The Unfinished Green Revolution—The Future Role of Science and Technology in Feeding the Developing World[1/]

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Introduction

I am now in my 57th year of continuous involvement in agricultural research and production in the low-income, food-deficit developing countries. I have worked with many colleagues, political leaders, and farmers to transform food production systems and overcome the doomsday predictions of the 1960s of impending worldwide famine. As a result of these efforts, food production has more than kept pace with global population growth. On average, world food supplies in 1998 were 24 percent higher per person than they were in 1961 and real prices are 40 percent lower (Pinstrup-Anderson *et al*, 1999). Despite these successes in there is no room for complacency on the food production and poverty-alleviation fronts.

Agriculture is the "art, science, and industry of managing the growth of plants and animals for human use" which has developed over the past 10-12 millennia. It has taken all that time to expand food production to the current level of about 5 billion gross tonnes per year. By 2025, we will not only have to reproduce the current harvest in its entirety each year, but also expand it by at least another 50 percent. This cannot be done unless farmers across the world have access to currently available high-yielding crop production methods as well as the new biotechnological breakthroughs, which offer great promise for improving the yield potential, yield dependability, and nutritional quality of our food crops, as well as in improving human health in general.

Extending Our Understanding of Nature

Almost all of our traditional foods are products of natural mutation and genetic recombination, which are the drivers of evolution. Without this ongoing process, we would probably all still be slime on the bottom of some primeval sea. In some cases, Mother Nature has done the genetic modification, and often in a big way. For example, the wheat groups we rely

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on for much of our food supply are the result of unusual (but natural) crosses between different species of grasses. Today's bread wheat is the result of the hybridization of three different plant genomes, each containing a set of seven chromosomes, and thus could easily be classified as transgenic. Maize is another crop that is the product of transgenic hybridization (probably of ***Teosinte*** and ***Tripsacum***).

As Andre and Jean Mayer so eloquently expressed in their excellent essay, "Agriculture, The Island Empire" (Daedulus, 1974), "When human beings first learned the cycle of plants, they were scientists. As they learned when and how to plant, in what soil, and how much water each crop needed, they were extending their understanding of nature." Several hundred generations of farmers have accelerated genetic modification through recurrent selection of the most prolific and hardiest plants and animals. To see how far the evolutionary changes have come, one only needs to look at the 5,000-year old fossilized maize cobs found the caves of Tehuacan in Mexico, which are about 1/10th the size of modern maize varieties. Over the past 100 years or so, scientists have been able to apply a growing understanding of genetics, plant physiology, pathology, and entomology to accelerate the process of combining high genetic yield potential with greater yield dependability under a broad range of biotic and abiotic stresses.

Bringing Science-Based Agriculture to the Developing World

The term "Green Revolution" was coined in 1968 by the late William S. Gaud, Director of the United States Agency of International Development (USAID), to describe the breakthrough in food production caused by the introduction and rapid diffusion of the new semidwarf wheat and rice varieties in Asia. Many initial reporters chose to depict the Green Revolution as the wholesale transfer of technology from high-yield agricultural systems to peasant farmers in the Third World. To me, however, it signified a new era in which agricultural science was used to produce technologies appropriate to conditions of developing country farmers.

Green Revolution critics have tended to focus too much on the high-yielding semidwarf wheat and rice varieties, as if they alone can produce miraculous results. Certainly, modern varieties can shift yield curves higher due to more efficient plant architecture and the incorporation of genetic sources of disease and insect resistance. However, modern varieties can only achieve markedly higher yields over traditional varieties if systematic changes in crop management are made, such as in dates and rates of planting, fertilization, water management, and weed and pest control. This holds equally true for transgenic varieties. Moreover, many crop management changes must be applied simultaneously if the genetic yield potential of modern varieties is to be realized. For example, higher soil fertility and greater moisture availability for growing food crops also improves the ecology for weed, pest, and disease development. Thus, complementary improvements in weed, disease, and insect control are also required to achieve maximum benefits.

Over the past four decades, sweeping changes have occurred in the factors of production used by farmers. Let's take the case of Developing Asia (Table 1). High-yielding semi-dwarf varieties are now used on 84 and 74 percent of the wheat and rice area, respectively; irrigation has more than doubled—to 176 million hectares; fertilizer consumption has increased more than 30-fold, and now stands at about 70 million tonnes of total nutrients; and tractor use has increased from 200,000 to 4.6 million units. As a result, rice and wheat production has increase from 127 million tonnes to 762 million tonnes (FAOSTAT, 2001).

Table 1. Changes in Factors of Production in Developing Asia

	Modern varieties			**Fertilizer Nutrient**	
	Wheat	**Rice**	**Irrigation**	**Consumption**	**Tractors**
	M ha / % Area		**Million ha**	**Million tonnes**	**Millions**
1961	0 / 0%	0 / 0%	87	2	0.2
1970	14 / 20%	15 / 20%	106	10	0.5
1980	39 / 49%	55 / 43%	129	29	2.0
1990	60 / 70%	85 / 65%	158	54	3.4
1998	70 / 84%	100 / 74%	176	70	4.6

Source: FAOSTAT, April 2000 and authors' estimates on modern variety adoption, based on CIMMYT and IRRI data.

Agricultural intensification has not been free of negative effects on the environment or on social structures. However, I believe that the value of modern technology must be judged in the larger context of population growth. For example, population in Developing Asia has more than doubled—from 1.6 to 3.5 billion people between 1960 and 2000. What would have been the plight of the additional 1.9 billion people, had it not been for the Green Revolution technology? Although agricultural mechanization did displace field workers, I content that the benefits of an increased food supply and the steady decline in real cereal prices has resulted in far greater benefits to society.

Notwithstanding problems such as salinization, caused by poorly engineered and managed irrigation systems, and the pollution of some ground and surface water resources, caused in part by excessive use of fertilizers and crop protection chemicals, agricultural intensification has also helped to protect environmental resources. By increasing yields on the lands best suited to agriculture, world farmers have been able to leave untouched vast areas of land for other purposes. For example, had the global cereal harvest of 1950 still prevailed in 1998, instead of the 600 million hectares that were used for production, we would have needed nearly 1.8 billion ha of land of the same quality to produce the current global harvest (Figure 1), land that generally was not available, especially in highly populated Asia. Moreover, had more environmentally fragile land been brought into agricultural production, the impact on soil erosion, loss of forests, grasslands, and biodiversity, and extinction of wildlife species would have been enormous.

Despite the successes of the Green Revolution, the battle to ensure food security for hundreds of millions of miserably poor people is far from won. Mushrooming populations, changing demographics, and inadequate poverty intervention programs have eaten up many of the food production gains. In particular, South Asian countries have not done as good a job as they should have in using increased food supplies to combat poverty and malnutrition. China, on the other hand, has done a much better job. Nobel Economics Laureate, Professor Amartya Sen, attributes the greater success in China in reducing poverty and malnutrition—as compared to India—to the greater priority given by the Chinese government to investments in rural education and health care services. With a healthier and better-educated rural population, China's economy has been able to grow about twice as fast as the Indian economy over the past two decades and today China has a per capita income nearly twice that of India.

In other parts of the developing world, especially in much of sub-Saharan Africa and in the remote highland areas of Asia and Latin America, Green Revolution technologies have yet to reach most farmers. This is not mainly because—as some contend—that the technologies themselves are inappropriate. Our Sasakawa-Global 2000 agricultural program has helped small-scale farmers in 14 African countries to grow more than one million demonstration plots—ranging in size from 0.1 to 0.5 ha—in maize, sorghum, wheat, cassava, rice and legumes. Virtually without exception, yields on these plots are two-to-three times higher than national averages.

Africa's main barrier to agricultural intensification is that it has the highest marketing costs in the world. Efficient transport is needed to facilitate production and enable farmers to bring their products to markets. Finding better ways to provide effective and efficient infrastructure in sub-Saharan Africa will underpin all other efforts to reduce poverty, improve health and education, and secure peace and prosperity.

The failure of Third World governments and international development organizations to invest adequately in agricultural and rural economies is hard to understand, especially since history should have taught us that no nation has been able to reduce poverty substantially and bring about economic development without first sharply increasing productivity in its agricultural and food systems. Indeed, as Professor Gordon Conway argues, we will need a "Doubly Green Revolution" in the 21st Century if a more humane existence is to be assured for all who come into this world.

Luckily, improvements in crop productivity can be made all along the line—in tillage, water use, fertilization, weed and pest control, and harvesting. Both conventional breeding and biotechnology research will be needed to ensure that the genetic improvement of food crops continues at a pace sufficient to meet the needs of the 8.3 billion people projected in 2025. In addition, more fertilizer will be required, especially in sub-Saharan Africa, where only around 10 kilograms of nutrients are used per hectare for food production, compared to rates 10-20 times higher in most of Developing Asia and the Industrialized nations.

It is only since WWII that fertilizer use, and especially the application of low-cost nitrogen derived from synthetic ammonia, has become an indispensable component of modern agricultural production (nearly 80 million nutrient tonnes of nitrogen are now consumed annually). Professor Vaclav Smil of the University of Manitoba, who has studied nitrogen cycles for most of his professional life, estimates that 40 percent of world's 6 billion people are alive today thanks to the Haber-Bosch process of synthesizing ammonia (Smil, 2000). It would be impossible for organic sources to replace this amount of nitrogen, no matter how hard we might try.

What to Expect from Biotechnology?

In the last 20 years, biotechnology based upon recombinant DNA has developed invaluable new scientific methodologies and products in food and agriculture. This journey deeper into the genome—to the molecular level—is the continuation of our progressive understanding of the workings of nature. Recombinant DNA methods have enabled breeders to select and transfer single genes, which has not only reduced the time needed in conventional breeding to eliminate undesirable genes, but also allowed breeders to access useful genes from other distant species. So far, these gene alterations have conferred producer-oriented benefits, such as resistance to pests, diseases, and herbicides. Other benefits likely to come through biotechnology and plant breeding are varieties with greater tolerance of drought, waterlogging, heat and cold—important traits given current predictions of climate change. In addition, many consumer-oriented benefits, such as improved nutritional and other health-related characteristics, are likely to be realized over the next 10 to 20 years.

Despite the formidable opposition in certain circles to transgenic crops, commercial adoption by farmers of the new varieties has been one of the most rapid cases of technology diffusion in the history of agriculture. Between 1996 and 1999, the area planted commercially to transgenic crops has increased from 1.7 to 39.9 million hectares (James, 1999). Preliminary estimates for 2001 indicate that the area planted to transgenic plants could increase to 43-44 million hectares.

Ironically, it is farmers and consumers in the low-income, food-deficit nations who have most needed these new agricultural biotech products, since they can reduce production costs per unit of output, which can benefit farmer incomes, while increasing the availability and accessibility of food, so important for reducing poverty. Moreover, since the technology is packed into the seed, biotech products can help to simplify input delivery, often a major bottleneck in reaching smallholder farmers. But instead, the battle over biotech products is being fought mainly in the rich nations, whose governments collectively subsidize their very small farming populations to the tune of $350 billion per year and where many of the major problems of human nutrition are related to obesity.

Agricultural research and development today is primarily driven by private sector investment. Thus we are told that the fastest way is to get a new technology to poor people is to “speed up the product cycle” so that the technology can spread quickly, first among rich people and later among the poor. While these diffusion dynamics may well be the case, I believe that the private life science companies need to establish concessionary pricing now in the low-income countries so that poor farmers can also benefit from the new GM products. In addition, I believe that the large transnational companies should share their expertise with public research institutions and scientists concerned with smallholder agriculture, and form partnerships to work on crops and agricultural problems not currently of priority interest in the main transnational markets.

Beyond the food, feed and fiber production benefits that can be forthcoming through biotech products, the possibility that plants can actually be used to vaccinate people against diseases such as hepatitis B virus or Norwalk disease, which causes diarrhea, simply by growing and eating them, offers tremendous possibilities in poor countries. This line of research and development should be pursued aggressively, and probably through private-public partnerships, since traditional vaccination programs are costly and difficult to execute.

Of course, Third World nations must put into place reasonable regulatory frameworks to guide the development, testing and use of GMOs, both to protect people and the environment. In addition, the intellectual property rights of private companies also need to be safeguarded to ensure fair returns to past investments and to encourage greater investments in the future.

Standing Up to Anti-Science Zealots

Although there have always been those in society who resist change, the intensity of the attacks against GMOs by certain groups is unprecedented, and in certain cases, even surprising, given the potential environmental benefits that such technology can bring in reducing the use of crop protection chemicals. It appears that many of the most rabid crop biotech opponents are driven more by a hate of capitalism and globalization than by the actual safety of transgenic plants. However, the fear they have been able to generate about of biotech products among the public is due in significant measure to the failure of our schools and colleges to teach even rudimentary courses on agriculture. This educational gap has resulted in an enormous majority, even among well-educated people, who seem totally ignorant of an area of knowledge so basic to their daily lives and indeed, to their future survival. We must begin to address this ignorance without delay—especially in the wealthy urban nations—by making it compulsory for students to study more biology and to understand the workings of agricultural and food systems.

The current debate about transgenic crops in agriculture has centered around two major issues—safety and concerns of access and ownership. Part of the criticism about GMO safety holds to the position that introducing "foreign DNA" into our food crop species is unnatural and thus an inherent health risk. Since, all living things—including food plants, animals, and microbes—contain DNA, how can we consider recombinant DNA to be unnatural? Even defining what constitutes a "foreign gene" is also problematic, since many genes are common across many organisms. Obviously, it does make sense for GM foods to carry a label if the food is substantially different from similar conventional foods. This would be the case if there is a nutritional difference, or if there is a known allergen or toxic substance in the food. But if the food is essentially identical to regular versions of the same food, what would be the utility? To me, this would undermine the central purpose of labeling, which is to provide useful nutritional or health-related information to allow consumers to make "informed" choices.

On the environmental side, I find the opposition to the transgenic crops carrying the ***Bacillus thuringiensis*** **(Bt)** gene to be especially ironic. Rachel Carson, in her provocative 1962 book, ***Silent Spring***, was especially effusive in extolling the virtues of Bt as a "natural" insecticide to control caterpillars. But anti-GMO activists have decried the incorporation of the Bt gene into the seed of different crops, even though this can reduce the use of insecticides and is harmless to other animals, including humans. Part of their opposition is based upon the prospect that widespread use of Bt crops may lead to mutations in the insects that eventually will render the bacterium ineffective. This seems incredibly naïve. We can be quite sure that the ability of a particular strain of ***Bacillus thuringiensis*** to confer insect resistance inevitably will break down, and this is why dynamic breeding programs—using both conventional and recombinant DNA techniques—are needed to develop varieties with new gene combinations to keep ahead of mutating pathogens. This has been the essence of plant breeding programs for more than 70 years.

In the United States, at least three Federal agencies provide scrutiny over the safety of GMOs—the US Department of Agriculture (USDA), which is responsible for seeing that the plant variety is safe to grow; the

Environmental Protection Agency (EPA), which has special review responsibilities for plants that contain genes that confer resistance to insects, diseases, and herbicides; and the Food and Drug Administration (FDA, which is responsible for food safety. The data requirements imposed upon biotechnology products are far greater than they are for products from conventional plant breeding, and even from mutation breeding, which uses radiation and chemicals to induce mutations. But we must also realize, there is no such thing as "zero biological risk." It simply doesn't exit, which makes, in my opinion, the enshrinement of "precautionary principle" just another a ruse by anti-biotech zealots to stop the advance of science and technology.

There is no reliable scientific information to date to substantiate that GMOs are inherently hazardous (ACSH, 2000). Recombinant DNA has been used for 25 years in pharmaceuticals, with no documented cases of harm attributed to the genetic modification process. So far, this is also the case in GM foods. This is not to say that there are no risks associated with particular products. There certainly could be. But we need to separate the methods by which GMOs are developed—which are not inherently unsafe—from the products, which could be if certain toxins or allergens are introduced.

There certainly have been errors in the GMO certification process. A recent example was the "restricted" approval in the United States by the EPA of a Bt maize hybrid, Starlink, for use only as an animal feed because of possible allergenic reaction that this strain of Bt might have in humans. EPA granted this approval knowing full well that marketing channels did not exist to segregate maize destined for animal feed from that destined for human consumption. As a result, Starlink maize got into various corn chips and taco shells, and undermined public confidence. Lost in the furor, however, is the fact that there is probably little reason to believe that the maize was actually unsafe for human consumption—only an unsubstantiated fear that it might cause allergic reactions.

A second controversial aspect of transgenic varieties involves issues of ownership and access to the new products and processes. Since most of GMO research is being carried out by the private sector, which aggressively seeks to patent its inventions, the intellectual property rights issues related to life forms and to farmer access to GM varieties must be seriously addressed. Traditionally, patents have been granted for "inventions" rather than the "discovery" of a function or characteristic. How should these distinctions be handled in the case of life forms? Moreover, how long, and under what terms, should patents be granted for bio-engineered products?

The high cost of biotechnology research also appears to be leading to a rapid consolidation in the ownership of agricultural life science companies. Is this desirable? I must confess to uneasiness on this score, and believe that the best way to deal with this potential problem is for governments to ensure that public sector research programs, geared to produce "public goods," are also adequately funded, to help ensure that farmers and consumers cannot become hostages to possible private sector monopolies. Unfortunately, during the past two decades, support to public national research systems in the industrialized countries has slowly declined, while support for international agricultural research has dropped so precipitously to border on the disastrous. If these trends continue, we risk losing the broad continuum of agricultural research organizations—public and private and from the more-basic to the more-applied and practical—which are needed to keep agriculture moving forward.

The past benefits of relatively unfettered international germplasm exchange have been enormous. Two examples illustrate this point. Organized international germplasm exchange and testing only began in the early 1950s, in response to a devastating stem rust epidemic in wheat in North America, caused by race 15 B, to which all commercial varieties were susceptible. Faced with this crisis of epidemic proportions, the departments of agriculture in the United States and Canada appealed to other research programs in the Americas, to exchange a broad range of their best early- and advanced-generation breeding materials, and to test these materials at many locations simultaneously. The Mexican Government-Rockefeller Cooperative Agricultural Program with which I was associated, and several national agricultural research programs in South America, responded rapidly. Out of this initial effort, new sources of stem rust resistance were identified that have held up to this day. Indeed, no stem rust epidemics have occurred in the Americas in nearly 50 years.

Moreover, a new institutional innovation—international germplasm testing—was in the making. Coordination of these networks—involving national and international research organizations—has become a hallmark of the international centers supported by the Consultative Group on International Agriculture (CGIAR). International sharing of germplasm and information broke down the psychological barriers that previously had isolated individual breeders from each other, and led to the introduction of enormous new quantities of useful genetic diversity. It became accepted policy that individual breeders could use any material from these international nurseries, either for further crossing or for direct commercial release, as long as the original source was recognized. This led to the accelerated development of new high-yielding, disease- and insect-resistant varieties, and ushered in a golden era in plant breeding around the world.

Another major contribution of international cooperation has been the germplasm collection of native landraces pioneered in maize by the Mexican Government-Rockefeller Foundation agricultural program during the 1950s, with subsequent assistance from the U.S. National Academies of Science, and later the CGIAR centers and national agricultural research institutes. Today, the CGIAR seed banks contain much of the genetic diversity of the major food crops species, and are held in trust for the benefit of humankind. Without them, much of the biodiversity in many food crop species might have been lost by now. However, access to these germplasm collections is becoming increasingly restricted, often because of national interests driven by intellectual property rights considerations. This situation could affect all of the CGIAR centers. I understand that the International Potato Center (CIP) in Peru already has difficulty in obtaining permission from the national government to send the germplasm it develops to collaborating research institutions outside the country.

Opponents of biotechnology are now trying to convince Third World nations that their plant species are at risk of being stolen by the private sector gene prospectors—bio-pirates—and are recommending legal barriers to stop the flow of germplasm. This is unfortunate. Over the past 500-600 years, the concept of what constitutes “indigenous” germplasm has been greatly blurred. Maize, beans, groundnuts, cassava, potatoes, cocoa and peppers—to name only a few—were originally domesticated in the Americas and spread by explorers and traders throughout Europe, Asia and Africa. Rice, wheat, barley, oats, rye and peas spread from Asia to other continents, and sorghum, millet and coffee spread from Africa around the world. Thus, historically speaking, all nations are “bio-pirates” in one way or another. I say hooray for that, since this has brought tremendous diversity to our diets!

Closing Comments

The topics under consideration at the ***Seeds of Opportunity Conference*** are complex and contentious, and ones to which we don’t have full answers.

But, hopefully, a sufficient sense of goodwill and humanity will exist in current and future generations so that new forms of public-private collaboration come into being to ensure that all farmers and consumers worldwide will have the opportunity to benefit from the new genetic revolution. In this quest, we must take care not to confuse science with politics. So when scientists lend their names and credibility to unscientific propositions, what are we to think? Is it any wonder that science is losing its constituency? We must maintain our guard against politically opportunistic researchers, like the late T.D. Lysenko, whose pseudo-science in agriculture and vicious persecution of anyone who disagreed with him, contributed greatly to the collapse of the former USSR.

Thirty-one years ago, in my acceptance speech for the Nobel Peace Prize, I said that the Green Revolution had won a temporary success in man's war against hunger, which if fully implemented, could provide sufficient food for humankind through the end of the 20th century. But I warned that unless the frightening power of human reproduction was curbed, the success of the Green Revolution would only be ephemeral. I now think that the world has the technology—either available or well advanced in the research pipeline—to feed on a sustainable basis a population of 10 billion people. The more pertinent question today is whether the world's farmers and ranchers will be permitted access to the new technologies needed to meet the agricultural, food and nutrition challenges that lie ahead.

REFERENCES

American Council on Science and Health (ACSH). 2000. Biotechnology and Food. New York

James, Clive. 1999. Global Review of Commercialized Transgenic Crops. International Service for the Acquisition of Agri-Biotech Applications (ISAAA). Brief No.12 Preview. ISAAA: Ithaca, NY.

Pinstrup-Anderson, R, R. Pandya-Lorch and M. Rosegrant. 1999. "World Food Prospects: Critical Issues for the Early 21st Century." 2020 Food Policy Report. Washington, D.C.: IFPRI

Mayer, Jean and A. Mayer. 1974. Agriculture, The Island Empire. Daedulus. Vol 103, No. 3, pp 83-96

Smil, Vaclav. 2000. Feeding the World—A Challenge for the 21st Century. The MIT Press: Cambridge, Massachusetts.

The Green Revolution: An End of Century Perspective. R.E. Evenson Douglas Gollin*. Modern plant breeding originated in the late 19th century, drawing on techniques of selection and. crossing.Â developing world, a consensus emerged that the international community could play a useful role in encouraging the application of modern plant breeding technologies to the problems of poor countries. The development of modern crop varieties (MVs) for developing countries began in a concerted fashion in the late 1950s, using conventional plant breeding methods. The term â€œGreen Revolutionâ€ entered the popular literature in the mid-1960s when modern or high-yielding varieties of rice and wheat were developed and released to farmers in Latin America and Asia. A detailed retrospective of the Green Revolution, its achievement and limits in terms of agricultural productivity improvement, and its broader impact at social, environmental, and economic levels is provided. Lessons learned and the strategic insights are reviewed as the world is preparing a â€œreduxâ€ version of the Green Revolution with more integrative environmental and social impact combined with agricultural and economic development. Core policy directions for Green Revolution 2.0 that enhance the spread and sustainable adoption of productivity enhancing technologies are specified. global p The first Green Revolutionâ€”as developed in Mexico and then in South Asia in the 1960sâ€”succeeded in improving yields in the breadbasket regions where it was implemented.4 But it sometimes came at a high social and environmental cost, including the depletion of soils, pollution of groundwater, and increased inequalities among farmers.5 And the productivity gains were not always sustainable.Â Roots of the Future: The New Agricultural Paradigm. A few decades ago, agronomists were faced with a sharp increase in pest outbreaks in modern monocultures, while ecologists were starting to model the complex interactions between insects and plants.Â strongly advocated the increase of agroecological science and practice.18 Future technology: 22 ideas about to change our world. Save 52% when you subscribe to BBC Science Focus Magazine.Â Researchers believe the technology could be particularly helpful in diagnosing lymphoma, reducing patient anxiety as they await their results. At present, people with suspected lymphoma often have to provide a sample of cells, followed by a biopsy of the node to be carried out for a full diagnosis, a process which can be time consuming.Â Originally developed for blind people, itâ€™s a label that starts out smooth to the touch but gets bumpier as food decays. And since it decays at the same rate as any protein-based food within, itâ€™s far more accurate than printed dates. 17. Green technology is the application of green chemistry, environmental monitoring, environmental science, and different technological processes that are all directed toward environmental protection. This term also describes sustainable energy production technologies â€“ including wind turbines, photovoltaics, solar panels, bioreactors, recycling, autonomous vehicles, etc.Â These efforts led to increased agricultural production worldwide, particularly in developing countries. The â€œFather of the Green Revolution,â€ Norman Borlaug, is the man who started the green revolution, for which he received the Nobel Peace Prize in 1970. He is also recognized for saving over a billion people from starvation, thanks to his involvement in development of many green technologies.