University Bioscience Research and Regional Economic Development: You can't always get what you want . . . you don't always get what you need

Lessons learned by an ACE Fellow in Buffalo, NY

Lisa C. Freeman

Associate professor and Director of Mentored Training
College of Veterinary Medicine, Kansas State University

The view that federal investment in biomedical research can lead not only to improved physical well-being, but also to economic prosperity was advanced by Vannevar Bush in his 1945 report, *Science the Endless Frontier*: "Advances in science when put to practical use mean more jobs, higher wages, shorter hours. . . . Advances in science will also bring higher standards of living, will lead to the prevention or cure of diseases, will promote conservations of our limited national resources, and will assure means of defense against aggression. . . . Science, by itself, provides no panacea for individual, social and economic ills. It can be effective in the national welfare only as the member of a team whether the conditions be peace or war. But without scientific progress no amount of achievement in other directions can insure our health, prosperity and security as a nation of the modern world."[1]

Today, the Federal Government is the largest supporter of academic-based research in the life and health sciences.[2,3] In return for this investment of tax revenue, Americans expect steady progress in development of safe and effective diagnostic tests, surgical procedures, vaccines, drugs, and devices. Moving academic research from "bench to bedside" has demonstrable benefits for individual investigators, universities, companies, and general public. In fact, Americans today benefit from both the advances in health-related technology and the economic expansion that result from technology transfer.

Passage in 1980 of the Bayh-Dole Act served as a major stimulus for expansion of technology transfer by universities and academic medical centers.[2-5] This legislation gave universities the right to own and license their inventions that result from federally funded research. It has been estimated that university research contributed significantly to the development of 27% of the new products and 29% of the new processes commercialized by pharmaceutical companies in the 1980s.[6] For example, academic inventions with substantial public health significance include: the anti-cancer drugs cisplatin and carboplatin (Michigan State University); the prostate specific antigen (PSA) screening test for prostate cancer (Roswell Park Cancer Institute); the vaccine for hepatitis B (University of Washington); the anti-HIV drugs lamivudine and emtricitabine (Emory University).[3,7-8] University researchers have also played a key role in establishing biotechnology companies, such as Genetech, Chiron and Biogen.[7]

In 2003, universities received 3179 new patents and spun off 348 companies. Still, there is significant concern that translational research and technology transfer occur too slowly.[4,9] Intellectual property that is developed in academic laboratories, but not disclosed nor developed represents a loss to society—a failure to fulfill the dream of Vannevar Bush. At the federal level, recent attempts to remedy this have focused largely on facilitating basic research breakthroughs and accelerating the speed of translation of those discoveries into clinical practice. The most notable initiative is the NIH Roadmap, with its three major themes: new pathways to discovery; research teams of the future; re-engineering the clinical research enterprise.[9]

The emphasis of regional and state governments is decidedly more focused on economic health than on preventing or curing disease.[10] When the governor of New York announced in 2001 the formation of a Center of Excellence in Bioinformatics at the University at Buffalo (UB), the assembly speaker said:

> "Supporting projects such as the Center of Excellence at the University at Buffalo is a proven strategy for job creation and for the long term economic well-being of our communities." [11]

A local assemblyman echoed:

> "The UB Center of Excellence is an excellent example of how State government can help turn Western New York's economy around and make us a player in the global economy of the future. The project will help transform innovative ideas developed at our local colleges and universities into the good-paying jobs that will help more families put down roots in our region."[11]

Numerous regions are looking to local research universities to help them become national centers for life sciences research and industry. More than 40 states are pursuing a bioscience agenda as a statewide goal.[10-13] A 2001 survey of state government initiatives found that state strategies for support of the biosciences include tax credits and incentives, direct investments in research, technology and education infrastructure, and other measures aimed at improving the business climate for biotechnology start-ups.[13]

Even though the biomedical research enterprise is relatively widespread and there is growing interest by the states in leveraging university research into economic development, however, only a handful of the United States' largest metropolitan areas have demonstrated real success. Among the country's 51 largest metropolitan areas, nine regions account for the bulk of economic growth in biotechnology:[12]

- Boston (including Worcester-Lawrence, MA)
- San Francisco (incl. Oakland-San Jose, CA)
- San Diego, CA
- Research Triangle, NC (Raleigh-Durham-Chapel Hill)
- Seattle (incl. Tacoma-Bremerton, WA)
- New York (incl. Long Island, NY, and Northern NJ)
- Philadelphia (incl. Wilmington, DE, and Atlantic City, NJ)
- Los Angeles (incl. Riverside and Orange County, CA)
- Washington DC-Baltimore, MD.

Moreover, even these successful biotechnology clusters have produced only modest returns to local economy.[12] What do these data suggest for the areas looking towards a life sciences corridor for economic salvation? According to Mark Collar, president of the Global Pharmaceutical Division of Procter & Gamble: "There are going to be winners and losers. There aren't going to be 83 biotech epicenters in the United States."[10]

Winners vs. Losers

What determines whether a regional bioscience initiative will be the road to riches or a boulevard of broken dreams? The challenges facing aspiring regional biotechnology centers are significant and include: fostering a climate conducive to university spin-offs on campus and in the community, attracting adequate amounts of venture capital to move an idea from "mind to market," and developing a local workforce suitable to the life-sciences industry. When local officials assess their potential for success, they may overestimate the adequacy of existing resources and infrastructure, underestimate the time required for return on investment, and thereby foster or fuel unreasonable expectations.

Establishing Research Infrastructure

Realistic consideration of the infrastructure available to support a biosciences cluster must take into account the available research base, capital flow, and labor force. In 2002, the nine established US biotechnology corridors accounted for of 59% of NIH funding, 68% of biotechnology patents, 92% of active biotechnology venture capital firms, and 75% of biotechnology start-up firms.[12] Whereas biomedical research activity became more dispersed during the fifteen years between 1985 and 2000, patents, capital flow and the growth of biotechnology firms became more concentrated over the same time period.[12] Productivity in research and life sciences education is necessary but not sufficient for success in economic impact. Chicago and St. Louis are examples of metropolitan areas with high levels of research activity but below average levels of commercialization (Table 1). Buffalo and Kansas City are examples of aspiring biosciences corridors facing real challenges across the spectrum of research infrastructure (Table 1).

The North Carolina Research Triangle, San Diego, and Seattle were latecomers to biotechnology and boom. Each has above average levels of research activity, but all three are relatively stronger in commercialization than in research. These regions were tremendously successful in generating new ventures and attracting capital during the 1990s, and their emergence as biotechnology centers reflects these achievements.[12] It is important to recognize that significant financial investments contributed to the successes of the Raleigh-Durham-Chapel Hill, San Diego, and Seattle metropolitan areas. Each of these areas has had an average of $500 million in NIH funding annually for more than a decade, combined with $750 million in new venture capital during the past 6 years.[12]

Table 1. Research Infrastructure Comparison*

Metro Area	Bioscience PhDs granted 1999	$ NIH Funding 2000	# Patents 1990-99	$ Venture Capital Investment 1995-2001
Boston	355	1,422,875,474	3,007	1,915,654,300
San Francisco	215	703,529,044	3,991	3,028,917,500
San Diego	82	680,954,889	1,632	1,505,896,000
NC Research Triangle	166	469,119,754	796	379,687,000
Chicago	177	416,777,457	1,444	61,837,000
St. Louis	173	324,015,608	780	8,800,000
Buffalo	45	61,504,692	129	0
Kansas City	11	27,921,183	103	12,000,000

*Data excerpted from reference 12.

Interestingly, the pathway to prosperity was not identical for the upstart regions. Cutbacks in the defense industry left San Diego with a plethora of talented engineers, scientists and managers attached to the area and in search of new challenges. The University of San Diego was highly successful in transferring technology out of university laboratories and into companies, because of the availability of this unique workforce.[14] In the North Carolina towns of Raleigh, Durham and Chapel Hill, there were major research universities producing doctoral level bioscientists and no places for them to work in the state. In contrast to San Diego's strategy of advancing home-grown entrepreneurs through technology transfer, North Carolina developed a strategy based on recruitment and relocation of successful biotechnology ventures.[14] In the 1990s, a number of recruiting organizations such as the North Carolina Biotechnology Center focused their efforts on bringing big name biotechnology firms to Research Triangle Park by offering facilities an unusual variety of opportunities for formal and informal collaboration with the universities.

It is notable that the strategies used by San Diego and Research Triangle, NC, were focused beyond merely bolstering academic research funding and activity. In each case there was a long-term plan built around existing strengths and based upon support of sensible strategic partnerships, promotion of private capital investment, and encouragement of local entrepreneurship. These are key components of effective programs.

In metro areas like Buffalo and Kansas City, where traditional industries are outside of science and technology attracting private capital investment may represent the most significant challenge. Biotechnology is both expensive and risky. Funding for early stage technology, is difficult to obtain under any circumstances, and this investment gap is worse when market uncertainty is heightened by lack of investor proximity and lack of regional experience with commercialization of academic inventions.[10-15] In regions like these, it will be important for state and local initiatives to provide support for mid-to-late stage funding for development of products with commercial potential, to offer business development assistance, and to invest in workforce development. Academic institutions and established corporations also have the potential to contribute in these areas. Increasingly, universities are making venture funding and campus-based business expertise available to new life science companies.[16,17] Innovative corporate partnerships are allowing for enhanced educational opportunities in entrepreneurship and professionalism.[18]

Managing Expectations

Entrepreneurs and executives are highly susceptible to cognitive biases that lead to inflated self-confidence and an exaggerated view of their own power to influence complex series of events.[19] Organizational and political pressures to emphasize the positive and downplay the negative may also contribute to overoptimistic forecasts.[19] Unfortunately, the net result is too often a shared unrealistic view of future outcomes for major initiatives.

Many, if not most strategies to leverage university innovation into regional economic development suffer from this type of "delusional optimism." In this context, the results are flawed decision making and unreasonable community expectations. This phenomenon was evident at establishment of the Center of Excellence in Bioinformatics at UB.

As noted in the previous section, the formation in 2001 of the UB Bioinformatics Center of Excellence was a major step in an integrated plan for building a life sciences economy in the Buffalo-Niagara region of western NY. The Center was launched with a federal investment of $27 million, a state investment of $50 million, and corporate pledges for $150 million dollars. Early on in the life of the Center, its power as an engine of economic development was oversold, not only by politicians but also by academic and community leaders:

> "Buffalo has some unique strengths. The money for the new Center of Excellence in Bioinformatics will allow us to take those strengths and turn them into an economic engine for this area."
>
> Senior Associate Dean, UB School of Medicine20

> "A not-for-profit group called Bufflink that is working to foster a life sciences economy in the region estimates drug development work could create 5,000 to 8,000 jobs over the next several years." [21]

Projections based on realistic benchmarks were advanced only after significant media attention was paid to shortfalls from projections:

> "The Center missed initial projections of creating 4000 or 5000 spin-off jobs. Bufflink has tracked over 1000 jobs in the life sciences in the past few years, although not necessarily linked to the bioinformatics center."
>
> Buffalo News, 2005[22]

> "It's a difficult and challenging proposition to expand a region's economic base from one anchored traditionally in manufacturing to one that includes a life-sciences foundation; experience in other parts of the U.S. has shown it takes years for this occur."
>
> UB President, 2005[23]

The exuberant expectations for the UB Center of Excellence in Bioinformatics reflect over-optimism and result directly from the planners reliance on what Lovallo and Kahneman have called an "inside view."[19] The initial projections were based on knowledge of goals and resources, and imagined scenarios of progress. It is likely that more realistic expectations would have been generated by taking an "outside view" and adopting "reference class forecasting."[19] The latter approach ignores the details of the project at hand, and instead uses the experiences and outcomes of a class of similar projects to gauge the current position and forecast the future course.

The advantage of an outside view is most pronounced for large scale initiatives where the planners lack experience.[19] This is almost always the case for state and regional efforts to leverage academic research into economic development. Fortunately, precedents that can be used for reference class forecasting exist and are accessible. Comparison data similar to Table 1 can be excerpted from the surveys and reports generated by the Association of University Technology Managers (http://www.autm.net/index.cfm), the US Bureau of Census, the federal agencies that provide research funding to universities (NIH and NSF), TheCenter (http://thecenter.ufl.edu/), and the numerous for-profit and not-for-profit organizations that review the bioscience industry.

Implications

Optimism generates more enthusiasm and commitment than realism. Significant instability and lack of trust may be induced or exacerbated by promoting unrealistic expectations in the context of a state bioscience initiative. In these projects, it is typical for the alliances to be uneasy; the agendas to be in conflict; and the resources to be inadequate. Impatience is common where persistence is needed.

In truth, establishing a new biosciences corridor is a challenging, long term proposition. Regardless of where the journey ends, one can expect to encounter a long hard road with many obstacles, detours and potholes. Success will be driven by significant investment in research infrastructure, realistic long-term planning, and appropriate management of expectations.

References Cited

1. *Science the Endless Frontier*, report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945. (http:/www1.umn.edu/scitech/assign/vb/VBush1945.html, last accessed 8/13/2005)
2. Campbell EG, Powers JB, Blumenthal D, Biles B. Inside the triple helix: technology transfer and commer-cialization in the life sciences. *Health Affairs* 2004, 23(1):64-76.
3. Loftus M. Eureka! *Emory Magazine*, Spring 2005. (http://www.emory.edu/EMORY MAGAZINE/spring 2005/eur-eka.html, last accessed 9/25/2005)
4. Olds J. Intellectual property conundrum for the biological sciences. *Anat Rec* 2004, 277B:5-9.

5. Rubin ER. The Bayh-Dole Act: Issues, concerns and conflicts. Association for Academic Health Centers, 2005.
6. Mansfield E. Academic research and industrial innovation. *Research Policy* 1991, 20(1):1-12.
7. Kneller R. Technology Transfer: A review for biomedical researchers. *Clinical Cancer Research*, 2001, 7:761-774.
8. Landmark Achievements-Roswell Park Cancer Institute (http.www.roswell park.org/document 5169.html, last ac-cessed 9/25/2005)
9. Overview of the NIH Roadmap (http://nihroadmap.nih.gov/overview.asp, last accessed 9/25/2005)
10. Blumenstyk G. In the life sciences, a sprouting competition. The Chronicle of Higher Education, November 26, 2003, pp A23-126.
11. Governor, Industry announce Buffalo Center of Excellence, Dec. 6, 2001. (http://www.state.ny.us/governor/ press/ year01/dec6 01.htm, last accessed 9/27/2005)
12. Cortright J, Mayer H. Signs of life: The growth of biotechnology centers in the U.S. The Brookings Institution Center on Urban and Metropolitan Policy, 2002.
13. *State Government Initiatives in Biotech-nology 2001*. Columbus OH: Batelle/ SSTI, September 2001.
14. Cohen W. The new boomtowns. *ASEE Prism online*, American Society for Engineering Education, January 2001 (http://www.prism-magazine.org/january 01/boom/boom.cfm, last accessed 9/13/2004)
15. Branscomb LM, Auerswald PE. Between invention and innovation: An analysis of funding for early-state technology development. Economic Assessment Office, Advanced Technology Program, National Institutes of Standards and Technology (NIST GCR 02-841)
16. Mehta S. The emerging role of aca-demia in commercializing innovation. *Nature Biotechnology* 2004, 22:21-24.
17. University at Buffalo, School of Management. Center for Entrepreneurial Leadership. (http:www.mgt.buffalo.edu/ced/cel/overview. shtm, last accessed 4/11/2005)
18. Caroll CA. Rychlewski W, Teat M, Clawson D. Enhancing entrepre-neurship and professionalism in medical informatics instruction: a collaborative training model. *J Am Med Inform Assoc* 2004, 11:317-319.
19. Lovallo D, Kahneman D. Delusions of success: How optimism undermines executives' decisions. *Harvard Business Review*, July 2003, 56-63.
20. Unger S., Goldbaum E. Bioinforma-tics, Medicine's newest frontier. *UB today*, Spring/Summer 2001 (http://www.buffalo.edu/UBT/UBT-archives/17 ubtss01/features/, last accessed 9/28/2005)
21. Thompson C. Bioinformatics center may provide best hope for gritty city's economy. Associated Press. Copyright 2003, *The Baltimore Sun*. (http://www.bufflink.org/NewsText/37434427 3032407.html, last accessed 9/28/2005)
22. Watson ST. Williams FO. The bioinformatics dream gets a wake-up call. *The Buffalo News*, June 19, 2005.
23. Page A. UB Announces enhancement of Bioinformatics Center, Seven new units join core bioinformatics component.(http://www.bufflink.org/NewsT ext/380846574652778.html, last referenced 9/28/2005