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Abstract

Contrary to some popular beliefs, technology is not transferred based on needs but is strengthened when scientific and technological capacity exists and when effective regulatory systems are in place (biosafety, intellectual property rights, trade regulations). In the agricultural biotechnology area, a number of institutions facilitate technology transfer through a range of activities and initiatives. Many were created and built when technology transfer was something linear. Today, however, technology development and transfer is highly interactive. These elements are discussed in the context of globalization and public-private partnerships, among others.

It is concluded that many of today's development institutions that were created over the last half century or so are no longer effective in the new world order. The incremental changes taking place today in changing the institutions are certainly desirable but fail to deliver the full potential of these institutions and investments. A fundamental re-structuring is long overdue and proposes a number of initiatives to that effect including fundamentally re-structuring international institutions, leveraging the potential of biotechnology companies through new types of public-private institutional arrangements, unleashing private investments, and addressing the constraints imposed by the over-regulation of biotechnology. Unfortunately, it appears that the prospects for any of the needed changes to take place are not very good. Perhaps the plight of the world's poor has to become even worse to draw the attention of the developed world and motivate it for action.

1. Introduction

Contrary to popular beliefs, technology is not transferred based on needs. Needs are plenty in this inequitable world and yet technologies that could make a significant difference in the lives of millions, or billions even, do not find their ways to places and people where they are most needed. The main reason why technologies are not transferred to the poorest are the lack of:

1. sufficient scientific and technological capacity in developing countries;
2. effective regulations that are conducive to technology transfer (biosafety, intellectual property rights (IPRs), trade);
3. efficient technology diffusion and marketing mechanisms;
4. adequate investments by both the public and private sectors; and
5. strong international institutions, acting as brokers and intermediaries, able to adapt to the changing world.

Evidently, there are broader reasons also that hamper technology transfer, ranging from the geopolitical state of the world, epitomized by certain aspects of globalization, to either incompetence or outright corruption. The question for the purpose of this paper is not to analyze the root causes of the shortfalls of governance, nor of the process of globalization and how it has increased global inequity. Rather, the question within the scope of this chapter is to review the different elements listed above that contribute to or hinder technology transfer, re-evaluate the functioning of development institutions in the 21st Century, and explore new institutional mechanisms to harness the beneficial aspects brought about by globalization. In order to accomplish this in a meaningful manner, however, an extended discussion on globalization and on property rights and IPRs will precede the specific strategies needed to accelerate (bio)technology transfer in the realms of scientific and technological capacity, regulations (biosafety, IPRs and trade), public-private partnerships, and funding.

2. Technology transfer, globalization and property rights

2.1 From linear to interactive models of technology transfer

For a long time technology transfer has been linear: The movement may be from a research institute to another entity in another country, or from one production entity to another. In the area of inventions, technology transfer involves discovery, development, evaluation, acquisition, adaptation, and implementation. International technology transfer is said to take place when an existing technique of production is moved from one location to another.

This linear model of technology transfer has radically changed with the advent of globalization and with the emergence of the life sciences (viz. biotechnology). It is now interactive between downstream and upstream actors and interwoven between the public and private sector, adding several additional layers of constraints and challenges. In biotechnology in particular, transfers happen in both ways, within and between public/private networks. Those who are outside the network have difficulties getting in, not least because of the high transaction costs associated with IPRs and other regulatory aspects, particularly biosafety.

In international development, technology transfer is further obscured by a series of forces unleashed by globalization. The liberal economic fundamentalism of the 1980s and early 1990s, although somewhat fading in fashion these days, has caused a series of new actors to emerge and forced established actors to assume new roles. For example, the private sector has become an important pillar in development policy[1] with non-governmental organizations (NGOs) and civic society taking on an increasingly complex series of responsibilities, not least that of technology diffusion. This in itself does not need to be a factor that hinders technology transfer, but in practice, it often does because of the multitude of actors.

Most significantly, however, existing institutions that cushioned the negative effects of change in the past have been significantly weakened. This weakening is seen by the fact that economic and development policy formulation is becoming more and more reactive rather than proactive. Bilateral policy by and large is still based on the linear model with policy makers/advisers strongly discipline oriented. More importantly, however, bilateral development strategy is inappropriately influenced by geopolitical interests and historical national or personal relationships.

In other words, nowhere does one see a stronger entrenchment in the way things have always been done than in bilateral development agencies. Multilateral institutions, arguably, suffer from the same and an even wider range of problems, not least being profoundly under-funded and deeply over-bureaucratic, which make their effects accordingly limited. The major multilateral financial institutions (such as The World Bank and International Monetary Fund [IMF]) continue to promote economic reform. This, of course, is fine. But the programs are rarely accompanied by the necessary parallel initiatives and financial resources to meet basic human needs in the critical areas of health, agriculture, and energy, especially in the poorest areas of developing

[1] Witness for example the call in Johannesburg (the 2002 World Summit on Sustainable Development) for more public-private partnerships in the energy and water sectors.

countries. Other multilateral institutions, such as the Consultative Group for International Agricultural Research (CGIAR), or the Food and Agriculture Organization of the United Nations (FAO) have not come to terms with the fundamental changes in the environment in which they operate. That environment is so much more complex than it used to be during the height of these institutions. For example, the mandate of the CGIAR has become so broad, and even more important than a few decades ago, yet its organizational structure is increasingly inefficient at best, and its financial resources almost deplorable compared to the needs that one has to wonder whether these institution are still relevant. They can hardly be described as inspirational forces for change. How can they continue to be important agents of change when their own institutions are not anymore capable of changing themselves?

To illustrate the point, until the late 1980s, agriculture in the developing world had primarily been handled by nation-states and a few multilateral organizations. As globalization has radically reshaped agricultural research and production, the established political and institutional boundaries of institutions created one or two generations ago no longer fit well with current realities. The result is that FAO, for example, is not only overly bureaucratic, but its program formulation and strategic priorities are inappropriately influenced by "favouritism". The CGIAR system on the other hand is at an all time low, in financial dire straits, arguably leaderless, and unable to institute overdue reforms. This is largely due to its multi-stakeholder system of governance.

Globalization, with the ensuing segmentation of markets whereby the hurdles of the poor to enter the market economy becomes increasingly difficult, is accelerating the negative effects on the rural poor. And there are no new institutions, adapted to the new world order, able to mitigate the social costs of liberalization. Investments to transfer and adapt, yet alone generate technology are wholly inadequate. At a time when the world around the CGIAR has become more complex with many more actors and spheres of influence, rather than re-group and focus, the CGAIR has expanded over the last decade and become more and more diffuse an entity. This is particularly devastating because the work of these Centres is conceivably more important than ever from strategic and humanitarian points of view.

Paradoxically, over the same period, the private sector undertook mergers and acquisitions, reducing the number of key players from some 20 plus to a mere five or so. This happened during a time when development agencies, NGOs, and a plethora of other service organizations increased and multiplied.

2.2 Specifics on biotechnology transfer, humanitarian donations, and public-private partnerships

Technology tends to follow set stages and forms. Companies entering international technology markets typically go through a two tiered decision process. First the choice is between exports of goods and production in the target country(ies). Second is the decision of the business form for local production, whether license, joint venture or foreign affiliate. Export decisions are based on a range of criteria, including national and recipient country conditions. Decision factors include market knowledge and size, risk, size economies in production, need for local adaptation, and

recipient country regulations. Typically, companies prefer to enter new markets with exports before making the longer term, and more risky, commitment to local production.

When exports are not possible or permitted, companies consider alternative forms of local production. Licensing has the benefit of affiliation with established local partners and less investment risk. Disadvantages are limited control over the technology and quality assurance. Joint ventures are often mandated by national law which in many countries, especially developing countries, stipulates majority national ownership. Joint ventures are riskier because they imply a fixed in-country investment. Subsidiary operation is at the same time the source of the greatest control and the riskiest due to the need for higher fixed investments.

Associated with these methods of transfer is the forms of transfers. The most immediate is the transfer of products for direct use. These must be products of broad adaptability or larger markets justifying the expense of adaptation in the home operation. Capacity transfer refers to the dissemination of the capability for local production. This would be compatible with joint ventures and direct investment, and with certain forms of licensing. Finally, design capacity refers to training and related investments leading to the ability for local adaptation or further product development. Because design capacity carries the risk of creating a competitor if control is lost, subsidiaries are preferred for this type of transfer.

It is important when discussing technology transfer to remain cognizant of the appropriate form and stage. Many developing countries are interested in design capacity transfer, which, from the recipient country perspective translates into higher added value. Yet because this is often the most complex and risky activity for the private sector (i.e. the supplier of technology in this case), opportunities will necessarily be more limited.

In terms of donations of biotechnology applications for humanitarian and resource poor farmer use, all of the above considerations apply in principle. Donations of technology alone are not sufficient for the technology to reach the end-user. The same considerations of production, capacity, etc. are factors that not only need to be addressed, but also need investments. Therefore, the simple call for more donations or for more public-private partnerships is insufficient to have technology reach poor farmers. Such partnerships also need to be followed by increased funding.

The key issues with humanitarian donations and public-private partnerships, based on the experience of the author, are severalfold. From the perspective of companies, the key concerns when donating technologies or engaging in public-private partnerships are:
risk of loss of control of the technology;

- potential negative public relations if the products disseminated do not meet high quality product standards, thus indirectly defaming the technology and/or company;
- potential negative public relations if regulatory procedures, such as biosafety and food safety, are not followed appropriately;
- parallel imports (see also footnote 8); and
- longer term risk of creating or strengthening competitors.

At the same time, the opportunities and rewards for companies who engage in humanitarian transfers are significant (besides the intrinsic humanitarian, ethical and social benefits):

- delegation of technological leadership;
- sound regulatory development based on well trained and informed personnel;
- national technological capacity which is a prerequisite for technology adaptation and long term growth;
- goodwill and long term relations based on mutual trust and understanding; and
- improvement of the public image of biotechnology and of the company.

2.3 Specific constraints in biotechnology transfer and adoption

When considering factors that discourage the transfer of biotechnology applications, at least five main areas can be discussed. Many are directly or indirectly related to IP. These are not necessarily in order of importance, for that varies according to the technology to be transferred, specific situation in a given country, and the type of donors/recipients involved.

Public Acceptance: Biotechnology is currently caught in a maze of controversy; more of it flowing from emotions and beliefs than from rationality or science-based discourse. In practice there is much stated opposition to the use of biotechnology in the food supply chain within industrialized countries. Increasingly, many developing countries, fearful of being used as "technology proving laboratories," have reversed their initial broad acceptance of food biotechnology as the dawn of a new day of food security. Others are shying away for fear of jeopardizing their exports. Sometimes, the forces opposed to food biotechnology have pointed to the consolidation of the biotechnology industry in the portfolios of a few wealthy entities (multi-national companies, well-endowed universities, etc.) as "proof" that biotechnology is part of a plot to manage the world's food supply. These anti-transgenic voices point to expanded statutory or IP protection to prove their hypothesis or world views.

Evidently, what happens in Europe in terms of public acceptance will have a world-wide impact, not least because of trade considerations. In the view of the author, it will be another 3-4 years or so before Europeans will more broadly accept food biotechnology. What is particularly worrisome, however, is that many developing countries are currently in the final phases of formulating their biosafety regulations and the complex situation in Europe is not helping. Many such drafts, if enacted, will lead to huge administrative burdens that will slow research and collaborations, and hence technology transfer.

Technology Cost: The capital investments required for successful (or even unsuccessful) R&D in biotechnology are astounding. During the late 1980s and early 1990s, investment banks, private investors, companies, and research organizations pumped very large amounts of capital into biotechnology research and product development. Few of these investments returned the investment and fewer yet produced a profit to the venture capitalists. In an attempt to seek a fair return on their investments, the research entities aggressively pursued statutory protection

wherever possible. This aggressive, market-oriented stance within the culture of biotechnology in general, in turn, added additional costs to the R&D efforts. In many cases, it was cheaper and more effective to "buy" entire companies rather than endeavour in lengthy negotiation processes with uncertain outcomes. This may well have been the case for the purchase in the 1990s of Mogen by then Zeneca, or for the purchase of Agracetus by Monsanto as but two examples.

By the early 1990s, purchases of companies with strong patent portfolios or platform technologies were no longer major options because their numbers had shrunk significantly, either through the purchase or through bankruptcy. The strategy had therefore to be modified and led to the life sciences concept with the familiar mega-mergers. The value of the top 25 consolidations from 1995 to 1998 totalled US$17 billion (James and Krattiger, 1999). By the late-1990s, a new strategy in technology licensing was pursued with the advent of genomics. Because this was (and still is) a high risk research effort, companies spread their risks by making significant investment deals into emerging genomics companies (e.g. Maxigen) or by research collaboration deals and technology licensing agreements with upfront and milestone payments.

In summary, companies have had to consolidate, in part, because of:

- spiraling R&D costs (including regulatory costs and related delays);
- high patenting, legal, licensing and litigation costs;
- the emergence of high risk new technologies such as genomics; and
- slower consumer acceptance than anticipated.

It should be noted that for large companies, failure to be "in the technology game" could have cost them their comparative advantage later on; hence many of the investments were merely viewed as insurance policies. Also noteworthy is that mergers of equals saved those companies much of the patenting, legal, licensing and litigation costs. For example, Novartis may have spent US$70-90 million per year in the agricultural biotechnology area and AstraZeneca some US$50 million or more prior to their partial merger. The combined company Syngenta is unlikely to have a budget of more than 60% of the combined expenditures before the merger. It is perhaps worth mentioning here that the entire budget of the CGIAR for biotechnology is less than a quarter or so of what one major agricultural biotech/seed company spends.

R&D and Regulatory Costs: Across the world, from a perspective of agricultural R&D in general, there are three broad types of countries (slightly modified from Byerlee and Fischer 2001). These are:

Type I **Highly developed biotechnology research and regulatory capacity** within universities, companies, and public or private research institutions; these have predictable laws, regulations, and enforcement of statutory protection and biosafety regulations. Examples: The European Community, Japan, the United States.

Type II **Early stage biotechnology research and regulatory capacities** primarily within parastatal and international research centers and a limited number of universities; recently enacted and unpredictably enforced laws and regulations regarding statutory

protection of discoveries and biosafety. Examples: Brazil, India, South Africa, Mexico, China.

Type III **Very little or no biotechnology research and regulatory capacity**; have historically depended quite heavily on improved agricultural seed products from the international research centers; very newly enacted statutory and biosafety legislation and no predictable experience in enforcement. Examples: Kenya, Syria, most of Eastern Europe, Vietnam, Colombia.

The CGIAR and related institutions have directed their activities primarily toward serving the Type III and to some extent Type II countries, while their funding sources have been primarily located in the Type I countries.

Until recently, research at the CGIAR Centers proceeded without significant consideration of the issues of IP. However, as these Centers prepared to release their first biotech-based improved seed products, there was a realization that few of the IP issues had been adequately addressed. The impact upon the Centers' research capabilities because of the delay in resolving the IP issues for their improved products is only one aspect of the problem[2]. The more critical one is the limited ability of the centers of the CGIAR's client countries, particularly those of Type III, to receive and manage the Centers' improved products. This has placed a significant hurdle in front of the effective distribution of a great deal of expensive research that has been done by the centers.

Seed distribution systems: The seed, because it is a living organism, has the ability to reproduce itself. With the inclusion of transgenic components in many recently released improved agricultural products, these pass along their biotechnology components, whether the components are IP-protected or not, from generation to generation[3]. Biotechnology has thus prompted the invention of new seed marketing schemes and is calling into question the historical patterns of seed distribution. Nowhere is this shift expected to be more dramatic than among the Type II and Type III countries. The expensive proprietary technologies, it is feared in many quarters, will become public property in many such countries.

At the same time, the Type II and Type III countries are the ones that could potentially benefit the most from the technological advancements that are protected by IP, both from a socio-economic and environmental perspective. This conflict has promoted the development of "locking" technologies such as the so called "terminator gene". This "locking" gene had great potential to minimize the risk of environmental harm by transgenic crops while permitting the owners of IP protected components to extract a return on their investments. Whereas for public

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[2] It should be noted here that it is perhaps somewhat unfair to speak of "the Centers" in the IP context. The CGIAR is an amalgamation of a wide range of institutions; some centers, such as CIMMYT, have long taken a proactive stand towards sound IP management. Others are lacking behind. Unfortunately, however, the CGIAR is often viewed by policy makers in developing countries as an important source of information and relied upon for inputs on national policy making. It is in this context where one can easily speak of an overall failure of the CGIAR in providing the leadership so many expect it to take.

[3] Hybrids form a certain exception because they do not breed true. However, if they are transgenic, then the trait that has been added is still passed on to some of the offspring.

relations reasons the "terminator" will not be developed and incorporated into seed, other and more specific gene regulation technologies are likely to become the dominant mechanism. They are expected to emerge quite soon and afford acceptable IP protection in many crops, markets and circumstances.

IP complexity and freedom to operate: In addition to the complexities that are inherent to statutory protection laws worldwide, the impact of various international treaties (World Trade Organization (WTO), the Convention on Biological Diversity (CBD), etc.) has added another level of complexity. Further, as developing countries modify their legal systems and practices in response to the various laws and treaties, an even wider range of complexities begin to arise. The factors that discourage widespread adoption and easy transfer of agri-biotechnology are many and diverse. However, they are principally related to IP management activities.

A recent FTO review of the pro-Vitamin A containing Golden Rice has shown that a total of about 70 patents and patent applications are embedded in the product. Because patents are granted on a national basis, in a given country fewer than the 70 patents apply and range from zero in some developing countries to as many as 45 in most of Europe and the US (Kryder et al 2000). In the USA and most countries of the European Union, around 40 patents and patent applications were identified. In the 10 top rice producing countries, many fewer patents and patent applications were found, namely: China (11), India (5), Indonesia (6), Bangladesh (0), Vietnam (9), Thailand (0), Myanmar (0), Japan (21), the Philippines (1) and Brazil (10). Similarly, in the top ten rice importing countries, relatively few patents apply: Iran (0), Brazil (10), Nigeria (0), the Philippines (1), Iraq (0), Saudi Arabia (0), Malaysia (0), South Africa (5), Japan (21) and Côte d'Ivoire (10).

It should be noted here that it is unlikely that the majority of the patent applications will enter the national phase and thus very few IP constraints, if any, will become stumbling blocks for the commercialization of Golden Rice. The key issue, however, will be tangible property rights and contracts. Golden Rice is most likely to be transferred from universities and/or companies that already developed the vectors or transgenic plants. Such transfers will take place under contracts, or material transfer agreements (MTAs). This is not a minor issue. For more detailed discussions on MTAs, see Krattiger 2003a. What is needed here is a thorough identification of who has the right to transfer certain technologies.

Determining what entity has the right to grant licenses or sub-licenses is a very tedious process, one which continually evolves as companies re-structure, sell or assign patents, or grant licenses with or without the right to sub-license. The technical property (TP) flow further complicates the picture as is evident from Figure 1 which lists the TP flows for one of the three constructs necessary for the production of Golden Rice. In addition, "recognizing that patent claims may be granted for different kinds of inventions, claims may be worded to cover products *per se,* products-by- process, uses, or processes. Whereas the first three types of claims generally extend to the products that embed the new discoveries, "process" claims or claims for the claimed technical procedures do not extend to the products that are produced by the claimed processes. What is of great importance for "process" claims is the country in which the process is applied. If the product is made in a country where those "process" claims have not been issued, then a license for such claimed processes is not required" (Kryder *et al* 2000). A total of 26 of the

approximately 70 patents and patent applications identified in the above study contain primarily process claims thus reducing somewhat the number of applicable patents which could inhibit FTO in a given country.

INSERT FIGURE 1 APPROXIMATELY HERE

2.4 The various forms of globalization and how they limit the work of development agencies

The changes in the environment in which development agencies and institutions operate can be analyzed in many different ways. Presented here are three principal levels of globalization[4]. The first is the familiar economic dimension caused by revolutions in capital and information flows, international business regimes, and trade. The subsequent specialization and integration of companies makes a tremendous increase in aggregate wealth integration possible. What the efficiency gain of the "new corporation" achieves is an accelerated pace of innovation and scientific development. It is noteworthy that during the 1990s the economies of the developing world that were integrating themselves into the world economy grew more than twice as much as developed countries which were already integrated to a large extent. The non-globalizers, however, grew only half as much as developed countries. But this economic process has occurred partly at the expense of social justice. Economic globalization also exacerbated inequalities because it occurred so quickly. The liberalization of trade should have been much more gradual (or OECD countries should have opened their economies much faster), for how can it benefit a country that does not export much? In fact, for a number of economies in Central Asia, Latin America, the Middle East, and across Africa, trade is actually decreasing in relation to national incomes (this is one of the key measures of how globalized a country is). This is particularly true in Muslim countries, from Bangladesh to Morocco, and poses a special problem for global stability. The points here are that the manner in which investments are allocated has changed, the interest of corporations has changed, and the global rules have changed. As a result, the forces that act on developing countries' ability to grow economically have changed. Only development agencies have not changed significantly.

The second aspect of globalization is that of science and technology. It accompanied economic globalization and the two mutually reinforce each other. This is particularly the case with IPRs and the policies pursued by public research institutions in their inappropriate quest to increase their revenues from licensing their inventions. This appropriation of science, including—or especially—publicly funded science, whereas important in a few areas to ensure that the requisite investments are raised to bring a new technology to market, has so much increased the transaction costs that the effect on the overall societal benefits of public sector innovation has

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[4] Hoffman (2002) argues that there is yet another dimension of globalization, namely a cultural one, resulting from the increased flow of cultural goods, and resulting in uniformization. Another level of globalization is the combined effects of the economic, political, scientific/technological, and cultural globalization have led to the slow emergence of yet another dimension to globalization: a universal consciousness, which I like to call spiritual globalization (Krattiger, 2003). Never in history have there been so many people so conscious of humanity's inter-dependence, of the fragility of our interchanges, of the vulnerability—and value—of our shared environment.

arguably declined. One may conclude that the "modern" IPR system has gone too far, as epitomized in the huge sums of money companies spend to obtain freedom-to-operate and licensing (including mergers and acquisitions which are often cheaper than resolving the licensing needs) or in litigation, which excludes smaller companies and the public sector from the market and results in a sub-optimal use of innovation (see also the section below). An alternative view that could be advanced is not that IPR regimes are at fault, but the public policies that allow public science to be appropriated. There are some signs that this might slowly be shifting (see e.g. Atkinson *et al*. 2003). The point here is that the development agencies and institutions have neither kept up with the capacity to resolve IP issues, nor with the policies that would enable them to capitalize on the significant advances made by proprietary science.

The third dimension of globalization is political. Until the end of the cold war, global policy formulation was considered to be the sole prerogative of nation-states, expressed in part through foreign policy and in part through multilateral institutions. The end of the cold war and collapse of the Soviet Union, however, which coincided with the rise of the internet, mass communication, and arguably the biggest and most powerful wave of liberal economic fundamentalism in history, made possible the wave of globalization of the early 1990s. Today people have much easier access to information and can more easily influence global affairs through "soft" power. Interestingly, the increased power of civil and NGOs is even less accountable to democratic institutions than many governments. Indeed, civil society is not immune to the political problems that beset globalization. The structural connections that link NGOs to the people are often informal if at all existent, with the result that they are able to abuse their privileged place in civil society as much as corporations and governments can. It is naïve to believe that the self-interest of individuals and institutions plays no role in their decisions. After all, few can afford to operate altruistically if they want to survive, let alone grow.

In sum, we first have to recognize that globalization is not a policy anymore (the way it used to be from the time Thatcher and Reagan were elected up to the Seattle demonstrations during the meeting of the WTO). Now, globalization is a fact. Left on their own, however, globalization forces will exacerbate inequality, not least because many countries are not globalizing. (Notwithstanding that the liberalization of trade should be gradual, how can a country that does not export anything benefit from the liberalization of trade?)

2.5 The "eternal" debate around IPRs and the need for new paradigms of development policy

It is often argued that whereas the western world became rich by ignoring patent rules and protecting its industries, poor countries should be allowed to do the same (e.g. Monbiot, 2003). What these arguments ignore, however, is that the world was a very different place when the western countries (primarily Europe and the USA) industrialized. At that time, the word "globalization" had not been coined nor were the economies of the world so integrated and inter-dependent. Hence the conclusion of Monbiot (2003) and of popular anti-globalization discourse are perhaps quite erroneous. First, poor countries do not have the resources even to simply copy inventions and innovations from elsewhere in order to progress economically. Second, unlike in the 18th and 19th Century, economic development (viz. industrialization) did not depend on trade to the extent it does today. And third, development today can be accelerated significantly through

foreign investments. It took the western world a century or more to industrialize; hardly a cheerful proposition for the billions of poor people waiting to be hooked up on sewage, clean water and other essential amenities. If poor countries were to follow the route of the western world several centuries ago, little foreign capital would flow in their directions. Sure, some economic progress would take place, but it would pale at the rate of growth in industrialized countries and the divide between rich and poor would only deepen.

Property rights come in two forms: intellectual and tangible (or material). Whereas the tangible property (TP) rights are mirrored in natural ecosystems where certain species defend their property against others (both tangible property and spatial), intellectual property (IP) rights are first philosophical and social constructs, closely associated to "western" history and thought. In the case of IP, it is a negative right granted for a limited period of time by a nation-state to the owner (a person or an institution) to keep others from appropriating the invention. In the case of TP, the right is similar but generally not limited in time. However, IP also find a mirror image in the evolution of species. As natural selection provides one individual, and species, with certain advantages, these erode over time as other species react to the change and develop their own responses to the changing environment. In other words, the evolution of one species produces as an effect the evolution, and sometimes the extinction, of other species around it. With IPRs, the gains obtained by one entity (through research leading to innovation), other entities have to react to it or become bankrupt. The difference between ecosystems and institutions is that whereas with species, natural selection leads to advantages that are not readily transferable to other species, ideas and innovations are readily transferable to third parties. This is where IPRs come in: disclosure of the invention only provides the inventor with a monopoly limited to 20 years or so and allows others to build on the invention through the enabling disclosure.

In essence, both rights are nothing but distinctions between ***mine*** and ***yours***, a distinction that has been around since time immemorial and that has always characterized social and political organization. As is the case for just about any important concept, Plato and Aristotle in one way or another laid the groundwork for subsequent analyses; this is no different for the nature of property and its relation to "private" and "public". In Plato's *Republic* and Aristotle's *Politics*, both philosophers discuss the nature of justice and its relation to *ideal* politics but they advance opposing views. For Plato, private property is an impediment to the virtue of his perfect *polity*, whereas for Aristotle private property is a necessary requisite to achieve excellence. The arguments of both are compelling; Plato's main argument is based on the notion that the ruling class seeks within itself total commonality to gain unity and eradicate the corruption of wealth. Presenting his argument backwards in a highly simplified manner, Plato argues that to have virtue in a city, it must have unity; to have unity it must have total community; to have this community, all things private must be abolished. Aristotle, however, takes an opposing view and approach on virtue and property, severely criticizing his own teacher's proposals. Quite logically, he first questions whether unity of a polity is a worthwhile goal; but most importantly, he argues that even if such a unity was desirable, Plato's perfect polity would render it impracticable, partly because the roots of evil are in men's (*sic)* inherent wickedness (rather than generated through private property). According to Aristotle, people gain great pleasure from being able to call something their own. And most importantly, he argues that "that which is common to the greatest number has the least care bestowed upon it" (*Politics II,* 1261b33). If all

property can be called both *mine* and *not mine* at the same time, it will usually tend to become neither!

Aristotle's analysis of private property—of what it should be and how it should be administered— has not been radically improved upon and is still very relevant today. It provides a critical foundation for understanding the *Tragedy of the Commons*[5] (a term given currency by Hardin (1968), who builds upon Aristotle's claim that what is common to all has the least care bestowed upon it by individuals) and of the *Tragedy of the Anti-Commons* (i.e. the sub-optimal use of resources when too much is in private hands)[6]. In many respects, the discourse of Plato and Aristotle was last resuscitated fundamentally by the early theologians with property being regarded as the source of evil, capable of corrupting the soul and leading to sin. St. Augustine of Hippo (354-430 AD) "solved" the controversy by stipulating that a property-less society could only exist in Paradise because it required perfection to succeed. One can most certainly conclude that "perfection" today is even further from being a reality and that we need distinctions between "mine" and "thyne" more than ever before.

But at the same time when private property rights were being firmly established, Karl Marx and others offered an alternative (which was considered revolutionary at the time though Plato would have disagreed) by postulating that "private property is theft". The world's experience with communism, however, suggests that Aristotle's claim about the relationship of private property to prosperity has been vindicated. Communal property systems do not generate as much wealth as private property systems. There are many examples of this, even in the USA. Tom Bethell (1999)[7], for example, who had set his mind on finding an explanation for the wealth of nations,

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[5] "Even supposing that it were best for the community to have the greatest degree of unity, this unity is by no means proved to follow from the fact of all men saying 'mine' and 'not mine' at the same instant of time, which, according to Socrates, is the sign of perfect unity in a state… That which is common to the greatest number has the least care bestowed upon it. Every one thinks chiefly of his own, hardly at all of the common interest… Everybody is more inclined to neglect the duty which he expects another to fulfill…" (Aristotle, *Politics II*).

[6] When the common (interdependent or complementary) aspects of knowledge is divided into multiple competing, overlapping, or mutually blocking private property claims, the value of the public economic benefits that would otherwise have arisen from the common accessibility of these resources are diminished. Then, furthermore, if the resulting patent rights cannot be traded, the inventor-owners of these piecemealed resources are not able even to negotiate or purchase access to the other matching pieces that they need simply to make use of their own, in which case the power of the private incentives to innovate is sapped. The cumulative result is a crisis in research and innovation productivity that has been quite aptly dubbed *'the tragedy of the anti-commons'* (Heller and Eisenberg 1998).

[7] Bethell describes the experience of settlers in what was then the British colonies in the New World. In Jamestown, Virginia, for example, settlers were mostly servants who were required to deposit all their production in a common store which would then be distributed in equal parts to all. As a consequence, nobody worked very hard and famine and death followed. A new governor changed the policy and allowed colonists to work their own land, paying only a portion to the store (a form of flat tax). Production soared. Noteworthy is that the communal system had not been implemented for ideological reasons, but imposed by the business men who had financed their voyage to the USA. Traditionally, it is not the business establishment that calls for the abolishment of private property, but the proletariat or working class.

Today the existence of property rights *per se* is no longer really debated in any serious fashion. We see demonstrators, activists, and pressure groups, but fundamentally there is no serious debate about private property. Two things, however, are being called for. First, critics of the existing system seek ways to bridge the gap between the concepts of property rights in the west and the property systems of indigenous people. Studying

discovers that those nations through the ages who protected and defended private property were those that generated most prosperity. Bethell's book should be required reading for anyone who believes that government (or more properly public ownership) is always or even often the best solution to today's problems. His conclusions are somewhat extreme at times (for example, he seems somewhat paranoid about threats to property rights today in the USA), but he makes many valid points. Then and now many local and indigenous societies still have different property regimes, such as for example, those based on communal property. Many modern societies in the developing world, on the other hand, whereas they have private property rights, too many are not official nor defendable which, according to de Soto (2000), is the real reason why capitalism in the developing world failed.

One can easily argue that IPRs neither help nor harm the interests of the poor. IPRs have only an indirect effect on the poor. The key factors are to be found elsewhere, such as policy decisions, particularly as related to access to technologies and markets. Many critics of the globalized economy specifically condemn IPR systems, which has polarized discussions and, consequently, further marginalized the rural poor. The "modern" IP system is indeed far from perfect, but this is not due to an inadequate theorization of IP. Rather, it is the policy decisions made in the context of existing IPR systems in an increasingly globalized world that are the problem. As the protesters at Seattle confirmed, the growing back-lash against trade negotiations is making it increasingly perilous for the dominant powers of the IPR system to unilaterally define policy. New paradigms for developing policies are clearly needed to remedy the inequities that exist in the manner by which the modern IPR system is applied and used (or abused), which is failing to meet the needs of the poor in the short term and that of corporations in the long term as well.

2.6 Technology diffusion and market access

Overall, there is no doubt that IPRs have unleashed the creation of wealth and benefited many segments of society. Developing countries, however, can more easily measure the costs of enhanced IPR protection in the form of higher royalty and license payments than they can quantify the benefits of these increased R&D investments. Analysts thus conclude that domestic capacity levels are typically not sufficient for developing countries to fully benefit from IPR protection. To illustrate this point, it is often mentioned that developing country inventors account for less than 6% of all global inventions. Although this and other indicators can be discussed, argued about, and interpreted in different ways, the fact remains that in developing countries the costs of stronger IPR are frequently more visible than the benefits.

Nowhere is this more apparent than in the discussions surrounding the implementation of TRIPS standards. One recent study (Lesser 2002), examines the effects of stronger IPR protection in the area of Foreign Direct Investment (FDI) for selected developing countries in the post-TRIPS era. The results show both imports and FDI are positively and significantly associated with the IPR

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their systems provides unique insights into how different groups consider property. Rather than debate aspects from a purely ideological perspective, more studies are needed to better understand indigenous groups and perhaps, through such studies, new thinking may ensue. What is needed are new ideas and solutions on how to *bridge* different systems of ownership so that these societies can benefit from the western system rather than be exploited by it.

strength index. One point in the IPR score (about 10%) is associated with a $ 1.5 billion increase in FDI and an $ 8.9 billion increase in imports. These numbers are aggregate increases and should not be interpreted literally as predictions for any individual country. Rather, the significant point is that small changes in policy (such as joining UPOV, Union Internationale pour la Protection des Obtentions Végétales/International Union for the Protection of New Varieties of Plants) can boost trade and FDI. Enhancing the transparency of the IPR system is complex, which includes the important aspect of implementation according to the rules, provides additional evidence supporting IPR system's importance in the progression to a more value added economy. Accordingly, the study concludes that governments interested in enhancing FDI to generate employment and advance technology usage are well advised to strengthen IPR, particularly in relation to membership in international instruments or multilateral conventions.

Subsistence farmers and the poorer segment of the rural population, however, have essentially no access to the markets of proprietary technologies. They are "economically invisible". Their exclusion cuts them off from the economic growth fuelled by new proprietary technologies, further marginalizing them and exacerbating economic inequalities. To remedy this situation, we need to build stronger interfaces that level the playing field and allow the poor to have better access to proprietary technologies.

Somewhat surprisingly from an economic perspective, technological innovations have not spread to those who most need them even though they could be obtained in theory by many more countries at low marginal cost. Companies, in fact, would benefit from significantly increased market share. Differential pricing would be a prerequisite but could be managed[8]**.** It is increasingly being argued (e.g. Prahalad and Hammond 2002) that the inclusion of the nearly 4 billion people with purchasing power of less than $2,000 and of the nearly 2 billion people with $2,000-$20,000 purchasing power would increase the global marketplace by 10 to 15 times. (Today, only around 400 million people have purchasing power of over $20,000 per year).

2.7 IPRs and scientific and technological capacity

The globalization of science as related to agriculture is perhaps best illustrated in the international collaboration across the public and corporate sectors in genomics and related technologies. This collaboration, fuelled in part by property regimes, has led to an incredible pace of innovation and technological advance. Biotechnology in a broad sense represents one of the greatest opportunities embedded in globalization for the developing world and global food security. How can these scientific advances be leveraged for the benefit of global food security?

First, it should be clearly stated that without IP regimes, many of these powerful new technologies would never have been made. The public sector is good at making fundamental discoveries, but rarely demonstrates the will to invest significant financial resources in the risky

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[8] Without wanting to go into any details, for differential pricing to work in pharmaceuticals, at least, developed countries' pricing policies would need to change and effective measures against parallel imports would also need to be implemented. Prohibiting parallel imports are an important component in establishing a system of differential pricing (i.e. where markets are segmented to prevent low priced products or technologies undermining higher priced markets).

business of bringing scientific advances to commercial products. Similarly, in developing countries, where the percent of public expenditures spent on science and technology has steadily been decreasing, it is quite irrational to expect the public sector to significantly increase its level of spending, especially at a time when public coffers are emptier than ever. An increase in public spending, especially in agriculture, has not happened for decades, so why do many people still wait for the public sector in the developing world to better serve their farmers? It hasn't happened before in much of the developing world, the trend is not going in this direction, and so it is most unlikely to happen now nor in the foreseeable future. For who will invest in improved seeds, in market structures to disseminate the seeds, and in market access for the agricultural products of subsistence farmers? For decades, the national public sector and the international development community have invested significant sums of money but they have been unable to maintain that investment. The public sector's assets pale in comparison to the tremendous resources that the corporate sector can bring to potential products. This is not at all to say that IP systems have created a more equitable world. As a recent authoritative study on development policy and IP clearly demonstrates, the relationships between IP and social benefits are complex at best (Barton *et al* 2002), but it is fair to say that such systems have made possible the ongoing revolution in agricultural technologies. What is needed is a fairer distribution of those technologies. Developing countries, without a strong R&D base, cannot on their own participate and benefit from scientific and technological advances elsewhere.

2.8 Public and private goods

In the absence of global policy solutions for the improvement of the "modern" IP system, the question for the rural poor is not whether the public OR the corporate sector invests in increased agricultural R&D. The question, rather, is much more pragmatic and two-fold:

- How can corporate technologies and know-how be leveraged to serve the poor?
- How can the public sector's investments be made more effective to serve the "public good"?

"Private goods" are typically traded in markets: if the market agrees on a price (e.g. for cakes), the ownership or use of the good (e.g. the cake) or services is transferred. Several people can make an offer, or bid, and hence there can be competition, or rivalry, and some can (and always will) be excluded. Further, once the good is consumed (e.g. the cake has been eaten), others are excluded from eating the same cake.

A "public good", by contrast, is a good whose use by one person does not compete with nor rival its use by another person (non-rival) and no person can exclude other persons from its use (non-excludable). Sunlight, traffic lights, street signs, national defence, peace, the eradication of smallpox, etc. are examples of public goods. Who provides the public good is not important: governments provide public goods (e.g. defense, roads) and private goods (private housing, medical care). Similarly, the private sector may provide public goods (e.g. technical norms, street lights). However, because of the non-excludability, the private sector rarely contributes to the creation of a public good but quite often enhances existing public goods. As street lights or stop signs illustrate quite well, the private sector may make a certain good which, once purchased by someone (either public or private), becomes a public good. Finally, the creation of a public good is not necessarily free of costs. Costs may have been born by society at large (e.g. street signs)

but the enjoyment or use of it is free to any and all individuals who pass through that particular street.

Genetic resources, provided they are not protected by IP, are also public goods. In agriculture in general and with biotechnology in particular, "non-excludability" and "non-rivalry" are particularly relevant because with many crops, once a new variety exists and some seed has been shared or sold, it is difficult to prevent any farmer from using the new variety (non-excludable), and because many crops self-reproduce in one way or another, their use by one farmer does not compete with their use by another (non-rival). Indeed, the main conclusion we should draw from the debates about property and IPRs is that the underlying pros and cons are based on factors other than those that pertain to property or IP regimes *per se*. In other words, many argue that IP is bad and harms subsistence farmers. In fact, IP *per se* does not harm anyone, it is only how it is handled, or the policy context in which IP systems are implemented, that can cause problems. In addition, the "public good" in agriculture must increasingly rely on private inputs (e.g., proprietary science and technology); hence again it is the interface between the public and the private that needs to be addressed.

Solutions to the two questions posed above will require the authoritative management of IP. Those who really need proprietary technologies (and, by extension, access to IP) are the poor. But the generation of inventions (based on the number of patents filed) is broadly proportional to the per capita gross national product. In other words the richer a nation the more R&D, which in turn leads to more inventions and discoveries. As a logical consequence, one can hardly be in favour of abolishing IPRs, especially not of those of the rich, because what would be left to transfer or distribute? The poor have a chance to escape the cycle of poverty by reaping the rewards of their own labor enhanced with access to both public and proprietary technologies. This does not require the rejection of patents and related rights but the levelling of the playing field by enabling them access to property. This is precisely the value of public-private partnerships come to play.

3. Breaking the mould: New opportunities in biotechnology transfer

The preceding section highlighted a number of areas where new or improved institutional arrangements and policy shifts could make a significant difference in accelerating the transfer of biotechnology. The purpose of this section is to propose a number of concrete initiatives. The different topics provided to the author, viz. the role of capacity, regulations (biosafety, IPRs and trade), and funding, will be dealt with indirectly through a number of cross cutting initiatives, each affecting and improving at least two or more of the key constraints.

Without doubt, the incremental changes taking place today are certainly desirable and worth while. However, merely increasing foreign aid through traditional channels is unlikely to attack the root causes of poverty and inequity. What is needed are new modalities for better access to technologies, stronger public institutions that deliver added-value, and access to markets for the sale of surplus production. With the imbalance in R&D expenditures discussed above, and with inadequate funds going into technology transfer, not surprisingly, few technologies have been and are being transferred—and even fewer find their ways to where they are needed most. The societal cost of underutilizing existing technologies is huge (viz. the tragedy of the anti-commons). Again, this is perhaps most true with biotechnology.

What is needed to drastically reduce the plight of billions of people living in abject poverty, therefore, more than additional funds alone, are bolder actions and initiatives. The sections below propose initiatives, some of which are somewhat traditional whereas others rather bold and daring. The author recognises that some of the ideas advanced here may not be feasible from a political perspective; he believes, however, that advancing them anyway might perhaps inspire some to come up with more feasible options and eventually make a difference in the lives of millions, if not billions.

It should be noted that there has been a multi-fold increase in the number of actors in biotechnology, technology transfer, and IP. At the same time, the sphere of influence of each actor is diminishing. Whereas the private sector deals with similar realities though mergers and acquisitions, the development institutions are becoming increasingly fragmented and multi-fold, hardly a recipe for efficiency, growth, impact and sustained success. The proposals below aim at addressing some of this reality.

3.1 Re-structuring the CGIAR and FAO

The exceptional achievements of the CGIAR in the second half of the 20th Century are undisputed. The CGIAR system's success was based on the transfer of public technologies, but it has not been able to "recover" from its successes and adapt to the changing environment in which it operates. One of the key changes is the advent of proprietary science. After years of internal debate on the impact of IP and biotechnology, among others, the CGIAR still does not have an effective and consistent policy towards either, yet alone a comprehensive strategy on how to deal with the proprietary nature of the science on which it relies. The CGIAR operates in a global context, but so far it has failed to "use" globalization to its own (and the countries it serves) advantage and thus it has failed to serve the poor most effectively with its dwindling

financial and technological resources. The solution, perhaps, lies in the creation of an entirely new type of enterprise.

One of the problems with today's CGIAR is its "top heavy" institutional structure. The investment of nearly US$400 million pales in comparison with the total corporate investments in agricultural R&D (estimated by the author to be in the area of US$3-4 billion). To optimize the returns on this small—but strategically important—investment, the CGIAR has always been faced with a dilemma: should the Centers focus on areas with high potential productivity gains or should they focus on the needs of marginal areas and least developed countries where poverty is highest?

As more advanced developing countries are served by a more vibrant private sector, a process accelerated through the proposals under sections 3.2 and 3.3), the CGIAR could re-focus its attention on two strategic areas: the poorer developing countries with weak agricultural research and extension programs, and crops of specific importance to resource poor and subsistence farmers[9]. Neither of these crucial areas will be addressed by the private sector. But such reform will require a major re-structuring of the Centers. For as the last decade has shown, gradual re-structuring is not leading to any fundamental change. A radically new institutional framework is needed that would permit the Center to focus not only on the geographic areas outlined above, but also on two other strategic areas: the "public good" and interface with the private sector.

The latter will allow a re-structured CGIAR to specifically harness the capacities of global science (corporate and academic) by "channelling" existing technologies to the specific needs and priorities of the least developed countries and regions. Such an entity would negotiate with technology owners and seek licenses with the right to sublicense on a crop-by-crop, market-by-market, or technology-by-technology basis (i.e., market segmentation). This can be done by granting royalty-free licenses in some cases and royalty-bearing licenses in others (see also section 3.5 below). Policies that promote different pricing strategies across markets, based on price elasticity, will lead to higher technology use and thus higher overall societal welfare and greater equity, all of which are also in the interest of the national and multinational corporate world. The challenge is to manage these pricing strategies and ensure that technologies licensed for free to one country do not spill-over to others. In the countries in which this organization operates, it would truly focus on addressing the public good. The pricing strategy would allow certain products to be licensed to the public sector, others to the nascent private sector, thus encouraging private investments.

The above agenda could be implemented cost-effectively by combining all of the sixteen centers of the CGIAR into one global World Agriculture Organization (WAO) that would negotiate bilaterally with science and technology providers to access technologies for the global public good. As long as nation-states and their ever less efficient (and gradually redundant) intergovernmental systems are solely responsible for policy leadership and global agricultural food security, we cannot expect to find our urgently needed solutions. A WAO must embrace a new agenda, one led by a coalition of actors in civil society, individuals, and academia, as well

[9] In addition, a unit should specifically look after the genetic resources. This has earlier been proposed by Robert Herd (personal communication).

as the global corporate community. At the moment, a company that wishes to license biotechnology on preferential terms, or even donate technology, needs to work through a maze of institutions or is approached by a myriad of individuals from the CGIAR, national agricultural research services, universities and other service and research organizations. Dealing with each of them requires significant management time and increases the transaction costs for companies to the point where they shy away from donations and public-private partnerships.

Similarly, FAO should be restructured completely with one third privatized (for example its valuable agricultural and trade statistics services), one third closed down completely, and one third devolved to other UN agencies. One element of what would be kept in the public domain of FAO could be folded into the new WAO, another third could become the backbone of the investment service (section 3.3). Clearly, international development needs more funds, much more. But the problem of inefficiency needs to be tackled concurrently.

Finally, as already proposed by Jeffrey Sachs (Sachs, 2000) three years ago, the World Bank should get out of banking and become the World Development Agency, focusing exclusively on the poorest of the countries.

3.2 A new public-private (or "privic") type of entity: Or why developing countries should buy Monsanto

At a seminar at Cornell University in September 1999, the author proposed the creation of a novel, highly efficient and sustainable organization as a model for the next century, with the potential to exceed many-fold the impact of the CGIAR and the green revolution of the twentieth century. In short, the vision is to "sustain globalization in the life sciences" by creating a new form of private/public partnership with the life science capabilities of a large biotechnology company as the keystone. Development, both economic and scientific, would be accelerated through the synergy of private/public energies.

At the centerpiece of the "privic" strategy would be, for example, the large biotechnology company's agricultural life sciences division, such as Monsanto's, with the following attributes.

- The science and technology would be poised to deliver the long-promised benefits of biotech, gradually, to the entire world. Meanwhile, the value embedded in other divisions of the biotechnology company, including chemicals and seeds, would be returned to shareholders as these business units of the current enterprise are spun-off.
- Financing for the new entity would come from public (government, multilateral), foundations, and private sources, and from future licensing of its technologies (to corporations and at a discount to developing countries). All would benefit from this strategy as the most effective means of sustaining agricultural and economic advancement, and human well-being.
- Market growth would come by expanding biotechnology into developing-world markets where the technology is needed most. Current revenue streams would be maintained and expanded through licensing arrangements with corporations (current competitors), the CGIAR, universities, and national programs around the world.

- Public opposition to plant biotechnology would be curbed rapidly as a result of the display of its startling value for the world's poorer people, thus realizing biotech's promise in the near-term.
- Research and development would be efficiently expanded by focusing on a mix of commercial (for licensing) and developing-country needs and priorities. Human capital would be enhanced by ensuring that researchers in developing countries would participate in the R&D and would have ready access to biotech's tools to solve their national and regional agricultural and nutritional problems.
- The staff, talent, strategies, R&D priorities, and finances of the "privic" would be managed according to corporate principles by a chief executive supported by an executive and management board. A small non-executive oversight board of senior people serving in their individual capacities would represent national and topical interests.

To make this happen, the next steps would be to:

1. Commission an investment bank's preliminary assessment of Wall Street value, transaction costs and broad financial projections.
2. Prepare short issues papers on financial projections, governance, management, licensing, financing, interface with developing countries, link with CGIAR (if any), R&D strategy, licensing to developing countries, etc.
3. Convene a meeting to:
   - further determine feasibility and set broad policy and implementation strategy
   - elaborate specific areas for further investigation/determination and allocate follow-up tasks
   - identify members for formal Steering Committee.
   - formally establish steering committee.
   - identify possible future chief executive (or senior savy manager for transition)
4. Seek limited funding for feasibility study and retreat.
   - Prepare detailed issues and options briefs (as item 2 above but in detail). 2 months.
   - Commission investment bank's \assessment of valuation and financial options. 2 months.
   - Approach Chairman of Monsanto and key institutional investors.
5. Convene a "retreat" meeting with senior people to:
   - determine feasibility, refine concept, and set policy and implementation strategy;
   - elaborate specific areas for further investigation/determination and allocate follow-up tasks.
6. Complete transaction over the following 3-6 months.
7. Launch privic entity.

Back in late 1999, Wall Street had valued Monsanto at approx. $32 billion with an estimated $1.6-$1.8 billion for the biotechnology component. At the time, the investment banking fees were estimated at $200 million. Recognizing that shareholders would have wanted to extract at least a premium of 10%, a total of about $3 billion would have been needed to extract the biotech side and finance the deal. At least $1 billion would have come from the value unleashed by splitting up Monsanto. The remaining $2 billion could conceivably have been financed by a mix of:

- $600 million through deals with competitors in exchange for settling all outstanding lawsuits (this was discussed with some competitors at the time and the idea was received positively)
- $800 million by granting fully paid up non-exclusive licenses to all of Monsanto's then existing technologies (i.e. issued patents) to the then competitors (again, the idea was discussed with some of the competitors and most positively received)
- $400 million through a World Bank loan to a selected list of governments (e.g. South Africa, China, India, Mexico, or others). These countries would pay back the loan as a "virtual" royalty as and when improved products would reach their markets. The virtual royalty rate would be calculated, according to an agreed formula, based on agricultural GNP increase. Half the royalty would be paid to the Bank to repay the loan and the other half to the new Privic entity in order to generate cash flow for the entity.

  Other countries that are not initial "shareholders" of the Privic entity would pay a higher virtual royalty rate based on the same agreed formula.
- $200 million from an "angel" humanitarian investor.

When the author first proposed the concept, Monsanto had already been in advanced negotiations with Pharmacia, a deal that was announced in December 1999. However, with Monsanto's current troubles (see e.g. New York Times 2003), perhaps the time will come again.

3.3 Create an agricultural investment service

Policies to bring about a stronger involvement of the private sector are urgently required. These, however, need to be followed up by appropriate instruments that facilitate private sector investment. This suggestion is based on the premise that public funds are insufficient, and equally importantly, that the private sector has comparative advantage to deliver technological solutions in the area of biotechnology. The corporate world has tremendous advantage to develop and adapt new technologies which are specific to the needs of the poor and where rich-country technologies will not suffice. Technological development, such as a malaria vaccine or more nutritious foods, will require major grants to science-based institutions, as well as new partnerships between business and academia spurred by innovative institutional arrangements. The idea of a tax credit or guaranteed purchase fund to encourage R&D in some of these areas (e.g. malaria vaccine, more nutritious crops, technologies aimed at agricultural export diversification) would be particularly appropriate. But here too, rich-country convenience, sheltered by ideology, intrudes on the real needs of the poorest countries. Sub-Saharan African countries today are as dependent on a narrow range of primary commodities as they were twenty years ago, but now with even lower real world prices for those commodities. In fact, development institutions have usually acted as if there is no need to foster diversification or manufactured exports from Africa, content to encourage yet greater reliance on primary commodities.

Related to the above is an equally urgent aim of attracting increased investments in rural agricultural economies by promoting small enterprises, particularly in the agribusiness area. Such an Investment Company for Development would provide business investment services to local entrepreneurs, small companies, and university researchers in order to facilitate the acquisition and transfer of innovations from the laboratory to the market, but focus more specifically on integrating technology and managerial expertise from multinational companies to poorer rural areas. It would also leverage official development assistance (ODA) and foreign direct investment (FDI). The Latin American Agribusiness Development Corporation (LAAD) has been doing something similar on a small scale for nearly two decades. Linking finance and agricultural companies with small entrepreneurs in the rural areas, and assisted by loans from the US Agency for International Development (USAID), the LAAD brought important growth to localized rural areas.

Similar entities need to be created on a regional or sub-regional basis so that investment funds from bilateral and multilateral donors, from the philanthropic sector, and from corporate entities can be leveraged and managed with respect to local conditions. The Rockefeller Foundation is currently considering such a fund in selected countries of sub-Saharan Africa. What will be important is that such an investment service be proactively engaged in leveraging technology and know-how from multinational companies to upgrade and further enhance the value of the local entrepreneurial entities in which it invests.

The proposed strategy (see Krattiger 2002b for more details) is based on the rationale that the adoption rate of biotechnology crops in certain developing countries has been impressive (e.g. Argentina, China, South Africa). There is also significant biotechnology research capacity in selected countries and the development of products in Cuba (vaccines), Mexico (seeds in general by Seminis, CINVESTAV's aluminum toxicity research) and Brazil (several crops). World class scientific capacity exists in many public institutions but few have achieved biotechnology product development and market successes. The emerging markets are also the setting for the exploitation of many industrial biotechnology applications, notably the use of fermentation technologies in antibiotics and biopesticides, biological systems for toxic substances removal in textiles, and the widespread use of tissue culture for the multiplication of horticultural crops (e.g. in Costa Rica for banana, Malaysia for oil palm, Kenya and South Africa for ornamentals). Tissue culture has been shifting away from Europe and Israel and there is evidence of some advanced engineering products in industrial production shifting offshore (e.g. precision agriculture). Over time, major biotechnology products are likely to increasingly originate from emerging markets notably soy products from South America, cotton from Asia, genomics services from Southeast Asia and China, and phytomedicine from Costa Rica. The proposal here is to significantly accelerate this trend.

The strategy would call for the following three thrusts:

1. marketing investment opportunities on a regional basis;
2. providing sustained high quality deal flow, including feasibility studies, investment advice and management services;

3. working with investors to increase participation, including philanthropic institutions, bilateral agencies, regional development banks, national governmental agencies to leverage ODA, and private investors;

Thrust 1 relates to the need for localized business development, the reduction of both risks and costs for investors, and the costs for entrepreneurs to access capital. A service that specializes in a particular geographic region is needed for local businesses. Thrust 2 and thrust 3 are closely related but require different approaches. Credible investment services can only be provided if well conceived, feasible, and financially sustainable investment opportunities are described and valued. Traditionally, business growth has occurred a) through mergers and acquisitions of operating assets, leading to short-term growth, or b) traditional market development *de novo*. Acquisition strategies for life science activities have overall been unsatisfactory in many developing countries due to a lack of sound indigenous companies available for acquisition or licensing deals. This forces the corporate sector into the slow, expensive, and risky process of development *de novo*. This limitation is particularly apparent in agriculture. Investors have a low interest in this area due to complications arising from shortcomings in management, the lack of trained managers, the need for technological upgrading, the lack of plant breeders' rights, and high risk exit strategies.

3.4 Biosafety/food safety regulatory services[10]

The development of the biotechnology regulatory environment has created the need for capacity building to ensure that countries enact and implement safe and effective regulatory mechanisms. The international community is devoting relatively significant resources through the implementing funds of the CBD and other donors to create the capacity for governments in developing countries to regulate biotechnology applications, but it is not devoting any significant resources to develop the capability of scientist to work under those emerging regulatory frameworks. The result is that in most developing countries over the past five years have seen a massive increase of human resource inputs in a regulatory system that have little to do, because there are few who can afford the costs of preparing applications.

The high costs associated with delays in field testing is in part due to the lack of regulatory capacity within the scientific institutions and research establishment. Many countries have been waiting for the deliberations a the CBD to come to closure with the Biosafety Protocol. Yet what seems to have been forgotten is that biosafety still needs to be dealt with on a local/national level and that capacity must be put in place irrespective of whether or not a Bisoafety Protocol exists. Much valuable time has thus been wasted with no apparent benefits.

In the developed world the application side of the regulatory review process is usually handled by private companies, who have in depth knowledge and experience in this matter. They are usually able to adapt to a changing regulatory environment. For ag-biotech, we face the unique situation that enormous expectations are generated by the research done in public research

[10] I am grateful to Willy de Greef of the International Biotech Regulatory Services (IBRS), Belgium, for significant inputs in this section.

institutions in developing countries, but without consideration of the fact that the results of that research cannot reach the target environment without developing the capacity to obtain the regulatory approvals for field testing, up-scaling, commercial scale release and food safety evaluation that are taken for granted when done by multinational companies.

A rapidly growing number of research institutions in the South and the North have created a variety of biotechnology solutions in crops of relevance to the agricultural systems of developing world farmers. Most of these projects are stalled by the unpredictability and the complexity of the regulatory environment. While there is a large amount of discussion going on about the regulatory systems per se, there is very little structured support for such institutions if they actually want to move from theory to practice and take their projects through the regulatory reviews needed for different types of field release: experimental release and commercial scale approval.

The consequence of the lack of expertise in the public sector about the regulatory requirements for large scale release of biotechnology crops is that many research projects are planned without appropriate consideration of regulatory requirements later on. This adds to the disadvantage of public sector projects, because many transgenic lines are at risk of being rejected at late stages of product development, which puts back entire development programs. For example, one key requirement for commercial growing of any crop in a country is to evaluate international trade in its products, and to ensure that in the key import countries, the equivalent import permits for food/feed use are obtained. Few, if any, public sector researchers consider this element.

In private sector technology developers, the regulatory expertise consists of two major components:

- The biosafety assessment specialists, who, on the basis of access to a range of other experts (e.g. ecology, weed science, entomology, nutritional science) develop the information required for a commercial permit, and compile the core regulatory files.
- The local/regional regulatory affairs specialists, who have the expert knowledge about rules and procedures in the countries where permits have to be obtained to submit high quality applications on the basis of this core file, with high chance of obtaining the permit.

Very few public sector institutions could copy this model on their own and thus the issue of biosafety requires new models to succeed. A two pronged strategy is proposed:

First, a community of public researchers should create a consortium that of groups who would assist each other in parts of their respective regulatory compliance work. Because public institutions do not have the capability of spreading fixed costs over several projects, this approach would achieve certain economies of scale. It costs massively less per product to build up the capacity to bring four or five products through the regulatory process than one.

Second, regulatory standards applied to field trials and commercialisation, urgently need to be changed. The standards prevalent in Europe, or even the USA, have as a consequence that the total costs for regulatory clearance (biosafety and food safety) of a new transgenic product is in the range of $5-8 million. Many biotechnology projects in developing countries, and within the

CGIAR, do not even have a fraction of this amount for the total R&D. This situation will either stall the majority of transgenic products or they will find their ways into the environment without proper biosafety and food safety review.

3.5 Public vs private goods and technology licensing

One a more generic level, development policy and development institutions should more clearly focus on either public or private goods. This strategy would allow for a sharper focus on the generation of public goods and the leveraging of private technologies for the public good. In the past, technology was being transferred to developing countries in two principal ways: direct transfer through private investments and indirect transfers through public intermediaries, especially those in the public sector. These actors strengthened the R&D capacity in developing countries, developed the regulatory environment, and let the national public sector and the international private sector take care of the rest. Today, existing institutions are attempting to serve both objectives, namely those of public good generation and of increased private sector participation. The CGIAR in particular is trying to meet both goals but, as a result, achieves neither as well as it could. There is ample room to involve the private sector much more heavily in the generation of public goods through technology donations.

The key issue is how to segment the markets. In other words, how can private technologies be shared with the public sector without such sharing interfering in the business of the private sector. If this could be achieved with significantly lower transaction costs, much technology would be finding its way towards the poorer developing countries.

Interestingly, although the agricultural biotechnology community has been developing models in the area of market segmentation for over a decade, it is in the area of public health where much is being done today. A recent paper by Friedman *et al* (2003) also outlines the approach for drugs in a most concise and clear fashion. Briefly, the authors discuss the rationale for and modalities how pharmaceutical patent holders could award out-licences (or voluntary licences) to generic manufacturers who agree to manufacture and supply medicines to poor, developing countries. "Under the legally binding terms of these licence agreements, several generic manufacturers could compete against one another on price in poor countries, but would not be allowed to compete against the patent holder in rich countries, where revenues and the incentives for inventing new medicines would be undiminished. Use of outlicensing in this way separates these fundamentally different markets, promoting access to affordable medicines for the world's poor, while reaffirming patents as indispensable for successful pharmaceutical research" (Friedman *et al* 2003).

The major hurdles in agriculture, or for agricultural biotechnology companies to voluntarily license more of their technologies, are the high transaction costs including the opportunity costs and the lack of institutions able to absorb the technologies. To mitigate the former, the authors, in association with Dodds & Associates, a law firm in Washington DC, under a grant form the Rockefeller Foundation, are developing a computer based contract generation software to facilitate such transactions and hopefully bring about a certain standard in such technology and germplasm licenses.

4. Conclusions

The prospects for any of the changes outlined in this paper to take place are, frankly, not very good. Perhaps the plight of the world's poor has to become even worse—and global mayhem even more precarious—to draw the attention of the developed world and motivate it for action. History, however, has repeatedly shown that if people are given sufficient emotional drive and motivation, they have the capacity to make remarkable change. The question is where will that emotional drive come from? What further bad choices does the global society in general have to make to find the strength for redress?

Three thousand years ago Plato argued against property because it corrupts the personality by infecting it with greed. He had an important point. Aristotle disagreed: according to him, property enhances an individual's sense of identity and self-esteem, provides satisfaction, and allows for the optimal economic use of "the commons". He too had an important point. Both claims appear true in today's unequal world, where neither extreme will be beneficial. But a property-less society, as St. Augustine of Hippo (354-430 AD) asserted, can only exist in a perfect world. But can the world wait for Paradise?

We must act today. Everyone likes progress but nobody wants change. In the end, everything comes down to the choices we make. To make sound and consistent *choices*, we need to understand the *potential* of our property (intellectual or material), the *options* available, the *implications* of each option, and the *risks* of each course of action we may want to undertake. Such assessments can be guided by a sense of "balance", namely a better balance between the public and private, and between the developed and developing world. Regardless of the length of our discussions here, and regardless of the number and scope of our policy initiatives, a balance will have to come from "within", a balance within and between institutions certainly, but more fundamentally a balance within the people who make up these institutions; a balance within each of us, a balance from "within" humanity.

More specifically, technological change is the product of a complex system of private, public, and academic institutions, where the financing comes from markets, government, and foundations. But what of technological development in the poorest countries to meet the specific needs of those countries? For example, for malaria or for enhanced crops that can withstand salinization, heat and drought stress, or better nutritional composition? Sachs (2000) estimated that all grants and loans for science and technology for all of the poor countries of the world at the end of the 1990s was less than 3% of the public science and R&D expenditures of the USA alone. No wonder progress is slow. The foreign assistance by the USA is currently around $15 billion, or less than 0.2% of GNP. And of this contemptible amount, only around one-sixth goes to the least developed countries (or $7 per American is spent on the world's least developed countries; and this in a country with $35,000 average income and where investors have enjoyed well over $1 trillion in capital gains over the last decade. There are approximately 600 million people in the least developed countries. Aid from the USA to these amounts to $2.50 per American. Moreover, the response by the government of the USA to the atrocities of September 11, 2001, has been mind-boggling and paradoxical. The number of children under the age of five that die each year from malnutrition related causes that could be prevented with the moneys spent by the USA in response to September 11 is "10,000 times" higher than the number of

victims of the atrocities of September 11. These deaths and the related misery—and the negative effect on peace, stability and economic growth—could be prevented in this modern age with technologies already used in developed countries. It is surprising that these "atrocities" that have been with us for decades—at least partially brought about by the political economy of modern times (and perhaps a lack of humanitarian impulse)—have not engendered a passion to bring solutions to those suffering. Our actions—or lack thereof—compares very badly with the huge response in the USA and elsewhere to the fight against terrorism, which is ironic given that it is precisely poverty and inequality that breed discontent, social unrest, and terrorism.

Given the worldwide emphasis on privatization, there is a mood of minimization for the proper actions of government. The approach and options proposed here in many ways support that view. There are no new proposals for direct government action in technology transfer. Governments are not effective at such things; they are better left to the inventors, the businesses and the users. What governments are effective at is broader, longer term activities, those beyond the scope or planning horizon of the direct participants. The proposals suggested here are of that nature. Some could be done by, and perhaps should be done in conjunction with, NGOs and other civic groups. Others could be done by private entities.

Individual proposals could also be modified to meet somewhat different needs; much will depend on the priorities assigned by the region to the different objectives and constraints. The key step will be to identify leaders who dare to initiate and implement change. More generally, it should be noted that the distribution of wealth, and, by extension, of property (intellectual and material), can also be seen as a dynamic "goal" that emerges out of an essential partnership; a partnership among and between states, institutions, and individuals; a partnership of ideas, concerns, apprehensions, hopes and aspirations. The stakes are high and this is an opportune moment—now that the global consciousness about inequity is growing—to reflect on the new issues inequity raises, to develop challenging solutions, and to embark upon ways of implementing them. Clearly, for resolving many of the central issues that our global society faces today, we need the emergence of new partnerships, partnerships that stretch across all segments of society, partnerships that help us understand the new global responsibilities bestowed upon us, and partnerships that build on an appreciation of cultural diversity. Perhaps the world is not unequal enough to find the strength for a new impetus for collective and responsible action.

If there is one major benefit brought about by the "materialization" of everything from life to science since Charles Darwin, then it must be the exploration of the material world in which we live and the emergence of "technology'. Only the abandonment of the spiritual and religious and a clear separation of such establishments from scientific inquiry over the past two plus centuries allowed such tremendous material progress, unparalleled in the history of humankind. But it has not gone unchallenged. In his 1976 book, James Webb uses the fitting phrase "rejected knowledge" for the ideas that, at a given point in history, prevailed, then were opposed by science, and finally were rejected as false, only to be revised at a later date. Though vitalism (the belief in some form of "energy" or "lifeforce" at work in all things) has been rejected by the mainstream of science over the last two centuries, this "rejected knowledge" has become central to systems of organic agriculture and alternative medicine. This thinking is now part of the contemporary critique of modernity and science. Or is it a longing for a return to the incorporation of "spiritual" values into the mechanistic and materialistic world order? At the

moment, those who find themselves alienated from society identify established knowledge with the established social and economic order; they criticize excessive wealth as it epitomizes materialistic values. They turn to "rejected knowledge" as a basis of their rejection of the mainstream.

From an economic perspective, Adam Smith in his Wealth of Nations (I, 4) perhaps unwittingly described the same paradox between the spiritual and the material when he wrote that "things which have the greatest value in use have frequently little or no value in exchange; and, on the contrary, those which have the greatest value in exchange have frequently little or no value in use. Nothing is more useful than water: but it will purchase scarce anything; scarce anything can be had in exchange for it. A diamond, on the contrary, has scarce any value in use; but a very great quantity of other goods may frequently be had in exchange for it."

The opposite of this valueless dimension, if taken as moral strength and spiritual striving, is perhaps the most valuable in today's "valueless" society. We expect moral leadership but rarely display it ourselves as we struggle to meet our daily obligations and approach our aspirations. We all are all too fast at criticizing existing institutions, including (or especially) those for which we work. Yet when it comes to acting and instituting change, we shy away from bold actions that would jeopardize our own employment. The accepted conceptions of what we want are unusually simplistic, and often wrong; wrong not in the sense of dishonest, but wrong in the sense that our own wants, when more deeply probed, are often different than what we say. In other words, our actions are often different, if not opposed, to what we think we may want. There is a wide disparity between what humankind *thinks it wants* and what, judging by its actions, *what it really prefers*.

Epilogue

I am currently in Bangkok where I am in the process of doing the final edits of this paper. It reminds me of 13 December 1999 when I was also in Bangkok, at the time organizing an Intellectual Property and Technology Transfer Workshop and "plotting" to buy Monsanto (section 3.2). I was writing on that day the cover letter to the biennial report of the organization I was at the time leading and want to share with a wider audience some of the sentiments already communicated at the time.

That event coincided with the celebrations for the 72nd birthday of His Excellency, the King of Thailand. Everyone there wanted to be part of the celebrations, and on the previous Sunday night the entire city of Bangkok came to a halt. All the lights went out at 7:59 PM, and each and every Thai, young and old, came out to light a candle in the street and to sing in unison a series of both secular and sacred birthday songs. I was deeply moved to see an entire democratic nation find one symbol and freely unite around it. I felt this extraordinary event was a manifestation of basic, essential human values. Clearly, however, one may wonder whether these thoughts have anything to do with biotechnology transfer, science and technology, or intellectual property.

But this inspiring sight led me to consider my own efforts and those of my friends active in international development in these areas. Too often the abstract operations of institutions work to elide even the faces of those we seek to help, and we cannot be too frequently reminded of the common humanity that connects all of us to one another. If we want to mobilize global science and technology for the betterment of the lives of billions, maybe we need to re-think our strategies and place more emphasis on evoking and mobilizing the basic human values that link us together. One such fundamental value is trust, and I believe that people who know and trust each other can and will make better decisions.

But how do we instil more trust between and among nations and people? Perhaps as the late Prince Sadruddin Aga Khan, then President of the Bellerive Foundation in Geneva, Switzerland, aptly noted: "*Whether we are believers or non-believers, perhaps the time has come to focus more on Inner Space"* (Aga Khan 1999). These words were from his closing statement of a conference on globalization. Globalization has many upsides and downsides, but one upside is that it can help us mobilize science and technology to improve the lives of people throughout the world like never before. Yet this promise is ours only if we deploy improved products to the poor and wealthy alike. New plant biotechnology initiatives are clearly warranted to deliver the capabilities of the new technology to the world's poorest two billion people. United together, the readers of this handbook, their partners and their friends are uniquely positioned to bring these benefits to those who urgently need them, although this will require of us innovative, bold, and sometimes daring actions. The memory of the children here in Bangkok holding their candles with hopeful looks will provide me with all the reason and courage I need to make my contribution.

Let us not waste these first years of the new millennium, when people all over the world are united around the idea of a new beginning and are hopeful for a better future. Now is not the time for complacency. Let us work today for more effective institutions that will bring a more prosperous, equitable, and human tomorrow.

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Figure 1:

Flow chart of Tangible Property Transfers for one of the three constructs of Golden Rice

Source: Kryder, Kowalski and Krattiger, 2000 (for references cited in the figure, see the cited publication).