Journal of the Minnesota Academy of Science

Volume 53 | Number 1 Article 15

1987

Commercialization of Biotechnology

Daniel G. Miller
3M

Commercialization of Biotechnology

DANIEL G. MILLER

Daniel Miller is the Laboratory Manager for Biotechnology at 3M.

The question of how a specific scientific advance finds its way into a commercial product is at least as murky as any other issue addresed at this conference. Additionally, in the case of biotechnology, where a series of related advances is creating an entire new industry, the problem becomes incredibly complex as well.

The nature of this process, the identity and roles of the key participants, and the obstacles impeding progress are poorly understood. This misunderstanding extends not only to the general public, who expect to benefit from public support of biotechnology through the availability of biotech-derived products, but also to the investment, research, and surprisingly, the business communities. This lack of understanding is all the more striking, when one realizes that each of these groups expects to benefit from the economic consequences of the successful development of this industry.

Because of its inherent complexity, commercialization of biotechnology is a process that can only be conducted by large teams of individual specialists. The motivation for pulling together such teams and financing them for the length of time needed to generate the anticipated products is largely economic. Is the size of the market for biotechnology products worth the investment? Finally, we need to look at the key issues that will limit the success of biotechnology, particularly in the United States.

For the purposes of this analysis, we will restrict our attention to healthcare, which will limit the complexity of the issues involved at least to some extent. This is not to say that the other application areas of biotechnology are less important or that they have a more limited market impact. However, of the cumulative investment in biotechnology through 1986, 75% has gone into healthcare. Of the remainder, 18% of the investment has been in agriculture with just 4% going to chemical processing.

The key to the commercial introduction of any new technology is the identification of a customer who can benefit from the products resulting from the technology. Without this fit between products and market on one hand and technology on the other, the process of commercialization does not produce the expected stream of new products based on the technology. The principal characteristics of high technology businesses are unique products, high risk of failure, and the anticipation of a correspondingly high reward. These are not the characteristics of businesses where several manufacturers supply functionally equivalent products or of businesses where the customer has a desire but not a need for the product.

The major participants in a high-tech industry are 1) the university, 2) commercial research and development (which can be either a small start-up company or the research and development lab of an established one, and 3) an organization that provides the manufacturing, marketing, sales, and distribution functions required by an ongoing business. Each of these participants has its own source of resources and is rewarded in a particular way.

The university is responsible for fundamental research in a scientific area and for the training of new scientists, technicians, and teachers. It is funded with public money (taxes), which is provided as a consequence of the traditional public responsibility for education and the pursuit of new knowledge. The research conducted at this level is not goal oriented (e.g., a home test for strep throat) although there may be a mission associated with the program (e.g., the study of infectious diseases of the respiratory system). In healthcare, much of the funding comes from two federal agencies, the National Institutes of Health (NIH) and the National Science Foundation (NSF) with basic biomedical research funding exceeding $1 billion annually. These resources are allocated by a process known as "peer review" where teams of academic experts assess the scientific merits of investigator-initiated research proposals and award funds on a competitive basis. On the whole, this system has worked remarkably well for more than 30 years.

Industrial research and development is a highly directed, goal-oriented operation with specific product development objectives. This work, whether it occurs in a new company or an established one, is intended to answer questions such as: is the proposed product useful?; does it work?; how should it be manufactured?; and, for healthcare, can it meet requirements of safety and efficacy established by the Food and Drug Administration (FDA) and related healthcare regulatory agencies? Funding for this level of technology transfer comes from a number of sources, most of which are various forms of venture capital investment. In general, product development is considerably more expensive than the basic research that spawns it.

At the third corner of the technology transfer triangle are the conventional business functions of manufacturing, marketing, sales, and distribution. These operations insure that the product is available in a reliable form at an acceptable price to the right customer. They are funded by the proceeds received from the sale of the product and must be efficient enough to generate a profit, which is used for repaying investors, creating new jobs, and paying taxes (part of which are used to support the university, thereby regenerating the basic research community).

Healthcare products resulting from biotechnology have certain investment profiles that are relatively predictable. A

agnostic test based on a monoclonal antibody may take 10 ople one year to turn into a product at a cost of $1 million. In mparison, a biological replacement material such as insulin r diabetics or human growth hormone for hypopituitary warfism or a recombinant DNA vaccine such as hepatitis B, ill take up to five years and cost between $10 million and $20 million to develop through the FDA approval process. Finally, new therapeutic agents derived from biotechnology will frequently take more than $50 million in cumulative investment and 10 years to reach the marketplace. While these are only approximate numbers, the differences between the three situations in investment levels and time are significant with few, if any, shortcuts available to the product development team.

Furthermore, because of the time and investment required, each of these product areas creates certain demands on the organization attempting to commercialize in that segment. For example, a small organization is required in the diagnostic area and it has to remain stably committed to the task for only a relatively brief time before investors are rewarded by market entry. Increasingly larger, more stable (and more bureaucratic) organizations are required for pharmaceutical development, which need to maintain a high level of activity over a period of years. Very frequently, few of the scientists and business people involved at the onset of the program are still available by the time the product is ready for the marketplace.

If, in light of these considerations, we look at the biotechnology marketplace, we find that the largest number of new products are in the medical diagnostics area ($400 million in 1986 sales), the next largest are the biological replacement products ($100 million in sales) and the new therapeutic agents have not yet appeared in the marketplace, although large numbers are entering the clinical trial stage.

Through the first quarter of 1987, more than $6 billion has been invested in biotechnology companies in the United States by venture capitalists and other private investors. Currently, this investment has a valuation in the stock markets of approximately $10 billion, nearly one-third of which is embodied in one company, Genentech. In addition to this investment, more than 50 companies in the Fortune 500 have initiated some form of internal investment in biotechnology programs. While the extent of this investment is harder to estimate accurately because many of these companies have not commented publicly, based on information that is in the public domain, a $1 billion annual expenditure has been estimated by the NSF.

What products are all of these dollars chasing? Most estimates of the diagnostic markets for biotechnology are in the $1 billion dollar range by 1992. The estimates for the biological replacement products are similar. Clearly, in identified product areas, it is likely that the financial returns on an industry-wide basis will not justify the investment. What then are the prospects?

Biotechnology is a revolution in applied biology, which has been described in terms of operations such as cloning and expressing genes or the construction of hybridomas. While this is true, the full picture is much more exciting. Biotechnology represents the change of biology from a descriptive or empirical science with little or no theory to one firmly rooted in the physical sciences of chemistry and physics. When viewed in this way, biotechnology becomes not just the ability to make an enzyme or a peptide hormone, it becomes a new way of thinking.

Searching for a reasonable parallel, one quickly comes up with the changes in the electronics industry since the discovery of the transistor. The scientists at the time knew that they had a practical replacement for the vacuum tube but they did not foresee, in 1950, the pocket calculators or personal computers of the 1980s or many of the other things that semiconductors make possible.

Similarly, those of us involved in biotechnology can see clearly the possibility of producing, at economical prices, authentic human insulin or growth hormone. What we can only dimly forecast are the effects of chemical biology on procedures to design and synthesize pharmaceuticals and agrichemicals that are more effective and less toxic. The rapid pace of change in biotechnology shortens our forward vision from years to months and even weeks as results of basic and applied research from all over the globe pour forth. It is extremely difficult to predict the direction and outcome of research based on the tools now being applied to problems in neurology, rheumatology, and cancer. It is in this turbulent environment that investment decisions are being made, setting up the commercial organizations to pursue markets and products that are yet to be identified.

Even with the increasing unpredictability of the specific direction of biotechnology, it is becoming apparent that forecasts made just a few years ago of $20-$50 billion in biotechnology-derived products by the year 2000 are looking more achievable. More than 200 diagnostic tests with an annual market value of $400 million have been approved by the FDA and introduced in the past five years. In the United States, FDA approval and market introduction of six biological products have been achieved. Just one of these biologicals, human growth hormone, reached $50 million in 1986 sales for the treatment of one form of dwarfism. If this agent can be shown to be effective in other clinical situations, such as wound healing, this number would increase substantially.

What are the constraints that must be overcome in order to accomplish these goals? The larger scientific teams and longer timelines characteristic of biotechnology, represent a change from what the investment community, whether public or private, is accustomed to. An indication of this are the frequent press releases announcing this or that breakthrough, partly in an effort to maintain investor confidence during the long product development cycle. This also means that investments are larger and tied up longer than would be typical in other high-technology situations, translating to a higher risk and requiring a larger reward to justify the investment.

Another hurdle is that the manufacturing technology is relatively undeveloped for biotechnology, particularly in the United States. This means that scale-up problems occur frequently, causing problems with profitability. Recognizing this, a number of academic centers have been set up to address the problems in bioprocessing technology, including one at the University of Minnesota.

There continue to be problems with patent protection in biotechnology; the U.S. Patent and Trademark Office is struggling with policies and procedures in this area that will have to be worked out in the courts eventually. The federal regulatory policy concerning biotechnology is in serious disarray in spite of nearly 10 years of work at various levels. This makes it more difficult for commercial organizations to comply with regulations in a responsible and reliable way.

These last two issues, more than any others, increase the risk that a given biotechnology development effort could fail for arbitrary and capricious reasons unrelated to the success or failure of the technology itself.

Finally, at least three issues need to receive attention if effective biotechnology public policy is to be established.

First, biotechnology, like any other rapidly developing technical area, requires a strong academic base for both training and research purposes. The current system of funding by NIH and NSF based on peer review of research proposals, has worked well at the national level in research universities and should be continued. However, problems remain in areas such as the academic preparation of high school students in basic disciplines such as math, science, reading and communications skills, problems which are the province of state and local administration.

Second, it must be recognized that while the United States leads in many areas of high technology, including the principal components of biotechnology, our ability to successfully commercialize that technology is under tremendous competitive pressure from Europe and Japan. Much has recently been written about the death of the competitive spirit in America. This debate misses the point. Whatever the state of the American competitive spitit, that spirit is very much alive and well in the rest of the world. This is particularly true in biotechnology, a technology that easily crosses borders in the form of scientific publications and international technical meetings. Students from other countries, trained in U.S. research institutions, return home to work in industrial and academic facilities with colleagues that equal, in most respects, those in the United States. A sense of complacency in matters relating to biotechnology would certainly have the same predictable result for the United States economy that is currently being seen in the automotive and electronics industries.

Third, we need a better informed public. In many areas of high technology, the United States is becoming a two-tiered society: the minority who know about and understand the technology and its implications and the rest, who don't. This has several undesirable consequences including the abdication of decisionmaking power to the knowledgeable minority leading inevitably to mistrust, overregulation, and lost opportunities. It also diminishes the attractiveness of a technical career, reducing the number of U.S. students pursuing advanced technical education, and forcing U.S. academic institutions to go abroad in search of adequately prepared students. Obviously, this accelerates the development of strong foreign competition in high-technology fields, including biotechnology.

Biotechnology: Promise and Potential in Animal Healthcare

DAVID REED

David Reed is Director of Product Development at Molecular Genetics.

I would like to present my views on the promise and potential of biotechnology as it relates to the animal healthcare industry. Using various examples, some of which are based on experiences at Molecular Genetics, I will attempt to discuss current and future barriers to commercializing biotechnology in this area, review what progress has been made to date in the animal healthcare field, and briefly touch on some policy issues relating to the above.

Recombinant DNA-derived bovine somatotropin (rDNA-bGH) or growth hormone is clearly one of the most visible animal healthcare products to undergo commercialization. The promise of biotechnology for this hormone is the potential to produce huge quantities of this protein at a very economical cost. Current estimates claim that rDNA-bGH will cost about five cents a dose, and that thousands of kilograms will be produced annually for the dairy and beef cattle markets. Treatment of cattle with this synthetic form of a naturally occurring hormone may result in a 15% increase in milk production and a 10 to 15% increase in feed conversion efficiency. These figures mean that farmers will be able to produce significantly more milk and meat per animal while using the same, or perhaps, less feed costs resulting in cheaper costs of production.

Unlike many other extravagant promises you hear from biotechnology advocates, the benefits of rDNA-bGH are real and attainable in the near term. Only a few technical barriers prevent rDNA-bGH from reaching the marketplace; few other rDNA-derived proteins or substances can make that claim. With rDNA-bGH, the barriers to commercialization are either in marketing or regulatory approval. The market issues concern the impact increased milk production will have on the price support structure within the dairy industry. There is a very real danger in producing 15% more milk per year without reducing the number of producing animals. With introduction of rDNA-bGH, dairy farmers will have to consider reducing the size of their herds so that the real benefit from using this hormone can be realized (i.e., reduced labor and feed costs). The public should not fear rDNA-bGH because of the science or technology involved or because milk may contain the hormone (native bGH has probably been in the milk you have