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Will NYS Miss the Biotech Train?

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Is New York State doing enough to capitalize on the state's position in the growing biotechnology industry? New York's share of the biotechnology marketplace is strong by many measures, but falls short in others. Home to many world-class research institutions achieving path-breaking discoveries in biotechnology, New York can and should be the location of choice for new private sector biotech R&D and manufacturing. In this report CGR documents the promise of biotechnology as an economic development engine, New York State's signal achievements in basic research—and its disappointing showing in the creation of jobs in this key sector.

- It is time to make significant public investments in biotech research. The stakes are high. The economic return from investments in biotechnology is likely to be dramatic.
- The state economy gains little from scientific discovery that is isolated from the commercial marketplace. Recipient universities and research centers must devote significant resources to the difficult task of transferring newly-acquired knowledge to start-ups and established firms.
- Ventures based on new discoveries must be located within the state if state taxpayers are to achieve the maximum possible benefit from biotech investment. Support for technology-based startups is key to maximizing the economic return to the state's residents.

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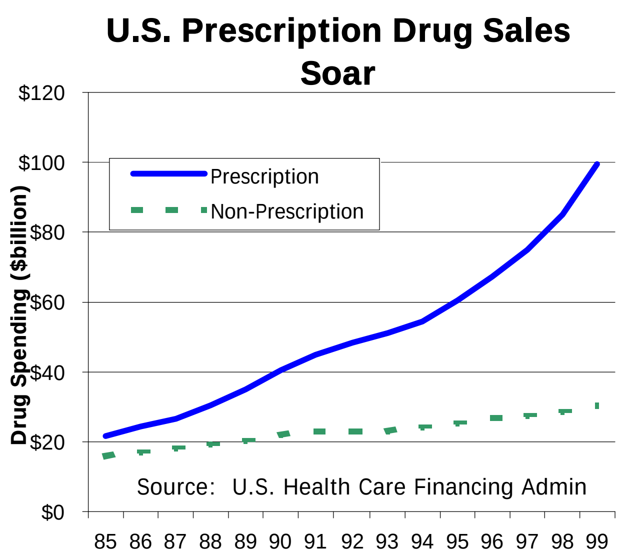
Biotech Poised for Growth

With the first stage of a human genome "map" completed, the biotechnology industry is poised for a period of spectacular growth. As of 2000, about 90 drugs on the market were developed through biotechnology and an additional 369 were in clinical trials, fully one third of all drugs in clinical trials in the United States (Pharmaceutical Researchers & Manufacturers of America (PhRMA) survey).

Biotech is the future of the pharmaceutical industry, an industry that has grown dramatically in recent years. The aging of the population, the proliferation of new drugs and the newly-bestowed right to advertise have spurred a five-fold increase in prescription drug sales between 1985 and 1999. This compares to a doubling of non-prescription drug sales during the same period (Health Care Financing Administration).



The pace of drug approvals has also increased as a result of changes in Food and Drug Administration (FDA) procedures. Between 1992 and 1996 the final stages of the approval process fell to 15 months, about half the time formerly required (*Kiplinger's Personal Finance* February 1999, 53:80). The FDA approved 58 new drugs in 2000, up from 47 in 1999. The Freedonia Group and the Institute for BioAbility estimate that sales of biotech drugs will grow 10-15% per year through 2004 (*BioPharm*, June 2001).

Eight biotech drugs with over $6B in sales will go off patent between 2001 and 2007.

As the biotech drug market matures, the opportunities for biotech manufacturing will soar. *BioPharm* reports that eight biotech drugs with over six billion dollars in sales will go off patent between 2001 and 2007. This includes Eli Lilly's patent for human insulin, which expires in 2001. The opening of these drugs to generic biotech drug manufacturing will lower prices and expand the market, thus increasing jobs for states in which these firms locate their facilities.

Drug Biotech & Ag Biotech Converge

Biotechnology is not limited to medical applications, of course. Plant and animal science has been a target for intense research and are highly profitable. Despite some public fears, the market continues to grow rapidly for genetically modified seed, medicine-producing plants and animals, and food products that ripen more slowly and last longer. A joint report of the National Research Council and Congress released in April 2000 (*Seeds of Opportunity: An Assessment of Plant Genomics and Agricultural Biotechnology)* declared that food and crops improved through biotechnology have the potential to "reduce the environmental impact of farming, provide better nutrition and help feed a rapidly growing world population."

Agricultural and medical fields of biotechnology are converging, enabling successful researchers in one sphere to cross over into new markets. Human insulin produced in cow's milk is only one example of potential plant and animal-based human drug "factories" and the convergence of drug and agricultural biotech markets. New York-based Genencor—with significant commercial successes in ag biotech—just announced plans to invest $25 million in health care drug discovery and development over the next 12 months. Genencor estimates the size of their target market at $20 billion. According to Merrill Lynch, next generation protein drugs have a $17 billion market. Genencor has just completed the development of a mouse that has been genetically altered to incorporate a complete human immune system (*Rochester Business Journal*, June 22, 2001, p.1). Even animal health can benefit. In April 2001, Cornell announced a genetic cure for a retinal degenerative disease in dogs.

Biotech R&D Spending Accelerates

Total spending on biotechnology research has been growing rapidly, from basic research through start-up firms to "big pharma," the immense pharmaceutical companies that dominate the industry. The pharmaceutical industry is heavily invested (either directly or through partnerships) in biotechnology. PhRMA reports that research spending by member firms will reach $30 billion in 2001 (phrma.org). While this includes more than just spending on drugs based on biotechnology, given the one-third share of clinical trials devoted to biotechnology, biotech's share of PhRMA member research budgets may actually be greater.

Biotech firms spend eight times the U.S. corporate average per employee on R&D.

Ernst & Young reports that the average biotech firm spent $69,000 on research and development in 1995—*eight times* the U.S. corporate average. In a 1995 survey, *Business Week* ranked firms by total spending on R&D—five of the top ten were in biotechnology (Office of Technology Policy, p.10).

The pace of R&D spending on biotechnology has accelerated in recent years. A survey of genomics research funding among government and nonprofit sources found that funding increased 80% from 1998 to 2000 ($448m to $820m). The R&D spending of publicly traded firms specializing in biotech increased more than tenfold between 1993 and 1999 (*World Survey for Genomics Research*, Stanford University Report to the Global Forum for Health Research and the World Health Organization, September 2000). PhRMA member companies reported an increase in their aggregate R&D budgets from $24 billion in 1999 to $30 billion in 2001, a 25% increase in only two years.

Financial markets endorsed the promise of biotech in 2000. Nearly $39 billion was raised through IPOs by biotechnology firms (*Biotech Finance* June 2001, p. 42), a substantial increase over previous years. This injection of new research funding for new and small firms will surely add to the number of innovations in the pipeline. The late 2000 retreat of financial markets from technology IPOs began to erode those gains, but biotech finance observers see signs of a revival as we pass the middle of 2001. The Nasdaq Biotech Index, while down 30% from August 2000, rose 17% between late March and early August, 2001.

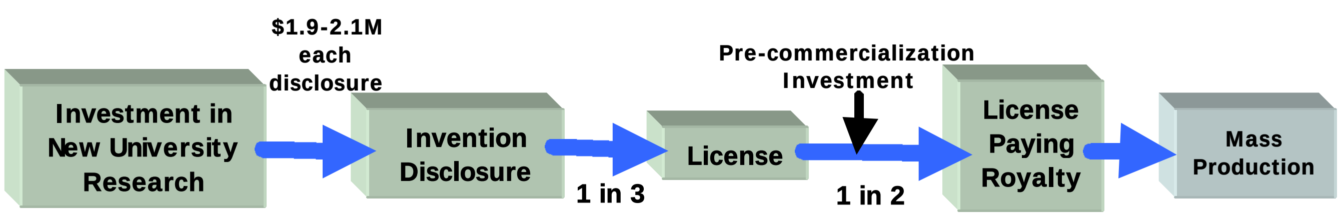
Despite strong growth in private biotech R&D, the key discoveries that drive the creation of new products come from the laboratories of the nation's universities. The path to commercial success often flows from a basic discovery at a university. As a consequence, ties between universities and commercial labs are very strong.

State Investment in Innovation Expands Economy

Spending on university-based basic research stimulates innovation that can lead to new products *and* more jobs. With appropriate and timely support, innovation can stimulate an expansion of the state's economy. The process of turning discovery into jobs includes these elements:

- The university that receives the public investment adds researchers directly, enhancing its standing in the academic world.
- Strategic state investment can stimulate additional funding for the university from federal and private sources, reinforcing the initial impact.
- Pro-active technology transfer efforts ensure that discoveries in the laboratory become the subject of patent applications and licenses to private firms, either start-ups or established companies.
- Licensees spend additional funds turning discoveries into products, typically working closely with the scientists responsible for the initial discovery.
- Successful commercialization engenders a manufacturing phase, adding to the state's workforce, provided that the manufacturing occurs within the state.

The figure below shows the process of bringing a product from the laboratory to the factory. The key shows the connection between each stage—each disclosure is associated with about $2 million in research spending; about one-third of disclosures are licensed; about half of all licensed innovations pay royalities.



University Research Stimulates Innovation

Harvard economist Adam Jaffe in 1989 demonstrated a strong association between university research and corporate patents by state. The relationship was particularly strong with drug patents. States with higher levels of university research had more patents. Jaffe also found evidence that high levels of university research were associated with high levels of industry R&D. "Thus a state that improves its university research system will increase local innovation both by attracting industrial R&D and augmenting its productivity" (Jaffe, p.968). Building on Jaffe's work, Stanford economist Andrew Toole showed in a paper published in 2000 that an increase in basic drug research of 1% led to an increase in the number of commercially-available drugs of 2% to 2.4% (Toole, p.5).

Industry R&D Occurs Near University Research

Not only did Jaffe show that more research meant more patents, but he also found that these innovations do not simply flee to the most appealing manufacturing venue. His findings demonstrate that university research increases patenting in the same state in which the university is located.

University innovation: 82% of licenses in SAME STATE as university

This is confirmed in the 1999 member survey from the Association of University Technology Managers (AUTM 2000). For licenses reported by AUTM member institutions in 1999, 82% of these licenses went to firms located in the *same state*. A strong relationship exists between the location of research activity and the commercial investment that turns research into new jobs.

Job Creation Occurs Both Pre and Post-Commercialization

Innovations stimulate economic activity both while the innovation is being turned into a product and after the product has reached the marketplace. Both are substantial and important sources of high technology employment.

Pre-Commercialization Impacts

The Massachusetts Institute of Technology (MIT), the University of Pennsylvania (Penn) and others have measured pre-commercialization investments through surveys of firms holding licenses from their institutions. The MIT and Penn studies estimated that each exclusive, active patent license stimulated almost $1 million per year of induced investment (R&D spending by the licensee to make an idea commercially viable) *prior* to bringing a product to market ($.98 M in the MIT study and $.93 M in the Penn study).

The National Science Foundation reports that about $177,000 in R&D was associated with each scientist or engineer employed at an R&D-performing company in 1999. If biotech license holders employ staff at the same ratio, each license would be stimulating the employment of more than five highly-skilled workers. Small firms (under 500 workers) are less capital intensive, thus employ more workers for the same R&D expenditure. In the case of small firms, each license would stimulate the employment of more than six workers. The 1999 AUTM survey reports that 63% of licenses are issued to firms under 500 workers (12% to start-up companies and 51% to established small companies).

AUTM reports that a typical technology license requires the payment of two percent of sales as a royalty (although universities are increasingly taking an equity position in start-ups that license university technology). Thus total sales from innovations licensed from university innovations can be estimated from reported royalty earnings.

CGR obtained sales and employment statistics from Hoover's Online: The Business Network for pharmaceutical companies. The median sales per employee for the 92 firms included in the Hoover's list was $181,000. Based on this finding and the AUTM statistic on royalty payments, one can infer that a royalty payment of $50,000 is associated with $2.5 million in product sales and about 14 workers (Hoover's Online).*

Returns to Biotech Exceed Those in Physical Sciences

Drug manufacturing employment grew at a compound annual rate of 2.5% between 1989 and 1999.

At each phase of the process of turning academic inquiry into jobs, investments in biotechnology research appear to earn higher average returns than similar investments in physical science research. This is not to imply that every biotech investment will even be profitable, much less surpass the return of every physical science investment of similar scale. The strength of the market for pharmaceuticals, when combined with the rate of innovation in the biological sciences, makes the return to biotech investments unusually large. The trend for drug sales was discussed above. The same phenomenon can be observed in employment: Drug manufacturing employment grew 28% between 1989 and 1999 while the entire economy grew about 19%.

More Invention Disclosures for Same Investment in Sponsored Research

On average, biological science research stimulates a larger number of invention disclosures than does the same level of spending on physical science research.

AUTM data show that a smaller research investment is associated with each invention disclosure at hospitals and medical research institutions. One invention disclosure is reported for every $1.9 million in sponsored research spending. For all respondents to the AUTM survey, one invention disclosure is reported for every $2.2 million in sponsored research spending.

* There is a tremendous degree of variability inherent in these estimates. Several firms—presumably in the drug development phase—reported very low product sales, thus very small sales per employee. Other firms, likely the owners of particularly lucrative patents, report sales per employee of $1 million or more.

Biotech Licensees Spend More in Pre-Market Phase

Biotech licensees spend larger sums bringing a particular innovation to market. The MIT and Penn studies of pre-commercialization spending by licensees found that while the average licensee spent just under $1 million per year developing the license, biotech licensees spent about three times that total—$2.75 million in the Penn study and $3.16 million in the MIT study (Pressman *et al.*, Kramer *et al.*).

Higher License Fees to Universities Imply Greater Market Success

Medical innovation pays higher average license fees, suggesting a more lucrative market for medical discoveries. As drug sales are more profitable than other types of products, the royalties earned by institutions and, by inference, total sales and employment of licensees are also greater.

The average royalty per active license reported by universities to AUTM was $51,000 in 1999. Respondents from hospitals and medical research institutions reported an average royalty of $70,000, nearly 40% larger. The gap is probably greater than these figures would imply as the AUTM survey does not require universities to separately report innovations from their medical schools. The financial return to non-medical innovations is probably much lower than the $51,000 average reported by AUTM.

The *Haemophilus influenzae* type b (Hib) vaccine—discovered at the University of Rochester in the 1980s—was the first approved for infants since the polio vaccine. Believed to have reduced incidence of bacterial meningitis in children by over 90%, it is now administered to nearly every newborn in the United States and many other countries. More than $43 million in royalty income was generated by the license by 2000—almost all since 1991. Many discoveries in nonmedical fields, perhaps of similar scientific challenge to the discovery of the Hib vaccine, have a much smaller potential market, thus a smaller economic impact. Market forces dictate that many medical innovations pay very well.

Combined Impact Implies 75% Bonus to Biotech Research

When each of these factors is combined, CGR estimates that the impact on employment and payroll for biotech investments exceeds that of physical science investments by about 75%. Of course, this finding does not mean that strategic investments in physical science research do not also promise significant returns or that proposals in biotechnology should be funded uncritically.

Forecasting the Economic Impact of Biotech Investments

Forecasting the economic impact of new investments in university research is somewhat speculative. That there will be an economic impact is nearly certain, but the variation in its magnitude across institutions and fields of inquiry remains significant.

How a state benefits from investments in new research is also highly variable. “Upstream” investments in scientific discovery must be complemented by “downstream” investments in technology transfer (licensing & patenting assistance for researchers), plus support for new ventures such as revolving loan funds and incubator space.

CGR estimates that a $20 million investment in biotech research will stimulate employment outside the university of about 81 workers in the pharmaceutical industry, earning $5 million annually. The indirect impact of this addition to the industry would be an estimated 66 jobs, with payroll of $3.4 million. If we assume that the increase in jobs in the pharmaceutical industry (the direct employment) and the industries supplying the industry (the indirect impact) were fully served by in-migrants to the state, there would also be an induced effect of 82 jobs and $2.6 million in payroll. In addition to impacts within the universities, *the aggregate potential impact on jobs and income would be nearly 230 jobs and over $11 million in annual payroll.*

New York’s Biotech Industry

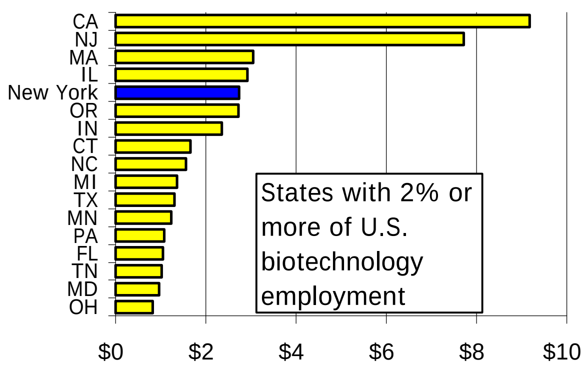
New York has long been a leading state in the pharmaceutical industry and in life science research. While traditional drug development continues, innovations both in drug design and manufacture based on biotechnology are fast taking over the industry. As existing information sources do not permit the separation of traditional pharmaceutical activities from those based on biotechnology, all statistics in this paper include the entire drug industry, along with medical equipment and commercial physical research.

So defined, New York’s biotech industry makes a substantial contribution to the state’s economy. In 1999 New York employed almost 45,500 people in over 750 firms engaged in biotechnology, earning direct wages of $2.7 billion dollars*. These are particularly

* Following the lead of a number of other studies, biotechnology is herein defined as including SIC codes 283 (drugs), 384 (medical instruments & supplies) and 8731

well-paying jobs, thus stimulating employment in a number of other industries. Workers in the biotech industry earned $63,000 per job in 2000 compared to a statewide average of $45,000. *

NYS is a Leading Biotech Employer



The biotechnology industry has an aggregate impact on the state's economy that is much larger, as many firms depend on the purchases of the biotech companies and their employees. CGR estimates the indirect impact of the biotech industry in NYS to be an additional 37,000 jobs and $1.8 billion in payroll. Given the specialized skills of workers in this field, it is reasonable to assume that the industry has attracted new workers to New York State expressly to work in this industry. The spending of workers and their families (the "induced" effect) can reasonably be added to this total. The induced effect is an additional 46,000 jobs and $1.4 billion in payroll. *The aggregate impact is thus 128,000 jobs and about $6 billion in payroll (in $2000).* †

The contribution of this sector to statewide tax revenue is also large. Annual personal income tax revenue from those directly employed by the industry is approximately $102 million. With personal income tax revenue from indirect and induced income added in, the total NYS personal income tax total rises to about $208 million.‡ Workers and firms also pay sales and property taxes

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(commercial physical research). Another common definition excludes SIC 384. The conclusions of this paper are unchanged by use of the alternate definition.

* This estimate for 2000 is based on Q1-Q3 average from the Covered Employment Series, NYS Department of Labor. 2000 figures are not yet available for other states.

† These estimates have been developed by CGR using IMPLAN. Further information about the IMPLAN regional input-output modeling system can be obtained from CGR or by consulting IMPLAN's web site at www.implan.com.

‡ Based on effective tax rate on total NYS income for income tax filers in 1997, the latest figures published by the NYS Department of Taxation & Finance, Office of Tax Policy Analysis. This assumes an effective rate of 3.7% for the relatively high paid workers in biotech firms and a 3.3% rate for indirect and induced employment.

to the state and localities. Firms are also subject to the Corporation Franchise Tax.

NYS a Leader in Life Science Research & Innovation

While biotech makes a major contribution to New York's economy already, it should be even larger. Well endowed with top ranked research institutions—recognized for path-breaking work in life science research—New York should be the location of choice for expanded biotech industry R&D and manufacturing.

New York Institutions Awarded $1.3 Billion in Grants From NIH in FY2000

NYS research institutions captured almost ten percent of the nearly *fifteen billion dollars* in research grants awarded by the National Institutes of Health to U.S. institutions in fiscal year 2000 (nih.gov), third after California and Massachusetts. Six New York state research institutions—Columbia, Cornell, Yeshiva, Mt Sinai School of Medicine, New York University and the University of Rochester—received more than $100 million from NIH in FY 2000. (See *NYS's Technology-Driven Industries: Biotechnology & Pharmaceuticals*, Empire State Development for a description of NYS's research institutions by region.)

New Yorkers Awarded 2,700 Health-Related Patents

New York's research efforts have also borne fruit in the number of patents awarded to NYS inventors. The U.S. Government Patent Office database includes almost 2,700 health-related patents attributed to New York state inventors for the period 1996-2001. This places New York 4th in the nation after California, Massachusetts and New Jersey.

New York's share of health-related patents over this period is about seven percent. New York and New Jersey together capture fourteen percent of total patents awarded in health-related fields over this period.

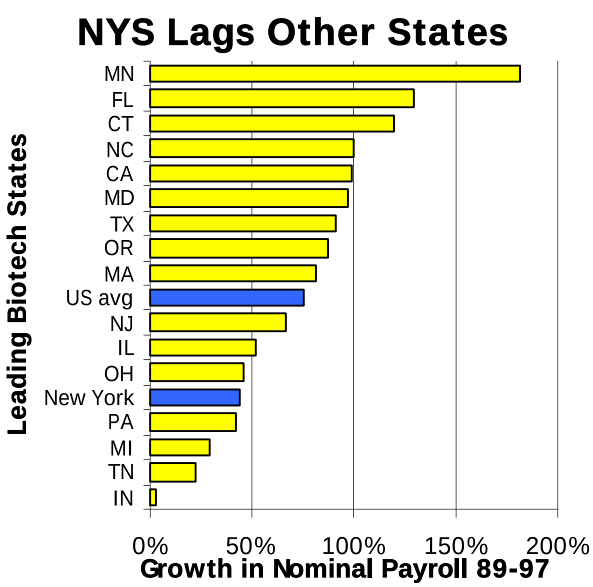
New York's Share of Big Pharma is 19%

Of the fifty largest pharmaceutical companies in the world, five have either their world headquarters or their U.S. headquarters in New York. By revenue, these firms account for almost one fifth of the total.

New York is also a big player in a NY/Northern NJ/Philadelphia pharmaceutical cluster. New Jersey is home to an additional fourteen companies, which capture 43% of total revenue from the fifty largest firms. When Philadelphia is added to New York and New Jersey, the combined total revenue is nearly two-thirds. Just as New York can benefit from its own big pharma companies, the state should be a contender for R&D and manufacturing facilities from neighboring states.

But New York Loses Market Share in Jobs & Payroll

New York state payroll and employment in biotech is between five and five and one-half percent of the national total. While large, this is less than we would expect given the high concentration of innovation, as measured by NIH grants and patents, and the fact that nearly two thirds of the pharmaceutical industry's U.S. headquarters are located either in New York or nearby.



Not only does NYS have fewer biotech jobs than its share of life science innovation would suggest, but also the state has been *losing* market share over the past decade. Between 1989 and 1997, New York ranked 13th in nominal payroll biotech growth among the 17 states with at least two percent of national employment in biotechnology. New York's rate of nominal payroll growth over the period was 44%, well behind the 75% rate of growth experienced by the entire U.S. industry. New York's share of total biotech payroll fell from almost seven percent in 1989 to about five and one-half percent only eight years later. During the same period, Minnesota's share rose from only 1.7% to nearly 3% and industry leader California's share rose from 17.8% to 19%.

New York's performance was consistently below the national average in all three components of the biotech industry, ranking 11th of 17 in payroll growth in "commercial physical research," 11th in the drug sector (13th using comparison data through 1999) and 15th in "medical instruments & supplies."*

* This analysis is based on the *County Business Patterns* series of the U.S. Department of Commerce, Bureau of the Census for the years 1989-1997. The change from the use of Standard Industrial Classification codes (SIC) to the North American Industrial Classification System (NAICS) in 1997 made later comparisons impossible. The one exception is drug manufacturing. In this instance the classification of firms under SIC and NAICS is identical. SIC 283 is equivalent to

It is worth noting that New Jersey's position has also slipped, although less than New York's in aggregate. Despite the concentration of "big pharma" company headquarters, total drug industry employment increased in New Jersey at one-third the national rate between 1989 and 1999, suggesting that the dynamic edge of the pharmaceutical industry has shifted to Minnesota, Connecticut, California, Florida and Maryland. The importance of the NYC-Northern New Jersey economy to New York state's economic vitality suggests that New Jersey's inability to attract and retain cutting edge facilities may further endanger New York's biotech economic base.

Competition From Other States & Nations

New York is not alone in its desire to increase its return from biotechnology industry growth. Building on recent successes, groups in Minnesota, Missouri, Oregon, North Carolina, Texas and Tennessee and many other states have announced new investments in biotechnology research and commercialization.

The European Commission and the European Parliament announced its support for a new biotechnology initiative in March 2001 that would increase funding by EU institutions and member states for biotechnology R&D (*BioWorld International* March 21, 2001). Israel announced plans in January for a "research village" in the Negev funded at $185 million and targeting biotechnology (IPR Strategic Business Information Database, January 25, 2001). Recent years have seen new initiatives in the United Kingdom, Switzerland and other nations.

Formula For Success

Clearly, New York has the manpower and the research institutions to reclaim its position as a leader in this rapidly growing industry. *Strategic investments in biotechnology—particularly where the link between innovation and commercialization is strong—have the potential to expand the New York state economy as this industry explodes in coming decades.*

Build on Established Concentrations of Technology Talent

Nor is the relatively high cost of doing business in New York necessarily a barrier to reinvigorating the state's biotechnology sector. A 1997 survey of bioscience firms in New York identified the "high cost of doing business" as an important factor determining the location of R&D facilities—half of those

NAICS 32541. SIC/NAICS differences in other categories are insurmountable at the state level.

responding termed "cost of doing business" as "very important." However, of the top five states in biotech payroll growth between 1990 and 1997, three (Massachusetts, Connecticut and California) are *not* known as low cost business locations. Business costs do matter—but the 1997 survey identified "availability of good senior staff" and "availability of good support staff" as at least as important and "proximity to universities & research institutions" as nearly as important as business costs (Willoughby).

Certainly the NYS Legislature and the Executive Branch need to continue to work to streamline regulation, reduce the cost of energy and lower taxes. The lessons from Silicon Valley and Boston's Route 128 are clear, however: High technology industries locate near concentrations of talent.

Connect Innovation & Discovery to Product Development & Manufacturing

Key to maximizing the potential of new innovations in biotechnology, however, is the connection between commercialization and product development and manufacturing. As an example, building on the successes of Cornell's Institute for Biotechnology and Life Sciences Technology and its strength in traditional plant and animal research, the university and the City of Geneva in Ontario County are planning an Ag and Food Tech Park to help commercialize innovations at Cornell's Agricultural Experiment Station. This kind of investment will promote the capture of biotech innovations in the state.

Building Biotech as a Major Contributor to NYS's Economy

New York can capitalize on its already-established biotechnology assets by harnessing the strengths of the state's major research institutions to explore basic and applied biotechnology science. This can work to the mutual benefit of the universities, business and the state's economy.

CGR has been studying how other states structure their investments in new technology (and will be the subject of a forthcoming report). Elements of successful programs include:

- Industry participation, in the form of significant financial support and participation in expert panels,
- University commitment to meaningful collaboration with industry,
- Government commitment to long-term funding and participation,

- A structure for commercializing innovation, including staff skilled in licensing and, preferably, a physical facility (tech park/incubator) to serve as a receiver of new ventures formed from the initiative, and
- An accountability structure to encourage participants to consider the impact of their programs on economic growth.

By investing in biotechnology innovation and commercialization now, New York will be poised reap the benefits of the industry's exponential growth in the years to come.

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