by introducing into the very heart of the academic enterprise a new and powerful motive—the search for utility and commercial gain." He notes that "Academic scientists have always feared what Vannevar Bush once termed 'the perverse law governing research,' that 'applied research invariably drives out pure.' "

There is a role for industry to play in the resolution of these conflicts, but as Edward E. David, Jr., president of Exxon Research and Engineering said at the bar association colloquium, "There is going to have to be compromise on both sides." Researchers, for example, are likely to have to accept some delay in publication while corporate officers review manuscripts with patent applications in mind. Business, on the other hand, will have to curb its insistence on "micromanagement" of research, lest it so restrict academic science that it loses that very creativity it is buying.

Samuel Eletr, president of Applied Biosystems, Inc., of Foster City, California, contemplated the issues as a Pajaro Dunes conferee. "These problems, the ethical questions about conflict-of-interest and so forth, are really internal to the universities which have to decide for themselves what is acceptable to them," he told *Science*. "There is only so much we can do to help."

Although what Upjohn Company vice-president Theodore Cooper calls "commercial traffic through university labs" is increasing, it is not clear that it will long continue at the present pace. "The current situation is an aberration," Rockefeller University president Joshua Lederberg said at the bar association colloquium in New York. Biotechnology caught industry "napping" and companies are now scrambling to catch up by drawing on university talent it does not yet have in-house. Or as attorney Griesar put it, "Industry is going back to school to learn genetics because it has fallen behind." Applied Biosystems president Eletr also thinks the present situation is somewhat aberrant. There is a kind of "time compression," he says, as far as basic and applied science are concerned that makes things different from previous instances of business capitalizing on university research. "Usually," says Eletr, "the time between an invention and its full commercial development—the transistor, for instance—is a period of many years, a decade or two. But with biotechnology the promise of commercial development seems to be a very short time away. Two or three years maybe." Industry saw the promise in molecular biology but hadn't the "foggiest" idea about what was going on. "Once industry catches up," Eletr predicts, "things will be less frantic, industry will breathe a little easier."

There is ample evidence already that industry is taking substantial steps to establish in-house strength in biotechnology. Its very collaboration with university scientists is part of that effort. Most of the present agreements, in addition to patenting and licensing provisions, also contain terms for university training of industry researchers. Through contractual provisions for seminars, prepublication copies of scientific papers, and arrangements for exchange of scientific personnel, industry is making sure it is getting an education for its investment. This new, and from the university's vantage newly respectable, association with academe is also providing industry with unprecedented, informal access to the doctoral students it may wish to lure away from academic life. [Indeed, when Monsanto signed a $23-million contract with Harvard for the support of cancer research by Judah Folkman and Bert Vallee (*Science*, 25 Feb. 1977, p. 759), the company declared that it was as interested in the basic biology it could learn from the collaboration as it was in any specific product that might result.]

Investment in academic science is one foundation of industry's effort to develop the capacity to conduct biotechnology research in its own laboratories.

In addition, many of the major pharmaceutical and chemical houses are currently beefing up their own capacity for research in molecular biology—Upjohn, Monsanto, and Allied Chemical among them. DuPont, which has collaborative agreements with researchers at the University of Maryland and the California Institute of Technology as well as the new one at Harvard, reports spending $120 million on life sciences research in 1981—33 percent more than in the preceding year. A new DuPont laboratory for biotechnology research in medicine and agriculture is being readied; the company says it will create 700 new jobs. Eli Lilly and Company also recently announced plans to open a new Biomedical Research Center for which it will hire 600 scientists and technicians to "allow significant expansion of research with recombinant DNA technology."

The list of major corporations joining the ranks of the molecularly savvy is long; observers see at least two predictable consequences. First, these corporations can be expected to acquire or drive out some of the small, scientist-founded biotechnology companies of which there now are nearly 200. That in no way abrogates the present need for conflict-of-interest guidelines but does suggest that some of the tensions attendant to large numbers of faculty with a personal stake in a fledgling business will fade.

Second, as Eletr notes, industry soon will begin to "breathe easier," and the frantic pace of negotiations and investment will slow down. In the present political and fiscal climate, industry is seen as a complement to government in support of basic research. But corporate officers are quick to refute the notion that the private sector has the resources to even begin to take government's place. Nor does it see as its responsibility the funding of fundamental science for its own sake. Industry will generally support only that basic research that fits its short-term interests.

Although recent agreements in the several million dollar range command considerable attention, the fact is they are relatively few in number and highly specialized as to research. According to Edward David of Exxon, industry now spends about $200 million a year in support of academic research nationwide, which is about 4 percent of the federal commitment. David, a former presidential science adviser, says, "I advocate tripling that amount to $600 million or 15 percent of the federal effort." Were that to happen, corporate support would still be comparatively small. (Even in these stringent times, the NIH budget alone is more than $3.5 billion a year.)

Nevertheless, if a constant, stable pattern of corporate funding emerges over the next decade, industry's influence on academic science, particularly biology, could be significant. Several of the recently signed contracts have been described optimistically as "models" of the way university-industry agreements ought to be. The validity of that assessment is becoming the subject of important debate as administrators and faculty try to come to grips with the new academic-industrial complex.

—BARBARA J. CULLITON

U.S. DEPARTMENT OF COMMERCE

Feb 1, 1983

To : Al Trivelpiece / Jim Decker

From: Norm Latker

Attached is an article which discusses Yale's policy on conflict-of-interest problems arising from collaboration with industry. While it is debateable whether the Yale approach is ideal, it does indicate a positive approach to the transfer of technology developed at universities with some caveats.

I will see if the Yale policy statement is available and make copies for you.

copy when get
Alan Clayton -
DOE

Consult on Gov. Relations
861-2597 -
Milt Goldberg -

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TIP

Pl. call Joe Warner at Yale and ask for copy of Yale's conflict policy statement. Norm

search and development, and commonly in the equipment required by new products or methods of production. A profit-making enterprise will undertake such an investment, and all its associated risks, only when it can reasonably expect an adequate return, a return not likely to occur if competitors are first to the marketplace. The opportunity for private profit provides the encouragement for the socially beneficial application of new technology. To realize profits from technological innovation, however, a company must strive to protect its proprietary knowledge and to prevent its exploitation by commercial competitors.

The development of theoretical concepts, born in the university, and the transformation by industry of those concepts into practical application, are often complementary processes. The complementary nature of their activities, however, simply throws into relief the basic difference between universities and industries: the academic imperative to seek knowledge objectively and to share it openly and freely; and the industrial imperative to garner a profit, which creates the incentive to treat knowledge as private property.

With these underlying principles of free inquiry and free market in mind, we can now examine specific issues concerning university-industry relationships. The first is the appropriate nature of faculty involvement with profit-oriented companies, particularly such companies which seek to market new processes and products growing from university-based research. The second is the appropriate conditions of grants or contracts for basic research by existing companies to universities, especially when these conditions require some form of exclusive relationship, of license or treatment, by the university with the company as a condition to the grant. There may well be cases that are ambiguous and where reasonable people will have to wrestle with the application of whatever policy emerges. For that reason, I see the provost's Research Advisory Board playing a continuing role in administering our policy. I believe that the following considerations must be taken into account in forming that policy.

Faculty Involvement with Profit Oriented Companies

There are potential conflicts of commitment and potential conflicts of interest whenever a member of the faculty is involved with extra-university entities. Let us here consider the specific issues surrounding the involvement of a member of the faculty with a company seeking to exploit university-based research.

I doubt that a faculty member can ordinarily devote the time and energy the university requires and also pursue a substantial involvement in any such outside company. Such involvement necessarily demands great concentration and commitment, particularly at the outset or if business goes badly. When a faculty member becomes substantially involved in a company, the conflict in norms governing the dissemination of knowledge becomes very difficult to reconcile. The burden of maintaining a teaching program and two separate research programs, where the results of one research program are to be widely disseminated and the results of the other may have to be kept secret in the pursuit of commercial success, is more than even the most responsible faculty member can be expected to shoulder. Finally, such involvement risks putting one's students and research associates in ambiguous circumstances, such that the graduate or postdoctoral student would not know, when working with a professor, for whom he or she was working—the university, the professor, or the company. Of all members of the university community, the student especially ought to be working for himself or herself, and ought to be guided in research and trained in skills and techniques that are designed to produce a first-rate scholar, not profit for a company in the private sector.

I believe that if a faculty member becomes a manager of a company pursuing commercial application of his or her university-based research; or acquires, through gift or purchase, stock shares in this kind of company in such proportion to the total number of shares that he or she can have a significant effect on the decision-making of that company, then there is a presumption that the faculty member's involvement in the outside entity is substantial. In such an event, there should be a review of the relationship, the possible consequence being that the faculty member might well have to decide to leave the faculty for a limited period of time, perhaps 1 year, by taking an unpaid leave of abscence to pursue those outside interests. If, at the end of that time, the faculty member were to wish to retain the outside interests described above, then that person would relinquish tenure, if he or she had it, and assume "adjunct" status if the relevant department or school were to recommend such an appointment in the usual way. The alternative for such a person would be to sever completely all ties to the university. Were such a person to wish to become a full-time member of the faculty at a later date, such a possibility would require the availability of an open position and the use of the institution's full appointments procedure.

There are relationships of individual faculty members to commercial companies, even those using the results of university-based research, that traditionally the university has allowed and will continue to allow. In these "consulting" relationships members of the faculty provide advice to companies but do not directly manage corporate research. "Consulting" can enhance a person's professional competence, and further the mission of the university. Our rule is that a faculty member may spend not more than 1 day in a 7-day week in such a role. Thus there is a limit on the commitment of time and energy.

Serving as a consultant to a company or, within the rule of reason, accepting payment in equities from some cash-poor, idea-rich company, is less likely to create conflicts of commitment or conflicts of interest than serving in a role that has a significant effect on corporate decision-making. A faculty member who has gone beyond any reasonable definition of "consulting" has reached the point where the question arises whether he or she should remain a full-time member of the faculty.

Universities frequently require that faculty members wishing to engage in consulting obtain the permission of a chairman or dean. More recently, the Committee on Cooperative Research, Patents, and Licensing has also recommended that each faculty member provide, as part of the routine annual report to the president, a description of the commitment and the organizations involved in his or her nonuniversity professional work. This recommendation has been accepted, and it will be implemented in the coming academic year.

Such disclosure—of consulting relationships, of relationships with outside companies engaged in application of a Yale faculty member's research, or of relationships with companies that sell to the university goods or services—is, I believe, the best stay against conflicts of interest or conflicts of commitment. Disclosure of this sort recognizes that there are grey areas where reasonable people might have differing views and it provides the occasion for discussion. In such disclosure to the administration, there is no monitoring of colleague by colleague. Rather a premium is put where it ought to be, on trust and openness.

Conditions of Grants and Contracts

The second issue for university-industry relationships concerns the appropriate principles in an agreement between an established company and the university when a company wishes to support basic research in a specific area. In discussing such agreements, questions of exclusivity often arise, either with regard to proprietary information provided by a company as part of an arrangement for cooperative research or with regard to exclusive license to whatever the university is entitled to patent.

The university is the only entity that can enter into arrangements for cooperative research, and the university's position with regard to exclusive licensing agreements is the following. In general, the university would prefer to grant nonexclusive licenses, in order to make knowledge as widely available as possible. The university, however, in certain circumstances, may grant an exclusive license, thus encouraging a firm to develop an invention. It will sometimes be clear that society will be better served by the grant of an exclusive license in order to bring the knowledge to the public and that the benefits to society from such exclusivity are greater than the costs of any diminished competition.

Each individual agreement must and will be negotiated on its merits. Through such negotiations, Yale will insist on principles which seek to assure that its patentable inventions will be fully and beneficially used, and that knowledge with a potential benefit to society at large will reach the public in a timely and useful fashion.

Research grants from business firms raise other questions as well, questions that are the same as those raised by research sponsored by the federal government or by private foundations. When contemplating a prospective grant or contract with any sponsor, the university will first consider whether the potential would exist for upsetting the intellectual equilibrium and human relationships in a department were one kind of research to be funded out of proportion to other kinds of research. As an indispensable condition to arrangements for cooperative research with industry, just as with government-sponsored research, the university will not accept restriction, inhibition, or infringement upon a member of the faculty's free inquiry or capacity orally to communicate the results of his or her research. In addition, the university will not accept any restriction of written publication, save the most minor delay to enable a sponsor to apply for a patent or license. Such a delay should not be so long as to lengthen appreciably the time normally required to bring results into print.

Yale has, through its faculty Committee on Cooperative Research, Patents, and Licensing and its Research Advisory Board, the capacity to assess adherence to these principles and conditions. The university will only agree to arrangements for sponsored research, from any sector of society, which are compatible with its norms and mission, and will not agree to any arrangement which will impair the environment of openness and free communication of ideas.

I have by no means addressed all the issues in this area. Difficult cases and anomalous situations, requiring the patience, wisdom, and goodwill of members of the faculty and administration alike, will present themselves. I have, however, suggested here some principles and general guidelines. We have responsible forums to explore these suggestions and to assess the cases that exist or that will arise.

The opportunities for cooperative research between universities and industries are very exciting and can rebound to the benefit of society. These opportunities should not drive us toward arrangements for basic research that abridge our principles. Nor should the university ignore the potential availability of funds from commercial sponsors. We should negotiate appropriate arrangements, openly arrived at, that can further our mission. The constant challenge for the university is to know in clear and principled terms how to cherish learning, and its pursuit, for its own sake; and how to assist in bringing the results of free inquiry to the rest of the society for the good of the public.

German Energy Technology Prospects

Manfred Popp

"Big science" in energy research and development, which depends on the strong involvement of governments through financing and planning, began with the first Geneva conference on the peaceful utilization of nuclear energy in 1955 and was devoted to the economic exploitation of a highly promising new technology. A second phase began with the energy crisis in 1973, which marked the beginning of an era of basically changed energy economics. At that time the success of the nuclear energy development program was clearly visible as the first full-scale commercial power plants were beginning operation. It seemed promising to pursue a similar R & D effort devoted to other new energy technologies in the areas of energy conservation, new and renewable energy sources, and coal, which had not been seriously considered before because of apparent economic problems. Many technologies suddenly seemed to offer new opportunities for providing a more efficient and economic energy supply or, at least, setting a ceiling on further price jumps in the oil sector. It was widely assumed that the remaining technical and economic problems could be solved by sufficiently strong R & D efforts. Consequently, a comprehensive energy R & D program was launched in the Federal Republic of Germany, as in all major industrialized countries of the Western world. International cooperation resulted in combined judgment on technological potentials, improved information exchange, and in a number of cases led to jointly financed projects.

Today, almost 10 years after the beginning of this second phase of energy R & D, it seems clear that this approach was too optimistic. Although the price of oil is at a level that even the most pessimistic forecasts did not predict in 1973, a breakthrough of another new energy

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 Chemical and Engineering News

University technology licensing set to rise

Although recession may be holding back this source of technology for industry, several factors point to an upswing in near future

Rebecca L. Rawls
C&EN, New York

After more than a decade of gradual growth, the licensing of technology from universities to industry seems poised for a new phase of rapid expansion. At both universities and corporations, the attractiveness of such licensing arrangements is becoming increasingly apparent. At the moment, most observers agree, the recession is holding back much of the licensing of all types that industries would like to be undertaking. But when industry research budgets start to grow again, a larger share of the new money may be channeled into licensing university-developed technology.

Universities have been licensing technology to companies to some extent for several decades. New York City-based Research Corp., for example, has been invoived actively in assisting universities and otner not-for-profit institutions in patenting and licensing new technology since 1925. And a few individual schools, notably the University of Wisconsin through its Wisconsin Alumni Research Foundation, also started in the 1920's to license technology to interested companies.

There seems to be little or no information on the extent of this licensing or how it has been growing over the years, however. This lack of quantitative data may be due to the lack of a single organization big enough to be able to estimate reliably the total quantity of technology being licensed. Certainly, Dr. Dvorkovitz & Associates, a Florida-based company that probably handles more university-licensable technology than any other single group, refuses to make current projections of the size of this market based on its own business. Other groups likewise refuse.

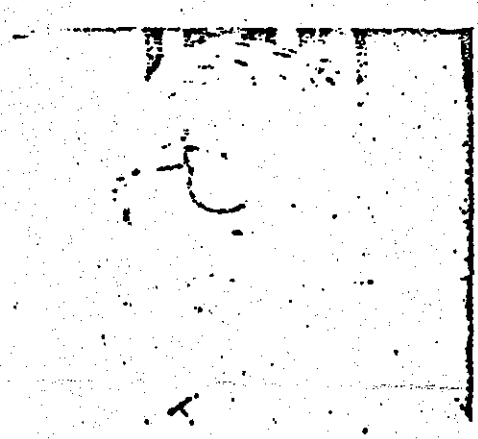
Even the federal government, which has been particularly interested in recent years in increasing the usefulness of government-sponsored university research by increasing licensing to interested companies, has not made a quantitative evaluation of the technology being transferred to industry by this mechanism.

Still, most observers knowledgeable in technology licensing agree that university-industry licensing is on the rise, that it has been for the past decade, and that fundamental changes that are taking place now, particularly at universities, make it likely that there will be a large upswing in licensing in the near future.

As a source of licensable technology, universities traditionally have not rated very high, according to companies that promote technology transfer. They usually rate about third, after inventions from other industries—particularly from foreign companies or companies in unrelated fields. (Companies in the same field remain distrustful of technology their competitors are willing to sell.) Private research laboratories are also a better source of new technology for licensing than most universities.



Marcy: bridging a time gap

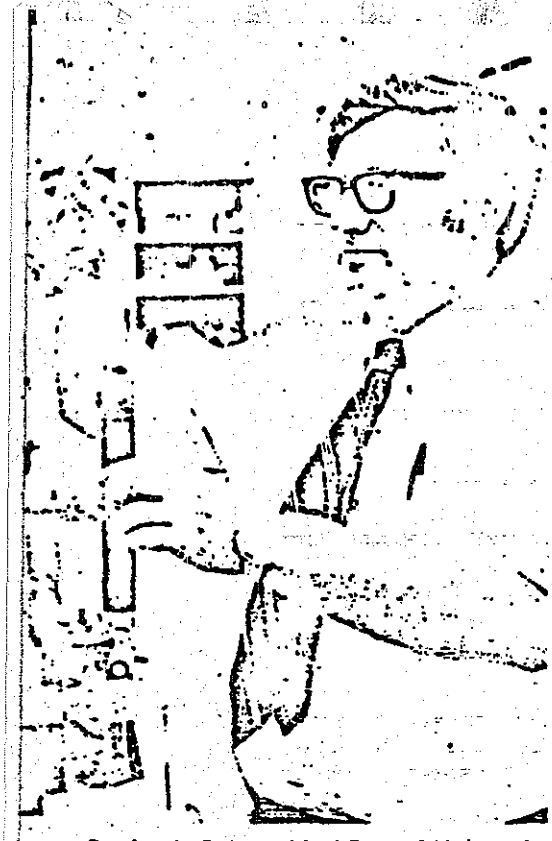


Dvorkovitz: industry more willing

The reason is that universities have not been, and generally still are not, organized to take advantage of the commercial prospects of the technology they originate. Technology coming from universities is usually at a very early stage of development, a stage where patent protection is especially important to make it profitable for a company to make the investment required to continue development to commercialization. But many universities are not organized to encourage patenting of newly developed technologies. Frequently, tenure policy and other faculty inducements foster the earliest possible disclosure of new developments in a manner that often makes subsequent patents and licensing impossible. "The universities aren't really equipped to handle the [licensing and commercial development] of the intellectual capabilities that they have," says a representative of Battelle Development Corp., another company that assists universities in patenting their developments and offering them for license. "But when you look at them as a whole, properly developed, they should be an excellent source of new technology."

Attitudes toward licensing appear to be changing at most schools. On the one hand, the financial benefits of licensing are becoming apparent to universities, not infrequently with the help of one of their more business-minded trustees. Licensing represents a potentially important source of income to support university research programs, and in this period of diminishing research funds from other sources, this avenue is becoming more attractive to many schools.

Also, scientists and other developers of new technology are coming to realize that the fastest way to get the benefit of their work into the hands of the public is likely to be through patenting and licensing. "Physicians used to think that patent was a dirty word," says Research Corp.'s Dr. Willard B. Marcy, who heads that group's patent program. "Now, there's a realization that there's a time gap that needs to be bridged in getting ideas to the market place." It took penicillin 15 years to travel from laboratory to the market place, he points out, because no company was actively promoting its com-



Dr. Louis Pytlewski of Drexel University works with inorganic coatings that resist soiling or give water-repelling material an affinity for water. Patented method for making the coatings is licensable through Research Corp.

mercial developments for most of that time. A comparable new drug advance today, under exclusive license to one of the major drug companies, would reach the market much faster, even with today's much more rigid safety requirements.

Specific indications of the changes taking place at universities center on changes in patent policy. The first step toward a regular program of technology licensing is to establish a regular place for patenting in the procedures of the university, explains Dr. Lawrence Gilbert, director of patent administration at Massachusetts Institute of Technology. MIT and several other high-technology schools such as the University of Wisconsin, Stanford University, and California Institute of Technology have had formal patenting and licensing programs for many years.

Today, however, Gilbert sees a ground swell in the number of other schools trying to establish similar programs. About half a dozen schools have contacted MIT within the past year, he says, to find out exactly how their patenting program operates. At least a dozen other universities have hired people within the past year and a half to work exclusively with patenting of new technology, Gilbert says, and a number of other schools have designated a specific person already within the school's administration to serve as the focal point for technology patenting.

As for the reluctance of some industries to invest in technology that did not originate in their own laboratories—the so-called "not invented here" or NIH syndrome—most groups that license to industry today say that this barrier essentially has disappeared. "I don't think this NIH thing is a problem now," says Battelle Development Corp.'s vice president and manager, R. F. Dickerson. "Any time you have a good idea, I think companies are going to buy it."

Dickerson does not think that industry ever felt real reluctance to use good technology coming from the outside. Others, however, such as Research Corp.'s Marcy, say they have seen a definite dying out of the NIH syndrome within the past 10 years.

Dvorkovitz, too, thinks that industries are considerably more willing to license outside technology now than they were in the past. Some of the door-to-door peddling of licensable technology that his company and others have done over the past 15 years may be some of the reason for this shift. Licensing has gotten a boost in the past couple of years, too, he says, from the cutback in industry research budgets that has been occurring. Companies are realizing that it is much cheaper to license technology that already has been initially developed than to redevelop it from scratch in their own research departments. More and more companies are coming to realize that the key to new technology advances is not coming up with new ideas as much as it is recognizing which new ideas have commercial application for that particular company. Hence, valuable new technology can come from anywhere, including licensing.

Industries presently have one foot on the gas pedal and the other on the brake when it comes to technology licensing, explains Bruce Dalbo of Dr. Dvorkovitz & Associates. They are definitely more interested in finding useful available technology than ever before, but the recession makes it a bad time for them to be introducing new products or beginning new development ventures. Once the recession is over, he says, his company expects the brake to be released and a surge of technology licensing to follow.

MIT's Gilbert sees much the same situation at his university. He has been seeking companies interested in a joint-venture arrangement to further develop a number of new antibioticlike compounds. He has not been able to sell any of these projects to drug companies in the past year. But many of these companies probably would have been interested in a more normal period, he says. These companies might license a fully developed product, he says, but if R&D funding is required for development, they are not interested right now. He says a similar situation exists in other technology areas. Still, there is an increasing amount of industry-sponsored research going on, he says, in part because universities are more willing to enter into agreements to do it. And MIT's licensing for the year may well hold at its usual levels despite recession problems.

On a national scale, the increase in interest in licensing on the part of both companies and universities can be seen in part by the success of the University/Industry Forum that has been held annually for the past three years to offer universities a place to exhibit their licensable technology before prospective buyers. Sponsored by Dr. Dvorkovitz & Associates, this year's forum, held in February in Chicago, attracted 45 universities and 150 companies looking for university technology. This is about the level of attendance of the 1974 forum, which, considering the nature of the economy last February, is considered a sign of strong interest in the field. Next year's forum will offer technology for licensing from industry as well as universities, and both companies and universities already are expressing strong interest, according to Dvorkovitz.

Other signs of current interest include the newly organized Society of University Patent Administrators, a spinoff from the older Licensing Executive Society, designed particularly to assist schools that are just getting into technology patenting and licensing. This group, which will have its first meeting at this winter's University/Industry Forum, already has attracted 30 university members, more than half of which are schools that have not been involved previously in the licensing process. ☐

Decontrol of natural gas prices hoped for

When Congress reconvenes next week, one important piece of unfinished business that will command quick attention is what to do about the natural gas shortage. Petrochemical companies will be watching developments carefully. And while they are watching, they will be hoping that, among the several proposals bouncing around in the Congressional hopper, the one that sees daylight will permit some form of price decontrol on natural gas.

The petrochemical industry will not be alone. Many other users of natural gas, along with gas producers, have been beating the drum for decontrol. They believe that allowing gas prices to go higher is the only way to give producers an incentive to drill more wells and to reverse the downward trend in natural gas production. As a spokesman for the Petrochemical Energy Group points out, "We would rather have natural gas at higher prices than no gas at a lower price." PEG is an ad hoc group of 23 independent petrochemical companies.

It isn't difficult to see why the petrochemical industry is concerned, even

Monsanto Gives Washington U. $23.5 Million

The company considers its new university agreement a "strategic investment" for expansion into the health field

A $23.5 million, 5-year research agreement between Washington University and the Monsanto Company ranks among the largest so far in the current university-industry sweepstakes, rivaling the $70 million contract between the Massachusetts General Hospital and Hoechst AG that provides funding for 10 years for a new department of molecular biology at the hospital (*Science*, 11 June, p. 1200). Each of the many university-industry agreements that have been reached recently represents an effort to preserve academic values while also acknowledging corporate needs. The newest agreement, announced by Monsanto on 3 June, has two distinctive features in this regard.

The Academic-Industrial Complex

This is the third in a series of occasional articles about the emerging relationships between industry and universities.

First, the Washington University–Monsanto contract is an "institution-to-institution" agreement, quite deliberately drafted to deviate from the majority of arrangements in which corporate funds are earmarked for research by one or two senior investigators of the company's choosing (*Science*, 28 May, p. 960). Under terms of the contract, medical school faculty whose research meshes with the scientific aims of the collaboration may apply for the Monsanto funds, which will be awarded by an advisory committee composed of four scientists from each institution. Washington University chancellor William H. Danforth told *Science* that "This will be like an internal granting agency to which people can come for all or part of their funding." David Kipnis, head of the department of internal medicine at the university, will be chairman of the advisory committee. He maintains that the "institution-to-institution" character of the new agreement will alleviate "elements of divisiveness" that may crop up when one or two superstars control significant corporate funds. "We're very much breaking the pattern in this regard," he says.

The second feature of the Washington University–Monsanto arrangement that sets it somewhat apart is the extent of constant, intimate collaboration it anticipates between researchers at the two institutions. Whereas most of the new contracts contain provisions for some training of corporate scientists and for occasional interaction, this deal provides for what Howard A. Schneiderman, senior vice president of Monsanto, terms a "true partnership." Dozens of company scientists may be working on campus at any one time, once the agreement is in full swing, he notes, adding that Monsanto researchers will not be "token" members of the collaborative team. Indeed, the desire for close collaboration was one of the reasons Monsanto decided to deal with Washington University. Says Schneiderman, not only is it a "major research university," it also has the distinct practical advantage of being "only 15 minutes away" from company headquarters in St. Louis.

The Washington University–Monsanto arrangement, which Schneiderman describes cheerfully as "the culmination of a long love affair between two institutions," is a clear sign that Monsanto, one of the country's largest chemical producers, is serious about moving into the pharmaceutical business. "This is a real strategic investment on Monsanto's part," Schneiderman said in an interview with *Science*. After all, $23.5 million spent at Washington University is $23.5 million that will not go to the company's in-house labs. Calling the contract a "very hard-nosed, pragmatic move," Schneiderman acknowledges what other corporate officers have said about turning to academe as the source of talent and data in biotechnology. "We believe we'll get more at Washington University than we'd get by spending the money in-house," he says, "but we'll be expanding our own capacity too."

Although Monsanto has research agreements with scientists at a number of major academic institutions, its $23 million, 12-year contract with Harvard (*Science*, 25 February 1977, p. 759) is in part the inspiration for the Washington University deal. The Harvard-Monsanto contract, which provides support for research by Judah Folkman (see story on p. 1304), was a major factor in the company's move into pharmaceuticals. That contract "sensitized Monsanto to the health care area as one to move into. Don't underestimate the importance of that," Schneiderman states.

The scientific focus of the Washington University–Monsanto venture will be on proteins and peptides that modify cellular behavior. The point, of course, is to go from basic studies to research that is "directly applicable to human diseases." Neither party to the agreement will discuss research expectations with any precision; Kipnis says only that the modulation of polypeptides is a field "on the verge of explosion." Understanding peptide regulation has implications for a multitude of diseases, including malignancy, arthritis, immune disorders, hypertension, and blood clotting, Kipnis observes. Schneiderman says that "if everything works right, we'll see a few products approaching the marketplace by the end of the decade, given luck and a few people lighting some candles."

Industry's legitimate, undisguised self-interest in sponsoring academic research is an obvious source of worry to university scientists, who feel distinctly uncomfortable in the corporate milieu. Thus, efforts to negotiate can be prolonged. The mating ritual between Washington University and Monsanto lasted 3 years and included a retreat to which a dozen scientists from each side were invited. Altogether, some 15 to 18 university researchers participated in discussions leading up to the agreement, which has helped generate enthusiasm for it, Kipnis says. The fact that they also more or less "kept their mouths shut" until it was worked out is also considered an important element in the successful negotiation.

The initial step, Kipnis reports, was to agree on certain "baseline rules" for a contract. First and foremost, he says, was the decision to make it an "institution-to-institution" deal and to identify a field of research to pursue rather than specific products; thus, proteins and peptides. A commitment to put a "significant" amount of money into purely basic research was also crucial. (The

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agreed-upon figure is 30 percent.) "From the very beginning, we insisted on this," Kipnis recalls. Yet another requirement was a provision for a separate, outside advisory committee, with no ties to either institution, to provide external review of the scientific quality of the collaborative research and also to assess the effect of the contract on the company and university. Once these terms, designed to protect academic values, were agreed to, the rest, apparently, was easy.

During the first year of the Washington University–Monsanto agreement, $3 million will be available to researchers from six departments (biochemistry, immunology-microbiology, genetics, medicine, pathology, and pharmacology) eligible to compete. Eventually, the "internal granting agency," as Danforth calls it, will accept applications from any member of the medical school faculty.

As is the case with all university-industry contracts, this one contains provisions regarding patents and licenses. Patents will be held by the university, which will license Monsanto to develop them. Exclusive licenses will be granted for inventions emerging from work solely supported by Monsanto. According to Edward MacCordy, assistant vice chancellor for research, faculty who submit applications to the eight-man Washington-Monsanto advisory committee will have to disclose information about all other research plans and sources of funding. The committee can reject applications that would present a challenge to Monsanto's rights, particularly if another profit-making company is involved. One question that looms large where licenses are concerned is this: What happens if a company-sponsored researcher ends up in a productive collaboration with a colleague whose funds come from the federal government. According to MacCordy, federal patent law, as revised by Congress in 1980, allows the university to own the patent and to license it on an exclusive basis "for a limited term, not for the life of the patent," with priority going to U.S. companies. Thus, a company would not have the same protection it could get from exclusively funded research but still would have a chance to get a head start on its competitors.

Other provisions of the Washington University–Monsanto agreement include these:

• **Royalties.** Should commercially useful drugs or diagnostic tools result from the research, royalties will go to the medical school and relevant departments and laboratories. In no case, Kipnis emphasizes, will individual faculty members get any personal financial reward.

Because no one has any real idea of what might come out of the collaboration or what it might be worth, royalty rates have not been set. Instead, says MacCordy, "they will be negotiated on a case-by-case basis if something develops." The money from royalties "could be an important by-product" of the agreement, chancellor Danforth observes, "but that isn't our main reason for going into this."



David Kipnis

"We're breaking the pattern. . . ."



Howard A. Schneiderman

"I've been a great marriage broker."

• **The "deep pocket" provision.** In addition to contractual protection of its academic virtue, Washington University sought protection of its endowment. There is an attitude among the public that universities have "deep pockets," MacCordy notes, citing concern about the possibility of a product liability suit a decade or two down the road. "The issue is fairly new, but it is an especially serious threat in the medical area," he says. Monsanto will indemnify the university for all licenses it receives.

• **Publishing.** Washington University scientists will be free to publish their data, but the company will review manuscripts first. In the event Monsanto wants to file a patent application, submission to a journal can be delayed for at least 30 days. Provisions such as this are quite common now in university-industry agreements, although they were resisted initially by faculty who did not like the thought of any enforced delay at all.

As several persons have noted, once you point out the obvious—that routine publishing delays far exceed 30 days—a brief delay in manuscript submission is accepted as one of the costs of doing business with business. Furthermore, once patent considerations have been taken into account, it is often in a company's interest to have its academic brethren publish. "It is," notes MacCordy, "the best possible publicity," because it does a lot to establish the credibility of the science.

One of the more contentious issues in this area has to do with foreign patents. In the United States, one can file for a patent up to a year after disclosure of an idea or invention. Abroad, any disclosure (including discussion at a lecture or seminar) may preclude a patent filing. There are few satisfactory solutions to this problem (short of silence). However, MacCordy suggests that the close collaboration between corporate and academic scientists anticipated here may be useful as an early warning system. If Monsanto researchers see something coming along, the company can be notified and foreign patents filed before informal disclosure destroys rights overseas.

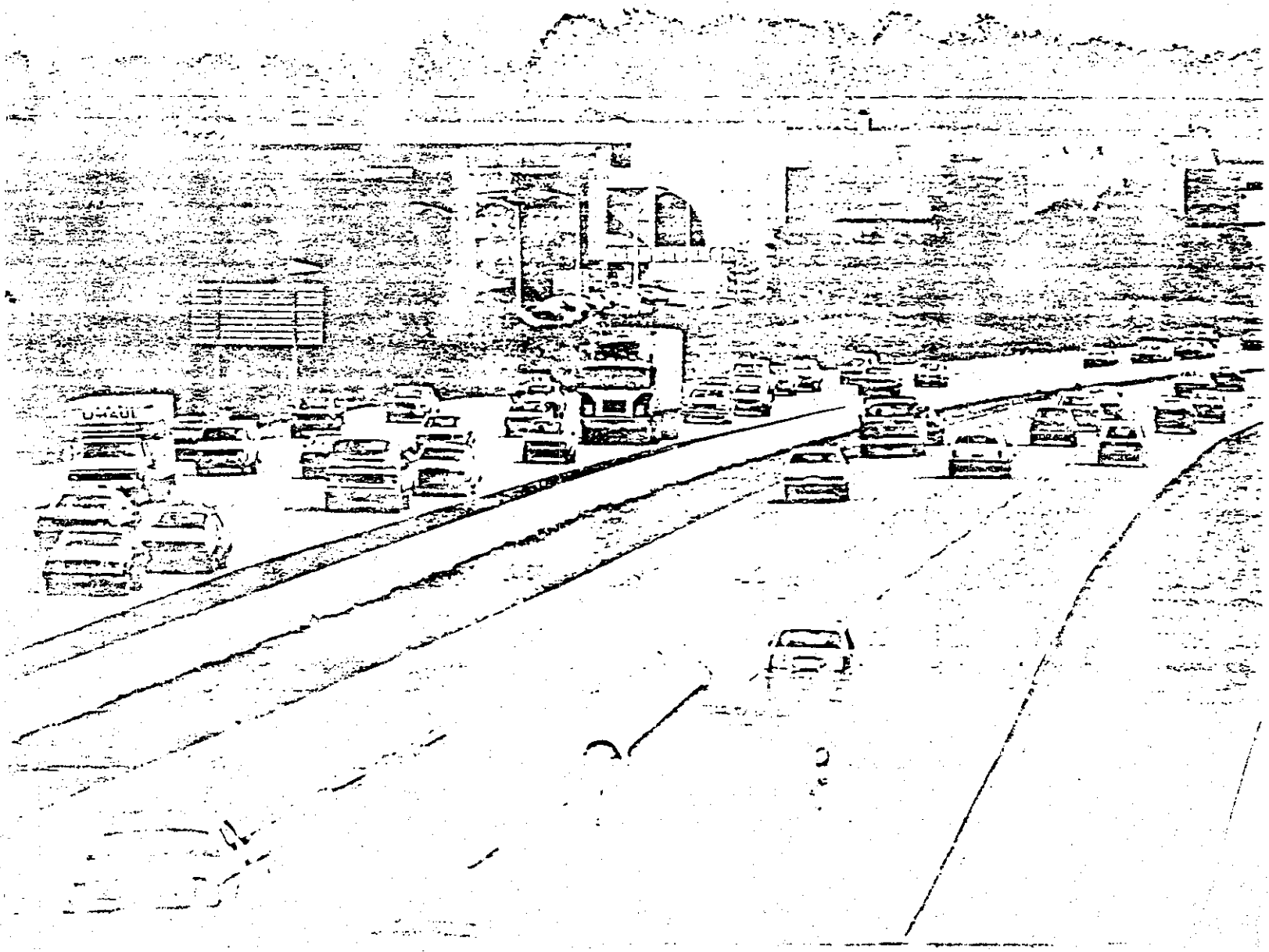
With general concerns about what corporate ties will do to open communication and easy collaboration among researchers, another issue is gaining currency as more and more university-industry deals are struck. That is, fear that corporate funds will drive out government money. There is no way that industrial support of research can ever fully substitute for government funding, virtually everyone agrees. Nevertheless, the subtle perception that campuses with substantial corporate ties are less in need of federal funds appears to be taking hold. At Washington University and elsewhere, there are reports that grant applicants are getting a cool reception from federal peer review committees. According to Kipnis, the Monsanto agreement "allows us to explore new areas freely and to expand." New faculty recruitment is anticipated and money will be available for instruments. "It does not relieve society of its obligation to support science," he says. If the price of corporate support is the loss of federal funds, universities may find the price too high. All around, as MacCordy observes, "the acid test will be in how many of these agreements are renewed."—BARBARA J. CULLITON



"Satellite Alley"

By JEFF KOSNETT / Photos by RICHARD LAKIN

The southern end of I-270 (below) is highly developed and carries heavy traffic loads daily. An aerial view looking south (opposite top) shows some of the development along the highway. Comsat (opposite below) is one of the many space-related operations located on 270 which have given it the Satellite Alley nickname.



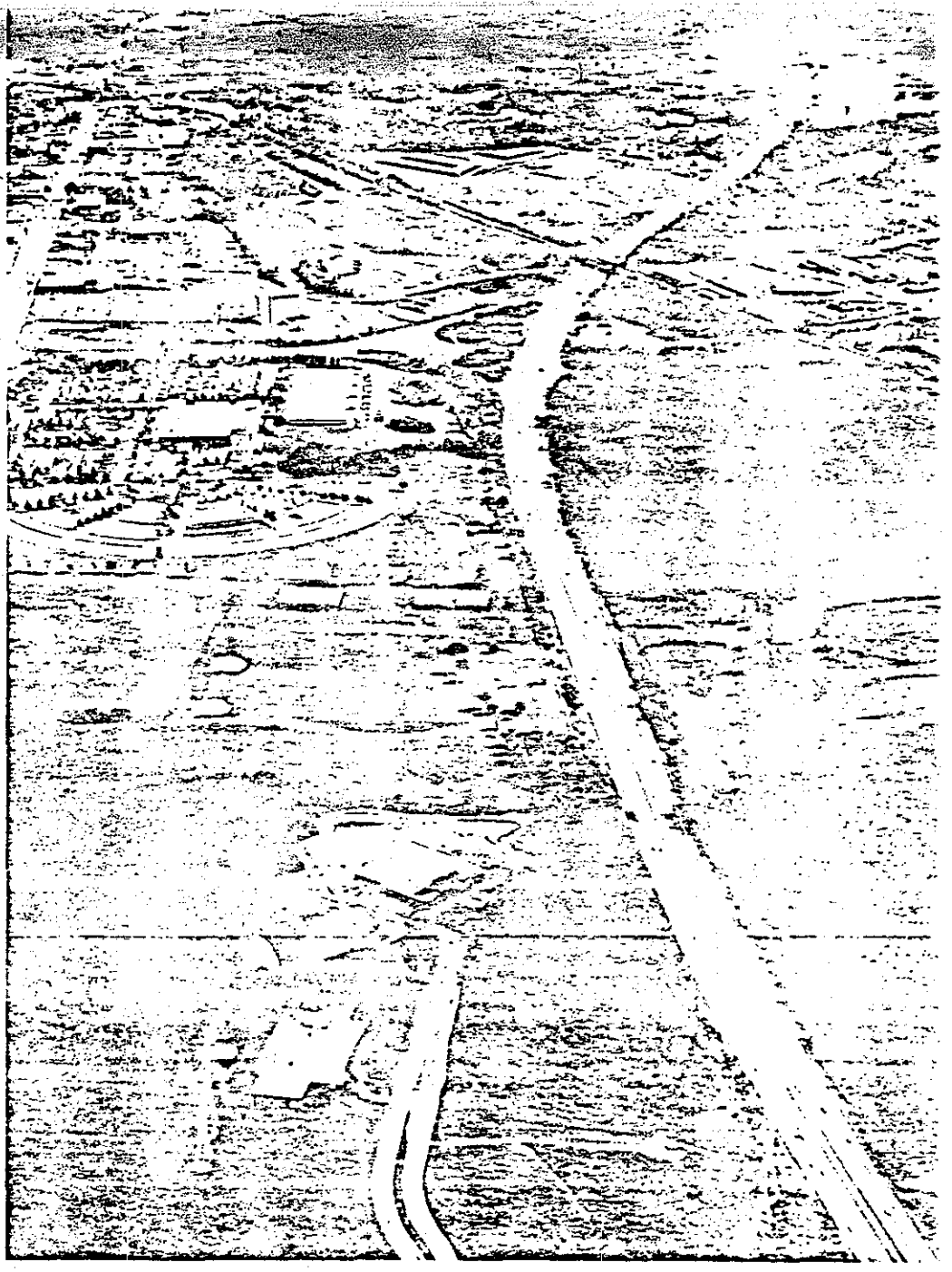
To thousands of Marylanders, I-270 is the way from Washington to Frederick, with connections north and west. To more than 80,000 scientists, engineers, technicians, and computer wizards, I-270 is more than a mere highway. It's the backbone of a concentration of telecommunications, electronics, biomedical, genetic, and environmental expertise that may be unmatched in the nation.

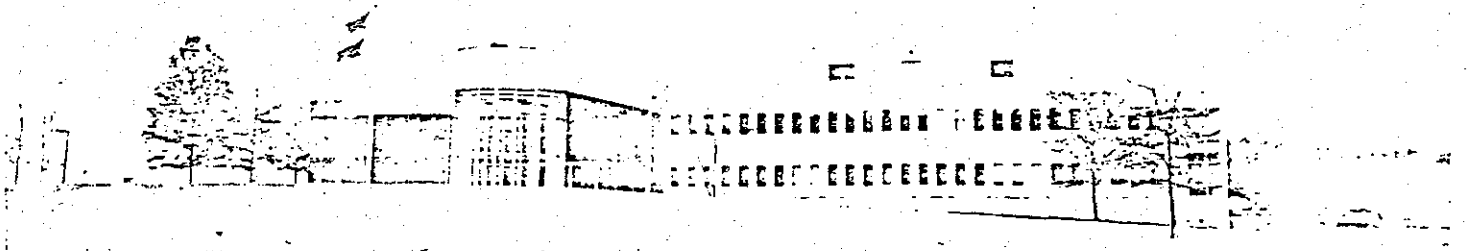
This collection of brains and investment—dubbed "Satellite Alley" after northern California's well-known "Silicon Valley"—has transformed Montgomery County from a tree-lined address of commuting Washington lawyers and government officials into Maryland's richest self-sustaining local economy.

The county is one of the few places in the region, if not the country, where the number of jobs is growing several times faster than the population. From 1970 to 1980, employment soared 63 per cent while the number of residents increased 11 per cent. The county government estimates 55 per cent of the residents who work earn their paychecks in Montgomery.

This economic progress has brought not only security and development to much of the county, but a feeling of being "not just another suburb." The I-270 corridor "is really the pride of the county—the people as well as the government," says Duc H. Duong, manager of the Business and Industrial Division of the County Office of Economic Development.

I-270's economic impact began in the 1960s with governmental research installations. After the National Institutes of Health, National Bureau of Standards, and the Energy Research and Development Administration sprouted in rural





territory, highways, housing, schools, and shopping centers naturally followed.

Several factors have played a role in the development of the corridor over the past two decades. The federal presence looms large in recruiting government contractors; defense electronics is expected to grow rapidly in upcoming years; expansions tend to be local, and most new jobs result from these expansions rather than the relocation of new companies from out-of-state.

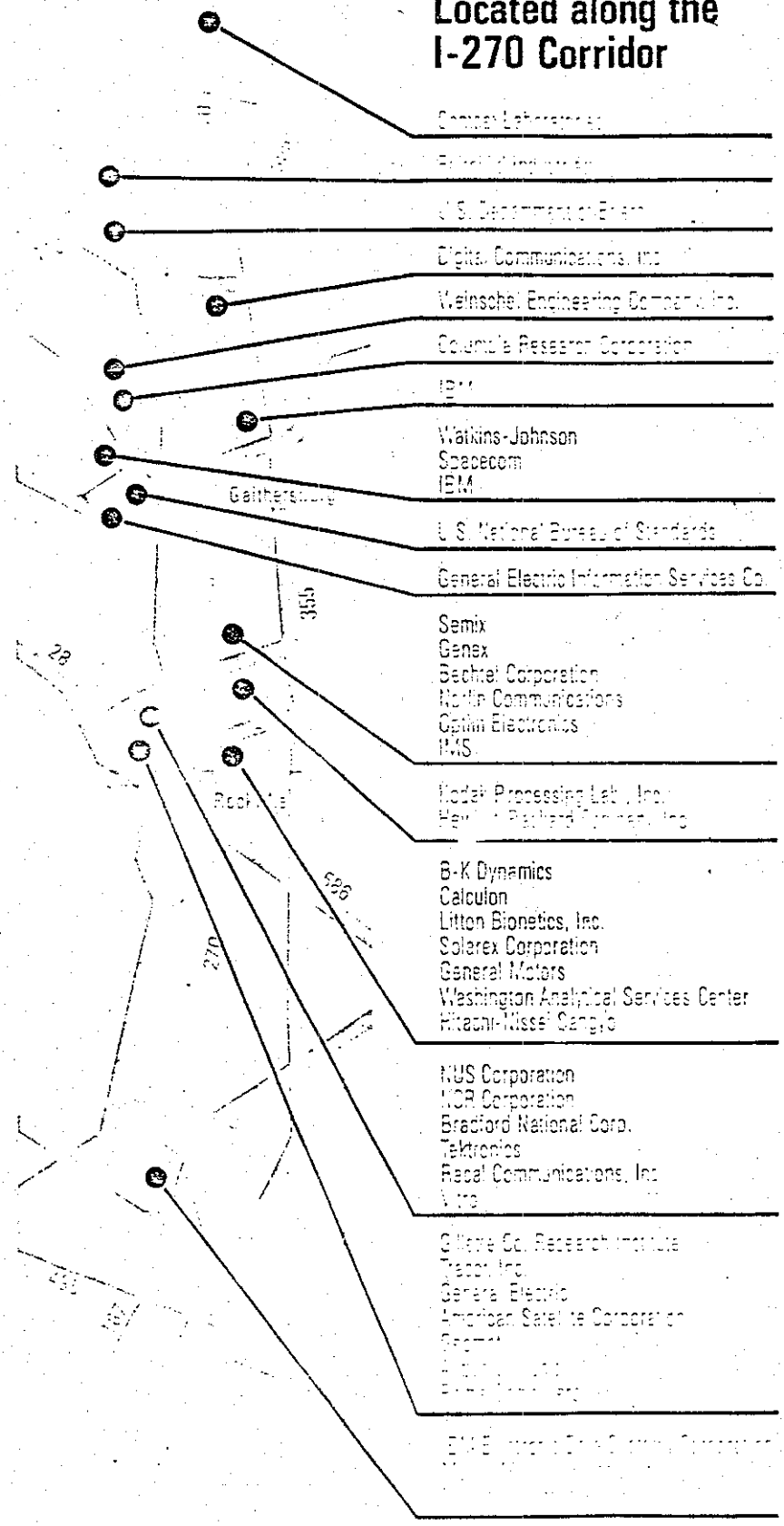
Today, as one cruises I-270 and explores nearby feeder roads, the contrast is apparent: shady suburbs with Victorian houses stop where the laboratories, institutes, and office parks begin. Horses roam as they have for decades in the rolling country across from Comsat Laboratories; cornfields flourish near Fairchild Industries' roadside headquarters. As the current northern "anchors" of the corridor, Comsat and Fairchild are also indicative of many of the companies along the Alley whose futuristic purposes are reflected in the exterior architecture. The 21st-century-like buildings lend an "air of tomorrow" to the entire stretch of highway through Montgomery County. For instance, clustered near the silver-and-white Comsat complex and Fairchild's series of sleek, tan, low-rises is home base of Digital Communications. It's just one of many buildings featuring satellite receiving dishes out front or on the roof, leaving little doubt as to the origin of the Satellite Alley nickname.

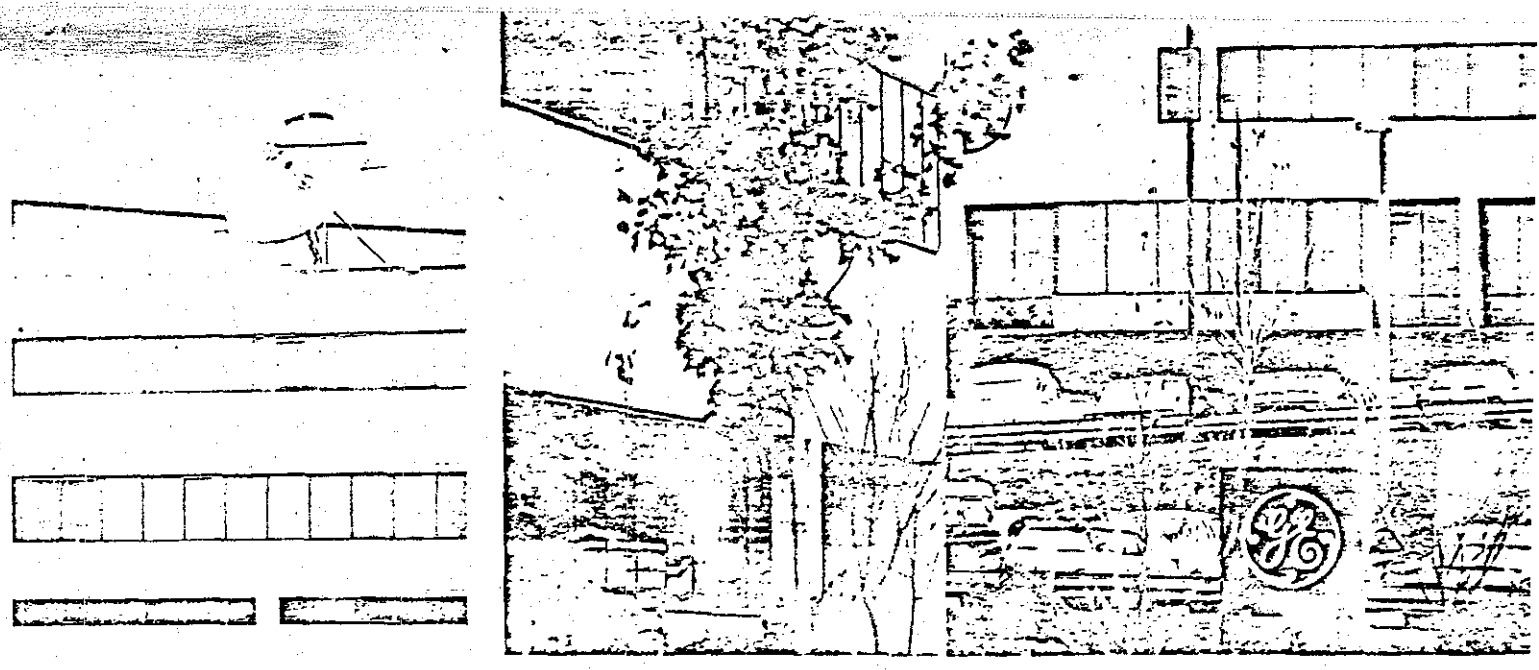
The Department of Energy's vast complex resembles a college campus, complete with a baseball diamond where helicopters land in left field. Also in the campus motif is the National Bureau of Standards, which, with the IBM Federal Systems Division, dominates the Quince Orchard area of Gaithersburg. IBM overflows its main quarters east of I-270 into some of the scores of office buildings nestled among the townhouses, apartments, and retail development in the area.

General Electric Information Services, Hewlett-Packard, Bechtel Power, Kodak Processing, American Satellite, Litton Bionetics and dozens of smaller research and computer service firms — some homegrown spinoffs of the giants — dot Rockville and environs. Every building seems to bear a high-tech name on the brickwork or the lawn. The few exceptions are basically allied, white-collar enterprises whose offices contribute to the scientific community's bent for architectural distinction.

Many companies on the Corridor are

High Technology Corporations Located along the I-270 Corridor





Some of the I-270 "tenants" include Digital Communications Corp., a Comsat spin-off (top left); and General Electric (above). Unique design makes each structure distinctive (left).

among the most advanced in their fields. Comsat, with its history of breakthroughs in broadcasting and telecommunications, is the father of numerous once-small firms that have earned distinction. Notable among these is Digital Communications, which produces "the guts" of satellite carrier systems, equipment for earth stations, and the parts to decode and unscramble TV signals sent by satellite.

The area's rapid development (especially north of Rockville) and the need to move thousands of people *en masse* in and out of giant employment centers twice a day has driven traffic planners back to the drawing boards. The rapid transit system and a newly-planned Interstate spur in the Shady Grove area, which undoubtedly will help, are still a year or more away.

However, the slower-than-customary population growth does give local officials time to catch their breath. A priority in Montgomery County is to avert the damaging effects of overcrowding and astronomical housing costs and taxes that are driving computer and semiconductor industries from the Silicon Valley to other western states.

Meanwhile, in Frederick County

The development potential of the I-270 corridor is now being felt at its northern end in Frederick County, bringing new

housing and industry to the base of the Catoctins.

Workers having to commute to jobs out of the area have helped bring Frederick County into the high-tech economy. Donald R. Date, Frederick's economic development director, says a company opening its doors in the county is deluged with applications from local residents tired of driving long distances each day.

The National Cancer Institute installation at Fort Detrick at the edge of Frederick and plentiful land are ready-made magnets for industry in Frederick County. The newest local showpiece is Solarex's "solar breeder," the world's first, near the junction of I-270 and I-70.

Also significant to the county's continuing economic development are industrial parks and research centers surrounding the city of Frederick as well as office development near the county's well-equipped airport.

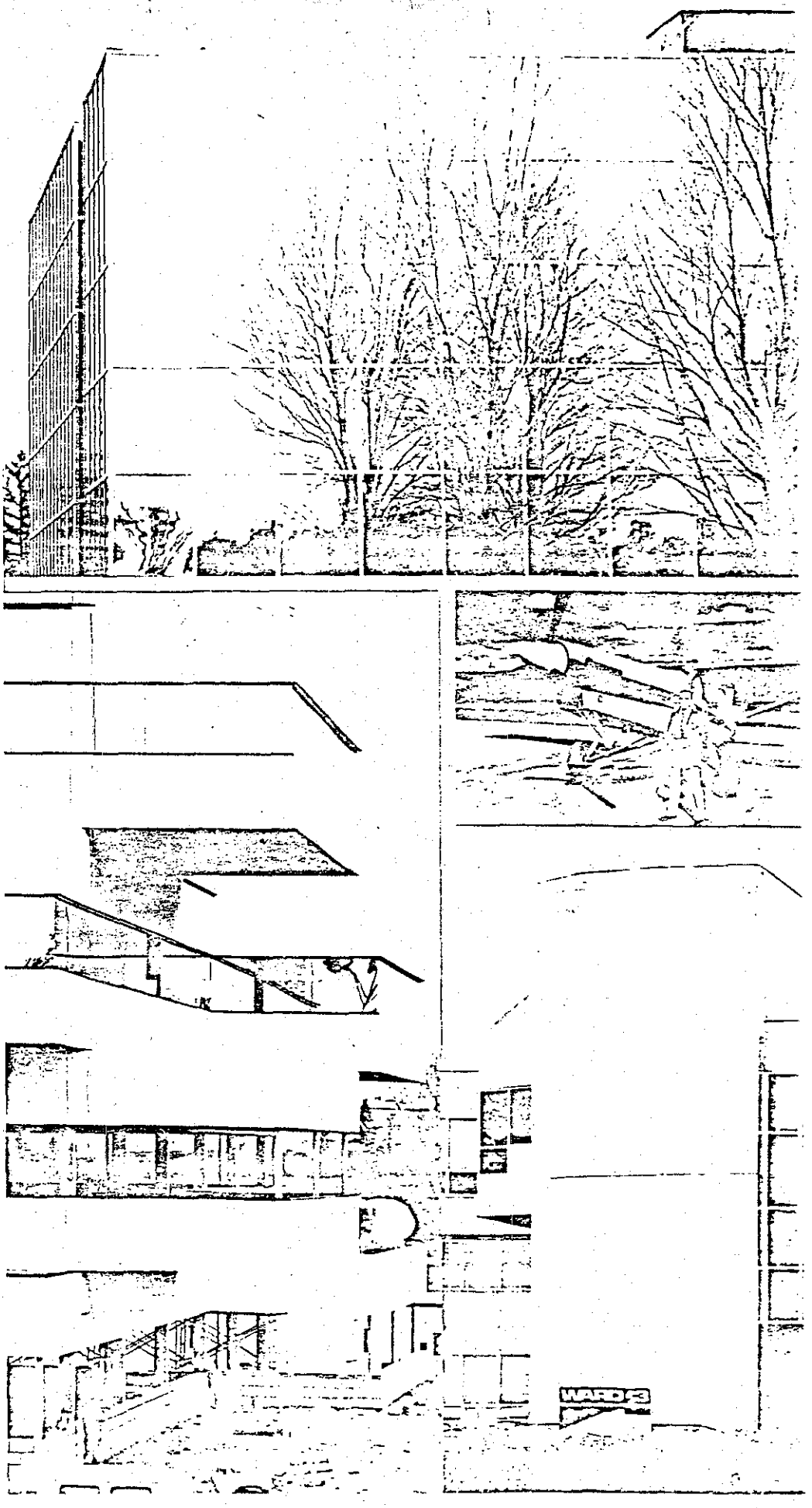
The thrust of the county's development, according to Date, will be three-pronged: light manufacturing, high-tech, and research and development firms.

He views the northern end of the I-270 corridor as being "very important for future employment." The county is reserving the open land along the Interstate for economic development through its Master Land Use Plan. Mr. Date expects the area to reach its fullest potential for accommodating industry within the next three to seven years.

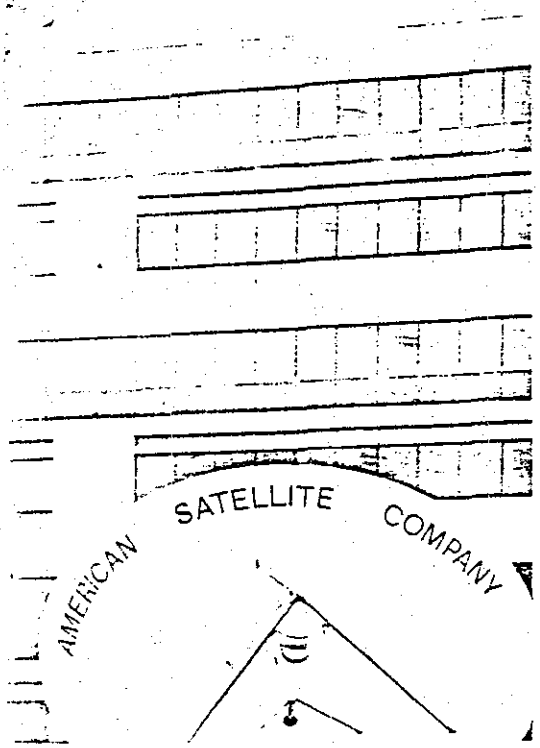
Looking ahead, the day is coming when Comsats and Fairchilds will line the corridor from Montgomery County to the Monocacy River, bringing to the rolling farmlands and wooded hills the look and technology of the 21st century.

The southern end of the corridor also does not depend on labor-intensive manufacturing of computers and electronic parts. High land costs here make assembly-line manufacturing impractical, although Montgomery County officials do recognize a need to generate entry-level jobs for the less-skilled.

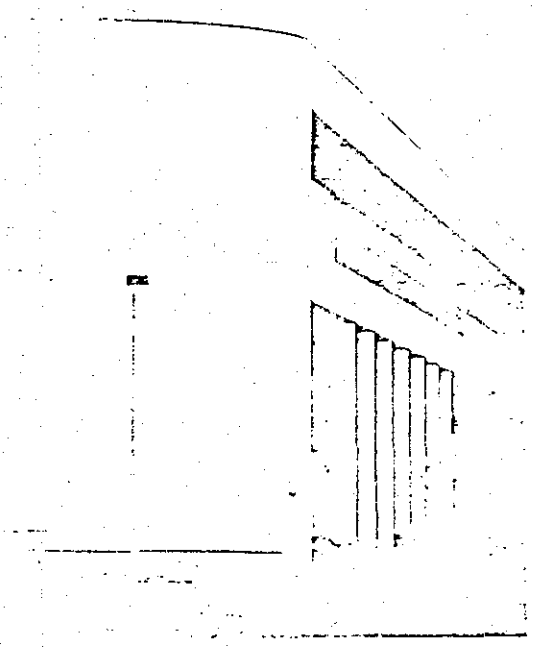
Whatever it takes to get the job done, Montgomery is prepared to do. For Mr. Due and his counterparts in Frederick County agree that, to a large degree, the future of their areas lies along the winding ribbon of asphalt known on the road maps as I-270.

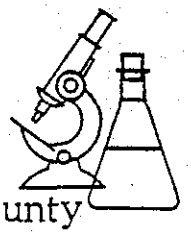


JEFF NOSNETT spent four years as a business writer for The Sun before taking his current job as Associate Editor for Changing Times. The Howard County resident's third contribution to MARYLAND Magazine.



CLOCKWISE FROM TOP RIGHT.
Another new office building on Shady Grove Road in Gaithersburg joins the boom. American Satellite Co. is on Research Road in Rockville. The Systems & Applied Sciences Corp. is in Rockville, while the 270 Corporate Center is in Germantown. Al Maye, corporate pilot for Fairchild Industries, has watched the growth along I-270 from the air.





Biotech "Boom" in Montgomery County

Though we may not be aware of it, one of the most rapidly expanding technologies of the 1980s—and the one most likely to affect us in the most intimate ways—involves neither hardware nor software, silicon chips nor missile guidance systems. It is the "technology of life," the engineering of biological organisms—and Montgomery County, with NIH and numerous "big name" genetic engineering firms, is a primary focus of this scientific revolution.

Bioengineering, as it is called, is both a very new and very old technology. In a formal sense, it may have begun when Gregor Mendel, a scientifically-minded, 19th-century Augustinian monk, demonstrated that living organisms pass along some kind of hereditary factors (later dubbed genes) from generation to generation, factors that determine, among other things, whether little Suzy gets her mother's blue eyes or her father's brown ones.

In 1954, the genes themselves were isolated. They proved to be giant molecules, fashioned of a substance called deoxyribonucleic acid (DNA). Once biochemists had learned to read this "genetic code," it was perhaps inevitable that they would also discover a way to rewrite it.

This breakthrough came in the early 1970s, when chemical tools, called *restriction enzymes*, were developed that allowed scientists to slice apart the genes of certain bacteria and recombine them with the genes of other organisms, thus creating hybrid organisms that had never existed in nature.

So what good is this for us, one might ask. These recreated bacteria can be "designed" to serve as microscopic chemical factories manufacturing useful substances such as human insulin, for diabetics, and human interferon, used in cancer treatment.

Their advantage is that they are neither artificial nor animal-derived and hence are fully potent and unlikely to cause allergic reactions; further, they can be produced in large quantities for low cost, a considerable boon in the case of interferon, which in its natural form is worth many times its weight in diamonds.

Some visionaries see even more astonishing vistas beyond the current boundaries of biotechnology, including the genetic engineering of human beings and the conquest of death itself.

With such promise comes great peril, and it was perhaps inevitable, when concerned scientists and citizens raised a cry in the mid 1970s over the potential risks and abuses of this technology, that the National Institutes of Health in Bethesda would become involved as a kind of clearing house for determining the safety of genetic technologies.

Because NIH contracts most of its genetic research to private firms, it has served as a magnet for corporations seeking to gain lucrative government funding for their R&D, thus turning Montgomery County into a kind of genetic silicon valley, one of three major biological boom areas in the United States. (The others are in California, where the technology was born, and in Massachusetts, near Harvard and MIT.)

Apparently, this corporate strategy has paid off. Of the funds appropriated by NIH for genetic research since the mid 1970s, fully 90 per cent have been spent in Montgomery County! Biotech companies, such as Genex and Bethesda Research Laboratories, Litton Bionetics, and Biosci, represent the cutting edge of what is already becoming a major high-technology industry. And they have further been encouraged by the Montgomery County government, now involved in the creation of a major biotech center off I-270—the Shady Grove Medical Park.

The best known of these gene-splitting firms is Genex, founded by J. Leslie Glick and based near Rockville. Almost as well known is Bethesda Research Laboratories, which started in 1975 with President Stephen Turner carrying enzymes from laboratory to laboratory in a bucket.

These are the "big-shots" of the genetic engineering world, but there are also any number of feisty smaller firms. One such is EMV, near Gaithersburg. Vice President James MacAlear, not one to stint on imaginative speculation, predicts a time when the gene splicers will be able to genetically engineer ultra-miniature, "living" computers from the very molecules of life, molecular electronic circuits which may even be capable of biological reproduction!

A far-reaching vision indeed—and one that weds the gene-splicers with the more conventional high-technology firms that thrive along the I-270 corridor.

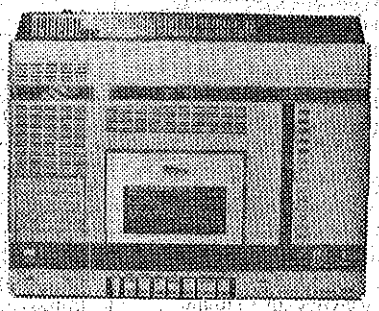
By Chris Lawton

Lessons of the VCR Revolution

How U.S. Industry Failed to Make American Ingenuity Pay Off

Second of a series

By Boyce Rensberger
Washington Post Staff Writer



RUDE AWAKENINGS
THE CHALLENGE OF THE GLOBAL ECONOMY

The videocassette recorder is an American invention, conceived in the 1960s by Ampex and RCA. The first VCR for home use to reach the U.S. market, in 1971, was the American-made Cartri-Vision.

By the mid-1970s, however, every American manufacturer had judged the VCR a flop and had left the business.

Today not one American company makes VCRs. All of the 13.2 million units sold in the United States last year—36,000 every day for a total of $5.9 billion—were made in Japan or Korea.

Even RCA, once a proud, patent-holding pioneer of the new technology, is now simply a middleman, buying Japanese VCRs and reselling them under its own label.

The story of the VCR, according to many experts, illustrates some of the reasons why American industry is losing its global competitiveness. It challenges the popular notion that a loss of innovative capacity lies at the heart of this country's eroding economic position. While there is evidence that American innovation may have lost some vigor and that other nations are gaining fast, many experts believe the United States is still the world leader in scientific and technological innovation.

"The problem is not so much with American innovation," said Harvey Brooks, a specialist in technology and public policy at Harvard University. "Our scientists and engineers still lead the world in the origination of new ideas. The problem is what happens after that point. Where we're falling behind is in the ability to develop new ideas into products and to manufacture them to the high standards that we've come to expect from the Japanese."

The VCR is an example.

In the early '70s several companies in the United States, Holland and Japan unveiled VCR prototypes with great fanfare. Industrial-sized video recorders were already common in television studios, and the key to the home market seemed to be scaling down size, cost and complexity of operation. Most of the problems seemed near solution when the prototypes were demonstrated.

One hitch, it developed, was that the cassette would record only one hour of program. Market research showed that people wanted to get two hours on a tape, enough to record a movie. Cartri-Vision, named when cassettes were cartridges, was a one-hour machine that industry analysts say failed for that reason and because the recorder came built into a 25-inch TV set.

Despite the Japanese and Dutch activity in VCR development, the American firms did not think of

See COMPETE, A10, Col. 1

The University, Industry, and Cooperative Research

A. Bartlett Giamatti

Summary. Yale University intends to issue a statement of policy governing the nature and extent of university and faculty involvement in the commercial application of scientific research. This policy will be based on the university's principles of openness and free dissemination of ideas, and will recognize the need of profit-oriented companies to treat knowledge as private property. The university will continue to allow relationships between faculty members and commercial companies, even in arrangements involving university-based results, but a faculty member who goes beyond any reasonable definition of "consulting" may be asked to take an unpaid leave of absence or to sever his or her ties with the university. While a university should not ignore the potential availability of funds from commercial sponsors, neither should it be driven to arrangements that are not compatible with the norms and mission of the university.

In this century, the time lag between the creation of a new scientific concept and its general application is usually measured in decades. Occasionally, however, the gap is compressed as a new theoretical insight moves swiftly to the stage of application and, hence, of wide, practical dissemination. We are now in the throes of such a movement in the field of applied research in genetic engineering.

At times of swift and intellectually exciting development, with the potential for enormous benefits to society and financial profits to skillful entrepreneurs, it is natural to ask questions about the appropriate relationship of universities to commercial sponsors of university research, and, indeed, about the very nature of the university. Because Yale participates actively in many developing areas of science and technology, we have been seeking answers to these questions. For the past year, a faculty Committee on Cooperative Research, Patents, and Licensing has been considering the issues raised by our increasing relationships to private commercial firms. On the basis of the committee's recommendations, and in consultation with the Research Advisory Board, chaired by the provost, we will soon bring before the Yale Corporation the results of these deliberations. The corporation will then issue a statement of policy to govern the nature and extent of university and faculty involvement in the commercial application of our scientific and scholarly research. In this article I discuss some principles on which such a policy can rest.

The university exists to protect and foster an environment conducive to free inquiry, the advancement of knowledge, and the free exchange of ideas. Such an environment depends crucially on trust and openness, and on a clear understanding of a set of principles governing scholarly inquiry. The principles are simply stated: the university and individual members of the faculty pledge themselves to the open, unimpeded, and objective pursuit of ideas; to the exchange of ideas openly and without deceit; and to the full and wide dissemination, through teaching and written publication, of the results of scholarly inquiry. The appropriate discipline on the dissemination of ideas is the critical scrutiny of responsible experts in order to assure the general public that completeness in investigation and citation, and rigorous and logical analysis in drawing conclusions, have been applied in the work.

As the university in its corporate body pledges to protect and foster an environment conducive to free inquiry, so also must the individual members of the faculty. As that environment and those principles engage a spirit that transcends the letter of stated principles, so each faculty member must sustain the university's commitment to free inquiry by fostering a spirit of collegiality, a shared sense of respect for and trusteeship of shared values of openness and intellectual freedom that the university exists to embody in the larger society. And, as the university in its administrative body must recognize that the members of the faculty, collectively and individually, are at the core of the university; and that, on behalf of members of the faculty, it is essential to protect academic freedom as well as to foster traditions of faculty self-regulation and self-government, so also is it essential that each faculty member recognize that the primary and overriding obligation of every faculty member, in terms of his or her commitment of time, attention, and intellectual energy, is to the university, that is, to the students, colleagues, and general mission of the university.

These principles of free inquiry and open dissemination of ideas, as well as the values of collegiality, mutual trust, and primary commitment, exist to protect the environment for free inquiry. They also form the principles and assumptions underlying all that follows.

Both university-based research, concerned primarily with the advancement of fundamental knowledge, and industry-based research, concerned primarily with marketable application, should serve the general well-being of society albeit in differing ways. Since the knowledge typically developed in university-based research is of a fundamental nature, it will often have a multitude of potentially useful applications. Because many of these eventual applications cannot be foreseen, it is particularly appropriate that such knowledge be disseminated as widely as possible so that all may use it if they will. While private industry pursues basic research, it does so less often, in part because it is so difficult to capture an adequate financial return from such long-term, risky efforts.

Universities are marketplaces where ideas are freely available; where knowledge is pursued by way of the norms of free discussion and the free access to and exchange of information; and where the freedom to publish must obtain. In contrast to the university, the commercial enterprise is appropriately animated by the profit motive. Commercial application of new knowledge typically requires a substantial investment in applied re-

The author is president of Yale University, New Haven, Connecticut 06520, and is professor of English and Comparative Literature. This article is based on a speech given in September 1982 to incoming graduate and professional students at Yale.

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