainly by inventors whose chief concern is the British market.

In addition, the cost of an EPO search is often prohibitively high for single-market-oriented producers. But according to UKPO project liaison Peter M. Back, his agency and the EPO are not in direct competition, since they serve the needs of two different sectors of the economy.

"Patents are a tremendous source of technical information," says Scholand. "But patents have a tradeoff: The government gives you a limited monopoly on your invention in return for your revealing the smallest details of your innovation and thus allowing other people access to your ideas." And since patents—published documents—are often released long before an idea reaches the pages of technical journals, patents usually serve to publicize the lat-

est developments in any field.

Adds Petrin, "Patent offices actually have a vital societal responsibility to spur technology, since industry needs the strategic tools which new ideas provide."

As result of their work, the team found that in the previous independent study of UKPO and EPO searchers, the patent agents interviewed either misunderstood the differences between the two agencies, or were subject to a poorly constructed and analyzed questionnaire. Further, the students found that the price-quality balance of UKPO searches is reasonable, but that certain parts of the search report could stand to be improved.

According to Levy, all engineers and scientists should be interested in the arcane world of patents: "Just as technologists should be interested in improving society, they should also be aware of the fact that intellectual property can be defended."

Petrin says he hopes the results of the team's work will enable the UKPO to better market itself, an especially important task now that the number of patent applications is falling in the U.K. from as many as 20,000 per year.

ONE BRITISH INVENTOR who owned his share of patents was Albert H. Midgley (1881–1961). The son of an engineer, Midgley grew up at the time when electricity was gaining broad acceptance but was still in need of technological and safety developments.

It was the Victorian Age. England was well into the Industrial Revolution. Society demanded attention to high personal and professional standards, yet was reluctant to adopt new ideas and products. It was also a period of dramatic growth in the commercial and cultural development of London. Young, energetic technologists were flocking to the city to make their entrepreneurial marks. Albert Midgley was among them, coming south from his native Yorkshire to play his hand in the development of such innovations as electric streetcars, motor cars, lighting, radio, and cinema.

He did leave his mark, not only as an inventor, but also as an entrepreneur and businessman who improved on the ideas of others. Dynamos, electronic organs, radios, bomb fuses, and automatic timers and switches would bear his trademark throughout the first third of this century.

Midgley's papers, artifacts, drawings, journals, invoices, and patent specifications chronicle the remarkable changes in British technology during his life. But until three WPI students arrived in London, Midgley's things were stored, unsorted and uncataloged, in 81 boxes and tea chests at the British Institution of Electrical Engineers (IEE).

The tasks before juniors David A. Burrage, Henry J. Clark III, and Michelle Pence were to catalog the contents of the Midgley collection, at the same time suggesting which things might reasonably be discarded. In so doing, the team developed a computer program for fast, reliable indexing of the collection. Finally, the three wrote a biographical sketch of the inventor, based on sources in the collection, interviews with Midgley family members, and other

Among the distinguished guests at the banquet were (left to right) Dr. Elizabeth Laverick of the Institution of Electrical Engineers; R.J.F. Howard, master, Worshipful Company of Scientific Instrument Makers (WCSIM); Baroness Platt of Writtle, chairperson of the U.K. Equal Opportunities Commission; Professor Maria Watkins, co-director of the LPC; and G.G. Zahler, deputy master, WCSIM.

The banquet seemed to lend a sense of British grace and style to the entire LPC venture.

research, which placed him in the context of his time.

"We've tried to give researchers, historians, and inventors a resource to help them access information on one of Britain's most prodigious inventors," says Pence, "and at the same time create a cataloging system that can be useful for similar IEE archival collections."

In the process, adds Clark, "we've come to understand a lot more about British culture in Midgley's time and the dynamics of how new technologies are both developed and put on the market."

The inaugural banquet, held in Glaziers Hall, featured a keynote address by Baroness Platt of Writtle, chairperson of the U.K. Equal Opportunities Commission.

"IT'S OUR SECOND DAY in London. We walk into an IEE conference room for our first project meeting with our project advisors, expecting a 'Hi, how was your flight? How are you finding London?' But instead, we find ourselves face to face with a committee of eight serious people, obviously awaiting our arrival with high expectations of our future performance."

This, says John T. Powers '88, set the stage for what would become seven weeks of intensive efforts to both address the complex issue of his team's project and fulfill the expectations of IEE.

The students' mission, to project the manpower needs of electrical engineers in the U.K. to the year 2000, was based on fears that, by the turn of the century, the U.K. will be experiencing serious shortages in many engineering disciplines. To avoid this situation, says team member Karen A. Desrosiers '88, it is imperative that both British industry and education—from secondary schools through universities—take remedial steps now. "But considering economic supply and demand projections, the government may well need to do more to encourage careers in science and technology."

One way to do this, the team recommended, is to provide British students with more information on the bright future and excellent job opportunities in electrical engineering. Another is to increase the number of college courses offered at night, which would enable practicing engineers to gain further education and credentials in their chosen fields.

"The nation will clearly need more engineers in the decades ahead," says Mark Wartski '88, "but this means greater resources and publicity from grammar school on up. Without this kind of collaborative commitment by industry and government, and with the number of 18- and 19-year-olds still declining in the U.K., as in the U.S., the imbalance could worsen considerably."

To complete their project, the team relied on the data contained in IEE salary surveys of practicing engineers, together with extensive research of British industrial and educational programs. Salary surveys, says Wartski, yield significant indications of where the best opportunities lie in competing fields.

"To stimulate a nation's economy," he says, "there need to be adequate supplies of professionals in the appropriate fields. And in an increasingly technological—and competitive—world economy, in engineers and scientists lies much of the hope of a nation."

Already, five IQPs are planned with 15 students in London in the spring of 1988. According to Lance Schachterle, the Patent Office and the IEE have both indicated strong interest in continuing to

"We've got to develop resource networks quickly," says Junior Paul R. Mancini, "building something from nothing in a strange place."

offer project topics regularly, and plans are well along for a series of projects at the IEE on British women engineers.

New project contacts are being developed with the London office of Digital Equipment Corporation, with the British electronics firm Ferranti, and with the London Dry Docks Corporation, which oversees the major urban redevelopment project for the growth of London's financial district.

Schachterle and co-director Maria Watkins are also discussing a project on the patent activity of Dennis Gabor, perhaps best known for his fundamental work in holography. The Gabor project will be especially interesting in that the London liaison will be Prof. T. E. Allibone, a colleague of Gabor's and a member of the prestigious Royal Society, where the students will be doing much of their work.

"The success of the 1987 projects was crucial to getting such good contacts for 1988," says Schachterle. "Professor Zeugner not only worked the students hard, but also pushed himself to the limit to assist them." Working under the constraints of a new and unfamiliar environment, he adds, both students and faculty produced outstanding reports that prove again the basic philosophy of the WPI project program: If you treat students like young professionals and give them appropriate resources and responsibilities, you'll be astonished with the high quality of the results.

"What we need to do now," Watkins adds, "is to learn from our returning students how to arrange the living and social patterns to best support their tight work schedule. Being scattered around the northern suburbs is not an optimal living arrangement, and we all look forward to a day when WPI can establish a formal residential center in London for students and faculty to share."

During their visit to London in April, deans Lutz and Grogan also advanced plans for new cooperative programs with King's College and Imperial College, the two leading engineering programs in London. Along with the LPC, these new contacts will complement programs already in progress at the National Institute for Higher Education in Limerick, Ireland; University of Stirling, Scotland; and with several technological institutions in Switzerland, Sweden, and Germany.

Plans call for Professor John van Alstyne to serve as co-adviser to the LPC in 1988. A veteran of the Washington Project Center, where he'll advise projects again this fall, of his spring '88 plans he says, "After seeing how successful the LPC has been in just its first year, I'll have my hands full just keeping up with what our sponsoring agencies are coming to expect from WPI. But considering the caliber of students selected to represent the college, I guess I shouldn't be all that worried."

"Besides," he adds, "I can't wait to get back to London."

William F. Noel, Jodi-Ann Medeiros, and Paul R. Mancini, all juniors, take a break from a busy day in their offices that overlook the river Thames.

Better Access to Expanding Knowledge

INFO-TECH

One thing is certain about working in Gordon Library—you never know what people are going to ask next. And if you think the hardest research questions involve knotty engineering problems or esoteric scientific concepts, guess again.

Take, for instance, the Case of the Notre Dame Fight Song. "One morning I got a call from a woman who needed to find the words to the Notre Dame fight song, which she was supposed to sing for a gathering that night," recalls Carmen Brown, Gordon Library's head of public services.

A search through the Library's holdings and a call to a friend in WPI's financial aid office who had Notre Dame connections proved fruitless. But on her way to lunch that afternoon, Brown bumped into a faculty friend who was a Notre Dame alumnus. "I said, 'Quick, what are the words to the Notre Dame fight song?' The only way he could remember was to sing it, so we stood there on the quadrangle, singing at the top of our lungs, while I scribbled the words down on a copy of the *Boston Globe*."

Later that day, when she reached the inquiring party, Brown once again sang a rousing rendition of the fight song as she dictated the words over the phone. "It turned out that the caller wasn't too sure of the tune, either," she laughs.

Certainly, it was not your run-of-the-mill research request. But Brown recounts the story as a good illustration of the way she and the other librarians are able to draw on all the resources WPI has to offer in order to find information. "The faculty and staff are really happy to help us," she says.

That story also tells a lot about the nature of library work. "The best thing about my job is the element of surprise,"

As computers help define the future of 20-year-old Gordon Library, Al Anderson and his staff rise to the challenge of satisfying more and more patrons hungry for knowledge.

By Evelyn Herwitz

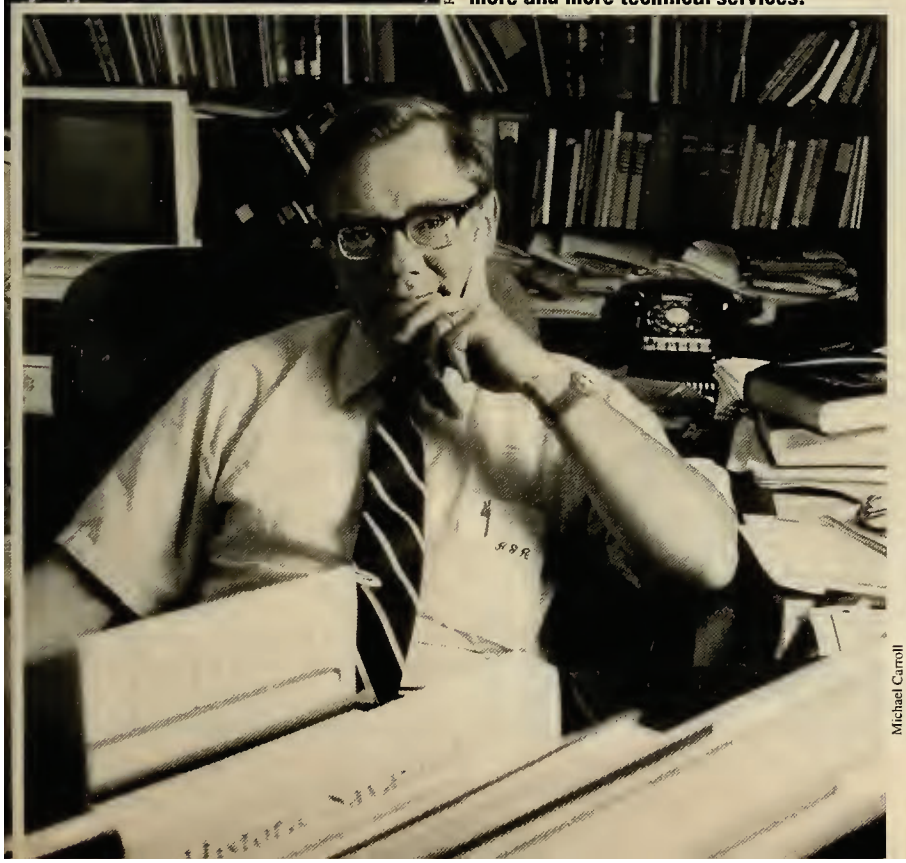
says Special Collections Librarian Lora Brueck. As keeper of WPI's archives, Brueck likens her tasks to being on a treasure hunt: "You never know what's going to come in, or what's in a collection that hasn't been looked at for years. Sometimes you can uncover something quite valuable or original."

Responding to any and all information requests and sharing research discoveries with the WPI community are two of the George C. Gordon Library's most important tasks. Doing so in a way that makes the best use of available information technologies within an aesthetically pleasing and convenient setting has been the Library's goal since its creation 20 years ago.

While that mission has been largely realized, as it enters its third decade, Gordon Library is facing new challenges. Both the Library's holdings and WPI's student body have outgrown the Library's physical plant. As plans are made to accommodate that expansion, Library staff members are also wrestling with a broader issue: how to remain an adaptable, high-quality academic resource in an era when computer data bases are radically changing the way information is researched and stored.

Those concerns, if not anticipated, certainly were not a major worry when the Library was conceived in the mid-1960s. At the time, the main issues were much more basic: how to centralize the various departmental libraries around campus, to make books and other resources readily available across disciplines.

Robert S. Arnold



Michael Carroll

Gordon Library, now 20 years old, remains unchanged outside, but much is new within. Below: Head Librarian Albert G. Anderson, Jr., strives to answer the need of a growing academic community for more and more technical services.

Planners were also thinking about some subtler, but equally significant, questions—questions about aesthetic design, adaptable space, and ways to unify the campus with a special building that all would enjoy using.

The impetus for the new library came from an accreditation review that criticized WPI's then-disparate department collections as insufficient for academic purposes. At the time, humanities and social science titles were located in the Library's precursor in Alden Hall, while the Electrical, Mechanical, Civil, and Physics departments all maintained their own collections, and the Chemistry and Chemical Engineering departments shared resources.

According to Albert G. Anderson, Jr., who joined WPI in 1963 to help plan the library of which he is now head librarian, the idea of a centralized facility did not go over big with some members of the faculty. "Many of them wanted to maintain their own collections," he says. "But President [Harry P.] Storke insisted."

Championed by Storke, the project took shape. The final plans called for a 65,000-square-foot, four-story building that could hold 200,000 books and seat 450 patrons, plus another 150 people in a special seminar room.

But it was also designed to be "more than just a typical library of the late '60s," says Anderson. "The architect wanted it to be aesthetically pleasing, a campus showcase. He wanted it to be what a building in WPI's future would look like, while staying within a reasonable budget."

Among the Library's foresightful innovations were wall-to-wall carpeting and the campus' first central air-conditioning system. Other features included a music room for listening to records and tapes,

Below: Special Collections Librarian Lora T. Brueck with some of the treasures of the Gordon Archives, including (far left) a bronze head of the WPI mascot.

space on the top floor for art displays, meeting and seminar rooms, and storage for the Institute's archives.

The building's $2.5-million price tag was met in large part by a $5-million bequest from Cleveland industrialist George C. Gordon, of the Class of 1895, whose name is chiseled over the Library's entrance. Federal aid totaling $750,000 also paid for construction expenses.

Much has changed since Gordon Library opened its doors in 1967. To begin with, WPI's very makeup has radically altered, both in size and composition. In the past 20 years, enrollment has more than doubled, from 1,700 to 3,800.

How those students are learning has changed as well. Though classroom and individual study are still essential to the curriculum, with the introduction of the WPI Plan in the early 1970s undergraduates began spending much of their time working in groups for project courses.

For the Library, that growth of and shift to group study have put a premium on space. Particularly for project coursework, notes Carmen Brown, the few available study rooms are staked out early in the day, marked with "in use" signs to define turf, and not vacated until late at night. Those who can't find a room of their own often meet in the Music Room, which has evolved into an ad hoc project meeting place because it is also an enclosed, more private space.

To meet the growing demand for information, the Library has increased its book collection over fivefold, from 40,000 volumes when it opened to 200,500 today. But all those books, as well as 750,000 pieces of microform (microfilm and microfiche), 1,350 magazine titles, and 1,650 videotapes of various course lectures, take up a lot of room.

Michael Carroll

Buried Treasure

Theo Brown's extraordinary diaries have a special place in the WPI archives

SOME ODD AND INTRIGUING ITEMS have found their way into WPI's archives. There's the collection of tinware that WPI founder John Boynton made in his tin shop, a few of rocketry pioneer Robert Goddard's ('08) lab notebooks, and the bronze goat's head that replaced the stuffed remains of the Class of 1893's unfortunate mascot. (Legend has it that the Class of '93 couldn't decide what to do with their favorite goat over the summer, so they decided to do away with it but preserve its head. The stuffed goat—which inspired the naming of the former Goat's Head Pub, now Gompei's Place—lasted until the 1920s, when the Tech men decided a bronze version would be a more fitting mascot than the venerable but, by that time, tattered original.)

Then there are the diaries of Theophilus Brown. A member of the Class of 1901, Brown was a mechanical engineer and inventor of agricultural equipment who religiously recorded the details of his life in daily journal entries. Beginning with a brief entry in an 1893 pocket diary about electric cars running again on schedule, and ending with a poem on aging in the back of a novel-size 1970 blank book, the leather-bound journals fill a narrow bookcase in Gordon Library's archives.

What makes the diaries so fascinating is not only Brown's description of his life and ideas—many of which became patented inventions incorpo-

rated into tractor designs by John Deere Co.—but his illustrations as well. A talented artist with an eye for detail, Brown first drew many of his ideas in his journals, carefully illustrating each thought with pen and colored pencils.

During his 92 years (1879–1971), Brown came up with 158 patented inventions, most while working for Deere from 1911 until 1952. From time to time he enumerated those patents in his diaries; in one 1942 entry, he listed 24, including a mechanical power lift, a double power lift, and a self-contained power lift. Elsewhere that year he also mentioned patent applications for a plow that would maintain "constant depth of operation" and a mechanized manure spreader.

But such entries make up only a part of Brown's diaries. A family man, he included snapshots of his wife, children, and grandchildren, as well as sketches of his granddaughter, "Pooh," and Christmas cards he designed. And with as much care as he detailed his inventions, Brown also copied into his diaries letters from his son, Bill, and other family members.

Those letters provide the meat between often brief accounts of daily activities. And during World War II, they provide a window on daily life during a period of national crisis. "We are all projecting ourselves into the future these days, for in the next week or two our immediate fates will be fixed," wrote son Bill in November of 1942 from Officer Candidate School. "White slips of paper will soon be given to us to report to day or night 'boards'—night boards being fatal 99% of the time."

Underscoring the tension of the times, Brown illustrated the pages of his wartime diaries with carefully replicated newspaper headlines and hand-colored maps showing progress on the

various battle fronts. On October 27, 1942, beneath a headline copied from the Chicago *Tribune*, "BIG JAP DRIVE IN SOLOMONS! New U.S. Naval Losses: Sinking of Carrier Wasp Bared," Brown wrote:

"Quarterly Directors' [of Deere Co.] Meeting today. Implements are rationed and sales have taken a nose dive. Our volume for the year will be close to 95 million however. We have 60 millions in cash. The allotment for next year has just come out and will be for the Industry about 20% of 1941 production, but since manufacturers are graded into A, B & C classes, and the A class (which does more than 10 millions a year) is curtailed much more, it looks as tho' 10% of 1940 would be as much as we can expect to do. We are getting into war work in a big way so most of our employees will be busy."

And so was Brown. Despite the war, he kept on inventing. By the end of his life, Brown had received numerous awards for his work, including the first Cyrus H. McCormick Medal for outstanding service in agricultural engineering, WPI's Robert H. Goddard Award for Outstanding Professional Achievement, and the Distinguished Service Award from the National Safety Council for his work in farm safety.

That list could just as easily have included recognition of Brown as an historian and an artist. But such discoveries are perhaps best left to the curious reader who visits the Gordon Library's archives and learns firsthand from Theo Brown.

Below: Gordon's carrels are largely vacant in the early summer, but the library staff stays busy: (left to right) Helen M. Shuster, head of technical services; Cornelia B. Pomeroy, circulation librarian; Diana J. Johnson, reference/interlibrary loan librarian; and Carmen M. Brown, associate librarian and head of public services.

The storage problem was eased somewhat two years ago when space in Founders Hall was set aside to handle some of the Library's overflow. But constraints on storage and study space have prompted the Library staff and WPI administration to begin planning for some form of expansion in the near future. As part of that process, last February the Library surveyed students' opinions of its space and services; not surprisingly, the need for more group study rooms topped the list of findings. This fall, a survey of faculty priorities for the Library is planned.

One plan on the not-too-distant horizon calls for the College Computer Center, which houses academic and administrative computing resources, to be moved to Fuller Laboratories, WPI's planned information sciences building. Construction of Fuller will begin soon on land adjacent to the Library, Atwater Kent and Kaven Hall. This change will free some 9,000 square feet for Library use.

Michael Carroll

"We've got two to three years before we get into serious problems," Al Anderson says. "I hope that by 1990 we'll have more space, including additional seating, stacks, and materials storage."

Despite those spatial limitations, Gordon Library has been able to expand its resources in other ways. Located in a city with a vast array of college and university libraries, as well as specialty libraries at cultural institutions such as the Worcester Art Museum and American Antiquarian Society, Gordon Library is part of a cooperative which enables students to access 2,000,000 books within Worcester alone.

Formed at WPI in 1967 under the aegis of the Worcester Consortium for Higher Education, the Worcester Area Cooperating Libraries (WACL) comprises 14 local academic, public and specialty libraries. Through the Inter Library Loan program, students can borrow books from diverse resources; a daily shuttle service among WACL members makes most books available within 36 hours.

Anderson says Gordon Library lends about as many books as it borrows from other area institutions. "No library can be self-sufficient any more," he says. "We all need to cooperate."

In large part, the need to share materials has been brought about by the rising cost of books and the need for libraries to specialize in order to best utilize limited resources. Gordon Library's strengths, says Anderson, are in engineering and technology, as well as the basic sciences.

In turn, he says Clark University is a major resource for social science references, Holy Cross College for the humanities, and the University of Massachusetts Medical School for biomedicine and biotechnology.

Those three institutions do the most trading with WPI, though Anderson adds that Worcester State College's library is known for its education holdings, and Assumption College is the place to turn for books on languages and philosophy.

A quiet place to study is just the beginning of the comprehensive services Gordon Library provides; it now offers more than 1,300 magazines and journals.

Bill Denison

But the universe of lending institutions accessible to WPI students and faculty is not limited to the Worcester area. Two computer networks, one in operation and one still being developed, enable Gordon Library patrons to borrow books from thousands of libraries across the country.

Via the On-Line Computer Library Center (OCLC), users can search for reference material in more than 4,500 libraries by typing information about an author or title into a computer terminal. The system will locate the source; through Inter Library Loan, the user can place an order. Assuming the material in question circulates and is available, Anderson says it will arrive an average of seven to 10 days later.

The system's major shortcoming, however, is that it can only be used for title or author searches; information is not stored by subject. In addition, the data base indicates only whether a resource is part of a library's collection—not whether it is actually on the shelf or available for borrowing.

An alternative computerized cataloging system, which will enable the user to survey resources by subject, as well as title and author, is being developed on a regional basis through another library consortium—Central/Western Massachusetts Automated Resource Sharing (C/W MARS).

Thirty-four academic and public libraries, including Gordon Library, are members of the system, whose computer facilities are housed on the grounds of Anna Maria College in Paxton, Mass.

Ultimately, the consortium's Public Access Catalogue (PAC) will replace traditional card catalogs in member libraries. Rather than digging through drawers of index cards for appropriate references, users will type inquiries into a computer terminal, accessing titles in libraries throughout the C/W MARS system. In addition, the PAC will identify whether a book is already checked out, non-circulating, or available for borrowing. Books located at a different library could then be obtained through Inter Library Loan.

But that powerful research network is at least a year from being realized, according to Helen Shuster, Gordon Library's head of technical services and automation. Currently, Shuster says her staff are still in the process of entering all of the Library's holdings into the system data base.

An enormous clerical undertaking, that process was started 10 years ago, even before C/W MARS existed, when Shuster anticipated the need to begin cataloging books on computer tapes for some future reference system. Though most of the Library's resources have been entered into the data base, there is still the task of recording individual books in a series, such as volumes in an encyclopedia.

As other member libraries computerize their catalog information, work continues at the regional level to link the data bases together. "We know the computer hardware will work, but the software from C/W MARS [for the PAC] is still being perfected," says Shuster. "We're still very much in the planning process, though I hope the system will be available in the next fiscal year."

In the meantime, librarians are using C/W MARS for circulation control within Gordon Library. When students check out materials, that information is recorded within the C/W MARS data base. The system can also be used at present to search for titles within the Gordon Library, as well as within member libraries such as the University of Massachusetts Medical School and Clark University, which also have their collections on-line. The advantage of the PAC, once perfected, is that it will enable more searches and be more "user friendly."

Books are not the only items being cataloged on computer at the Gordon Library. Eighty years' worth of WPI undergraduate theses—part of the Institute's archives—are also being recorded on a separate data base by archivist Lora Brueck.

"Up to now, the information about each thesis was written on a card and grouped by class year, in alphabetical order," explains Brueck. "Now, as I look

at each thesis, I decide on the appropriate subject heading and enter that information into the computer. That way users will be able to do a search by subject or title."

Yet another important computerized research tool is the Online Search Service. A link to over 200 data bases nationwide, the system can access information as varied as U.S. government R&D reports, chemical research abstracts, or an index to the *Harvard Business Review*. Rates for data searches during business hours vary, but at night, students can use the End-User Search Service for $24 an hour.

Computers are available to students for a different purpose elsewhere in the Library. In the audio/visual room, VCRs and television sets share space with about a dozen AT&T microcomputers for student use. An adjoining room that has been set up for training WPI staff on the new DEC administrative computer is also open to students after hours.

Other computer resources are in the planning stage. Among the most intriguing developments that are changing the way libraries of the future will store information is the compact disk (CD/ROM). Like the small disks that are revolutionizing the recording industry, CD/ROM will eventually be used to store words, graphics, and even moving images.

Currently, bulky resources like *Books in Print* are available on compact disk. Shuster says disks are also being produced that contain not only entire encyclopedias, but also subject outlines with references to individual sections of the encyclopedia, to help users write research papers.

The advantages of such new technologies are obvious for a library where storage space is at a premium. But at the same time, with so many new options to choose from, Shuster says one of the greatest challenges is knowing what *not* to invest in.

"There is a danger of letting technology drive you in certain directions," she cautions. "Like going out and buying CD/ROM (information stored on compact disks) because it's there, without having any real need for the applications.

"But we also have to be very careful that other people don't take our jobs away from us. There are a lot of commercial enterprises in the business of providing information. We have to keep up with the technology and advances in automation, to make sure we have the services people need."

The key to making the right tradeoffs as Gordon Library begins its third decade, says head librarian Anderson, is flexibility. And the key to that—and what has enabled the Library to adapt successfully in the past—is the Library's staff and their commitment to service. "As change has come about, they've been willing to experiment and go along with the changes," says Anderson. "The Library's staff is outstanding."

Evelyn Herwitz, a freelance writer living in Worcester, is a frequent contributor to the Journal.

The Gordon Gallery

ARTWORKS as well as books fill the Gordon Library, from Laurence Sisson's acrylic "Ice Elegy," in the main lobby, to a life-size sculpture of a horse's head in the Music Room, to a wall of art on the third floor.

More than just decorations, the art collection is evidence that one of the Library's major goals is being fulfilled. Head Librarian Albert Anderson expressed it in a 1967 *Journal* article:

"[The] Library has been designed so that the student may view the best in contemporary art, architecture, and photography as well as works in the established periods of the past."

In addition to the Library's private collection, which includes many original prints from the Pratt Institute in New York and gifts from WPI alumni, special loaned exhibits are often on display. Sources range from the Smithsonian Institution to local and regional artists. To ensure good exposure, the works are shown along the third floor corridor. Comfortable benches are placed at intervals along the hall, providing a restful spot for meditation or a simple study break.

"Students and visitors respond very positively to the art and special exhibits," says Anderson. "This building is not just a library. It's a showplace."

President's Message
Continued from page 2

last 16 years. Interestingly, the recent WPI goal statement, developed and endorsed by the WPI faculty, includes the above criteria, albeit from a more technological perspective: "To lead students to develop an excellent grasp of fundamental concepts in their principal areas of study, to lay a foundation for lifelong renewal of knowledge, to gain a mature understanding of themselves, and, most importantly, to form a deep appreciation of the interrelationships among basic knowledge, technological advance, and human need."

The recommendation from the Carnegie Report regarding faculty scholarship is perhaps the most important goal for WPI in the coming decade. As Frederick E. Terman, former vice president and provost of Stanford University, eloquently said, "Quality is not produced by magnificent buildings nor is it assured by huge enrollments. It is not even based upon beautiful laboratories with expensive equipment. What counts is the quality of the faculty or, more precisely, the quality of those few members of the faculty who combine leadership in education with research qualifications in engineering and science. Outstanding faculty members will attract outstanding students who, under their influence, will be trained to make important contributions in higher education, industry and to society." Thus, to ensure its future, WPI must direct significant resources toward faculty development. There is no better way to guarantee continued quality and growth for the years to come.

The philosopher Alfred North Whitehead once said that the function of a college was "to preserve order amid change and to preserve change amid order." One dynamic that will most assuredly face all students in the future is change—rapid and in many ways uncontrollable. The students of today and of the years to come must be adaptable, yet also structured. They must be able to reflect the lessons of history as they make proper choices for the future. But they will also need to be able to ride a wave of technology that will be difficult to control.

To accomplish this, WPI will continue to develop the extraordinary undergraduate education embodied in the WPI Plan, but to do this WPI will need a group of exceptional scholars, able to conceptualize as well as teach. WPI's *Campaign for Excellence* is now in progress to help provide the resources necessary to support this new emphasis on scholarship as a foundation for the 21st century. The efforts and dedication of every member of the WPI family will be required during the next three years to attain the ambitious $52.5 million goal of the *Campaign* so necessary for WPI's important and exciting role as a premier independent technological university.

Dr. Jon C. Strauss is president of WPI.

Room with a View
Continued from page 12

ket," he notes, "so we've invested in resources like CAD systems."

Indeed, a tour of Data's facilities turns up computers of every size and shape: a room full of sales representatives log every phone contact by computer, engineers have them taken apart on tables, the marketing department has desktop publishing systems.

"What often happens," Molinari continues, "is that companies get so big that they become uncontrollable, and that's a failure of management. I think there's an optimum level where people can work well together, and when a company begins to get too big it needs to be broken down so that people are allowed to do what they do best."

The key is communication. "If you and I are working in a room together, it's easy to communicate. But what about when there's 10 people? Or 100? The way you communicate has to change. So we spend a lot of time and energy on trying to communicate effectively."

And they'll be spending even more time in the future. With one successful subsidiary currently operating in England, and plans to open a company in Germany this year and one in Japan next year, there's a lot going on. Data Translation's products are sold in 42 countries.

But, as with technology in general, Molinari says there is no end in sight.

"The challenge is to stay on top. It's really difficult. You have to be careful not to stop to pat yourself on the back. There's too much farther to go. We've only just scratched the surface."

Michael Shanley is a freelance writer living in Holden, Mass., and a frequent contributor to the Journal.

LETTERS

Editor:

I was both intrigued and distressed while reading Paul Susca's "The IQP" (Spring 1987). The article provides an interesting overview of some complex interactions between society and technology. My particular concern, however, lies in the treatment of the abortion issue by the students involved. Let it be clear that my goal is not to judge the students themselves.

Can a fetus truly be considered human life only if it can survive outside its mother's womb? Is the fetus "entitled to its right to life" only if it is 24 weeks or older? What about the rights of developing babies that are 23 weeks old, or 23 days old, or yes, even 23 seconds old? Would a 23-week-old fetus inside the womb suddenly become a human being because an apparatus that could sustain it outside the womb had just been developed thousands of miles away? How arbitrary is it to define human life according to the necessary means of sustenance or the latest advance in life support technology?

If a newborn baby were to die without a respirator, would it have to wait until being taken off of the apparatus before it could be considered human life? Does an adult cease being human life the moment it is placed on a respirator, without which it could not survive?

The human being begins growing at conception and continues to grow until adulthood. The heart of a fetus is beating at about three weeks, and brain waves have been recorded at 40 days. By the end of the first trimester, the fetus squints, swallows, kicks, sucks its thumb, and has fingerprints. Yet it is being suggested that it would be ethical to mutilate and destroy a further developed fetus!

The point to be made is that human life begins at conception and continues to develop until it reaches adulthood. To deny the right to life to a fetus or any other person at any point is a grave injustice. As Nobel Prize winner Mother Teresa of Calcutta has said, society cannot hope to save itself if it cannot attempt to save the lives of its youngest members.

Timothy J. Watkins '84
Naugatuck, Conn.

REUNION '87

Robert S. Arnold

with a splash of color
and sunshine