Technology Transfer at the Agricultural Research Service (ARS)

The U.S. Department of Agriculture has a long history of close collaboration with private agricultural industries, in part because public agricultural research has in the past been more applied in nature than other types of public research (Fuglie et al., 1996). Still, new mechanisms for public-private collaboration in research have had a significant impact at the agency. ARS has increased technology transfer to the private sector considerably in the last decade (table 3). All three goals of Federal technology transfer policy—bringing the benefits of public R&D to potential users, finding innovative ways to fulfill the agency mission in an era of relatively scarce resources, and influencing the direction of technology development—may have played a role in this expansion of technology transfer.[21]

[21]Actual implementation of Federal technology transfer policy may differ from agency to agency. For example, ARS has a relatively small research budget and a single coordinated technology transfer program. The National Institutes of Health (NIH) have a large research budget, but also a coordinated technology transfer program. Department of Energy labs, on the other hand, are often run by different contractors, and these labs differ in, for example, the extent to which employees are encouraged to pursue commercially relevant activities.

Alternatives and Complements in ARS Technology Transfer Policy

Patents and Licensing

Patents are both an old and a new means of technology transfer. The Federal laboratories have long had the option of patenting innovations, but before 1980 only nonexclusive licenses could be granted. Passage of the Stevenson-Wydler Act in 1980 allowed Federal laboratories to issue exclusive licenses to patents

Table 3
USDA technology transfer activities

Year	Patents awarded	Patent license royalties	Active CRADAs[1]	Value of CRADAs[2]
	Number	*Million dollars*	*Number*	*Million dollars*
1987	34	0.09	9	1.6
1988	28	0.10	48	8.7
1989	47	0.42	86	15.6
1990	42	0.57	145	18.9
1991	57	0.83	181	17.1
1992	56	1.0	172	15.0
1993	57	1.5	172	50.5
1994	40	1.4	208	32.9
1995	38	1.6	229	33.2
1996	53	2.1	244	98.9
1997	35	2.3	273	155.5
1998	57	2.4	271	120.2
1999	74	2.4	298	136.7
2000	64	2.6	257	125.1
2001	64	2.62	219	117.9
2002	53	2.57	225	114.7
2003	64	2.29	229	84.8
2004			205	89.0

[1]Number of Cooperative Research and Development Agreements (CRADAs) with the private sector.
[2]Value of CRADAs includes the total value of USDA and private-sector resources committed to active CRADAs over their lifetime.

Sources: Agricultural Research Service, USDA; Cooperative State Research, Education, and Extension Service, USDA.

on their inventions. In ARS, the decision to apply for a patent is taken by a Patent Review Committee, working in conjunction with the inventor and a patent advisor (see box, “The Patent Review Committee”).

ARS structures its total licensing fees such that they partially cover the technology transfer program costs. Licensing fees are not used to fund research.[22] The individual inventor(s) receives a percentage of the fee, usually 25 percent, and the remainder goes toward defraying the costs of patenting and licensing [23]

While patenting and licensing are the focus of this report, there are other mechanisms for transferring technologies developed within the Federal Government. The multiple means used by ARS to transfer technologies are not mutually exclusive. For example, for a given technology, several aspects may be reported in scientific publications; another aspect may be the subject of a patent application; and a licensed patent may be further developed through a Cooperative Research and Development Agreement, or CRADA (described in the next section).

Publications and Networking Among Scientists

The traditional means of scientific exchange, publications, are ARS’s primary means of conveying the results of its research. Scientists publish results of their research both within ARS and through external organizations, such as refereed journals or books and book chapters produced by academic and commercial publishers. Internal publications may be specialized, but also include less technical newsletters and reports for nonspecialists.

Researchers, whether Federal, academic, or private, attend many of the same professional conferences. Through such conferences and through the literature associated with particular fields of study, private sector scientists are informed about the activities of their public sector counterparts (and vice versa). This familiarity often leads to informal relationships that contribute to technology transfer. We observed these relationships in several of our case studies.[24]

TEKTRAN

ARS informs potential cooperators of research advances through announcements at workshops and conferences, advertisements in the *Federal Register*, electronic postings, and an Internet database Technology Transfer Automated Retrieval System (TEKTRAN). Maintained by ARS, the database reports research findings that have been peer-reviewed and cleared by ARS management. TEKTRAN summaries are synopses of published or soon-to-be-published articles describing recent research (though some summaries are excluded to protect potential patents before publication). Thus, the summaries can help potential technology transferees identify new innovations.

The ARS Office of Technology Transfer also posts available technologies (whether protected by patent, the subject of a patent application, or other) on its website.

[22]Table 2 shows that in FY 2000, the mean annual revenue per license for ARS was just over $11,000. For all 10 Federal agencies reported in that table, the mean annual revenue per license was around $23,000. In the same fiscal year, universities and other academic institutions reported a mean annual revenue per license of about $60,000 (AUTM, 2002). As table 4 will show, many ARS licenses do not generate revenue in a given year, and the distribution of license revenue is skewed, with mean annual revenue higher than median annual revenue. This kind of skewed license revenue distribution is typical of other Federal agencies and academic institutions as well. Revenue data for licensing from private sector technology owners are usually not publicly available.

[23]ARS inventors also receive the first $2,000 in licensing revenue.

[24]In the economics of science, informal networking is one basis for the assumption that knowledge spillovers have a geographic component.

The Patent Review Committee: How ARS Decides To Patent An Invention

At ARS, the patent process begins when an invention report is submitted by an ARS scientist. Each scientist has an assigned patent adviser, who is available for consultations regarding issues of patentability. Invention reports are submitted through the scientist's line managers, who approve the invention for patent filing, subject to the recommendation of a Patent Review Committee. Each committee consists of ARS scientists and representatives of the Office of Technology Transfer, who participate in the discussions as nonvoting members.

For each invention report submitted, a Patent Review Committee considers the following questions in deciding whether to recommend patent protection:

(1) Is there current commercial interest in the invention or a high probability of commercialization in the future?

(2) Is the magnitude of the market relative to the costs of commercialization large enough to warrant a patent?

(3) Would a patent likely play a significant role in transferring the technology to the user?

(4) Would a patent be enforceable; i.e., is the invention drawn to, or does it employ, a unique and readily identifiable material or device which could be bought or sold?

(5) Is the invention of sufficient scope to justify patenting?

The committee can recommend to "approve," "defer," or "suspend"" an invention report. "Approve" means that a patent application should be filed. "Defer" means that the invention report is sent back to the scientist for some specific additional information. Often, the committee recommends seeking potential commercial partners in order to be able to respond to the first question above. "Suspend" means that patent protection will not be sought, and information about the invention will be distributed through some other means, such as scientific publication.

After an invention report is approved, a patent application is prepared and submitted to the U.S. Patent and Trademark Office, and licensees are sought. Prior to granting an exclusive license, a notice must be published in the Federal Register, with a comment period during which objections may be raised. If more than one U.S. business would like to obtain a license, co-exclusive licenses, or multiple licenses in different fields or territories, may be granted. There is a preference for small businesses if they are as qualified to receive the license as a larger company is.

Source: Office of Technology Transfer, Agricultural Research Service, USDA.

Cooperative Agreements

Cooperative Research and Development Agreements (CRADAs) are a tool for formally linking government and industry researchers. This program, authorized under the Federal Technology Transfer Act of 1986, allows Federal laboratories and businesses to form commercial partnerships that help move new technologies into the marketplace. ARS scientists and companies work together to develop a research plan that is consistent with the agency's mission. Under a CRADA, ARS scientists collaborate with outside institutions (e.g., private firms) to help commercialize technologies.

With CRADAs, both sides may contribute inhouse research resources such as personnel, equipment, and laboratory privileges. The non-Federal collaborator may provide the Federal laboratory with research funds; however, Federal laboratories do not provide financial resources to non-Federal partners (Congressional Research Service, 1991). Patents resulting from a CRADA may be jointly owned. In cases where the Federal laboratory retains title, the non-Federal partner has first right to negotiate an exclusive license. Some data also may not be publicly disclosed for a certain amount of time.

CRADAs are generally initiated by ARS scientists (W. Phelps, personal communication, 1997). According to USDA technology transfer officials, the guidelines for these arrangements are that the research must be consistent with the agency's mission, that there be no conflicts of interest, and that fairness be shown to potential cooperators (D.J. Blalock, personal communication, 1997).

Other Means of Protecting and Transferring Technologies

ARS also has used Plant Variety Protection Certificates (PVPCs) to protect its innovations. PVPCs allow for the use of the variety in breeding programs without permission of the holder and permit farmers and growers to save seeds for their own use; thus, they are less likely to be licensed.[25] Most of the plant variety protection certificates are held with State agricultural experiment stations.

ARS scientists use material transfer agreements (MTAs) when they want to provide material to someone outside of ARS but also want to maintain control over the material. This agreement states specifically what the material is and what it can be used for, restricts giving it to a third party without permission, and prohibits commercial use of the material. All MTAs are reviewed by an ARS technology transfer coordinator.

In some cases, ARS must share certain confidential information with a company to determine if there is sufficient mutual interest to proceed with a CRADA and/or a patent license. A confidentiality agreement is used to prevent public disclosure of potentially patentable innovations.

Trends in ARS Patenting

The "Technology Transfer by Federal Agencies" chapter demonstrated that as the number of U.S. utility patents increased rapidly over the past 25 to 30

[25]The intellectual property regime for cultivars of commercial crops includes plant patents for asexually reproduced crops, dating to 1930, PVPCs, dating to 1970, and utility patents, first formally recognized in 1985. See Fuglie et al. (1996). Although ARS holds utility patents across a wide range of agricultural technologies, it has only occasionally used IP protection of any kind for cultivars.

years, the number of patents issued to Federal Government and affiliated research agencies held relatively steady.[26] This implied a decline in the already small percentage of total patents issued to Federal labs. Over the same period, the number of patents issued to ARS fluctuated, although from 1985 onward there has been a fairly strong upward trend in these patents. Nonetheless, the rate of increase in the number of patents issued to ARS (4.4 percent annually from 1985 through 2003) was not as great as the rate of increase in total patents issued (5.1 percent annually over the same period).

There seems to be little evidence that over time technology transfer via patenting and licensing has come at the expense of publishing as the traditional means for disseminating research results from ARS. Figure 4 compares ARS patent counts from 1990–2003 with publication counts over the same period. Patent counts, which are much lower in absolute terms, are normalized by 100 scientist years, and publication counts by scientist years.[27, 28] This is done to give trends a common denominator for easy comparison. Publication counts, taken from the Institute for Scientific Information's Current Contents database, identified all publications for which at least one author had "ARS" or "Agricultural Research Service" as an affiliation. Around 1998, ARS patent counts rose somewhat, while publication counts dipped slightly for several years before rising slightly again. However, even with this increase in patenting, ARS was granted roughly 60 to 80 patents a year, at the same time that scientists with ARS affiliations were partially or fully responsible for roughly 4,000 or more publications annually.[29] Normalization by scientist years suggests that output/input ratios have not decreased over time for publications even as patenting has increased. Normalization by ARS budgets, not shown here, also supports this conclusion. Recent empirical studies of the relationships between patenting and publishing in the life sciences (Azoulay et al., 2005; Murray and Stern, 2005) suggest that patenting and publishing can be complementary. The ARS data are consistent with these findings.

Patenting at USDA versus Other Public Agricultural Institutions

Within the U.S. public sector agricultural research system, the land grant universities could be considered to be the State level counterpart to ARS. Comparing changes in the numbers of patents issued to both sets of institutions gives a sense of the relative importance different institutions give to patenting. The available data indicate that in recent years ARS patenting has increased only modestly when compared with university patenting, whether or not the universities are land grants. This is completely consistent with the modest changes in all Federal patenting compared with university patenting (see chapter titled "Technology Transfer by Federal Agengies"). It is difficult to disentangle patents applicable to agriculture from general biological patents, but the available data suggest that university biological patenting that may have agricultural applications also grew much more rapidly than ARS patenting.

It is important to note that many patents issued to land grant universities fall outside the area of agriculture. Large research universities such as the University of California-Berkeley or the University of Wisconsin have many other subject areas in their patentable research portfolios. It is also important to note that it is usually not possible to determine whether a patent has potential agricultural applications without looking at the individual patent. For example,

[26]In the USPTO database patents resulting in part from ARS research are assigned to "the United States of America as represented by the Secretary of Agriculture." In some cases, such patents could have other assignees as well, for example, universities that also participated in the research.

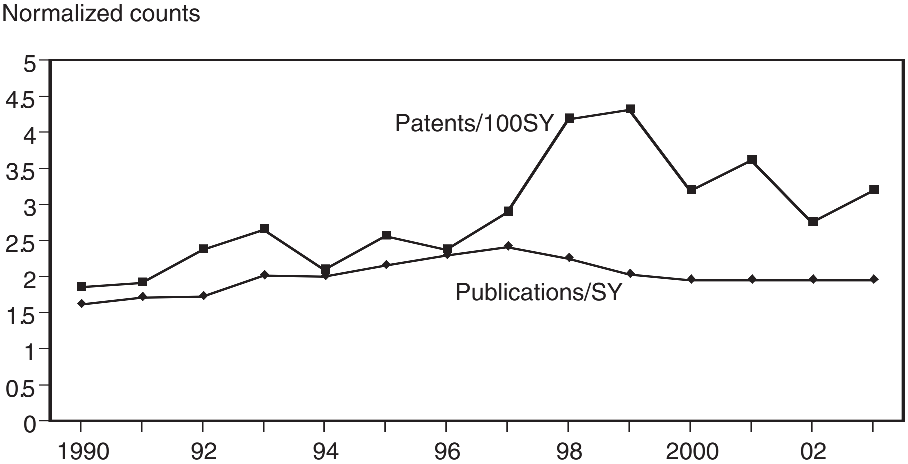
[27]Patent and publication counts could also be normalized by ARS's real budget. There is also a question of lags—what is the average length of time between initial research investment and output in the form of publications, a patent, or both? In fact, for both scientist years and budgetary measures, incorporation of a 5-year lag suggested greater increases in per scientist year output, over the period reported here, for both publications and patents.

[28]A scientist year is the work done by a person who has responsibility for designing, planning, administering, and conducting research in 1 year (i.e., 2,080 hours).

[29]We examined publication counts using the AGRICOLA database of the National Agricultural Library. Changes in catalogues over time have hampered the creation of a consistent, long-term time series of ARS publication counts in this database. Using the search terms "Agricultural Research Service" or "ARS" in several different ways showed no particular secular trend in publication counts in this database, either.

Figure 4

ARS patents and publications, normalized by scientist years



Source: ERS calculations based on USPTO, Institute for Scientific Information (ISI) Current Contents, and USDA Current Research Information System (CRIS) data.

USPTO classifications 435 (molecular biology and microbiology) and 800 (multicellular living organisms) are two important codes that may have potential medical applications, agricultural applications, or both.[30]

In any case, the rate of increase in patenting by land grant universities over the period since 1976 is striking. Although the number of patents issued to the land grant universities appears to have leveled off somewhat in recent years, from 1985 to 2003 this figure rose at an average annual rate of 11.2 percent, compared with the average annual rate of 4.4 percent for USDA patents (fig. 5). Furthermore, patenting in biologically related categories grew faster than in many other areas. The USPTO (2002) has published a breakdown of patents issued to all universities, and to individual research universities in the top 100, by patent class and by date of application (as opposed to date of issue). Before 1980, less than 5 percent of all patent applications by top research universities were in classes 435 and 800. By the mid- to late 1990s, over 20 percent were in these classes. We looked at annual growth rates in university patent applications for easily identifiable biological classes—primarily 435 and 800 but also including several more traditional agricultural categories. Over the 1980s and early 1990s, these growth rates were very high (13 percent to 20 percent or more) whether universities were land grants with significant medical research expenditures, land grants with little to no medical research, non-land grants with significant medical research, or non-land grants with little to no medical research. This suggests that university biological patenting with potential agricultural applicability grew rapidly whether or not it was primarily medical in intent.

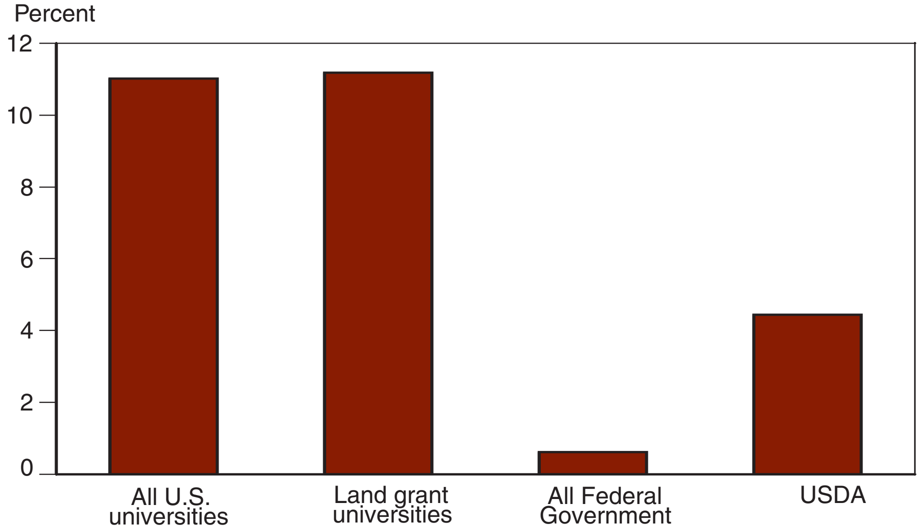
Patenting of Agricultural Biotechnologies

The Economic Research Service (ERS) and other research partners have recently completed the first phase of an online database of agricultural biotechnology intellectual property (ABIP). One major component is a database of U.S. agricultural biotechnology utility patents issued from 1976–2000. Agricultural biotechnology was broadly defined to refer to

[30]In some cases biological research findings that might be patented under these classifications originally may have been directed at medical applications, but might have potential agricultural uses as well.

Figure 5

Percentage growth rate in utility patents awarded, 1985-2003



Source: ERS calculations based on USPTO data.

general biological processes in agriculture and food. The selection procedure was designed to include patents not only for genetically engineered agricultural plants or animals, or the processes used to produce such genetically engineered species, but also for research processes such as tissue culture, research tools with potential applications to agriculture, crop varieties produced via biotechnologies other than genetic engineering, and other biological processes (such as fermentation) used in the food and nutrition industries. The database also features a rule-based classification scheme that allows alternative, narrower definitions of agricultural biotechnology, for example, genetic transformation technologies (King and Heisey, 2003; 2004).

Agricultural biotechnology patenting has grown at a faster rate than the rate of utility patenting in general. Figure 6 shows, in logarithmic scale, changes over time in agricultural biotechnology patents issued to various U.S. based institutions: U.S. private companies, U.S. universities (land grant and non-land grant), and U.S. Government.[31] Most of the U.S. Government agricultural biotechnology patents were issued to ARS. For comparative purposes, the time series for all patents, "biotech" and "non-biotech," issued to ARS is also shown.

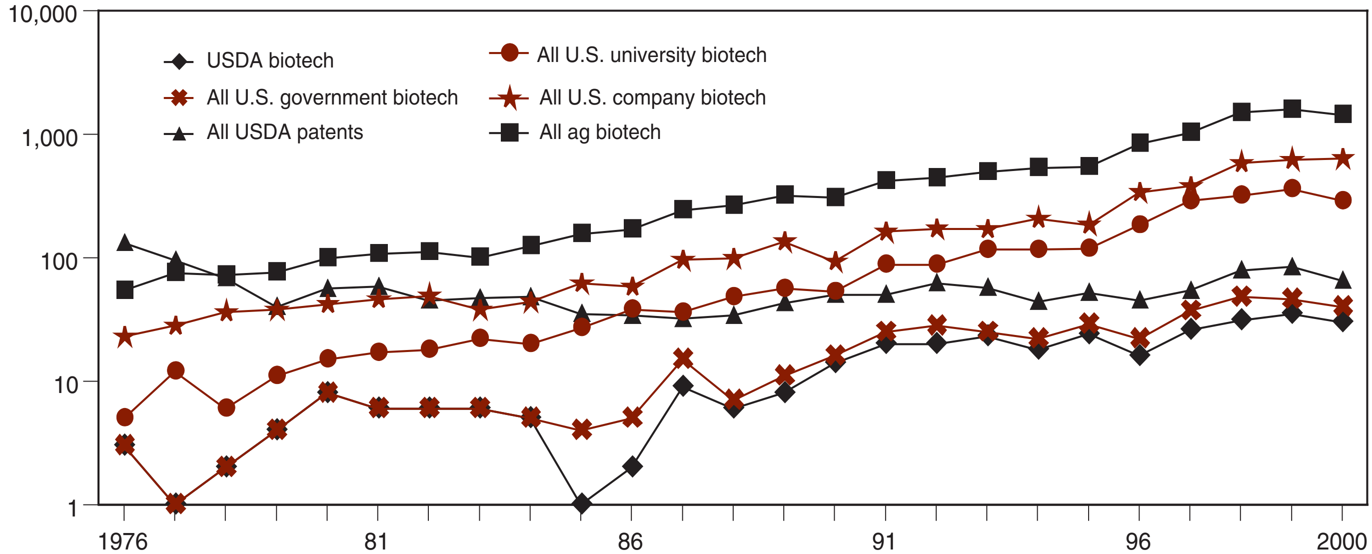
It is clear from figure 6 that (especially since the mid-1980s), agricultural biotechnology patenting has grown rapidly in all U.S.-based sectors. Over certain periods, it appears to have grown even faster for universities than for private sector firms. Agricultural biotechnology patenting by ARS has grown somewhat more slowly than it has for the other two U.S. sectors. However, biotechnology patenting by ARS has grown much more rapidly than ARS patenting in general. Thus, since the mid- to the late 1980s it has occupied an increasing share of ARS's patent portfolio.

[31]The database also includes U.S. utility patents issued to non-U.S. institutions, but these are omitted as separate categories to maintain clarity.

Figure 6

USDA and other U.S. agricultural biotechnology patents

Log scale



Source: USDA ERS Agricultural Biotechnology Inellectual Property Database and ERS calculations based on USPTO data.

The area of agricultural biotechnology that has received the most public attention, genetic transformation of plants, comprises a relatively limited proportion of ARS patents. Figure 7 compares patenting in genetic transformation and plant technologies with total agricultural biotech patents as defined in the ABIP database.[32] Patents that fall under both the "genetic transformation" and "plant technology" headings simultaneously are more likely to be those relating to the commonly used, narrow definition of biotechnology. The figure demonstrates that only in the last 3 years of the database did ARS receive more than a single patent falling under both classifications. Instead, ARS patented more frequently in areas such as biological control of pests or animal protection technologies such as vaccines than in the agricultural biotechnology subfield of genetic transformation.

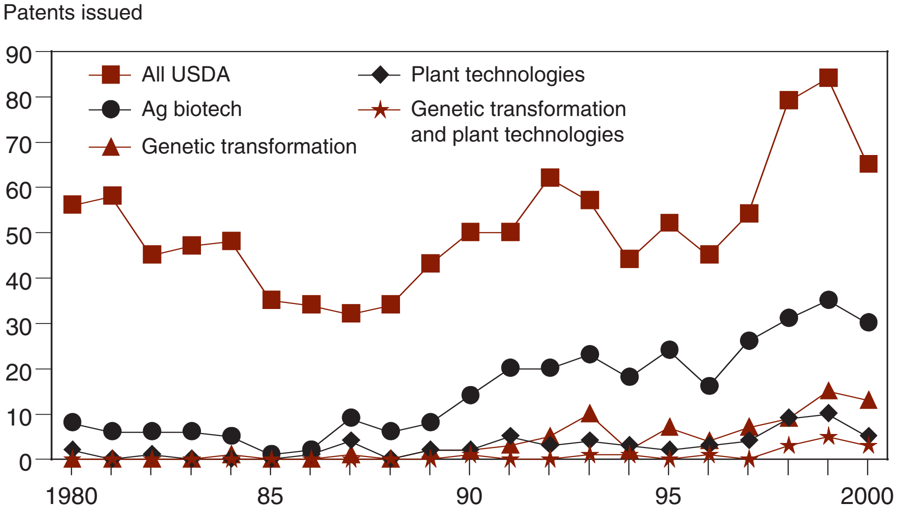
Licensing of ARS-Patented Technology

Trends in patenting provide one measure of the intellectual property produced by an institution. The licensing of these patents is another measure that shows how this intellectual property is being used. Table 4 indicates the current state of technology transfer for patented and licensed USDA technologies. Of the currently active patent licenses, about one-fifth are generating earned royalty income. The median earned royalty income is small ($3,102) in FY 2003. Apart from the amounts set aside for inventors, ARS applies financial returns to the operation of its OTT, not to financing research (Day Rubenstein, 2003).

Day Rubenstein recently completed a comprehensive examination of 224 active licenses granted by USDA's Agricultural Research Service through June 2000. These licenses were categorized on the basis of research problem areas

[32]The time period 1980-2000 was chosen in preference to 1976-2000 to make trends more clear; the total patents issued to the USDA fell steeply from 1976-79.

Figure 7
USDA biotech and other USDA patents



Source: USDA ERS Agricultural Biotechnology Intellectual Property Database and ERS calculations based on USPTO data.

Table 4
Selected USDA technology transfer data for FY 2003

Item	Amount
Active CRADAs[1]	229
U.S. patent applications filed	60
U.S. patents issued	64
Active patent licenses	270
Licenses generating earned royalty income	56
Total license revenues	$2.3 million
Median earned royalty income	$3,102

[1]CRADA: Cooperative Research and Development Agreement.

Source: D.J. Blalock, 2004.

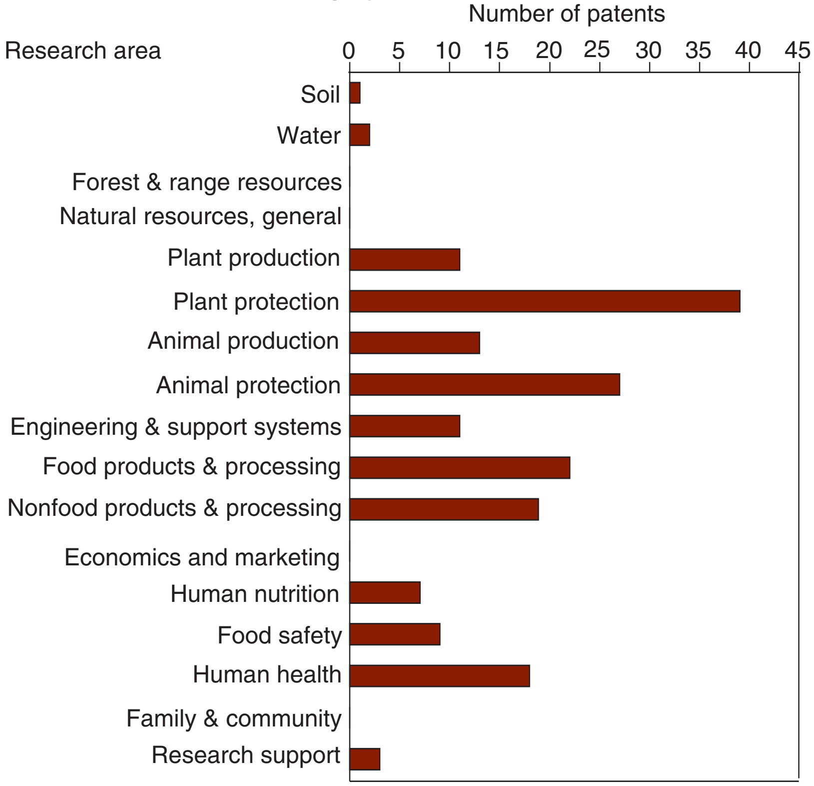
as designated by the Current Research Information Systems (CRIS). Here we consider some of the characteristics of these licensed technologies.

On the basis of patent counts (i.e., not taking into account the effects of multiple licenses issued for certain patents), the most frequent areas for licensing were plant protection, animal protection, food products and processing, nonfood products and processing, and human health (fig. 8). Somewhat fewer patents were licensed in the traditional research areas of plant and animal production. Food safety and human nutrition are areas with strong public-good components. There were relatively few technologies patented in the environmental research area, which also includes strong public-good components.

Day Rubenstein also examined licensed technologies for the social (as opposed to purely private) benefits they might offer. As she points out, exclusively licensed technology is, almost by definition, unlikely to offer pure public good. Nonetheless, each licensed technology was examined to determine whether it offered one of four social benefits: food safety, human nutrition, human health, and environmental or natural resource protection.[33]

[33]The author's judgment was the basis for this examination. Criteria were explicitly stated, consistently applied, and therefore replicable.

Figure 8
Patents in ARS's licensing system[1]



[1] Patents may be captured in more than one category.

Source: Day Rubenstein, 2003.

In a sense, this exercise attempted to answer the question of whether the patenting and licensing mechanism can still be used to transfer technologies that have some public-good components that may not necessarily be captured by the private sector partner.

The number of licensed technologies in each research area with some of these social benefits depended on two things: the total number of technologies in that research area and the percentage of licensed technologies associated with one or more of the four social benefits. Over half the technologies licensed offered one of the four social benefits, though findings varied by research area. Plant protection technologies—primarily those in the subareas of biological pest control or resistant varieties—had the greatest number of licenses that offered particular social benefits. Almost 70 percent of the licenses for nonfood products and processing technologies (an area typically associated with higher private benefits) provided one or more social benefits. Therefore, evidence from the study indicates that the use of patenting and licensing is not limited to technologies whose benefits are associated solely with private research interests.