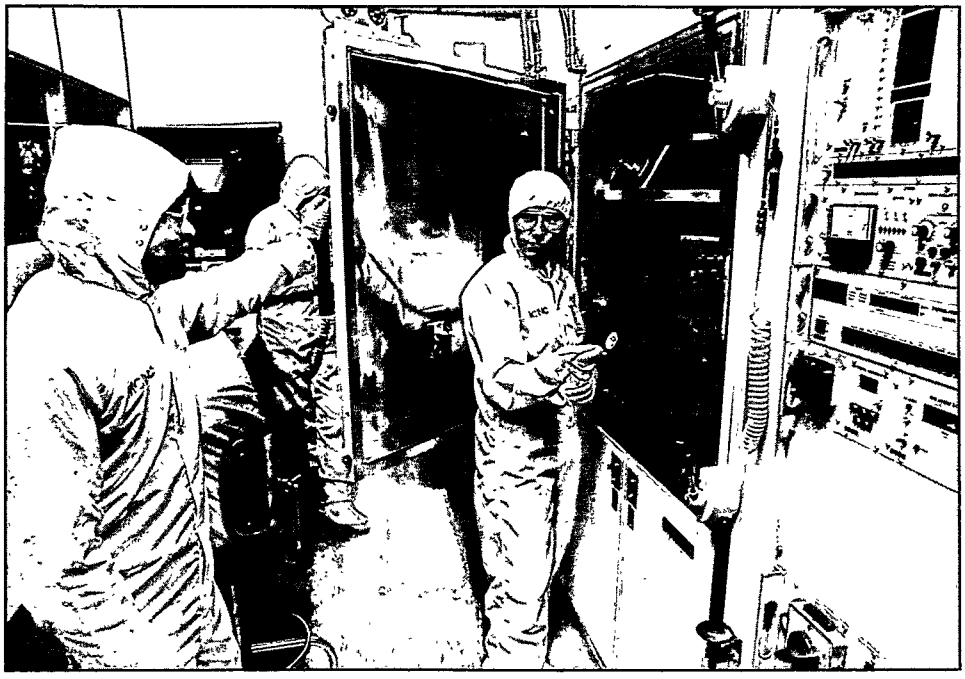


Jeff VanDyke

Microelectronics research is conducted in "clean space" fabrication facility at MCNC.

Drop Anchor or Full Steam Ahead?

High Tech—The State's Flagship Strategy?

by Dale Whittington and Bill Finger

Can high-technology applications assist small business growth? Does the state need stronger technical and analytical planning to shape long-range high-tech policy initiatives? And will high tech endure as the favorite son in the current world of economic development?

During the early 1980s, promoting high-tech development was everyone's top economic development policy. Many believed North Carolina had hit on a hot new economic development strategy that would provide new high-wage jobs and help retool traditional industries. But the groundwork for this leap into the high-tech world had been laid 20 years before.

In the early 1960s, Gov. Terry Sanford held a series of informal meetings with business and academic leaders to explore possible new scientific programs. These gatherings led to the 1963 formation of the Board of Science and Technology, with offices in the Research Triangle Park. It had the dual purpose of strengthening scientific research in the state and monitoring scientific-related areas as they affect industrial development. This effort "represented in essence a state-level National Science Foundation to provide grants for the state's scientists," writes Ezra F. Vogel in *Comeback*, a 1985 book analyzing how American business can build a resurgence.[1]

Dale Whittington, professor of planning at the Department of City and Regional Planning at the University of North Carolina at Chapel Hill, is editor of High Hopes for High Tech, *University of North Carolina Press, 1985. Bill Finger is editor of* North Carolina Insight.

While interest in this board declined in the early 1970s, Gov. James B. Hunt Jr. (1977-85) brought the group back to center stage in his administration, along with other high-tech related ideas. The first of Hunt's high-tech initiatives began to take shape in 1978 when the legislature appropriated $150,000 to start the N.C. School of Science and Mathematics. Now part of the University of North Carolina system, this high school in Durham draws students from around the state who are highly motivated and talented in science and math. Three other initiatives followed shortly: the Microelectronics Center of North Carolina (MCNC) in 1980, the Biotechnology Center in 1981 (see sidebar on page 78), and the N.C. Technological Development Authority in 1983 (see article on page 53). Collectively, these four, according to Vogel, "benefited the universities, whose faculties had enhanced facilities for work in new areas, companies which had access to new technology and trained manpower, and workers and families seeking better jobs and a higher standard of living."[2]

In recent years, high-tech jobs in general have increased in the state, helping the average state hourly manufacturing wage climb to $7.01 an hour in July 1984 (the first time over $7.00). From 1983 to 1984, North Carolina moved from 15th to 13th nationwide in high-tech employment, going from 47,000 to 55,000 high-tech jobs, according to a study by the American Electronics Association, a California-based trade group. Finally, in a December 1985 paper, the Southern Growth Policies Board reported that the results of the Microelectronics Center's work "strongly support the belief that R&D (research and development) are effective economic development strategies and good investments .... [A]pproximately $600 million in new capital investment and about 6,000 new jobs are directly attributable to MCNC's efforts to advance technology, which increases state tax revenues by about $25 million from initial investments and by approximately $32 million each year from recurring taxes."[3]

Despite these upbeat figures, by 1986, some of the luster was off the high-tech boom. Last year, the microelectronics industry nationwide laid off almost one of every four employees — 64,000 of the 336,840 workers, or 19 percent. The top five producers of integrated circuits lost $195 million in the third quarter of 1985 alone. Sales of U.S. circuits fell from $11.6 billion in 1984 to $8.3 billion in 1985, due largely to the slump in sales of personal computers. North Carolina did not suffer as much as California's Silicon Valley, but employment in the electronics industry did decline. And the upbeat figures on new electronics jobs, announced by the N.C. Department of Commerce at the end of 1984, came into question as one study found that *only one of every two announced* electronics jobs have come on line (see page 50 for a discussion of this study).

Even so, high-tech jobs remain the state's number one economic development strategy in terms of total dollars spent. From 1980 through 1985, the state spent some $51.6 million on the Microelectronics Center alone. Last year, the General Assembly continued this commitment by approving $11.2 million for the MCNC in fiscal year 85-86 and $12.1 million for FY 86-87. In addition, the legislature sent $5.8 million in capital funds through the MCNC to UNC-Asheville, Winston-Salem State University, and Wake Forest University's Bowman Gray School of Medicine (for high-tech communications systems). And these figures don't even count the millions going to the Biotechnology Center, the Technological Development Authority, and the School of Science and Mathematics (see table on page 24 for expenditures for these and other state economic programs).

"My occupational hazard is, my occupation's just not around."

—"A Pirate Looks at Forty" by Jimmy Buffett

"I am of the opinion that having a strong basic manufacturing industrial sector is essential for the 'services industries' to exist," says former Governor Hunt. "Thus, I believe it is nationally important for us to have centers where high technology manufacturing is going on and one of those is clearly in North Carolina."

The administration of Gov. James G. Martin inherited the state's financial commitment to these high-tech endeavors. The euphoria that surrounded their beginnings can now give way to an examination of the long-range impact of the state's investment in this business. Much can be learned from the public-private partnership that helped establish the MCNC, such as the benefits of such a partnership and the weaknesses of giving so much state money to nonprofit corporations. Other questions range from examining what "high tech" actually means to potential dangers of this industry to workers and the environment.

What is High Tech?

Alvah Ward, head of North Carolina's industrial recruitment efforts, takes the term "high tech" to its broadest common denominator. "Soon there will be very little difference between high tech and basic industries because any new plant that goes in will employ the highest technology available," says Ward. Under this definition, "high tech" could refer to virtually any capital improvement that employs computers in some way—from the textile and furniture industries to large farming operations planned and managed through computer technology.

The U.S. Bureau of Labor Statistics classifies as high tech those companies with at least twice the portion of their net sales *devoted to research and development*, compared to all manufacturing companies. Under such a definition, a company in *any* Standard Industrial Classification (SIC) code could be called "high tech."

In 1984, Kirsten Nyrop, then director of the N.C. Technological Development Authority, developed a table called "Employment in N.C. High-Technology Firms, by SIC Codes." In the table, published with an article in *North Carolina* magazine, Nyrop included 27 separate SIC code lines, taken to three digits; these 27 subgroups fit into nine two-digit categories. The largest number of jobs in the chart (23,525) appeared under SIC 739, "research and development laboratories."[4]

Everyone's definition of a high-tech industry would include the microelectronics industry, a part of the electronics sector (SIC 36). This sector has three main parts: 1) electrical equipment (power distribution, transformers, generators, telecommunications equipment, and other products); 2) electronic consumer goods (television receivers, phonographs, hi-fi equipment, and other products); and 3) electronic components (resistors, capacitors, electronic tubes, and semiconductor devices). The microelectronics—or semiconductor sector—falls under this third category (although integrated circuits for in-house use are not included under SIC 36). The Bureau of Labor Statistics (BLS) treats SIC 367—electronic components and parts—as a surrogate for the microelectronics industry. Others use the more restricted SIC 3674, semiconductors and related devices.

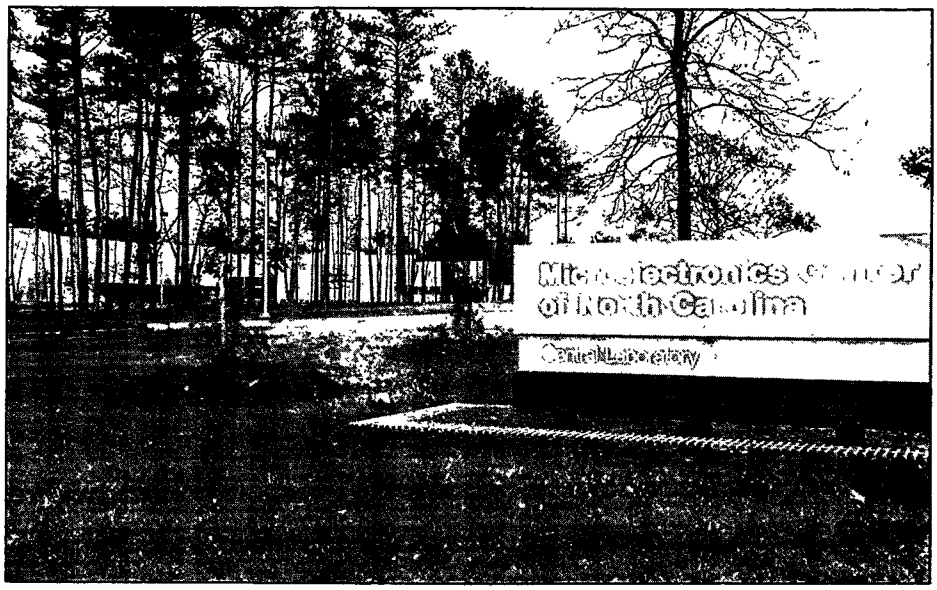
Increasingly, people use interchangeably the terms "microelectronics" (*one* BLS three-digit SIC code) and "high tech" (*27* three-digit codes in Nyrop's study). This usage reflects the conventional wisdom that the microelectronics industry includes firms that are routine *producers and users* of integrated circuits. The use of integrated circuits has already expanded beyond the computer, electronic components, and scientific and measuring instrument industries. Soon, as Alvah Ward suggests, most American manufacturing will fall within this larger characterization of microelectronics.

The *lack of precision* in classifying the microelectronics and other high-tech industries *makes evaluating the success of high-tech economic development policies difficult*. At various times, the Hunt administration claimed that its efforts in the microelectronics area were directed at: 1) recruiting semiconductor *research and development* companies; 2) recruiting semiconductor wafer *assembly* plants; 3) promoting microelectronics technology in North Carolina's traditional industries; and 4) creating spin-off enterprises, including research and development firms, not tied directly to microelectronics (of the narrow SIC 367 variety). These objectives need not be mutually exclusive. In fact, the Hunt administration tied the success of all of them to a single flagship enterprise—the Microelectronics Center of North Carolina (MCNC).

The Microelectronics Center Today

In 1980, Governor Hunt launched the Microelectronics Center with an organizational strategy similar to that used by Gov. Luther Hodges 21 years before for the Research Triangle Park.[5] Both governors endorsed a private, nonprofit organizational structure that incorporated the state's political and financial elite in the planning stages and the university hierarchy in the final structure.[6] But there was one major difference—taxpayers' money. The Research Triangle Foundation and Research Triangle Institute (the nonprofit vehicles Hodges helped create) received almost no state funds, while the MCNC depended upon direct state appropriations from the General Assembly, both for capital seed money *and* for continuing operating support. The MCNC could have begun as a laboratory or branch of RTI, evolving slowly from internally generated contract revenues, or as a separate institution within the University of North Carolina system. But Hunt rejected such options. He chose the creation of a new organization, which had both high visibility and political appeal.

Of the initial $24.4 million in state funds going to the MCNC, $10.5 million went to build a new, 100,000 square foot building in the Research Triangle Park, and $8.6 million went for purchasing equipment, much of it highly sophisticated. From later appropriations, another $6.5 million went for a telecommunications system linking campuses and private corporations around the state for broadcasting lec-



Jack Betts

Microelectronics Center of North Carolina is nestled among the pines in Research Triangle Park.

tures in computer science, electrical engineering, and other sciences. The main purpose of the center is to sponsor research and development efforts and to train students in microelectronics technology and applications. This resource, ideally, would be an added inducement to bringing new high-tech companies to North Carolina such as General Electric, which opened a major facility in the Park after Governor Hunt made the initial commitment to the MCNC.

Research and development at MCNC concentrates in three areas: 1) semi-conductor materials, devices, and fabrication processes; 2) computer science and computer-aided design; and 3) integrated circuit design to support advanced microelectronics applications. The MCNC offers state-of-the-art facilities for such research, including a world-class, 10,000 square-foot "clean space" fabrication facility. To assist with industrial recruitment, the MCNC assists the Department of Commerce in welcoming visitors and prospects and seeks to create a national and international awareness of North Carolina's growing potential in the field.

"We have a dual role—to enhance the participating universities in their education and research and to support the state in attracting industry," says Richard Fair, MCNC vice-president of design research and technology. "We're trying to play both roles, but mostly our orientation is to support the universities as a means of getting to that final goal—developing the state."

Microelectronics firms rely heavily on the skills of physicists, chemists, electrical engineers, metallurgists, ceramicists, mechanical engineers, industrial and software engineers, computer scientists, and optic specialists who have been trained at the graduate level. MCNC has tried to strengthen university education in these fields. But why did the state create a new organization to do this training instead of allocating more money to existing universities for computer science and electrical engineering?

There are several explanations. First, the MCNC is a much more visible and politically useful symbol than a beefed-up computer science department. In any case, obtaining the level of funding granted the MCNC for universities would have been politically impossible. Second, the MCNC provides an institutional arrangement that can pay university faculty in computer sciences and electrical engineering more than would be possible through the university pay structure alone. Third, the MCNC laboratory facilities and equipment are too expensive to be duplicated and can be shared to some extent because of the location of the MCNC facility.

Unlike the Microelectronics and Computer Technology Corporation created by 12 major corporations in Austin, Texas, the MCNC is primarily a public-sector initiative tied to five participating universities (UNC-Chapel Hill, Duke University, North Carolina State University, North Carolina A&T State University, and UNC-Charlotte). Financially, the MCNC has asked the legislature to meet at least two-thirds of the MCNC's operating budget. "We've told the state that we will bring in from external sources the other one-third of our operations cost so that the state doesn't have to support the MCNC completely," says Fair, who holds a dual appointment at MCNC and in the Duke Univer-

sity electrical engineering department. "Given our current level of external support, we could not plan to operate with less than two-thirds state support." The MCNC currently has a 120-person staff, 10 of whom have a joint appointment with a university. Its annual operating budget is $16.9 million, according to MCNC documents presented to the General Assembly.

The MCNC gets external funds through two primary means, from affiliate private-sector members and through sales of products it has developed. The center currently has seven corporate affiliates, including Northern Telecom Inc., General Electric Co., and International Business Machines Corp. (IBM). An affiliate must contribute $250,000 in money or equipment per year for a minimum of three years, which allows that company's staff to participate in MCNC research programs and work with the MCNC facilities. Ownership of inventions or products arising from MCNC's research resides with MCNC. Affiliates can use these new products in-house at no charge and on the open market on a "preferred royalty" basis. Under such an arrangement, the affiliate company pays the MCNC a one-time royalty fee so that it won't be enjoined from using the "intellectual" property created at the MCNC.

The first major product from MCNC's research efforts was VIVID, a software system for custom VLSI (very large scale integration) design. In 1985, the center made two sales with VIVID. The Metheus Corporation, based in Massachusetts, paid the MCNC $25,000 to be able to use VIVID as part of its software offerings. Then in October, the Canadian Microelectronics Center paid $225,000 for VIVID (and backup support) for use in its own work. While the state receives none of the profits from such sales, "all the dollars get plowed back into our

Biotechnology

Manipulating Cells for the Economy

In high-tech economic development policies, the new kid on the block is biotechnology. Until 1981, only a handful of state officials had ever even heard the word, and most of them worked for, or with, the N.C. Board of Science and Technology. Gradually, this intimidating term worked its way into the vocabularies—and then onto the agendas—of influential political figures like state Rep. Bobby Etheridge (D-Harnett), who chairs the House Base Budget Appropriations Committee.

"I think it's germane to many sectors of our economy—agriculture, high technology, pharmaceuticals," says Etheridge, who co-chaired the legislature's two-year Biotechnology Study Committee (1983-84). "We spent a lot of time and received an awful lot of input. We heard a lot about the long-term economic benefits."

In 1983, the General Assembly appropriated $500,000 to the N.C. Biotechnology Center (then under the rubric of the N.C. Board of Science and Technology) and created the Biotechnology Study Committee under the Legislative Research Commission. Responding to an interim report from the study committee, the 1984 legislature voted another $1 million to the Biotechnology Center and $3.6 million to the University of North Carolina system for biotechnology research. Also in 1984, the N.C. Biotechnology Center incorporated as a private, nonprofit corporation. Then in 1985, the General Assembly voted $6.5 million to the center for the upcoming fiscal year, plus another $1.2 million for a new building.[1]

While biotechnology seems to have arrived only recently as a prominent area of research for economic development, biotechnology in the traditional sense has been around as long as people have used living organisms to help make some kind of product. "People have used biotechnology since the discovery of leavened bread and alcoholic beverages, and today fermentation is an important production method that relies on biotechnology," explain Frank B. Armstrong and Durward F. Bateman of N.C. State University. "The new biotechnology deals with manipulating the chemistry of living organisms or their components to bring about desired effects.... Many of the current developments in the biological sciences are a direct result of discovery of Watson and Crick of the structure of the genetic material of DNA (in 1953)."[2]

What's new about biotechnology is the ability of scientists to manipulate components of a cell and reproduce the results of that manipulation. "Biology will be to the 21st

research program," says Fair.

Policy Considerations

The Martin Administration has begun to refine its economic development priorities (see article on page 22). As the administration moves into its second year, how much will it—or should it—continue to stress high-tech efforts? Answering that question requires some awareness of four policy issues: the role of state-funded nonprofit groups, wage levels and job location, health and environmental risks, and applying microelectronics technology.

State-funded nonprofit groups. Some national analysts see the public-private partnerships involved in the Microelectronics Center and Biotechnology Center as models for the nation. This cooperative activity "was much easier for North Carolina to undertake because of the working relationships between universities, government, and industry developed through the Research Triangle," writes Ezra Vogel. "This pattern of relationships was extended not only within the triangle area but in other parts of the state as well. In Charlotte, for example, a smaller-scale research park was developed, and in Wilmington new cooperative relationships were established between academics and business, both drawing on the positive lessons from the original Research Triangle Park."[7] Visitors from around the world have come to the Research Triangle Park hoping to learn how such a model might work for them.

While these nonprofit groups have been perceived by some as ideal models, their organizational structure also raises a key policy question. Should the state channel tens of millions of dollars for high-tech recruitment and research to private organizations, outside the purview of traditional government budgetary and oversight

century what physics and chemistry were to this century," writes John Naisbitt in *Megatrends*. "The next 20 years will be the age of biology in the way that the last 20 years have been the age of microelectronics."[3]

Because cells can be altered, concern has arisen that organisms can be rearranged in dangerous ways. "With the arrival of bioengineering, humanity approaches a crossroads in its own technological history," explains Jeremy Rifkin at the beginning of his book, *Algeny*. "It will soon be possible to engineer and produce living systems by the same technological principles we now employ in our industrial processes. The wholesale engineering of life... raises fundamental questions." Rifkin identifies the critical concern as the day when " 'harmful' genetic traits can be eliminated from the fetus at conception."[4]

Many scientists, however, say that Rifkin exaggerates these dangers. "The majority of the scientific community believe that Rifkin's predictions concerning the wholesale manipulation of life are not well-founded," says Laura Meagher, vice-president of the N.C. Biotechnology Center. "He does not do justice to the scientific complexities involved."

Meagher, along with Rifkin and many others, point out the many benefits of biotechnology. In the pharmaceutical industry, bioengineering might revolutionize the production of antibiotics, enzymes, hormones, and vaccines. In the energy field, oil companies are experimenting with renewable resources as a substitute for oil and gas. In the chemical industry, scientists say that renewable plant and animal material might one day replace petroleum. Organisms might one day even do the work of miners, eating away salts in the ore and leaving pure metals.

Other important industries that might benefit from biotechnology are forestry and agriculture, which are important to North Carolina. To produce a stronger, faster growing pine tree, for example, botanists once required a 20-year growing period before being able to select the strongest trees for a new strain. Now scientists have the potential to develop new breeds much faster by manipulating the actual tree cells. The forestry industry, vital to many North Carolina farmers and corporations, might benefit enormously from such research breakthroughs.[5] Other areas of potential benefit include agriculture, marine life, and pharmaceuticals. One analysis "showed that a breakthrough in agriculture biotechnology in even a single area, such as corn, could return approximately $42 million in incremental farming profits over a 15-year period, in discounted 1985 dollars."[6]

The legislative study committee designated the N.C. Biotechnology Center as the lead agency for this research, "in consultation with appropriate groups, such as the universities, the Department of Commerce, the Department of Agriculture, and the commercial sector."[7] The funds, the report explained, "should be for the attraction and support of world-class researchers and for promoting interaction between universities and industry, bridging any gaps

continued page 80

procedures? The state has already spent more than $50 million for the MCNC. The state's flagship economic development policy, in terms of state monies, has been launched through private nonprofit corporations. The question for the future is how long should the state continue to underwrite two-thirds of the operations of the MCNC? Answering this question now is important because the legislature appears prepared to begin underwriting the N.C. Biotechnology Center in a similar fashion (see sidebar on page 78).

In addition, if MCNC research efforts result in scientific discoveries or products with significant commercial value, the revenues from sales would belong exclusively to MCNC. At some point in the future, MCNC conceivably could sell enough products to become financially independent—which would appear to be a desirable goal. That possibility raises the question of what rights the citizens of North Carolina have in the ownership of MCNC's research. Already, IBM, Northern Telecom, and other corporate affiliates use the MCNC facilities and products.

Wage Levels and Job Locations. The hopes tied to the microelectronics industry for new, high-wage jobs must be analyzed in the context of the type of jobs actually created by microelectronics companies and the location of those jobs. The hope of microelectronics recruitment depends on "how well a resulting supply of new jobs 'matches' the existing pool of unemployed workers in the state," says Michael I. Luger of the Duke University Institute of Policy Sciences and Public Affairs.[8] Luger and others point out the importance of distinguishing within this industry among skilled jobs (engineers), semi-skilled jobs (technicians), and unskilled jobs (assemblers). Moreover, Luger explains that factors such as the location of the Microelectronics Center and the need for a major airport will mean that most new microelectronics jobs will come to a seven-county "projected location zone" extending from Wake to Guilford counties.

Luger's study yielded three conclusions: 1) microelectronics, when considering all jobs, may not be a high-wage industry; 2) these companies are unlikely to spread far beyond the Research Triangle area; and 3) the demand for skilled and semi-skilled jobs in the "location zone" will outstrip the supply of workers since these counties have low unemployment rates.

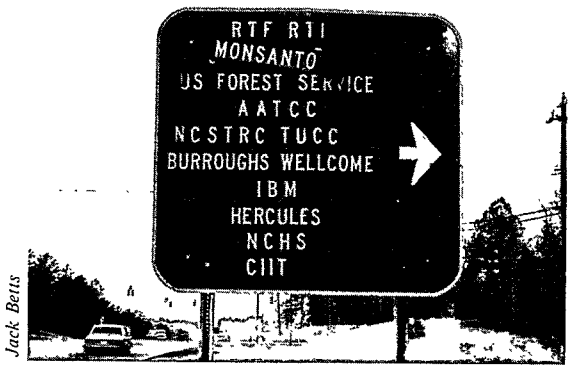
Health and Environmental Risks. Some

between them, so that, where appropriate, the results of basic research can quickly benefit industrial and agricultural development. In addition, there needs to be aggressive promotion of the state as an international center of excellence for biotechnology, both academically and commercially."

Calling itself a "nerve center" for the biotech business, the Biotechnology Center appears to have laid the groundwork for such an ambitious program through various activities. "The role of the Biotechnology Center is to catalyze research and commercial activity in biotechnology," explains a recent newsletter. "The center itself is not planning to establish an independent biotechnology research or training facility." The center's latest annual report groups its programs into eight categories. Five of the eight concern various specialized research activities, such as industrial scientists and engineers, biomolecular engineering and materials applications, and others which may never be in a legislator's vocabulary—the Monoclonal Lymphocyte Technology Center and the Polysacharide Materials Interdisciplinary Group.

A key difference exists between the structure of the Microelectronics Center of North Carolina and the Biotechnology Center. Specifically, the Microelectronics Center (MCNC) is an independent research facility *itself* and thus could be complementary—or competitive—with other university research programs. This independent research capability has caused tension among some university personnel, say legislative observers, because the MCNC now has the capability of setting research directions in a critical high-tech field independent of the directions being pursued through the UNC system. The Biotechnology Center, in contrast, does not intend to function as a research center itself but rather as a catalyst and coordinator for biotechnology research efforts. (See pp. 76-78 for more on the MCNC.)

The Biotechnology Center represents a potential national model. In a 1984 report to the U.S. Congress, the Office of Technology Assessment examined local efforts to promote the development of biotechnology in the United States. "The oldest and best known of these (local efforts) is the North Carolina Biotechnology Center," the report found.[8] But the materials introducing the center contain a heavy promotional tone, occasionally detracting from the genuine accomplishments of the



Jack Betts

analysts of high-tech industries have stressed the potential health risks for workers and for the environment caused by the wide range of chemicals used in the electronics industry, and particularly in semiconductor manufacturing.[9] In 1983, the N.C. Department of Labor reported that employee illness rates for North Carolina's electronics workers ran about three times higher than manufacturing workers as a whole. Workers create microcircuits on wafers of silicon using various chemical manipulations, and some of the chemicals such as the solvents trichloroethane (TCE) and 1,1,1, trichloroethane (TCA) can be harmful. The first big reported leak from a Silicon Valley, California plant was 60,000 gallons of discarded TCA, according to a 1984 report by the U.S. Environmental Protection Agency and other regulatory agencies.

Such reports indicate how this industry poses potential dangers to those who make the silicon wafers as well as those who live near such plants. Leaders in the field are aware of potential dangers and use elaborate protection systems. The General Electric Co., which runs a wafer production facility at the Research Triangle Park, has elaborate filtration machinery to help keep stray chemicals from contaminating the wafers, yet the GE plant uses some 120 chemical "products" regularly. Because technology in this field is changing so rapidly, keeping abreast of dangers to workers and the environment is difficult, even for the best trained people. Currently, there appears to be a shortage of technical expertise in the public sector to monitor this technology and to determine problems that might accompany certain recruitment strategies.

Applying Microelectronics Technology. The investment made in the MCNC, the Biotechnology Center, and other high-tech enterprises can enhance other economic development strategies. For example, the MCNC and the Textiles

four-year old center. "Among comparable technological centers nationwide, the center is unique in its commitment to an enlightened constitutency," boasts its own brochure.

Because biotechnology has come into the economic development vocabulary only recently, policy issues for state officials outside the scientific community are only gradually emerging. At the least, legislators and others following this state investment of funds for biotechnology research should:

- Monitor the activities of the N.C. Biotechnology Center, a private, nonprofit group, to be sure that: 1) its work complements (and doesn't duplicate) other economic development efforts, and 2) it oversees the biotech research being done in universities and other state agencies;[9]
- Assume responsibility for helping ensure that biotech research focuses on areas of potential economic benefits and does not stray into potentially harmful areas; and
- Continue to educate themselves and the public about what biotechnology is, and can become, and to what extent the N.C. Biotechnology Center really is a leader in this field.

—Bill Finger

FOOTNOTES

[1]In 1985, Republican Gov. James G. Martin deleted $5 million for biotechnology research from his proposed budget; the money had been included in the budget proposed by former Gov. James B. Hunt Jr. Martin's action prompted some partisan debate in the legislature, with leading Democrats considering moving the funding mechanism for the Biotechnology Center from the Department of Commerce (under the Martin administration) to the office of Lt. Gov. Robert Jordan, a Democrat. This action never came to pass, however, and the 1985 appropriation went to the Biotechnology Center via the Department of Commerce. (See Senate Bill 1, sections 2 and 132.)

[2]Frank B. Armstrong and Durward F. Bateman, "The Nature of Biotechnology," *Tar Heel Economist,* Agricultural Extension Service, North Carolina State University, November 1985, p. 1.

[3]John Naisbitt, *Megatrends—Ten New Directions Transforming Our Lives,* Warner Books, p. 73.

[4]Jeremy Rifkin, *Algeny: A New Work—A New World,* Penguin Books, Author's Note and p. 14.

[5]See "Small Woodlot Management," *North Carolina Insight,* Vol. 6, No. 1, June 1983, pp. 24-49.

[6]"Biotechnology Development: Legislative Research Commission," Report to the 1985 General Assembly of North Carolina, Dec. 13, 1984, p. 32 and appendix F.

[7]*Ibid,* pp. 22-23.

[8]*Commercial Biotechnology: An International Analysis,* Office of Technology Assessment, U.S. Congress, 1984, p. 26.

[9]In its report to the 1985 General Assembly, the Biotechnology Study Committee said that the N.C. Biotechnology Center "should prepare a cost-benefit analysis of its activities for FY 85-86 through FY 88-89 so that the economic benefit from the state's investment can be quantified" (p. 16).

School at North Carolina State University might work together to help bring the textile industry into a more competitive stance with Asian countries. Computer applications can be useful to many small businesses, and not just those in the computer field. Many of the efforts of the Technological Development Authority are channeled in this direction. The state's investment in microelectronics and high tech in general can affect far more than just training a university scientist or recruiting a semiconductor assembly operation.

Conclusion

If America is to compete in the international economy of the future, American high-tech businesses must take risks. But because the microelectronics era is still relatively young, even the strongest firms in the industry can, and often do, fall on hard times. In 1985, for example, the stock of GCA Corp., a semiconductor equipment maker, fell 70 percent. The current stresses on the electronics industry make such efforts as the MCNC an important resource for a beleaguered industry.

"There's lots of discussion going on as to how to pool resources to be more competitive with Japan, the major threat to the U.S. semiconductor industry," says Fair. "Joint programs like MCNC can take a look at problem areas that haven't been clarified yet and reduce some of the expense. Joint programs have an appeal to industries facing strong competition."

In addition to serving as a risk-free research base for companies, MCNC also strengthens university facilities and hence enhances the development of persons who will move into the private sector. This work with the universities, believe some analysts, may be the best strategy toward attracting the microelectronics industry.[10]

Helping to keep microelectronics jobs in this country and enhancing university training are noble goals. But these goals do not alleviate the need for carefully articulated, well-reasoned economic development strategies. Thus far, the debates over high-tech economic development policies have been more concerned with not missing out on the "second industrial revolution" than with employment dislocations, environmental hazards, or an analysis of precisely whom the high-tech era will benefit.

If the General Assembly continues to fund high-tech efforts and the Martin administration endorses this economic development strategy, the state needs much stronger technical and analytical planning capabilities to shape and coordinate long-range policy initiatives. Without such planning, the state will continue to rely on ad hoc, informal policy planning efforts and will delegate its responsibilities in this area to non-profit corporations.

Such discussions and scrutiny ultimately will benefit the public. If the high-tech field deserves to remain the flagship venture for state economic development, it may emerge from such scrutiny all the more deserving of state efforts—and will be less likely to lose its favored status when challenged by the newest fads in the field.

FOOTNOTES

[1]Ezra F. Vogel, *Comeback—Case by Case: Building the Resurgence of American Business,* Simon and Schuster, 1985, p. 258.

[2]*Ibid,* p. 260.

[3]Stuart Rosenfeld, "Sowing the Seeds for Growth—State Support for R&D," in the Southern Growth Policies Board's "Analysis of Emerging Issues" series, December 1985, pp. 8-9.

[4]Kirsten Nyrop, "North Carolina's Hopeful Quest for Slice of the High-Tech Pie," *North Carolina,* magazine of N.C. Citizens for Business and Industry, February 1984, pp. 14-24.

[5]For more on the beginnings of the MCNC, see the six-part section on microelectronics, especially "Easy Angling in Legislative Waters," in *N.C. Insight,* Vol. 4, No. 3, September 1981, pp. 18-22; and Dale Whittington, editor, *High Hopes for High Tech: Microelectronics Policy in North Carolina,* especially chapter 1, University of North Carolina Press, 1985.

[6]The MCNC Board of Directors includes the president of the Research Triangle Institute, one representative of state government, six citizens appointed by the governor, the president of MCNC, and the chancellors of the five universities involved (UNC-Chapel Hill, Duke University, North Carolina State University, North Carolina A&T State University, and UNC-Charlotte).

[7]Vogel, p. 260.

[8]Michael I. Luger, "The Economic Hope of the Microelectronics Industry—Promises and Policies," *N.C. Insight,* September 1981, pp. 27ff. See also Luger's "The States and High-Tech Development: The Case of North Carolina," Institute of Policy Sciences and Public Affairs, Duke University, September 1984; "Employment and Earnings in the Semiconductor and Electronics Industry: Implications for North Carolina," by Gregory B. Sampson in *High Hopes for High Tech, ibid.;* and "The N.C. Microelectronics Industry: Consequences for Local Labor Market and Implications for Job Training" by James Stein, a paper developed for the Department of Natural Resources and Community Development, 1982.

[9]See Monte Basgall, "High-Tech Hazard," a three-part series in *The News and Observer* of Raleigh, August 4-6, 1985, p. 1A; Joseph T. Hughes Jr., "A Healthy Future for North Carolina?" *N.C. Insight,* September 1981, pp. 33-38; and "Computers Can't Save North Carolina," *The Independent* of North Carolina, June 24, 1983, p. 1.

[10]See "University and Industry Cooperation in Microelectronics Research" by F. Dana Robinson in *High Hopes for High Tech, ibid.*