CORNELL AGRICULTURAL ECONOMICS STAFF PAPER

PATENT AND TECHNOLOGY TRANSFER ISSUES IN BIOTECHNOLOGY

William B. Magrath

February 1986 Staff Paper 86-2

Department of Agricultural Economics
Cornell University Agricultural Experiment Station
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York, 14853

PATENT AND TECHNOLOGY TRANSFER ISSUES IN BIOTECHNOLOGY*

William B. Magrath

*This report was initially prepared for the Committee on a National Strategy for Biotechnology in Agriculture of the U.S. National Academy of Sciences. Any opinions expressed or implied are those of the author and not of any organization.

Patent and Technology Transfer Issues in Biotechnology

Summary

Despite the attention given to intellectual property rights and technology transfer in discussions of public policy toward biotechnology, little data has been assembled relating to these issues. In this note I briefly review the economic role and effects of patents and patenting and present as many data as are available on general levels of patenting, on federal government efforts to patent and license technology and on public, private and university biotechnology patenting.

Numbers of patents and other forms of intellectual property protection are imperfect indicators of technological progress and inventive activity. Patenting is a strategic decision with legal, financial and technical dimensions. Moreover, the issuance of a patent does not translate into the commercial application of an invention. Nonetheless, it is useful to consider data on patents as one indicator of the productivity of research and development efforts.

In the United States almost 70,000 patents (including <200 plant patents) are issued annually, of these the vast majority are awarded to private industry or individuals. An average of 91 Plant Variety Protection Act Certificates are also awarded. Only about 1% of the patents are granted to the federal government. More than 70% of the roughly 1,000 patents granted to the federal government are awarded to four agencies which obtain these patents primarily to protect procurement of goods and services. Only recently has serious effort been devoted to the licensing of other U.S. government patents as a means of promoting economic development. Current programs appear to be successful at marketing inventions and in generating income via royalties. Academic research also provides other evidence that federally owned patents contribute to technological development.

Biotechnology patent data is available for 1983 and 1984. This data indicates that about 1,000 biotechnology patents are granted annually by the United States. Slightly more than half of these patents are granted to U.S. based individuals and corporations. Although less than 10% of biotechnology patents are granted to U.S. government agencies, it appears that the rate is higher than for other fields. Similarly, available data on patents issued to universities support the perception that universities are disproportionately active in biotechnology.

While in general the patent issues associated with biotechnology are similar to those in other areas of science and technology, the level of uncertainty that currently exists and the role of the government and universities do set biotechnology apart.

Economic Aspects of Patents

Patents provide a means of control or ownership over intellectual property. As such they provide the owner with a form of monopoly power over an invention for the life of the patent. Although monopolies are

generally considered undesirable, an exception is made for new inventions on the theory that the prospect of "monopoly profits" serves to induce inventive activity. The tradeoff is between the potential short-term gains of allowing free access to the invention and the expected long-term advantages of continued technical progress (or, conversely, higher cost and/or slow technical progress versus the losses due to monopoly power).

In addition to privatizing benefits for inventions, a patent system in which the inventor can exclude all others generates at least two externalities that may be important with respect to biotechnology.[1] First, although a given invention is protected, the process of patenting reveals to competitors a "neighborhood" around the invention. Other firms can use knowledge of this "neighborhood" to produce similar technology without actually violating the patent. In this way some of the inventors' returns can leak away. This will induce firms to either maintain inventions as trade secrets or to seek the broadest coverage possible in their patent applications. It will also tend to reduce research and development investment below the socially optimal level.

The second externality posed by patenting is a tendency to promote "winner-take-all" races for inventions. This tends to promote research but possibly toward socially inefficient allocations. For example, given that one firm wins (receives a patent) other firms are given an incentive to develop alternative technology which is not as good as the winners but is at least better than the existing technology. It is also possible that the prospect of losing out entirely on the new technology will lead to over investment in research from society's viewpoint (for example, parallel research efforts on the same problem by competing firms).

Once a private sector inventor is granted patent protection, the onus falls to him to seek commercial outlets for the new invention. Because the profits available to the successful inventor-entrepreneur are generally considered sufficient incentive, relatively little attention is given to the transfer of technology from private laboratory to private industry.

It is with respect to the results of public sector research and development that patents have come to be considered as instruments to advance technology transfer and economic development. While it at first seems perverse to invest public resources in the generation of new technology, to restrict its use through patents and then to privatize benefits through licensing agreements, in areas such as biotechnology and other capital and/or risk intensive technologies such a policy can probably be justified. While the issuance of a patent implies a judgment of the commercial or economic significance of an invention, it does not guarantee a financially successful product. Moreover, a technology can be patented short of being a commercially viable product (i.e., additional, and often significant, investment and risk are involved in eventual product

---

[1] The externalities associated with patents are described by Richard R. Nelson "Research on Productivity Growth and Productivity Differences: Dead Ends and New Departures," Journal of Economic Literature, Vol. 19, September 1981, pp. 1029-1064.

development). For these reasons, even though initial research has been conducted by the public sector, the only way to ensure appropriate amounts of development may be to grant some form of more or less exclusive license.[2]

General Data on Patent Activity

Patent activity is often used as an indicator of the output of research and development expenditure. In 1980, approximately $62.7 billion was spent in the United States on research and development. Slightly less than half (47%) $29.7 billion of this was spent by the federal government, 49% ($30.8 billion) by industry, 2% ($1.3 billion) by universities and colleges and 1.4% ($0.9 billion) by nonprofit organizations (NSF, Science Indicators, 1982, p. 235). In terms of patents, private sector patents (including corporations, colleges and individuals) clearly dominate receiving more than 97% of the patents granted. The gap stems from a greater emphasis on basic research and less emphasis on the patenting process. For example, basic research accounts for 18.7% of federal government research and development expenditures and only 4.1% of industrial expenditure. Excluding development expenditures, the comparison is 45% versus 16% for the federal government and industry, respectively. Still, although the federal accounts for 43% of development expenditure and 45% of applied research, it receives only 3% of the patents issued (all calculations based on NSF, pp. 238-241).[3] In the United States approximately 68,000 patents are granted each year. As much as 40 percent of U.S. patents are granted to nationals of other countries, a similar number of foreign patents are granted to U.S. nationals (NSF, Science Indicators, 1982, p. 209). See Table 1.

Reliable data are not available on the license value of patents. It is generally accepted that the average royalty earnings of patents is low. Figure 1 reproduced from Roberts[4], illustrates the cumulative probability of annual royalty earnings from a sample of patents awarded to 33 technology oriented firms. Yearly earnings per patent tended to follow a log-normal distribution. For example, 20 percent of the licenses resulted in less than $1,000, 40 percent in less than $5,000, 60 percent less than $10,000 and 95 percent is less than $100,000.

---

[2] Alternatively, this continuing work could be done by public sector research agencies themselves until a full commercializable technology is developed. This is generally considered beyond the mission of public sector "basic" research agencies and is also probably not an area in which they possess a comparative advantage.

[3] Also note that in 1980 more than 50% of federal research and development is defense related, the projection for 1984 was 70% (NSF, p. 243).

[4] Roberts, Edward B. "Is Licensing an Effective Alternative?" Research Management, September 1982.

Table 1. Patents Issued 1979-1984

	1979	1980	1981	1982	1983	1984
U.S. Based Inventors (other than U.S. Government)	33,391	36,978	42,050	38,092	34,129	40,857
U.S. Government	992	1,156	1,144	1,007	993	1,205
Foreign Based Patents	21,035	23,093	27,816	26,053	24,593	30,087
Total U.S. Patents	55,418	61,227	71,010	65,152	59,715	72,149

Source: Commissioner of Patents and Trademarks Annual Report Fiscal Year 84.

Plant Patents and Plant Variety Protection Act Certificates

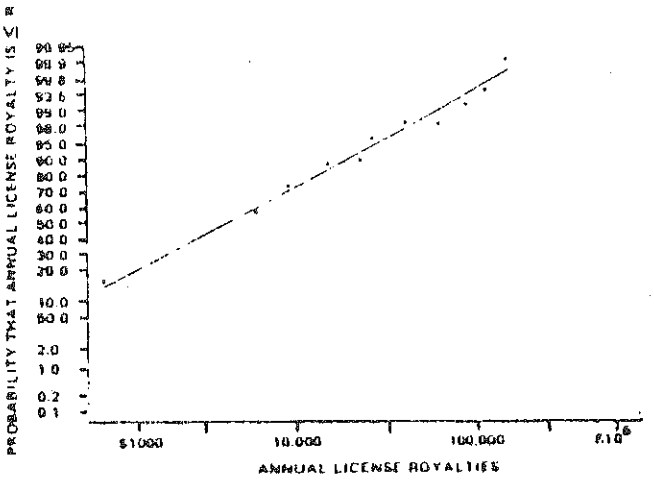
Of special relevance to the protection of intellectual property related to agricultural biotechnology are plant patents and Plant Variety Protection Act (PVPA) Certificates. While details vary these mechanisms are intended to provide plant breeders with protection similar to that provided to inventors in other fields. Plant patents are available for asexually reproduced materials (in practice, orchard fruits and ornamentals), and PVPA Certificates are for sexually produced plants. Table 2 compares PVPA certificates by crop and by private versus public (USDA and SAES) breeders. Evenson ("Intellectual Property Rights") maintains that the availability (since 1970) of PVPA protection has been central to the increase in the development and use of privately developed varieties such as soybeans.

Plant patents granted by the United States amount to less than 1/2 of one percent of all patents granted. Over the last five years the number of plant patents has ranged from 120 (in 1982) to 219 (in 1983). In 1984, 174 plant patents were issued. There is no breakdown available on the number of public versus private plant patents.

Federal Government Patenting and Technology Transfer

The federal government's use of patenting as a means of furthering technology transfer is a fairly recent development. Between 1973 and 1983 four agencies (Air Force, Army, NASA, Navy) accounted for 71 percent of the

Figure 1. Distribution of Annual Royalties to Privately Owned Patents



Source: Roberts, Edward B. "Is Licensing an Effective Alternative?" Research Management, September 1982.

Table 2. Plant Variety Protection Act Certificates Granted 1971-1983

	Private	Public	Total
Soybean	207	37	244
Wheat	91	36	127
Pea	113	0	113
Bean	108	2	110
Cotton	89	13	102
Lettuce	44	0	44
Marigold	25	0	25
Alfalfa	19	6	25
Ryegrass	22	1	23
Fescue	21	1	22
Bluegrass	16	3	19
Oat	8	8	16
Barley	12	2	14
Tobacco	14	0	14
Onion	14	0	14
Rice	12	0	12
Corn	10	2	12
China Aster	10	0	10
Watermelon	9	1	10
Peanut	6	3	9
Nastertium	9	0	9
Tomato	9	0	9
Other	NA	NA	105
Total			1,088

Source: Evenson, "Intellectual Property Rights", p. 971.

NA = not available.

15,740 patents granted to the federal government.[5] According to officials at the National Technical Information Service, the motivation behind obtaining these patents is to protect government procurement of goods produced under these patents. Under recent and pending legislation greater emphasis has been placed on patenting and licensing at other agencies. Inventions generated by federally funded extramural research may, in general, be patented by the cooperating institution. For levels of government agency patenting see Table 3.

Generally the decision of whether and how to patent an invention is left to the agency in which the discovery was made. At the U.S. Department of Agriculture's Agricultural Research Service responsibility for patenting starts with the scientist who is encouraged to file an invention report with one of four Patent Advisors. Based upon the Advisors estimate of patentability a Patent Committee evaluates the invention and decides whether to pursue a patent filing. The criteria upon which such decisions are to be made include the relationship of the invention to the ARS mission, the potential impact of the invention, its economic value and significance, and Patent Advisors estimate the patentability and the sufficiency of the data to support a patent claim. ARS scientists are increasingly actively encourage to disclose patentable inventions; USDA conducts Patents Awareness Training for research leaders, and scientists are awarded $150 when a patent application is filed and $300 when a patent is actually awarded.

The Department of Commerce's National Technical Information Service (NTIS) plays the lead role in marketing of Federally owned patents. However, in the last three years only HHS and DOT have relied exclusively on NTIS for marketing of licenses (GAO, "Federal Agencies Polices", GAO/RCED 85-94, August 29, 1985). The NTIS program covers at least some of the inventions developed by the Departments of Health and Human Services, Agriculture, Interior, Commerce, Transportation, Army, Air Force, the Veterans Administration and the Environmental Protection Agency. NTIS publicizes inventions that are available for licensing, files for foreign patents and negotiates licensing agreements that may include exclusivity. Nonexclusive licenses maybe granted when it would not adversely affect commercialization. Table 4 shows the breakdown of licenses granted by NTIS by originating agencies as well as the number of licenses granted by originating agencies themselves. Table 5 shows the level of licensing activities since FY1982 and projected to 1990. As a part of negotiations with licenses companies are required to file development plans for the subject inventions. These plans specify the amount the license will invest in further research and development, regulating approvals and commercialization. For the 77 licenses granted in FY's '83 and '84 licensees pledged a total of $178 million.

---

[5] If the Department of Energy is added, the share increases to 86 percent, (Commissioner of Patents and Trademarks, Annual Report Fiscal Year '83.

Table 3. U.S. Government Agency Patents[a] (1974-1984)

	1980	1981	1982	1983	1984
Agriculture	54	53	46	45	46
Air Force	159	133	89	120	168
Army	233	229	196	205	200
Commerce	6	5	7	5	7
Engery	59	234	210	170	263
Transportation	3	5	1	0	-
NSA	1	1	2	1	6
EPA	3	10	1	3	3
HEW/HHS	23	27	19	26	38
Interior	35	43	27	23	16
NASA	74	70	73	114	143
Navy	390	326	319	278	306
Postal Service	0	2	0	0	-
TVA	0	0	0	0	4
Treasury	0	2	1	1	1
VA	2	0	2	0	1
USA[b]	14	12	12	2	2
FCC	0	2	2	0	1
TOTAL	1,156	1,144	1,007	993	1,205

Source: Commissioner of Patents and Trademarks, Annual Report Fiscal Year 84.

[a] Data in this table represent utility patents assigned to agencies at the time of patent issue.

[b] United States of America -- no agency indicated in data base.

Table 4. Sources of Inventions Licensed by NTIS and Other Federal Agencies

	FY1982	FY1983	FY1984
Granted by NTIS for:			
Commerce	6	3	2
Army	1	0	0
HHS/NIH	15	30	24
USDA	3	7	7
Verterans Administration	1	0	2
Total Licenses by NTIS	27	41	36
Granted by Originating Agency:			
Air Force	2	1	0
Army	4	5	5
Navy	15	9	11
Interior	3	2	0
NASA	43	25	33
USDA	18	33	19
Total Licenses of Government Owned Inventions	123	140	136

Source: NTIS Staff, see also U.S. GAO., "Federal Agencies Policies and Practices are in Accordance with Patent and Trademark Amendments of 1980." Report by the Comptroller General of the United States GAO/RCED-85-94, August 29, 1985.

Table 5. National Technical Information Service Patent Licensing Activities

FY	Revenues ($000) Execution Fees	Minimum Payment Fees	Running Use Fees	Total	Licenses Granted	In Force (EOY)
1982	45	41	69	155	27	76a
1983	78	59	770	907	41	117
1984	91	88	689	868	36	154
1985 (est)	90	170	1,140	1,400	40	163
1986 (est)	95	210	2,000	2,300	40	175
1987 (est)	105	260	2,500	2,850	45	190
1988 (est)	115	310	2,500	2,950	50	206
1989 (est)	125	375	3,000	3,500	50	220
1990 (est)	135	450	3,500	4,000	50	232

a Licenses have been issued prior to the establishment of the current NTIS program.

For the 154 licenses in effect at the end of 1984, average annual revenue was $5,636. This is in the same range as the average private sector license as indicated above. Federal government receipts from the NTIS program are shown in Table 4 and are expected to grow from $868,000 in FY1984 to $4 million in FY1990. Revenues from licenses are returned to the U.S. Treasury, with a percentage going to the original inventor. Recently, $40,000 was distributed to 100 inventors with maximum payments between $7,000 - $8,000. The NTIS program reports returns to the U.S. Treasury of 53% in excess of program costs (David T. Mowry,Testimony to Senate Subcommittee on Science, Technology and Space, April 17, 1985).

The USDA conducts its own program to promote and license inventions developed within the agency. This involves advertising and promoting available inventions and negotiating nonexclusive licenses. Table 6 shows the level of USDA patent license activities. In addition to royalties USDA also requires licenses to specify the amount that they will spend on the commercialization of inventions. Currently $30 million has been pledged for the development of 30 ARS inventions.

Table 6. USDA Patent License Activities

	1979	1980	1981	1982	1983	1984	1985
Patents Issued	39	53	55	45	45	46	39
Public Inquiries	77	119	185	293	241	407	666
Nonexclusive Licenses Awarded	68	69	30	21	40	26	16
Exclusive Licenses Awarded	0	0	3	5	6	14	17
Annual Reports Received (nonexclusive licenses)	101	158	186	140	122	162	62
Patents Transferred to Commerce for Exclusive Negotiations	2	4	8	9	22	22	17

Source: Coordinator, National Patent Program, USDA.

In addition to direct technology transfer via licensing, Evenson and Wright have presented evidence that shows that publicly owned patents serve as "technology building blocks". For a sample of USDA and privately held food related patents, USDA patents were cited more than proportionately in subsequent patent filings. Thus, even though federally owned patents may not be directly commercialized, they do contribute to future inventive activity.[6]

Biotechnology Patenting Activity

Data on biotechnology patenting are scarce, but at least one consulting company (OMEC International) compiles and publishes data on new

[6] Evenson, Robert E. and Brian Wright, "An Evaluation of Methods for Examining the Quality of Agricultural Research." Washington, D.C., Office of Technology Assessment, U.S. Food and Agricultural Research Paper No. 6, 1980. See also Evenson, Robert E., "Intellectual Property Rights and Agribusiness Research and Development: Implications for the Public Agricultural Research System, American Journal of Agricultural Economics 65(1983):967-925.

biotechnology patents.[7] According to its recently published analysis (Biotechnology Patent Digest, Vol. 4, No. 10, May 13, 1985), approximately 2% of recently granted U.S. patents cover biotechnology inventions. Between 40 and 45% of these patents are granted to foreign individuals or organizations, roughly the same percent as with all patents. Roughly 40% of biotech patents are granted to U.S. Corporations. In 1983 and 1984 a similar number of patents were granted to U.S. and foreign corporations, although the share of patents granted to foreigners had declined slightly (see Table 7).

Table 7. U.S. Biotechnology Patent Activity[a] (Patents Issued)

	1983	1984
All Patents[b]	59,715	72,149
U.S. Corporate Biotech Patents	400	441
U.S. University Biotech Patent	68	95
Other U.S. (Government, Nonprofits and Individuals	94	127
Total U.S. Based	562	663
Foreign Corporate Biotech	383	371
Other Foreign Biotech	73	80
Total Foreign	456	451
Total Biotechnology	1,018	1,114

[a]Source: Biotechnology Patent Digest, Vol. 4, No. 10, May 13, 1985 (OMEC International, Inc.) unless otherwise indicated.

[b]Source: U.S. Commissioner of Patents and Trademarks Annual Report Fiscal Year '84, U.S. Department of Commerce/Patent and Trademark Office, January 1985.

The use by private industry of patents to protect biotechnology inventions is a developing field and still subject to considerable uncertainty. This arises in part from the fact that the breadth of protection available via patenting is unknown and will only become clear through litigation or legislation. Biotech firms currently differ in their approaches to protecting intellectual property and their approaches also vary by field of technology. Based on a review of Form 10-K, Annual Reports filed with the U.S. Securities and Exchange Commission, most firms

[7]The OMEC definition of biotechnology is "The application of intact biological organisms or isolated cellular components to solve problems or obtain desirable benefits."

report that they will seek patent protection when and where they believe that patents would be valid and enforceable. In the case of technology where this does not appear likely, they will attempt to maintain the technology as trade secrets. For example, Monoclonal Antibodies, Inc. has stated that it believes that the basic hybridoma technology used in the production of monoclonal antibodies is in the public domain and unpatentable. In addition it states that because of the difficulty of enforcing any patents rights that could be obtained to any variations and improvements in the basic technology, it will protect its interests by keeping its technology as trade secrets. However, the company believes that patents may be more defensible for the immunoassay procedures it is developing, and has filed patent applications in this area (see Monoclonal Antibodies, Inc., Form 10-K, 1984).[8] Table 8 shows biotechnology patents assigned to selected U.S. Corporations.

Federal Government Biotechnology Patenting

There are no systematic data on the number of biotechnology patents granted to or licensed by the federal government. USDA staff indicates that licensing and patenting activity in biotechnology is only just beginning. NTIS does not maintain any statistics on biotechnology licenses. OMEC data does not report the number of patents granted to the United States government. Roughly 10% of U.S. biotechnology patents (94 in 1983, 127 in 1984) are granted to individuals, nonprofits and (presumably) the government. As an unscientific sample of 23 biotech patents recently reported by OMEC, one (4%) dealing with identification and purification of Human Lund Tumor-Associated Antigens was assigned to U.S. Department of Health and Human Services.

Alternatively, assuming that all USDA and NIH patents relate to biotechnology, then only 84 such patents were granted to the federal government in FY1984. This would be less than 7 percent of all government patents.

University Biotechnology Patents

Table 9 shows levels of patenting activity for the 11 U.S. Universities that accounted for the greatest number of biotechnology inventions. At any university, the level of biotechnology patenting is generally consistent with its overall level of patenting. Note that while biotechnology patents account for about 1.5% of all patents granted by the U.S., for these universities the figure ranges from 14% from Iowa State University to 37% for the University of Wisconsin.

---

[8] In August 1985, Monoclonal Antibodies, Inc. won a lawsuit in which Hybritech, Inc. had claimed infringement on its 1983 patent on a "sandwich" immunoassay technique. The court ruled, in part that "The said patent is invalid because it teaches nothing new in the art, the art alleged to be taught was obvious and logical to anyone skilled in the field." (Monoclonal Antibodies, Inc., News Release, August 29, 1985).

Table 8. Biotechnology Patents Assigned to U.S. Corporations

	Patents Assigned 1983	1984
Agrigenetics Corp.	2	5
Baxter-Travenol Laboratories, Inc.	3	9
Bethesda Research Laboratories, Inc.	0	0
Biogen, Inc.	0	0
Cetus Corp.	1	5
Collaborative Research, Inc.	0	2
Corning Glass Works	4	1
Damon Corp.	3	0
E.I. du Pont de Nemours & Co., Inc.	2	14
Eli Lilly & Co.	15	15
Enzo Biochem, Inc.	0	0
Genentech, Inc.	1	5
Genex Corp.	1	1
Green Cross Corp.	3	3
Hoffman-LaRoche, Inc.	17	12
Hybritech, Inc.	1	1
Lever Brothers, Inc.	2	6
Merck & Co., Inc.	32	32
Miles Laboratories, Inc.	16	18
Molecular Genetics, Inc.	0	1
Monoclonal Antibodies, Inc.	0	0
Nabisco, Inc.	7	9
Ortho Diagnostics, Inc.	3	7
Pfizer, Inc.	9	8
Phillips Petroleum Co.	6	7
Smithkline Beckman Corp.	2	6
Stauffer Chemical Co.	2	4
The Upjohn Co.	8	10

Source: Biotechnology Patent Digest, Vol. 4, No. 10, May 1985 (OMEC International.

Table 9. Number of Biotechnology Patents Granted Selected to U.S. Universities

	Biotechnology Patents[a]		All Patents[b]
	1983	1984	1984
University of California	16	16	45
Massachusetts Institute of Technology	8	6	47
University of Wisconsin (WARF)	3	6	16
Stanford University	2	6	16
Harvard College	8	5	NA
Cornell University	2	5	12[c]
Purdue University (Research Foundation)	1	4	14
University of Illinois	1	2	NA
Iowa State University (Research Foundation)	1	2	14
Montana State University	1	2	NA
Northwestern University	1	2	NA
All Other	24	39	--
Total	68	95	--

NA = not available.

[a] Biotechnology Patent Digest, (OMEC International) May 13, 1985.

[b] IPO News, Vol. 15, No. 4, November 1985, p. 3.

[c] Cornell University Patent and Licensing Office, personal communication

Patent Policy Issues

The public policy issues related to intellectual property rights in biotechnology are the same as those for any other field of science and technology. While they are complicated somewhat by the forms which protection might take (patents, plant patents, plant variety protection9), the essential concerns are the promotion of research and development investment by insuring property rights, promoting inventive activity via the publication of new inventions, and the provision of new and improved products to consumers. Two things that do make biotechnology different (at least in degree) are the uncertainty that now exists as to the scope of protection provided to patent owners and the role of the government in generating basic research results.

Uncertainty regarding patent rights exists in fields that have long experience with the patent system.[10] Courts will ultimately arbitrate property rights in biotechnology. The public policy issues are whether existing law is both efficient and sufficient guides to the courts and whether the probability of litigation (under current or expanded legislation) will influence the rate and direction of inventive activity.

A technical issue that relates to the uncertainty around biotechnology is the appropriate scope of protection available to inventors. As mentioned above patents serve to protect a "neighborhood" around an invention. The size of this "neighborhood" has implications for the value of the patent, and for the effect of patents on research resource allocation. Too large a neighborhood may unduly impede research and development and product development or turn the acquisition of technology into a race, while too narrow a one will allow copying and lower the rewards to invention. There have been charges (see "Biotechnology Firms Gird for Clash over Patent Claims", Chemical and Engineering News, December 10, 1984, pp. 18-24), that excessively broad patents have been issued. If this is true, it can be anticipated that firms will be induced into socially undesirable levels and patterns of R and D expenditure, and prolonged litigation and delays in commercialization can be expected.

The patent data also reinforce the perception that the federal government and universities are more heavily involved in biotechnology than in other fields of science and technology. This is consistent with the more basic orientation of federal and university research and the basic research nature of biotechnology. In addition to raising the now familiar concerns over conflict of interest and freedom of research in these

---

[9] For a more detailed description of these forms of protection, see National Association of State Universities and Land-Grant College Emerging Biotechnologies in Agriculture: Issues and Priorities, November 1984, pp. 11-20.

[10] Witness the recent dispute between the Kodak and Polaroid Companies over instant film developing.

institutions, this concentration of patenting activity focuses attention to organized mechanisms of technology transfer.

The current NTIS program of patent licensing and the USDA patent program are still in relatively early stages, but do appear to be performing effectively (see GAO, "Federal Agencies' Polices", GAO/RCED-85-94, August 29, 1985). However, because of the even more recent nature of biotechnology these agencies do not have proportionate experience with these kinds of licenses. In fact, just as the federal government is unable to report the amount spent on biotechnology research, it is unable to report the number of biotechnology patents that it controls. Before serious efforts can be given to federal technology transfer in biotechnology, some effort should be given to developing an inventory of federally owned inventions in this area.

References

Commissioner of Patents and Trademarks Annual Report Fiscal Year '84. U.S. Department of Commerce, January 1985.

Evenson, Robert E., "Intellectual Property Rights and Agribusiness Research and Development: Implications for the Public Agricultural Research System," Americal Journal of Agricultural Economics 65(1983):967-925.

Evenson, Robert E. and Brian Wright. "An Evaluation of Methods for Examining the Quality of Agricultural Research," U.S. Food and Agricultural Research Paper No. 6, Office of Technology Assessment, Washington, D.C., 1980.

General Accounting Office. "Federal Agencies' Policies and Practices Are in Accordance with Patent and Trademark Amendments of 1980." Report by the Comptroller General of the United States (GAO/RCED-85-94), August 29, 1985.

Mowry, David T., Statement for the Record for the Hearings of April 17, 1985 on the Status of the Stevenson-Wydler Technology Innovation Act held by the Subcommittee on Science, Technology and Space Committee on Commerce, Science and Transportation United States Senate (processed).

National Association of State Universities and Land-Grant Colleges, Emerging Biotechnologies in Agriculture: Issues and Priorities, November 1984.

National Science Foundation, Science Indicators 1982, U.S. Government Printing Office, 1983.

Nelson, Richard R. "Research on Productivity Growth and Productivity Differences: Deand Ends and New Departures." Journal of Economic Literature 19, September 1981, pp. 1029-1064.

OMEC International, "Patent Analysis," Biotechnology Patent Digest 4(10) May 13, 1985, pp. 150-151.

Roberts, Edward B. "Is Licensing an Effective Alternative?" Research Management, September 1982.

Webber, David, "Biotechnology Firms Gird for Clash over Patent Claims," Chemical and Engineering News, December 10, 1984, pp. 18-24.