CASE WESTERN RESERVE UNIVERSITY

INDUSTRIAL RESEARCH AGREEMENT

MODEL ONLY

This Agreement made on date is between Case Western Reserve University, a corporation having a principal place of business in Cleveland Ohio (hereinafter CWRU) and XYZ Corporation, a corporation of the State of ______ and having a principal place of business at ______ (hereinafter XYZ).

BACKGROUND:

CWRU proposes to conduct on behalf of XYZ a program of research in field of research

described in the attached proposal incorporated as Appendix I. CWRU has facilities, staff, and graduate students available for the conduct of such a program.

XYZ desires to have CWRU conduct such a program on its behalf.

TERMS AND CONDITIONS OF THE AGREEMENT

ARTICLE I: THE RESEARCH AGREEMENT

1.1 CWRU agrees to conduct and supervise during the term of this Agreement the program of research which is described in Appendix I, including such modifications in the project as may be mutually agreed upon during the course of the program. XYZ will wish to consult with CWRU periodically concerning the course of the research and the results obtained, and to this end CWRU shall keep XYZ fully informed of the progress of the research through direct discussion and with periodic written reports.

1.2 In support of the research program XYZ will pay CWRU the sum of $ ~~~~ . Payment shall be made either monthly or as otherwise agreed on by the parties.

ARTICLE II: LICENSE OF PATENTS AND TECHNICAL INFORMATION

2.1 CWRU grants to XYZ , in the field of field of use ~~~~~~~~ , exclusive world-wide license, with the right to sublicense, of all patents and appropriate information arising from the research program of paragraph 1.1. The term of the license shall be for the lifetime of the patent or, for proprietary information, seventeen years from the effective date of this agreement unless terminated by the provisions of paragraph -.3.

2.2 As to all licenses granted to XYZ , CWRU retains a royalty-free right to practice the licensed patents and to use the licensed information for research, testing and educational purposes of CWRU.

ARTICLE III: PATENTS RIGHTS AND PUBLICATION

3.1 Title to all inventions, discoveries, information, data and know-how (patentable or unpatentable) arising from the research program of paragraph 1.1 shall be retained by CWRU. CWRU shall, upon prior notice to XYZ , have the right to file patent applications in its own name on all inventions arising out of research and testing provided for in paragraph 1.1.

3.2 In the event that CWRU elects not to support a patent application with its own resources for any invention arising out of the research and testing, CWRU shall promptly notify XYZ as to the nature of the invention and its need for support in pursuing a patent. Thereupon, if requested by XYZ , the University will file a patent application at the expense of XYZ . CWRU will cooperate fully with XYZ in the preparation and prosecution of all such applications and shall execute all documents as are necessary to the filing.

3.3 CWRU will notify XYZ, in writing, of its desire to publish results or conclusions from the research and testing conducted and reported in accordance with paragraph 1.1 of this Agreement. XYZ will have thirty (30) days from such notice to review all materials proposed for publication and designate any material that is proprietary information needing patent protection. Further, upon XYZ's request during the thirty (30) day notice period, all publication shall be delayed for up to ninety (90) days from the date of the request to provide adequate time for preparation and filing of a patent application related to information that is proposed for publication.

3.4 CWRU will use a best efforts approach to keep information generated under the research program from being disseminated beyond CWRU except by the vehicle of publication or patents.

ARTICLE IV: ROYALTIES, PAYMENTS AND REPORTS

4.1 In consideration for the right of exclusive license for patents and proprietary information developed from the research program of this agreement, XYZ agrees to pay CWRU as follows:

a. A royalty on all devices sold by or under the authority of XYZ that are covered by a valid claim of the patents licensed hereunder or are based on unpatented proprietary information developed as part of the research program.

The royalty shall be ~ percent (~) of the net sales price of all such devices including any associated devices or hardware sold in conjunction with them. Royalties under this paragraph shall be due and payable semi-annually.

b. For any sublicenses granted by XYZ under the provisions of Article III, XYZ will pay CWRU 50% of the royalty income from those sublicenses.

4.2 XYZ shall submit to CWRU semi-annual reports on all sales of devices upon which the royalty of paragraph 4.1 is based. Such reports shall be subject to audit and, upon thirty (30) days written notice, XYZ shall make available such records as are reasonably necessary to such audit at the place where such records are regularly kept.

4.3 If, for any period of two consecutive years beginning ~ years from the effective date of this agreement, royalties paid to the University shall fall below ~ per year, the license granted in Article II shall be terminated unless XYZ chooses to make up the difference between actual annual royalties and ~.

ARTICLE V: PATENT INFRINGEMENT

5.1 Each party shall promptly notify the other party of any infringement of patents developed and licensed as part of this agreement. XYZ shall have the unqualified right to fully participate in any legal action to protect its interests, and CWRU and its attorneys shall fully cooperate with XYZ to this end.

5.2 If XYZ requests that CWRU bring an action for patent infringement and, within sixty (60) days, CWRU fails or refuses to do so, XYZ shall have the right to institute suit in CWRU's name against any such third party. If, after said sixty (60) days, XYZ elects to institute suit against any third party, all such costs and attorneys' fees shall be fully credited against any amount due as royalties and against any further royalties accrued pursuant to this Agreement and all damages awarded plaintiff in such suit shall belong exclusively to XYZ.

ARTICLE VI: MISCELLANEOUS

6.1 XYZ agrees that CWRU shall be held harmless in any legal actions resulting from XYZ's application or marketing of technology arising from this agreement. CWRU agrees to hold XYZ harmless from any liability for damages of whatsoever nature arising from research performed under this agreement.

6.2 XYZ agrees not to use the name of CWRU or related schools and departments in any publications or marketing materials without the written consent of CWRU.

6.3 All notices to the UNIVERSITY under this Agreement shall be in writing and sent to:

Director
Office of Research Administration
Case Western Reserve University
2040 Adelbert Road
Cleveland, Ohio 44106

6.4 All notices to XYZ under this Agreement shall be in writing and sent to:

6.5 This Agreement shall be construed, interpreted and applied in accordance with the laws of the State of Ohio.

6.6 This Agreement sets forth the entire understanding between the parties as to the subject matter hereof and merges all prior discussions between them. Any amendment to this Agreement shall be in writing signed by the parties.

IN WITNESS WHEREOF, the [illegible] have executed this Agreement on the day and year first above written:

FOR CASE WESTERN RESERVE UNIVERSITY	FOR INC.
______________________________	______________________________
Name ______________________________	Name ______________________________
Title ______________________________	Title ______________________________
Date ______________________________	Date ______________________________

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on asbestos. But Gorham projects that, even without any further regulatory strictures, U. S. demand will continue to fall, to 250,000 m.t. in 1985 and 170,000 m.t. by 1990.

Confidence. SNA, meanwhile, is so confident that its pilot plant will produce a marketable product that it already is planning for full-scale production. "By the end of the year, we hope to have the information available to proceed to construction of a proper factory," says Jean-Marc Lalancette, SNA vice-president of research and development. Industrial production using the patented process could begin by 1986, he adds.

SNA's technology converts the terminal hydroxyl groups of magnesium in chrysotile asbestos—the most commonly used asbestos and the only kind produced in Canada—into phosphate groups. These phosphate-treated asbestos fibers are considered less carcinogenic than untreated asbestos because they reduce cancer-causing asbestos dust.

Conversion is accomplished by exposing agitated asbestos fibers to circulating phosphorous vapors, a reaction that is carried out in an inert, dry atmosphere. Lalancette says that such phosphate treatment will result in a "slight" price increase of about $100 (Canadian)/m.t. of asbestos, most grades of which currently sell for $400-600 (Canadian)/m.t.

SNA claims that its treated asbestos can be substituted for all grades of asbestos fiber in virtually all industrial and construction applications. And the company also claims that its treatment method, unlike other physical and chemical modifications, leaves the chrysotile's fibrous structure intact.

Competition. But SNA's modified asbestos will have to compete with a number of substitutes. Glass fiber priced competitively with asbestos dominates the asbestos substitute market, according to Alvin Keene, vice-president and director of marketing services for Gorham International. Silica and other mineral products also compete in the lower end of the market. In some high-performance applications, higher grades are being replaced by aramid fiber.

While the provincial government of Quebec is focusing on modifying asbestos to make it safer, the Canadian government is directing its efforts toward influencing Washington's asbestos policies. Canada's concern is not surprising: During 1983, Canadian asbestos mines operated at only 55-60% of capacity, according to Oliver Vagt, a mineral economist with the country's Energy, Mines and Resources Dept. Production dropped from 1,492,000 m.t. in 1979 to 820,000 m.t. in 1983. "The outlook is for an improvement in 1984, but it all depends on the regulatory front in the U. S.," Vagt says.

Gotlieb: blaming U. S. policy for Canada's bind.

Departure. Canada exports 90% of its asbestos, much of it to the U. S., where the Environmental Protection Agency is threatening to ban the use of a variety of asbestos products sometime this year and to establish a staged production cap on remaining uses. In a recent speech delivered in Washington, Allan E. Gotlieb, Canadian ambassador to the U. S., charged that the direction of U. S. policy is an "apparent departure from the mainstream international approach that has implications for the general principle of international harmonization of regulations on asbestos supported by both our governments.

"There is no doubt that the recent economic recession has had a large bearing on the poor performance of both our asbestos industries," Gotlieb continued. "But there is also no question that the public concerns about health have taken their toll." □

A new biotech center allies diverse groups

Plans to develop a new advanced biotechnology research center in Montgomery County, Md., outside Washington, D. C., have generated quick interest among some of the area's most promising biotechnology companies. The $5 million project will [redacted] as well as by the county. The plans have interested such firms as Genex, the Litton Institute of Applied Biotechnology (LIAB) and Biotech Research Labs, as well as officials of the 31-member Industrial Biotechnology Assn. (IBA). According to John S. Toll, president of the University of Maryland, "This will be the first center of its kind in the country to involve industrial firms, a university and government at the federal, state and local levels."

Ensuring preeminence. Joint projects involving industry, government and academia are "essential," says Michael G. Hanna, Jr., director of LIAB. "We simply must do the fundamental scientific research now in order to ensure continued U. S. preeminence in this field." So, he adds, "This new center is exactly what U. S. biotechnology firms need at this stage of their development." Litton is exploring ways in which "we can participate in the center."

The facility itself, [redacted] located within a new 232-acre research park being developed in Montgomery County's expanding "high-tech" corridor along Interstate 270 between Rockville and Gaithersburg. [redacted] nology programs. And county officials hope the new center will help to attract even more firms in this field.

Signing up. So far, two large companies have agreed to build in the new park: Microbiological Associates, a subsidiary of Whittaker (Los Angeles), and Japan's Otsuka Pharmaceutical. Microbiological Associates plans to build a 110,000-sq ft headquarters and laboratory complex, and Otsuka is planning a 100,000-sq ft facility.

One interested observer is Harvey S. Price, executive director of IBA, an organization whose members include Dow Chemical, Du Pont, Shell Oil, Standard Oil of Indiana, Phillips Petroleum, Monsanto and Exxon Research & Engineering. Says Price: "We are happy to see the research center getting under way. In time, I think it will help the [Washington] area compete with other biotechnology centers."

Advanced study. According to NBS, the new center will promote advanced study in biotechnology, biomolecular engineering, analytical chemistry, biochemistry and other fields. Specifically, it will:

- Develop computer applications for modeling and theoretical analysis of biological systems. This effort will be directed toward prediction of structure, function and design of biomolecules.
- Develop tools and techniques for study and manipulation of genetically engineered or natural macromolecules.

The work of the new center will include basic research, applied research and product development, ultimately leading to marketing, dissemination and use. Research, NBS states in the center's official charter, will be "conducted in an atmosphere of open inquiry, with the understanding that developmental activities may need to be conducted in a more proprietary context."

Mechanisms for industry participation will include purchase of technology and services, collaborative-research arrangements, contract research programs and general affiliation with the center, so that companies have access to training and general information resources. "Ultimately, we will develop a truly synthetic biochemistry that designs and produces totally novel biochemicals and biomaterials not found in nature," NBS declares. To achieve future goals, it notes, "we must move boldly to establish a truly unique center staffed, instrumented and equipped to address the fundamental scientific and technical problems that will be the focus of the next decade in biotechnology."

Admirable plans. Kevin Ulmer, vice-president of advanced technology at Genex, says the center's plans are admirable if they remain intact. He says Genex will probably become involved because "the plan at the moment is to have the center provide computers or sophisticated biophysical instrumentation of the caliber not available at Genex." Ulmer hopes that CARB will attract "world-class talent, who would be available for collaborative projects." □

wrap-up

A push for detergent sulfates

Courtaulds North America says it will invest more than $10 million at its Mobile, Ala., viscose rayon plant to reduce energy costs and improve the quality of its fibers. Among other things, the company plans to install a coal-fired boiler and new evaporation technology to reduce the steam required.

According to industry sources, a major thrust of the program is to upgrade the quality of sodium sulfate byproduct from the process so that Courtaulds can command a higher price when selling it to the detergent industry. The modifications will allow Courtaulds to "considerably increase" those sales, says a spokesman.

Dow upgrades a metals plant

Dow Chemical plans to invest more than $10 million to modernize and expand capacity for Zetabon plastic-clad metals at its Findlay, Ohio, plant. The new capacity, says Dow, will allow it to make its new Zetabon products, which include coated steel, a coated stainless steel and what is said to be the first coated copper tape for wire and cable uses in moist environments.

The stainless steel product is for the fiber optics market; the new coated steel is for bonded sheath construction in wire and cable. In another move last week, Dow acquired 1 million shares, at $7/share, of Magma Power, a developer of geothermal resources.

Polycrystalline silicon. Union Carbide says it is starting to design a $200 million polycrystalline silicon plant with capacity of more than 3,000 metric tons/year. The plant will supply the semiconductor industry. Carbide is now building an $85 million, 1,200-m.t./year polycrystalline silicon plant at Moses Lake, Wash., due onstream in the third quarter.

Drug scuffle. Searle Pharmaceutical has decided to withdraw a court motion to stop Key Pharmaceutical's marketing of Key's theophylline antibronchial drug, Theo-Dur. Searle says recent action by the U. S. Food and Drug Adminstration against Key has eliminated the need for legal action. Searle filed suit last September against the Florida drug maker, claiming that it had misrepresented Theo-Dur, as well as Searle's theophylline Theo-24 product, in a direct mail campaign. FDA, however, has ordered Key to mail statements to clarify the alleged misstatements.

Styrene monomer. Gulf Oil Products, the downstream operation of Gulf Oil, plans to modernize its St. James, La., styrene monomer plant to reduce manufacturing costs and improve energy efficiency. The company says that when the project is completed in mid-1985, the plant will consume 20% less energy. Capacity of the plant will remain at 600 million lb/year.

Circuit boards. Morton Thiokol's Dynachem unit has established a new company to acquire two Italian companies. Dynachem Italia has been formed to buy B. C. Equipment, a maker of specialized equipment for the printed circuit board industry, and CGS Prodotti Chimici, a distributor to the Italian printed circuit board market.

Product liability. Overturning a lower court decision, the Michigan Supreme Court has ruled that a group of 238 women can sue all 16 producers of diethylstibestrol (DES) when it is impossible to identify which product their mother took. DES has been linked to a rare form of cancer in the female offspring of women who took the drug—no longer marketed—to prevent miscarriage. The women have requested damages in excess of $10,000/each from the 16 companies, which include Eli Lilly, Abbott Laboratories, McNeil Laboratories, Merck Sharp and Dohme, Upjohn and E. R. Squibb.

Industrial gases. Air Products and Chemicals has formed Air Products Ireland to market industrial gases to customers near Dublin. The new affiliate will sell specialty cylinder-gas products to the electronics industry.

Super-safe plant. The Occupational Safety and Health Administration has praised Mobil Chemical for its superior safety and health record at seven of its plants. The awards were given for its two plants at Beaumont, Tex., two in Covington, Ga., and one each at DePue, Ill., Edison, N. J., and Macedon, N. Y. Du Pont and American Cyanamid are the only other chemical companies that have qualified for the "Star" award, which exempts plants from unannounced OSHA inspections.

Now there's a Silicon Mountain, Silicon Desert, and Silicon Bayou.
But is every town a potential high-tech mecca?

High-Tech Highways

BY KEVIN FARRELL

Ron Sherman

Suddenly, America is being paved over with high-tech highways. Until a few years ago, the nation's original technology centers, California's Silicon Valley and Boston's Route 128, had a corner on attracting and cultivating state-of-the-art companies. Now, as those areas strain their resources to the limit, companies are moving to new centers with names like Silicon Bayou (Lafayette, La.) and Silicon Mountain (Boulder, Colo.). Entrepreneurs are discovering they can prosper in fledgling high-tech outposts. Some areas are fairly new to the world of high-tech, such as Burlington, Vt., a rural ski and farm town which got its start when IBM built a semiconductor manufacturing facility there a few years back. Others are more mature, such as Bellevue, Wash., now headquarters to some 75 budding software developers. There are already 50 centers in various stages of development, half of which are less than five years old. Another two dozen are on the drawing boards. At a time when most people believe technology holds the keys to prosperity in a transformed economy, these new areas embody the high-tech aspirations of every town and region. The question is, however, how much will these centers deliver?

"While these beltways are changing the economic face of the country in many areas," says Paula Raymond, sociology professor at Brandeis University, "their ultimate promise is unclear." Another question is whether the centers can be built artificially. Silicon Valley and Route 128 developed gradually and naturally over a few decades. But some centers, like Philadelphia's Route 202 or Dayton's I-675, needed help from politicians or civic boosters.

Some areas are specialized, attracting companies in high-tech niches, such as Florida's "Robot Alley," from Gainesville to Orlando, with eight robot companies. Others, such as I-494 in Minneapolis, harbor a broad spectrum of industries.

Most centers are stretches of roads that roll out past high-tech company after company in suburbs and even rural areas. Interstate 495, the Capital Beltway, which rings Washington, is the principal artery for two centers, one in Prince George's County, Md., and another across the Potomac in Fairfax County, Va. However, the length and breadth of the enclaves can range from the sprawling Sacramento technology community, where 35 new companies have sprung up in three surrounding counties over the last five years, to a single research center, such as the Institute for Manufacturing Sciences (IMS), now being built in Cincinnati. Like other technology "incubation centers" IMS is seen by its backers as a potential core for a more fully developed technology community.

Research is still the singular focus at such mature centers as Research Triangle Park outside Raleigh, N.C., and Huntsville, Ala.'s Cummings Technical Park. Many other areas, including Beaverton, Ore., and Rhode Island's Aquidnick Island, comprise a blend of research facilities, corporate headquarters, and manufacturing plants.

High-tech centers crop up most naturally around universities, government research labs, and mature companies. However, capital, a plentiful supply of technical, managerial, and assembly labor, universities and other R&D facilities, access to markets, and a good business environment all are

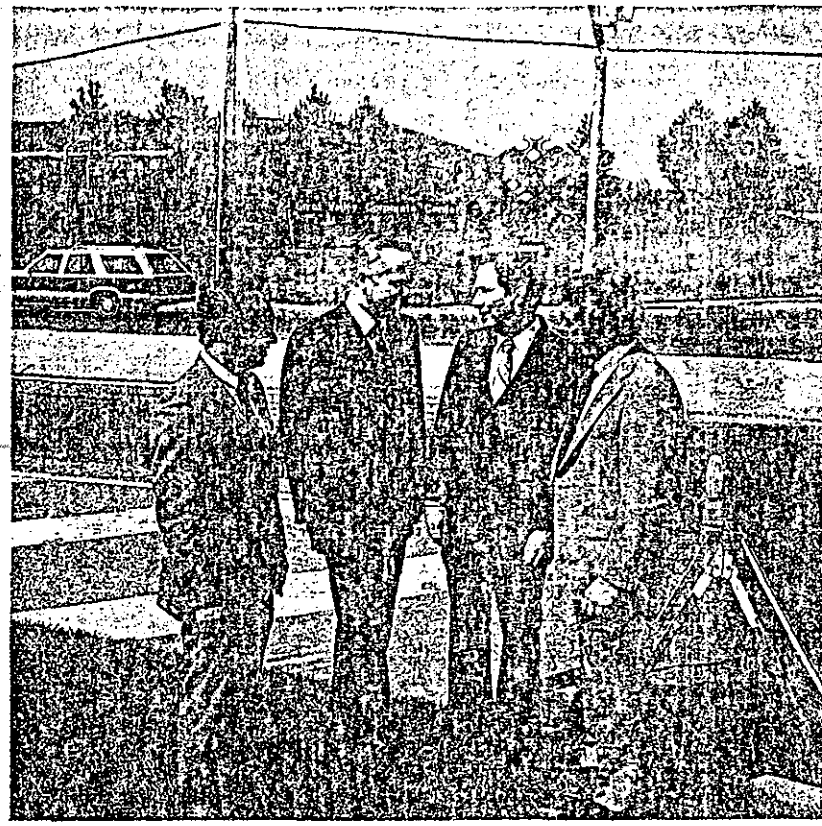
Among those who helped make Bellevue happen are (front and l. to r.): Woody Howse, investment banker; Alan Dashen, president, Washington Research Foundation; Karl Vesper, professor at Univ. of Washington; Roger Camp, founder, Applied Computer Sciences Inc.; Ann Llewellyn and husband Andy Evans of Evans Llewellyn Securities; Wayne Erickson, founder MicroRim; and Bill Gates, founder of Microsoft

On the campus (above, left) of Atlanta's Georgia Institute of Technology are (l. to r.): Dr. Joseph M. Pettit, president of Georgia Tech; Thomas Koehler and Bob Duncan, founders of Catronix, a software company, and Jerry L. Birchfield, chairman of Georgia Tech's Advanced Technology Development Center

Doug Wilson

needed for the region's high-tech "infrastructure."

After all, why move to Boston or San Francisco when you may already have a potential high-tech center in your own back yard? Says former Californian Richard D. Sanford, founder of Lionville, Pa.-based Intelligent Electronics Inc., on Philadelphia's Route 202: "The decision to stay here was simple. I knew I could attract just as many good technical people and dependable workers here as I could in California. Also, the market is here for what we do [sell computers through department stores] and most importantly, I like it here."



Sal DiMarco Jr./Black Star

Outside a Route 202 business park are Robert E. Mittelstaedt, chairman of the Wharton School's Innovation Center at the Univ. of Pennsylvania; Raymond E. Rafferty Jr., founder Century IV Fund, a $20 million venture capital fund; Frederick D. Lipman, chairman Philadelphia Chamber of Commerce Technology Council; and Richard D. Sanford, founder Intelligent Electronics Inc., a computer retailer

INTENSE COMPETITION

The advantages a high-tech highway can bestow upon a community are enormous. It can transform a region by creating jobs through a "multiplier effect" that begins in the area's high-tech specialty and spreads to service and support businesses and then to other industries. In the early to mid-1960s, for example, Route 128 blazed a path through rural Massachusetts farmland. But the growth of the high-tech companies that sprouted like weeds along the highway turned farmland into corporate campuses and gave life to new communities.

But, as April Young, executive director of the Fairfax County, Va., Economic Development Agency, points out: "Creating a high-technology strip is much easier said than done. The competition to set up research areas conducive to attracting and growing new companies is intense. There are bound to be losers." Fairfax's fast-growing strip along I-495 outside Washington has been successful because so many companies wish to be near their major customer, the U.S. government.

During the 1973 to 1975 recession, Fairfax County was hit hard. Unemployment climbed to over 5% while nationally it was 7.5%. But in the most recent recession, unemployment never passed 3.9%. The local labor force had grown by 50,000 between the recessions as the county's high-tech corporate population grew by 30%.

The shocks that resulted from the wrenching change that brought Route 128 from a farm economy to a highly industrial one seem to be worth it for other areas. Seattle, up until a few years ago, was heavily dependent on Boeing and the regional timber business. "But since we've grown more high-technology companies, I think we're safer should another prolonged recession come along," says Alan Dashen, president of the Washington Research Foundation. "It's apparent that the world economy is rapidly changing, and it won't be advantageous to be dependent upon the sale of timber products to have jobs for residents."

The Golden Triangle has had the same kind of result in southern New Hampshire. Notes Paul Guilderson, director of the New Hampshire Office of Industrial Development: "It has resulted in a marked difference in the unemployment situation."

Technically oriented universities are probably the single greatest drawing card, as the newer areas have discovered. Philadelphia claims nine medical schools alone, which accounts in part for the medical orientation of its technology companies. In Lafayette, La., the University of Southwestern Louisiana, now offering a PhD. program in computer sciences, has contributed immeasurably to the area's focus on computer applications in the oil and gas business.

Government research facilities offer fertile ground for high-tech centers. In Tennessee, Oak Ridge National Laboratories played a key role in the creation of 22 new companies in the last two years. In Dayton, over two dozen companies involved in avionics, weapons, and telecommunications have formed in the last three years.

A loosening of restrictions on technology transfer has increased activity around Oak Ridge Labs, which had forbidden staffers to consult in their areas of expertise. And in Seattle, the University of Washington, notorious for preventing technology transfer, recently helped form the Washington Research Foundation to transfer technology from universities to the private sector. The group has applied for 13 patents in the last 18 months, compared to only two in the preceding five years.

The growth of a high-tech highway can often be traced directly to one vital corporation which spawned numerous entrepreneurs who remained in the area. While Silicon Valley can trace many of its roots directly to two companies—Hewlett-Packard and Shockley Semiconductor Laboratory—Princeton, N.J., credits its high-tech success to a pastoral setting and a lode of talent which comes from

"You get to a point where there is a critical mass of companies," says Patterson, "and it can do nothing but go up from there. It just snowballs"

nearby major R&D units of RCA and Bell Labs.

High-tech centers may start for strictly business reasons, as a result of the particular culture they spawn, something that cannot easily be legislated into existence. Explains David Patterson of the Tennessee Technical Foundation: "A few years ago, the university professor with a good idea lived in a community with other university professors, and that's who he socialized with. But once entrepreneurial activity gets going and a guy with a good idea sees his friends starting companies, he starts to see things in a whole diffferent light. If he does form a company, he does it near where his buddies are. And then the whole thing just takes off."

This ripple effect is what development agencies pray for. "You get to a point where there is a critical mass of companies," says Patterson, "and it can do nothing but go up from there. It just snowballs."

A CONCERTED COMMUNITY EFFORT

The competition for new technology projects has intensified, as seen in the recent competition to attract the Microelectronics & Computer Technology Corp. (MCC), the joint venture that will employ 350 engineers. Austin won among four finalists from 57 regions. A showcase like MCC can give a region the momentum it needs to attract more quality companies. In Atlanta, the Advanced Technology Development Center at Georgia Institute of Technology, has been at the forefront of the movement to make Atlanta's Route 285 a high-tech mecca with more than 100 companies. Says Wayne Hodges at Georgia Tech: "The state became active, we began to attract more venture capital, we started to bring entrepreneurs and money together at conferences, and it all worked together."

Watching the new centers are politicians scraping for new sources of jobs and taxes. Many are trying to create high-tech highways of their own, but critics doubt how much any government entity can contribute. Arkansas is hoping to grow a full-blown community from a medical research center seeded with federal funds to study AIDS, and New Mexico has spent $7 million to set up so-called "centers of excellence" in several disciplines.

More successful than staking its hope in a single research center is the concerted action a community can take to chart its high-tech plans. For example, Philadelphia's civic boosters, money men, and government agencies banded together to attract companies to its fledgling Route 202. The Technology Council, under the auspices of the Chamber of Commerce, has been responsible for sowing seeds that grew into a $20 million venture capital pool to focus investments in the Philadelphia area, a region noted for its dearth of venture capital sources.

Pennsylvania's public/private partnership is a route now being followed by many states, including Michigan, Massachusetts, and New York. "After all," says Walter Plosila, Pennsylvania's deputy secretary for technology and policy development, "the idea is to grow private companies, not to create a government jobs program."

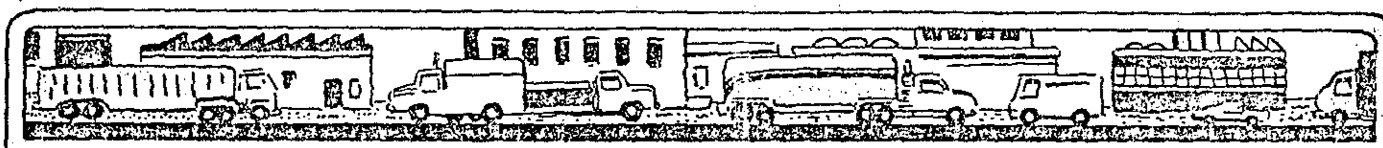
In selecting a site, comanies need no longer locate near supplies of raw materials, rivers, ports, or customers as was once necessary. But airports are important. In Fairfax County, the Dulles Airport access road, which runs from I-495 to the airport, is about to be developed for high-tech firms. In Boston, the $130 million, 20-acre Massachusetts Technology Center now under development at Logan Airport will be the first major airport high-tech park. Fifty companies employing 1,500 workers are expected to eventually occupy the center.

Oregon's proximity to the Pacific Rim and Portland's deep water port have attracted companies which rely on exports to I-5 in the Wilmette Valley. New Hampshire's "Golden Triangle" in the south and the area surrounding Portland, Me., have benefited from their proximity to Massachusetts' thriving Route 128. And Bellevue, Wash., has become a high-tech mecca in part because traffic across Lake Washington to Seattle is so heavy at rush hour that companies began building their facilities on the other side of the lake in Bellevue.

It appears venture capital is following, rather than leading, the movement to new geographic high-tech areas. Says one observer: "Venture capital has this reputation for being so risky, but that's really a myth. These guys want to see results in an area before they start dumping their money in."

Nationally known venture capitalists have been active in Seattle, Portland, Dallas, and Denver, but have done little more than test the waters in Philadelphia, Columbus, Dayton and Austin. Triangle Ventures, with offices in Menlo Park, Calif., and Research Triangle Park, N.C., has been trying to raise a pool of up to $10 million for nearly a year. In other areas, local planners or civic boosters have decided to take matters into their own hands. Two venture capital firms are expected to open in Philadelphia; in Portland, Me., one fund and an SBIC have opened in the last 18 months.

Explains Thomas Walker, managing director of the $30 million Cardinal Development Capital Fund I in Columbus, Ohio: "We're seeing a deal a day from Ohio, many of them from Dayton. Dayton offers a good climate for future-oriented businesses, and we want in on the action." ▽



AMERICA'S 50 HIGH-TECH HIGHWAYS

Entrepreneurial companies have clustered together in at least 50 high-tech enclaves. Often located along an interstate or a state road, the centers spring up around transportation and university facilities, and industry leaders. The mature centers that have sprouted the most entrepreneurial spinoffs; the developing group, with a substantial number of startup companies; and the emerging high-tech centers, those areas that show promise but have not yet come of age.

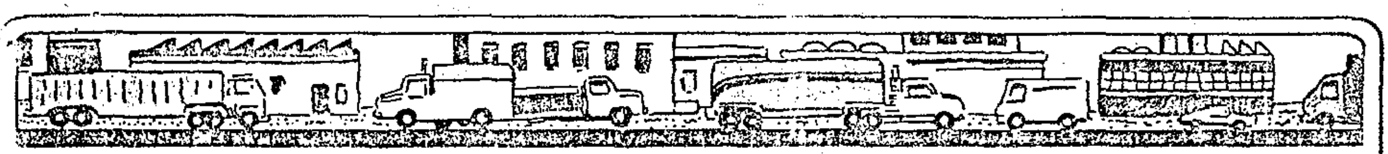
MATURE HIGH-TECH CENTERS

Area	Gov't. Agency	Universities, Gov't. Entities, Base Companies	Specialties	Comments
California				
"Silicon Valley" (Santa Clara County)	Calif. Dept. of Economics & Business Dev. 1030 13th St. Suite 200 Sacramento, Calif. 95814	Stanford Univ., Fairchild Camera & Instrument, Hewlett-Packard, Apple Computer, National Semiconductor, Intel	Personal computers, disk drives, software, silicon chips, microprocessors, printed-circuit boards	Great-granddaddy of them all. Remains a model for high-tech communities. Plentiful venture capital.
Massachusetts				
Rte. 128 (beltway around the north and west of Boston)	Massachusetts Dept. of Commerce & Dev. 110 Cambridge St. Boston, Mass. 02202	MIT, Harvard, Boston Univ., Tufts, Northeastern, DEC, Wang, Honeywell, General Electric, GTE, RCA, Raytheon	All phases of computers, biotechnology, robotics, metallurgy	With a broad industrial base area is less prone to recession. MIT, a strong venture capital community, and large companies in the area spawn startups.
North Carolina				
Research Triangle (I-40 and I-85, Raleigh-Durham-Chapel Hill)	North Carolina Dept. of Commerce Industrial Development Div. 430 North Salisbury St. Raleigh, N.C. 27611	N.C. State Univ., Univ. of N.C., Duke Univ., Environmental Protection Agency, IBM, Becton, Dickinson, GE Semiconductor Div., Burroughs Wellcome Co., Data General, Northern Telecom	Pharmaceuticals, semiconductors, microelectronics, fiber optics, agricultural products	The 5,000-acre triangle (2,500 still available), is dominated by large company divisions, although this is beginning to change. No venture capital.

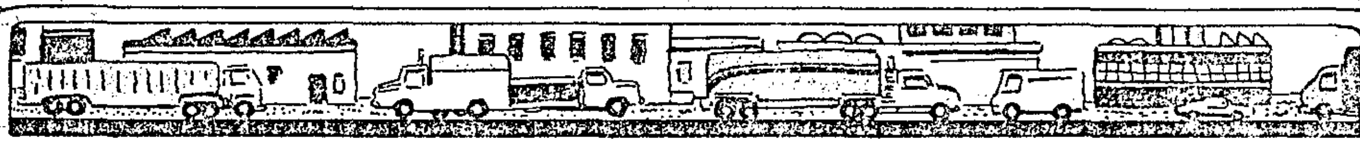
DEVELOPING HIGH-TECH CENTERS

Alabama				
Huntsville (western corridor of city from airport to downtown)	Development Div. of Chamber of Commerce 305 Church St. Huntsville, Ala. 35804	Univ. of Alabama-Huntsville, Redstone Arsenal, Intergraph Inc., Army Corps of Engineers, Army Missile Command, Lockheed, Rockwell, Boeing	Weapons systems, CAD/CAM multiplex and modern telecommunications products, defense electronics	11,000 government R&D employees. City plans industrial park near airport to encourage startups. New venture capital funds.
Arizona				
Phoenix-Tempe (area of city from airport to outskirts of city)	Arizona Office of Eco. Planning & Dev. Executive Towers Suite 505 1700 W. Washington Phoenix, Ariz. 85007	Arizona State Univ., Motorola, Sperry Rand, ITT, Intel, Goodyear, Honeywell, IBM	Aerospace, avionics, CAD/CAM, printed-circuit board manufacturing	Arizona now sells IRBs, the proceeds of which will capitalize R&D companies that locate in a 320-acre park to be built by the university.
Tucson (south and west of city near airport)	Tucson Economic Development Corp. 265 West St. Mary's Rd. Tucson, Ariz. 85702	IBM, Hughes Aircraft, Anaconda Copper, National Semiconductor, Univ. of Arizona-Tucson	Solar energy research, microchips, geological survey equipment, chemical production	New venture capital. The population is expanding. Labor availability excellent.
California				
Orange County (primarily Irvine, off Hwy. 55 near John Wayne airport)	Economic Dev. Corp. of Orange County 17962 Cowan Irvine, Calif. 92714	Univ. of Calif.-Irvine, Calif. State Univ.-Fullerton, Long Beach State Univ., North American Aviation, Ford Aeroneutronics, Baker International, Xerox, Cannon	Aircraft/aerospace, telephone systems, microwave R&D, microcomputers, laser optics, semiconductors	A new venture fund joins others in area south of LA. Two 600-acre industrial complexes located near airport.
Sacramento (three-county area surrounding city)	Sacramento Commerce & Trade Org. 1007 7th St. Suite 450 Sacramento, Calif. 95814	Univ. of Calif.-Davis., Calif. State Univ. at Davis, Hewlett-Packard Co., Signetics, Intel, Teledyne, Shugart	Telecommunications, data processing, defense electronics, microwave equipment	Attracting branches of large companies and startups. Unemployment is 11.3%. Close to San Francisco venture capital.
San Diego "Golden Triangle" (north of city: Oceanside Vista, Sorrento Valley, Torrey Pines)	San Diego Economic Development Corp. 701 B. St., Suite 1850 San Diego, Calif. 92101	Univ. of Calif.-San Diego, San Diego State Univ., Scripps Institute of Oceanography, General Dynamics, Rohr Industries	Electronic manufacturing, semiconductors, telecommunications	Univ. of Calif.-San Diego makes 40,000 sq. ft. of space available for joint research with area companies. Venture capital firms have feelers out to establish local offices.

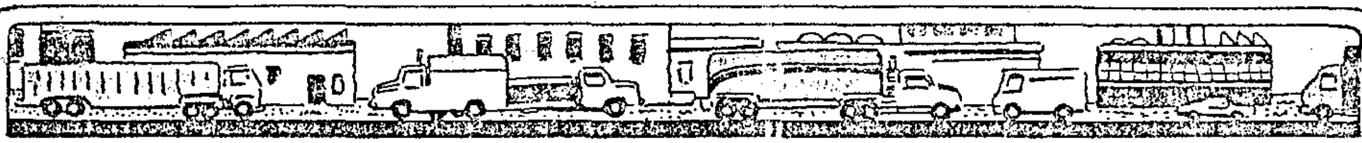
Robert Neubecker



Area	Gov't. Agency	Universities, Gov't. Entities, Base Companies	Specialties	Comments
Colorado				
Colorado Springs (southeast of city toward airport and Cheyenne Mountains)	Div. of Commercial Development State of Colorado 1313 Sherman St. Room 523 Denver, Colo. 80203	Univ. of Colo.-Colo. Springs, Rolm, Ford Aerospace, TRW, Honeywell	Aerospace, semiconductors, defense electronics, telecommunications	Three venture funds and a number of private investors. An industrial park created by larger companies will also house startups.
Denver-Boulder (north of Denver along Rte. 36 through Boulder to Longmont)	(see above)	Univ. of Colo.-Boulder, Colo. State Univ., Hewlett-Packard, DEC, NCR	Disk drives, agrigenetics, semiconductors, recombinant DNA production, agricultural research	Corporate headquarters and satellite offices have spawned a number of entrepreneurs. Growing venture capital community.
Florida				
"Electronics Belt" (Central Florida-Orlando area)	Florida Div. of Economic Development Florida Dept. of Commerce 107 W. Gaines St. Tallahassee, Fla. 32301	Pratt & Whitney, GE, IBM, Westinghouse, Honeywell, Harris Corp., Martin Marietta, Western Electric	Defense electronics, aerospace, lasers, robotics, intelligent machines	High tech rapidly replacing agriculture and construction as major industries. An attractive climate and established companies encourage spinoffs and startups. The number of venture capital firms has doubled in three years.
"Silicon Beach" (Southeast Florida: Dade, Broward, Palm Beach Counties)	(see above)	Univ. of Miami.	Electronics, aerospace	
Georgia				
Atlanta	Office of the Governor 203 State Capitol Bldg. Atlanta, Ga. 30334	Georgia Tech., Rockwell, Scientific Atlanta	Software development	Arrival of SBIC s and venture capital funds in last two years has further increased starting activity.
Illinois				
Chicago (northwest along I-90, north along Rte. 41, west along Rte. 5)	Ill. Dept. of Commerce 310 S. Michigan Ave. Suite 1000 Chicago, Ill. 60604	Northwestern Univ., Univ. of Ill., Ill. Inst. of Technology, Univ. of Chicago, Bell Labs, Western Electric, Amoco, Abbott Labs, Searle, Gould, Northrup, Fermi Labs, Argonne Nat'l. Labs	Medical research, genetic engineering, biomedical instrumentation, defense elecronics, CAD/CAM, telecommunications	Vibrant venture capital community trying to help area shed image of old-line industrial center.
Indiana				
Indianapolis (north side of city along I-465)	Office of the Mayor 2521 City County Bldg. Indianapolis, Ind. 46204	Purdue Univ., Indiana Univ., General Motors, Eli Lilly, Renault, International Harvester, Naval Avionics Centers	Machine tools, blood chemistry analysis equipment, research on recombinant DNA, micrographics, software	City, county, and International Harvester have set up a $500 million plant to develop a diesel engine. SBIC funding.
Louisiana				
Lafayette "Silicon Bayou" (all of Lafayette Parish)	Lafayette Harbor Terminal & Industrial Development District 804 East St. Mary Blvd. P.O. Drawer 51307 Lafayette, La. 70505	Univ. of Southwestern Louisiana, Regional-Vocational Technical School, Celeron, Shell, Texaco, NASA, Exxon	Printed-circuit boards, microprocessors for oil & gas industry, telecommunications, CAD/CAM, petroleum, helicopters	Although most startups are oil & gas-related, area is growing. Close to New Orleans and Houston.
Maryland				
"Satellite Alley" Montgomery County (along I-270 north of I-495)	Maryland Industrial Dev. Board 1748 Forest Dr. Annapolis, Md. 21401	COMSAT, Fairchild, Litton, IBM, NASA, National Security Agency, National Institutes of Health	Telecommunications, photovoltaic cell manufacture, medical product research, gene splicing	Even with federal cutbacks, job growth outstripped population growth. Research scientists and venture capital plentiful.
Prince George's County (I-95 corridor around Washington)	Prince George Eco. Dev. Corp. 9200 Basic Ct. Suite 200 Landover, Md. 20785	Univ. of Maryland-College Park, Litton Systems, NASA, OAO Corp., Martin Marietta	Defense electronics, telecommunications, software development, microcomputers, aerospace	8,000 new jobs between 1979–1982; new companies have rented 3 million sq. ft. of R&D space since 1980.



Area	Gov't. Agency	Universities, Gov't. Entities, Base Companies	Specialties	Comments
Minnesota				
Minneapolis/ St. Paul (to south, west along Rte. 494)	Minnesota High Technology Council 4900 W. 78th St. Minneapolis, Minn. 55435	Univ. of Minnesota, Control Data, Honeywell, 3M, Cray Research	Medical electronics, computer software, hardware, CAD/CAM, microcomputers	Strong venture capital community has contributed to the rapid growth of startups and spinoffs.
New Hampshire				
"Golden Triangle" (Salem-Manchester-Nashua)	New Hampshire Office of Industrial Development P.O. Box 856 Concord, N.H. 03301	University of New Hampshire College, Lowell Univ. (Mass.), DEC, Bedford Computer, Sanders Associates, Kollsman Instruments, Computervision, Data General	Electronic components, avionic instrumentation, medical instrumentation, word processing equipment, precision sheet metal fabrication	Low taxes and proximity to Rte. 128 spur spinoffs, especially in electronic components. State starting $6 million venture fund.
New Jersey				
Princeton (along Rte. 1 from South Brunswick south to Trenton)	New Jersey Dept. of Commerce & Economic Dev. 1 West State St. Trenton, N.J. 08625	Princeton Univ., RCA, Grumman Aerospace, American Cyanamid, Exxon, Mobil	Telecommunications, aerospace research, office automation, environmental and health science, biotechnology	Forrestal Research Center, a 600-acre corporate park, is under development by Princeton. State plans $100 million for infrastructure.
New York				
Long Island "Tech Island" (western Suffolk County, eastern Nassau County)	New York State Science & Technology Foundation 99 Washington Ave. Albany, N.Y. 12210	SUNY-Stonybrook, Polytechnic Inst. of N.Y., Grumman Aerospace, Brookhaven Nat'l. Labs, Plum Island Nat'l. Labs, Cold Spring Harbor Labs, Harris Corp.	Aerospace, electronic instrumentation, microbiology research, avionics, molecular biology, magnetics	$40 million federal microbiological fund shared by research facilities to create startups. Two venture funds; two more to come.
Ohio				
Cleveland (on a spur of I-480 and Westlake, off I-90 near Rte. 80)	Dept. of Economic Development City of Cleveland 1501 Euclid Ave. Cleveland, Ohio 44115	Lewis Research Center (NASA), Defense Contract Admin. Services, Case Western Reserve Univ., Picker International, Johnson & Johnson, TRW, Bendix	Polymer R&D, factory integration, lasers, robotics, medical instrumentation, fiber optics, medical supplies	A heavy manufacturing location with high labor costs, but good technical labor force. Venture firms, SBICs, and banks becoming more active.
Columbus (around I-270, which rings city)	State Dept. of Development P.O. Box 1001 Columbus, Ohio 43216	Ohio State Univ., Western Electric, Bell Labs, Rockwell International, Battelle Memorial Research Institute	Robotics, welding technology, chemical testing, data processing	57 insurance firms create a natural venture capital pool. Ohio State has robotic center.
Oregon				
Tualatin Valley "Sunset Corridor" (U.S. Rte. 26, west of Portland)	Business & Community Dev. Div. Economic Dev. Dept. State of Oregon 155 Cottage St. N.E. Salem, Ore. 97310	Tektronix, Intel	CAD/CAM	Oldest high-tech area in Oregon still has land for development. 75 high-tech companies in area.
Wilmette Valley (Rte. I-5, from Portland to Eugene)	(see above)	Oregon State Univ., Hewlett-Packard, Spectra-Physics	Microprocessors, personal computers	Still rural; good land values. Close proximity to Port of Portland and Pacific Rim.
Pennsylvania				
Philadelphia (Rte. 202, west and north of city)	Technology Council Chamber of Commerce 1346 Chestnut St. Philadelphia, Pa. 19107	Univ. of Pennsylvania (Wharton), Drexel Univ., Univ. City Science Center, Commodore, IBM	Drug testing and manufacturing, biotechnology, software development, robotics	Universities and community support. Two venture capital funds about to close.
Pittsburgh (three areas: Rte. 28 northwest of city, I-79 and I-76)	Commonwealth of Pennsylvania Dept. of Commerce Harrisburg, Pa. 17120	Alcoa, Pittsburgh Plate Glass, U.S. Steel, Westinghouse, Gulf, Univ. of Pittsburgh, Carnegie-Mellon	Factory automation, metal manufacturing, medical instrumentation, robotics	Carnegie-Mellon offers Engineering/MBA program. Univ. of Pittsburgh setting up 80,000 sq. ft. to lease to new companies.
Texas				
Austin and San Antonio (along I-35 between the two cities)	Texas Industrial Dev. Commission P.O. Box 12728 Capitol Station Austin, Tex. 78711	Univ. of Texas.-Austin, Univ. of Texas-San Antonio, Motorola, Lockheed, Tandem	Microelectronics, semiconductors, software, electronic components, interactive graphic systems	New home for Microelectronics Technological & Computer Corp. New venture funds springing up.



Area	Gov't. Agency	Universities, Gov't. Entities, Base Companies	Specialties	Comments
Texas				
Dallas-Fort Worth (along I-20, which encircles both cities)	(see above)	Univ. of Texas-Dallas, Univ. of Dallas, Texas Instruments, E-Systems, Sunrise Systems, Nuclear Medicine Labs	Software, robotics, defense communications, electronics, nuclear medicine testing	Dallas is most rapidly growing area in state for electronic industries. Good assembly and white collar labor. Banks are friendly.
Houston (bordering I-610 and I-45 north to Woodlands for 20 miles)	(see above)	Texas A&M, Rice Univ., Univ. of Houston, Tex. Medical Center, Litton, Shamrock Computers, Visidyne, Switch Data Inc., major oil companies, NASA.	Seismic instrumentation, oil & gas computers, computer components, personal computers, energy extraction research, avionics, biomedical	State is developing research park with local universities and companies. Texas Medical Center also setting up biomedical research center. Venture capital is plentiful.
Utah				
Salt Lake City (entire city and environs)	Utah Eco. Dev. Div. 200 S. Main St. Suite 620 Salt Lake City, Utah 84101	Univ. of Utah, Univac Aerospace, Eaton, U.S. Steel, Kennecott Copper	Biomedical research, artificial organ production, CAD/CAM, robotics, energy mechanics	The Utah Innovation Center is developing a 350-acre research park to house companies to work with Univ. of Utah.
Virginia				
Fairfax County (part of I-95 corridor and Washington)	Fairfax Eco. Dev. Authority 8330 Old Courthouse Rd. Vienna, Va. 22180	George Mason Univ., AT&T Long Lines, GTE, McDonnell Douglas, Westinghouse	Microwave and satellite transmission, telecommunications, gov't. contracting, defense electronics	Close to Washington regional corporate offices. Unemployment a third of national average. Little manufacturing.
Washington				
Seattle-Bellevue (I-5 corridor from Everett to Tacoma)	Dept. of Commerce and Eco. Development 101 General Administration Bldg. Olympia, Wash. 98504	Univ. of Washington, Boeing, John Fluke Co., Eldec Corp., Squibb, Weyerhaeuser	Software, aerospace, avionics, medical electronics	Smaller, high-tech industries moving in. Venture capitalists and investment bankers recently attracted.

EMERGING HIGH-TECH CENTERS

Arkansas				
"Technology Corridor" (Hwy. 65 from Little Rock to Pine Bluff)	Arkansas Industrial Development Commission 1 State Capitol Mall Little Rock, Ark. 72201	Univ. of Ark.-Pine Bluff and Little Rock, Little Rock Medical Center, BEI Electronics, Pine Bluff Arsenal, Nat'l. Center for Toxicological Research	Engineering instrumentation, lasers, microchips, genetic engineering, electronic assembly	No venture capital firms; startups spinning off from gov't. medical facilities and electronics firms.
Florida				
"Robot Alley" (stretching from Gainesville through Orlando, south)	Fla. Div. of Economic Development Fla. Dept. of Commerce 107 W. Gaines St. Tallahassee, Fla. 32301	Univ. of Fla.-Gainesville, IBM, GE, Westinghouse	Robotics	Florida hopes to become major robotics center. University houses Center for Intelligent Machines & Robotics.
Maine				
Portland	Maine State Dev. Office Statehouse Station 59 Augusta, Me. 04333	Univ. of Southern Maine, Data General, DEC, Fairchild Semiconductor, Sprague Electric	Medical products, blood testing, serum production, computer parts testing	Two venture capital firms formed in last two years. Area dotted with mfg. facilities.
Michigan				
Ann Arbor	Office of Eco. Dev. Dept. of Commerce P.O. Box 30225 Lansing, Mich. 48909	Univ. of Michigan, General Motors, Ford, Chrysler, Bendix	Robotics, artificial vision, quality control, agricultural biotechnology	State has made $375 million in venture capital available to enhance its business image.
New Mexico				
"Rio Grande Research Corridor" (along state-length river)	New Mexico Economic Development Div. Bataan Memorial Bldg. Santa Fe, N.M. 87503	N.M. Tech., Univ. of N.M., N.M. State Univ., Intel, Motorola, Signetics, GTE, GE, Western Electric, Kirkland AFB, Los Alamos Labs, Sandia Labs, Sperry Rand	Microprocessors, lasers, genetic engineering, medical diagnostics	With gov't. and private R&D, the corridor is becoming fertile for startups. State attempting to provide startup capital.

Stronger ties between industry and university call for clear understanding of roles

America's Rising Research Alliance

by Lewis M. Branscomb

Wanted: University to set up lucrative partnership with business desiring research in new technologies. Millions in funding available. Contact director of corporate contributions.

The advertisement, from a recent article in *U.S. News & World Report,* is fictitious, but it dramatizes an expanding partnership between research universities and private companies.

This long and fruitful relationship has rested and continues to rest on industry's need for highly qualified new scientists and engineers, for the results of fundamental research in science and engineering—both of which are essential to a company's ability to innovate and increase its productivity.

Strong and dependable federal support for a broad spectrum of academic research is a major factor in making our universities fruitful places for industrial collaboration. On the other hand, since private investment in a competitive marketplace is the best means for allocating the scientific and engineering resources of industry, it is appropriate that government leave to industry the task of exploiting the knowledge base created by our universities.

The more effectively industry carries out this task, the greater the economic leverage of our public investment in university research. Further, exposure of professors and students to industry's knowledge needs not only helps prepare young scientists and engineers for careers and future technical leadership in industry, but also improves coverage by academic researchers of industrially relevant areas of investigation.

The National Science Board's 14th annual report to the president and Congress (on which this article is based) sets out to illuminate the complex but important processes whereby university scientists participate in the solution of important industrial problems and the industrial community avails itself of the vital public investment in academic science.

Quantitative assessment of the university-industry research connection is difficult, owing to the diverse mechanisms of exchange: contracts, grants, purchase orders, solicited and unsolicited gifts, loans of equipment or facilities, discounts on equipment purchases, personnel exchanges, scholarships and consulting arrangements. These are just the principal forms and universities and corporations have kept track of only some, and then not necessarily consistently.

Data from National Science Foundation surveys on dollar support of research in universities—which are more or less limited to tracking grants and contracts—suggest that from 1960 (and probably from 1953) to 1965, the industrial share of university research and development support remained virtually flat in constant dollars. Industry's percentage share of support, however, fell sharply—from just over 6 percent in 1960 to below 3 percent in 1965—due primarily to rapidly growing federal support. Since 1965, industry's share has remained at 3-4 percent, but, in constant 1972 dollars, that support for university R&D has doubled.

Available data also suggest a strong variation in this support, by field. Over the past decade, for example, it appears that 6-10 percent of all academic engineering research was supported by industry.

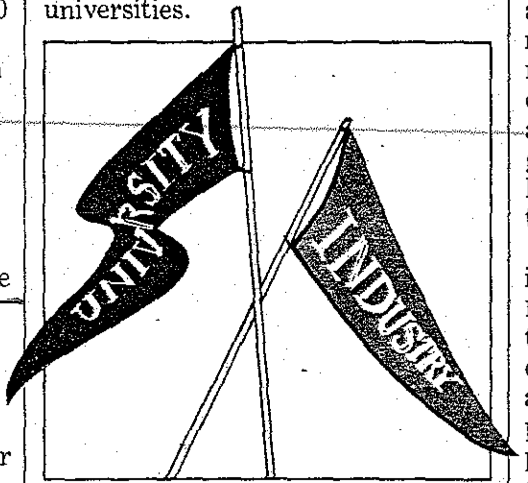
The relative magnitude of academic research supported by corporate contracts, on the one hand, and by corporate philanthropy, on the other, is not clearly understood. An educated guess is that academic research supported by corporate gifts and grants roughly equals that supported by corporate contracts.

The signs of increased traffic between companies and campuses are numerous:

☐ Major chemical companies have established a Council for Chemical Research, aimed at funding academic research and forging new relationships between academic and industrial chemists and chemical engineers.

☐ The Semiconductor Industry Association has set up a nonprofit subsidiary, the Semiconductor Research Cooperative, designed to encourage increased efforts by manufacturers and universities in long-term semiconductor research and to add to the supply and quality of professional degree-holders in the field. Expenditures of $20 million over the next two years have been planned.

☐ A variety of consortialike programs in which several companies jointly provide support for focused academic research have generated a surprising amount of support. Caltech's Silicon Structures Project and Stanford's Center for Integrated Systems (*page 13*) were early examples. More recently, 12 U.S. firms joined together to form the Microelectronics and Computer Technology Corporation, a consortium that plans to pool the costs and share the results of advanced computer research, some of it conducted in universities.



☐ Another significant development is documented in a survey conducted by the National Governors Association. This survey of all 50 states looked for programs to spur technological innovation and productivity growth. At least 88 separate initiatives were found under way with state leadership, many involving public-private partnerships.

☐ In addition to these collective efforts, a number of individual companies are stepping up their support programs. IBM Corporation (an NAM member) for example, gave more than $22 million in grants to U.S. educational institutions during 1982, compared with $17 million in 1981. Our most important relationships with universities, however, arise through collaborative activities on technical problems of common interest. At last count, IBM had more than 400 such projects with 100 U.S. universities.

It seems clear, in recent times at least, that all administrations, regardless of their political and economic complexion, have viewed the university-industry research connection as a positive and desirable element in national economic policy. They have differed, however, in their concepts of the appropriate government role and in their degrees of emphasis on different means to encourage this relationship. The current administration's approach reflects the fact that effective long-term university-industry research interaction will be based on the perceived worth of the university work by the industry—not on initiatives originating in Washington by third parties.

While previous administrations had attempted to develop government-directed programs for the stimulation of research and development in general, or university-industry research interactions in particular, President Reagan's administration demanded a more limited view of government intervention in the private sector.

The principal thrust of the new policy involved provision of incentives for R&D investments through tax legislation. The Economic Recovery Tax Act of 1981 includes several provisions aimed at stimulating increased support for R&D by industry. Two sections provide specific tax incentives for gifts of research equipment to universities and for the conduct of research in universities sponsored by companies with growing R&D investments.

Why should universities and companies cooperate? Company representatives cite many reasons for their interest in establishing research interactions with universities. Mentioned most frequently in an NSB-commissioned study were

☐ access to manpower (students and professors),
☐ access to technology,
☐ problem solving or obtaining needed information,
☐ prestige or enhancement of the company's image,
☐ use of an economical resource,
☐ general support for achieving technical excellence,
☐ proximity, and
☐ access to university facilities.

Universities interact with industry mainly to acquire funding for basic research and graduate training, or to support the facilities that make research possible. In general, industrial funding is seen as involving less red tape, and reporting requirements are seen as less time-consuming than equivalent support from the federal government. Other motivating forces for a university to seek industrial support for its research are as follows:

continued

- access to scientific and technological areas where industry indisputably has special expertise,
- the opportunities through industrially sponsored research to expose students to new insights and practical research problems that may be of immediate importance to society,
- availability of some government funds for applied research where a university joins with industry, and
- job expectations for graduates.

Another potential role for university-industry relationships is improving the participation of minorities in research. Many companies, of course, are active in sponsoring minority fellowships, loaning employees to teach courses and help develop curricula, and otherwise encouraging minority enrollments in science and engineering. But only a handful so far have seized the abundant opportunity to collaborate in building research programs (of mutual benefit) at predominantly minority universities.

An historical perspective also teaches that, in different time periods, universities dominate some fundamental research areas and industry dominates others. Molecular biology and biotechnology were long creatures of academic research laboratories but are now being rapidly assimilated into industrial laboratories as their commercial potential unfolds. Research on polymers and catalysts was carried forward for years in industrial laboratories, and universities began to make contributions at a later stage. The same has been true in microelectronics and computer engineering. Thus, technical experience may flow in either direction and, more commonly, in both directions.

How do universities and companies cooperate? Assuming that the parties are sufficiently motivated, cooperation involves some key transfers:

Resources. General gifts in support of university research are highly valued because of their flexibility and because they provide benefits that greatly exceed the dollar percentage of support. Such funds, for example, may be used to begin new projects, help young scientists get started, or provide for travel to conferences.

Cooperative Research. Unlike donations of funds, equipment, research facilities or endowed contributions, cooperative research essentially involves interactions of people and offers the most creative movement. Three principal approaches are found in institutional agreements:

- The greatest dollar support to universities from industry is through individual research agreements involving university researchers. Industrial support in this mode is generally mission-oriented and specific to a research program or project, with fairly immediate benefits in mind.
- Another approach, more sweeping in scope—though not necessarily in total funding—is to broaden participation and, at the same time, create stable industrial support of university research by engaging firms through an industrial affiliates program or consortia arrangements. Emphasis is on individual contacts between the representatives of member companies and the faculty, staff and students in the program. Access to students is the prime motivation for companies to join such programs.
- A third approach to cooperative research involves the use of university facilities. Research centers and institutes, for example, help attract industry support by providing coordinated research and/or equipment in a central facility.

> "Private industry has neither the resources nor the intention to compensate for any substantial cuts in publicly funded academic research."

Personnel and Information Exchanges. Forging stronger ties between universities and industries is best accomplished by personal interactions among scientists. Informational contacts—seminars, speaker programs, consulting, personnel and publication exchanges—are the most frequent means by which a university-industry research link is forged.

The availability and desire for resources, personnel and information does not ensure that a flow in either direction will ensue from those who have to those who want. Inertia, uncertainty, institutional sloth, rejection, disincentives of various kinds all take their toll of initiative in university-industry interactions.

Despite the fact that these exchanges are proceeding rapidly, academicians often attribute a lack of sophistication to industrial researchers, while company people are often skeptical of the capacity of academicians to produce useful and timely research. These negative stereotypes do not necessarily prevent the parties from "doing business" when mutual interests coincide, but they may inhibit seizing opportunities and unnecessarily protract negotiations.

There are also real limits to joint activity, including limits on available faculty time and industrial resources. Other limitations are imposed by the university's need to fit most research into pieces that meet the requirements for Ph.D. theses in terms of scheduling, depth, originality and sophistication of the work. Further, patent and license rights, the right to review manuscripts for possible proprietary information and other critical questions frequently cause difficulties in negotiating agreements. Fortunately, such problems can be resolved when mutually perceived needs are pursued in an atmosphere of trust and willingness.

In their pursuit of new sources of support for research and teaching, universities have been rightly concerned about protecting the freedom of inquiry that is at the heart of their real contribution to society. A critical issue for them is how to ensure that the professor's teaching and research agenda is enriched and informed by, yet not subordinated to, his contract research or his technical consulting.

What's important here is that university-industry partnerships must respect the needs of both partners. I don't believe, for example, that companies should use universities for near-term proprietary projects or for development. Generally speaking, universities should not be asked to do proprietary work and should remain free and open. Companies should control what must be controlled and not depend on universities to do it for them. The roles of industry and academia are different and we should not confuse them.

CLOSING THE GAP

NAM's agenda for high technology includes the following statement:

The advantages of increased cooperation between industry and the academic sector are most clearly seen in the rapidly burgeoning joint arrangements in commercial operations. These types of relationships have been most evident in the biotechnology, robotics and computer fields. The academic environment has led many high-tech firms to locate near a university to tap into the pool of expertise.

Yet, despite these obvious areas of common interests, the gap between university education and industry needs appears to be widening.

Funding. The major boon provided to universities in the 1960s and 1970s of increased federal support has, in a time of fiscal constraints, been eroded. At the same time, industry funding of basic research has declined on a percentage basis. This creates difficulties for universities striving to maintain standards and levels of activity.

Academic Freedom. The expanding role played by industry in academic affairs in funding and cooperative agreements has led to concern over the pursuit of knowledge and learning. Academic researchers entering into contracts with industry often are accused of violating ethical educational values, such as open communication, free dissemination of research results and independent choice of research topics.

Contractual Arrangements. Concern has also been expressed over commercial relationships governing disposition of corporate patent rights and licensing arrangements. Academic researchers feel such conditions may delay publication of research results, adversely affect the educational process and prevent promising lines of research from being pursued.

Solutions. NAM supported the passage of P.L. 96-480, the Stevenson-Wydler Technology Innovation Act, which established several cooperative programs within the Department of Commerce to improve industry-university relations. NAM supports funding of these programs at statutorily authorized levels.

☐ NAM supports tax, regulatory and other policy measures that provide incentives for limited research and development partnerships (promoted by the U.S. Department of Commerce) between industry and universities.

☐ NAM supports measures that seek to prevent disputes over the disposition of patent and licensing rights.

Despite the questions raised earlier, there is optimism about the likelihood of increased university-industry research interaction during the 1980s. Three general factors characterize this change:

First, product and process improvements in some industries have evolved to such levels of complexity that not only is an understanding of fundamental physical and biological phenomena required but also much higher levels of training in and use of basic science and engineering. Manufacturing is becoming process-oriented rather than assembly-oriented. And while this type of manufacturing is easier to automate and is more productive, it also calls for much greater involvement with the fundamental properties of the materials being worked. In microelectronics, for example, when puzzling phenomena occur, the manufacture of circuits is pushed down to ever smaller dimensions. These phenomena must be explained before further progress can be made.

Further, incremental advances in narrowly focused technical areas—characteristic of much industrial development in the past—are giving way to the use of a broad range of science and engineering disciplines on complex, often ill-defined problems, or exploitation of new analytical capabilities. Hence, it is becoming increasingly difficult for any one industrial laboratory to fully encompass the requisite expertise. A partial remedy for this situation is to seek out the pertinent skills wherever they may be found in the nation's universities.

And, finally, the rapid expansion of the nation's R&D system over the past three decades has diffused research capabilities over a much broader range of institutions—academic and industrial—than ever before. Thus, it is quite unlikely that any one company could hold and maintain a leading edge on technical advance in a given area.

It remains a fact of life that, should corporate contributions to academic research double or even treble, they would still support only a small portion of the total academic research effort, and such support would be concentrated in selected fields.

The implication is clear: If the present level of academic research is to be maintained, the principal burden will continue to fall on the public purse, federal and state.

The most essential contribution of state governments is to provide a support base for fundamental research through the expectation that professors on state salaries devote a significant portion of their work time to research. Teaching assignments should reflect this role.

The federal government supports the majority of fundamental research in the country, most of it in universities. Beyond this contribution to national strength, the role of the federal government is, and should be, limited to encouraging, not directing, university-industry relationships.

Clearly, the future paths for university-industry cooperation will depend on the way that each university and corporation perceives the essential role of the university. If the university moves nearer to a partnership with industry, more resources can become available. But the university may relinquish some of its unique freedom of action. There are no absolutes and the issues become matters of degree and common sense. The primary requirement, therefore, is not so much increased partnership, but increased understanding of each other's role. ■

Lewis M. Branscomb, vice president and chief scientist for International Business Machines Corporation (an NAM member), is chairman of the National Science Board and a member of President Reagan's National Productivity Advisory Committee. Copies of the board's 14th annual report (*see text*) may be obtained from the NSB at 1800 G Street, NW, Washington, DC 20550.

COLLABORATION BASED ON TRUST

by Howard A. Schneiderman

The Monsanto way of forging ties with academia

Controversy provokes change. A current controversy that promises to significantly change the relationships between universities and industry stems from the increasing number of joint research contracts being developed by America's research universities and research-driven companies. What are the pros and cons?

Supporters of research collaboration between universities and corporations argue that the research talents of America's great universities are unsurpassed in the world. They suggest that these talents, coupled with the splendid technological and product development skills of American industry and our national entrepreneurial spirit, could accelerate both basic research itself and the application of basic research. They see hybrid scientific vigor emerging from such collaboration—a vigor that would keep America at the leading edge of scientific, technological and industrial change and ensure that it remains the leading scientific and economic power in the world. They also argue that without such university-industry collaboration, American industry may lose its technological leadership in key areas to industry—university-government consortia such as those established by the Ministry of International Trade and Industry (MITI) in Japan. As a consequence, key American industries may fail in the international marketplace. Finally, they point out that university-industry collaboration can provide important research funds to universities, which largely support basic research.

Detractors suspect that contracts between companies and universities threaten academic freedom by discouraging basic research and the sharing of knowledge. They believe that such collaboration will undermine our system for discovery of new knowledge and training the scientists and opinion leaders of the future. They question whether our universities are morally strong enough to withstand what is construed by some to be the corrupting influence of big business. In particular, they believe industry will encourage universities to pursue excessively utilitarian goals and to neglect long-term fundamental questions. And some of them question whether it is sensible for public companies to invest research dollars in university research, where the companies' control over conduct of the research is limited or nonexistent.

I understand the hesitation of some of my scientific colleagues in universities and their concerns about protecting academic freedom. I agree that the university must be protected and nurtured as a place for pure scholarship, a place to some extent insulated from excessively utilitarian goals.

If, in the interest of short-term rewards, corporations damage the basic intellectual structure of America's universities, they will kill the goose that lays the golden egg. I am convinced that America's major corporations recognize this and are sensitive to the importance of the university as society's main arena for the discovery of facts, explanations and ideas. Monsanto certainly understands the importance of great, independent, research universities. Yet we have become convinced that industry-university research collaborations can benefit academic institutions, industry and society.

Today, Monsanto is a participant in several research collaborations with U.S. universities. In 1982, the company announced a five-year, $23.5-million agreement with Washington University in St. Louis to conduct research on proteins and peptides that regulate cell function. Also in 1982, Monsanto signed an agreement with Rockefeller University for a five-year, $4-million basic research program in plant photosynthesis.

Since Monsanto creates and sells science and technology, our company has a vested interest in the future of the scientific endeavor in this country.

We see the nature and direction of science changing, primarily in its quickening pace—with sharp accelerations recently.

- ☐ The time between making a discovery and having it enter the commercial world is getting shorter, particularly in the life sciences.
- ☐ Technology transfer from the university is also quickening—more of what the university discovers can be applied by industry than was the case 20 years ago.
- ☐ The traditional boundary lines between basic and applied research—or between university and industrial research—are blurring rapidly.
- ☐ Funding patterns are changing. Nondefense federal research spending has slipped 38 percent in constant dollars since 1967, with nearly half this decrease over the past two years.
- ☐ International competition in high technology is becoming increasingly

intense. Japan, for instance, has legislatively created cooperative agreements among government, industries and universities.

All these factors are pushing industry and universities into a reassessment and redirection of their roles in science. We are finding ourselves becoming logical partners for scientific innovation and technology transfer.

Monsanto supports this concept of partnership because it is one means of adapting to competitive change. Market forces, for example, have led, or driven, an increasing proportion of American industry toward higher value-added products—products that rely increasingly on science and technology transfer. The lines between the chemical, agricultural, medical and drug, textile and computer industries are growing less and less distinct.

While this change offers us the opportunity for synergy between what have traditionally been different technologies and sciences, it also produces the problem of developing new and needed skills.

Molecular biology is an example. Chemical or drug companies cannot match the massive skills that have evolved in America's great research universities. But we need this science and technology to develop products that meet basic human needs. One way to accelerate this process is to work with universities.

Monsanto's association with Washington University is part of a plan to bring original science and technology to bear on problems of great social and commercial importance. By using and supporting the research skills of this distinguished academic institution, Monsanto enhances not only its own competiveness in changing world markets but also America's.

Stephen Wagner

About 15 years ago, Monsanto and Washington University entered into an agreement with the Office of Naval Research to conduct scientific investigations on high-performance composite materials. That collaboration and a later association with Harvard University served as a precedent for the recent agreement with Washington University.

Neither Monsanto nor Washington University views the agreement as a formula for other companies and universities to follow. It was designed to suit the particular cultures of these two particular institutions. It may be useful, however, to enumerate the contract elements we believe critical for undertakings of this sort.

Negotiations started two years ago, when Monsanto scientists began talking with David Kipnis, chairman of the Department of Medicine at the Washington University Medical School, and his colleagues. In those two years of careful planning, Washington University and Monsanto developed a plan for bringing the benefits of important medical discoveries to the public faster than would otherwise be the case.

The goal of the Washington University agreement is to provide society with health-care products. Yet, at the same time, it specifies that 30 percent of the research conducted is to be allocated to the pursuit of fundamental biological questions. The other 70 percent is focused on cures for as yet incurable major diseases.

Provisions were made for specific project agreements. The Washington University contract not only builds a framework for these but also establishes a joint advisory committee made up of four Monsanto representatives and four from the university to decide what research will be supported.

The presence of this committee enables the undertaking of a broad variety of research as well as a competitive situation for the awarding of research funds. The university tells the committee what research it is doing or wishes

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to do. The committee selects projects it believes offer the highest promise for solving important health-care problems. If the committee elects not to support a particular research endeavor, the university probably will seek other sources of funding.

Academic researchers retain their freedom to publish; the agreement establishes a 30-day period for Monsanto to review any manuscript.

The contract also calls for an independent oversight committee of leading citizens from the scientific and academic communities and public arenas representing society's stake in the research. There is a special requirement for a scientific peer committee to review the work after a certain time and to assess its scientific merit and impact on the two institutions.

This all leads to a mutual exchange of ideas among scientists. Because of the proximity of Washington University to Monsanto (only 15 minutes away) and because of the rapid growth of biological expertise inside the company, this will be a true collaboration. Monsanto scientists will work on each project with Washington University scientists, in their labs and our labs.

Monsanto has the exclusive right to license any patents that may come from the research. This important provision is basic to how effectively this research collaboration will serve the ultimate beneficiary: the public. The forte of academic research is fundamental investigation: the R, if you will of R&D. While industry is also capable of doing highly original research, the place where it excels is in the development phase, or the D of R&D. Development is an expensive, time-consuming, high-risk process. For every research dollar spent on discovery, it takes hundreds more to develop that discovery into a useful product that can be manufactured and sold in the marketplace.

No less significant is the time commitment. A rule of thumb is that it takes at least 10 years to go from the original discovery to a product on the shelf. That was true of the Lasso and Roundup herbicides as well as the AstroTurf stadium surfaces we developed. To develop plant-growth regulators that will enhance the yield of major crops, Monsanto already has spent well over a decade and tens of millions of dollars. Yet it still has not commercialized an important plant-growth regulator.

Obviously, a company cannot afford to invest shareholders' money in this kind of high-cost, long-term development process without some guarantees that success will provide an opportunity to recoup the investment.

In the future, we may expect to see more companies and more universities forging partnerships. Hopefully, each partnership will be tailored to the particular university and corporate cultures involved. But, in all cases, the keystone to the success of the partnerships will be the regard in which each partner holds the other. Integrity and mutual trust are essential. So is a deep conviction that the rights and interests of both parties must be safeguarded.

By accelerating the processes of discovery and technology transfer, these partnerships can help university researchers better understand some of society's important needs and enhance their ability to meet those needs. Conversely, industry stands to gain through an infusion of basic knowledge that will enhance its own applied research. New perspectives and new ways of thinking should emerge from both institutions.

The controversy over industry-university collaboration is resulting in change—positive change that can enable America to remain a technological leader in a world of increasing competitive challenge. To maintain that leadership, however, we must ensure that the rights of both institutions are secured; and we must demonstrate that society is the ultimate beneficiary of these relationships. ■

Howard A. Schneiderman is senior vice president of research and development at Monsanto Company (an NAM member) in St. Louis, Mo.

ROBOTICS RESEARCH

Researchers from five corporations are working with scientists at Purdue University, Lafayette, Ind., in a major effort to develop the first factory that will be computer-controlled—from product design to the loading dock.

The Computer-Integrated Design, Manufacturing and Automation Center (CIDMAC) is a cooperative venture organized by Purdue and sponsored by Cincinnati Milacron, Inc.; Cummins Engine Co., Ind.; Ransburg Corp.; and TRW Inc. (all NAM members); and Control Data Corp. It was established "to attack problems of productivity and innovation in American industry," explains John C. Hancock, dean of Purdue's Schools of Engineering.

While acknowledging that other universities and private firms have also teamed up to tackle the productivity dilemma, Hancock claims the CIDMAC approach is unique. Center researchers will seek to integrate the traditionally separated functions of computer-aided design (CAD), computer-aided manufacturing (CAM), robotics, group technology, and simulation of product processes and management techniques for production management.

Several research projects entail designing "more intelligent" robots:

☐ Improved tactile sensing would make robots capable of bringing objects together—a "must" in the fully automated factory of the future.

☐ Sight capability would especially improve the inspection process.

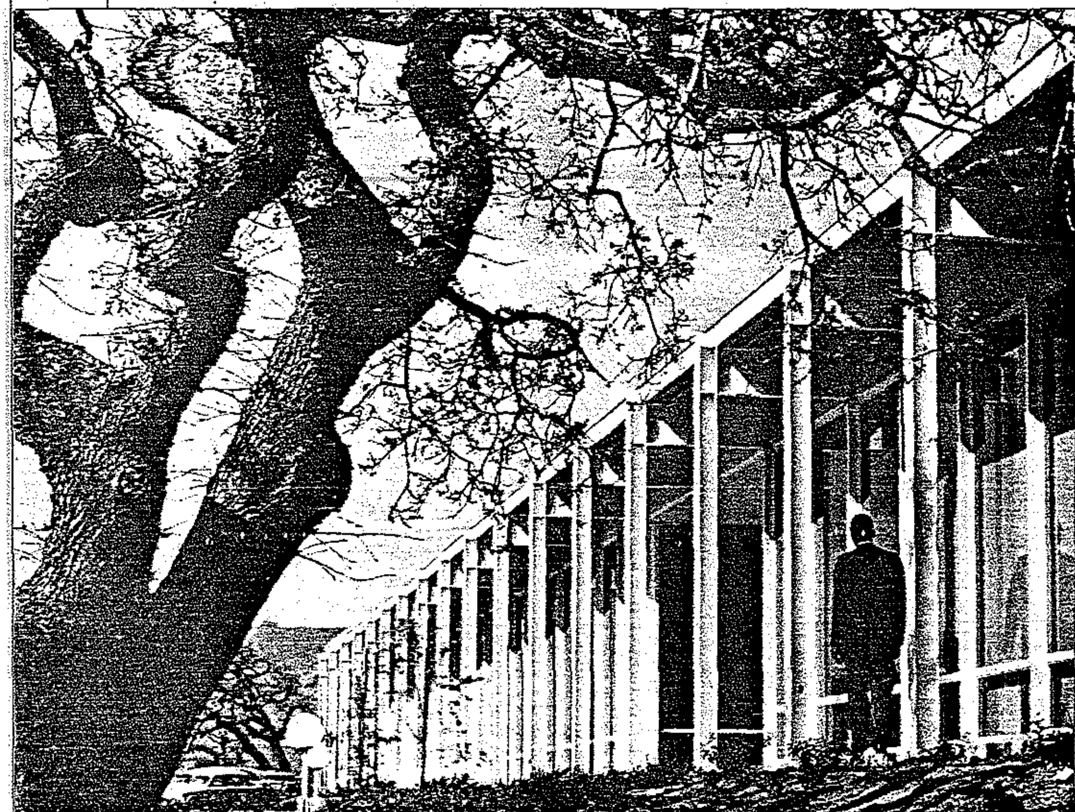
☐ Flexible fixtures would allow a robot to automatically adjust itself to parts. At present, "cradles" for holding the parts are not flexible and must be replaced each time a different or new part is manufactured.

☐ Cooperative work projects would improve work flow and efficiency. Currently, robots are capable of interacting with other machines, such as computers, but cannot work with other robots to share work tasks.

☐ Free-moving vehicles would improve flow-time and inventory by a factor of 10 and reap dramatic improvements in productivity. At present, robot vehicles that carry parts or pick up objects are guided by cables around the plant, making direct point-to-point trips impossible.

The industry-academic coalition does not expect instant results but is confident of significant increases in productivity—without sacrificing human values.

THE GROVES OF SILICON



Stanford University

Stanford's community of technical scholars and how it grew

by Bob Beyers

What *Fortune* magazine has described as the world's leading center for new technology—Silicon Valley—was the handiwork of the late Frederick Emmons Terman.

Terman, who joined the Stanford faculty in 1925 and was its provost from 1965-1975, also set the stage for an era of unprecedented collaboration between that university and industry.

Even before World War II, Terman was instrumental in encouraging talented students to start their own business ventures. After the war, he explicitly recognized the potential for combining federal research funds, academic programs and industrial development. And Silicon Valley was born.

In 1937, Terman encouraged two of his graduate students, William R. Hewlett and David Packard, to build an audio-oscillator, a device to generate signals of varying frequencies. Starting in a Palo Alto garage, they proceeded to build a worldwide, multibillion dollar electronics firm.

In the same year, at Terman's suggestion, a Stanford physics professor, William W. Hansen, gave Stanford graduate student Russell Varian and his brother, Bill, work space and $100 for materials. In return, they offered the university half the royalties from any inventions they made.

Their invention of the klystron tube played a key role in improved radar for Britain during World War II, provided the basic technology for the Stanford Linear Accelerator Center and now is used in cancer treatment. The univer-

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sity realized millions of dollars in royalties on the patent.

Working closely with Stanford's then-president, Wallace Sterling, and others, Terman played a central role in setting up the Stanford Industrial Park in 1951. Hewlett-Packard and Varian Associates were among early tenants. Today, the park's 90 firms employ about 25,000 people on campus lands adjoining faculty housing.

Terman deliberately sought to create a "community of technical scholars." He did so by picking promising areas for basic intellectual discovery, then seeking the best people to build what he called "steeples of excellence."

Faculty were free to spend one day in seven consulting. Some were instrumental in bringing firms directly to the industrial park. Chemist Carl Djerassi, the father of the contraceptive pill, brought Syntex and later became president of Zoecon.

Terman's recruitment of William Shockley, coinventor of the transistor, from Bell Labs in the mid-1950s, eventually led to the creation of 55 electronic firms in Silicon Valley.

Stanford's recruitment of Arthur Kornberg, Joshua Lederberg and others laid the intellectual foundation for the emergence of biotechnology in the Bay area.

The driving factor was intellectual, not industrial. But individuals were free to get their hands "dirty" developing their ideas, within guidelines that assured their basic academic responsibilities were met. Computer Curriculum, Telesensory Systems, Catalytica and Failure Analysis Associates were among the many firms springing up on the basis of faculty research or consulting.

Terman created an honors cooperative program, enabling hundreds of employees, regularly admitted as graduate students, to take courses direct from campus classrooms to more than 100 firms, realizing more than $3-million annually in revenues. Most of the proceeds are plowed back in support of professors' salaries.

An innovative technique, called tutored video instruction, pioneered by Prof. James Gibbons, extends further the reach of Stanford, using a combination of videotapes, regular course materials and local talent to keep professionals up-to-date.

Another means of enhancing Stanford's academic ties with industry for mutual benefit was the creation of industrial affiliate programs in more than 20 fields, ranging from applied math, chemistry and construction to synchrotron radiation and Northeast Asia policy.

Managed by faculty members, these affiliate programs enable sponsors to meet on campus and review research, obtain publications and discuss nonproprietary questions or key problems in advancing the state of the art in their field. Affiliate programs also give graduate students direct exposure to industry.

In the post-war period, both at Stanford and as general procedure elsewhere, a fairly standardized historical sequence of innovation has emerged.

The first phase is publicly funded and oriented toward the discovery and explanation of basic phenomena. It is characterized by loose, informal organization and very open communication (which includes quick publication of all details of an experiment).

The second phase is best called application. It is focused on processes and takes place in various settings: applied institutes, some university departments (of engineering, for example), nonprofits (such as SRI International or the Battelle Institute) and industrial laboratories. There is a mix of public and private funding and environments that are variable with respect to proprietary secrecy.

In the third stage—development—attention is given to practical application, including such matters as scale, rates and means of economical production. The innovation emphasis is on products; funding is by private risk capital, and the environment tends to be closed for proprietary reasons and tightly managed. All such work takes place in commercial laboratories.

Stanford President Donald Kennedy, a biologist and former commissioner of the U.S. Food and Drug Administration, points to a time of transition: "Now we are seeing a revolutionary compression of this three-stage process or innovation. The social sponsorship of discovery is being rearranged in a very fundamental way."

Kennedy believes the following factors contribute to this trend:

☐ A number of scientific disciplines are now being recognized as "ready" for accelerated application. As a discipline matures in power and confidence, leaps from the laboratory to applications that once seemed intimidating become commonplace. This now appears to be the case, for example, in immunology and genetic engineering, as well as in microelectronics.

☐ There is a growing social awareness of the importance of scientific discovery to national productivity and a consequent impatience with the traditional time requirements for diffusing technology to the public.

☐ Concern is increasing in research universities—where more than two-thirds of the nation's basic science is done—about the retreat in public support for research. Federal funds for nondefense research have shrunk by about 33 percent in real dollar value since 1968. Half this decline took place in the first two years of this decade.

☐ Perhaps most unexpected of all, the venture-capital financing of small, research-intensive firms in fields such as biotechnology and microelectronics has been transformed. Since major changes were made in the capital gains tax, the investment funds available for such ventures have jumped from an estimated $70 million in the mid-1970s to about $1.5 billion in 1982.

The Stanford president tracks the developments: "Very large changes in value can take place with successive generations of private investment in high-technology firms and larger changes still when the firm goes public. At its initial public offering, for example, Genentech was valued at $38 per share. Then it soared to $80 before settling down.

"Despite some disillusionment about the soundness of biotechnology investment, Wall Street was quick to learn that in this new work, big potential is associated with early possession of an idea.

"The result is an entirely novel mixture of influences on university scientists and their institutions. For the university itself, there are new and challenging pressures on investment policy (Does the institution go into business with its own faculty?), on technology licensing (Should the university license inventions to faculty-led ventures?—to their competitors? And if yes, under what terms?), or research contracts with industry (What restrictions on communication are acceptable and should there be full disclosure of terms?), and on policies relating to consulting, faculty, conflict of interest and the protection of graduate student interests."

As the Stanford president points out, "many of the problems are simply not solvable by the institution alone. For the scientists themselves, and the 'invisible colleges' that hold them together in national and international networks, there are other questions such as: How much can or should they guard against the withholding of information and exchange for proprietary reasons? How much involvement outside a faculty member's primary institutional affiliation is appropriate?

"In general, this new climate offers more opportunities than problems. What we must try to do is involve industry more productively and creatively with university research components and the division of faculty time between on and off-campus ventures."

Two promising industry-university collaborative ventures involving Stanford illustrate how these objectives can be achieved.

Stanford recently broke ground for a new Center for Integrated Systems (CIS), dedicated to fundamental explorations of what would popularly be called microelectronic chip development. Its purpose, however, is not to get a jump on the market by developing the next generation of integrated systems, but to advance the overall state of knowledge by orders of magnitude.

Without industry support, Stanford's Center for Integrated Systems would not exist. With industry support, Stanford has an exciting opportunity to discover fundamental knowledge in an area full of promise.

The basic arrangement is this: 19 leading industrial firms in microelectronics and physics each have pledged to contribute $750,000 for the construction of a building to house CIS. Once the building is completed, those firms will contribute annual dues to the center.

In return, those firms may participate in the CIS program by sending to the center one visiting scholar, approved by Stanford, to work with the CIS faculty on fundamental research.

The rules under which research is conducted at CIS are quite clear: A free and open flow of ideas and swift publications of results are a mandate.

"Industry in general gains from such ventures by assuring that fundamental work in this area will be undertaken," Kennedy emphasizes. "The particular affiliated firms gain through their exposure to new ideas in these fields and to the faculty leaders who are asking the new questions. Perhaps most important, the sponsors have a chance to become acquainted with bright students, whose education we also hope to enrich through the center."

A second arrangement, providing a rather different model for the development of new industry-university collaboration, is the new nonprofit Center for Biotechnology Research. It will fund research in genetic engineering and biotechnology, and is affiliated with a for-

> "The driving force was intellectual, not industrial. But individuals were free to get their hands 'dirty' developing their ideas."

profit firm, Engenics Inc., which will seek to develop commercial opportunities in the same field.

Six major firms collaborated in financing the new entities. A unique feature of the arrangement is that the center will hold 30 percent of the equity of Engenics, and its charter provides that any capital appreciation and dividends realized on Engenics stock be devoted to the further support of basic university research as determined by the trustees of the center.

Stanford owns no equity in Engenics, nor will Stanford lay any special claim to research funds available from the center. The six sponsoring firms of the center and Engenics may have licenses to any patents developed in the center's funded projects, but these licenses will be offered at commercial rates and in accordance with existing policies at the universities.

"The novelty of the research agreements with the Center for Biotechnology comes not from any special conditions developed by the universities," explains Kennedy, "but from industry's willingness to form a new funding consortium for university-based research.

"These new forms of industry involvement in university research did not emerge easily; they evolved out of a process of hard negotiation.

"The condition under which university research flourishes—open and free exchange of ideas—is really quite different from the proper and necessary secrecy that shrouds end-product development."

Sponsoring research, Kennedy continues, "is not the same as making a charitable contribution. The same firms that make charitable contributions for philanthropic reasons, rightly insist on getting their return, even if long-term, from sponsored research.

"For their part, universities have no objection if their research benefits business. Indeed, they rather like the idea, but they are zealous about ensuring that the conditions essential to free inquiry for teaching and research are not compromised."

In congressional testimony on behalf of the Association of American Universities and the National Association of State Universities and Land Grant Colleges, Kennedy has backed tax credits for business firms that sponsor basic research at universities.

Besides providing an incentive for fundamental research that individual firms often cannot undertake alone, such tax credits would, as a critical by-product, train scientists and engineers more attuned to the needs of industry.

"We must find a way to increase the rather small proportion of industry contribution to university research—it is around 5 percent at Stanford and averages only about 3.5 percent for U.S. research universities—without launching a migration of the universities' best research talent into industry," Kennedy emphasizes.

While it cannot substitute for sustained, large-scale federal funding of basic sciences (*page 4*), increased industry support could help meet the critical need for instrumentation in university laboratories, buffer long-term research from sharp fluctuations in federal funds and further quality training of future researchers.

Hewlett-Packard recently announced a $6-million program to encourage promising graduates to continue teaching after completing their degrees—in essence, rewarding

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them for not coming to work on the company payroll.

If Stanford's experience is any guide, such long-term concern for academic quality—a concern that today extends far down into the primary and secondary schools—is vital for maintaining a strong, productive economy.

Innovation and entrepreneurship both remain vigorous on campus.

Stanford's faculty of 1,100 produces an average of nearly three inventions or processes a week that are reviewed for possible licensing. Gross income from technology licensing topped $2.5 million last year.

"We are in the third year of a very high rate of discoveries—two or three per week—which shows no sign of abating in the near term," notes Director Niels Reimers of the Office of Technology Licensing.

"Molecular biology and information sciences are the areas of greatest activity," he notes. In these areas, the technology often involves tangible research property (TRP), such as a piece of biological material or a computer software program. University rules make TRP promptly available to scientific colleagues while protecting its commercial value. A recently established Software Distribution Center helps meet these objectives.

Biological products of greatest research and commercial interest are hybridomas, DNA probes and plasmids. So far, researchers have made more than 100 disclosures of biological materials to the Office of Technology Licensing.

During 1981-82, Stanford received income from 56 separate technologies. Earned royalty income on sales came from such products as a biological cell sorter instrument, text-editing software, a chemical reagent, an infant hearing-detection system and an infant transporter, an insect attractant and hybridomas.

Advance payments were received on FM-sound synthesis for musical instruments, human hybridomas, acoustic microscopes, computerized axial tomography (CAT) technology, blood-flow detection systems, cryptology systems and computer-aided design software.

"The gestation period of a university discovery until significant income from sales is received is generally long," Reimers observes. "In 1981-82, more than 88 percent of the income came from cases disclosed to the Office of Technology Licensing in 1974 or earlier."

Unlike most industries and many other universities, Stanford permits individuals to retain a one-third share of net income from their inventions. Another third goes to their department and the rest to their school. While small, these funds are growing fairly rapidly and provide continued support for campus R&D.

Hundreds of students, both graduate and undergraduate, have attended student-organized conferences on entrepreneurship in the past two years, scores creating their own companies.

Computer software is the hottest single field. Other ventures range from fiber optics and new methods of drilling for oil to earthquake safety inspections for homeowners, books, chocolate-chip cookies and truffles.

There's no rigid, lock-step master plan involved.

As in Stanford's many relations with business and society generally, there's a concern for finding bright people, creating a climate where their talents can flourish in a wide variety of ways, and—hardest of all—having the patience to wait years, even decades, to see how it all comes out. ■

Bob Beyers is director of Stanford University News Service, Stanford, Calif.

SCIENCE HAS ITS DAY

by Theodore M. Hesburgh

Wouldn't the world really be a better place if we could replace the current leadership—the politicians, the philosophers, the lawyers, the humanists, and the theologians—with scientists and engineers?

I am sure that this question, on the surface, sounds somewhat preposterous, but there are scientists who profess to have an answer for everything, who have been disillusioned by political and legal forces, who often feel unduly inhibited by philosophy and theology, who legitimately bristle when they are portrayed by the humanists as the new savages, bringing the world to the brink of destruction.

One might make the point that the nonscientists acted mighty selfishly themselves when they had their day. I must resort to some oversimplification here, but I think the main point at issue will be evident.

The Greeks in their day reduced all knowledge to philosophy. A remnant of this remains, as many scientists today receive Ph.D.—doctorates of philosophy. The Romans brought to our civilization a heritage of law and political order. Many of our current legal principles were formulated long ago in the Code of Justinian, when science was fairly primitive. Renaissance man almost worshiped the arts. Science was simply a liberal art in those days.

In medieval times, theological synthesis was in highest vogue. The earliest universities turned around about the faculty of theology. The queen of the sciences was theology's most cherished title. No scientist or engineer would have had then the ascendency each enjoys today. In fact, the explosive beginnings of science and technology were most often met with resistance and misunderstanding.

Would it be any surprise then if history were to repeat itself, if those who hold the ascendancy today were to claim as their exclusive rights the center of the stage, as the philosophers, the lawyers, the humanists and the theologians did?

Would it be incomprehensible if scientists and engineers were to claim today that they, with their revolutionary new knowledge and power, could do a better job of running the world than those who preceded them in man's long history of intellectual developments?

There is historical precedent for those who answer in the affirmative and claim exclusive leadership today for scientists and engineers as the best the world may expect and need.

I could readily understand this stance, but again, in disagreeing, I would only underline one perceptive statement: that those who are merely children of their day, who do not understand history, condemn themselves to repeat all human errors of the past.

The Rev. Theodore M. Hesburgh is president of the University of Notre Dame and a former member of the National Science Board. Excerpted from *The Hesburgh Papers: Higher Values in Higher Education.*

A TALE OF TWO PATRONS

by Robert M. Rosenzweig

It is illuminating to compare the circumstances that attend the growth of new associations between universities and industrial patrons with those that attended the growth of the new (at the time) relationships between universities and their government patrons. It is illuminating because the contrast is so sharp as to be shocking. One will search the record in vain from 1945 to about 1965 for evidence of the kind of concern about the impact of government patronage that is represented by the Pajaro Dunes meeting [California, March 27, 1982], by tens of other meetings, and by the carload of published material on the subject of universities and business.

Can it be that association with industry either threatens or promises greater change in universities or in science than was occasioned by government's role? To ask the question is as good as to answer it. It is improbable . . . that anything coming out of industrial sponsorship can approach the fundamental transformation of American universities and American science that began with World War II and continued with the peacetime growth of federal programs.

Can it be, then, that dealing with business presents greater danger to important academic and scientific values than did dealing with government? Is the prospect of profit, in other words, a greater inducement to compromise than were the benefits—personal and institutional—that came with government money? Well, perhaps for some people that is the case, but it is hard to imagine a set of challenges to long-held values greater than those that grew out of the conditions attached to government funding.

The secrecy imposed by classified research was more complete, more constraining and more long-lasting than anything that is likely to flow from proprietary considerations, and ordering of the research agenda was surely influenced in important ways by priorities derived from outside the logic of science itself. One could cite many examples, but the one closest to current concerns about the commercialization of biology would probably be the effect on research programs induced by the politically inspired decision to wage war on cancer.

My purpose in citing this record is surely not to suggest that since we endured large effects more or less thoughtlessly, we can endure probably smaller effects equally well without thought. On the contrary, what I intend by the comparison is to demonstrate that we appear to have learned something. The experience with government, the knowledge that good fortune frequently carries danger in its wake, has led to an attentiveness to the risks of new relationships that

should encourage our belief in the ability of people to learn from experience.

Difficult and searching questions about the dangers of business involvement in university-based research have been raised by Congress, the media and the faculties, administrators and trustees of universities.

A large number of institutions have undertaken reviews of policies governing faculty consulting, conflicts of interest, patents and licensing, secrecy in research and a variety of other topics raised by contracts with business. There is an unprecedented amount of thought being devoted to the policy consequences of these new associations. And what is most encouraging is that individual institutions—the proper makers of policy in a society that values pluralism and that rejects the notion that there is only one road to heaven—are looking for solutions that make sense for them.

Let me be careful to say exactly what I mean to say. I emphatically do not mean to say that the possibility—I would personally say, the probability—of foolishness and error has been removed. It has surely been reduced, but no one has yet discovered, in any activity involving human beings, the way to eliminate bad decisions. What I do mean to say is that never in my memory have the conditions been more propitious for the development of sound institutional policies about such important issues.

There is room for improvement; there always is. In this case, one needed improvement is in the national capacity to gather and disseminate information about a wide variety of developments at a large number of institutions. Good policy making rests on good information, and we can improve the quality and quantity of information available for institutions.

The Association of American Universities, in cooperation with other concerned national organizations, hopes to start an information clearinghouse that will distribute widely the experience of institutions and business as they come to terms with one another. If the clearinghouse succeeds, it will bring assistance to where it is most needed, namely to the universities and businesses that will be grappling with the policies that should govern their mutual relationships. ■

Robert M. Rosenzweig, who organized Pajaro Dunes for Stanford University, is now president of the Association of American Universities. Preceding portions from Robert M. Rosenzweig, "The Pajaro Dunes Conference" in *Partners in the Research Enterprise: A National Conference on University-Corporate Relations in Science and Technology* are used with permission of the University of Pennsylvania Press. To order, contact University of Pennsylvania Press, 3933 Walnut Street, Philadelphia, PA 19104.

R&D WITH A TWIST OF HIGH TECH

The role of government is to expedite the process

The long tradition of industry-university cooperation in education and research has recently been even more closely cemented, particularly in heavily financed research agreements. How do you view this?

Skeen: I view the trend very positively. Every aspect of what we know about education and university-run research and development points to the need for greater cooperation between industry and universities. Over the past few months, we have all been alerted to the long-term decline in the quality of U.S. education, especially in the sciences. There is also the problem of a rapid change in the technologies used in the private sector—so rapid that few universities can be expected to keep up with the state of the art in training and research facilities.

Industry can benefit its own R&D operations and perform a tremendous public good by helping meet the instrumentation needs of universities and assisting in the improved quality of students' education. Everybody wins. The industry gets access to the best research capabilities in the world; the university gets financial and equipment support; and the student ends up better-educated and more qualified for the modern workplace.

Somerville: What current and future areas of industry-university cooperation do you see as most significant?

Skeen: Without doubt, I see high-technology development as the most significant area both now and in the future, specifically in the areas of education and research. My own state of New Mexico's Rio Grande Valley has become a prominent center of modern science and high-technology development, with large and varied assets in institutions of higher learning, government laboratories and industry staffed with professional and skilled personnel. To that end, I have supported the establishment of governing and administrative mechanisms to initiate and guide the active development of the Rio Grande Research Corridor (RGRC) to enhance the quality and quantity of employment in New Mexico by attracting high-technology industries.

One area where industry-university cooperation in education and research has resulted in dividends for the state is in explosives-technology research and application with emphasis on the areas of metallurgical and ceramics-materials processing, and ore-quality improvement and materials extraction for enhanced yields and reduced energy use.

New Mexico has for more than 40 years been the focus of high-technology activity in explosives applications by universities, defense-related national laboratories and industry. At the New Mexico Institute of Mining and Technology, these technologies reside side-by-side with active mining and metallurgical engineering departments and with explosives-related research in the institute's research and development division. Combining these individual efforts to develop high-technology applications of explosive energy to metallurgical and mining problems will result in an enhanced center of excellence with national and international significance.

Explosives technology is an unusual field that has been given little attention by private industry, yet New Mexico Tech now provides explosives-related research and testing services for many government agencies as well as industrial clients such as Boeing, Honeywell, Vought, McDonnell Douglas, Brunswick, Motorola, BDM, Hughes, Aerojet General and others. Four of these industrial clients have already expressed a keen interest in locating facilities in New Mexico Tech's research park area and in working cooperatively with the institute.

I feel strongly the proposed effort will provide the catalyst for combining current research efforts, in-place laboratory capabilities and industrial client relationships into a nationally important center for the application of explosives technology.

Somerville: If industry-university cooperation—in its many facets—is viewed as enhancing the U.S. research-and-development effort and providing benefits to education institutions, is there justification for government action to spur cooperation?

Skeen: Certainly—in a supportive manner. I have always felt that one of the roles of government is to assist the public good. Not to do the job in most cases, but to assist those better qualified and closer to the problem to solve it for themselves.

The most appropriate role for the federal government in this case is to remove any impediments to these cooperative agreements and then to provide as many incentives as good fiscal and public policy permit. Many bills have been introduced this session to that very end. The appropriate committees have to act on those bills before anyone can say exactly what is likely to happen.

The Reagan administration is certainly aware of and sensitive to the problem. There are, however, limits to what can be done as long as the deficit remains so large. I believe industry-university cooperation to be an important component in a program to increase our rates of innovation and productivity—leading to a stronger economy, so you cannot drop one issue to pursue the other.

Somerville: Antitrust laws have often been cited as providing a disincentive to cooperative ventures involving industry and universities. Should antitrust laws be changed to stimulate even greater cooperation? Or do you believe that antitrust limitations on research cooperatives could be changed administratively?

Skeen: I don't think current antitrust laws prevent these cooperative relationships at all. We see this same problem in joint R&D ventures among firms, especially in the high-tech area. It is easy to forget the important role antitrust policy, when first enacted, played in strengthening free enterprise in this country. Most of our industries, however, no longer compete in a national market. The international competition we now face necessitates a joining of certain industry interests—such as R&D—to better arm American industry for the market-share battle under way in world commerce.

Several major conferences have been held on the subject, one of the better ones, as a matter of fact, by the NAM in Boston last fall. The consensus seems to be that a clear policy from the Commerce Department—combined with the removal of treble damages in the antitrust regulations from the Department of Justice—might help a great deal. The Commerce Department held a high-level meeting in May on the subject and considerable progress was made.

Somerville: Several bills before the House and Senate address the capability of schools and universities to deliver more quality scientists and engineers. Do you believe that university-industry research relationships can generate new opportunities for quality education, particularly at advanced levels?

Skeen: Absolutely. In keeping with the administration's commitment to ensure our country's future strength, the director of the National Science Foundation and the secretary of education were instructed to examine the adequacy of science and engineering education for the nation's long-term needs. I highly recommend their report, "Science and Engineering Education for the 1980s and Beyond," which provides a comprehensive study of important and difficult issues facing the nation's science and engineering education system.

Somerville: Many of the issues the report raises have been partially addressed by the administration as part of its economic recovery program. The National Science Foundation, for example, is slated for an 18 percent budget increase by this administration. In addition, the president has initiated reforms in the tax system to stimulate investment and spur growth. I am hopeful these efforts will promote cooperation in research among industry, universities and government. These measures, taken together, will do much to stimulate new interest in science and engineering careers and strengthen the research-and-training base of the nation: the universities and engineering schools nationwide.

Somerville: More difficult problems than antitrust or taxes in the university-industry relationship have been raised. The ethics issue is one; take, for example, a professor's conflict between his academic responsibilities and his commitments to a company's research needs. Your subcommittee has held hearings to examine aspects of this in the biotechnology fields. What were the results?

Skeen: That depends on one's perspective, I'm afraid. Not all my colleagues on the subcommittee are as comfortable as I am with the growing trend in these agreements. Many have raised legitimate concerns, well-documented in the lay press and academic literature. Let me say that I do not think the problems are insurmountable, nor do they prompt a need for extensive government oversight. The issues are not new. Several institutions, like Stanford (*page 11*) and MIT, have a long and successful history of collaborative relationships.

The subcommittee recently held a hearing in New Mexico and examined the plans for the Rio Grande Research Corridor, which builds on the talents of the state's university system to attract industry in such fields as biotechnology and robotics. The development of the research corridor depends on a multitude of collaborative research relationships and can only improve university education, industry R&D and the local economy. Sure, there will be some problems but the benefits to all involved will prompt a quick solution. You can count on it.

Somerville: Another problem lies in data publication. Academic freedom demands extensive publication of research results, while industry is more protective of results until they are safeguarded (by patents, for example). Some believe that university-industry research cooperation is not likely to be so extensive that temporary limitations on open-data exchange would harm the overall academic need for free publication. What are your views?

Skeen: Academic freedom must be maintained. In our hearings on the decline in the quality of education in America, a number of witnesses felt that perhaps there has been too much pressure on professors to publish instead of educate. The balance between research and education is dynamic and shouldn't, in my mind, be toyed with. However, it may be that a little less emphasis on quick publication of *all* research findings and a little more emphasis on the educational advantages of collaborative research endeavors might do the universities and students some good. Again, many universities have worked out this issue with their industry partners. Both sides must make compromises; this just has to be accepted. ■

Rep. Joe Skeen (R-NM) is ranking minority member of the Science and Technology Committee's Subcommittee on Investigations and Oversight. Brendan F. Somerville is NAM director of innovation, technology and science policy.

NEWS REVIEW

FROM: PUBLIC RELATIONS–F3EB

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Monsanto

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Universities Help Fill Research Gap, Says Official

By MIKE McFARLAND
Staff Writer

Joint research ventures between universities and private industry create a national resource and allow the United States to remain on the cutting edge of technology, says an official of a major American research firm.

"Without it, the United States industries will lose leadership . . . and a large opportunity to develop major new industries and thousands of jobs," said Howard A. Schneiderman, Monsanto Co. senior vice preseident for research and development, in an address on the UNC campus Wednesday night.

America could face drastic setbacks in biotechnology without joint research, he told a Venable Hall audience.

By the turn of the century, America could discover cures for several diseases and even succesfully control and prevent degenerative brain diseases, Schneiderman said.

Scientists also could discover how to genetically engineer crops, which would increase crop yields, and might eliminate the need for the use of pesticides, he said.

But, Schneiderman said, such breakthroughs will never occur without the formation of research partnerships between universities and private industry.

AND SUCH JOINT efforts will be-

Research Gap

(Continued from page 1A)

come increasingly important as countries like Japan form huge research consortiums between major corporations, he said.

From 1977 to 1981, Japan held 60 percent of the patents in biotechnology compared to the United States' 10 percent, Schneiderman said.

Federal antitrust laws prevent such consortiums in the United States, he said, and that leaves the universities to help fill the gaps in this country's ability to remain commercially competitive with the rest of the world.

"The talents of America's research universities are unsurpassed in the world. It could keep America on the leading edge of scientific adventure. It could benefit American society in terms of useful producst and find ways to meet basic human needs throughout the world."

There are risks involved in joint research ventures, probably more for the universities than for the industries, he said.

"If in the interest of short-term rewards corporations damage the (universities) . . . they will kill the goose that laid the golden egg. I am convinced America's major corporations recognize this."

As an example of one partnership that has evolved recently, Schneiderman cited a joint research program between Monsanto, a St. Louis-based chemical company that produces synthetic fibers, plastics and other products, and Washington University's Medical School there.

The agreement, which was reached in 1982 and carries a $23.5 million price tag, has two important conditions, Schneiderman said. The university owns the patents to any discoveries while Monsanto has the authority to license the patents.

There also is a joint advisory committee — made up of four representatives each from Monsanto and the university — that decides what research will be funded under the contract, he said.

THE CASE FOR the Monsanto-Washington University agreement is even stronger when funding support nationwide is examined, Schneiderman said.

Industry contributed only $250 million (4 percent) of the $6.6 billion universities received in support of research in 1981, he said. The rest came from federal and state sources. The maximum industry will ever be able to contribute to university research will be 6 percent, Schneiderman added.

"As a nation, we cannot continue to prosper in the long-term (if we keep) assembling imported goods and exploiting imported ideas," he said.

Schneiderman's visit here is sponsored by the UNC departments of biology and chemistry. In conjuction with his visit, biotechnology research conducted at UNC will be presented in a poster session today from 2 to 4 p.m. in the Coker Hall lobby. Schneiderman will deliver another lecture, "What Biotechnology Has In Store For Us," at 4 p.m. today in the Coker Auditorium.