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## *Technology*

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## CHAPTER 13

# *How Technology Is Changing What and How We Eat*

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To begin, two love stories are presented—both unlikely. One is derived from a novice farmer, the other from a cytogeneticist.

Henry David Thoreau (1817–1862) famously left the creature comforts of what constituted modern life in his day to build a home by his own hands, and grow his own food. In an oft-quoted passage he describes his motivations for his experiment in living so consciously close to nature: “I went to the woods because I wished to live deliberately, to front only the essential facts of life, and see if I could not learn what it had to teach, and not, when I came to die, discover that I had not lived.... I wanted to live deep and suck out all the marrow of life” (Thoreau [1854] 1965, 67). Essential to living deep and sucking the marrow of life was eating food he had grown.

The attention he showered on his garden indicated nothing short of love. He dedicates an entire chapter to his bean field. Thoreau explains, “I came to love my rows, my beans.... They attached me to the earth” (115). He develops a relationship with the beans, listening for what they might teach. “What shall I learn of beans or beans of me? I cherish them, I hoe them, early and late I have an eye to them” (115).

Thoreau advocates hunting, particularly for the young, as an introduction to nature. However, he maintains that after this education those who are humane will discontinue hunting. Thoreau muses, “Perhaps I have owed to employment and to hunting, when quite young, my closest acquaintance with Nature” (157). He believes such pursuits introduce youth to nature in a way that encourages giving it their full attention (157). However, Thoreau goes on to share his hope that the student of nature “goes thither first as a hunter and fisher” until later when, with the “seeds of better life” in them, they identify the hunted creatures as proper objects of poetry or natural study and leave “the gun and fish-pole behind” (159). Thoreau trusts that “No humane being, past the thoughtless age of [girlhood or] boyhood, will wantonly murder any creature which holds its life by the same tenure that [she or] he does” (159). Thoreau clearly illustrates a man who loves the entities he eats prior to consuming them.

Next, consider a far more recent, but no less amorous, relation to organisms that provide food. Barbara McClintock (1902–1992) was the first solo female winner of the Nobel Prize in Physiology or Medicine. She was a cytogeneticist (a scientist who studies the

structure and function of chromosomes) who focused on maize (corn). McClintock advanced knowledge in genetics in part through showing that specific elements on the chromosome did not remain in the same place on the chromosome—they moved, and she named this capacity to change position *transposition* (Keller 1983, 8–9).

McClintock’s scientific process was remarkable in that she adopted a different approach to seeing further and deeper into the mysteries of genetics than her colleagues (Keller 1983, 197). In the words of biographer Evelyn Fox Keller, “Over and over again, she tells us one must have the time to look, the patience to ‘hear what the material has to say to you,’ the openness to ‘let it come to you.’ Above all, one must have a ‘feeling for the organism’” (198). McClintock’s approach requires that one know an organism both as an individual and as a part of a much wider environment. Much like Thoreau, she had a deep connection to the plants she dealt with. Highlighting how each plant is fundamentally unique, McClintock notes, “I feel I really don’t know the story if I don’t watch the plant all the way along. So I know every plant in the field. I know them intimately, and I find it a great pleasure to know them” (198). Her approach resonates with Albert Einstein’s position that “only intuition, resting on sympathetic understanding, can lead to [these laws]; ... the daily effort comes from no deliberate intention or program, but straight from the heart” (201).

On McClintock’s approach, conventional reason is not by itself sufficient for debating the complexity and mystery of living forms: “Organisms have a life and order of their own that scientists can only partially fathom”; the ingenuity of nature surpasses scientific knowledge (Keller 1983, 199). McClintock developed a special sort of sympathetic understanding that heightened her powers of discernment until the objects of her study became subjects in their own right. McClintock evidenced a “deep reverence for nature, a capacity for union with that which is to be known” (200). Again, it is not a stretch of the imagination to say McClintock loved the organisms she studied.

You are encouraged to be mindful of these stories of love as this chapter explores different stories of how technology is changing what and how we eat.

## INTRODUCTION

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In what follows, three areas in which technology is changing what and how we eat are addressed: agricultural plant biotechnologies, industrial agricultural animal production technologies, and transportation technologies. Although they are separated into three sections, themes will overlap. For example, the industrial logic that currently permeates most animal production is the same logic that underpins dominant corporate trends in plant agriculture.

The cases discussed are, for the most part, circumstances in which the word *technology* is already entrenched in the literature about the food practice discussed. Technology is a ubiquitous term (as this volume usefully illustrates), and as such, a one-size-fits-all definition will not be presented. To help give shape to the discussion, though, it is worth noting that in what follows the focus is on instances where humans have generated a product or process that has left an intentional, and often indelible, impact on the world, be that for better or worse. In the absence of humans, or a functionally similar species, such technologies would likely not have come into being. The technologies discussed are unique, human-generated, interventions.

The special focus is food-related technologies. Food is consumed by humans for many reasons. For example, food is consumed to stay alive, to meet nutritional needs, to share in community, to bond over, to soothe, to meditate, to create health, and to celebrate. What food will mean to people depends, in part, on their social, economic, political, cultural, and geographical situation. As a case in point, if one is facing poverty then food is not a luxury. Rather, it is a daily, pressing, and often desperate need. How the biotechnology of genetically modified organisms (GMOs) is promoted as a solution to the problem of world hunger, among other things, will be a focus later in this chapter. If, in contrast, one is fiscally overprivileged then access to food will not be an issue in the same way. However, with excesses come other potential challenges, though the challenges are not on par with those faced by the impoverished and hungry. In developed nations, for example, obesity is a growing problem. The reasons for obesity are multifaceted. However, one can say with certainty that obesity can only exist as an issue if there is an excess of food available to some. Another fact that complicates the obesity problem is the abundance of food that lacks nutrient density, which is particularly worrisome for the poor in developed nations as those foods are least expensive.

The focus in what follows is primarily on food technologies in the United States. The “we” in how technology is changing what and how we eat refers to middle-class and affluent Americans. It serves as a good example with regard to food practices in a dominant developed nation. A significant way that what people eat has changed is that people now eat foods that have been genetically modified by modern biotechnological processes. In 2005 it was estimated that 75 percent of processed foods in the United States contained some genetically modified ingredients (McLean 2008, 82).

## **PLANTS: BIOTECHNOLOGY AND GENETICALLY MODIFIED ORGANISMS**

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The benefits and harms of current genetic biotechnologies are hotly debated. Developing a working definition of biotechnology is, therefore, a good place to start analysis. The following definition comes from the Food and Agriculture Organization of the United Nations (FAO) 2000 Statement on Biotechnology. They quote from the Convention on Biological Diversity, which defines biotechnology as: “any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use” (FAO 2000). This is a broad and inclusive definition, wide enough, some would argue, to include many practices that have been used far before the language of biotechnology came on the scene.

Regarding the use of traditional biotechnology, farmers have long engaged in the practice of plant and animal selection. Plants and animals are selected for, and bred, with the intent of encouraging particular, desired, traits such as a plant’s ability to grow well and the ability to resist disease, pests, and shifting weather patterns (McLean 2008, 80). The selected plants and animals are then bred to populate the next generation so as to ensure the next generation manifests the desired traits, thereby shifting the way organisms develop over multiple generations.

These practices are far from new. Since the advent of agriculture in Mesopotamia 10,000 years ago, farmers have kept the best grains from their harvests to use as seed for crops for the following year (Robin 2010, 136). American Indians discovered that by dusting the pollen from the tassel of one corn plant onto the silks of another, new plants

could be created that combine traits of both plants (Pollan 2006, 29). The changes that resulted in how plants and animals developed took place over long expanses of time, in constant relationship with the environments in which they were growing. A number of other technologies have been implemented and have impacted human relationships with food in addition to farming practices, such as cooking with fire, hunting with tools, and food preservation (Pollan 2006, 6). Although these technologies involved novel innovations, they are not the types of technologies that cause significant debate today. Instead, what tends to be of concern are newer processes used for modifying organisms. More recent and controversial processes can be identified as modern biotechnologies, as distinguished from traditional biotechnologies.

The modern biotechnologies focused on in this chapter use molecular tools that allow for removing or inserting a gene or genes to produce plants with novel traits. Changing a plant's genetic sequence changes the plant's characteristics. For example, scientists have attempted to increase the shelf life of tomatoes and have tried to create different nutrient content in foods (McLean 2008, 80). Manipulating genes in this way is referred to as genetic engineering (GE), and a developed genetically manipulated (GM) seed is a GMO (80). Throughout the chapter GE and GM are used interchangeably.

The modern biotechnology of genetic engineering developed following the discovery of the structure of deoxyribonucleic acid (DNA). In 1953, James Watson and Francis Crick determined the double helix structure of DNA (Ruse and Castle 2002, 23; Robin 2010, 132). DNA is the molecule that holds the genetic code for every living organism (Robin 2010, 132). Watson and Crick's discovery signaled the birth of molecular biology. Recombinant DNA (where DNA is literally recombined) began with transferring genes from one part of an organism's chromosomes to another, and later from one organism to another (Ruse and Castle 2002, 23). In 1972, Paul Berg successfully recombined DNA by putting together fragments of DNA from two different species to form a hybrid molecule (Robin 2010, 133–134). Modern biotechnologies can be used to change a plant's genetic sequence directly in a short amount of time, as opposed to the numerous years of selective breeding that one finds with traditional biotechnologies (McLean 2008, 80). Modern biotechnological processes also enable the transfer of genes from one organism to another across great evolutionary distances (e.g., inserting the gene from an African frog into a plant such as a rhododendron to generate enhanced resistance to root rot). When genes are moved between species the result is transgenic plants and crops (80).

The narrower definition of modern biotechnology, as opposed to the initial and more general definition of biotechnology offered by the FAO, focuses on developments such as new DNA technologies, molecular biology, and reproductive technological applications that cover technologies such as gene manipulation, gene transfer, DNA typing, and cloning animals and plants (FAO 2000). For the remainder of the chapter when plant biotechnology is referred to, it is modern plant biotechnology unless otherwise indicated. It is the products of this narrower definition that will be the focus of what follows. More particularly, in the realm of agriculture, one form of biotechnology is a source of great disagreement—namely, GMOs. It is worthwhile to take a moment to consider a case study regarding how a particular GMO came into being.

#### **A CASE STUDY: ROUNDUP READY SOYBEANS**

One example of the process used for genetically modifying seeds can be found through looking at the case study of Roundup Ready Soybeans, which are marketed by the

corporation Monsanto. Herbicides kill weeds. The most widely sold herbicide in the United States is the trademarked herbicide Roundup. Monsanto was interested in generating plants resistant to the Roundup herbicide (a key ingredient of which is glyphosate), so that Roundup could be sprayed on crops at any time to destroy weeds without killing the plants that were to be harvested (Robin 2010, 138). The goal was to find the gene that would immunize plant cells against Roundup, so scientists went to Monsanto's Luling, Louisiana, plant where millions of tons of glyphosate were produced annually (139). Decontamination pools that were intended to treat production residues had contaminated nearby lands and ponds, so samples were taken of microorganisms from these lands and ponds to identify the microorganisms that naturally survived glyphosate and to identify the gene believed to give them that resistance (139).

Once the molecular structure of the bacteria that survived glyphosate was identified, scientists had to find the genetic construct that would enable the gene to function once it was introduced into plant cells of soybeans (Robin 2010, 139–140). It took a US\$80 million investment and 700,000 hours to “attain the result: a genetic construct including the gene of interest (CP4 EPSPS), the promoter 35S from the cauliflower mosaic virus, and two other fragments of DNA derived from the petunia intended to control the production of the protein” (140). Because the Roundup-tolerant soybean gene cassette (which is basically a DNA sequence) is artificial, it was difficult to introduce it into the soybean cells. Given this resistance from nature, the research team used a gene gun to force the desired DNA to penetrate into the target cells (140). At the time, alternative approaches other researchers were employing included using microscopic needles or electric charges to make holes in cell walls so that the DNA could enter (140). The gene gun became the preferred method, though. It attaches genetic constructs to microscopic bullets (composed of gold or tungsten), which are then shot into a culture of embryonic cells (141). The precision of the gun left much to be desired, however. The gun inserted DNA at random, and sometimes a bundle would splinter before landing, and sometimes the DNA would land in a spot that interfered with cellular function. As such, the gun had to be fired tens of thousands of times to get a few dozen plants that looked promising. Following three years of field tests on these plants, a single line of transformed soybean was selected because it could resist heavy doses of glyphosate (141).

Contrary to traditional biotechnologies, a number of which were developed by people who lived in close relationship to the creatures they were seeking to alter and who had an extensive awareness of the particularities of their ecological surroundings, modern processes for changing traits are often being developed by scientists with the funding of major corporations looking for methods of generating capital from their discoveries. As Susan Wright (a sociologist who wrote a history of biotechnology) explains: “As genetic engineering became seen as a promising investment prospect, a turn from traditional scientific norms and practices toward a corporate standard took place. The dawn of synthetic biology coincided with the emergence of a new ethos, one radically shaped by commerce” (Robin 2010, 135). There are, however, other reasons for pursuing the genetic modification of food. Governing bodies as well as corporations provide additional rationales for wanting to develop modern biotechnology.

## **BENEFITS OF MODERN PLANT AGRICULTURAL BIOTECHNOLOGY**

Although not the only corporation generating GMOs, Monsanto became the largest seed company in 2005 and now owns 90 percent of all GMOs grown in the world. Therefore, it serves as a useful example of the corporate interests of a biotech giant (Robin 2010, 2).

Monsanto describes itself on its website as a “sustainable agriculture company” focused on empowering farmers to produce more while conserving more natural resources such as water and energy, and they claim that they do this in part through producing leading in-the-seed trait technologies aimed at protecting farmers’ yields, supporting on-farm efficiency, and reducing on-farm costs. Monsanto tells its customers that they operate under a value system that operates as a foundation to everything they do that demonstrates integrity, respect, ethical behavior, perspective, and honesty. Sustainable agriculture is advertised as being critically important to Monsanto, given that humans depend on agriculture for basic needs to be met. Monsanto’s website notes that with a global population expected to grow by 40 percent in the next few decades, agriculture will need to become more productive and sustainable to meet growing demands (Monsanto).

The potential benefits of genetically altered food include more productive crops due to resistance to pests, disease, and severe weather, resulting in more food from less land (McLean 2008, 82). Current data show that in the absence of pests GE seeds do not increase maximum crop yields. However, they can prevent yield loss due to pests (Fernandez-Cornejo, Wechsler, and Livingston 2014). US Department of Agriculture (USDA) data show that in 2015 GE Bt corn (designed to control the European corn borer, the corn rootworm, and corn earworm) yields were 17 bushels higher than conventional corn, and in 2010 approximately 26 bushels higher. Data for the yields of GE seeds designed for herbicide resistance (soybean, corn, and cotton) are mixed. Findings range from researchers finding no difference, to some finding higher yields, to some finding lower yields (Fernandez-Cornejo, Wechsler, and Livingston 2014). The hope is that genetic engineering might lead to higher yields not only in the United States but in countries that cannot, at present, grow enough to feed their own people (FAO 2000).

Additional potential benefits include a longer shelf life for fruits and vegetables, which could decrease the waste associated with transportation and storage as well as lessen the carbon footprint of agriculture. Genetic modification could also be used to enhance nutritional value and make healthier foods (McLean 2008, 82). For example, rice has been genetically engineered to contain beta-carotene (namely Golden Rice, which will be discussed in more detail shortly), which could help improve the health of those with low incomes and limited or no access to natural sources of vitamin A (such as, for example, fruits and vegetables) (FAO 2000; McLean 2008, 82). The potential gains for developing this technology are thus sizable and far reaching.

Robert Shapiro, chief executive officer of Monsanto from 1995 to 2000, captures the potential of modern biotechnology to solve current pressing issues. After pointing out 1.5 billion people live in abject poverty and that the world population will double by around 2030, he went on to say the future will be a “world of mass migration and environmental degradation at an unimaginable scale. At best, it means the preservation of a few islands of privilege and prosperity in a sea of misery and violence.” Resultantly,

[the entire] system has to change.... Most arable land is already under cultivation. Attempts to open new farm land are causing severe ecological damage. So in the best case, we have the same amount of land to work with and twice as many people to feed. It comes down to resource productivity.... The conclusion is that new technology is the only alternative. (Robin 2010, 189)

These are moving words, and the current trajectory of population growth is most certainly of serious concern. The FAO likewise notes that genetic engineering can potentially increase both productivity and production in agriculture (FAO 2000).

Additional potential benefits include the following. Genetic engineering could be used to remove the genes associated with allergies. One example would be blocking the gene that produces the allergenic protein that one finds in peanuts (McLean 2008, 82). The FAO goes on to say, “Marker-assisted selection and DNA fingerprinting allow a faster and much more targeted development of improved genotypes for all living species. They also provide new research methods which can assist in the conservation and characterization of biodiversity” (FAO 2000). Moreover, it is believed that the “new techniques will enable scientists to recognize and target quantitative trait loci and thus increase the efficiency of breeding for some traditionally intractable agronomic problems such as drought resistance and improved root systems” (FAO 2000). Thus, the perceived benefits of modern agricultural biotechnology involve assisting in conserving and characterizing biodiversity while increasing efficient breeding for resisting drought and improved root systems. Pest-resistant and disease-resistant crops could reduce the need for pesticides and other chemicals (McLean 2008, 82). In summary, then, the potential benefits of utilizing modern biotechnologies to alter foods include increased sustainability, empowered farmers, increased productivity in part through more productive crops, less land use, longer shelf life for fruits and vegetables, healthier foods, and a way to meet the food needs of a population expanding at what some would call a catastrophic rate.

Governmental representatives likewise highlight the potential of biotechnology for helping to combat moral harms such as starvation. President Bill Clinton’s secretary of agriculture, Dan Glickman, said the following in an April 2000 speech to the Council for Biotechnology Information: “I believe that biotechnology has tremendous potential for consumers, for farmers, and for the millions of hungry and malnourished people in the developing world” (Robin 2010, 165).

Thus, the recurring argument from multiple sources in favor of using genetically modified foods is that doing so may solve the problem of world hunger. Anyone who argues against pursuing such technology will likely be perceived as rather monstrous. Who, after all, would say that they are against solving the problem of the starvation of innocent oppressed persons? Unless one is able to call into question the underlying premises of the argument in favor of biotechnology as a solution to hunger, one must present significant harms associated with such technology to call into question the active pursuit of current techniques for the genetic modification of foods. Next, some of the significant harms that have resulted from the pursuit of plant biotechnology are identified. Later the moral argument is addressed.

#### **HARMS OF MODERN PLANT AGRICULTURAL BIOTECHNOLOGY**

In weighing the virtues of pursuing modern plant technology, it is important to assess the performance of a number of genetically modified food organisms that are currently grown, thereby enabling judgment of this technology in light of concrete cases. In particular, one can attend to how plant biotechnology is developed, used, and marketed within the current economic, corporate, political, and social climate. Technology never happens in a vacuum. It is always implemented in particular times and places. It is thus worth assessing how genetic engineering is faring in practice at present. A number of the concerns outlined in the following focus on Monsanto. There are many other biotechnology corporations, but Monsanto serves as the best case study to date due to its size and economic and political power.

### UNSUSTAINABLE: INCREASING HERBICIDE USE AND RESULTANT HEALTH HARMS FOR HUMANS AND ANIMALS

One way in which sustainability is meant to be achieved via GE foods is through decreased insecticide and herbicide use. Monsanto sells Roundup, the most widely sold herbicide in the world, which is the trade name for glyphosate (Robin 2010, 70). It is marketed as needing to be sprayed less often due to its potency, thereby enabling farmers to reduce overall herbicide use as well as to reduce fuel consumption and soil erosion (UCS, "Eight Ways"). Although initially the results were good, as of 2000 weeds began to develop resistance to Roundup, and by 2011 eight agriculturally important weeds had developed resistance to Roundup (UCS, "Eight Ways"). These superweeds are causing immense problems for farmers in the United States given that some of these weeds cannot be effectively or economically controlled (UCS, "Eight Ways"). As a result, farmers are increasing their overall herbicide use and in some cases returning to heavy plowing, which increases soil erosion, thereby directly undermining two of the benefits claimed to be derived from using the Roundup Ready system (the system is composed of Roundup Ready seeds coupled with the herbicide Roundup) (UCS, "Eight Ways"). Because the number and extent of resistant weeds have dramatically increased, and because some Roundup-susceptible weeds have been replaced by weeds less capably controlled by glyphosate, the result has been an overall increase in herbicide use, with a recent estimate that in the first 13 years of commercial GE crop use (1996–2008) there has been an increase of about 383 million pounds of herbicide (Benbrook 2009, 2). This is particularly disturbing given the health-related harms associated with the herbicide Roundup.

Initially, Roundup was marketed as respecting the environment, leaving no residues in the soil, and being 100 percent biodegradable. As such, farmers were quick to adopt its use (Robin 2010, 70). The New York State Attorney General's office undermined the legitimacy of these claims, however. It found Monsanto's claims that Roundup was safe, nontoxic, harmless, and free from risk were false and misleading and thus barred Monsanto, under penalty of fine, from declaring Roundup to be any of these things (73). The state attorney general's ruling also prohibited Monsanto from claiming that Roundup is known for its environmental properties or is good for the environment (73–74).

More strongly, some studies have shown Roundup (1) to be a probable cause of cancer in humans and has been detected in water, food, and air after it has been sprayed (*Guardian* 2015); (2) to result in increased miscarriages and premature births in humans (Robin 2010, 83); (3) to be lethal to amphibians (Robin 2010, 86); and (4) to be threatening the welfare of monarch butterflies. Roundup kills milkweed in and near fields treated with it, and milkweed is the required food of monarch butterfly larvae and a critical part of the annual monarch migration through the US Midwest (UCS, "Eight Ways"). Monarchs are a keystone species. Therefore, their absence can have significant and deleterious impacts on ecosystems (Fears 2015).

### UNINTENDED GENE CONTAMINATION, EXPENSES INCURRED BY FARMERS

Unintended gene contamination is another concern, given that engineered genes are turning up in a number of non-GE crops and therefore negatively impacting non-GE and organic farmers by threatening the purity of their crops through gene contamination. In a 2004 study, conventional (non-GE) corn, soy, and canola seed were tested, and pervasive contamination with DNA derived from GE varieties was found. Roughly 50 percent of corn

and soybean samples and more than 80 percent of canola samples were contaminated, and Monsanto's genes were detected in all three crops (UCS, "Eight Ways").

Of further concern for non-GE farmers is the 1980 ruling of the US Supreme Court that rendered transgenic microorganisms patentable (Robin 2010, 202–203). Monsanto sought out, and received, a patent protecting not just Roundup-resistant soybeans, but also, by extension, a patent for the genetic cassette that allows plants to be resistant to Roundup—thereby extending the patent's application potentially to any number of crops (204). Prior to the advent of biotechnology, the patenting of seeds was prohibited (205). Now that biotechnology crops are protected by US patent law, Monsanto has hired what are colloquially known as gene police who track down farmers with crops that have evidence in their fields of GE seed that wasn't purchased from Monsanto that year (206–207). This has led to thousands of investigations, nearly 100 lawsuits, and numerous bankruptcies for farmers. The incident between Monsanto and Percy Schmeiser is an illustrative case.

Famously, Canadian farmer Percy Schmeiser refused to pay Monsanto when they detected transgenic canola in his fields. Schmeiser had used Roundup herbicide (but not the



*Canadian farmer Percy Schmeiser in 2007. When Monsanto decided to take Schmeiser to court for using its seeds, the US biotech giant didn't know it was creating a folk hero for the anti-GM crop movement. Since losing a series of court battles with Monsanto, Schmeiser has been traveling the world on a crusade against genetically modified crops and patenting seeds, speaking to environmental groups and public gatherings. MANPREET ROMANA/GETTY IMAGES.*

Roundup Ready GE Seed) and noticed that a number of plants outside his area of cultivation had resisted the spraying. He called Monsanto to inquire about what was going on and was informed that what he had discovered was Roundup Ready canola (therefore designed to resist Roundup herbicide) (Robin 2010, 214). Monsanto later contacted him to inform him that inspectors detected transgenic canola in his fields and proposed that he provide a settlement to avoid being sued. Schmeiser insisted that any Roundup Ready canola that was growing on his land was spread by the wind or grain trucks traveling on roads adjacent to his fields, and went on to say that Monsanto showed a callous disregard for the environment by introducing Roundup Ready seeds into the area without proper controls (and therefore resulting in contamination) (Ewins 1999). The Supreme Court of Canada eventually found in favor of Monsanto, but also found that Schmeiser had to pay neither damages nor Monsanto's legal costs (Robin 2010, 216).

There have also been cases not involving Monsanto products in which experimental or unapproved GE varieties were discovered, for example, in corn-based taco shells sold to consumers (the Starlink taco shell incident in 2000) and long-grain rice bound for export (the LibertyLink rice contamination in 2006) (UCS, "Eight Ways"). The Starlink incident caused a number of recalls and export restrictions, costing farmers somewhere between US\$26 million and US\$288 million (UCS, "Eight Ways").

#### **BIODIVERSITY LOSS, MONOCULTURES, AND INEFFICIENCY**

Biodiversity loss is an important result of Monsanto's increasing control of seed and food markets. Because Monsanto emphasizes limited varieties of a few commodity crops, in part because of the high cost of developing GE traits, the result is monocultures—the production of only genetically identical or nearly identical crops in a field year after year (UCS, "Eight Ways"). Monoculture farming is heavily reliant on chemical inputs such as synthetic fertilizers and pesticides (UCS, "Industrial Agriculture"). Fertilizers are required because growing only one type of plant in the same place every year quickly depletes the soil of the nutrients on which that particular plant relies.

With monoculture, because huge areas are devoted to one or two crops on large farms with little uncultivated area, more pesticides are needed (UCS, "Eight Ways"). This is because pests can accumulate more easily on crops when they are given the opportunity to adapt to these crops and practices. As such, traditional practices are being lost, such as crop rotation (growing different crops in succession in the same field). Crop rotation is a tool of sustainable agriculture in which soil nutrients are replenished and the food supplies of insect pests are disrupted, thereby greatly lessening the need for chemical fertilizers and insecticides. When biodiversity is increased through traditional farming practices such as crop rotation, natural pest predators (such as birds), beneficial insects, and spiders find a more hospitable home and therefore decrease the need for insecticides (UCS, "Eight Ways").

The harms associated with insecticides include the treatment of Bt corn (which is a genetically altered strain of corn) with neonicotinoid insecticides, which are associated with honeybee colony collapse disorder, and other bee mortality. This is all the more troubling when one recognizes the essential role bees play in pollination and the fact the 35 percent of US crops rely on bees and other pollinators to be productive (UCS, "Eight Ways"). This issue is of sufficient concern that the US federal government took note, with President Barack Obama's administration announcing a commitment to (1) an increased budget on honeybee research, (2) making federal lands more bee friendly, and (3) considering the use of fewer pesticides (AP 2015).

## QUESTIONABLE METHOD FOR ENDING WORLD HUNGER

The claim that biotechnology in plant agriculture could help end global hunger is a powerful one. The argument runs as follows. As the human population continues to increase rapidly, food production will need to continue to increase rapidly if the human population is to be fed. Climate change further complicates the matter given that the nature of those needs will be made more complex and pressing given the impacts climate change will have (IPCC 2014). However, contrary to appealing to GE foods as a solution, many people advocate alternative approaches.

Leading corporations in the agriculture industry demand, and produce, monocultures. However, in contrast to the monocultures that developed in tandem with GE crops, “data show that small farms can be more productive per acre than large ones on an overall (rather than single-crop) basis” (UCS, “Eight Ways”). There is also a safety mechanism in place for ensuring productivity when multiple types of food are grown. When multiple crops are planted, if one crop is threatened, the other crops that are simultaneously grown that year can help offset the losses for the farmer. When different crops are rotated, as opposed to growing the same crop year after year, the soil can maintain the needed nitrogen levels without chemical nitrogen fertilizers. The associated runoff and environmental harms with chemical nitrogen are therefore averted. Chemical nitrogen runoff stimulates the growth of algae in places such as the Gulf of Mexico, creating what are called dead (or hypoxic) zones (Pollan 2006, 47). Fertilizing with chemical nitrogen results in altering the planet’s composition of species and shrinks biodiversity.

Contrary to the claim that modern biotechnology will be crucial for ending world hunger, hundreds of international scientists who contributed to the International Assessment of Agricultural Knowledge, Science and Technology for Development report agree that “non-GE approaches that cost less and are more effective should be prioritized” (UCS, “Falling Short”). One example of a non-GE approach is the push-pull system for corn developed by scientists in Kenya and the United Kingdom (UCS, “Eight Ways”). To manage pests, rather than inundate crops with insecticides, scientists selected a plant that repels stem borer moths (these moths reduce corn yields) and attracts the moths’ natural enemies. To push in the desired direction, silverleaf desmodium is planted alongside the crop, which (1) repels the moths, (2) kills a parasitic witchweed (which is also the bane of farmers), and (3) converts nitrogen from the air into a form other plants can use (thereby improving soil fertility). To pull in the desired direction, Napier grass is also planted alongside the corn. This perennial is used as fodder for livestock and acts as a trap crop because it attracts the stem borer moths to lay eggs but exudes a sticky gum that traps the larvae (UCS, “Eight Ways”).

## NOT EMPOWERING FARMERS

One of the perceived benefits of employing biotechnology is that it empowers farmers. However, some argue that because giant biotechnology corporations have seized control of natural resources in developing countries through an abuse of the patent system, it is the farmers themselves who are suffering (Robin 2010, 1–2). Now patents for seeds are not limited to GE seeds. Currently patents are being granted for nontransgenic plants if a company discovers, for example, a therapeutic use (203). Such a move fails to respect the fact that the plant, and its virtues, could have been known by others for thousands of years (203).

Indian physicist and seed activist Vandana Shiva argues that those who control seeds control food, and because food is essential to survival, no company should have ownership

of seeds in the form of patents. Historically, because farmers could save seeds from their crops, the sharing and preservation of seeds was common (Shiva 2000, 101). Today patent laws often side in favor of large corporations (as seen in the case of Schmeiser). As a result, in many places, seed saving and preservation is no longer a viable option. The impact of today's corporate ownership of seeds has had devastating impacts on many farmers. For example, farmers in India have been committing suicide in unprecedented numbers due to debt (Robin 2010, 293). GM crops are designed for large industrial farms. They are not adapted to small-scale farmers (70 percent of which make India's population). GM crops are not adapted to Indian soil and are therefore more vulnerable to pests and require more pesticides (Shiva 2000, 10; Robin 2010, 293). Peasants who buy GM seeds go into debt from which they cannot rebound if a crop fails. When crops failed, numerous extremely poor farmers who had bought both seeds and chemicals on credit committed suicide by consuming the very pesticides that had gotten them into debt (Shiva 2000, 10). The claim that GMOs empower farmers is thereby brought into question in the case of Indian farmers. For the purposes of cost comparison, the growth of cotton in India serves as a good example. Because cultivating GE crops is more expensive than conventional crops due to a higher priced seed, technology fees, and the need for increasing use of chemicals, cultivating Monsanto's Bollgard cotton is estimated to cost Indian farmers nearly nine times more than if they cultivated a conventional variety (101).

Contrary to the goal of empowering farmers generally, and small-scale farmers in developing countries in particular, Monsanto sought to ensure that the plants they sold produced sterile seeds, widely referred to as terminator seeds (Robin 2010, 196). To quote Pat Mooney, who works for the Erosion, Technology, and Concentration Group (a Canadian nongovernmental organization that fights for the protection of biodiversity), this "technique was a direct threat to food security, especially in developing countries where more than 1.5 billion people survive by saving seeds" (Robin 2010, 196). Mooney has us imagine that terminator "plants cross breed with neighboring crops and make the seeds gathered by peasants sterile. It would be a catastrophe for them, but also for the diversity they maintain precisely because they continue to replant every year local varieties adapted to their climate and their soil" (196–197). The counterresponse to the potential introduction of terminator seeds was so great that Monsanto agreed in 1999 "not to commercialize the technologies popularly known as terminator or sterile seed technologies" (199–200). To date this is still the case.

#### **EXTENDED SHELF LIFE: WORRIES ABOUT TOXICITY AND UNINTENDED CONSEQUENCES**

Another perceived benefit of GE crops is the potential to create a longer shelf life for fruits and vegetables. The Flavr Savr tomato, which was designed to have a longer shelf life, failed, in part, because scientists cannot predict the array of traits that will result through combining pieces of DNA, as is evident through the manifestation of unexpected results. The US Food and Drug Administration (FDA) approved the Flavr Savr tomato in 1994, which was created by Calgene, a California biotech company that was later bought out by Monsanto in 1996 (Robin 2010, 149). The intent was to slow the ripening process of the tomato. The FDA passed its "Statement of Food Policy: Foods Derived from New Plant Varieties" in May 1992, and states in it that GMOs are considered substantially equivalent to non-GMOs. It was therefore decided prior to performing tests to prove substantial equivalence is actually in fact the case that transgenes could be marketed without toxicological testing (146–147). The inventors of the Calgene tomato had asked a laboratory

to conduct a toxicology test designed to measure the health effects of the transgenic tomato on rats (even though they were not obligated to by law), and when the FDA published its regulation it did not know the results of the study (because the FDA assumed the Calgene tomato was substantially equivalent to its non-GMO counterpart, the FDA assumed no tests were needed) (148). Results showed that seven of the forty test animals died after two weeks, and a significant number developed stomach lesions (148–149). In terms of growing the GE tomato, the tomato yields in California were so low that production was moved to Florida, where the crop was destroyed by diseases (149). In 2001 an FAO study concluded: “Since 1996, Flavr Savr tomatoes have been taken off the fresh produce market in the United States. The manipulation of the ripening gene appeared to have had unintended consequences such as soft skin, strange taste and compositional changes in the tomato. The product was also more expensive than non-modified tomatoes” (149). Moreover, the claim of substantial equivalence potentially undermines the claim that such organisms are sufficiently novel to obtain a patent and intellectual ownership.

### **DIFFICULTIES PREDICTING RESULTS OUTSIDE THE LABORATORY**

Another potential benefit of GE foods, namely, healthier foods for starving populations, has also failed to come to fruition. A common example appealed to is Golden Rice, which is a type of GE rice with enhanced beta-carotene to help populations deficient in vitamin A. Although Golden Rice looked promising in the laboratory, when it was grown in real conditions the amount of beta-carotene produced was negligible (Robin 2010, 326).

### **ALLERGIC REACTIONS**

Allergic reactions to new GE plants are extremely hard to predict (Cummins and Lilliston 2000, 37). In 1996, Pioneer Hi-Bred hoped to market a GE soybean that had been spliced with a Brazil nut. Although the testing was not mandatory, testing on animals had turned up negative when looking at allergenicity (36). However, in an independent study, University of Nebraska researchers found that when Brazil nut DNA was gene-spliced into conventional soybeans, the result could induce potentially fatal allergies in people sensitive to Brazil nuts (36). Plans for production therefore ceased.

### **RELIGIOUS CONCERNS**

If the public is not informed of GE products, an additional worry is that given some religious rules around forbidden foods, people seeking to follow their religious custom may inadvertently eat an organism that has been merged with the DNA of another organism that they are not permitted to eat in their religious practice (Feit 2002, 123–129).

### **LOST TRUST**

Polls consistently show that most North Americans want to know if the food they buy contains a GMO or not (NGMOP). For example, “a 2012 Mellman Group poll found that 91 percent of American consumers wanted GMOs labeled,” and 53 percent of consumers said they would not buy genetically modified food in a 2008 CBS/New York Times poll (NGMOP). All of the concerns outlined in this chapter help substantiate the importance of making such data available so that consumers can make more informed choices. In spite of a clear majority wanting to be informed of the content of their purchases, to date there has been no federally mandated GMO labeling laws in the United States. When consumers are

kept in the dark about what sort of foods they are buying, when they demand transparency and are met with opacity, loss of trust is an unsurprising result.

#### FOOD FOR THOUGHT

Despite the impressive potential benefits of GE foods, the actual, concrete harms associated with their introduction have been devastating. In 1998, a conference was held in which scientists, philosophers, lawyers, and environmental activists agreed on the necessity of adopting the precautionary principle for both public health and environmental decision-making. The precautionary principle runs as follows: “When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically” (Science and Environmental Health Network 1998). Thus, even though debate rages on regarding the merits and threats of using GE plants, one could argue wisdom requires much more precaution than has been exercised thus far (Dagicour 2002).

### ANIMALS: INDUSTRIAL AGRICULTURAL TECHNOLOGIES

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Next, another way in which technology is changing what and how we eat is addressed. Due to the implementation of industrialized livestock agriculture, humans are eating more animals and animal products. The method of production has changed to implement technologies that reflect the industrial ethos of efficiency and increased production.

#### INDUSTRIAL ETHOS AND BENEFITS

From the second half of the eighteenth century, and for approximately 100 years following, the Industrial Revolution fundamentally transformed the distribution of people and their work patterns. Many shifted from sparse populations engaged in a largely agrarian lifestyle to dense concentrations of populations in cities, working in factories that utilized various industrial machines. An industrial revolution necessitated an agricultural revolution, because more food was needed for people in urban environments, and food had to be provided by proportionately fewer rural workers (Ruse and Castle 2002, 22). During the Industrial Revolution scientific principles of crop management and breeding were discovered and implemented. Once root crops were improved, instead of animals needing to be killed (because there was a lack of food for them over the winter months), significant, long-term animal husbandry could be practiced.

There was also a marked shift following World War II in that Americans started eating a lot more meat. After World War II, industrial production systems took over what had previously been small farms (Earth Policy Institute 2012). An industrial ethos began to dominate animal agricultural practices. The logic of industry involves industrial principles in which one monitors inputs and outputs, in which streamlined simplicity is valued (thus the hallmark of the industrial food chain is monoculture), and in which time is money and yield is the priority (Pollan 2006, 8, 45–46). The goal in industrial manufacturing is achieving maximum speed, output, and efficiency. Thus, the primary benefits taken to follow from implementing new industrial technologies in animal production were maximum speed of production, increased output regarding production, and increased efficiency regarding production. The most important of the alleged benefits is that such an approach generates more food from animals for a growing population at a lower cost.

## **HIGHER EFFICIENCY: CONCENTRATED ANIMAL FEED OPERATIONS (CAFOS)**

The technology of concentrated animal feed operations (CAFOs; also called factory farms) embraces industrial logic, and has increased meat production. This increase has allowed many more people to eat meat, and eat it more often. Thus, there is a benefit for meat eaters: increased production and therefore increased availability.

The US Environmental Protection Agency defines a CAFO as an animal feeding operation (AFO), which is an agricultural operation in which animals are kept and raised in a confined situation (EPA, “What Is a CAFO?”). In AFOs, animals, feed, manure, urine, dead animals, and production operations are confined to a small area of land. Rather than animals grazing or seeking food in pastures, fields, or rangeland, feed is brought to them. An operation is an AFO if “you confine animals for at least 45 days in a 12-month period” and there is “no grass or other vegetation in the confinement area during the normal growing season” (EPA, “Regulatory Definitions”). CAFOs are AFOs that meet certain criteria. In particular, CAFOs are defined by their size (EPA, “Overview”). A large CAFO for cows, for example, has 1,000 or more cattle or cow/calf pairs, a medium CAFO has 300 to 999, and a small CAFO has fewer than 300 but has been designated a CAFO by the permitting authority as a significant contributor of pollutants (EPA, “Regulatory Definitions”). The reference to pollutants is important because CAFOs not only increase the amount of animals, they also increase the amount of pollution associated with those animals. The pollution associated with CAFOs will be discussed in more detail shortly.

## **INCREASED PRODUCTION: CAFOS**

With the advent of CAFOs, there has been a marked increase in the amount of meat produced and consumed annually. Between 1909 and 1950 Americans, on average, ate anywhere between roughly 10 billion to 20 billion pounds of meat (it varied from year to year) (Earth Policy Institute 2012). Compare this with the peak in 2007 of 55 billion pounds. It is hard to conceptualize what this means concretely, so it is worth considering in terms of average yearly consumption per person. USDA data show that in 2004 in the United States each person ate on average 184 pounds of meat annually. In 2011, it was 171 pounds (Earth Policy Institute 2012).

The sorts of animals currently eaten in the United States are primarily cows and chickens, with pigs following in third place (Barclay 2014). In 2012, the average American consumed roughly 71.2 pounds of red meat and 54.1 pounds of poultry (Molla 2014). Because this average does not take into account the 5 percent of the population that is vegetarian, nor does it take into account lower amounts of consumption by babies and children, nonvegetarian adults probably average more meat consumption than these numbers indicate.

An immense number of animals are slaughtered to meet this demand. The USDA Livestock Slaughter Summary for 2014 shows that the number of cows slaughtered totaled 30.2 million and the number of calves totaled 565,800. Also, 106.9 million pigs were slaughtered. Additionally, 2.31 million sheep and lambs were slaughtered, with lambs and yearlings constituting 93.5 percent of the slaughtered animals in this group (USDA, April 2015). In the same year over 8.6 billion chickens were slaughtered (USDA, February 2015). The consumption of animal products is also on the rise; consider the following statistics, which account for just one month. During November 2014, there was an average of 360

million laying chickens, and they produced 8.31 billion eggs (USDA 2016). The industrial goal of increased production has been wildly successful in the United States.

### **MORE FOOD**

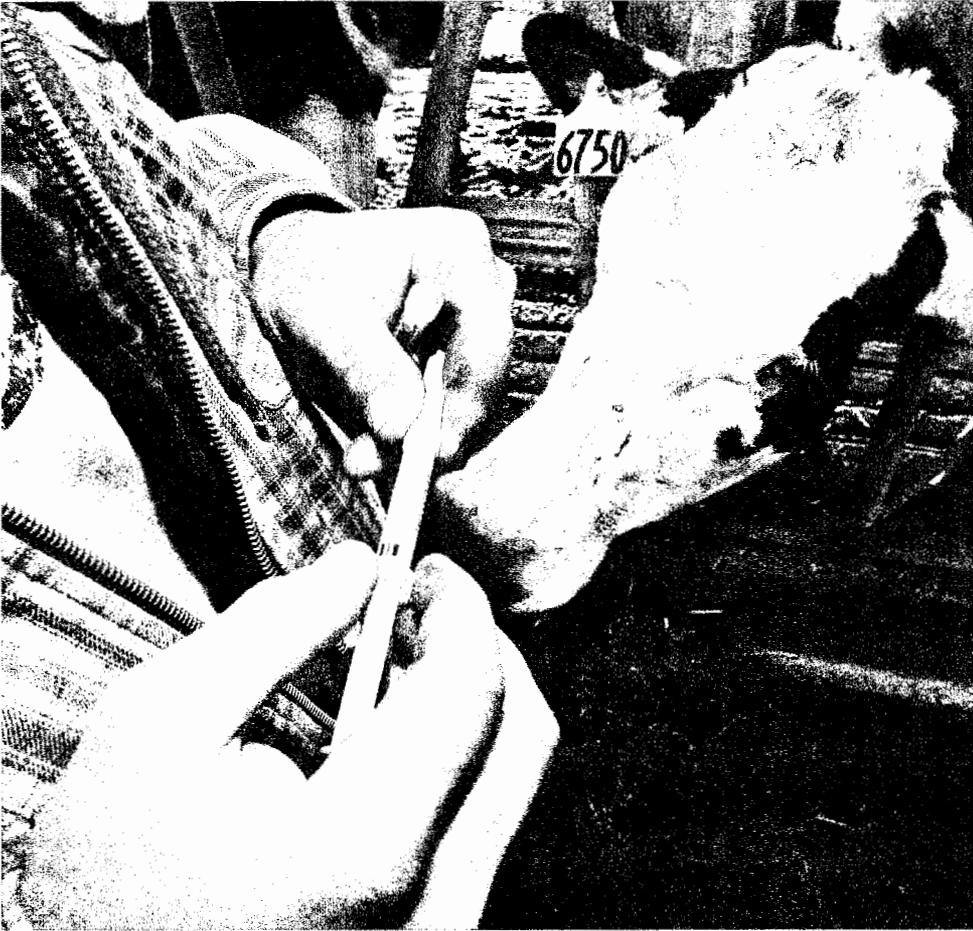
Put simply, industrial technologies have increased the amount of food in the form of nonhuman animals and their products. The data bear out this increased production and consumption. Animals are used, in part, to consume their reproductive products (eggs), consume their flesh (meat), and consume the products of lactation due to pregnancy (milk). The topic of milk introduces the first harm associated with industrial animal agriculture. In keeping with the industrial ethos, research was done regarding ways to artificially increase milk yields in cows.

### **HARM TO HUMAN HEALTH: INCREASED USE OF ANTIBIOTICS**

One method for increased yields (and therefore greater productivity) is exemplified by Monsanto's research for a way in which to increase the milk productivity of cows. A cow lactates naturally only when pregnant, and milk production begins to decrease around six months after the birth of her calf (Singer and Mason 2006, 57). The veal industry developed around the need to find a use for the calves that were not being allowed to drink their mother's milk because their milk was slotted for human consumption. To increase the milk productivity of cows, scientists sought to identify the gene that produced the hormone somatotropin, which is a natural hormone secreted by the pituitary glands of cows after calving that stimulates lactation. After the scientists isolated the gene that produces the hormone, they used genetic manipulation to introduce it into a bacterium, making it possible to manufacture on a large scale (Robin 2010, 91). The transgenic hormone was named recombinant bovine somatotropin (rBST), which is called recombinant bovine growth hormone by Monsanto's opponents. rBST increases milk production by about 10 percent (Singer and Mason 2006, 57).

The transgenic hormone rBST had unfortunate, and unexpected, results. One of these was mastitis, a painful inflammation of a cow's udders, which results in pus in the milk—the cows then have to be treated with antibiotics that can leave residues in the milk (Robin 2010, 92). There is also concern with decreased efficacy of antibiotics because they are being overused (both in animal agriculture and more generally as well) (UCS, "Prescription for Trouble"). When bacteria are overexposed to antibiotics, hardy strains of the bacteria survive the exposure, and then pass on the resistance to successive generations and to other bacteria that are unrelated, including bacteria that cause human disease, thereby rendering the antibiotic no longer an effective treatment. When humans consume antibiotic residues from the milk of lactating female cows, bacteria can then become resistant to antibiotics, resulting in new outbreaks of diseases the medical community thought they had eradicated (Robin 2010, 102). Although countries such as Canada, New Zealand, Australia, and Japan ban the use of rBST, it was approved by the FDA in 1993 and is sold across the United States without mandatory labeling.

Antibiotics are being used not only for cows with mastitis, but also with livestock animals more generally, given that the probability of illness increases in CAFOs. The agricultural uses of antibiotics and related drugs account for 70 percent of drugs used in the United States, and meat eaters come into contact with these animals regularly at mealtime (Pollan 2006, 78; UCS, "Prescription for Trouble"). The practice of using antibiotics in animal feed for the quantity of animals currently being processed is generally acknowledged as leading directly to new antibiotic-resistant superbugs (Pollan 2006, 78). The Centers for



*rBST.* Jesus Guzman holds a couple of vials of the hormone rBST before injection. AP IMAGES/GARY KAZANJIAN.

Disease Control and Prevention (CDC) concluded that antimicrobial use in food animals is the dominant source of antibiotic resistance among food-borne pathogens in the United States (UCS, “Prescription for Trouble”). Both the World Health Organization and the CDC have called for a cessation of the use of drugs that are used to therapeutically treat humans being used to treat animals in nontherapeutic ways. The nontherapeutic use of antibiotics includes (1) animals being given antibiotics not to cure illness but rather to promote feed efficiency, in other words, to increase the animal’s weight gain, and (2) when animals are given drugs as a preventive measure to prevent diseases caused by the overcrowded and unsanitary conditions of CAFOs. On March 27, 2015, the Obama administration released a National Action Plan to Combat Antibiotic-Resistant Bacteria, which included elimination of the use of medically important antibiotics for growth promotion in food-producing animals. It was noted in the press release that the CDC “estimates that drug-resistant bacteria cause 23,000 deaths and 2 million illnesses each year in the United States” (The White House, Office of the Press Secretary 2015).

Likewise worrisome are the outbreaks due to the sheer number of animals confined in intensive production facilities. For example, in 2005, a United Nations task force identified farming methods that crowded enormous numbers of animals into small spaces as one of the root causes of the bird flu epidemic. High-intensity chicken farming is an ideal environment for generating virulent avian flu virus (Singer and Mason 2006, 34).

#### **HARM TO HUMAN HEALTH: OBESITY**

In another vein, livestock products provide one-third of the protein intake of humans on average, and are a contributing cause of obesity (FAO 2006). Obesity in the United States costs the health-care system an estimated US\$90 billion a year. Three out of every five Americans are overweight, and one in every five is obese (Pollan 2006, 102).

In 2000 the number of people worldwide suffering from being overweight or obese (1 billion) surpassed the number suffering from malnutrition (800 million) (Pollan 2006, 102). Although there are certainly other potential contributing causes, including poverty (healthier foods cost more), forms of technology that render us sedentary (computers at work, remotes at home), supersized portions, and changes in diet to more processed foods, it still remains the case that when food is abundant and cheap, people will eat more of it (Schlosser 2002; Pollan 2006, 102, 107). And CAFOs have made meat abundant and more affordable.

#### **INEFFICIENT**

Increased efficiency is heralded as a strength of industrial agricultural production, but this claim depends on what one's measure of efficiency is. It is true that more animals are grown and slaughtered than before. But many argue that eating industrially produced animals and their products is an inefficient way for feeding a growing population. Although intensive animal production is more efficient at producing meat, eggs, or milk per pound of grain, those grains would be more efficiently used if they were consumed directly by our growing human population (in terms of consumable calories produced). Rather than increasing the total amount of food for human consumption, CAFOs actually reduce the total amount of food available for human consumption (Singer and Mason 2006, 231).

Consider how animals use much of the caloric value of the food they consume: to move, keep warm, form bone, and so on (Singer and Mason 2006, 231). To make one quarter-pound hamburger it takes 6.7 pounds of grain and forage, 52.8 gallons of water for drinking and irrigating feed crops, 74.5 square feet for grazing and growing feed crops, and 1,036 Btus for feed production and transport (Barclay 2014). Instead, if one chose to eat lower on the trophic pyramid (trophic levels are where one stands in the food chain), fewer resources would be used in the process. By humans consuming grains and legumes directly, the majority of their caloric energy is not wasted in the way that it is when those grains and legumes are fed to animals that are eaten later by humans. Using cropland to grow food for humans to eat is a more efficient way to generate food than using cropland to feed animals that humans eventually eat (Singer and Mason 2006, 231). Roughly 13 pounds of grain are required to produce a single pound of beef (232). For chickens it takes 3 pounds of grain for every 1 pound of chicken meat. As such, it can be argued that if feeding humans efficiently is the goal, it makes more sense to eat the grains rather than feed them to animals (Singer and Mason 2006, 232).

Moreover, the increase in meat eating as currently practiced is not sustainable. It is not possible for everyone in the world to eat as much as affluent people do, because it would

require 67 percent more agricultural land than actually exists on the planet (Singer and Mason 2006, 232–233). Additionally, CAFOs place greater demands on the environment than other forms of farming when you attend to land, energy, and water use (231). The question of efficiency needs revisiting insofar as the majority of resource use and associated ecological harm is not being factored into the current industry calculations.

### **ECOLOGICAL IMPACTS**

In the United Nations' widely cited report on the ecological impact of animal agriculture, a number of sobering statistics were brought to the fore about the direct impacts of the livestock sector as well as the impacts of feed crop agriculture for livestock production (FAO 2006). The livestock sector is the single-largest human-caused user of land, with livestock production accounting for 70 percent of all agricultural land and 30 percent of the land surface of the planet (FAO 2006). Livestock production is a key contributor to deforestation. For example, in the Amazon 70 percent of previously forested land is now occupied by pastures, and feed crops cover a large part of the remainder (FAO 2006). Annually 6 million acres of Amazon rain forest is cleared to graze cattle and grow soy as animal feed (Singer and Mason 2006, 233).

In terms of concerns about climate change (rising temperatures and sea levels, melting ice caps and glaciers, and shifting weather patterns and ocean currents), which has been identified as the most serious challenge facing the human race, the livestock sector's negative influence is significant, contributing 18 percent of greenhouse gas (GHG) emissions measured in carbon dioxide (CO<sub>2</sub>) equivalents, which is a higher share than transport (FAO 2006). Livestock, through their waste, contribute a sizable amount of methane gas. The sector emits 37 percent of anthropogenic (meaning humans are responsible for this happening) methane, with most of that coming from enteric fermentation by ruminants. The sector also emits 65 percent of anthropogenic nitrous oxide, the great majority of it coming from manure, and 64 percent of anthropogenic ammonia emissions (which contribute significantly to acid rain and the acidification of ecosystems more generally) (FAO 2006). A 2010 FAO report found that the global dairy sector alone contributes 4 percent of total global anthropogenic GHG emissions (FAO 2010).

As the world population moves closer to a severe shortage in freshwater, the contribution of the livestock sector is important to address. Livestock accounts for over 8 percent of global human water use, primarily in the irrigation of feed crops (FAO 2006). The US beef industry uses 792,000 gallons of water to produce a 1,000-pound steer (Singer and Mason 2006, 235). The livestock sector is also likely the largest source of water pollution, contributing to dead zones in coastal areas, degraded coral reefs, and multiple human health problems (such as the emergence of antibiotic resistance discussed previously) (FAO 2006). Animal wastes, antibiotics and hormones, chemicals from tanneries, pesticides and fertilizers used for feed crops, as well as sediments from eroded pastures are all major sources of pollution. In the United States, livestock generates an estimated 55 percent of erosion and sediment, 37 percent of pesticide use, and one-third of the loads of nitrogen and phosphorus harming freshwater sources (FAO 2006).

In terms of threats to biodiversity, species loss is occurring at a rate 50 to 500 times higher than background rates in the fossil record, and 15 out of 24 important ecosystem services are in decline (FAO 2006). The 2006 FAO report estimates that the livestock sector may be the foremost contributor to the reduction of biodiversity because it is the major driver of deforestation and a leading driver of land degradation, pollution, climate change,

invasions of alien species, sedimentation of coastal areas, and overfishing. Moreover, “most of the world’s threatened species are suffering habitat loss where livestock are a factor” (FAO 2006, xxiii). One of the recommendations made by the United Nations is to make it a priority to “achieve prices and fees that reflect the full economic and environmental costs, including all externalities.” This is emphasized because at present most natural resources are treated as free, which leads to overexploitation, pollution, and perverse subsidies that directly encourage livestock producers to engage in environmentally damaging activities (FAO 2006, xxiii). Again, the legitimacy of claiming that the livestock sector has increased efficiency through the use of CAFOs is called into question insofar as environmental and health costs are treated as externalities.

### ANIMAL WELFARE

Peter Singer changed the landscape of food ethics and philosophical ethics in the West with his groundbreaking book *Animal Liberation*, first published in 1975. He outlines the suffering experienced by animals living in factory farms. Insofar as one recognizes that morally one should not support practices that generate unnecessary suffering, and factory farms cause unnecessary suffering, one should not support factory farms (Singer 1990, 7). The concern with causing suffering is all the more important when one recognizes the fact that the suffering beings’ most significant needs are being trumped by trivial human wants—and Singer argues that this is precisely the case with factory farmed animals (9). The vast majority of people do not need to eat the flesh of nonhumans, nor consume animal products, because human nutritional needs can be met through a vegan diet (a diet without the consumption of animal flesh or animal products). The American Dietetic Association (which became known as the Academy of Nutrition and Dietetics in 2012) holds that “appropriately planned vegetarian diets, including total vegetarian or vegan diets, are healthful, nutritionally adequate, and may provide health benefits in the prevention and treatment of certain diseases” (2009). The US Department of Health and Human Services and USDA publication *Dietary Guidelines for Americans 2010* outlines numerous benefits of a vegetarian diet and includes a vegan template for recommended intakes. The suffering of animals farmed in CAFOs is immense (as will be illustrated in what follows), and given that meat eating isn’t nutritionally necessary, it is often done for the sake of a taste of a dish rather than any primary need. As such, morally, those who do not require the consumption of nonhuman animals to meet basic requirements should stop eating factory farmed meat. Looking at the life cycle of a factory farm chicken helps validate Singer’s contention that factory farmed animals suffer immensely. Virtually all chicken sold in the United States comes from a factory farm (Singer and Mason 2006, 22). Following chickens, pigs and cows will be addressed.

Almost all broiler chickens sold in supermarkets are raised in large sheds (490 feet by 45 feet), with a typical shed holding 30,000 or more chickens (Singer and Mason 2006, 23). In terms of space, each chicken is allocated the same amount of space as roughly the size of a standard sheet of paper (8.5 by 11 inches). As they near market weight, they are unable to move without pushing through other birds, unable to stretch their wings, unable to escape more dominant, aggressive birds, and the birds experience stress because they are unable to engage in their usual social behaviors such as establishing a pecking order. The primary motivation for the state the chickens are kept in is financial returns. As the Commercial Chicken Production Manual notes, the crucial question is “What is the least amount of floor space necessary per bird to produce the greatest return on investment” (Singer and Mason 2006, 23).

Upon entering a typical chicken shed one's eyes and lungs start to burn due to the ammonia buildup from the bird's droppings, which pile up on the floor—typically for an entire year. This high ammonia level gives the birds chronic respiratory disease, breast blisters, sores on their feet and hocks, and makes their eyes water, and in some cases, birds may go blind (Singer and Mason 2006, 24). Because the birds have been bred for extremely rapid growth, as they grow it begins to hurt to keep standing up, so they spend a great deal of time sitting on the excrement, thereby getting breast blisters. Given the breeding for maximum flesh in the shortest amount of time, chickens today grow three times as fast as those in the 1950s, even though they consume roughly one-third as much feed. The single-minded pursuit of efficiency has generated chickens whose bone growth is outpaced by the growth of fat and muscle. According to one study 90 percent of the birds resultantly had detectable leg problems, and 26 percent suffered chronic pain as a result of bone disease. Sometimes vertebrae outright snap, causing paralysis. These paralyzed birds cannot get to food or water, so they die of thirst or starvation (Singer and Mason 2006, 24).

After living for only six weeks, chickens are brought to slaughter (Singer and Mason 2006, 25). To put the six weeks into perspective, the natural life span of a chicken is roughly seven years (Singer 1990, 99). The chickens are often grabbed by a leg and thrust into cages. Dangling chickens from one leg causes the terrified birds to flap and writhe and as a result they often suffer dislocated and broken hips, internal bleeding, and broken wings (Singer and Mason 2006, 25).

The same industrial goals shape slaughterhouses. Motivated by the industrial ethos, speed is taken to be of the essence because the slaughterhouse is paid by the pounds of chicken generated. A killing line typically moves at ninety birds per minute (which is twice as fast as in the mid-1980s)—at such speeds it is impossible for the handlers to handle the birds with care (Singer and Mason 2006, 26). Upon arrival, the chickens have their feet snapped into metal shackles upside down on a conveyor belt that moves in the direction of the killing room. The chickens' heads are dropped into an electrified water bath that fails to render the majority of the chickens unconscious; as such, they still experience distress and pain after being electrified. After being electrified, the birds move on to have their throats cut, but the throat cutting misses some birds due to the fast line speed. In those cases live, conscious birds go to the next stage of the process—a tank of scalding water (Singer and Mason 2006, 26). Documents obtained under the Freedom of Information Act indicate the number of birds that are therefore, in effect, boiled alive, could be as many as three million a year in the United States (Singer and Mason, 2006, 26). An undercover filming of a Kentucky Fried Chicken supplying slaughterhouse showed workers slamming live chickens into walls, jumping up and down on them, and kicking them like footballs (27). According to Professor John Webster of the University of Bristol's School of Veterinary Science, chicken production is “in both magnitude and severity, the single most severe systematic example of man's inhumanity to another sentient animal” (24). In chicken production the focus is on speed of production and cutting labor costs, with relative indifference to ethical concerns (35). The people who work in such conditions are themselves underpaid for brutal, and often brutalizing, work.

The chickens discussed previously are bred to be eaten, but there are also laying hens that are used to create eggs. These chickens live in cages with sloping wire floors, which help the eggs roll to the front for easy collection, but the angle makes it difficult for the chickens to stand comfortably (Singer 1990, 108–109). They are typically crammed into cages so

small no bird can stretch a single wing (Singer and Mason 2006, 37). To ensure the birds do not peck at each other, the beaks are seared off with a hot blade and no anesthetic. After a year or so, the hen is debilitated and the egg production goes down. Many American producers then starve the birds until they molt (lose their feathers and stop laying eggs) and then start feeding them again to get a few more months of eggs out of them before they are killed (38). To get an “Animal Care Certified” seal, hens must be allowed a mere 67 inches of space, and searing part of their beaks is still permitted—a chicken’s beak is full of nerve endings and plays a key role in picking up food, thus beak searing causes both immediate acute pain as well as chronic pain (39–40).

Pigs are as intelligent as dogs, and although treating dogs in the way factory farmed pigs are treated is illegal in many countries, in the United States there are no laws for the treatment of pigs beyond their welfare when they are transported to, and arrive at, slaughter (Singer and Mason 2006, 45). Crowded indoor pens made of concrete and steel are the reality for more than 90 percent of pigs raised for consumption. Breeding sows are kept pregnant for most of their lives, and while pregnant, they live in gestation crates (steel-barred stalls or crates approximately a foot longer than their bodies and too narrow to turn around in) (46). Pigs are not only intelligent but highly social and sensitive animals. In CAFOs they are trapped without any opportunity to socialize or root around. Once a pig has given birth, she is put in a crate that keeps her teats exposed to her piglets; as such, she is unable to roll over (46).

As previously discussed, cows (which are female by definition) are kept pregnant so as to facilitate lactation for milking for human consumption of cow milk. Contrary to popular belief, cows have strong emotional lives and get excited when they solve intellectual challenges (Singer and Mason 2006, 56). Modern dairy cows’ bodies are strained because they have been bred to produce as much milk as possible (they now produce three times as much as an average cow in the 1950s) (57). As already discussed, rBST is also used in the United States to increase yield. Outside factory farm conditions once a cow gives birth, calves normally suckle for six months, which results in a strong bond between the calf and its mother. At dairy farms, when calves are taken away shortly after birth, the mother bellows ceaselessly. The majority of male calves are raised to be veal or are slaughtered for pet food, and some of the stronger ones are raised as beef cattle (56). Veal calves live for sixteen weeks, intentionally kept anemic and unable to move; they are tied up at the neck in a wooden crate so their flesh is tender and pale (58–59).

Cattle bred for beef evolved to eat roughage, but are fed corn. As a result many cattle on feedlots are sick (Pollan 2006, 77). Bloat is a serious concern, because the fermentation in the rumen of cattle creates a large amount of gas that is expelled through belching when cattle are eating grass and fails to be expelled when cattle are eating too much starch and too little roughage. The rumen inflates until it presses against the cattle’s lungs. If the pressure isn’t relieved promptly, the cattle suffocate (78). When cattle eat a continual diet of corn it can also cause acidosis, which can sometimes result in death, although usually it just makes them sick and can lead to liver disease, a weakened immune system, ulcers, diarrhea, bloat, and so on (78). Cattle usually live on feedlots for no more than 150 days, and some veterinarians hypothesize they could not survive much longer than that. To keep these sick animals functional, they are fed antibiotics, which results in the evolution of new antibiotic-resistant superbugs (78). It can be argued, then, that the practices outlined provide ample evidence that efficiency in industrial livestock production is bought at the cost of basic decency in terms of our treatment of fellow birds and mammals.

## TECHNOLOGY

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Developing technologies also radically changed the food landscape.

### TRANSPORTATION TECHNOLOGIES

With developments in transport technology, access to different foods at greater distances became a possibility. The diversity of what humans consume increased as a result. Food now travels by truck, rail, ship, and plane, and each generates its own ecological footprint. More often than not food has traveled quite a distance to reach your plate.

Food miles refer to the environmental impact of the distance food travels from the place it was farmed to one's plate (Sustain 1999, 2). Food miles are on the increase; since the 1950s food production, distribution, and consumption patterns have undergone a radical transformation (3). Increasing amounts of produce are imported as retailers create more extensive and complex distribution systems and outlets (3). This has set up expectations for consumers when it comes to the sorts of food that should always be conveniently available (3). Between 1968 and 1998 the world population increased by 91 percent, world food production increased by 84 percent, but food trade increased 184 percent (NRDC 2007, 2). The average American prepared meal now contains food from five or more countries outside the United States (NRDC 2007, 2). Part of this trend has been shaped by developments in grocery retailers who embrace the industrial ethos.

As large retail chains dominate markets, supermarkets exert a virtual monopoly so that many consumers have little choice but to shop at major supermarkets (Sustain 1999, 3). Questions of cost also factor in. Large chains can underprice local competitors given their position of relative dominance and the economics of scale at which they operate. The environmental and societal costs of large chains' overseas sourcing, drive for efficiency, central distribution system, and expansion of their retail area are not accounted for (3). Thus, those low prices are not genuinely reflective of comprehensively analyzed costs. The impact of increased food miles means more transport pollution, more packaging to maintain food quality (and more waste), more processing, more biodiversity loss (major chains prefer a limited range of varieties of crops to simplify packaging and distribution operations), more agrochemical use (chemicals are used in long-distance transport to preserve crops in transit or storage, and the demand for the same variety of produce grown in large quantities creates disease and pest problems as was discussed above with regard to monoculture), and finally, decreased nutritional content (storing and transporting fresh produce can result in decreased nutritional content, and the demand for only certain foods sidelines varieties of crops that provide better nutritional value) (6–7).

The average distance estimated from farm to plate in the United States is remarkably high. In a 2001 study led by Rich Pirog, it was estimated that food travels on average 1,500 miles from farmer to consumer (DeWeerd 2009). In contrast, locally sourced food traveled an average of 44.6 miles. The study was focused in Iowa, so variation across states is inevitable, as is variation within particular consumption patterns, but it serves to highlight related ecological concerns. Conventional food distribution systems generate 5 to 17 times more CO<sub>2</sub> emissions, and use 4 to 17 times more fuel, than regional and local systems according to Pirog's team's findings.

In terms of environmental impacts, the type of vehicle used for transporting the food makes a difference. The following are taken from the Greenhouse Gas (GHG) Protocol,

which is “the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions” (GHG Protocol 2015). The emission factors for different modes of transportation are based on 1,000 kilograms of product. Planes (1.055) have the highest total GHG emissions, followed by trucks (0.204) and then ships (0.033); and trains (0.017) have the lowest impact of the four forms of travel. This means the GHG emissions for food that has been transported by plane is 62 times higher than if it had traveled by train (GHG Protocol 2015).

The whole story of the ecological impact of any form of food must also include how it was grown, which was discussed in the first two sections of this chapter. Additional ecological impacts need to be taken into account, such as whether the local food was grown in a heated greenhouse in the middle of winter, whereas the imported one grew outside, and the like. Looking at a full life-cycle assessment of the food gives a more robust analysis of the ecological impacts. A full life-cycle analysis of the American diet shows that farm to plate accounts for 4 percent of transport-related emissions and about one-fourth of the total miles the food travels, with much of the transport and emissions associated with the American diet happening prior to when the food leaves the farm—distances traveled to transport fertilizer, animal feed, pesticides, and so on. Transport as a whole accounts for 11 percent of the total food system’s emissions (DeWeert 2009). In contrast, the bulk of the food system’s GHG emissions (83%) comes from agricultural production that happens before the food leaves the farm gate.

The effort to decrease the ecological impact of food transportation has been making impressive gains. By making a decision to buy from local farmers, the ecological impact of food transport is significantly lessened. Eating in season helps to ensure that foods are eaten when they are available. The local food movement is growing by leaps and bounds. The USDA reports that the number of farmers’ markets has grown significantly. Local food sales are estimated to have totaled US\$6.1 billion in 2012 (Low et al. 2015). The number of farmers’ markets went from 2,746 in 1998 to 5,274 in 2009, and the number of community-supported agriculture programs increased from 400 in 2001 to 1,400 in 2010 (Martinez et al.).

#### **FOOD FOR THOUGHT**

Much like in the case with GMOs, with factory farms technologies developed to meet the mandate of increased production. The technologies themselves are effective at increasing production, though the viability of this as a long-term approach is called into question by the ecological destruction that results from these technologies. Often ethical questions about impacts on human, animal, and ecological health are trumped by an industrial ethos to maximize efficiency, speed, and profits. Moreover, in the effort to grow ever more food, the question of the long-term impact of a growing population is being sidelined, as the effort to solve acute problems (such as world hunger) fails to address what has turned into a chronic issue (overpopulation). Consider what occurs when direct research and dollars are focused on a Band-Aid rather than a cure.

#### **POPULATION ARGUMENT**

One of the strongest arguments in favor of continuing current dominant trends in agricultural technology is the claim that more food is produced. There is a recurring argument from multiple sources in favor of using genetically modified foods to solve the problem of world hunger. Arguing in favor of feeding more people more meat through factory farms could likewise be advanced as an anthropocentric (only seeing worth in human

life) argument in favor of factory farms. As previously suggested, anyone who argues against pursuing technology that increases food production could be perceived as rather monstrous, given that in doing so a person could be arguing against feeding starving people. Unless one successfully calls into question the premises underlying the argument in favor of modern biotechnology as a solution to hunger, one must present significant harms associated with such technology to undermine the active pursuit of current techniques. Significant harms associated with both GMOs and factory farms have been identified earlier in this chapter.

But the argument can be questioned from another angle. An underlying premise of the previous argument is that, as Shapiro says, given an increasing population and no correlating increase in land availability, “The conclusion is that new technology is the only alternative” (Robin 2010, 189). One could argue that is a false dilemma. The two choices may not be between utilizing modern food biotechnology or starvation. There are alternative potential contributions to solutions that involve consuming less food, and less unhealthy food in particular, in developed nations (recall there are now more obese people than there are people dying of starvation). The CDC reports that annual medical costs attributable to people being obese or overweight add US\$25 billion to US\$38 billion to taxes and add US\$20 billion to US\$28 billion to private insurance bills (Singer and Mason 2006, 280). Another potential contribution to solutions is available via a more equitable distribution of wealth and therefore access to food that is available. The United Nations’ FAO director-general, Dr. Jacques Diouf, appealed to world leaders in 2008, highlighting that only US\$30 billion a year was needed to set in place the programs needed to end world hunger (Matthews 2008). To put this into context, Dr. Diouf highlighted that in 2006 the world spent US\$1200 billion on buying arms.

Moreover, US\$11 billion to US\$12 billion in subsidies was used to divert 100 million tonnes of cereal crops from human consumption to generate fuels (Matthews 2008). Also important by way of envisioning potential contributions to solutions is countering trends in food waste. Many of agriculture’s harmful effects could be reduced if people ate what is currently wasted—more than 40 percent of food grown in the United States is wasted, totalling approximately US\$100 billion of wasted food a year (Singer and Mason 2006, 268). In the United States, 14 percent of household waste is food that is still in its original packaging and not out of date (269).

Part of what is not being illuminated by discussions of ending world hunger through technological innovation is the fact that planetary health requires a decrease in the human population. Technological fixes thus far have failed to adequately feed the hungry, failed to protect complex biodiversity, failed to ensure functional ecosystems in the future, and have failed to protect the resources needed for future generations to survive, let alone thrive. It could be argued, then, that a technological Band-Aid for overpopulation cannot be pursued in isolation from, or at the expense of, other solutions. The problem of overpopulation itself must be treated. The world cannot sustain the current human population. If everyone consumed at the rate developed nations consume, then ten more planet Earths would be needed (Maguire 2009, 515). Simply extending what those in developed nations consume to others is not possible, as it would hasten the destruction of the biosphere, while limiting the consumer lifestyle to those who already have it is not politically possible, not ecologically sufficient for stopping the destruction of the environment, and not morally permissible (Durning 2009, 507). Rather, people need to consume less. Moreover, there have to be

fewer people in the future. Christine Overall argues that creating children is an ethical choice, and argues everyone has a personal responsibility to stop procreating at the rate humans currently are. Developed nations that consume vastly more resources than developing nations have a special responsibility to decrease their own contribution to overpopulation because a single child living in a developed country consumes vastly more resources than children in developing countries.

Contrary to Shapiro's stance, one could argue technological advances are neither the sole solution to world hunger nor are they dealing with the problem at the source. In fact, one could argue, postulating technological fixes facilitates a pseudo-justification for continuing current procreative and consumption patterns. One could argue, instead, that research and funds should be directed primarily at finding solutions to the problem of overpopulation and the unsustainable resource use that is currently necessarily tied to an increased population. One could argue such an approach is far more viable than hoping for solutions while primarily funding research and investing money in what has thus far amounted to ensuring a continuing increase in population and unsustainable resource use. It need not be an either/or, though, in which one must either focus on technology for feeding starving people or focus on decreasing overpopulation, resource use, and consumption. Those who are currently here and hungry absolutely need to be helped. Ecologically respectful and ethically defensible technologies can be developed in this pursuit. However, proactively decreasing the population of future generations of humans in a moral way is a necessary component of concrete and immediately available sustainable human practices.

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## Summary

The chapter began with love stories about people and food. Intimate relations of care were described, relations that involved knowledge, openness, intuition, and love. Then a story of the current, dominant relations people in industrialized nations such as the United States have with their food was presented. The juxtaposition is stark, and all the more telling for that. Thoreau's meticulous recounting of each seed he planted, and descriptions of the ways he doted on them daily was juxtaposed with agricultural systems so large that tracing the path of a single seed is rendered impossible through the sheer abstraction demanded by such large numbers (Pollan 2006). Barbara McClintock's invitation to dialogue with genetic structures was juxtaposed with using a gun to randomly insert bits of gene into organisms that would never combine without such a violent entry. The hunting of animals for food lending itself to stopping hunting out of respect was juxtaposed with billions of animals living in horrendous conditions to provide the US population's increased expectations for available meat. Food systems were presented that are so far removed from approaches such as McClintock's and Thoreau's that the language of love and respect is, in many cases, rendered unintelligible.

The pattern for current relationships with food is less one of love, humility, and awe in the face of the complexity of nature and more one of domination through industrial logic. Today's relationship with food production is more aligned with a reductive narrative, in which food exists to serve our interests and is lifted out of traditional ecological systems and forced into more linear, industrial ones. Further questions to explore include: What would technologies that grew out of love look like? What might love reveal for healthy ways to relate to that which is meant to nourish? How, through our eating choices, could the world be left better off for us having been here?

Michael Pollan contends eating is an agricultural, political, and ecological act (2006, 11). Although industrial food systems obscure this fact, what and how we eat determines in a significant way how we make use of the world, and how it is to fare in the future (11). Through the effort to minimize ignorance and eat with a fuller consciousness of all that is at stake, one is placed to make intelligent, caring, and informed decisions about the relationships one has with their food, each other, and the planet (11). What and how one eats is an act that is always charged with an ethical valence. It is an opportunity to contribute loving-kindness through the practice of compassion, or, as is all too often the case today, an opportunity to demand convenient and cheap food at the expense of the welfare of the plants and animals with whom the earth is shared, and on which we depend for our existence. Human-generated food technologies do not operate in a vacuum, and they would not exist without our support. Choose what you want your food technologies to reflect ethically, philosophically, environmentally, economically, socially, and politically. Thoreau famously said, “Men have become the tools of their tools” ([1854] 1965, 55–56). This is not a foregone conclusion, even though it may be the current state of affairs. The hope is that you choose your next meal wisely, or at minimum do it as an informed citizen in the full awareness of the impact of your next bite. Select the tools you use to shape the nature of your consumption with care.

This chapter has addressed the question of how technology changes what and how we eat. Developments in plant biotechnology are explained, and the benefits and harms of genetically engineered plants as food sources are analyzed. The impacts, both positive and negative, of industrial agricultural technologies for rearing farm animals are identified. Additionally, the impacts of changing transportation technologies on Americans’ food consumption are discussed. A substantive argument given in favor of using genetically modified foods is the hope it offers for starving populations. Reasons are presented for problematizing a number of underlying assumptions in this argument, and an argument is provided to support the view that a long-term solution to world hunger requires a more complex approach rather than solely a technological fix.<sup>1</sup>

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## Endnote

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- United States Department of Health and Human Services, US Department of Agriculture. *Dietary Guidelines for Americans 2010*. 7th ed. Washington, DC: US Government Print Office, 2010.
- The White House, Office of the Press Secretary. "Fact Sheet: Obama Administration Releases National Action Plan to Combat Antibiotic-Resistant Bacteria." March 27, 2015. <https://www.whitehouse.gov/the-press-office/2015/03/27/fact-sheet-obama-administration-releases-national-action-plan-combat-ant>.

## RECOMMENDED READING

See also other publications available online produced by the following groups:

- Environmental Protection Agency (EPA).
- Food and Agriculture Organization of the United Nations (FAO).
- Union of Concerned Scientists (UCS).
- US Department of Agriculture (USDA).

## DOCUMENTARY FILM

- Cowspiracy: The Sustainability Secret*. Dir. Kip Andersen and Keegan Kuhn. 2014.
- Food, Inc.* Dir. Robert Kenner. 2008.