

Conclusion

From an economic-development perspective, biotechnology is clearly a desirable industry. Although generally not among the largest employers in metropolitan economies, biotech firms have the potential to generate highly paid high-skill jobs. It is thus not surprising that as the industry's size and impact continue to expand, many regions across the United States are eagerly seeking to develop a biotechnology cluster. For some, this may mean building upon the early success of a few nascent firms. For others, it may mean working to expand a cluster that is already robust.

The present analysis set out to locate biotech activity by examining various indicators of research capacity and commercialization. The research revealed the relative strengths and limitations of the 51 metropolitan areas studied; from this examination a clear pattern of biotech activity emerged. Further analysis of these patterns helps illuminate the behavior of the industry, providing an indication of how it develops, how it is sustained, and where it might be heading. Several conclusions stand out.

The availability of venture capital and local entrepreneurship is critical.

What does it take to become a region in which biotechnology is routinely commercialized? The presence of at least some level of medical research activity definitely seems to be a prerequisite. All nine of the identified biotechnology centers have high levels of NIH funding and at least one medical research institution that is ranked among the nation’s top twenty. None of the ten metropolitan areas with the lowest levels of NIH funding has even 10 percent of the U.S. average of biotechnology commercialization activity.

A strong research presence appears to be a necessary condition for biotechnology commercialization, but it does not seem to be sufficient. Four metropolitan areas—Chicago, Detroit, Houston, and St. Louis—have very high levels of research but below-average values of commercialization activity.

A critical factor in the development of biotechnology appears to be the flow of venture capital to new biotechnology businesses. The relative importance of capital availability is apparent upon considering the relative concentrations of research activity, capital flows, and the growth of new firms.

TABLE 18: RELATIVE CONCENTRATION OF BIOTECHNOLOGY ACTIVITY

Measure	Period	Herfindahl Index	Relative Concentration
Population	2000	0.05	1.00
Medical School Research	1985	0.06	1.28
	2000	0.05	1.10
Patents	1970s	0.17	3.67
	1980s	0.13	2.94
	1990s	0.08	1.81
Venture Capital	1995–2001	0.17	3.77
Research Alliances	1990–1995	0.17	3.82
	1996–2001	0.22	4.84
Firms Established	Before 1980	0.06	1.42
	1980s	0.08	1.72
	1990s	0.09	2.03

A low value represents low concentration, and a high value represents higher concentration. To simplify comparisons, we computed a measure of relative concentration by indexing the Herfindahl statistic to the concentration of population (1.00 means that in the 51 metropolitan areas a variable is exactly as concentrated as population.)

Comparison of the relative concentration of various biotechnology indicators in the 51 metropolitan areas studied (**table 18**) reveals several patterns. First, in recent years the levels of research activity (patenting and NIH funding for medical schools) have been much less concentrated than have been all measures of biotechnology commercialization. In short, research is relatively widespread, but commercialization is concentrated.

Second, during the course of time, research activity has become more dispersed, but biotechnology firm formation has become more concentrated. NIH research funding has become more widespread and is only about 10 percent more concentrated than population. Patent activity appears to be only half as concentrated as during the 1970s.

Third, flows of venture capital and research alliance funding have been especially concentrated, with recent relative concentration values triple those of research and double those of patenting.

Thus the nine leading biotechnology centers may account for a smaller share of NIH funding and patenting than they did two decades ago, but now they account for a larger share of new biotechnology businesses. These nine areas’ share of NIH funding has declined from 63 percent to 59 percent of the national total, and their share of biotechnology patents has declined from 71 percent to 68 percent. At the same time, the share of new biotech firms in these regions has grown from 61 percent of all new firms prior to 1980 to 77 percent of all new firms in the 1990s. The critical factor in this process is the very high concentration of capital flows in biotech centers: the nine leading biotech regions account for 88 percent of all venture capital for biopharmaceuticals, 92 percent of the

most active biotechnology venture capital firms, and 96 percent of the dollar value of research alliances with pharmaceutical firms.

Why are these capital flows so concentrated into these nine biotechnology centers? The phenomenon would seem to reflect the agglomeration economies or critical mass of having a large number of biotechnology firms, workers, and investors all in a single location. These areas are more likely to have large numbers of professionals—both managers and research scientists—with previous experience in commercial biotechnology. The areas have concentrations of specialized financial expertise in the form of venture capitalists. Once established, these clusters of activity sustain themselves and even attract additional talent and additional money (especially in the case of alliances with pharmaceutical firms).

Developing a new biotechnology center is challenging.

Many U.S. metropolitan areas are hoping to develop stronger biotechnology industries in the years ahead. What does today's pattern of industrial activity suggest about the kinds of strategies that will be successful?

First, regions hoping to generate a biotechnology industry will need to look beyond strategies focused on significantly bolstering local medical research. The apparent scale of research funding required for becoming a biotechnology center may be beyond the reach of most metropolitan areas, as there is little chance that historically low-funded metro areas will substantially increase their share. In fact, none of the 51 metropolitan areas increased its share of NIH medical school research funding by even 1 percentage point during the last fifteen years. Furthermore, increased funding for research may have no effect on local commercialization. Even those areas with the largest funding increases (Pittsburgh and Cleveland, both up 0.9 percent in share since 1985) have lost ground in their share of biotech commercialization. Success in getting additional NIH research funding may in some cases be a substitute for increased entrepreneurial activity. Instead, the critical missing ingredient in most large U.S. metropolitan areas is likely to be the availability of venture capital for new biotechnology investments. Metropolitan areas looking to reap benefits from commercializing biotech-

nology may find policies to stimulate venture capital and to encourage local entrepreneurship to be the most important steps they can take to develop a local cluster.

Second, it seems clear that conventional industrial recruiting activities will be of limited utility. There is little evidence that biotechnology firms move from place to place. Biotechnology firms develop locally, drawing on the ready availability of talented workers, relevant research, and localized venture capital. Most firms are small, young, single-establishment firms that remain located in the metropolitan areas in which they are started. Consequently, metropolitan areas interested in biotechnology should focus on indigenous biotech development strategies.

Finally, at least at its current pace of development, even successful biotechnology strategies will take a decade or more to bear significant fruit. Developing a biotechnology industry in metropolitan areas that do not already have a significant biotech concentration will require a considerable investment of time and money. The profile of the three metropolitan areas that have successfully developed a significant biotech presence in the past decade (Raleigh-Durham, San Diego, and Seattle) suggests the level of effort required. Each of these areas has had an average of \$500 million annually in NIH funding (in 2001 dollars) for more than a decade and \$750 million new venture capital investment during the past six years, and each area also has one or more of the nation's 20 top-ranked medical research universities and two or more of the nation's 50 principal biotechnology venture capital investment firms.

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The ultimate impact of biotechnology on metropolitan economies is unclear.

Biotechnology is a visible and rapidly growing industry, but it is not yet very large. Nationally, the best estimates suggest that fewer than 200,000 people work for biotechnology firms. Based on the average levels of pay for medical researchers and skilled technicians, these are good jobs. But will a successful biotechnology cluster generate enough jobs to be a major driver in a metropolitan economy?

Even in established biotechnology centers, the overall size of the biotechnology sector is small relative to the economy. For the nine leading biotechnology centers, the total level of employment in pharmaceutical manufacturing and life sciences research (a definition that includes many non-biotechnology firms) is equal to 3.5 percent of all manufacturing employment. In only two metropolitan areas—San Diego and Raleigh-Durham—is the combined level of pharmaceutical and life science research equal to 10 percent of regional manufacturing employment.

Most biotechnology companies seem to have little interest in growing to the size of incumbent pharmaceutical firms. Indeed, most biotech companies form alliances with pharmaceutical giants to obtain revenue; biotech firms that actually succeed in getting a product to market generally either license or sell their intellectual property to a large pharmaceutical firm or contract to such a firm for the product's manufacture, marketing, and distribution. At the metropolitan level, this means that the downstream economic benefits of production and marketing occur in the metropolitan areas that are pharmaceutical centers rather than in metropolitan areas that specialize in creating new products.

Metropolitan areas looking to reap benefits from commercializing biotechnology may find policies to stimulate venture capital and to encourage local entrepreneurship to be the most important steps they can take to develop a local cluster.

Much of the interest in biotechnology stems from the assumed parallels to the revolutionary impact of information and communication technology. Many assume that the new insights about the human genome will produce changes as sweeping as those induced by the personal computer and the Internet. It is of course impossible to predict, but there are some indications that the implications of biotechnology may be far less sweeping. The growth of computer technology was characterized by mass-produced technologies with constantly falling prices. Steady decreases in prices for computer processors, memory, and disk drives and for communication services stimulated their rapid adoption. No one has yet identified any biotechnology corollary to Moore's Law (transistor density doubles each 18 months and falls in price by one-half). Biotechnologies often tend to be quite expensive. Moreover, most biotech products are applicable to only a narrow fraction of the population. The widely heralded new anti-cancer biotech drug Gleevec, for example, may be useful in treating about 5,000 persons per year, at a monthly cost of \$2,000 to \$4,000 per patient (Stout 2001).

Nevertheless, predicting the future path of technological development, much less the economic impact of new technology, is extremely difficult. Even the experts have tended to err on the conservative side: the President of IBM once foresaw a market for no more than a handful of computers worldwide. Changes have tended to happen quite rapidly; a decade ago there were fewer than a dozen dot-com addresses in the world. But it does seem likely that when these as yet unimagined biotechnology breakthroughs come to pass, they will be the product of biotechnology companies located in metropolitan areas with a strong base of research and commercialization.