THE ROLE OF TECHNOLOGY TRANSFER IN PARASITE CONTROL IN DEVELOPING COUNTRIES*

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Technology transfer has played an instrumental role throughout human history in the tranformation of new knowledge into constructive use by society. The major agents of this transformation have been universities, industry, government, and other organizations. This process is crucial to meeting the demand on science to increase its accountability with respect to society's goals, as reflected in the public renegotiation of the social contract (Byerly and Pielke, 1995). This shift in the science paradigm was recognized by Nobel Laureate Gertrude Elion (1994):

"Scientific researchers have a strong responsibility to work for the public good. Regardless of where those researchers reside-in universities, corporations, or government laboratories-this obligation remains undiminished. From each source, ideas must be transferred inexorably to ever more real application, and to even more public benefit. Probably, some money will be gained along the way, but so will much more of a greater currency: improvements in human lives and economic prosperity."

This message should resonate strongly among scientists. Research dollars are no longer being seen as money benefitting solely the pursuit of knowledge, rather they are viewed by the public as investments (Murrell, 1995). As never before, research is expected to pay off in the short term; for policy makers, the sooner the returns, the better. Society wants assurance and evidence that it is getting something concrete in return for the money invested in research. If science is to sustain political support, research programs must demonstrate their relevance to national welfare. The transfer of knowledge and innovations from their place of origin to a place of practical application has never been of greater importance.

This growing demand for relevance (or "strategic research") places great pressure on scientists and institutions to find effective ways to transfer their new knowledge. Scientists must realize that research results have got to get out of the laboratory in order for them to have any effect on society's problems and needs. Getting a research result into the hands of industry or the end user is the market equivalent of getting research results out of notebooks and into a refereed journal (Murrell, 1995). In many circumstances, however, the means of doing this are unclear, and often such efforts are ineffective or only partially successful. An example of inadequate communication affecting the introduction of a beneficial technology is food irradiation. The difficulties encountered in introducing this technology arose because industry and the scientific community have had a difficult time in getting across the message that this is a safe technology, despite the broad scientific consensus that it poses few risks (Loaharanu and Murrell, 1994).

Communication of knowledge: New opportunities

Technology transfer is a conceptual framework for the communication of knowledge. It deals explicitly with relationships that facilitate the translation of results of research into useful knowledge, products and services. Education is a fundamental form of technology transfer whereby information is transferred from its origin to the work place through a variety of transmission forms (chiefly the oral-aural and visual modes). Semeiotics recognizes four major communicative shifts in history: the shift to speech (50,000 to 100,000 years ago); to script (~ 6,000 years ago); to print (~ 1,000 years ago); and to the computer and

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screen (in the last 50 years or so). The latter, the fourth shift, is based on electronics and is often referred to as "a media revolution," or "information explosion," and reflects the new growth modes of the economy-information, entertainment, high-end business services, international trade and design (Kotkin, 1995).

In general, the scientific community has not fully exploited the tools of the mass media to get its messages across. This is a shortcoming that must be addressed if science is to play an important role in efforts to improve global well-being. The research community has a dual responsibility to both inform people of the value returned from their investments in research, and to improve the transfer of technical knowledge to the users of its innovations (*eg*, farmers, consumers, industry, action agencies, public health agencies, and other scientists).

It is not possible to reach every citizen with information on public health, therefore, an alternative is to target key constituencies (Murrell, 1995). These groups may include the mass media, governmental leaders and policy makers, faculty and administrators, economic development groups, the entrepreneurial community, and other audiences deemed useful (Memory, 1994). This diverse audience may not always be reliably reached by traditional communication methods (journals, magazines, extension literature). Therefore, exploitation of other mass media opportunities must be considered. The explosion in communication alternatives such as the Internet, electronic libraries, movies, videos, *etc*, are some examples. However, utilization of the mass media will require very creative message construction to make them attractive and effective. The messages must be provocative and persuasive, and, in some instances, they may communicate best in a "sound-bite" fashion, as distasteful as that will be for many scientists. Most scientists are not familiar with these techniques and, therefore, journalists and professional consultants can be enlisted in constructing effective messages. While this may be difficult for individuals to manage, a professional society or a government agency is more likely to have the ability to muster the collective effort and resources necessary to produce and promote effective messages. Major parasite control programs should include, as a necessary component, a communication (technology transfer) plan.

Middlemen

Traditionally, the translation of knowledge from the laboratory to the user has relied on government education and extension systems. For example, the positioning of extension personnel with agricultural or public health researchers on campuses has greatly facilitated reaching audiences with practical and relevant information. This has been a major reason for the outstanding achievements in agriculture. However, this model is becoming less and less the dominant means of technical communication; instead, a collection of what might be characterized as "middlemen" are increasingly more responsible for making parasitological research results available to target audiences. These middlemen include pharmaceutical companies, other commercial vendors, consultants, and cooperatives. In some instances, the middleman may participate in further development of the technology (*eg*, commercial vendors), or in cooperative testing (*eg*, consultants, cooperatives, farmer associations). These "middlemen" can be considered a target constituency.

The evolution of computer networks is fostering a revolution in the manner in which the scientific community communicates with the beneficiaries of its research. Although computer use and availability among many communities at highest risk for parasitic zoonoses (developing countries) is not yet high, there are opportunities for such communication links with local public health and agricultural agencies. User-friendly and attractive systems can enhance the transfer of up-to-date information to target audiences on a nearly continuous basis. Developing such systems will require a concerted effort on the part of both private and government action agencies in alliance with the research community. Such partnerships have been quite successful in this developed countries (Murrell, 1995). A priority for international and national assistance programs should be the establishment of such communication networks.

Community self-help programs

As pointed out by Suweta (1991), transferring knowledge to farmers and members of rural communities is difficult, especially through formal education programs. Knowledge transfer in these circumstances may be more successful if it is an informal style of adult education. The success of this, however, is dependent upon clearly demonstrating to the audience that the change being urged is profitable to the users (*ie,* economic, improved health and welfare). Importantly, active participation of the beneficiaries in the research at all stages of the program is very desirable. This can be carried out, for example, through their involvement in demonstration projects.

One proven strategy for transferring technology among local people is in assisting them to form self-help groups (Suweta, 1991). The group approach is the basis for agricultural extension in many developing countries. This approach has proven very effective in Indonesia ("Farmer Field School" system) and in Thailand ("Farmer Self-Help Worm Control Program") (Murrell, 1994). The key to both of these programs is the empowerment of farmers to participate in developing both local control strategies and procedures for educating other farmers (peers). This model should be considered for its applicability to the control of foodborne parasites at the community level.

Commercialization of research innovations: Classical technology transfer

The terms "commercialization" and "technology transfer" are often treated as if they are interchangeable, although they are not (Tallent, 1992). Commercialization is the process of getting a product into the market place for the purpose of economic gain. Technology transfer, in contrast, is a strategy for ensuring access to technical details that facilitate the production of the product being commercialized (Tallent, 1992). The sources for these new technologies may be generated from within the organization, purchased or licensed from others, or developed collaboratively with others who have complementary expertise and material goals.

A frequent criticism of technology transfer is that "some one is getting rich" from research supported by public funds. This can be answered by open dialogue with the public on the purpose and utility of technology transfer in realizing the full public value of public-supported research. The technology transfer process should be characterized as offering the potential to create new societal benefits, such as improved health, jobs, and tax revenues, which provide a return to the taxpayer. In a free enterprise economy, commercialization of research innovations or inventions has repeatedly proved to be the most practical and effective means of bringing benefits to the widest segment of society. Technology transfer, in all of its aspects, is undoubtedly the most effective means for overcoming obstacles to achieving real control of foodborne parasites. An integrated parasite management (IPM) strategy requires the availability of a variety of technologies and practices. For example, the control of meatborne parasites is dependent upon tools such as immunodiagnostic tests, drug treatments, improved animal production systems and food treatment and preparation practices; the latter could include irradiation treatments.

Commercialization of innovations by the private sector to meet these needs is usually the best means for getting such tools into the hands of the users realizing the benefits of the public research investment. Technology discovered in the public research laboratory that has commercial application, but is not transferred to the private sector, can be seen in many cases, as a wasted asset. Discoveries in biotechnology, for example, must be patented and passed to a commercial entity if the discovery is to be translated into new medicines, diagnostic tests and other beneficial products and services for consumers. Importantly, companies often advance the science behind the technology by investing in further research, either in the public laboratory or within their own organizations. This adds to the benefits of research that can be returned to the public as a return on investment.

Collaboration with industry has further benefits to the public research laboratory. It allows university and government researchers to learn from the ideas and experience of industry scientists and the lessons learned from the development and marketing of technologies.

Government–private sector partnerships

In developed countries, a new, highly integrated system has evolved to facilitate the demand for greater access by industry to the entire range of national research and development programs; a system which emphasizes locally defined partnerships with State and Federal governments. While industry remains free to choose its own investments, government at all levels strives to make business and technical services available in order to bring technology to fruition in the form of some societal gain, such as economic growth. In this integrated system of partnerships, industry and government will be expected to participate as a matter of course in planning and executing government technology investments that stand to benefit the wider society through serving both public and private needs (Coburn, 1994). This evolving system in developed countries should be carefully considered by the governments of developing nations in their efforts to find new strategies for improving the health and welfare of their citizens. In some cases, this may require privatization of some government activities (World Bank Report, 1993).

Because a company has to acquire the research information and turn it into a product which can be sold, most nations have adopted a policy of exclusive licensing to attract greater interest in adopting research innovations by the private sector. Significant patenting may continue in the public research sector, but private participation is replacing many public efforts at the applied end of the research spectrum. But as emphasized by Mitchell (1995), the prospects for a new product development, such as a parasite vaccine or immunodiagnostic test, will be determined by an evaluation carried out by the potential manufacturer that includes assessment of technical risk, commercial potential and compatibility with the corporation's strategic objectives. The intellectual property position and market size may also influence commercial attractiveness. Because the regulatory and registration process for many ventures is so arduous and lengthy, only well-financed and brave enterprises are likely to undertake the development of products for non-affluent markets. Hence, governments have found it necessary to allow private industry to acquire intellectual property protection in order to encourage their participation.

Substitution of private for public research will generally remain focused on the development stage, where further patenting is possible (Busch, 1993). The means for providing private cooperators with licensing agreements to public innovations are varied and differ in important ways between countries. The following example from the United States is illustrative. In 1986, the US Congress enacted the Federal Technology Transfer Act, which markedly changed the relationship between public agencies and the private sector. This act granted to industry the opportunity for first right to exclusive licenses on publicly-patented inventions made under a Cooperative Research and Development Agreement (CRADA) between both parties. Importantly, the Act encouraged the close collaboration between scientists of public and private organizations to help commercialize the technology resulting from the CRADA. Under a CRADA, the cooperating firm provides the know-how needed for development and commercialization of a new product, process, or service. The firm may also provide funds to cover some of the added costs to government laboratories for work done under the agreement. Or, the firm might contribute personnel (for example, a scientist or technician), equipment, or materials. Importantly for public agencies, entry into a CRADA occurs only when the research objective is compatible with their mission.

The scientist is key

While there are many players in the sequence of events leading to the transfer of knowledge to the end user, the scientist is at the heart of the process (Murrell, 1995). They are the "explainers" of the technology, and they must be allowed intimate interaction with the key individuals responsible for technology development and transfer. Such involvement, generally, rests on the personal dedication of two, three or four key individuals involved in the transfer process. The success of the technology transfer effort can be improved by (Szakonyi, 1990) :

1. Empowering scientists to work closely with the private sector and facilitating, if appropriate, the involvement or actual participation of the scientist in the private sector operations.

2. Facilitating access of industry scientists and personnel to government-sponsored research laboratories. Close contact will enhance knowledge transfer.

3. Establishing an incentive and awards program to encourage the interest of research scientists in technology transfer.

Obstacles to technology transfer

The resource constraints, cultural and philosophical differences and the sometimes conflicting objectives of the participants can make technology transfer a complex and time consuming activity. Perhaps one of the most difficult obstacles to the transfer of technology is the lack of public understanding of the nature and risk/benefits of the innovation; this has been especially true for the pioneering products of biotechnology. The failure to educate the public on the nature and benefits of a general technology has proved to be serious handicaps for innovations such as food irradiation and genetic engineering.

There are additional risks for public sector institutions that must be recognized and mitigated if the cultural change necessary for greater technology transfer is to occur. Among the most important risks are (Memory, 1994):

Delayed publishing of research results. Institutions should have an established policy on this that is consistent with national practice.

Misuse of graduate students may occur, including the use of students' time to work on "corporate" or proprietary projects, which may restrict opportunities to publish. Clear institutional policies and guidelines must be in force.

Falsification of data in publishing or in clinical trials has occurred in isolated instances. It is imperative that a peer review system be utilized to discourage falsification of data. Most institutions prohibit scientists with financial ties to a company from being involved in any way with that company's clinical trials.

To avoid conflict of interest by researchers, administrators, and institutions, strong, clear guidelines must be in place and known by all participants in the technology transfer process; these policies must be communicated frequently to all concerned.

International assistance in technology transfer

Persistent effort must be made to make more available to developing countries the technologies used in the developed countries in the control of foodborne parasites. As discussed above, the commercial development of a product is dependent upon a number of factors, such as technical risk, market size, corporate strategies, etc. This becomes even more critical when the markets for such products are among less-affluent populations. This makes the creation of alliances between local agencies, local manufacturers and international organizations especially necessary for the development phases of R&D. There is a great need to find better means for transferring knowledge on process development and on clinical and regulatory processes to appropriate organizations in developing countries, with due recognition for the technological, infrastructural and cultural differences existing in these countries (Mitchell, 1995). Numerous international programs have been created to help developing countries deal with public health problems. Among these, private, non-governmental organizations (NGO) are playing an increasingly important role (Murrell, 1994). The result is a large number of somewhat independent, targeted assistance efforts. However, the problems of foodborne parasites generally require attack from several aspects. For example, socio-economic conditions play an important role in fishborne parasitic diseases. Therefore, solutions that address cultural, economic, and scientific factors are likely to be more effective. A systems approach to problems such as foodborne parasites is needed, one that is a holistic approach to the broader issues of health and welfare, than just simply addressing the infectious disease. This approach will require far greater multidisciplinary and multi-agency coordination and planning than is normal (Murrell, 1994). In this respect NGO's may have a greater role to play than has been generally appreciated (World Bank Report, 1993). NCO's typically have simpler bureaucratic structures, with the result that they can be quite flexible in both their planning, responsiveness, and implementation of programs. This makes them potentially highly effective partners with national and international government organizations. Only within the context of a broad, well-coordinated strategy, involving alliances with government, universities, private industry, and NGOs, will a control strategy realize its potential for helping solve the serious problems of foodborne parasites.

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