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Overcoming Nature

There has been a nightmare bred in England of indigestion and spleen among landlords and loom-lords, namely, the dogma that men breed too fast for the powers of the soil; that men multiply in a geometric ratio, whilst corn multiplies only in an arithmetical; and hence that, the more prosperous we are, the faster we approach these frightful limits. . . . Henry Carey of Philadelphia replied: "Not so, Mr. Malthus, but just the opposite of so is the fact." . . . It needs science and great numbers to cultivate the best lands, and in the best manner.

—Ralph Waldo Emerson, 1858¹

Thomas Jefferson. George Washington Carver. John Harvey Kellogg. Percy Spencer. Who are these guys and what do they have in common? They were food and agricultural entrepreneurs. Their delicious innovations led to new healthy, tasty, convenient, and environmentally friendly comestibles. The creations were *unnaturally* delicious. Unnatural because the foods

and practices they fashioned were man-made solutions to natural and man-made problems.

Innovating our way to a brighter food future is as American as apple pie. Benjamin Franklin was an all-around tinkerer. Thomas Jefferson treated his vegetable garden as a laboratory, trying out seeds from across the Old World to carefully select what would work in the new. He even confessed to illegally smuggling rice seeds out of Italy in his coat pocket. The innovating tradition of Eli Whitney's cotton gin and George Washington Carver's peanut creations carried right through to Kellogg's new cereal, Busch's new beer, John Deere's plow, and George Harrison Shull's hybrid corn. Percy Spencer, a radar engineer, created the first microwave oven after finding a melted candy bar in his pocket. TV dinners, Betty Crocker cake mix, Tang, and Lunchables saved time and made home life easier for millions of American men and women. We've inherited a bountiful world of food. One that our ancestors could scarcely have imagined.

La Grand Épicerie is the magnificent food market of Le Bon Marché, the finest Left Bank department store in Paris. Walk in the door and you're greeted by pistachio macaroons, *chouquettes* (pastry puffs covered in scrumptious sugar crystals), beef filets coated with pâté, Roquefort and Chèvre cheese, and wines so expensive they are kept behind lock and key. The sights and smells are enough to tantalize even the least discerning of food palates. My wife's first reaction to the menagerie of temptations that met us on our first grocery-shopping trip while living in Paris? Tears. Not tears of joy, mind you.

The variety and abundance overwhelmed her. What to choose? Will fromage blanc substitute for sour cream? Which brand? What to do with a sea of cheeses of all shapes, sizes, and flavors when one is looking for something simple to top a Triscuit? Of course, we faced the same dilemma back home. Last time I checked, there were more than a hundred different types of bread at our local Walmart. We scarcely notice the abundance because it is so common.

Beneath the tranquil calm of diverse, healthy, affordable food runs an undercurrent of obesity, diabetes, food insecurity, climate change, and environmental degradation—a confluence of forces so powerful that they threaten to upend our very way of life. Alarm bells are sounding amid talk of animal cruelty, unsustainability, corporate farms, and the marketing of junk food.

The problems are real. They are serious. Yet it would be a mistake to think ours was the first generation to have food problems. Or a way out. Carver, Deere, and Kellogg are old news. Fortunately, a new generation of scientists, entrepreneurs, and progressive farmers is carrying on the hunt for unnaturally delicious foods. The problems upon which they've fixed their sights are both new and old.

Before the dawn of the nineteenth century, the eminent scientist Sir William Crooks stood before the British Association for the Advancement of Science and shared these near panic-stricken thoughts:

Civilised nations stand in deadly peril of not having enough to eat. As mouths multiply, food resources dwindle. . . . It

is almost certain that within a generation the ever-increasing population of the United States will consume all the wheat grown within its borders, and will be driven to import, and . . . will scramble for the lion's share of the wheat crop of the world.²

In expressing what became known as the "wheat problem," Crooks resurrected a then-century-old concern brought to the public's attention by the British cleric and economist Thomas Malthus: If population continued to grow at an exponential rate, there simply wouldn't be enough land and other resources to sustain an ever-hungrier human race. "Misery and vice" was the phrase Malthus used to describe the consequences and cause of the cycles of population growth and privation that he predicted.

Fewer than 1 billion people were living on Earth when Malthus fretted. There were about 600 million more by the time Crooks became concerned. Today more than 7 billion of us inhabit the planet. Despite the impending doom foreshadowed by Malthus and Crooks, La Grand Épicerie has more than we can ever want. And even if wallets are a little thin, one of those inexpensive bread choices from Walmart will surely suit our needs.

How did we avert the mass starvation predicted by the leading intellectuals of the seventeenth and eighteenth centuries? Ralph Waldo Emerson's quote at the beginning of the chapter came from a talk he gave to a group of farmers in 1858. Even then Emerson recognized the key to escaping the Malthusian trap. He said, "We must not paint the farmer in rose-color" but rather look to see that "he is habitually engaged in small economies."

The farmer becomes more productive by planting fences, using underground drainage systems to direct the water, and, even in 1858, using creative fertilizers. Emerson wrote that the farmer "will attend to the roots in his tub, gorge them with food that is good for them. . . . If they have an appetite for potash, or salt, or iron, or ground bones, or even now and then for a dead hog, he will indulge them. They keep the secret well, and never tell on your table whence they drew their sunset complexion or their delicate flavors." Today the key to averting the Malthusian problem is what it was then: innovation.

We tried new things. We tinkered. We invented. We made mistakes. And we tried again. The result is that we now get more than 500 percent more corn and 280 percent more wheat per acre of planted farmland than we did a century ago. Today in the United States we produce 156 percent more food than was the case in the late 1940s despite using 26 percent less land.³

Yet public intellectuals remain worried. Lester Brown, founder of the World Watch Institute and the Earth Policy Institute, argued in 1965 that "the food problem emerging in the less-developing regions may be one of the most nearly insoluble problems facing man over the next few decades." In 1974 Brown argued that farmers "can no longer keep up with rising demand; thus the outlook is for chronic scarcities and rising prices." As late as 1997 Brown projected that "food scarcity will be the defining issue of the new era now unfolding."⁴ He is by no means alone. In 1968 the Stanford biology professor Paul Ehrlich penned his bestselling book *Population Bomb* with the following prediction as the opening sentences: "The battle to feed all of humanity is

over. In the 1970s hundreds of millions of people will starve to death in spite of any crash programs embarked upon now. At this late date nothing can prevent a substantial increase in the world death rate."

It would be easy to pick on Malthus, Ehrlich, and their fellow prognosticators. Making predictions is risky business. Given the information available to them at the time, the impending trends seemed to lead to unmistakable conclusions (and dire forecasts create good publicity, too—Ehrlich appeared on the *Tonight Show* with Johnny Carson more than twenty times). In many ways these folks were right. We *were* headed for doom. We would have witnessed mass starvation, *if* the status quo had prevailed. What made the prophets wrong was how people responded to the challenges they faced. And we should probably be thankful for the soothsayers. Without the doubt and worry they incited, the motivation to change and innovate might have come too late. In Crooks's case he actually pointed the way to scientifically working around one of the greatest limiting factors in agriculture: extracting nitrogen fertilizer from thin air.

Even a brief glance at today's popular writings reveals that pessimism about food and agriculture abounds. If anything, the apocalyptic forecasts have increased and expanded into ever-new areas of concern. Distrust of the food system has become the status quo. At least another billion people are likely to join the human ranks in the next thirty years. Researchers for the United Nations project an 80 percent chance that the world's population will increase by 70 percent, to 12.3 billion people, by the year 2100.⁵ As late as 2014 Ehrlich and a coauthor argued

there was only "about a 10 percent chance of avoiding a collapse of civilization."⁶

But population growth is not the only concern. Today's food problems are complex and multifaceted. Worries about the environmental impacts of food production persist. Although we get much more food from our land than in Malthus's time, we also use more fossil fuels and have created problems like dead zones in lakes and waterways caused by excessive fertilizer use. For many people in the developed world, there are problems of *overabundance*: obesity and growing rates of diabetes. Marion Nestle, a nutrition professor at New York University, argued that the costs of obesity and diet-related diseases will be "astronomical," and James Hill, director of the Center for Human Nutrition at the University of Colorado Health Sciences Center, argues that diabetes alone "will break the bank of our healthcare system."⁷ The bestselling author Michael Pollan summed up the prevailing view he helped cement: "Americans have a national eating disorder."⁸

We have problems. But we've had them before. Many would argue that the state of food in the United States is not a happy story. However, below the surface of the food problems are churn, change, and innovation. Much of what is happening is imperceptible to the average American just trying to put food on the table for the family. People have a tendency to focus on such headlines as "Obesity Is Rising Out of Control!" without seeing the progress being made: the trend is that waistlines no longer are expanding at the pace they once were.⁹ The Green Revolution sparked by Norman Borlaug, who was awarded the Nobel Peace Prize in 1970, lifted millions of people out of desperate conditions in the 1960s

and 1970s by introducing hybrid seed technologies and synthetic fertilizers in places like India, Mexico, and Pakistan. There remain places on Earth that could still benefit from applying the concepts and technologies introduced by Borlaug, but, like the Apple II, science and technology must adapt if they are to remain relevant.¹⁰

Two narratives currently dominate popular thinking about the future of food. The one with the cultural cachet is the so-called food movement—a movement that seeks a retrogressive “return to nature.” The food movement has issued a call to eat slower, more natural, organic, local food. Those are all good things in their own right. The trouble is that most of us aren’t willing to pay (and many are not able to pay) what it costs to produce food that way. And most farmers aren’t willing to give up their modern conveniences without sufficient compensation.

Faced with this impasse, many leaders of the food movement say the answer is to subsidize the food systems they like, tax and guilt-trip the people eating the foods they don’t, and regulate the undesirable foods and farming practices out of existence. I exposed the ineptitude and unintended consequences of many of these ideas in *The Food Police*. The food movement is a compassionate, romantic cause, but only the most credulous will believe that its most visible policy activities—advocating soda taxes, mandatory labels for genetically modified organisms (GMOs), subsidies for fruit and vegetable farmers, and support for farmers’ markets—will have a substantive effect on any of our most pressing food challenges.

The counternarrative is made by the heirs to the Malthusian concern. They say the answer to feeding a rising world population

is to produce more, whatever the cost to health or the environment might be. Quantity over quality. Efficiency trumps humanity. Subsidize largess. Consumer preferences be damned.

Is there a way to have the best of both worlds? More affordable *and* healthy food for our families? Environmentally friendly *and* convenient food? Surely you have been warned about politicians who offer a free lunch. We simply cannot have lower taxes *and* build more roads. There are trade-offs. Yet there is a sense in which scientific and technological development offer at least an inexpensive lunch. As the author and MIT researcher Andrew McAfee recently put it, “The old joke among economists is that technology progress is the only free lunch we believe in.”¹¹ If entrepreneurs develop a new way to make concrete or if managers find more effective use of labor, it might very well be possible to have more roads *and* lower taxes.

To get these (almost) free lunches, we will have to make some trade-offs and be willing to do things differently than in the past. That includes giving up not only current practices but also the way our grandparents and great-grandparents farmed: it was drudgery, and it wasn’t sustainable. And we may need to be willing to change the way we think about our food problems.

A couple years ago I gave a talk at a small liberal arts college. Before my talk I had dinner with about a dozen bright students who were well versed in the popular writings about food and agriculture. Smart and motivated, with an elite education, they had futures that shimmered with promise and hope. And yet, when the topic turned to food and agriculture, pessimism abounded. The students peppered me with questions and expressed fear and

skepticism related to unfair farm labor practices, genetically engineered crops, pesticides, soil runoff, and animal abuse.

They were doing what they could to address these problems in their own way. The students earned course credit by working on a small farm owned by the college, part of the college's sustainability curriculum. The students (with the help of faculty advisers and administrators) encouraged the school cafeterias to spend about 40 percent of the food budget on local products. Some students volunteered their time to work on small local farms.

A couple students were a bit startled to hear that I intended to spend about half my talk that evening discussing the research that directly challenged the idea they had been taught to cherish: that local foods are inherently better for the environment, health, and the economy.¹² I received a warmer reception when I mentioned that I planned to talk about another way we can solve many of the food problems they cared so passionately about. After I described how scientific breakthroughs and technological development in agriculture can spare sensitive lands and bring down the price of food for the poor, one earnest young woman caught on and remarked that what we really need are people working on soil and plant sciences and on environmental impacts of animal production. I was happy to report that there are.

I suspect so much of the negativity that surrounds our food discussions stems from a sort of hopelessness that comes from the inability to see how our problems will be solved. Compared to my fellow diners, I'm much more optimistic about the future of food, in part because I have the great pleasure to work at an agricultural college where I see firsthand good, intelligent people applying

their scientific craft in the pursuit of better farming and better food. I look out at the sea of plant pathologists, soil chemists, ruminant nutritionists, agricultural economists, food engineers, ecologists, range scientists, microbiologists, and many others who are hard at work at universities and research centers throughout the world. I routinely encounter food and agricultural entrepreneurs asking for help in raising capital for their new ventures; jaw-dropping developments in the labs of seed, biotechnology, and food companies; as well as everyday farmers who are eager to use the latest technology.

This is the story of the innovators and innovations shaping the future of food. I'll introduce you to David Waits, the farmer-turned-entrepreneur whose software is now being used on more than 100 million acres in twenty-three countries to help farmers increase yields and reduce nutrient runoff. You'll meet Tom Silva, who helped his employer build a new hen-housing system that improves animal welfare at an affordable price. Mark Post is a scientist whose work may lead us away from eating animal products altogether. He's growing meat in his lab. Without the cow. I'll take you behind the scenes of a student competition at which Sarah Ritz and Aaron Cohen coaxed bacteria to signal when olive oil is stale and Paul Tse and Marco So engineered a probiotic to fight obesity. I'll take you to South Dakota, where Eldon Roth created a new way to fight food waste. You'll learn about work by my former student Abdul Naico and the German scientist Ingo Potrykus that aims to fight malnutrition in the developing world with nutrient-enhanced rice and sweet potatoes. My plant science colleagues at Oklahoma State University reveal how they're

helping wheat farmers sustainably grow more with less. And the engineering professor Hod Lipson discusses how to get fresh, tasty, 3-D printed food at the touch of a button, perhaps even delivered to us by Mark Oleynik's robotic chef.

Some of this might seem a bit scary or even unappetizing. But the same could once be said of the refrigerator and the microwave. And broccoli. And kale. These are *unnatural human* inventions. Before people had refrigeration, they ate a lot more canned and salted meat and had to have milk delivered every day. Some food elitists bemoan the microwave, but come on! Would you really give up yours? Broccoli, cauliflower, cabbage, brussels sprouts, and kale didn't exist before humans came along. All these veggies are descendants of the same plant, and they originated through artificial selection. Nothing seems more natural than Irish potatoes or Italian tomatoes, but these plants arrived in Europe only after Columbus sailed the ocean blue.

There is a tendency to want natural food—to eschew the foods that we humans have tinkered with. I've had more than one person tell me they just want to “eat the food that God gave us.” The historical reality is that we've been altering our food and innovating new diets since the beginning. Indeed, one thing that separates us from other animals is that we invented the technology of cooking. Rachel Laudan, speaking of our ancestors in her book *Cuisine and Empire*, writes:

Before the first empires, indeed long before farming, [our ancestors] had passed the point of no return, where they could no longer thrive on raw foods. They had become the

animals that cooked. Cooking softened food so that humans no longer had to spend five hours a day chewing, as their chimpanzee relatives did. It made it more digestible, increasing the energy humans could extract from a given amount of food and diverting more of that energy to the brain. Brains grew and guts shrank. Cooking created mouthwatering new tastes and pleasing new textures. . . . It became possible to detoxify many poisonous plants and soften others that had been too hard to chew, so that humans could digest an increased number of plant species. . . . Ways of treating flesh and plants so they did not rot permitted the storage of food for the lean times of hard winters or dry seasons.¹³

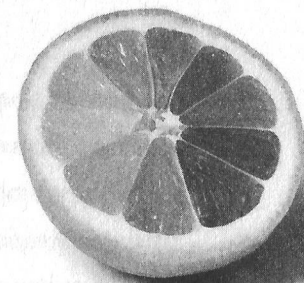
We've been inventing and adapting all along. And we're better for it.

Organic and local foods get the headlines. Farm subsidies, soda taxes, GMO labels, and bans on fast-food advertising are political lightning rods that are sure to get your friends riled up. These things captivate our attention because they give us a way to feel like we're “doing something” by paying a premium or fighting a political battle. But good intentions don't always produce good outcomes.

One of the problems some people may have with relying on technological innovation to address our food problems is that it seems to leave nothing for us to do. How can the passionate food activist, sociologist, or chef use science and technological innovation to produce the food system they desire? The first step is to recognize the innovation that is under way. Some technology

adopted by farmers is a bit frightening because the public is so unaware. Fewer than 2 percent of Americans work on a farm. Thus many find it difficult to understand why farmers adopt certain practices or technologies or what problems they may be solving when they do. Getting their perspectives can help shed some light. Moreover, as I will discuss, food and agriculture innovation doesn't come only from Monsanto, Cargill, and McDonald's. It comes from students, nonprofit scientists, university professors, and struggling entrepreneurs. Fostering an environment that is hostile to innovation and growth in food and agriculture not only thwarts the plans of Big Food but also makes it harder for scientists to get their innovations to market.

If I accomplish nothing else with this book, I hope a few young people might see a new way to effect food change. Yes, take classes in food journalism and environmental sustainability. But don't forget mathematics, biology, geography, engineering, and genetics. Ironically, the greatest outcomes from study of the natural sciences may well be all the unnatural things we learned to create: planes, cars, iPhones, air conditioning, and vaccines. We may romanticize the past, but most of us would not wish to be born in 1800. Changes in automotive, medical, computing, communications, *and* agricultural technology deserve the credit. Life—particularly in the realm of eating—is substantially better today than it was in our great grandparents' time. And, if history is our guide, it will become better still. Let me tell you how.



2

The Price of Happy Hens

When I was in college, one of my food science professors would often tell us that eggs were a near-perfect food. They are a complete source of protein, containing all the essential amino acids that our body can't make on its own. Fear of cholesterol caused a significant reduction in per-capita egg consumption throughout the 1960s, 1970s, and 1980s, but the latest report from the Dietary Guidelines Advisory Committee (the group responsible for creating the food pyramid and MyPlate) suggests those fears were unfounded and now says that "cholesterol is not a nutrient of concern."¹

Not only are eggs nutritious, but it's hard to imagine how we could make some foods without them. Obviously, dishes like omelets and deviled eggs would have to go, but eggs are also the crucial ingredient in mayonnaise and salad dressing: they bind the water and vinegar to the oil. Hollandaise and bearnaise sauces,