"From the Green Revolution to the Biotechnology Revolution: Food for Poor People in the 21st Century"

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My topic today is the next Green Revolution. Not the old one, with which you are all familiar, but the one we need today. I think most of you would agree that we are at a critical moment in our planet's history, a moment when we are being brought closer together at time-warp speeds by astonishing new leaps in scientific and technological capability, while hundreds of millions of us lack sufficient food and have few reasons for hope.

It is also a moment when we can look backward and see more clearly the successes and the shortcomings of the Green Revolution that went before. We can see why that Revolution did not give Africa the ability to help itself, as it did Asia. It is a moment when, for every one of us, the changed understanding of our place in the world – our inescapable interdependence and mutual vulnerability – makes the problem of world hunger more urgent. We are at the beginning of a new era in technology and science. The question for us now is, can we improve upon what didn't work in the last century to help the next Green Revolution work? The central dilemma is the enormous inequalities between the developed and developing world. The challenge of making the technology address the problems of the poor in part depends on institutions we in the developed world have put in place to manage technology and knowledge for our advanced economies.

We all know the new revolution must be different. It must focus on the needs of the countries of sub-Saharan Africa, and it must include a mix of new technologies and new policies that will make those technologies work for poor countries. I want to talk today about developments that will make the new Green Revolution work better for the poor and developments that will make it difficult. I want to talk about my conviction that, unlike the first Green Revolution, the new Revolution will require both public and private sectors working together. I shall conclude by describing two new initiatives of the Rockefeller Foundation designed to bring US universities, corporations, African scientists, NGOs, governments, businesses and farmers closer together in the struggle to help Africa feed itself.

The first Green Revolution offered farmers new crop varieties that allowed them to improve their agricultural yields -- to grow much more wheat and rice per acre. It was most active during the late 1960s and early 1970s, and was most widely accepted in nations such as Mexico, India, and the Philippines. The Ford and Rockefeller foundations, together with bilateral aid agencies such as USAID, helped to create and fund the International Agricultural Research Centers that carried the Green Revolution forward in different parts of the world. It was these centers, such as the International Rice Research Institute (IRRI) in the Philippines and the International Maize and Wheat Improvement Center (CIMMYT) in Mexico that bred the new varieties and developed the technologies to accompany them. But it was the Rockefeller Foundation that began the process, hiring a small team of American agricultural scientists -- among them a former Iowa farm boy called Norman Borlaug -- to work on improving corn and wheat yields in Mexico. Although it was long before my own tenure, I am proud of what the Rockefeller Foundation did through that great initiative. I am proud that the Foundation was willing to take a risk and make what was then a huge commitment of resources to address a root cause of poverty and hunger in these largely agrarian countries. The call to action was the prediction of massive famine for India in the

1960s. Before the Green Revolution nearly two thirds of India's rural population was hungry and poor, and the nation depended on donated US grain. The Green Revolution brought India close to self-sufficiency, with grain stocks available to move around to the most hard-pressed regions. Famine was averted.

The Norwegian Nobel Committee showed great insight into the workings of the world when it awarded Norman Borlaug the Nobel Peace Prize for this work in 1970. It saw the connection between food security and peace—a connection I fear many of us in the developed world have forgotten today.

The Green Revolution—Pro and Con

The Green Revolution has been criticized both rightly and wrongly, thoughtfully and not. What, in fact, were its accomplishments? Almost everybody would agree that its major advance was to increase farm production. Between 1970 and 1995, the new high-yielding varieties, plus fertilizer and irrigation, more than doubled cereal production in Asia using only 6% more land. While Asian populations grew by nearly 60%, per capita cereal availability increased by nearly a third.[1]

It lowered food prices for everyone, including both urban and rural poor. This was important, because the poor spend the highest proportion of their income on food. Prior to the Green Revolution, half of the population in the less developed countries did not get enough to eat; today that percentage has fallen to one-fifth. The Green Revolution also greatly increased employment in the rural non-farm economy and, while patterns varied, agricultural wages generally rose. Across Asia the annual income per person rose several fold, and the number of poor people dropped rapidly. In 1975, six out of ten Asians lived in poverty; by 1993, it was only two out of ten East Asians and four out of ten South Asians.[2]

However, the Revolution had real failings. These failings—and I am using a very broad brush in this historical sketch – were both environmental and social.

The new rice and wheat varieties were designed for irrigated land. They had short stems and required only shallow root systems. They were bred to put all of their growth energy into seed production – that is, wheat and rice grain. To thrive, they needed more water and fertilizer than traditional varieties, a lot more. Increased use of pesticides created pesticide resistance, while killing off some beneficial insects. Fertilizers allowed farmers to avoid costly and labor-intensive work on agricultural preparation and maintenance, such as soil aeration, crop rotation, and working organic matter into the soil. But these steps, we understand today, are key to long-term sustainability. The results of omitting them were soil erosion, nutrient depletion, falling water tables and salinization, even in some of the world's most fertile regions like India's vast Punjab. US and European intensive agricultural systems have similar drawbacks. I discussed such problems, and their prevention, in a book called *The Doubly Green Revolution*.[3] The original "green" of the Green Revolution referred to increased crop production; the next – the doubling "green" -- refers to the creation of environmentally sound agricultural systems, the part we need to pay special attention to this time.

The Green Revolution has also been criticized for being socially harmful, both for what it did and what it did not do. The seeds for the new varieties and the inputs required – fertilizer, irrigation, etc. – were expensive, affordable mainly by the richer farmers (who by Western standards were still quite poor). The

[1] Hazell, Peter B.R., 2002. *The Green Revolution and the Poor*. International Food Policy Research Institute, Washington, D.C.
[2] ibid
[3] Conway, Gordon, 1997. *The Doubly Green Revolution.* Penguin Books Ltd., London, U.K.

"rich" got richer and in some regions bought out the poor -- to quote the critics, they "drove them off the land." As investment in new technologies makes what can be grown on the land more valuable, the land itself becomes more valuable, out of the reach of the poor. This is not an exotic problem in agriculture: US farm policies have allowed richer US farmers to get bigger over the past few decades, buying out the smaller or unsubsidized farmers and "driving them off the land." But this pattern teaches us that, if you want small farmers to benefit from new technology, secure ownership or tenancy rights are key conditions. So, too, are efficient markets for inputs, credit, and products to provide the fertilizer, seeds, and other modern inputs needed. These farmers also require government and trade policies that do not discriminate against them, so they can sell their crops at reasonable prices.

By the early 1970s many of the problems associated with the Green Revolution had been well documented and better understood. During the next two decades, governments in many parts of the world, most notably India and China, put in place policies such as credit programs, input subsidies, and input delivery mechanisms to ensure that the Green Revolution might benefit more of the poor. Village-level studies of the second-generation effects of the new technology in South India showed that small farmers had gained proportionally more income than large farmers, and the distribution of income improved. Nor, in most regions of India, did the disproportionate land distribution worsen. In China, vast numbers of small farmers gained from Green Revolution technologies after government policy reforms in the late 1980s shifted responsibility away from state-run communal farms and marketing strategies to the household level, which allowed farmers and their families to keep more of the profits. As most of you probably know, in the past decade China has reduced its numbers of hungry people by 74 million in an amazing demonstration of what can be achieved by combining productivity-enhancing technologies with policies attentive to the needs of the poor – what we call "pro-poor" policies.[4]

Why Africa Missed Out

The Green Revolution missed Africa almost entirely, and in the clarity of hindsight, it is easy to understand why. The Revolution focused on the food staples rice and wheat, grown primarily on irrigated land. Although international research centers were established in the 1960s to work on African staples, such as millet, sorghum, chickpeas, cowpeas, and cassava, they received little support from Western scientists. Then too, African farmers operate in a wide diversity of ecosystems, while Green Revolution technology was "one size fits all." Africa has some of the oldest, most depleted soils in the world. It has harsh rainy and dry seasons. Many of the poorest African farmers live in arid regions and farm dry, sandy, or salty soils without access to the water needed for most of the new crop varieties. The continent is beset by diseases of crop and livestock, and by many chronic human diseases that, among other tragic consequences, make farm labor difficult. Low population densities and poor roads make marketing and outreach difficult. While India has labor surpluses in rural areas, Africa has a scarcity of laborers in many of its rural areas. Yet African birth rates are relatively high (about 2.4% per year)[5] and although this is somewhat offset by the cruel scythe of the HIV/AIDS epidemic, per capita crop production remains low. Cereal yields per hectare average about one tonne, compared with nearly three tonnes in the developing countries of Asia, and per capita grain production is only 124 kg/yr.[6]

The record of agricultural assistance in Africa is a textbook case of the one thing critics and proponents of the Green Revolution alike agree upon: improving agriculture requires more than technology. Among the things it requires are good governance, wise policies, infrastructure and investment. And Africa faces particularly high hurdles in these areas. Only 21% of its roads are paved, making it hard to get crops to

[4] FAO. *Food Insecurity in the World*, 2002. FAO, Rome.
[5] Population Database, 2002 Revision. United Nations Population Division.
[6] FAOSTAT (www.fao.org)

market or new technologies to farmers.[7] It has few agronomists, and its agricultural marketing systems are underdeveloped except for cash crops like coffee and tea. The absence of credit systems and inadequate land tenure combine to retard investment and technology adoption. In 1965, Africa had more tractors per acre of arable land than South and Southeast Asia; by 1995, it had only one quarter as many.[8] Policies traditionally "over-tax" African agriculture production through overvalued exchange rates. Schemes within Africa to keep food costs down for urban consumers and subsidies in the wealthy countries have made it cheaper, usually, for African governments to import grain from the US and Europe than to invest in their own farmers. The state systems that dominated marketing and input supplies have been notoriously inefficient and unreliable and, until very recently, discouraged entrepreneurship. Fertilizer use has remained low, averaging only 8 kilograms per hectare in 1995, as compared to China, where the rate of fertilizer use is 279 kilograms per hectare of arable land.[9] Despite relatively high tax levels, African governments have tended to invest little in agriculture or rural infrastructure; since 1965, less than 4% of Africa's arable land has been irrigated, as compared to 15% in Asia.[10]

We have learned a great deal since the beginning of the Green Revolution. We now know that investment in technology for increased agricultural productivity in countries with large percentages of their labor force in agriculture will benefit many but not all of the poor and may even *dis*advantage some. But without such investment, the rural poor will be increasingly worse off, and entire nations will be less able to generate wealth, create off-farm jobs and feed their people. We now know that sound policy support is critical to the success of new technologies.

African Progress Needs Farmers

We also have learned that when African agriculture does not function, Africa does not function. Some 70% of the African labor force are still primarily involved in agriculture, and virtually all African farmers are small-scale farmers. Low and declining agricultural incomes have increased poverty, hurt non-farm business, and made rural people both less healthy and less able to afford health care. Leading Africans such as UN Secretary General Kofi Annan believe strongly that one of the reasons Africa has lagged so far behind the rest of the developing world in jobs creation, income growth, non-farm development and trade is that its countries never received the technological boost that Asia did from the Green Revolution. While the best answer for Africa may ultimately be to generate other sources of employment for poor farmers, this will not happen overnight. A preliminary step for such a re-sorting of national economies, essential for the survival of those now sequestered on small, unproductive farms, is to improve their production so that they can generate income for food, for health care, for education for their children, and perhaps to begin training for non-farm jobs.

African governments have a lot to answer for, but so do we, for our response to African conditions. Because it was tougher than Asia, we essentially gave up on Africa's ability to feed itself -- a surrender

[7] Africa Database, 2002. The World Bank, Washington, D.C.
[8] Eluhi, S., S. Benin, J. Pender, and M. Rosegrant, 2002. *Why has the Green Revolution By Passed Africa?* Plenary Session Paper presented at the International Conference entitled, Why has Impacts Assessment Research not made more of a Difference? 4-7 February, 2002, Melia Confort Hotel, San Jose, Costa Rica, organized by the International Maize and Wheat Improvement Center (CIMMYT). Forthcoming Socio-economic and Policy Research Working Paper. International Livestock Research Institute, Addis Ababa, Ethiopia.
[9] FAOSTAT
[10] Eluhi, S., S. Benin, J. Pender, and M. Rosegrant, 2002. *Why has the Green Revolution By Passed Africa?* Plenary Session Paper presented at the International Conference entitled, Why has Impacts Assessment Research not made more of a Difference? 4-7 February, 2002, Melia Confort Hotel, San Jose, Costa Rica, organized by the International Maize and Wheat Improvement Center (CIMMYT). Forthcoming Socio-economic and Policy Research Working Paper. International Livestock Research Institute, Addis Ababa, Ethiopia.

that contributed to perpetuating its poverty and underdevelopment. In the past few decades, these problems loomed so large in any discussion of African agricultural development that they became self-fulfilling prophecies: because there were few roads, there has been little investment in roads; because there were few scientists, there has been little investment in scientific education. Investment in African agriculture by the OECD countries dropped sharply in recent years. Their overall development assistance dropped by 22% in 1991-97, while their aid to Africa dropped by 35% (1995-99). OECD aid to agriculture decreased by almost 50% between 1986 and 1997.[11] The share of that agriculture aid for Africa was 30% in 1990; it fell to 21% in 1998.[12] Such aid as there was became increasingly focused on emergencies.[13] Only in the past few years have there been signs that this trend was reversing. But during the bad years, Africa saw falling production, stagnant internal markets, and dependence on imports – particularly from the US. There have been cyclical famines, chronic and acute hunger, and rural and urban poverty.

The difficulties for agriculture in Africa are great, but there are also some advantages. It is a huge, resource-rich continent, with enormous potential for agricultural growth. The very diversity of ecosystems that makes "one size fits all" technology ineffective means that there are many areas that are uniquely well suited for intensive agriculture of particular crops. Africa has twelve times the land area of India and only half as many people to feed. With a rapidly growing labor force (despite HIV/AIDS), there is growing scope for adopting higher-yielding but more labor-intensive technologies and farming systems. Markets are growing because of rapid urbanization at home and new export opportunities as a result of trade liberalization and globalization. With few exceptions, the distribution of land is still equitable by international standards. Small farms that are efficient but poor dominate the continent, and raising the output of small farmers would not only raise their incomes and increase food security, but also lower national food prices, stimulate the rest of the economy, and reduce poverty. Half of all Africans earn less than $1 a day; three fourths earn less than $2 a day. A one percent increase in yields would help six million more people raise their incomes above one dollar per day.[14] At this rate, a smallholder-led growth strategy could lead to huge cuts in Africa's rural poverty within a couple of decades.

But despite recent policy changes recognizing the importance of farming and despite a renewed interest in investing in the potential of small farmers, African agriculture and the livelihoods of its rural people continue to deteriorate. Without a heroic intervention, experts predict that conditions for the poor will rapidly get worse. In 2000, Africa had 44% of the world's hungry; if present trends continue, the number may be 73% by the year 2015.[15] Africa is the only region in which the actual numbers of hungry people are increasing, not just the percentage.

Those trends must be changed, and one way to do it is to invest in small-farm agriculture *now*. Enabling those who are hungry and struggle on depleted land to produce more food and bolster their livelihoods through income from cash crops will ultimately stimulate non-farm economic growth. But these investments must be environmentally sound. To do all this, we need another revolution, a Doubly Green Revolution, and we need it now.

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[11] Cohen, Marc J., 2002. Presentation at the World Vision/Rockefeller Foundation meeting held at ICIPE, Nairobi, Kenya. International Food Policy Research Institute (IFPRI).
[12] ibid
[13] ibid
[14] Thirtle, C., X. Irz, McKenzie Hill and S. Wiggins, 2001. The Relationship between Changes in Agricultural Productivity and the Incidence of Poverty in Developing Countries. *DFID Report No. 7946 27*, Department for International Development, United Kingdom.
[15] ERS/USDA Food Security Assessment Project, December 2000. United States Department of Agriculture.

What Rockefeller has Learned

The world and the Rockefeller Foundation have changed considerably since the early Green Revolution days. We now understand the need to balance social and environmental concerns with getting new technologies right. Perhaps most important, we are trying hard to adapt to the new realities of globalization: new global markets, and possibilities for broader, global debate. We know the ways in which globalization can be hard on the poor. But we are also trying to seize and develop the opportunities of globalization: more transparency of process, more reporting of adverse effects in remote places, more informed criticism, and the possibility for faster and more precise course correction when the debate so indicates.

Let me give some examples of our own internal changes. First, until my tenure as President, the Foundation mission statement spoke of the "betterment of mankind." We now focus all of our energy and grantmaking on that part of humankind that is poor and excluded. So although one of our main focuses remains the application of knowledge, especially in science and technology, we are unlikely to get involved in any new technology unless we are sure it will benefit the poor. Our work increasingly focuses on Africa, where the problems of health, nutrition and opportunity for the poor seem most intractable and most likely to overwhelm an entire continent.

Second, we work on policy. The problems that blunted the Green Revolution – problems of social inequity, unequal access to resources, and policies that are short-sighted or benefit only the wealthy – are still very much with us. But now they are global. As a global foundation focused on the poor, we have had to recognize that without policies to reduce the unequal burden of poverty, hunger, and disease in the world, no amount of new science or technology will promote a more peaceful and just future. Thus we work not only on pro-poor science and technology, but also on pro-poor policies.

Third, we continue to help build strong institutions in the developing countries, staffed and run by individuals with the experience and the commitment to ensure that the fruits of the science, technology, and humanities we support will benefit the poor and excluded. When we speak today of institution-building and creation of human capital, we are not speaking only of universities, government bodies and scientists. We are speaking of NGOs, civil society groups, farmers' organizations, and private companies.

We still believe in good government policies and the concept of "public goods," and we aim much of our resources toward this end. But we no longer believe that government alone can accomplish what needs to be done, as many of us thought at the time of the Green Revolution. The private sector is needed – including non-academic scientists, corporations, and business people. They have a tremendous contribution to make, and they are in a position to make it. We believe it is in their interest to make it. But for private and public to work in partnership, we recognize that there is a need for more and stronger institutions to develop the rules of trade and the terms of relationships between the private and public sectors, as well as among individuals. Much of our work to build local institutional capacity and stronger international institutions includes the development of public-private partnerships.

We believe the combination of public purpose with private entrepreneurship and resources can significantly improve the sustainable livelihoods of the poor. By bringing together powerful actors from different parts of the world, different economic sectors, cultures, and walks of life, public-private partnerships can help cut through the barriers that keep us from building political support to benefit the poor. We only have to look at the current debate over agricultural biotechnology to realize how polarized positions stymie our ability to learn from past mistakes, and from each other. We must always bear in mind that nobody is ever 100% right or 100% wrong. Governments, companies, and citizens'

organizations are all beginning to recognize the same truth: the best solutions are very rarely "either/or;" they are almost always "both/and."

"Both/And" for Africa

In terms of science, technology, and knowledge, the scene is set today to begin an agricultural revolution in Africa. The first step for Africa is to begin with the basics—building human capacity, a critical mass of people with the abilities to evaluate and manage technology within the individual countries themselves. Some policy improvements are needed (inside and outside Africa), strengthened political will is needed (also both inside and outside the continent), and capital for investment. African countries need to invest less of their own resources in their armies and in grand, showcase projects, and more in education, from basic literacy to farmer outreach to the training of agronomists and other scientists. They need to build roads and railways to connect centers of production with centers of population. Africa has a long way to come in terms of its politics, priorities and policies, but it has recently taken some important steps, like the creation of NEPAD, the New Partnership for African Development. NEPAD is a pledge by African leaders to consolidate democracy and sound economic management and to promote peace, security and people-centered development.

The first Green Revolution taught us that technology is necessary, but not sufficient. We know, too, that the world has changed so much since then we could not do it the old way again even if we wanted to. We must increase overall agricultural production, but we must also help small-scale, poor, remote farmers get their surplus production to markets to generate income that will eventually allow them to move into the non-farm economy. All farming systems will be required to be more, not less, intensive; more, not less, environmentally sound; and more, not less, "sustainable." They must be economically profitable, environmentally sound, and culturally appropriate. I am speaking of Africa here, but this goes for the whole planet -- not excluding the US. We are raising the bar for this Doubly Green Revolution, because our understanding of rights, of consequences and of our essential planetary fragility has grown, because we know we are battling for the survival of all of us.

There are four sub-revolutions I see as the necessary bases for the coming Green Revolution in Africa. I shall touch on them briefly. They are:

- New ways for agronomists to work effectively with farmers to identify obstacles and opportunities;
- Better and more integrated uses of existing resources;
- Ways for African farmers to benefit from the global market;
- Ways to manage the continuing revolution in science and technology -- including, but certainly not limited to, biotechnology.

Saying a bit about these areas of opportunity will, I think, show you why the Rockefeller Foundation decided to undertake its two new initiatives.

Learning to Work with Farmers

The vast majority of people in Africa are small-scale farmers living in rural areas distant from capital cities. These are the people we must reach, not only because they are the most at risk, but because they are the ones who understand their land and what they need to improve their livelihoods better than outsiders do. This small-scale farmer is usually a woman, frequently caring for her land and children by herself, because many of the men are away working in cities, and many have died of AIDS. The farmer with whom scientists must communicate is often illiterate. In the past, when researchers ran trials in farmers' fields, they tended to use the farmers simply as laborers, but our recent experience has shown

that results are better when farmers become researchers too. In recent years researchers have developed techniques for working with such farmers to make the most of indigenous resources and knowledge - techniques that enable the farmers to take the lead, undertaking their own analyses, developing solutions to problems and recommending changes and innovation.[16] We call this Participatory Learning Appraisal.

Breeders from one International Agricultural Research Center working in Zimbabwe have had notable success in introducing new varieties of corn that are more resistant to the stresses of drought and low nitrogen, success that was due in large part to the active participation of local farmers in the breeding efforts.[17] In Kenya, a group of researchers has helped organize farmers to plant trial plots on their land, investigating varieties, spacing, fertilizer treatments, intercropping, and erosion control, mixing treatments suggested by scientists with those suggested by the farmers. A committee of farmer researchers has overseen the experiments, and neighboring farmers are now taking up the successful innovations.[18]

Using Resources Better

Such new collaborative research tools will help us perfect the second sub-revolution, using resources better – that is, integrating the management of agricultural inputs. It is risky to generalize about Africa, but one generalization that holds up well across the continent is that soil fertility is low and fertilizer prices are high. For example, the price of urea in Western Kenya is $400 per metric ton vs. $90 in Europe.[19] African soil needs fertilizing, and in most parts of Africa it is not possible to "go organic," because there is not enough organic material available, whether animal dung or crop residues. However, what *is* available can be used more effectively.

So some NGOs are working with multinational companies to provide cheaper fertilizers and improved seeds – and even to help farmers get better prices for farm products. For example, in Kenya scientists from the Kenyan Agricultural Research Institute (KARI), Kenyan universities, the International Centre for Research on Agroforestry, and the Tropical Soil Biology and Fertility Programme take soil samples to find out which elements and micronutrients are lacking. The results are compared with a database that describes the nutrient content of over 300 *locally available* materials that can provide soil inputs for improvements. Alternative strategies to enhance soil productivity are being developed based on nutrient cycling, livestock-crop interactions, biological nitrogen fixation, rock phosphate, improved fallows, and efficient use of small amounts of fertilizer formulated to provide key missing nutrients.[20]

Pests, plant diseases and other environmental stresses remain problems, and integrated pest management is providing some answers. For instance, *Striga* is a nasty weed whose seeds cling to corn seeds, so farmers actually plant the weeds that will attack their crops. Planting corn together with the legume

[16] IDS, 1996. *The Power of Participation: PRA and Policy,* Institute of Development Studies, Briefing Issue 7, University of Sussex, U.K.
[17] Banziger, M., J. DeMeyer, 2002. Collaborative maize variety development for stress-prone environments in southern Africa. In *Farmers, Scientists and Plant Breeding: Integrating Knowledge and Practice,* D.A. Cleveland and D. Soleri (eds.) CABI, Oxon, U.K., pp. 269-296.
[18] Largat, M., E. Mukhwana, P.L. Woomer, *MBLI Update: Testing an innovative cropping arrangement.* Sustainable Agriculture Centre for Research and Development in Africa (SACRED Africa), Bungoma, Kenya.
[19] Sanchez, P.A., 2002. Soil Fertility and Hunger in Africa. *Science* 295: 2019-2020.
[20] Seward, P.D., D. Olello, 1998. *Methods to develop an infrastructure for the supply of appropriate fertilizers for use by small-scale farmers in sub-Saharan Africa, Experience from Western Kenya.* Sustainable Community-Oriented Development Programme, Ukwala, Kenya.

Desmodium uncinatum helps to control *Striga*.[21] A South American wasp that is a natural enemy of the cassava mealy bug was introduced into Africa and successfully controlled this important pest. [22]

Joining the Global Market

There are few subsistence farmers left in Africa, and fewer still who want to be. There would be little point in investing in African agriculture if the goal were to keep smallholder farmers poor, uneducated, and hungry. Let me state it clearly: We are not seeking to create sustainable poverty. We are seeking to create growth in agriculture and, through that route, the non-farm economy.

African farmers could provide Africa with much more of its food needs and help spur non-farm growth if they could get their products to market and if they could get a fair price. But the rich countries fix the game. The OECD countries spend about $1 billion *per day* helping the world's richest farmers compete against the world's poorest farmers.[23] Europe is perhaps more subsidies-addicted than the US, but the US, while continuing to call for freer trade, recently increased its own agricultural subsidies. What this means is that while US scientists have helped Mexican farmers produce more corn, US politicians have made it impossible for those farmers to compete against floods of subsidized corn from the US. It means that it is often cheaper for Mozambique to buy corn from the United States than from next-door Zimbabwe.

Basically, Africa needs to become part of a global market, and not the one that exists today, which is skewed in favor of wealthy nations, but one based on the aspirations that produced the agenda of the new round of trade talks agreed in Doha, Qatar, in November 2001. There, World Trade Organization (WTO) delegates signed a declaration seeking, among other things, reform of subsidies and anti-dumping rules; a focus on opening Northern markets to Southern farm products by means of tariff reductions, quota removal, the long-term elimination of export subsidies, and helping developing countries deal with the system of intellectual property rights that blocks access to scientific innovations, including, most notoriously, access to essential medicines.

The Doha Ministerial Declaration is an important international consensus on capacity-building and technical assistance for developing countries, a framework for WTO activity in the area of technical assistance, and a work program for the fuller integration of small economies into the global economy, for least-developed countries, and for the establishment of working groups on debt, finance, and technology transfer. If this determination can be turned to concrete action in the coming trade round, then Africa just might enjoy an agricultural revolution. If, on the other hand, we miss this chance, it is not only Africa that will suffer. All of the other trade goals of the OECD countries will suffer, since everyone will be watching to make sure we can make progress on agriculture before they tackle other things that may be more important to the developed world's economies, like the service sector.

Managing Biotechnology

This leads me to the fourth sub-revolution, which is agricultural biotechnology. When I talk about biotechnology, I am talking about a wide spectrum, from conventional technologies to simple applications of biotechnological techniques to later, more sophisticated ones. I am also talking about the need to build

[21] Khan, Z.R., et al. 2002. Control of Witchweed *Striga hermonthica* by intercropping with *Desmodium* spp. and the mechanism defined as allelopathic. *J. of Chemical Ecology 28: 1871–1885.*
[22] Herren, H.R., 1995. Cassava and Cowpea in Africa. In G.J. Persley (ed.) *Biotechnology and Integrated Pest Management,* CABI, Wallingford, U.K., pp. 136-149.
[23] OECD Statistics.

up the human capacity to use it. This is another example of a "Both/And" Solution. In terms of technology, let me say that I believe that the best technology is the one that will safely get the job done in the simplest and least expensive way possible. We are interested in the new, more sophisticated applications of biotech because we believe that, managed well, they can be simple and less expensive tools to help poor farmers, and help them quickly. But we do not think biotech is the only tool. Traditional plant-breeding sciences are crucial, and these have long been, and will continue to be, our focus. Cassava resistant to viruses, beans resistant to fungal diseases, and corn more tolerant of drought and containing higher quality proteins are just a few of the products of conventional breeding African farmers have readily adopted.[24]

But we would be irresponsible if we did not help Africans begin to build a foundation from which to take advantage of the capabilities of new techniques and products made possible by biotechnology, including genetically modified, or GM, seeds. Biotech can help us improve pest resistance while reducing reliance on chemical pesticides that are expensive and damaging to the environment. It can help us to adapt plant varieties to the different growing conditions of Africa's many different ecosystems. To speak more specifically, it offers the promises of creating millet and corn varieties that are resistant to *Striga*, cowpeas that can resist pod borers, and bananas resistant to weevil and fungus. It can help us create crops more resistant to drought, and crops with greater nutritional value. Most of the Foundation's work is aimed at capacity building in African countries and traditional methodologies, but we believe it will be a very great advantage for Africa to begin to introduce biotechnology -- slowly at first, so that the capacity of Africans themselves to use it effectively and safely can be established. We believe that this is by far the better course than waiting to have it sprung on unprepared nations.

What we call agricultural biotechnology consists of three practical processes resulting from basic advances in cellular and molecular biotechnology. Most of its applications are not controversial, but simply make traditional methods more efficient and more powerful. Only the third of these processes has excited controversy, and that is, of course, genetic engineering, the direct transfer of genes from one organism to another.

The first process is *tissue culture*, which permits the growth of whole plants from a single cell or clump of cells in an artificial medium, and has so far provided the greatest benefits to poor farmers. Tens of thousands of African farmers are now growing food crops produced by this form of biotechnology. In East Africa, tissue culture is allowing for the micro-propagation of improved and disease-free banana seedlings.[25] The increase in production is generating income for small farmers in a region where bananas are a staple food.

Some very dramatic achievements for both farmers and consumers have been made with rice. Using tissue-culture techniques called embryo rescue and anther culture, African scientists have crossed the high-yielding Asian rice *Oryza sativa* with the African rice *O. glaberrima.* The new rices combine the high yields of the Asian rice – three tons per hectare with little or no fertilizer – with the weed-competitiveness, drought-tolerance and disease resistance of the African rice.[26] They are now rapidly being planted over many thousand hectares in West Africa.

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[24] DeVries, J., G. Toenniessen, 2002. *Securing the Harvest: Biotechnology Breeding and Seed Systems for African Crops*. CABI, Wallingford, U.K.

[25] Wambugu, F.M., R.M. Kiome, 2001. The benefits of biotechnology for small-scale banana producers in Kenya. *ISAAA Briefs* No.22, ISAAA: Ithaca, New York.

[26] Jones, M.P., 1999. Basic breeding strategies for high yield rice varieties at WARDA. *Japanese J. of Crop Science 67: 133-136.*

Marker-aided selection uses our ability to detect the presence of particular DNA sequences at specific locations on a chromosome and link these to the presence of genes responsible for particular traits. Marker-aided selection allows us to identify segments of the plant genome that are closely linked to the desired genes so that the presence or absence of the trait – that is, the success of the cross – can be determined at the seedling or even the seed stage. This makes it possible to achieve a new variety in four to six generations instead of ten. It is particularly useful for breeding for drought-tolerance, which is the result of a number of different traits, such as deeper roots, early flowering and changes in osmosis within plants all working together. Breeding for drought tolerance is a particularly difficult and slow process using conventional techniques, but markers are now permitting combinations of these traits to be accumulated. For example, using markers the combination of traits that make corn drought-tolerant are now being crossed into the many locally well-adapted varieties growing in Africa.[27]

G*enetic engineering* is the third biotech approach. It is based on recombinant DNA technology, which enables the direct transfer of genes from one organism to another. In genetic modification, genes are moved between organisms, including those that do not cross in nature. The resulting plants, called transgenic or genetically modified (GM), have been the focus of most of the controversy over biotechnology. For some good reasons, including those connected with early episodes of corporate haste and arrogance, people in many countries are suspicious of GM crops and hostile to their use, especially in food.

For poorer farmers, the main benefits so far have come from growing cotton that is resistant to insects. The resistance is conferred by introducing gene constructs derived from the bacterium *Bacillus thuringiensis* (Bt). Last year in China over three million resource-poor farmers grew more than 1.5 million hectares of Bt cotton, over 30% of China's total acreage.[28] They were able to reduce the number of pesticide applications substantially, obtain higher yields, and derive benefits estimated at $330 to $400 more per hectare. Cutting the use of chemical pesticides reduces harm to human life and health, as well as to the environment. The benefits to health have been particularly notable for Bt cotton in China, where pesticides have traditionally been applied manually without protective clothing, resulting in high incidences of poisoning.

Genetically modified cotton with Bt genes has been grown in South Africa for three seasons and provides the only practical experience African smallholder farmers have had with GM crops. In the Makhathini Flats region of KwaZulu Natal Province, 95% of smallholder cotton producers grew Bt cotton in the 1999–2000 growing season.[29] They increased yields, increased profits, and significantly reduced pesticide use. Interestingly, the smaller the farm, the greater the benefits received.

The "Both/And" of Biotech

Although the benefits of agricultural biotechnology introduced in developing countries thus far have been predominantly economic benefits for farmers, it is when we look at the potential of GM plants to address chronic nutrition problems in the developing countries that we can see their real importance, particularly for children, because the effects of early hunger cause the worst damage. Although increasing productivity and income among small farmers in Africa is critical to addressing hunger there, the

[27] Ribaut, J.M., et al, 2002. Use of molecular markers in plant breeding: drought tolerance improvement in tropical maize. In *Quantitative Genetics, Genomics and Plant Breeding,* M.S. Kanage (*ed*.), CABI, Wallingford, U.K., pp. 85–99.
[28] Pray, C., J. Huang, R. Hua, S. Rozelle, 2002. Five years of Bt cotton in China – the benefits continue. *Plant Journal* 31: 423–430.
[29] Yousouf, I., R. Bennett, S. Morse, 2001. Farm level impact of Bt cotton in South Africa. *Biotechnology and Development Monitor* 48: 15-19.

magnitude of the nutrition crisis is such that this cannot be the only effort. We must try multiple ways to prevent another generation of Africans from growing up stunted and diseased from poor nutrition. Programs, like school lunch programs, that provide food outright have been a critical weapon against under-nutrition at a critical time in a child's development both here and in the developing countries. In those countries such programs are particularly important for girls, because they can get around the family politics that determine who goes hungry in struggling societies – men get the most, women and children less, and girls less than women and boys. Increasingly, the importance of the connections between under-nutrition, health and disease is being understood—particularly in the battle against AIDS in Africa.

As most of you know, the Rockefeller Foundation was involved with what may be but the first of a series of biotech innovations to address malnutrition in the world's poorest countries, the nutritionally enhanced "Golden Rice." Vitamin A is required for human growth, and rice, the staple food of Asia and the world's most important source of human food, lacks Vitamin A. More precisely, it lacks beta-carotene, or pro-Vitamin A, which allows Vitamin A to be manufactured by the body. Beta-carotene is manufactured in the leaves of the rice plant, but conventional plant breeding has been unable to coax the grain, the part that is eaten, to produce it. To make Golden Rice, scientists at the Swiss Federal Institute of Technology in Zurich, after much trial and error, successfully transferred one bacterial gene and two daffodil genes that are expressed preferentially in the grain, and the new genes resulted in the synthesis of nutritionally significant levels of pro-Vitamin-A in the edible grain of the rice.[30]

Vitamin A deficiency, which is practically unknown in the United States, permanently blinds a half million people in South Asia and sub-Saharan Africa. About 15 years ago it was discovered that even smaller deficiencies of Vitamin A in children —too small even to cause night blindness in adults— contributed to nearly two million yearly childhood deaths from ordinary childhood diseases, such as measles.[31] Researchers began a series of trials in which children were fed mega-doses of Vitamin A twice yearly in tablet form. In many of the trials, mortality was reduced by 40%. In Nepal, 37,000 village women volunteers reach over two million children during special "Vitamin A days" twice a year.

The impact of being able to provide this essential vitamin through a staple food of the poor is obvious. Nutritionists and other experts believe that diversified cropping patterns and greater access to a balanced diet is the ideal solution to Vitamin A deficiency, and to malnutrition generally, but they also recognize that there are long periods in large parts of Africa and Asia known as "the hungry season" in which few fruits and vegetables are available and people eat stored grain. And even when they are available, it takes many servings of green leafy vegetables to provide enough Vitamin A. Meat and dairy products, a richer source, are not part of many Asian diets, and large-scale Vitamin A supplementation is difficult to administer to children in rural areas.

Experts still debate the best way to treat Vitamin A deficiency in these circumstances, but they all agree that it must be treated, and that no one way will suffice. It is not an "Either/Or," but a "Both/And" solution that is needed here. Think for a minute. In the developed world, where most of us have access to a balanced diet and by law our rice is fortified with vitamins, doctors still recommend a daily supplement of Vitamin A. We do or we don't follow that advice. Poor consumers, too, must have choices that are within their reach and control.

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[30] Ye X., S. Al-Babili, A. Kloti, J. Zhang, P. Lucca, P. Beyer, I. Potrykus, 2000. Engineering the provitamin A (β carotene) biosynthetic pathway into (carotenoid-free) rice endosperm. *Science* 287: 303–305.

[31] Sommer, A., K. West, 1996. *Vitamin A Deficiency: Health, Survival, and Vision*. Oxford University Press, New York, N.Y.

More testing will be required for Golden Rice to reach its full potential for the poor, and no one should hype it as the proverbial "silver bullet." But, along with other interventions, GM crops such as Golden Rice do hold the potential to expand significantly the nutritional solutions available to the poorest of the poor. Breeders in several Asian countries are crossing the genes now into locally adapted rice varieties. Other foods with increased nutritional value are in development, including quality protein corn, vitamin E-enriched soy beans, sweet potatoes and cassava with greater Vitamin A and protein content.

The Biotechnology Controversy - In Brief

The controversy around Golden Rice and other GM foods may obscure the fact that virtually all of the reports of the scientific bodies we rely on, including a large study conducted for the European Union, conclude that the engineering *process* by which GM products are created poses no inherent threats to human health. For regulation for human use, we should be evaluating and testing the *product,* not the process by which it was created. Testing GM food plants for human health risks is relatively straightforward. Testing them in diverse ecological systems for long-term environmental effects, however, is still a challenge. In part this is because we have not done very much of this kind of "ecological" testing, even with conventional agriculture; in part it is because of the extended time periods required for full testing of long-term effects -- the technology simply hasn't been around for that long. I do not have enough time today to explore fully the questions about environmental risks of plant biotechnology or the controversies that surround them, but as the controversies have reached Africa, I cannot leave the subject alone altogether.

We tend to forget, when we are weighing the risks and benefits of something new, that we are weighing against existing alternatives. To assess the environmental risks and benefits of biotechnology for agriculture, it is necessary to look first at agriculture as it is practiced today, and particularly its effects on the environment in both developed and developing countries. We have learned that much of the technology of the Green Revolution was not environmentally benign. If we do not move forward, we are restricted to continued use of current technologies that present known environmental risks and do not take advantage of the best science has to offer. If, to feed the world's population, significantly more acreage must be turned over to food production – and with current practices, that is what would have to happen – environmental damage will increase. The land brought into cultivation for increased agricultural production will be more fragile and more easily damaged. Much of it will have to be obtained by clearing forests, jungles, and wetlands. Using present agricultural techniques we would need to increase chemical inputs – fertilizers and pesticides – which will contaminate wider areas of land and water, and we may have to do this simply to maintain, not necessarily increase, productivity. In short, this is not a situation in which staying with the *status quo* is a cost-free option. The *status quo* is environmentally high-cost.

This is not to say that we do not need to monitor and manage the uses of new plant biotechnology. We do. It is to say that, because of the greater power of biotechnology, sticking to the *status quo* will mean missing the opportunity to do better — in terms of human welfare, social stability and the environment – in both rich countries and poor. As a global society, we cannot continue to afford either the environmental damage associated with the first Green Revolution or the misery associated with the extensive agriculture of much of Africa. Each in its own way is dangerous to our future. We must let our remarkable scientific capabilities help us here. I will tell you that my great fear is that debate in the developed world, which has become toxically polarized, with all sides trying to use the poor for their own advantage -- as happened in the Golden Rice controversy -- will stifle the potential of biotechnology to benefit the poor, particularly in Africa.

The controversy about biotechnology was present in Africa before the recent fracas over food aid. The initial refusal of badly needed food by African countries made clear that most of them simply do not as yet have the experience and scientific capacity to make informed decisions about GM food. They saw no

middle ground. Although many African farmers want to grow GM crops, they also want their products to be marketable in other countries. Other Africans fear that GM crops will be misused, or will not benefit the poor or will make them even more dependent on foreign companies. Developing countries with thin scientific and regulatory experience have traditionally looked for safety signals from more developed countries. But becoming enmeshed in the arguments over GM foods that rage in the developed countries -- arguments in which African interests are not considered -- is not what Africa needs now. Africa needs the ability to make its own decisions for its own situations.

As in some cases it is lack of experience with scientific decision-making that makes Africa hesitant, in other cases, it is past experience itself. Some of the fears of new science have their roots in earlier mistakes made when we knew less about ecology and diversity and risk than we have learned since. I recently heard these concerns expressed eloquently by Yoweri Museveni, the president of Uganda. Relative to many other African countries, Uganda has a strong scientific community and a first-class national university. The president is himself a livestock breeder. He said: "I am concerned. I see how long it takes for genes to stabilize. How do we know when products have been tested long enough? I've seen the mistakes of the past. Europeans introduced water hyacinth, which now chokes our waterways. They introduced the Nile perch, which has eaten everything else in Lake Victoria. So how can we be sure that biotech will not lead to bigger mistakes?"

I had no easy answers for the president. I told him that GM crops are not the only way forward for African agriculture, but that they offer such great promise – certainly for bananas, which are the food staple of Uganda – that it would be a great shame to steer away from them categorically. I suggested that to be sure that biotech crops will be of long-term benefit both to farmers and consumers, three things will be required, in Uganda or any other country:

- First, a strong scientific community, to help select the best and most useful biotech applications and to avoid any for which the risks outweigh the benefits. All biotech applications are not the same, all are not equally beneficial, nor equally well understood. It is critical for each country to be able to pick and choose carefully, reflecting its own needs and capabilities;
- Second, policies that encourage both advanced research in the laboratory and also regulatory systems on the ground, to ensure the safety of new technologies for both human health and the environment; (As an aside, the Rockefeller Foundation has been supporting work by Uganda's Ministry of Health and National Bureau of Standards to modernize their food laws and food safety systems, including efforts to develop a national biosafety regulatory framework.)
- Third, a better understanding of the complexities of biotech. It is often described as a powerful tool, but by itself, it is not. The power comes from a combination of the technologies with systems, such as domestic regulations and policies, international agreements and research agendas. Individual governments must carefully align the technologies they choose with these systems and support the choices with sound policies.

The African response in the food aid crisis offers yet one more compelling reason why the capacity to understand and handle biotech must be developed widely, and why the planet's policy-makers need to develop a trustworthy, unified approach to GM crops that will build public confidence globally. We must take action that is global in scope because the problem is global in scope, for all the reasons having to do with the interconnectedness and mutual vulnerability conferred on us by globalization. But action at the national and local level is necessary too. We must work with African farmers, scientists, governments -- and consumers -- to help them develop the required capacity to begin to use new sciences comfortably and well for the broad benefit of their own people within their individual situations and culture. Let me emphasize that it is not only biotech I am talking about here, but the full range of possibilities that science is delivering to us, across the board.

The challenge of making technology available to address the problems of the poor is in part dependent on institutions we in the developed world have put in place to manage it. Herein lies the dilemma I called "central" at the beginning of my talk: the enormous inequalities between the developed and developing countries. For the developing countries, particularly the poorest, the need to assure the safety of biotech products poses seemingly insurmountable problems, since most of these countries do not have testing and regulatory systems that would meet our consumer standards, nor can they afford to develop them. The cost of testing and regulation affects price, and the price of food affects the hungry. If resource-poor governments must spend $20 million to ensure that a new product is safe for each ecological setting in which it may be used -- as is routinely the case with pharmaceuticals -- new products will never reach the poor. I do not mean to imply that safety is a luxury poor countries cannot afford. Quite the opposite. Globalization means that the safety of one is now the safety of all. I mean that if safety requirements are not to inflate the price of food out of the reach of the poor, new strategies for institutional management and sharing of scientific and technological capabilities will be required. And I mean that the United States needs to become active in the Cartagena Biosafety Protocol, rather than sitting on the sidelines as it has been, hoping for the best by expecting the worst.

Collaborative action can help. Groups of African nations working together can save money by pooling expertise to develop regionally appropriate systems. Indeed, African governments have begun to work regionally to develop shared regulatory regimes for GM crops with the formation of NEPAD (the New Partnership for African Development), which I mentioned earlier. They need to make their own assessments of risks and benefits -- including the risks of not using new technologies to boost food production. Politics is personal, and what you eat is even more personal. Polls show that for most people in the world, the most trusted source of information about food is -- their mothers. Making decisions about food safety closer to home moves in the right direction.

Intellectual Property

Having spoken of the four sub-revolutions that can help Africa toward an agricultural renaissance, I want now to turn to a major area in which good policy is urgently needed to make these sub-revolutions possible, and that is the area of intellectual property rights (IPR). I shall say something about what the Foundation is doing here, and I must tell you that it is in this last policy area that we have found the greatest barriers to a new, Doubly Green Revolution.

Food biotechnology was introduced just as globalization changed the boundaries between public and private – from *public* good, *public* domain, *public* obligation to *private* enterprise, *private* decision-making, *private* advantage. International rules controlling the rights to private ownership of research and technology have been changed, while, at the national and international levels, governments have appeared almost passive, as if ceding basic responsibilities for the public good to the private sector. I believe many of the arguments about biotechnology are embedded in larger concerns about the fairness of the international systems regulating trade and intellectual property rights, about the adequacy and reliability of protections for public safety and the environment, about global "market failures," and about the equity implications of the emerging systems of global governance.

Globalization hooks national decisions about biotech and national IP systems up to international systems, particularly trade. The ability of national governments to stand up for the best interests of their people becomes key. The elaboration and implementation of IP policies take place in an array of international fora—from regional and bilateral trade negotiations to multilateral discussions at the World Trade Organization (WTO) and the World Intellectual Property Organization (WIPO), and in a range of other United Nations bodies as well, including the World Health Organization, UNESCO and the Convention on Biological Diversity. Over the past several years, part of the Foundation's work has been aimed at assisting developing countries to promote their own interests in intellectual property matters more

effectively by supporting research, policy analysis, participation in dialogues and negotiations, and capacity building in the individual countries.

A second aspect of the Foundation's approach to intellectual property has been to look for ways to create a space or mechanism to increase the flow of scientific information, materials, and affordable and safe products to scientists, NGOs, local businesses and governments to address the needs of the poor. In health we have helped to establish several public-private partnerships, including the International Aids Vaccine Initiative (IAVI) and the Centre for the Management of Intellectual Property in Health Research and Development (MIHR) -- but today I will focus on agriculture.

Before the Green Revolution, up until the advent of plant biotechnology, the Foundation's work was able to make use of the best agricultural research in more advanced countries for developing-country needs – the process Isaac Newton called "standing on the shoulders of giants." Advances in knowledge were openly published and freely shared, and with relatively modest investments, the Foundation could have significant impact by supporting focused efforts on applying that knowledge in developing countries. Increasingly, this mode of operation has been threatened. The chief threats are two:

1) The trend towards exclusive private control of agricultural discoveries, as more publicly-supported research now comes with IPR protections and restrictions: Universities, particularly in the US, now license most of their scientific innovations to private companies, including important enabling technologies -- the technologies for conducting further research. As a result, three fourths of the new biotechnology products, including those originally made possible by publicly supported research, are controlled by the private sector.[32]

2) The shift in academic research away from public objectives towards corporate objectives as a result of the growth of corporate support for university research: Corporate funding increasingly determines the direction of university research. The first interest of corporations is, naturally, to create profit for their shareholders, not to worry about African farmers.

To put it another way, in contrast to the earlier Green Revolution, the biotechnology revolution is being driven by the private sector. Private interests now dominate all aspects of research, production and the marketing of biotechnology. Even the regulatory systems favor big corporations with cadres of lawyers. The United States is now issuing patents at the rate of one million every five years, and the scope of what can be patented continues to expand.[33]

Fierce competition and low margins in the seed industry compel companies to stockpile IP that does not have sufficient market value for development, so as to keep it out of the reach of competitors. This tends also to make it unavailable to public scientists still willing to work on crops for poor farmers. The number and complexity of ownership rights that must be negotiated—and paid for—to take a product to market have multiplied so quickly that some useful products are sitting in greenhouses going nowhere and some useful ideas are not being pursued.[34] Increasingly, only big corporations—not public scientists—are able to assemble the mosaic of IP rights necessary for "freedom to operate" (FTO).

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[32] Bennett, A.B., Greg Graff, 2002. *Intellectual Property in Agricultural Biotechnology: Fueling the Fire or Smothering the Flame.* Office of Research Administration & Technology Transfer, University of California.
[33] USPTO, "Patent Counts by Country/State and Year, Utility Patents: January 1, 1963-December 31, 2001," http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_utl.pdf.
[34] Gianessi, L., C. Silvers, S. Sankula, J. Carpenter, 2002. *Plant biotechnology: current and potential impact for improving pest management in U.S. agriculture: an analysis of 40 case studies.* National Center for Food and Agricultural Policy, Washington, D.C.

This new world of research has made the work of public agencies traditionally responsible for virtually all of the products made available to the poor considerably more difficult across the board, but more so for agricultural research. Agriculture differs from pharmaceuticals in many ways, but the significant difference in this respect is that farmers and scientists need access to basic materials to experiment and adapt crops for local growing conditions. Issues connected with access to fully developed products like Bt corn may be closer to pharmaceutical issues, but what is most critical for poor farmers working on crops is missing information and materials, like improved germ plasm and DNA libraries, and of course the enabling technologies. Farmers work by trying everything, in many combinations, to find what works best to adapt plants and seeds for their own growing conditions. These missing materials are their potter's clay.

It is easy to miss the old days when Norman Borlaug routinely shared breeding lines with colleagues in the US and would wander into Asia with new seeds in his pocket and ask local scientists and farmers to try them out, and we at the Rockefeller Foundation are not exempt from nostalgia. But a return to those days is not possible -- nor, actually, is it desirable. Many of the new technologies need regulation, as well as farmer and consumer education, and it would not be a good idea to have them too casually available. But in today's global markets, ownership rights and liability concerns have perhaps gone too far the other way and made access too difficult. The multinational corporations that own the seeds understandably want to maximize profits from their sales. But poor farmers need to save money, for instance by saving seed from this year's crop to replant next year. Today, seed companies sue US farmers for doing that. In Africa, local seed companies, too, need to profit from selling seeds, but are better able to serve the needs of small-scale farmers so that prices stay reasonable and competitive, local investment is stimulated, and off-farm employment is generated. Poverty and hunger cannot be met today by simply increasing the overall supply of food. We must pay attention to the many linkages between the developers of the technology and poor farmers.

It is a simple fact and a complicated tragedy that the present systems guiding research budgets, regulation, marketing, product liability, and other aspects of a modern industrial agricultural system do not take account of the needs of the poor countries. I am not hinting at dark conspiracies, nor am I seeking villains. Profit is not a dirty word; the private sector needs and is entitled to fair returns on its investments. It is just that there is no strong voice asking: "How will this new law, treaty, policy, or technology affect the poor?" None of us wants to see 4/5ths of the planet in misery -- and roughly 80% of the planet's people are poor, and most are farmers. Nor do we want to see food and agriculture follow the path of pharmaceuticals, where the private and public sectors locked horns and snorted at each other while the world watched. We've seen what happens. We know that is no way to run the world. What we need to do is combine the disparate interests – not "either/or" but "yes/and."

Getting good farm technology to poor farmers in a way that is responsible and sustainable will require that governments – rich and poor - change some of the framing assumptions of their systems, both domestic and international. The framework must expand to include the interests of poor countries and poor people as well as the concerns of the technology providers and users. The work that needs to be done by farmers, NGOs, civil society organizations, foundations, universities, local businesses, and big multinationals *can* take place in a framework that also protects and advances the interests of economic development and market growth generally.

The Foundation's New Initiatives

In this changed environment, Africa cannot rely on the work of public institutions alone. The expertise and resources of the private sector must be engaged. For these and other reasons, we at the Foundation came to believe that if the poor are to benefit from the best of new agricultural technologies, the private sector has to be enlisted. Therefore, the Rockefeller Foundation and its partners are developing two new

initiatives that build partnerships designed to connect companies and US universities more closely to the work for the future of Africa and its agriculture. These partnerships are designed to work within – not against - the new IPR systems, but they are also designed to address those parts of the systems that unfairly impede the poorer countries. The first part of that effort is to make sure that valuable science and technology does not get exclusively locked up in the future; the second is to make available what is needed that is already locked up.

The Public Sector IP Resource for Agriculture (PSIPRA). This initiative is an effort to make intellectual property developed by universities but patented or licensed by them available for public-sector humanitarian work. We are working on the PSIPRA with the McKnight Foundation, which also supports plant biotechnology research in developing countries, and with a number of major agricultural research universities, including California, Cornell, Michigan State, North Carolina State, Texas A&M, and Wisconsin. Universities like these have generated much of the intellectual property in crop biotechnology, but they have also entered into exclusive licensing agreements for this IP with the private sector. These agreements eliminate their ability to share their technologies for commercial use even for the poor with other public-sector institutions such as national and international research centers that are working on staple crops for developing countries.

For many of our public universities, the practice has also constrained their ability to use their research to produce specialty crops for commercial use to benefit the farmers of their own states – a mission that is part of their charters. There are dozens of new GM varieties of crops like strawberries, apples and lettuce in university greenhouses around the country, plants that can grow without pesticides, that would benefit both local farmers and the environment, and that were paid for with taxpayer dollars, but are not being brought to market. Neither the universities nor small companies have sufficient IP rights to commercialize them, and the companies that hold the rights are only interested in major crops like corn and soybean.

The irony is that, collectively, the universities have exclusively licensed to these companies the IP rights they themselves now need. The universities involved with our new initiative, PSIPRA, will promote licensing strategies that favor retention of some of the rights to their own technologies, while realizing a return on licensing the major market rights to the private sector. The licenses they grant will therefore no longer be exclusive. The universities would retain rights to use their technologies for humanitarian purposes, and also for the development of specialty crops for which markets are small and which do not compete with the large private companies. By maintaining a public database, PSIPRA will also provide information about technologies that are now available to the public sector. It could also explore IP pooling mechanisms designed to help scientists develop new crops that can truly reach those that are most in need.

The African Agricultural Technology Foundation (AATF) is our other new initiative. The AATF is an African-based, African-led institution, a facilitative organization that will operate by creating partnerships with existing organizations. The AATF will not be aimed primarily at distributing finished products such as new seed or chemicals. We see it as a focal point where Africans can access new materials and information on which technologies can be built. It is a way of giving very poor nations the tools to determine what new technologies exist in the public and private sectors, including but not limited to biotech; which ones are most relevant to their needs; how to obtain them and how to manage them; and how to develop nationally appropriate regulatory and safety regimes within which to introduce them. Right now, there is no opportunity for such experiential learning.

The AATF will transfer materials and knowledge, offering its partners access to advanced agricultural technologies that are privately owned by companies and other research institutions on a royalty-free basis. In exchange for access to these technologies, the AATF will identify partner institutions that can use them

to develop new crop varieties that are needed by resource-poor farmers, conduct appropriate biosafety testing, distribute seed to resource-poor farmers, and help create local markets for excess production. Most of the major international seed companies and the US Department of Agriculture have expressed a serious interest in working with the AATF to accomplish its goals. The AATF will provide the organizational stimulus to bring together the elements of the public-private partnerships. The existence of new technologies with great potential, not only for food security but also for income generation by resource-poor producers, and the willingness of companies to collaborate make this the right time to bring these elements together.

Let me give two models of the way we see the AATF working on the application of new technologies, supporting the simple to the more complex solution over time, building human capacity as the science progresses.

Healthier Banana Crops. Bananas are an extremely important food crop for many small, resource-poor farmers in sub-Saharan Africa. To prepare next year's crop, farmers cut off a sucker sprouting from the roots of the adult plant and replant it. If the adult is diseased, the offspring will be diseased. For example, the leaf fungus black sigatoka and the banana weevil routinely devastate the crops, and with them the food security of these small farmers. Traditional breeding has made little progress dealing with these three problems, so researchers turned to modern biotechnology. They employed tissue culture to propagate disease-free banana plantlets for planting, instead of the diseased vegetative cuttings from adult plants. Drawing on the success of companies in countries like South Africa, several sub-Saharan national research programs are now working to develop tissue culture facilities and to put in place mechanisms to deliver the plantlets to farmers.

At the same time, a laboratory in Belgium, in collaboration with the Uganda National Agricultural Research Organization (NARO) and Makerere University, is working on inserting genes that will enhance tolerance to black sigatoka and banana weevils. If successful, delivery of these new resistant varieties will be greatly speeded by the existence of the tissue-culture facilities and delivery mechanisms that have already been established. Addressing all three problems successfully will increase banana [and plantain] production in some areas by 75%, providing not only food for the farmers and their families who depend on these crops, but also the possibility of generating income from sale of the excess production.[35]

Nutritionally Enhanced Cereal Grains. Major seed companies have successfully used both conventional breeding and biotechnology to improve the nutritional quality of cereal grains, i.e., new varieties with higher levels of bioavailable vitamins, iron and zinc. Their primary objective has been to increase the economic value of feed grain, but the same traits crossed into African cereals would improve human nutrition.[36] A more upstream partnership might simply involve giving African national breeding programs access to the vast databases and bioinformatics capacities of the companies. The AATF will not only take on the challenge of helping to make such deals, but also of making the deals work for poor African farmers once they are agreed to.

These are the sorts of unfolding applications of strategic technology together with development of a local capacity to manage it that the AATF will promote and guide.

[35] Progress Report of the National Banana Research Program (NBRP), National Agriculture Research Organization (NARO), Uganda, 2002.
[36] Bouis, H.E., 2002. Plant breeding: a new tool for fighting micronutrient malnutrition. *Journal of Nutrition* 32: 491S–494S.

Before I close, let me say that I am not here to "launch" the AATF. Although it has been incorporated, it will be launched in Africa, as it should be. I am here because it is the last month in Washington of the distinguished African agricultural scientist who will be its director, Dr. Eugene Terry, who is here with us today. Gene moves to Nairobi next month to set up the AATF's operational headquarters, in preparation for its official launch in September 2003, and I wanted to be with him to discuss our plans with policy people, NGOs and others in Washington before he leaves.

The AATF is an experiment. It is a novel approach to some of Africa's problems and it has its risks. But we believe the opportunities created by the amazing scientific progress of recent years are too great not to try to find ways of bringing the benefits of new science to African farmers and consumers.

It is our hope that the AATF will be a catalyst for the next agricultural revolution in Africa, not alone, but working in partnership with governments, companies, NGOs, the international agricultural research centers and other partners. It will work with the private sector owners of the essential intellectual property rights, and it will explore and encourage policy initiatives to support the technologies.

Finding the Future

Our two new initiatives are focused, in different ways, on adjusting the way intellectual property rights operate in connection with poor and developing countries – not on getting rid of IPR. They are focused on agricultural technology generally -- not on biotechnology or GM crops in particular. But neither do they rule these out, as developing-country governments develop the policies, expertise and infrastructure to manage them. What propels them both is our conviction that new combinations of public and private interests – a new "Both/And" – can change the future, for Africa and for the planet.

Do you recall a time when Western children were told to "pity the poor, starving Chinese," who were doomed to perpetual hunger and famine, with population growth set to forever outstrip food production? Now, however, Chinese farmers are on the cutting edge of agricultural biotechnologies and the country is exporting food. Do you remember hearing about "the poor, starving Indians," eternal hunger victims? Now, famine has been averted, and India is moving towards self-sufficiency in food. Both countries still have numerous poor and hungry people, but the numbers are decreasing rapidly.

I am certain that Africa is no more a permanently hopeless case than those two countries once appeared to be. But I am equally certain that its progression from so-called "basket-case" to bread-basket will not happen without investments from richer countries like the US – investments in science, policy changes, and money, investments that will pay vast returns in terms of the prevention of rogue states, civil wars, and exported violence. The goal of both our initiatives is to start this process moving and kick off the new Doubly Green Revolution.

Remember, it was the Nobel Peace Prize that Norman Borlaug won – not the Economics Prize.

Thank you.