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Commons-Based Agricultural Innovation

Innovations Case Discussion: CAMBIA-BiOS

Computation and access to existing scientific research are important in the development of any nation, yet both still operate at a remove from the most basic needs of the world poor. On its face, it is far from obvious how the emergence of the networked information economy can grow rice to feed millions of malnourished children or deliver drugs to millions of HIV/AIDS patients. On closer observation, however, it becomes apparent that a tremendous proportion of the way modern societies grow food and develop medicines is based on scientific research and technical innovation. Important implications for the direction of innovation and for access to its products exist in the basic choice between two models: (1) a system that depends on exclusive rights and business models that use exclusion to appropriate research outputs and (2) a system that weaves together various actors—public and private, organized and individual—in a nonproprietary social network of innovation.

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This discussion is excerpted from The Wealth of Networks: How Social Production Transforms Markets and Freedom *(New Haven: Yale University Press), 2006, pp. 341-356. The editors of* Innovations *initiated the proposal to publish this excerpt, benefiting from the provisions of Creative Commons Noncommercial Share alike license under which an online version of* The Wealth of Networks *was distributed.*

the HIV/AIDS crisis in Africa—particularly with regard to the lack of access to existing drugs because of their high costs. However, that crisis is merely the tip of the iceberg. It is the most visible to many because of the presence of the disease in rich countries and its cultural and political salience in the United States and Europe. The exclusive rights system is, as a general rule, a poor institutional mechanism for serving the needs of those who are worst off around the globe—not only the victims of HIV/AIDS. Its weaknesses pervade the problems of food security and agricultural research aimed at increasing the supply of nourishing food throughout the developing world, and of access to medicines in general, and to medicines for developing-world diseases in particular. Each of these areas has seen a similar shift in national and international policy toward greater reliance on exclusive rights, most important of which are patents. Each area has also begun to see the emergence of commons-based models to alleviate the problems of patents.

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Leaving aside national efforts in developing nations, there are two major paths for commons-based research and development in agriculture that could serve the developing world more generally. The first is based on a loose affiliation of university scientists, nongovernmental organizations, and individuals such as played significant role in the development of free and open-source software. The second is based on existing research institutes and programs cooperating to build a commons-based system, cleared of the barriers of patents and breeders' rights, outside and alongside the proprietary system. The most promising current effort in the former vein, and probably the most ambitious commons based project for biological innovation currently contemplated, is BIOS (Biological Innovation for an Open Society). The most promising models of the latter are the PIPRA (Public Intellectual Property for Agriculture) coalition of public-sector universities in the United States, and, if it delivers on its theoretical promises, the Generation Challenge Program led by CGIAR (the Consultative Group on International Agricultural Research).

CAMBIA-BIOS

As Richard Jefferson's case narrative in this issue of *Innovations* describes, BiOS is an initiative of CAMBIA (Center for the Application of Molecular Biology to International Agriculture), a nonprofit agricultural research institute based in Australia. BiOS is based on the observation that much of contemporary agricultural research depends on access to tools and enabling technologies—such as mechanisms to identify genes or for transferring them into target plants. When these tools are appropriated by a small number of firms and available only as part of capital-intensive production techniques, they cannot serve as the basis for innovation at the local level or for research organized on nonproprietary models. One of the core insights driving the BiOS initiative is the recognition that when a subset of necessary tools is available in the public domain, but other critical tools are not, the owners of those tools appropriate the full benefits of public domain innovation without at the same time changing the basic structural barriers to use of the proprietary technology. To overcome these problems, the BiOS initiative includes both a strong informatics component and a fairly ambitious "copyleft"-like model of licensing CAMBIA's basic tools and those of other members of the BiOS initiative.[1] The informatics component builds on a patent database that has been developed by CAMBIA for a number of years, and whose ambition is to provide as complete as possible a dataset of who owns what tools, what the contours of ownership are, and by implication, who needs to be negotiated with and where research paths might emerge that are not yet appropriated and therefore may be open to unrestricted innovation.

The licensing or pooling component is more proactive, and is likely the most significant of the project. BiOS is setting up a licensing and pooling arrangement, "primed" by CAMBIA's own significant innovations in tools, which are licensed to all of the initiative's participants on a free model, with grant-back provisions that perform an openness-binding function similar to copyleft.[2] In coarse terms, this means that anyone who builds upon the contributions of others must contribute improvements back to the other participants. One aspect of this model is that it does not assume that all research comes from academic institutions or from traditional government funded, nongovernmental, or intergovernmental research institutes. It tries to create a framework that, like the open-source development community, engages commercial and noncommercial, public and private, organized and individual participants into a cooperative research network. The platform for this collaboration is "BioForge," styled after Sourceforge, one of the major free and open-source software development platforms. The commitment to engage many different innovators is most clearly seen in the efforts of BiOS to include major international commercial providers and local potential commercial breeders alongside the more likely targets of a commons-based initiative.

Central to this move is the belief that in agricultural science, the basic tools can, although this may be hard, be separated from specific applications or products. All actors, including the commercial ones, therefore have an interest in the open and efficient development of tools, leaving competition and profit making for the market in applications. At the other end of the spectrum, BiOS's focus on making tools freely available is built on the proposition that innovation for food security involves more than biotechnology alone. It involves environmental management, locale-specific adaptations, and social and economic adoption in forms that are locally and internally sustainable, as opposed to dependent on a constant inflow of commoditized seed and other inputs. The range of participants is, then, much wider than envisioned by PIPRA or the GCP. It ranges from multinational corporations through academic scientists, to farmers and local associations, pooling their efforts in a communications platform and institutional model that is very similar to the way in which the GNU/Linux operating system has been developed. As of this writing, the BiOS project is still in its early infancy, and cannot be evaluated by its outputs. However, its structure offers the crispest example of the extent to which the peer-production model in particular, and commons-based production more generally, can be transposed into other areas of innovation at the very heart of what makes for human development—the ability to feed oneself adequately.

THE PUBLIC INTELLECTUAL PROPERTY RESOURCE FOR AGRICULTURE

The Public Intellectual Property Resource for Agriculture (PIPRA) is a collaboration effort among public-sector universities and agricultural research institutes in the United States, aimed at managing their rights portfolio in a way that will give their own and other researchers freedom to operate in an institutional ecology increasingly populated by patents and other rights that make work difficult. The basic thesis and underlying problem that led to PIPRA's founding were expressed in an article in Science coauthored by fourteen university presidents.[3] They underscored the centrality of public-sector, land-grant university-based research to American agriculture, and the shift over the last twenty-five years toward increased use of intellectual property rules to cover basic discoveries and tools necessary for agricultural innovation. These strategies have been adopted by both commercial firms and, increasingly, by public-sector universities as the primary mechanism for technology transfer from the scientific institute to the commercializing firms.

The problem they saw was that in agricultural research, innovation was incremental. It relies on access to existing germplasm and crop varieties that, with each generation of innovation, brought with them an ever-increasing set of intellectual property claims that had to be licensed in order to obtain permission to innovate further. The universities decided to use the power that ownership over roughly 24 percent of the patents in agricultural biotechnology innovations provides them as a lever with which to unravel the patent thickets and to reduce the barriers to research that they increasingly found themselves dealing with. The main story, one might say the "founding myth" of PIPRA, was the story of golden rice. Golden rice is a variety of rice that was engineered to provide dietary vitamin A. It was developed with the hope that it could introduce vitamin A supplement to populations

	Total Revenues	Licensing and Royalties		Government Grants & Contracts	
	(millions $)	(millions $)	% of total	(millions $)	% of total
All universities	$227,000	$ 1270	0.56%	$31,430	13.85%
Columbia University	$ 2,074	$178.4	8.6%	$532	25.65%
		$100–120[a]	4.9–5.9%		
University of California	$ 14,166	$ 81.3	0.57%	$2372	16.74%
		$ 55 (net)[b]	0.39%		
Stanford University	$ 3,475	$ 43.3	1.25%	$860	24.75%
		$ 36.8[c]	1.06%		
Florida State	$ 2,646	$ 35.6	1.35%	$238	8.99%
University of Wisconsin-Madison	$ 1,696	$ 32	1.89%	$417.4	24.61%
University of Minnesota	$ 1,237	$ 38.7	3.12%	$323.5	26.15%
Harvard	$ 2,473	$ 47.9	1.94%	$416	16.82%
				$548.7[d]	22.19%
Cal Tech	$ 531	$ 26.7[e]	5.02%	$268	50.47%
		$ 15.7[f]	2.95%		

Table 1. Selected University Gross Revenues and Patent Licensing Revenues

Sources: Aggregate revenues: U.S. Dept. of Education, National Center for Education Statistics, Enrollment in Postsecondary Institutions, Fall 2001, and Financial Statistics, Fiscal Year 2001 (2003), Table F; Association of University Technology Management, Annual Survey Summary FY 2002 (AUTM 2003), Table S-12. Individual institutions: publicly available annual reports of each university and/or its technology transfer office for FY 2003.

Notes:
a. Large ambiguity results because technology transfer office reports increased revenues for yearend 2003 as $178M without reporting expenses; University Annual Report reports licensing revenue with all "revenue from other educational and research activities," and reports a 10 percent decline in this category, "reflecting an anticipated decline in royalty and license income" from the $133M for the previous year-end, 2002. The table reflects an assumed net contribution to university revenues between $100-120M (the entire decline in the category due to royalty/royalties decreased proportionately with the category).
b. University of California Annual Report of the Office of Technology Transfer is more transparent than most in providing expenses—both net legal expenses and tech transfer direct operating expenses, which allows a clear separation of net revenues from technology transfer activities.
c. Minus direct expenses, not including expenses for unlicensed inventions.
d. Federal- and nonfederal-sponsored research.
e. Almost half of this amount is in income from a single Initial Public Offering, and therefore does not represent a recurring source of licensing revenue.
f. Technology transfer gross revenue minus the one-time event of an initial public offering of LiquidMetal Technologies.

in which vitamin A deficiency causes roughly 500,000 cases of blindness a year and contributes to more than 2 million deaths a year. However, when it came to translating the research into deliverable plants, the developers encountered more than seventy patents in a number of countries and six materials transfer agreements that restricted the work and delayed it substantially. PIPRA was launched as an effort of public-sector universities to cooperate in achieving two core goals that would respond to this type of barrier—preserving the right to pursue applications to subsistence crops and other developing-world-related crops, and preserving their own freedom to operate vis-à-vis each other's patent portfolios.

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The basic insight of PIPRA, which can serve as a model for university alliances in the context of the development of medicines as well as agriculture, is that universities are not profit-seeking enterprises, and university scientists are not primarily driven by a profit motive. In a system that offers opportunities for academic and business tracks for people with similar basic skills, academia tends to attract those who are more driven by non-monetary motivations. While universities have invested a good deal of time and money since the Bayh-Dole Act of 1980 permitted and indeed encouraged them to patent innovations developed with public funding, patent and other exclusive-rights-based revenues have not generally emerged as an important part of the revenue scheme of universities. As table 1 shows, except for one or two outliers, patent revenues have been all but negligible in university budgets.[4] This fact makes it fiscally feasible for universities to use their patent portfolios to maximize the global social benefit of their research, rather than trying to maximize patent revenue. In particular, universities can aim to include provisions in their technology licensing agreements that are aimed at the dual goals of (a) delivering products embedding their innovations to developing nations at reasonable prices and (b) providing researchers and plant breeders the freedom to operate that would allow them to research, develop, and ultimately produce crops that would improve food security in the developing world.

While PIPRA shows an avenue for collaboration among universities in the public interest, it is an avenue that does not specifically rely on, or benefit in great measure from, the information networks or the networked information economy.

It continues to rely on the traditional model of publicly funded research. More explicit in its effort to leverage the cost savings made possible by networked information systems is the Generation Challenge Program (GCP). The GCP is an effort to bring the CGIAR into the biotechnology sphere, carefully, given the political resistance to genetically modified foods, and quickly, given the already relatively late start that the international research centers have had in this area. Its stated emphasis is on building an architecture of innovation, or network of research relationships, that will provide low-cost techniques for the basic contemporary technologies of agricultural research. The program has five primary foci, but the basic thrust is to generate improvements both in basic genomics science and in breeding and farmer education, in both cases for developing world agriculture. One early focus would be on building a communications system that allows participating institutions and scientists to move information efficiently and utilize computational resources to pursue research. There are hundreds of thousands of samples of germplasm, from "landrace" (that is, locally agriculturally developed) and wild varieties to modern varieties, located in databases around the world in international, national, and academic institutions.

There are tremendous high-capacity computation resources in some of the most advanced research institutes, but not in many of the national and international programs. One of the major goals articulated for the GCP is to develop Web-based interfaces to share these data and computational resources. Another is to provide a platform for sharing new questions and directions of research among participants. The work in this network will, in turn, rely on materials that have proprietary interests attached to them, and will produce outputs that could have proprietary interests attached to them as well. Just like the universities, the GCP institutes (national, international, and nonprofit) are looking for an approach aimed to secure open access to research materials and tools and to provide humanitarian access to its products, particularly for subsistence crop development and use. As of this writing, however, the GCP is still in a formative stage, more an aspiration than a working model. Whether it will succeed in overcoming the political constraints placed on the CGIAR as well as the relative latecomer status of the international public efforts to this area of work remains to be seen. But the elements of the GCP certainly exhibit an understanding of the possibilities presented by commons-based networked collaboration, and an ambition to both build upon them and contribute to their development.

CONCLUSION

The BiOS initiative and PIPRA are the most salient examples of, and the most significant first steps in, the development of commons-based strategies to achieve food security. Their vitality and necessity challenge the conventional wisdom that ever-increasing intellectual property rights are necessary to secure greater investment in research, or that the adoption of proprietary rights is benign. Increasing appropriation of basic tools and enabling technologies creates barriers to entry for innovators—public-sector, nonprofit organizations, and the local farmers themselves—concerned with feeding those who cannot signal with their dollars that they are in need. The emergence of commons-based techniques—particularly, of an open innovation platform that can incorporate farmers and local agronomists from around the world into the development and feedback process through networked collaboration platforms—promises the most likely avenue to achieve research oriented toward increased food security in the developing world. It promises a mechanism of development that will not increase the relative weight and control of a small number of commercial firms that specialize in agricultural production. It will instead release the products of innovation into a self-binding commons—one that is institutionally designed to defend itself against appropriation. It promises an iterative collaboration platform that would be able to collect environmental and local feedback in the way that a free software development project collects bug reports—through a continuous process of networked conversation among the user-innovators themselves.

In combination with public investments from national governments in the developing world, from the developed world, and from more traditional international research centers, agricultural research for food security may be on a path of development toward constructing a sustainable commons-based innovation ecology alongside the proprietary system. Whether it follows this path will be partly a function of the engagement of the actors themselves, but partly a function of the extent to which the international intellectual property/trade system will refrain from raising obstacles to the emergence of these commons-based efforts.

We invite reader comments. Email <editors@innovationsjournal.net>.

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1. This is similar to the General Public License of the GNU project <http://www.gnu.org/copyleft/gpl.html>. For further description, see chapter 3 of Yochai Benkler (2006), *The Wealth of Networks* (New Haven, CT: Yale University Press), available for free download at <www.benkler.org>
2. Wim Broothaertz et al. (2005), "Gene Transfer to Plants by Diverse Species of Bacteria," *Nature* 433:629.
3. Richard Atkinson et al. (2003), "Public Sector Collaboration for Agricultural IP Management," *Science* 301: 174.
4. This table is a slightly expanded version of one originally published in Yochai Benkler (2004), "Commons Based Strategies and the Problems of Patents," *Science* 305:1110.