Farm Foundation

Issue Report

University-Industry Relationships in Agricultural Biotechnology Research

The spread of plant biotechnologies is one of the fastest technology revolutions in the history of U.S. agriculture. In just over 10 years, U.S. farmers have made the decision to plant the majority of their soybean, cotton and corn acres with seed that has been genetically engineered for pest or herbicide resistance. To date, genetically-engineered crops have, on average, lowered farmers' production costs and reduced pesticide amounts and/or toxicities below those used in nongenetically-engineered crop varieties. Most genetically-engineered crops were developed and commercialized by business firms as "private goods." These firms control access to the products through the market and prices.

The next wave of plant, animal and fish biotechnologies is being developed in academic and corporate laboratories. Some of these biotechnologies have the potential to deliver "public goods" beyond the farm gate, such as downstream water conservation and less polluting renewable energy sources, in addition to food and fiber. Some biotechnologies may also introduce new risks that require careful research and testing. Assuring that both private and public goods result from these agricultural biotechnologies requires wise research planning in universities, government and industry. Public goods access is generally free or very low cost, e.g. through journal articles.

Many academic scientists worked with private firms during the first stage of the agricultural biotechnology revolution. These scientists provided basic science inputs and product testing in return for financial support, a share of genetic materials and/or other industry services. Such university-industry relationships can quicken the pace of technological commercialization. However, they also can reduce basic and publicly accessible science and inhibit the potential of biotechnologies to deliver public goods that are not effectively provided through markets.

The first national study of such university-industry relationships, *Public Goods and University-Industry Relationships in Agricultural Biotechnology*, involved two complementary investigations. First, scientists, administrators and technology transfer officers were interviewed at eight U.S. universities, along with their industry partners. The second part used findings from the interviews to develop a national survey of academic scientists conducting agricultural biotechnology-related research in Land Grant, public non-Land Grant, and private universities. The survey yielded responses from 865 researchers on the motivations that shape university-industry relationships, the influence of funding sources, and scientists' professional values.

Both the case studies and survey made clear that biotechnology is not a discipline but a technique employed in many agricultural sciences. While this study focused on biotechnology, its findings pertain broadly to agricultural research.

Key Findings

1. *Two cultures of science exist simultaneously.*

The interviews with academic scientists, administrators and their industry partners showed both a public and a private scientific culture. Key descriptors of each culture are shown in Table 1.

Given the different character of private and public research, expansion of university-industry relationships should be monitored closely to allow development of policies, practices and organizational arrangements that ensure scientific transparency and promote public- and private-sector goals. Tools to accomplish these objectives include patent, publication and conflict-of-interest policies, confidentiality agreements, material transfer agreements, and licensing provisions.

2. *Academic capitalism in the knowledge economy.*

The knowledge economy is the set of intellectual property policies and practices that convert advanced knowledge into commercial products. Because much of the

Table 1. **Descriptors of Public and Private Research**

Public Research

1. Societal responsibility
2. Advancement of knowledge and problem-solving
3. Open-ended goals
4. Long-term, deliberate planning horizons
5. Open communication
6. Egalitarian organization
7. Non-monetary goals
8. Individual-oriented activities
9. Basic and applied research
10. Disciplinary approaches

Private Research

1. Proprietary responsibility
2. Proprietary products and profits
3. Specific objectives and tasks
4. Short-term, quick, urgent planning horizons
5. Closed communication
6. Hierarchical organization
7. Monetary goals
8. Team-oriented activities
9. Applied research and development
10. Multidisciplinary approaches

advanced knowledge in the United States resides in research universities, a central component of the knowledge economy has been to integrate the research university into the intellectual property process. A prime force in that process is the Bayh-Dole legislation that allows universities to file for and own patents on innovations from federally funded research and to license the inventions to third parties.

Scientists interviewed in the study perceived the general purpose of university intellectual property policies to be to enhance the university's financial position. They felt that intellectual property policies were more directly tied to university's interests than to producing public benefits, such as regional development. Many also said patents have become important in enhancing their university's stature.

Many scientists expressed the ethic that university policies should primarily be used to protect scientists' academic freedom and the intellectual property developed through public funds. Academic scientists believe the university should use university-industry relationships to enhance the movement of new technology into commercialization. The overall message was clear: find ways to manage university-industry relationships for the public benefit.

3. *Industry partners praise university relationships but cite serious concerns.*

Interviews were done with 63 managers and scientists at agricultural biotechnology companies. Industry representatives expressed overwhelming praise for university-industry relationships in principle. In this way, they are similar to university administrators but different from university scientists. The industry managers and scientists cited the benefits of leveraging corporate research money, helping to facilitate regulatory approval for new products, and maintaining a useful division of research labor—basic research in academia and applied research in industry.

In open-ended questions, however, industry respondents generally were more critical of university-industry relationships than were university administrators. Industry representatives were concerned that the division of labor between the public and private sectors is fading, threatening to create competition rather than collaboration between universities and for-profit companies.

Industry scientists and managers offered ideas for improving university-industry relationships. Examples included: creating a standard template for university-industry relationship technology transfer; fostering start-up companies to replace university technology transfer offices; and boosting public funding in research universities to reduce dependence on private sources.

4. *Industry funding affects the character of academic research, leading to significantly more applied and excludable discoveries.*

While university-industry relationships can speed useful applications of basic research, they also can divert publicly funded resources to private ends. A central question is whether industry support leads to more applied and excludable research, diminishing basic and publicly accessible knowledge about agricultural biotechnology. Responses to the national survey were analyzed for factors affecting the "basicness" of a scientist's research program; the "excludability" of discoveries; the scientist's publication output; and the scientist's patent output.

"Basicness" is that percentage of a scientist's research that is basic versus applied. "Excludability" is the percentage of discoveries that may be withheld from public use. Publication and patent outputs were measured as the annual peer-reviewed publication and patent rates respondents reported between 2001 and 2005.

Some university administrators believe industry funding has no influence over the university's research agenda or the accessibility of its findings. Analysis of the national survey responses offered these key findings:

a. Funding sources differ significantly in their emphases on applied research. In rank order, the following sources encourage more applied research than does the National Science Foundation (NSF): industry; state; USDA; other federal and miscellaneous sources; and non-profit foundations. NSF was selected as the comparison base because it is considered to support more basic and publicly-accessible research than any other source.

b. Scientists reported the value they place on theoretical contributions, non-excludable findings, publishing and patenting in scientific research. Most of these values had a greater effect on the "basicness" of a scientist's research program than did funding. The potential to make a theoretical contribution had a larger positive effect on a research project's "basicness" than did publication prospects or patenting prospects.

c. In rank order, the following funding sources generated significantly more excludable research than did NSF funding: industry; National Institutes of Health; and state governments.

d. The more that scientists value public accessibility or theoretical implications of research, the less excludable is the work they pursue. In contrast, the more patenting prospects are considered by scientists when formulating their research plans, the more excludable are their research programs.

e. Assistant professors produced significantly more excludable research than faculty at higher ranks.

f. A scientist's publication rate is positively affected by the size of the research budget, the percentage of industry support, the importance assigned to theoretical contributions, and the more senior faculty rank.

g. The greater the scientist's research budget, and/or the greater the percentage of industry support and decreased NSF funding, the higher the importance assigned to patenting. Scientists with higher rank have higher patent production. As the value the scientist assigns to research accessibility increases, the number of patents earned decreases.

In summary, industry funding brings modestly less basic and more excludable or patentable research compared to NSF funding. Public support appears important for a balanced university agricultural biotechnology research agenda. However, a scientist's professional values exert even stronger effects on research basicness and accessibility than does funding source. Universities must find ways to understand and nurture this diversity of values, especially in light of stagnating public funding.

Policy Implications

Project findings were presented at a national conference in May 2006. Conference participants joined with the project team in identifying major policy implications for universities, industry, government and other university-industry relationship stakeholders.

1. *A strong public research program which complements private research and development is essential to satisfy the evolving needs of modern agricultural and food systems.*

- Public research is necessary to provide "public goods," such as publicly accessible platform technologies, orphan and minor crops, crop-based renewable energy sources, and non-market environmental services.
- Research should be multifunctional and involve all key stakeholders, including universities, industry, government, and environmental and other interest groups.
- Research should be multidisciplinary, incorporating all relevant sciences to address the economic, social and environmental dimensions of agricultural and food systems.
- Industry needs a strongly independent university research sector to provide credible and objective assessments of new technology.

2. *University relationships with industry require careful monitoring to assure that desirable amounts of basic and publicly-accessible science are maintained while advancing the commercialization of viable new agricultural biotechnologies.*

- Both academic and industry partners should be involved in developing monitoring systems and analyzing research findings to address significant problems and foster improvements.
- Important data on university-industry relationships include: the types of intellectual property generated; efficacy for technology commercialization; licensing terms; freedom of communication among university scientists and between scientists and the public; terms of graduate student involvement in university-industry relationships; effects on graduate student research opportunities; and the nature and reward structure of faculty consultancies, with particular attention to the potential for conflicts of interest.
- If university-industry relationships are found to move academic research away from the desired types of basic and nonexcludable discoveries, efforts are needed to strengthen professional values favoring fundamental and publicly accessible research.

3. *Publicly supported research is needed to transfer basic agricultural biotechnology discoveries, such as plant genome characterizations, into useful crop plant applications.*

- Research on model systems aids transfer of basic discoveries into useful crop plants. For example, publicly supported basic research on *Arabidopsis*, which no one eats, has led to valuable crop plant improvements. Mechanisms are needed to provide an uninterrupted pipeline from basic research to field applications.
- Even if basic discoveries are shown to be applicable, collaborations with industry usually are needed to move these discoveries into commercial applications.

4. *Commercialization of orphan and minor crops requires public research and development because private firms' potential net returns usually are negative for these crops.*

- Biotechnological advances in orphan and minor crops hold promise but lag the developments in such major crops as corn, soybeans and cotton.
- Public research and evaluation of orphan or minor crops should, in addition to translational research, assure cost-effective biosafety control.
- Development of a program similar to the IR-4 Minor Crop Pesticide Registration Program, which has $10 million in funding, could help offset the high cost of moving agricultural biotechnology products for orphan/minor crops through the regulatory process, while maintaining rigorous environmental and human health impact assessments.
- Consideration should be given to allowing grower groups to participate in intellectual property rights transfers of publicly-developed biotechnology products.

5. *Intellectual property management in university agricultural biotechnology benefits from the public availability of information on genetic innovations, which can be shared among academic programs and less developed countries.*

- One model for achieving public availability of information is the Public Intellectual Property Resource (*http://www.pipra.org/*). However, it requires broader participation than currently exists to assure coverage. Land Grant universities should lead such a development.
- Some academic researchers face barriers in obtaining the genetic materials necessary for advancing basic and translational research.

- Intellectual property development in agricultural biotechnology would benefit from a review of the goals of the Bayh-Dole Act to clarify whether all discoveries from research funded with federal money should be eligible for patenting.
- Methods are needed to compensate less developed countries that contribute intellectual property in the form of useful seed varieties carrying traits of interest in agricultural crops. One model is the University of California-Davis Genetic Resource Recognition Fund (*http://www.biodiv.org/doc/case-studies/abs/cs-abs-ucdavis.pdf*), but broad benefits can be assured only with broader participation.

Summary

Universities and industry have become increasingly intertwined in the agricultural research and technology commercialization process. Powerful forces pulling many public universities into economic development roles appear likely to reinforce this trend. University-industry relationships may expedite the application of academic science to agricultural biotechnology, while at the same time working against basic and publicly accessible discoveries. One challenge is to find ways to structure university-industry relationships so that basic and public-issue research are not neglected.

A strong public support base is key to assuring a balanced university biotechnology research program. A scientist's professional values substantially affect laboratory research, regardless of how the activity is financed. Most academic researchers make clear distinctions between their roles as public and private scientists.

University administrators and educators must assure that important distinctions are maintained between publicly-accessible research and privately-excludable research. Without systematic monitoring, basic and openly scrutinized investigation likely will decline given the public sector's stagnating support for university research. Agricultural biotechnologies have great potential for delivering public goods, such as advances in minor crops and environmental protection. The challenge and the opportunity are to see that university-industry relationships enhance that potential while contributing to profitable commercial activity.

The Source

This *Farm Foundation Issue Report* summarizes the findings of a study done by a multidisciplinary team from Portland State University, Oregon State University, University of California-Davis, Clarkson University, Pennsylvania State University, the Wallace Center, Cornell University, and Farm Foundation. This project, the first national study of university-industry relationships related to agricultural biotechnology, was funded by a 2001 grant from the U.S. Department of Agriculture's Cooperative State Research, Education, and Extension Service (CSREES). Findings of the project were presented at a national conference May 1, 2006. This report was authored by David Ervin of Portland State University, who coordinated the study.

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