A Recipe for a Sustainable Future, Part I

Will our children and grandchildren inherit a world that has adequate food and clean energy resources to offer quality of life? Anyone who offers an affirmative answer to that question must grapple with three thorny issues which threaten to reduce quality of life in the future:

1) Finding abundant clean energy to replace dwindling fossil fuels;
2) Bringing our world's population down to a long term sustainable level;
3) Slowing climate change.

My own perspective on the subject of sustainability has been influenced by my childhood experiences in the 1950s farming with my dad along the southernmost reaches of the Red River in South Dakota, one mile from the North Dakota border. Later on, my graduate school majors in plant physiology and microbiology, plus a teaching specialty in immunology, provided unique additional dimensions for developing my position.

My answer to the question posed at the outset of this essay involves both a look at agricultural practices and also at energy resources and polices; in this issue of *Agora*, however, I will focus primarily on the role of modern agriculture and food production in sustaining the our economy and our lifestyle. In Part II of this essay, which will appear in the next issue, I will concentrate on energy use and resources. The two subjects, however, are inextricably bound together, so I need to introduce them both.

Two schools of thought have developed on the issue of how to proceed after fossil fuels. We will review some of the details from both schools. One we will dub the "soft energy" approach and the other the "high energy" approach. The "soft energy" approach relies on renewable energy sources and conservation to meet our future energy needs. One of the leaders of those who recommend "soft energy" as the way to a sustainable future is Amory Lovins. Others I will mention below whose views cluster near those of Lovins include Paul Erlich, Dennis L. Meadows, George Mobus, Jeremy Rifkin, and Walter Youngquist.

Paul Ehrlich, author of the bestseller, *The Population Bomb* (1968) predicted a major starvation event before 1985, and is also in the soft energy camp. The catastrophe he predicted didn't happen because Norman Borlaug's Green Revolution prevented the loss of millions of lives to famine. In the May/June 1978 issue of the *Federation of American Scientists Public Issue Report*, Ehrlich, apparently still pessimistic, wrote: "Giving society cheap, abundant energy … would be the equivalent of giving an idiot child a machine gun."

In contrast to Lovins and Ehrlich's soft energy approach, Stewart Brand, the environmentalist who produced the *Whole Earth Catalog*, advocates a "high energy" approach. He describes his view as that of an "Ecopragmatist."

The Ecopragmatist shuns romantic notions that modern society might be guided back to an era when people lived simpler lives, or that a vastly less consumption-oriented world is possible. Instead he seeks real, high-capacity solutions to environmental challenges—such as nuclear power—which history has shown to be reliable. It is interesting to note that Paul Ehrlich was Stewart Brand's graduate school major professor and mentor. In spite of their differences on energy, Brand holds Ehrlich in highest esteem.

While I find areas of agreement with the soft energy crowd, simply stated my recipe for a sustainable future is to supply our world's energy needs with nuclear energy and our world's food production with biotechnology-based agriculture—in other words crops that include GMOs (genetically modified organisms). The most essential ingredients in this recipe are faith in education and human ingenuity and trust in science and technology.

by **JOHN TJOSTEM**

John is a Concordia graduate and earned his MS in microbiology and PhD in botany with a focus on plant physiology from North Dakota State. He taught his first classes at Luther in 1962 and became professor emeritus of biology in 2000. He regularly taught microbiology, cell biology, and immunology and conducted research on well water contamination and on cellulosic ethanol production from alfalfa.

Peak Oil

A few years ago I visited a museum in the DeSoto National Wildlife Refuge, located in Missouri Valley, Iowa, that houses 200,000 items salvaged from the wrecked steamboat *Bertrand*. The *Bertrand* sank in the Missouri River in 1865. Mud which was made anaerobic by bacteria soon covered over the vessel preserving its cargo from oxidation. The steamship's location remained a mystery for 104 years until it was rediscovered in 1969. In the museum displays, I was struck by a collection of

ornate whale oil lamps and a shelf which contained several rows of delicate glass oil lamp chimneys (Fig. 1). Whale oil lamps were used by rich folks. The common herd got along with dim light from tallow candles. Kerosene lamps came into use a few years after the *Bertrand* accident, sometime during the last quarter of the nineteenth century.

The first oil well in our country was dug in 1859. Since there was little demand for petroleum, the first refinery was not built for many years and when it was built the main product was kerosene for lamps—gasoline was burned off. The advent of kerosene saved a lot of whales, since until the new fuel came into use, their oil was the much sought after product of the whaling industry.

Petroleum played a major role in transforming America into an industrial giant. The abundance of cheap energy brought us unimaginable prosperity. However, within one hundred years of the first kerosene distillation U.S. domestic crude oil production had peaked.

In the fifties, M. King Hubbert compared the annual new oil discoveries to the amount of investment in oil exploration. Hubbert's basic assumption was that the discovery of oil would follow a bell curve. When half of the deposits have been discovered the amount oil discovered in the future would follow a downward sloping curve resulting in ever smaller annual amounts of new oil finds. In the 1950s his prediction that peak oil would occur in the USA in 1970 was borne out in fact and the drop off progressed as predicted. Today domestic oil production continues to fall, forcing us to import a majority of our petroleum from foreign sources.

Hubbert also predicted a world petroleum peak between 2005 and 2015. Peak oil and rapidly growing economies in China and India portend continuing price hikes.

In his 1956 paper, Hubbert saw nuclear energy as the primary long-term energy solution after the decline of fossil fuels. He seemed to suggest that wind, solar, and biofuels would basically act as fossil fuel extenders and would not remain beyond the time those fossil fuels last.

Debates on Sustainability of Economic Growth

In the early 1970s Hubbert's peak oil prediction aroused a discussion that continues today on finding our way forward after petroleum. A split in public opinion on the issue of sustainability of economic growth soon opened. One school of thought was influenced by an essay on population published by Reverend Thomas Malthus in 1798. "I say," wrote Malthus, "that the power of population is indefinitely greater than the power in the earth to produce subsistence for man. Population, when unchecked, increases in a geometrical ratio."

Neo-Malthusian school, which overlaps with the soft energy proponents, rejects the growth model for a sustainable economy, claiming that using sustainability and growth in the same sentence is an oxymoron. They assert that modern agriculture will literally run out of gas due to fossil fuel depletion. They offer intermittent and diffuse renewable energy from wind/solar sources plus conservation measures as alternative energy sources to replace fossil fuels. They concede that the prosperous lifestyles made possible by abundant energy from fossil fuel cannot be maintained with their proposed energy

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Fig. 1. Whale oil lamps salvaged from the steamboat Bertrand *which sank in the Missouri River in 1865.*

sources. Out of fear they reject any energy source capable of fully replacing fossil fuels. They believe that modern society would misuse an abundant energy source and over-tax our mineral resources. They claim that modern agriculture will fail not only from a lack of affordable petroleum but also from a lack of chemical fertilizer, especially potassium and phosphate.

A number of influential people hold this neo-Malthusian viewpoint. Amory Lovins, who was named by *Time* as one of the world's one hundred most influential people said in a *Mother Earth - Plowboy* interview, Nov/Dec, 1977: "We ought to be looking for energy sources that are adequate for our needs, but that won't give us the excesses of concentrated energy with which we could do mischief to the Earth or to each other." Jeremy Rifkin, who *Time* magazine called "the most hated man in science," but who nevertheless has a wide following and exercises genuine influence in stemming acceptance of the application of molecular genetics principles in public policy debates wrote: "The prospect of cheap fusion energy is the worst thing that could happen to the planet."

In 1972 Dennis L. Meadows co-authored a publication commissioned by The Club of Rome, *Limits to Growth,* which claims to be the most circulated environmental book ever. Meadows makes this assertion: "The basic mode of the world system is exponential growth of population and capital, followed by collapse." In the 2004 *Limits to Growth: The Thirty-year Update* the message has changed; Meadows explained: "Now we must tell people how to manage an orderly reduction of their activities back down below the limits of the earth's resources." Meadows' 2004 model continues the prediction that exhaustion of fossil fuels and minerals will cause industrial and agricultural output to crash after mid-century resulting in a famine causing billions of deaths by the end of this century.

George Mobus, Associate Professor of Computing and Software Systems, University of Washington, Tacoma wrote the following in the *Energy Bulletin*, July 2010: "Over the next twenty years the US and the world will need to transition from an industrial agriculture model to one based on permaculture and more organic, labor intensive approaches to growing food. Oil is going to decline, meaning that diesel fuels to run tractors and combines will become increasingly costly. And natural

gas, meaning fertilizers, will also go into decline. The era of agribusiness is coming to a close sooner than anybody might have imagined. And we are not prepared for what follows."

The potential exists for all the people of the world to industrialize and enjoy a first world's living standard for millennia to come.

The soft energy and neo-Malthusian proponents, such as Lovins, Rifkin, Meadows, George Mobus, and Greenpeace spokesperson, Jim Riccio, advocate lowering our energy input before fossil fuels run out. They favor moving the world population back onto the land with reliance on local food production. They reject modern agriculture which employs chemical weed control, commercial fertilizer, and genetically modified crops. Apparently, they do not share my trust in human ingenuity and science. Unfortunately, some environmental organizations and even universities buy into the soft energy anti-technology message and actively promote a gospel which limits energy options to renewable resources and energy conservation.

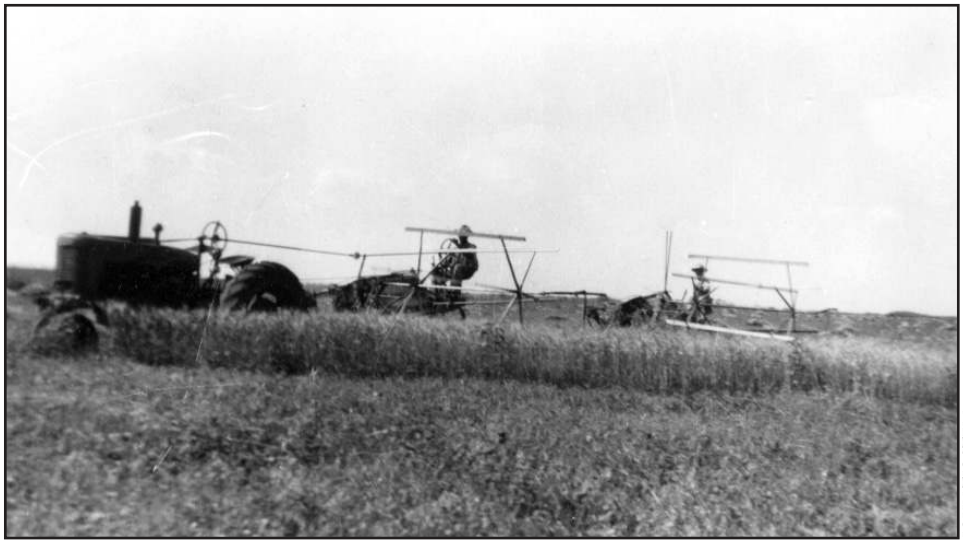
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Fig. 2. John Tjostem rides behind his father on the second binder in the late forties.

Our planet's mineral resources unlike fossil fuels are never used up. Recycling is the answer to continuing abundance. Our lithosphere is well endowed with the elements needed for plant nutrition. The potential exists for all the people of the world to industrialize and enjoy a first world's living standard for millennia to come. Given abundant energy, minerals should be recycled and also refined from seawater. Cheaper energy also makes lower quality ores affordable. But in the absence of energy even the richest mineral deposits are inaccessible.

While my heart may identify with some of the points made by the soft energy advocates, my head tells me their model is wrong. I was born in the mid 1930s and was a grade school kid during WW II. The world into which I was born and reared was one of drought, dust storms, economic depression, and scarcity, an era of labor shortage on the farm. I literally went from playing with my toys in the sandbox to riding the binder behind my father who guided the tractor remotely from where he sat on the first binder. When my leg was strong enough to trip the bundle carrier I was recruited to ride the second binder (Fig. 2). I recall a feeling of pride at being given the opportunity to do a man's work. Growing up while my parents and neighbors innovated their way through hardships and shortages was certainly a formative experience. Repeatedly, I was taught to defer gratification and I regularly saw the need of repair and continued use of what under other circumstances would be considered worn out goods. I have always found pleasure and even pride in innovating ways to repair and preserve utility. I especially find satisfaction in using ingenuity to transform an obsolete mechanism into another useful good. An electric motor replaced the washing-machine's the Briggs & Stratton engine when the REA came. I reduced the effort of pushing the reel-type lawn mower by mounting washing-machine engine on it. My innovation successfully transformed a push mower into a power mower that mowed our large farm lawn for several years (Fig. 3). I now reflect with satisfaction on the many times that I have used the skills and problem solving experiences acquired during my childhood.

The throwaway society is difficult to accept for one conditioned by events in the 1930s and war years of the 1940s. It is much more satisfying to repair and restore than to send a worn or broken appliance to the landfill and be assessed a humiliating fee, which communicates that this property is worse than worthless—it has been declared a liability that I must pay society to bury.

Why do so many of today's appliances remain "on" drawing electricity when not in use? Isn't that wasteful? I was taught that to waste is a sin.

Advances in Modern Agriculture

To meet projected shortfalls in food production and the catastrophes that would befall future generations, the soft energy folks advocate returning to a labor intense agriculture that is not dependent on fossil fuels. For example, Walter Youngquist, PhD Emeritus, Department of Geology, University of Oregon writes: "We inevitably face a future of less. The US population distribution in 2100 will look more like the rural geography of 1900 than like the urban geography of today."

I most certainly do not share Youngquist's position on agriculture. A bountiful food supply for the world that our grandchildren will inherit will require all the wonders that modern agriculture can produce. I see a return to low tech agriculture as a recipe for mass starvation. Also, I believe that bringing hordes of urbanites into rural areas would create an environmental disaster for our land resource. The worst con-

servation practices in the world are to be found wherever societies exist on low energy inputs. The "back to the land plan" such as Youngquist sketches would not promote zero population growth because agrarian societies benefit from child labor—a demand for larger families.


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Fig. 3. Teenage Tjostem with the lawnmower he ran with a washing machine engine.

Modern American agriculture is the most sustainable and the most environmentally friendly form of agriculture on the planet. My assertion, which draws plenty of flak from the sustainable agriculture and organic farming folks, is backed up here with facts and examples.

It may seem counter-intuitive that today's large scale farms and mega-sized farm tractors could be more fuel efficient than the farms of the 1970s or today's smaller organic farms. But it is true that modern farmers use less fuel per acre and much less fuel per bushel than in the 1970s. Efficiency gains help to reduce agriculture's dependence on oil. In the United States, the combined direct use of gasoline and diesel fuel in farming fell from its historical high of 7.7 billion gallons in 1973 to 4.2 billion in 2005—a decline of 45 percent. Broadly calculated, the gallons of fuel used per ton of grain produced dropped from 33 in 1973 to 12 in 2005, an impressive decrease of 64 percent. One reason for this achievement was a shift to minimum—and no till agricultural practices on roughly two fifths of US cropland. By the way, only 20 percent of the energy invested in our food is from farm energy input, which includes the energy invested in fertilizer and energy to operate irrigation pumps.

When I farmed with my dad in the mid 1950s before going away to college, commercial fertilizer was not applied on our farm or on most farms and chemical weed control was just beginning. Corn planters were equipped with a half mile spool of wire that was rolled out before planting commenced. The wire had knots spaced 42 inches apart. The corn planter dropped seeds at each knot. Corn hills thus grew out in checkerboard pattern making possible both lengthwise and crosswise cultivation for improved weed control. We cultivated our wire checked corn three times during the season and in the fall we plowed our fields with a moldboard plow. These tillage operations loosened the soil, causing inevitable water and wind erosion. Our corn yield of 40 bushels/acre was considered to be a good yield.

Today, the corn yield has tripled on this farm. No till and minimum till have replaced the plow. Monsanto's Roundup and Roundup Ready seeds have made possible the complete elimination of the corn cultivator. A sprayer with a 120 foot long boom replaces the two row cultivator. In the 1950s a net loss of soil was occurring. Today's agricultural practices can boast of actually building soil on much of the nation's farmland. Commercial fertilizer, plant breeding, and genetically modified crops (GMOs) have brought about abundant yields that are sufficient to feed our world's human population of 7 billion.

The fact that children go to bed hungry in this world is not because of food shortage, but rather because food distribution is not equitable. We cannot go back to the organic farming practices of 1900 or even the 1950s without causing massive starvation. The world population in 1900 was 1.6 billion and in 1950, 2.55 billion. World food production in 1960s was barely adequate for the world population of 3 billion people. Our world population today has just passed 7 billion. To go back would not only cause a shortage of food, but also a return to tillage practices which cause soil erosion. Agriculture that promotes soil erosion is not sustainable.

The Sprayer Replaces the Tiller

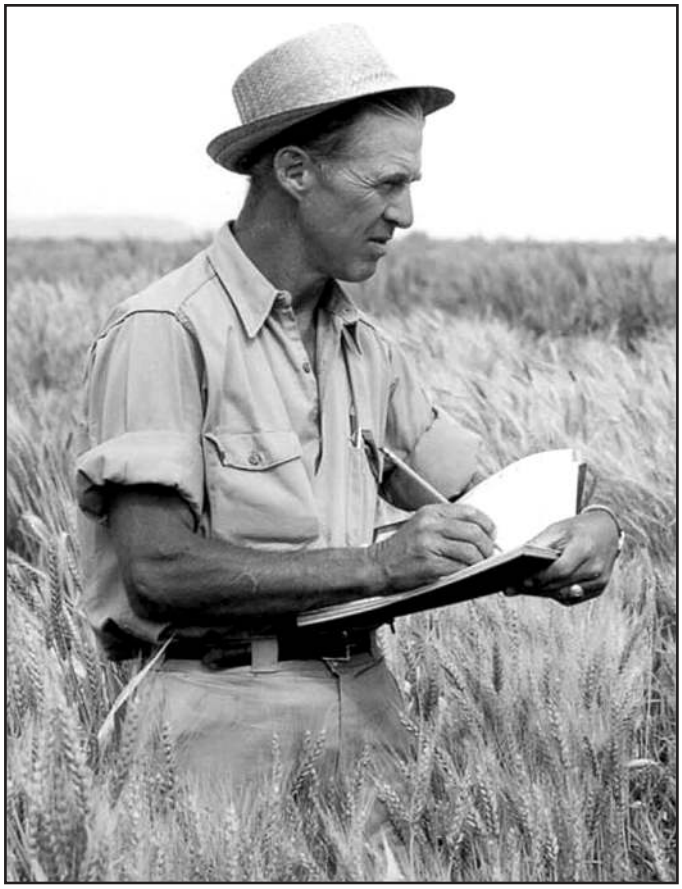
An estimated 70 percent of Iowa's farms evaluate soil fertility by taking multiple soil samples in a grid pattern from a plot of ground. Fertilizer spreaders that follow satellite guidance deliver differing levels of fertilizer to meet the varying soil fertility needs across the field. Satellite guidance also prevents the double application of fertilizer, chemicals, and seed by selectively turning off those nozzles that overlap previous paths of application. These high tech practices conserve resources and are environmentally friendly because they prevent over-application of fertilizer, chemicals, and seed.

Plant physiology and microbiology were my majors in grad school. I appreciate the great improvements in plant breeding and genetic engineering. Roundup and genetically engineered Roundup Ready seeds are a godsend. This completely safe, non-toxic technology has made possible a no till/minimum till agriculture which has greatly reduced soil erosion and even reversed soil loss.

Genetically Modified Crops

The tradeoff of the sprayer for the tiller is an important component to the success of modern agriculture. It is responsible for a more soil friendly and fuel efficient agriculture. Even so, there is strong political opposition to agribusiness, chemical companies, and corporate agriculture. The issue of trust and public acceptance of biotechnology has been highlighted by the debate over the acceptance of genetically modified (GM) technologies. *National Journal* magazine named Jeremy Rifkin one of the 150 people in the U.S. that have the most influence in shaping federal government policy for his "skillfully manipulated legal and bureaucratic procedures to slow the pace of biotechnology." There are many such politically motivated roadblocks in making ecopragmatic sustainability operational.

Genetically engineered—GM or GMO (genetically modified organisms)—crops are more efficient, giving higher yield on less land with less use of pesticides and herbicides. GMO crops are lifesaving breakthroughs for the developing world. Plants have been created that contain all the essential nutrients for human nutrition and GM seeds also make possible the tailoring of crops to specific local growing conditions.



AGRI LIFE, VIA WIKIMEDIA COMMONS

Fig. 4. Green Revolution icon and Nobel Peace Laureate Norman Borlaug.

It is a tragedy that well meaning "greens" from Europe have poisoned the minds of Africans against the use of GMO crops. According to Stewart Brand, the Greenpeace campaign is one of the causes of starvation for untold numbers of Africans. It is critical that advances in bioengineering be implemented in crops grown in areas of the world where human nutrition is an unfulfilled need.

Many fear that GMO crops are not safe. Truth be known, the food produced from GMO crops is safer than food from conventional crops. Plants have evolved in a highly competitive world. Evolution has endowed them with poisonous molecules to combat plant eating pests. Such crop plants may be toxic or they may cause serious allergies in humans.

In the 3.5 billion years that microorganisms have been around, they have likely evolved every possible chemical harmful to heath. On the other hand, there is really nothing to fear from GMO crops. The likelihood of the molecular biologist creating a harmful "Frankenfood" that contains a new or unique molecule is vanishingly small. On the contrary, GM seeds are required to pass tests to confirm that no harmful molecules are present in newly engineered crop varieties. They are much safer than varieties made by back crossing to wild type with conventional genetic breeding because unwanted genes often tag along with the sought after gene. GM seeds bring in only the sought after trait and they are subjected to extensive testing to verify safety.

Plants and insects have a long evolutionary history of intimate association. Over time they have traded lots of genes back and forth. Plant genomes contain insect DNA and insects carry loads of plant DNA. Likewise we humans share and trade genetic material with our microbial flora.

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Bacterial DNA is one of many sources used in making GM seeds. Knowledge that jumping genes in nature flit between widely different species should mute some of the negative connotations of GM seeds. The last week in August 2010 brought about two noteworthy developments in plant genetics—the sequencing of Chinese Wheat DNA and also the DNA of the Golden Delicious Apple.

Previously, agriculturists such as the late, great Norman Borlaug (Fig. 4) had to laboriously cross-breed varieties to develop new traits, such as the high-yielding dwarf wheat. Starting with eight seeds of dwarf wheat Borlaug completed 8156 cross pollinations. The dwarf wheat bred by Borlaug staved off famine for millions, perhaps billions. The world population in the 1960s was three billion and the agriculture was barely able to feed the population. Today our world's population stands at seven billion with a projection of nine billion by mid century. To prevent a catastrophic famine we must look beyond classical genetics to molecular biology for GMO's and associated technologies such as Roundup herbicide for use on crops planted with Round-Up Ready seeds.

Wheat rust should become a scourge of the past. I recall writing my freshman English term paper on race 15B wheat rust. Wheat, our main cash crop out on our South Dakota farm (Fig. 5), had been the victim of that fungus. I commuted from Concordia College to North Dakota State University library to research wheat rust in the *Journal of Phytopathology*. I also recall that the loss of the wheat crop did not dampen my Norwegian father's sense of humor. He teased my mother, who was the daughter of a Swedish immigrant, saying, "We have a crop of Swedish wheat—empty in the head."

My hope is that all farmers, including organic farmers, will take seriously this new biology and adopt GM seeds as they are engineered to efficiently produce the most nutritious and non-allergenic foods. At least one trait, added with molecular breeding of a gene from a wild strain of rice, has already been introduced in Asia and Africa. These new varieties of rice, called "scuba rice," because they resist flooding damage, are now being adopted in India, Bangladesh, and Southeast Asia. Each year, lowland floods in South Asia destroy four million tons of rice. Rice is a staple for more than three billion people.

Corn genes for C-4 photosynthesis are being researched for incorporation into rice. Special cells in corn store sun's energy for use in fixing carbon dioxide at night. This acquired efficiency could greatly increase the productivity of rice. Due to a dietary deficiency of vitamin A, childhood blindness is prevalent in Zambia. As a prevention for blindness, corn rich in vitamin A precursors is being targeted for release in Zambia by HarvestPlus.

Organic and other smaller scale farms are well positioned to market locally. Using local marketing saves fuel expended on long distance shipping. This niche becomes more important as fuel costs go up and it should be encouraged wherever locally grown food can be made available. However, with 50 percent of the world population living in cities and a projection of 80 percent by mid century, most people do not live near enough to avail themselves of a local farmer's market. Local marketing is not an solution for feeding the world population; rather it is like a bake sale for the purpose of funding a new school. It is a drop-in-the-bucket, but it gets people involved.

As a microbiologist, I know that microbes infect crops and impart toxins and carcinogens. If you opt for organically grown crops you take your chances with the microbial toxins and carcinogens. If you opt for crops produced by modern farms you expose yourself to agri-industry chemicals that have been applied to crops to control plant pests and parasites. It is probably a toss up, and it is a personal choice as to which method of crop production that you prefer for the food that you eat.

One concern that organic growers bring up is that open pollinated crops may get contaminated with GM crops. This is certainly possible and even when people try to be good neighbors and agree upon buffer strips it can happen. The complaint may be likened to that of the Model T owner who complains that the 45 mph freeway minimum is too fast for his vehicle. We may just have to live with GM crops. They play a vital role in providing human nutrition and in plant adaptation such as tolerance to a warmer climate. We have just begun to see the changes that will come from the plant engineers. My suggestion is to celebrate the new biology as we have done with Borlaug's Green Revolution.

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Fig. 5. Tjostem farmstead in the Red River Valley of South Dakota, c. 1950.

When I find continuing fear and mistrust of GM technology, effectively peddled by Rifkin et al., I recognize that science has to be promoted as much in the twenty first century as it was in the nineteenth century. One of the earliest defenders of science was Thomas Henry Huxley—known as "Darwin's bulldog." In 1860, a year after Darwin's *Origin of the Species* was published, Huxley's famous encounter with Archbishop Wilberforce occurred. The Bishop concluded his attack on evolution by asking Huxley whether his descent from the ape was on his father's side or his mother's side. As Alfred Noyes portrayed this moment in his long poem, *The Book of the Earth*,

> The lean tall figure of Huxley quietly rose.
> He looked, for a moment, thoughtfully, at the crowd;
> Saw rows of hostile faces, caught the grin
> Of ignorant curiosity; here and there,
> A hopeful gleam of friendship; and far back,
> The young swift-footed, waiting for the fire,
> He fixed his eyes on these—then in low tones,
> Clear, cool and incisive, "I have come here," he said,
> "In the cause of Science only."

A verbatim transcript of the exchange does not exist, but there is this from a letter written by Huxley: "If then, said I, the question is put to me would I rather have a miserable ape for a grandfather or a man highly endowed by nature and possessing great means and influence and yet who employs those faculties and that influence for the mere purpose of introducing ridicule into a grave scientific discussion—I unhesitatingly affirm my preference for the ape. Whereupon there was unextinguishable laughter among the people, and they listened to the rest of my argument with the greatest attention." (This account is reported in *Great Essays in Science*, ed. Martin Gardner.) Science was young and fighting for status in 1860.

The rapid pace of climate change brought on by greenhouse gases may lead to species extinctions rather than adaptation through evolution. The role for the genetic engineer is to speed up the process of biological evolution through production of GE crops. The genetic engineer will adapt plants genes to thrive in a warmer world. Some consider the genetic engineering to be tampering with Mother Nature. I would rather take the position that our Creator gave us an intellect and He expects us to use that gift to make a better world.

In Part II, which will appear in the spring 2012 issue of *Agora*, the topics I will address include the effect electric power on lifestyle, my glimmer of hope for achieving a zero population growth rate, and the replacement energy for fossil fuels. The debate over nuclear power will be a major focus. *Agora*