"Ronald and Adamchak's clear, rational approach is refreshing, and the balance they present is sorely needed in our increasingly polarized world."—*Science*

TOMORROW'S TABLE

Organic Farming, Genetics, and the Future of Food

PAMELA C. RONALD & RAOUL W. ADAMCHAK

Second Edition

OXFORD
UNIVERSITY PRESS

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Published in the United States of America by Oxford University Press
198 Madison Avenue, New York, NY 10016, United States of America.

First Edition published in 2008 (hardback)
First Edition published in 2010 (paperback)
Second Edition published in 2018

Library of Congress Cataloging-in-Publication Data
Names: Ronald, Pamela C., author. | Adamchak, Raoul W., 1953– author.
Title: Tomorrow's table : organic farming, genetics, and the future of food / Pamela C. Ronald, Raoul W. Adamchak.
Description: Second edition. | New York, NY, United States of America : Oxford University Press, 2018. | Includes bibliographical references and index.
Identifiers: LCCN 2017026975 | ISBN 9780199342082
Subjects: LCSH: Food—Biotechnology. | Organic farming. | Genetically modified foods. | Genetic engineering.
Classification: LCC TP248.65.F66 R66 2017 | DDC 664/.024—dc23
LC record available at https://lccn.loc.gov/2017026975

1 3 5 7 9 8 6 4 2
Printed by WebCom, Inc., Canada

Thirteen

Feeding the World Ethically

Pam

> The food movement—led by celebrity chefs, advocacy journalists, students, and NGOs—is missing, ironically, the perspective of the people doing the actual work of growing food. Their platform has been largely based on how to provide good, healthy food, while it has ignored the core economic inequities and contradictions embedded in our food system.
>
> Bren Smith, a shellfish and seaweed farmer on Long Island Sound[1]

Sanga Moses grew up in a Ugandan village without electricity, where food was scarce and children walked miles to search for wood for fuel. I met him in 2012 at an event where he was being honored for his innovative efforts at turning farm waste into fuel.[2]

"Uganda is predominantly agricultural. In my village, everyone has a farm. They grow food, mostly bananas. Enough to subsist," he told me. "My mother has been growing bananas on her farm for 20 years. Last year, she lost her whole banana crop to a disease. In just a couple months, her crop had turned into a black, wilted mess. It broke my heart."

His mother's bananas were infected with banana *Xanthomonas* wilt (BXW), a bacterial disease that seriously threatens banana production in Eastern Africa. The infection begins in the flowers, and yellow bacteria soon ooze from the cut stems, dooming the crop. Cutting off infected flowers provides some control, but during epidemics nothing helps. Out of the more than a thousand kinds of banana that can be found worldwide, none has robust resistance to banana *Xanthomonas* wilt.[3] Even if resistance were identified, most scientists think that breeding a new variety using conventional methods could take decades, which wouldn't help farmers like Sanga Moses' mother. Commercial banana varieties are seedless, making conventional breeding an especially difficult challenge.

Banana *Xanthomonas* wilt threatens the food security of some of the world's poorest people. Bananas and plantains are the fourth most important food crop after rice, wheat, and corn. Approximately one third of the bananas produced globally are grown in sub-Saharan Africa, where they provide more than 25% of the food energy requirements for more than 100 million people. Many banana diseases cannot be controlled by conventional agronomic methods, and subsistence farmers cannot afford most pesticides, which are in any case often ineffective or harmful to the environment. Researchers at the International Institute of Tropical Agriculture in Nairobi, Kenya,[4] are introducing genes from other plant species, such as rice[5] or sweet pepper,[6] to assess their roles in conferring resistance to banana *Xanthomonas* wilt.

"We need to figure out new ways to fight the disease. We need to find a solution that works." Sanga said. "If no one tries, nothing will change."

For anyone worried about the future of global agriculture, Sanga's story is both tragic and instructive. The world faces an enormous challenge: Food production needs to rise by 50% by 2050 in order to feed the growing population, which will expand from the current 7.6 billion to an estimated 9 or 10 billion by mid-century—the equivalent of adding the population of two Chinas.

Ensuring that farmers have the tools to produce and consumers have access to sufficient and nutritious food is a societal moral imperative. Although there is little debate about the need to farm effectively to feed the hungry, there are contested visions about what it means to do so ethically. Disagreements extend across the whole system, from appropriate strategies for production and distribution of food to its consumption.

In the fall of 2014, I participated in a meeting in Italy sponsored by the Johns Hopkins University Berman Institute of Bioethics and the Bloomberg School of Public Health to address these issues.[7] Our charge was daunting: identification of the core ethical issues that are critical to global food security.

On the first day of the meeting, I sat at a table in the hotel restaurant with agricultural economists, ecologists, sociologists, farmers, breeders, and nutritionists from around the globe. Collectively, we had devoted much of our careers to the study of sustainable food production, economic inequities in the food system, plant breeding, and the effects of pesticides on the health of farm workers and the environment.

At that moment, however, all eyes were on the steaming plate of short, thin, twisted pasta mixed with pesto that has just been placed at the center of the

table. I sat next to Dr. Ettore Capri, a researcher at the Institute of Agricultural Chemistry and Environment at the Università Cattolica del Sacro Cuore in Piacenza, Italy. "This pasta is called trofie," he explained. "It is a specialty of Genoa and is usually served with pesto. To shape the pasta, little pieces of dough are rolled and then twisted around knitting needles." He rotated his hands to show how his mother taught him to form the pasta.

He took a bite and frowned, clearly dissatisfied. "They did not store the basilica for the pesto in the right way," he said. "I will give you my recipe" (Recipe 13.1). Over dinner, I discovered that Ettore is an expert both on pasta and on the impact of agricultural chemicals on the environment.

Each of us heaped mounds of pasta onto our plates. "Watch out! The trofie is just the first course," said the woman next to Ettore, who introduced herself as Dr. Ruth Faden, the organizer of the meeting. She is the founder and former director of the Berman Institute and a senior research scholar at the Kennedy Institute of Ethics at Georgetown University.[8]

Ruth was right. As we spent the next hour getting to know each other, we were served two more courses and drank several local wines. This abundance prompted plenty of conversation around the table. "What do they do with all the food we don't eat?" Clare asked. Dr. Clare Narrod is an Assistant Research Scientist at the Joint Institute for Food Safety and Applied Nutrition at the University of Maryland. She has worked with economically disadvantaged farmers on six continents.

"I hate wasting food," she said. She then told us that in less developed countries, such as in sub-Saharan Africa and Southeast Asia, 20% to 50% of the food that is grown is lost before it reaches the table.[9] The waste is due to pests, diseases and environmental stress, inefficient harvesting, lack of transportation to markets, and poor storage. Often, there is no simple way to process the fresh food to extend its shelf life. Wasted along with the food are the energy, fertilizers, and water that have already been invested in its production.

In the developed world, the story is different. Forty percent of the food in Italy and the United States is wasted by retailers and consumers long after harvest. When food is wasted, carbon emissions associated with agriculture are wasted, too.[10] Supermarkets often reject perfectly edible fruits and vegetables because they do not match the size and appearance that consumers expect.[11] Canned goods that pass their "Sell-by" dates are discarded. How can it be ethical to throw away half of our food while others go hungry?

Ettore shared his strategy. "I adopted three stray dogs. If I can't finish the meal, I ask for a doggie box. This is a weird thing to do in Italy because not finishing your meal means you don't like the food. I apologize to the waiters

that I cannot clean my plate. I know that they made the food with care and want me to enjoy it."

"My approach is to feed our table waste to our 14 hens." I said. "We don't always finish our meals, but at least it gets recycled into eggs and fertilizer." Ettore and I look around the table waiting for help. We both know that our simple approaches will not solve the challenges faced globally with respect to food consumption and waste.

According to Dan Sumner, Distinguished Professor of Agricultural and Resource Economics at UC Davis, "Waste is defined as shifting something to a lower-valued use. So most would consider feeding perfectly good human food to hens very close to waste." Dan said, "In my house, I am the waste disposal, but if I gain 10 pounds, that is waste, too. If I have to run on a treadmill for an hour, are the food and my time wasted?" Dan's question raises a lot of issues about waste and value. Food is not just fuel; it is also eaten for enjoyment. Dan's extra 10 pounds and its consequences for him are the cost of enjoying his food. Is this waste? Maybe so if it affects his health.

After dinner, the discussion turned to the volatile topic of the ethics of eating meat. Human consumption of animal products puts huge and growing pressures on water, food, and land systems, and contributes to greenhouse gas emissions.[12] Some researchers have suggested that the three most important things consumers can do to cut their food carbon footprint is to reduce meat consumption, switch the type of meat consumed, and cut waste.[12]

The question posed to us was: Do humans need to eat any meat at all? Why not just live on plants? Livestock accounts for about 18% of global greenhouse gas emissions, including methane (CH_4) emissions from enteric fermentation (a process in which microbes in the rumen of cattle break down carbohydrates that are then absorbed into the bloodstream of the animal), nitrous oxide (N_2O) emissions from manure and fertilizer, and carbon dioxide (CO_2) emissions from conversion of forest and grassland to new cropland and agricultural energy use.[13]

Jessica Fanzo, Distinguished Associate Professor of Ethics and Global Food and Agriculture at the Berman Institute, told us, "It is much easier for high-income countries to give up animal protein than the rural poor, who are already nutrient deprived. The rich have lots of choices, and most do not need to worry about receiving sufficient nutrition. (Nevertheless, some consumers spend billions of dollars on supplementary pills they think will make them

healthier [see Box 8.3 in Chapter 8].) Jessica pointed out that the poor have limited access to a nutritionally varied selection of foods. Meals are mostly grain or tubers, which are lacking key nutrients such as zinc and iron (which are readily available in animal sources). Jessica remarks, "This is not healthy, particularly for young children who have high nutrient needs as they grow." Jessica has worked in sub-Saharan Africa, South Asia, and East Africa for more than a decade and has observed that increased consumption of meat and dairy products has significant positive impacts on the health of children.

Jessica's statements reminded me of my conversation with Veronique Bikoba, a scientist who grew up in the Democratic Republic of Congo. Veronique told me, "People in many developing countries are vegetarian, but not by choice. They are vegetarians because that is all they have. Most of the waste and pollution comes from developed countries, not the developing countries. If we look at how many cars a family has in the United States, we will understand part of the problem. Anyone bringing the idea of going vegetarian to people in developing countries is prone to failing and will meet resistance. I grew up in Congo, and we never wasted food or killed animals just for fun. We used them for a protein source. The problem is not meat consumption; it is the wasteful culture that needs to be addressed."

There are anthropological, sociological, and economic factors that are also ethical considerations. In the region of Italy where Ettore grew up, prosciutto, a dry-cured ham that is thinly sliced, is served at almost every meal, including breakfast. "Each of us has a food identity. It is our culture," he said. The idea of eliminating meat in the human diet is anathema to him and to many other cultures.

"Look at the history here in Italy," Ettore continued. "The food biodiversity here is the greatest in the world. We have built this biodiversity over 200 years. This is good. Others cannot change it. You cannot tell Italians to quit eating meat. Why do you feel better in your garden? Growing food and eating it is important, or if you cannot do that, connecting with farmers is important. Eating together is important."

My friend and colleague, Rashmi Jain, would agree. Rashmi is from India, a country with 300 million cattle—the most of any country in the world and three times the number in the United States.[14] The female cattle are valued for milk products, an important source of protein for the region's Hindus, who don't eat beef. Some of the males are put to work plowing fields, hauling cargo, or powering machines. Some are exported or sold locally to non-Hindus who will eat them.[15] However, others are left to wander, emitting millions of pounds of methane each year.[16]

"We see cattle roaming our roads. No one hurts them. We wait until they cross. We think it is a sin to kill a cow. We worship them like a mother," she told me.

On my last visit to India I saw cows chewing on plastic garbage, choking on exhaust, and walking through traffic. The worship Rashmi mentions comes with serious caveats! Partly because of their limited access to feed and partly due to their genetic makeup and other factors, milk production is low in Indian cattle. Low productivity means more methane is generated for each liter of milk produced.

In some places in the United States, there is renewed interest in allowing animals to graze in pastures. However, pasture-raised animals grow more slowly and take a longer time to reach maturity as compared to animals fed grain to get them to market weight. This intensive approach produces market-ready animals at a younger age than those raised in pasture grazing systems resulting in less GHG emissions per pound of beef. In this case the consumer is left with the choice of eating animals grown in pastures, which fits the pastoral ideal vs. those that have a lighter GHG emissions footprint. Which approach is more ethical?

One possibility we discussed was to sidestep the issue by switching from eating beef to eating chickens. Poultry and swine produce less methane—most of which originates from manure.[17] However, one drawback of switching from ruminants such as cattle to poultry is that more cropland would need to be devoted to feeding them because poultry eat cereals, whereas ruminants can use rangeland that is usually not suitable for arable food production.[18]

As the first day of the meeting wound down, Ettore suggested that those of us in the developed world could try to eat less animal protein. This struck me as a sound and ethical path forward. We cannot ignore culture, and we cannot ignore the needs of the poor and malnourished. It is unethical to ban particular foods, even if it were possible to do so. If raising or growing a particular food damages the environment, we can minimize the harm by reducing consumption and producing the food more efficiently. Skipping the breakfast prosciutto a few times a week would be a useful contribution. Another option would be for individuals to be vegetarians by day and carnivores by night.

Food was not always plentiful even when the Earth held half the population it does now. Seventy years ago, the poor in Italy were hungry, and in the 20th century, there were massive famines throughout Europe. The poor today are

faring better than just a few decades ago. But too many people are still suffering from hunger or malnutrition. It remains a moral imperative to continue to feed the poor. What are the alternatives? It is not ethical to reduce the population by starvation, and who would make that decision? It is also unethical *not* to do something about the problem.

There are huge differences between the needs of farmers who produce barely enough to feed their families and the needs of people with far more privilege who have many food choices. And there seems to be a disconnect between the average consumer who is far removed from agriculture and the skilled farmer who works hard to produce food. Consumers interact with a food environment—stores, schools, or a workplace in which they have to make decisions about food. This environment is part of the larger agribusiness-food system. It is highly influenced by industry and capitalism. This is not always a bad thing, but it is not always good either. The finery and comfort of our situation at this conference highlighted this stark contrast.

What I know is that food and agriculture are not binary. There is no simple "yes or no" answer that can solve our looming food challenges. It is fine for some of us to be vegetarians or vegans (who don't consume animal-derived meat, milk, or eggs), but according to Jimmy Smith, Director General of the International Livestock Research Institute, a global, public, and nonprofit partnership working for a food-secure future, no single dietary choice is the answer for achieving sustainable global development.[19]

Smith observed that researchers in the United States compared 10 eating patterns and concluded that diets incorporating some animal-source foods (especially milk and eggs) used less land than the vegan alternatives.[20] This is because more inclusive diets make optimal use of all existing land to feed people, such as croplands and rangelands for growing grain and hay to feed livestock.

RECIPE 13.1

Ettore Capri's Pesto alla Genovese

1 clove of fresh garlic
6 g (1 tsp) of coarse sea salt
100 g (3¾ to 4 cups) of basil leaves* (washed and dried; do not use stems)
40 g (2⅔ Tb or 8 tsp) of finely chopped pine nuts†
100 g (½ cup) of grated Parmesan cheese (best if aged for at least 26 months)
20 g (1¾ Tb) of aged Pecorino cheese

100 g (½ cup) of extra virgin olive oil (Ettore prefers the fresh, light oil from the Liguria region)

In a marble mortar with wooden pestle, mix the garlic and coarse sea salt to keep the basil leaves a vibrant green. Add fresh basil (ideally collected early in the morning), and use a pestle to grind the leaves against the side walls (not the bottom of the bowl) by moving the pestle slowly and gently in a circular direction. Transfer the mixture to a bowl. Stir in the pine nuts and cheese. Gradually stir in oil, one drop at a time, until the texture is creamy.

A couple of minutes before the pasta is ready, add some spoonfuls of boiled water to the pesto to achieve your preferred consistency. Enjoy.

*Pam recently visited a small farm with a community-supported agriculture program in Poughkeepsie, NY, that grows a diversity of vegetables.[21] The farm manager, Leon Vehaba, works hard to minimize chemical use. Things were not going well for the basil. It was infected with downy mildew, a destructive disease that has become prevalent in the region.[22] After the downy-looking spores of the fungus covered the lower leaves, the plants become yellow and then died. Leon had tried several varieties, and all had become infected. He had tried to reduce humidity by spacing the plants widely and using drip irrigation, but that approach also had not worked. Several organic and conventional fungicides did not halt the disease spread. He said, "If you scientists can produce a genetically engineered basil—can you put a spinach gene in there so it's resistant to powdery mildew?—I would be the first to plant it."

†If possible, use fresh pine nuts from the Mediterranean area harvested from Italian stone pines or from pinyon pines in the American Southwest. Global demand for cheaper pine nuts has fueled harvesting of Korean pines planted in the southern parts of the Russian Far East, and they are damaging this fragile ecosystem. A great alternative is to use roasted walnuts.[23]

On the second day of the meeting, I got up early to run. Hunger and poverty were remote. I thought of poor rural workers who have often been too ill nourished to do the hard physical labor required to be effective farm workers. Here I was, using my nourishment to run in circles to get back to where I started. Those of us in comfortable environments often find it difficult to comprehend the challenges faced by farmers. This lack of imagination may be one of the reasons that the political fights about food in wealthy urban areas often seem removed from the needs of farmers and the hungry.

I rejoined the conference where the discussion had moved on to the talk turned to genetically engineered crops in Europe. In 1999, farmers in Romania began planting herbicide-tolerant soybeans. Yields soon increased by more than 30%, and the soybean crop became the most profitable in Romania. The surplus soybeans were exported to other European countries. This productivity changed when Romania joined the European Union in 2007. Because cultivation of herbicide-tolerant soybeans was not authorized by the EU, Romanian

farmers returned to planting conventional soybean varieties. Profits plunged. As a consequence, the area planted with soybeans shrank by 70%. Within just 2 years, Romania, like the rest of Europe, had become dependent on expensive soybean imports, and farmers had lost a very profitable crop.[24] This case reflects a key ethical contradiction embedded in the EU food system: Local food security and safeguarding the environment are valued, but politics sometimes gets in the way of achieving those goals.

Ettore told us the story of Giorgio Fidenato, former President of Federated Farmers and Secretary of Futuragra, an Italian cultural association for technological innovation, business culture, defense of private property, and free markets in agriculture.[25] Fidenato wanted to grow Bt corn on his farm to show consumers and schoolchildren what a genetically modified organism (GMO) looks like. He also wanted to control insect infestations without the use of chemical sprays. For these reasons, he applied for a permit to plant Bt corn.[26]

It was a reasonable request. Bt corn had been approved for cultivation within the European market, and the European Food Safety Authority had concluded that the crop did not pose a danger to human health or the environment.[27] The problem was that despite EU approval, Italian laws prohibited Italian farmers from planting it.

This restriction on corn production was expensive for Fidenato and other European farmers who needed the crop to feed their pigs. Although Europe is a net exporter of wheat and barley, it does not produce enough corn to satisfy demand. Instead, Europeans rely on imports from the United States. In 2016, the EU imported a record 16 million metric tons of corn, up 83% from a year earlier. According to *Bloomberg News*, the EU raised about 148 million pigs, 88 million cows, and 6.3 billion chickens in 2015.[28] Before it joined the EU in 2007, Romania grew Bt corn on a larger scale than any other European country and was a key supplier of corn for the animals in Europe,[29] second only to France.[30] After becoming a member of the EU, Romania altered its legislation to fit EU rules, reducing Bt corn cultivation.

The Italian Ministry of Agriculture denied Fidenato's request, but he appealed and won. He planted the Bt corn in 2010. When it was mature, Greenpeace volunteers swarmed his field and destroyed the corn. *The New York Times* reported that Luca Zaia, a former agriculture minister and president of the nearby Veneto region, applauded the rampage, saying, "There is a need to show multinationals that they can't introduce Frankenstein crops into our country."[31]

No one at our conference seemed to think that destruction of a crop approved for consumption was ethical, especially when the crop reduced

applications of potentially harmful insecticide sprays. Furthermore, Italian farmers plant many types of seed produced by multinational seed companies. Destroying each of those fields would be costly for farmers, consumers, and the environment.

In January 2012, an Italian court disciplined the environmentalists who damaged Fidenato's property. The court also fined Greenpeace 86,000 Euros for destroying Fidenato's field. In 2017, the European Court of Justice ruled that a member state such as Italy does not have the right to ban GM crops given that there is no scientific reason for doing so.[32]

The conversation shifted away from farmers and policies in prosperous Europe to the economically disadvantaged. "Is it ethical to prevent farmers from growing or delaying release of Golden Rice when it has the potential to save the lives of thousands of children?" asked Ruth (see Chapter 7).

"No, it is not ethical," replied Per Pinstrup-Andersen, past president of the American Agricultural Economics Association, former Director General of the International Food Policy Research Institute, and 2001 World Food Prize Laureate. "Farmers must feed their families. They need a diversity of vitamin-rich foods and seeds to grow these crops. Genetic technologies have been available for years in the developed world, and we take them for granted," he says. "Why deny farmers in less developed countries access to the same tools?"

Per also pointed out the challenges of eggplant farmers in Bangladesh and India. One species of caterpillar pest in Bangladesh and India can destroy a farmer's entire eggplant crop if it is not controlled. To control this pest, farmers spray insecticides every couple of days. Many of these chemicals are harmful to human health, especially when farmers and their families do not have access to proper safety gear. To reduce chemical sprays on eggplant, scientists at the Bangladesh Agricultural Research Institute and Cornell University tried a genetic approach that builds on an organic farming technique. Bt is highly specific to caterpillar pests but is nontoxic to birds, fish, and humans (see Box 5.3 in Chapter 5). However, this strategy does not work well for eggplant farmers in Bangladesh because sprays are expensive, are hard to find, and do not prevent the insect from getting inside the plant.

Using genetic engineering, scientists cut the gene for Bt out of the bacteria and inserted it directly into the eggplant genome.[33] In 2015, Bangladesh eggplant farmers reported that they were able to reduce their chemical sprays by a huge amount—often down to zero. They could also save their seeds and replant them the next year.[33,34,35]

In a blog post for the Cornell Alliance for Science, Per articulated the need to consider the perspective of farmers: "Ask a developing country farmer who is at risk of losing her crop due to insect attacks or plant disease whether she would like a resistant crop variety. Ask her whether she would like a drought-tolerant crop variety. Ask a low-income mother whether she would like to have access to less expensive food and food with higher nutrient content—but they are not being asked. . . . Let's take existing evidence seriously, to get together to agree on a set of rules for sustainable food systems that combine the best aspects of organic and conventional production systems, and to implement these rules for the benefit of the people that we all pretend to want to assist. It is time to replace the polarized debate with evidence-based pragmatism."[36,37]

"The ethical situation seems clear here," Per said. "Farmers and consumers demand Golden Rice and insect-resistant eggplant. If they did not, the issue would evaporate because there would be no market."

Anthropologist Dean Greenland intervened, "Scientists do not work in an ethical framework. They do what they are told. They bring values to their work and publish the kinds of things that support their values. The scientists who created Golden Rice are the same as the scientists who created the atomic bomb."

I was stunned by his statement. There are times in life—and this most definitely was one—when you can feel the clash of disciplines, where the distance between agricultural scientists and others appears so vast that you wonder if the gap can ever be bridged.

I am curious if Dean understands the nature of the scientific process (see chapter 6, chapter 8). Scientists generate hypotheses, carry out experiments to test the hypotheses, analyze the data and then publish the results in peer reviewed journals. They do not determine outcomes based on their values and opinions.[38]

Before I could speak, Ruth cut in: "Dean, you are making a morally flawed analogy. Atomic scientists knew they were making a weapon of mass destruction. The intended consequence was to kill as many people as possible. We don't know how each of those scientists rationalized it or if they struggled with it. Some probably believed it was necessary to stop greater evil and death. Some went on to protest the use of atomic bombs in warfare. In any case, there is no comparison."

Dean was not convinced. "Scientists do not consider unintended consequences. Besides, science is always changing, so we cannot trust it," he said.

I don't agree with Dean. Sure, science can be slow and clumsy. It is an iterative process. As new knowledge or technologies become available, conclusions are sometimes changed or refined. But these modifications do not mean that science cannot be trusted. The opposite is true. The process of correction and the willingness of most scientists to correct mistakes make the conclusions of widely repeated experiments to be quite trustworthy.

Jessica also had something to say about this topic. "There are risks of unintended consequences for just about everything humans do. The reason that farmers plant new varieties of crops each year is that the benefits outweigh the risks.

There are also consequences of inaction. The effects of malnourishment are clear. Hundreds of thousands of children die each year due to vitamin A deficiency. How can the well-being of so many children be discounted so casually?"

Anthropologist Dr. David Groenfeldt from the Water-Culture Institute and Department of Anthropology at the University of New Mexico replied, "We shouldn't depend on scientists to know the moral implications of their science. We have policy makers and various levels of advisors, who have a more direct responsibility to society, who should serve as the moral frontline. Scientists should have a moral opinion about their own work; that's healthy, but their opinions need to be part of a larger ethical discussion involving a broad representation of society. Do I trust scientists to make moral decisions about the implications of their science? No. Do I trust science? Yes, in terms of trusting in the scientific method."

"It is the job of policy makers to apply the science." Ruth said, "However, it is also the responsibility of the policy maker to understand the science and to understand farming. If policy makers are unaware of the scientific consensus of our national scientific institutions, if they view *science* as simply a collection of individual opinions, they will distrust the scientific process and will lack a scientific framework with which to make important policy decisions that affect consumers. It is also the responsibility of the public to understand enough science so that they can elect government officials who can advocate for science-based policies."

Ruth went on to remind us that there is no evidence that scientists are less ethical than those in other professions. One study, in fact, has suggested that scientists are more likely to condemn unethical behavior and more inclined to help one another than people without scientific training.[39]

Over tea, some of us discuss the role of religious leaders in shaping consumers view of the ethics of particular technologies. Pope Francis, for example, has addressed the ethics of using modern genetic technologies to help the poor and malnourished. In 2013, Ingo Potrykus, the co-inventor of Golden Rice and a member of the Pontifical Academy of Sciences, attended a meeting at the Vatican on nutrition. He took the opportunity to share a packet of Golden Rice with the Pope. In response, Pope Francis gave his personal blessing to the Golden Rice.[40] Tyrone Spady, the Legislative and Public Affairs Director for the American Society of Plant Biologists, thinks that the Pope's blessing is an important indicator of slowly shifting global attitudes regarding the role that genetically engineered foods will play in the world's long-term food security.

In 2015, perhaps with Golden Rice in mind, the Pope commented on genetic technologies in his encyclical: "It is difficult to make a general judgment about genetic modification, whether vegetable or animal, medical or agricultural, because these vary greatly among themselves and call for specific considerations."[41] In other words, the Pope suggests that consumers treat each new crop on a case-by-case basis.

I am glad that Pope Francis seemingly cares about the science behind food and farming. That a leading religious figure is paying attention to science and encouraging consumers to use science in public policy making is important and challenges the stereotype that faith is in opposition to science.

In the afternoon, we broke into small groups to discuss whether there is a moral obligation to rely on the best available scientific information when assessing different farming systems. Ettore argued that agricultural regulations need to be science-based. If they are based only on politics, they can impede the advancement of sustainable agriculture. For example, when farmers are not allowed to grow Bt corn (Italy) or Bt eggplant (India), they instead spray chemical insecticides to control the pests.

The discussion turns to organic farming. "Because organic farming is subsidized in Italy," Ettore said, "pesticides used by organic farmers are also indirectly subsidized." This includes the application of copper sulfate, a heavy metal that organic farmers use to control fungal infections in their orchards and vineyards (see Box 2.2 in Chapter 2).[42] It was developed in Bordeaux 100 years ago and is still commonly applied to vines to protect them from infection.

"These subsidies do not promote the goals of sustainable agriculture. It makes no sense," said Ettore, "After 50 to 100 of years sprays, the soils are contaminated, the microbes are depleted, and it is impossible to make the soil fertile again.[43] Nothing will grow but grapes, which are fairly tolerant of poor soils."

"The regulations that farmers must follow in Europe are not based on science. The politicians even ignore the European Food Safety Authority. That is their own scientific agency! The regulations change all the time here, and we are outcompeted by more efficient farms abroad. Many people can no longer afford to farm. Kids don't want to farm anymore. This is why we are losing farmers in Italy."

Between 2000 and 2010, the number of family members working on farms in Italy fell by more than 50%.[44] An agricultural economist in the group pointed out that sometimes regulations can rebuild trust in the agribusiness-food sector. More often, however, a regulatory one-size-fits-all approach can run into serious difficulties, especially when a country tries to apply it to thousands of farmers who plant a diversity of crops under different growing conditions. According to agricultural economist Dan Sumner, the only way farm income can keep up with nonfarm income in this situation is to raise food prices or reduce labor on farms. "Farms remain tiny in Italy, and poor regulation is one reason they cannot compete."

Per agreed with Ettore, "And labels make it even more difficult for consumers to make choices." He was referring to the bewildering array of labels and designations faced by consumers (e.g., Fair Trade, Organic, Certified Humane, Equitable Food Initiative), which are intended to help them make food purchases that resonate with their ethical and other values. Many of the labels lack clarity; they are insufficiently reliable and are sometimes misleading (Fig. 13.1).

Another problem is that the labels target a narrow section of the population. The labels often miss the entire middle to bottom of the pyramid, the 6 billion people in the world who do not live in high-income countries. There is a huge difference between the basic needs of a subsistence farmer and those of an urban shopper who buys food according to whatever labels are on the packaging, which sometimes have little to do with sustainable production of that food.

Most consumers want transparency. They want a user-friendly labeling system that is informative. A bar coding system anchored to real metrics

FIGURE 13.1 Confusing and Misleading Food Labels. (From Saletan, W., "Unhealthy Fixation." *Slate,* July 15, 2015. Available from: http://www.slate.com/articles/health_and_science/science/2015/07/are_gmos_safe_yes_the_case_against_them_is_full_of_fraud_lies_and_errors.html.)

would be popular—a system that would address environmental sustainability, animal welfare, labor standards, and food safety. A scorecard comparing alternative approaches and costs for achieving these goals could be included. Such a system would allow consumers to identify and incorporate ethically based knowledge into their food choices. It would encourage participation along the entire food value chain. The labeling system that became law in the United States in 2016 is a start, but the information included about how the food was grown may be limited.[45] The precise rules governing implementation of the label will likely be debated over the next couple of years. This is an opportunity to advocate for a bar code that would allow consumers to access science based information.

We discuss the paucity of public funding for agricultural research and development, which plays a major role in providing the world's farmers with needed technology (e.g., genetically improved seeds) and evidence-based farming strategies (e.g., integrated pest management). Agricultural research is essential for ensuring sufficient yields, sustainable farming practices, food safety, and viable economic prospects for farmers. Agribusinesses may develop tools that are useful to farmers in the developed world, but they do not have financial incentives to develop tools to help those who cannot afford them.

Per added, "This is a huge ethical issue. Many poor farmers live in regions that will bear the brunt of climate change and the difficult growing conditions it will bring. For-profit industries are not going to directly help them."

Per emphasized that we need to align agricultural research and development policy, funding, and priorities with the needs of farmers in low-income countries (Box 13.1). Ruth and her team agree. To advance these goals, they are identifying specified, relevant experts and are seeking funding.[46]

There is little debate about the moral imperative to feed the world's population. It is also apparent that policy decisions are often made in a vacuum without

BOX 13.1 **The Social and Economic Costs of a Slow Pipeline**

There are dozens of useful traits[47] in the genetic engineering pipeline, including nitrogen-efficient crops[48] that reduce fertilizer runoff; Golden Rice, a provitamin A—enriched rice[49]; cassava that is resistant to viral infection[50]; and drought-tolerant corn.[51]

Some of these crops, such as cassava and Golden Rice, are important to the impoverished farmers and their families in developing countries who lack nutrients and cannot afford the varied diets people in rich countries take for granted. Consumption of Golden Rice in the normal diet of rice-dependent poor populations could provide sufficient vitamin A to reduce the 6000 deaths caused every day by vitamin A deficiency and to save the sight of several hundred thousand people each year. This biofortification approach complements conventional supplementation, such as the World Health Organization's distribution of vitamin A pills, which costs 40 times more and often does not reach the rural poor, who have little access to roads.[52]

Golden Rice can provide vitamin A at a fraction of the cost of current supplementation programs. However, the rules governing field testing in India, Bangladesh, and elsewhere are slow and costly. UC Berkeley agricultural economist David Zilberman[53] has calculated that swifter implementation would have saved at least 1 million more people from blindness and prevented the death of thousands of children.

UC Davis researchers Julian Alston and Kent Bradford and University of Missouri economist Professor Nicholas Kalaitzandonakes have observed that the regulatory approval process for new biotech crop varieties is increasingly slow and expensive.[54] If a lengthy process is necessary to ensure the environmental, food, and feed safety of a particular crop, it is regarded as worthwhile. However, if the approval process goes on longer than necessary to ensure safety with reasonable scientific certainty, the opportunity costs of missing out on innovation can mount. In one study, Kalaitzandonakes reported that each year of delay in approval of a new technology for soybeans results in approximately $1 billion of loss for the farmer and another $1 billion of loss for the consumer.[55]

adequate consultation with farmers—whether farmers of large acreages in the midwestern United States, specialty farmers in Italy, or subsistence farmers in Africa. This observation matches my own experience. I am often asked to serve on panels to discuss food and farming. Typically, the panels include a scientist, an urban activist, a chef, or a government official. Rarely are farmers included in the dialogue.

The perspective of the people doing the actual work of growing food is needed in discussions about ethical eating. There are few other ways of knowing what farmers need. Talking with Sanga Moses and other farmers in Uganda makes clear that Banana *Xanthomonas* wilt is a major problem in Uganda and that new tools are needed. According to Veronique Bikoba and Alemayehu Chala, researchers at Hawassa University in Ethiopia, the disease has also destroyed most of the banana plantations in South Kivu, Democratic Republic of Congo, as well as infected enset (i.e., false banana), an important crop in Ethiopia. Veronique's young brother Nicolas, who holds a degree in agronomy, is helping small-holder farmers in the Congo fight the disease. "Farmers need all the help they can get," Nicolas said.

Nassib Mugwanya, the outreach officer for Uganda Biosciences Information, emphasizes that it is critical to include farmers in decisions about appropriate agricultural technologies. "We cannot underestimate the ripple effects of debate in well-fed western countries on Uganda," Nassib says. "Agriculture in Europe and Uganda are different. In Uganda, 13 million people rely on cassava as their main food. Europeans are food secure and so can pick and choose what they eat. Africans cannot. We are struggling to feed the growing population. If genetic engineering technology could help save cassava and bananas, it should be given a chance. The last thing Africa needs is for Europeans to block technology that may help us. Farmers are pro-solution and quite practical. In my experience working with farmers, they are looking for approaches to solve their agricultural problems. Whether the solution is genetic modification or nongenetic modification, if it works for them, they will take it up."

At the end of the meeting, Ruth asked us, "In another 50 or 100 years, what kind of conversation will people be having with themselves? What will matter?"

Jessica replied, "Most people have only a few important needs: good health, adequate food, fresh air, clean water, education, assurance of personal safety, and freedom. We all want to have these values in our future. We just need to figure out how to get there."