

“Our National Eating Disorder”

Pollan, Michael. The Omnivore's Dilemma: A Natural History Of Four Meals. The Penguin Press: New York, 2006.

What should we have for dinner?

This book is a long and fairly involved answer to this seemingly simple question. Along the way, it also tries to figure out how such a simple question could ever have gotten so complicated. As a culture we seem to have arrived at a place where whatever native wisdom we may once have possessed about eating has been replaced by confusion and anxiety. Somehow this most elemental of activities—figuring out what to eat—has come to require a remarkable amount of expert help. How did we ever get to a point where we need investigative journalists to tell us where our food comes from and nutritionists to determine the dinner menu?

For me the absurdity of the situation became inescapable in the fall of 2002, when one of the most ancient and venerable staples of human life abruptly disappeared from the American dinner table. I'm talking of course about bread. Virtually overnight, Americans changed the way they eat. A collective spasm of what can only be described as carbophobia seized the country, supplanting an era of national lipophobia dating to the Carter administration. That was when, in 1977, a Senate committee had issued a set of "dietary goals" warning beef-loving Americans to layoff the red meat. And so we dutifully had done, until now.

What set off the sea change? It appears to have been a perfect media storm of diet books, scientific studies, and one timely magazine article. The new diet books, many of them inspired by the formerly discredited Dr. Robert C. Atkins, brought Americans the welcome news that they could eat more meat and lose weight just so long as they laid off the bread and pasta. These high-protein, low-carb diets found support in a handful of new epidemiological studies suggesting that the nutritional orthodoxy that had held sway in America since the 1970s might be wrong. It was not, as official opinion claimed, fat that made us fat, but the carbohydrates we'd been eating precisely in order to stay slim. So conditions were ripe for a swing of the dietary pendulum when, in the summer of 2002, the *New York Times Magazine* published a cover story on the new research entitled "What if Fat Doesn't Make You Fat?" Within months, supermarket shelves were restocked and restaurant menus rewritten to reflect the new nutritional wisdom. The blamelessness of steak restored, two of the most wholesome and uncontroversial foods known to man—bread and pasta—acquired a moral stain that promptly bankrupted dozens of bakeries and noodle firms and ruined an untold number of perfectly good meals.

So violent a change in a culture's eating habits is surely the sign of a national eating disorder. Certainly it would never have happened in a culture in possession of deeply rooted traditions surrounding food and eating. But then, such a culture would not feel the need for its most august legislative body to ever deliberate the nation's "dietary goals"—or, for that matter, to wage political battle every few years over the precise design of an official government graphic called the "food pyramid." A country with a stable culture of food

would not shell out millions for the quackery (or common sense) of a new diet book every January. It would not be susceptible to the pendulum swings of food scares or fads, to the apotheosis every few years of one newly discovered nutrient and the demonization of another. It would not be apt to confuse protein bars and food supplements with meals or breakfast cereals with medicines. It probably would not eat a fifth of its meals in cars or feed fully a third of its children at a fast-food outlet every day. And it surely would not be nearly so fat.

Nor would such a culture be shocked to discover that there are other countries, such as Italy and France, that decide their dinner questions on the basis of such quaint and unscientific criteria as pleasure and tradition, eat all manner of "unhealthy" foods, and, lo and behold, wind up actually healthier and happier in their eating than we are. We show our surprise at this by speaking of something called the "French paradox," for how could a people who eat such demonstrably toxic substances as foie gras and triple creme cheese actually be slimmer and healthier than we are? Yet I wonder if it doesn't make more sense to speak in terms of an American paradox—that is, a notably unhealthy people obsessed by the idea of eating healthily.

To one degree or another, the question of what to have for dinner assails every omnivore, and always has. When you can eat just about anything nature has to offer, deciding what you should eat will inevitably stir anxiety, especially when some of the potential foods on offer are liable to sicken or kill you. This is the omnivore's dilemma, noted long ago by writers like Rousseau and Brillat-Savarin and first given that name thirty years ago by a University of Pennsylvania research psychologist named Paul Rozin. I've borrowed his phrase for the title of this book because the omnivore's dilemma turns out to be a particularly sharp tool for understanding our present predicaments surrounding food.

In a 1976 paper called "The Selection of Foods by Rats, Humans, and Other Animals" Rozin contrasted the omnivore's existential situation with that of the specialized eater, for whom the dinner question could not be simpler. The koala bear doesn't worry about what to eat: If it looks and smells and tastes like a eucalyptus leaf, it must be dinner. The koala's culinary preferences are hardwired in its genes. But for omnivores like us (and the rat) a vast amount of brain space and time must be devoted to figuring out which of all the many potential dishes nature lays on are safe to eat. We rely on our prodigious powers of recognition and memory to guide us away from poisons (Isn't that the mushroom that made me sick last week?) and toward nutritious plants (The red berries are the juicier, sweeter ones). Our taste buds help too, predisposing us toward sweetness, which signals carbohydrate energy in nature, and away from bitterness, which is how many of the toxic alkaloids produced by plants taste. Our inborn sense of disgust keeps us from ingesting things that might infect us, such as rotten meat. Many anthropologists believe that the reason we evolved such big and intricate brains was precisely to help us deal with the omnivore's dilemma.

Being a generalist is of course a great boon as well as a challenge; it is what allows humans to successfully inhabit virtually every terrestrial environment on the planet. Omnivory offers the pleasures of variety too. But the surfeit of choice brings with it a lot of stress and leads to a kind of Manichaean view of food, a division of nature into The Good Things to Eat, and The Bad.

The rat must make this all-important distinction more or less on its own, each individual figuring out for itself—and then remembering which things will nourish and which will poison. The human omnivore has, in addition to his senses and memory, the incalculable advantage of a culture, which stores the experience and accumulated wisdom of countless human tasters before us. I don't need to experiment with the mushroom now called, rather helpfully, the "death cap," and it is common knowledge that that first intrepid lobster eater was on to something very good. Our culture codifies the rules of wise eating in an elaborate structure of taboos, rituals, recipes, manners, and culinary traditions that keep us from having to reenact the omnivore's dilemma at every meal.

One way to think about America's national eating disorder is as the return, with an almost atavistic vengeance, of the omnivore's dilemma. The cornucopia of the American supermarket has thrown us back on a bewildering food landscape where we once again have to worry that some of those tasty-looking morsels might kill us. (Perhaps not as quickly as a poisonous mushroom, but just as surely.) Certainly the extraordinary abundance of food in America complicates the whole problem of choice. At the same time, many of the tools with which people historically managed the omnivore's dilemma have lost their sharpness here—or simply failed. As a relatively new nation drawn from many different immigrant populations, each with its own culture of food, Americans have never had a single, strong, stable culinary tradition to guide us.

The lack of a steady culture of food leaves us especially vulnerable to the blandishments of the food scientist and the marketer, for whom the omnivore's dilemma is not so much a dilemma as an opportunity. It is very much in the interest of the food industry to exacerbate our anxieties about what to eat, the better to then assuage them with new products. Our bewilderment in the supermarket is no accident; the return of the omnivore's dilemma has deep roots in the modern food industry, roots that, I found, reach all the way back to fields of corn growing in places like Iowa.

And so we find ourselves where we do, confronting in the supermarket or at the dinner table the dilemmas of omnivorousness, some of them ancient and others never before imagined. The organic apple or the conventional? And if the organic, the local one or the imported? The wild fish or the farmed? The transfats or the butter or the "not butter"? Shall I be a carnivore or a vegetarian? And if a vegetarian, a lacto-vegetarian or a vegan? Like the hunter-gatherer picking a novel mushroom off the forest floor and consulting his sense memory to determine its edibility, we pick up the package in the supermarket and, no longer so confident of our senses, scrutinize the label, scratching our heads over the meaning of phrases like "hears healthy," "no transfats," "cage-free," or "range-fed." What is "natural grill flavor" or TBHQ or xanthan gum? What is all this stuff, anyway, and where in the world did it come from?

My wager in writing *The Omnivore's Dilemma* was that the best way to answer the questions we face about what to eat was to go back to the very beginning, to follow the food chains that sustain us, all the way from the earth to the plate—to a small number of actual meals. I wanted to look at the getting and eating of food at its most fundamental, which is to say, as a transaction between species in nature, eaters and eaten. ("The whole of nature," wrote the English author William Ralph Inge, "is a conjugation of the verb to eat, in the active and

passive.") What I try to do in this book is approach the dinner question as a naturalist might, using the long lenses of ecology and anthropology, as well as the shorter, more intimate lens of personal experience.

My premise is that like every other creature on earth, humans take part in a food chain, and our place in that food chain, or web, determines to a considerable extent what kind of creature we are. The fact of our omnivorousness has done much to shape our nature, both body (we possess the omniscient teeth and jaws of the omnivore, equally well suited to tearing meat and grinding seeds) and soul. Our prodigious powers of observation and memory, as well as our curious and experimental stance toward the natural world, owe much to the biological fact of omnivorousness. So do the various adaptations we've evolved to defeat the defenses of other creatures so that we might eat them, including our skills at hunting and cooking with fire. Some philosophers have argued that the very open-endedness of human appetite is responsible for both our savagery and civility. Since a creature that could conceive of eating anything (including, notably, other humans) stands in particular need of ethical rules, manners, and rituals. We are not only what we eat, but how we eat, too.

Yet we are also different from most of nature's other eaters—markedly so: For one thing, we've acquired the ability to substantially modify the food chains we depend on, by means of such revolutionary technologies as cooking with fire, hunting with tools, farming, and food preservation. Cooking opened up whole new vistas of edibility by rendering various plants and animals more digestible, and overcoming many of the chemical defenses other species deploy against being eaten. Agriculture allowed us to vastly multiply the populations of a few favored food species, and therefore in turn our own. And, most recently, industry has allowed us to reinvent the human food chain, from the synthetic fertility of the soil to the microwaveable can of soup designed to fit into a car's cup holder. The implications of this last revolution, for our health and the health of the natural world, we are still struggling to grasp.

The Omnivore's Dilemma is about the three principal food chains that sustain us today: the industrial, the organic, and the hunter-gatherer. Different as they are, all three food chains are systems for doing more or less the same thing: linking us, through what we eat, to the fertility of the earth and the energy of the sun. It might be hard to see how, but even a Twinkie does this—constitutes an engagement with the natural world. As ecology teaches, and this book tries to show, it's all connected, even the Twinkie.

Ecology also teaches that all life on earth can be viewed as a competition among species for the solar energy captured by green plants and stored in the form of complex carbon molecules. A food chain is a system for passing those calories on to species that lack the plant's unique ability to synthesize them from sunlight. One of the themes of this book is that the industrial revolution of the food chain, dating to the close of World War II, has actually changed the fundamental rules of this game. Industrial agriculture has supplanted a complete reliance on the sun for our calories with something new under the sun: a food chain that draws much of its energy from fossil fuels instead. (Of course, even that energy originally came from the sun, but unlike sunlight it is finite and irreplaceable.) The result of this innovation has been a vast increase in the

amount of food energy available to our species; this has been a boon to humanity (allowing us to multiply our numbers), but not an unalloyed one. We've discovered that an abundance of food does not render the omnivore's dilemma obsolete. To the contrary, abundance seems only to deepen it, giving us all sorts of new problems and things to worry about.

Each of this book's three parts follows one of the principal human food chains from beginning to end: from a plant, or group of plants, photosynthesizing calories in the sun, all the way to a meal at the dinner end of that food chain. Reversing the chronological order, I start with the industrial food chain, since that is the one that today involves and concerns us the most. It is also by far the biggest and longest. Since mono culture is the hallmark of the industrial food chain, this section focuses on a single plant: *Zea mays*, the giant tropical grass we call corn, which has become the keystone species of the industrial food chain, and so in turn of the modern diet. This section follows a bushel of commodity corn from the field in Iowa where it grew on its long, strange journey to its ultimate destination in a fast-food meal, eaten in a moving car on a highway in Marin County, California.

The book's second part follows what I call—to distinguish it from the industrial—the pastoral food chain. This section explores some of the alternatives to industrial food and farming that have sprung up in recent years (variously called "organic," "local," "biological," and "beyond organic"), food chains that might appear to be pre-industrial but in surprising ways turn out in fact to be postindustrial. I set out thinking I could follow one such food chain, from a radically innovative farm in Virginia that I worked on one recent summer to an extremely local meal prepared from animals raised on its pastures. But I promptly discovered that no single farm or meal could do justice to the complex, branching story of alternative agriculture right now, and that I needed also to reckon with the food chain I call, oxymoronically, the "industrial organic." So the book's pastoral section serves up the natural history of two very different "organic" meals: one whose ingredients came from my local Whole Foods supermarket (gathered there from as far away as Argentina), and the other tracing its origins to a single polyculture of grasses growing at Polyface Farm in Swoope, Virginia.

The last section, titled Personal, follows a kind of neo-Paleolithic food chain from the forests of Northern California to a meal I prepared (almost) exclusively from ingredients I hunted, gathered, and grew myself. Though we twenty-first-century eaters still eat a handful of hunted and gathered food (notably fish and wild mushrooms), my interest in this food chain was less practical than philosophical: I hoped to shed fresh light on the way we eat now by immersing myself in the way we ate then. In order to make this meal I had to learn how to do some unfamiliar things, including hunting game and foraging for wild mushrooms and urban tree fruit. In doing so I was forced to confront some of the most elemental questions—and dilemmas—faced by the human omnivore: What are the moral and psychological implications of killing, preparing, and eating a wild animal? How does one distinguish between the delicious and the deadly when foraging in the woods? How do the alchemies of the kitchen transform the raw stuffs of nature into some of the great delights of human culture?

The end result of this adventure was what I came to think of as the Perfect Meal, not

because it turned out so well (though in my humble opinion it did), but because this labor- and thought-intensive dinner, enjoyed in the company of fellow foragers, gave me the opportunity, so rare in modern life, to eat in full consciousness of everything involved in feeding myself: For once, I was able to pay the full karmic price of a meal.

Yet as different as these three journeys (and four meals) turned out to be, a few themes kept cropping up. One is that there exists a fundamental tension between the logic of nature and the logic of human industry, at least as it is presently organized. Our ingenuity in feeding ourselves is prodigious, but at various points our technologies come into conflict with nature's ways of doing things, as when we seek to maximize efficiency by planting crops or raising animals in vast monocultures. This is something nature never does, always and for good reasons practicing diversity instead. A great many of the health and environmental problems created by our food system owe to our attempts to oversimplify nature's complexities, at both the growing and the eating ends of our food chain. At either end of any food chain you find a biological system—a patch of soil, a human body—and the health of one is connected—literally—to the health of the other. Many of the problems of health and nutrition we face today trace back to things that happen on the farm, and behind those things stand specific government policies few of us know anything about.

I don't mean to suggest that human food chains have only recently come into conflict with the logic of biology; early agriculture and, long before that, human hunting proved enormously destructive. Indeed, we might never have needed agriculture had earlier generations of hunters not eliminated the species they depended upon. Folly in the getting of our food is nothing new. And yet the new follies we are perpetrating in our industrial food chain today are of a different order. By replacing solar energy with fossil fuel, by raising millions of food animals in close confinement, by feeding those animals foods they never evolved to eat, and by feeding ourselves foods far more novel than we even realize, we are taking risks with our health and the health of the natural world that are unprecedented.

Another theme, or premise really, is that the way we eat represents our most profound engagement with the natural world. Daily, our eating turns nature into culture, transforming the body of the world into our bodies and minds. Agriculture has done more to reshape the natural world than anything else we humans do, both its landscapes and the composition of its flora and fauna. Our eating also constitutes a relationship with dozens of other species—plants, animals, and fungi with which we have coevolved to the point where our fates are deeply entwined. Many of these species have evolved expressly to gratify our desires, in the intricate dance of domestication that has allowed us and them to prosper together as we could never have prospered apart. But our relationships with the wild species we eat—from the mushrooms we pick in the forest to the yeasts that leaven our bread—are no less compelling, and far more mysterious. Eating puts us in touch with all that we share with the other animals, and all that sets us apart. It defines us.

What is perhaps most troubling, and sad, about industrial eating is how thoroughly it obscures all these relationships and connections. To go from the chicken (*Gallus gallus*) to the Chicken McNugget is to leave this world in a journey of forgetting that could hardly be

more costly, not only in terms of the animal's pain but in our pleasure, too. But forgetting, or not knowing in the first place, is what the industrial food chain is all about, the principal reason it is so opaque, for if we could see what lies on the far side of the increasingly high walls of our industrial agriculture, we would surely change the way we eat.

"Eating is an agricultural act," as Wendell Berry famously said. It is also an ecological act, and a political act, too. Though much has been done to obscure this simple fact, how and what we eat determines to a great extent the use we make of the world—and what is to become of it. To eat with a fuller consciousness of all that is at stake might sound like a burden, but in practice few things in life can afford quite as much satisfaction. By comparison, the pleasures of eating industrially, which is to say eating in ignorance, are fleeting. Many people today seem perfectly content eating at the end of an industrial food chain, without a thought in the world; this book is probably not for them. There are things in it that will ruin their appetites. But in the end this is a book about the pleasures of eating, the kinds of pleasure that are only deepened by knowing.

One: THE PLANT

Corn's Conquest

1. A NATURALIST IN THE SUPERMARKET

Air-conditioned, odorless, illuminated by buzzing fluorescent tubes, the American supermarket doesn't present itself as having very much to do with Nature. And yet what is this place if not a landscape (manmade, it's true) teeming with plants and animals?

I'm not just talking about the produce section or the meat counter, either—the supermarket's flora and fauna. Ecologically speaking, these are this landscape's most legible zones, the places where it doesn't take a field guide to identify the resident species. Over there's your eggplant, onion, potato, and leek; here your apple, banana, and orange. Spritzed with morning dew every few minutes, Produce is the only corner of the supermarket where we're apt to think "Ah, yes, the bounty of Nature!" Which probably explains why such a garden of fruits and vegetables (sometimes flowers, too) is what usually greets the shopper coming through the automatic doors.

Keep rolling, back to the mirrored rear wall behind which the butcher's toil, and you encounter a set of species only slightly harder to identify—there's chicken and turkey, lamb and cow and pig. Though in Meat the creaturely character of the species on display does seem to be fading, as the cows and pigs increasingly come subdivided into boneless and bloodless geometrical cuts. In recent years some of this supermarket euphemism has seeped into Produce, where you'll now find formerly soil-encrusted potatoes cubed pristine white, and "baby" carrots machine-lathed into neatly tapered torpedoes. But in general here in flora and fauna you don't need to be a naturalist, much less a food scientist, to know what species you're tossing into your cart.

Venture farther, though, and you come to regions of the supermarket where the very notion of species seems increasingly obscure: the canyons of breakfast cereals and condiments; the freezer cases stacked with "home meal replacements" and bagged platonic

peas; the broad expanses of soft drinks and towering cliffs of snacks; the unclassifiable Pop-Tarts and Lunchables; the frankly synthetic coffee whiteners and the Linnaeus-defying Twinkie. Plants? Animals?! Though it might not always seem that way, even the deathless Twinkie is constructed out of ... well, precisely what I don't know offhand, but ultimately some sort of formerly living creature, i.e., a *species*. We haven't yet begun to synthesize our foods from petroleum, at least not directly.

If you do manage to regard the supermarket through the eyes of a naturalist, your first impression is apt to be of its astounding biodiversity. Look how many different plants and animals (and fungi) are represented on this single acre of land! What forest or prairie could hope to match it? There must be a hundred different species in the produce section alone, a handful more in the meat counter. And this diversity appears only to be increasing: When I was a kid, you never saw radicchio in the produce section, or a half dozen different kinds of mushrooms, or kiwis and passion fruit and durians and mangoes. Indeed, in the last few years a whole catalog of exotic species from the tropics has colonized, and considerably enlivened, the produce department. Over in fauna, on a good day you're apt to find—beyond beef—ostrich and quail and even bison, while in Fish you can catch not just salmon and shrimp but catfish and tilapia, too. Naturalists regard biodiversity as a measure of a landscape's health, and the modern supermarket's devotion to variety and choice would seem to reflect, perhaps even promote, precisely that sort of ecological vigor.

Except for the salt and a handful of synthetic food additives, every edible item in the supermarket is a link in a food chain that begins with a particular plant growing in a specific patch of soil (or, more seldom, stretch of sea) somewhere on earth. Sometimes, as in the produce section, that chain is fairly short and easy to follow: As the netted bag says, this potato was grown in Idaho, that onion came from a farm in Texas. Move over to Meat, though, and the chain grows longer and less comprehensible: The label doesn't mention that that rib-eye steak came from a steer born in South Dakota and fattened in a Kansas feedlot on grain grown in Iowa. Once you get into the processed foods you have to be a fairly determined ecological detective to follow the intricate and increasingly obscure lines of connection linking the Twinkie, or the nondairy creamer, to a plant growing in the earth some place, but it can be done.

So what exactly would an ecological detective set loose in an American supermarket discover, were he to trace the items in his shopping cart all the way back to the soil? The notion began to occupy me a few years ago, after I realized that the straightforward question "What should I eat?" could no longer be answered without first addressing two other even more straightforward questions: "What am I eating? And where in the world did it come from?" Not very long ago an eater didn't need a journalist to answer these questions. The fact that today one so often does suggests a pretty good start on a working definition of industrial food: Any food whose provenance is so complex or obscure that it requires expert help to ascertain.

When I started trying to follow the industrial food chain—the one that now feeds most of us most of the time and typically culminates either in a supermarket or fast-food meal—I expected that my investigations would lead me to a wide variety of places. And though my

journeys did take me to a great many states, and covered a great many miles, at the very end of these food chains (which is to say, at the very beginning), I invariably found myself in almost exactly the same place: a farm field in the American Corn Belt. The great edifice of variety and choice that is an American supermarket turns out to rest on a remarkably narrow biological foundation comprised of a tiny group of plants that is dominated by a single species: *Zea mays*, the giant tropical grass most Americans know as corn.

Corn is what feeds the steer that becomes the steak. Corn feeds the chicken and the pig, the turkey and the lamb, the catfish and the tilapia and, increasingly, even the salmon, a carnivore by nature that the fish farmers are reengineering to tolerate corn. The eggs are made of corn. The milk and cheese and yogurt, which once came from dairy cows that grazed on grass, now typically come from Holsteins that spend their working lives indoors tethered to machines, eating corn.

Head over to the processed foods and you find ever more intricate manifestations of corn. A chicken nugget, for example, piles corn upon corn: what chicken it contains consists of corn, of course, but so do most of a nugget's other constituents, including the modified corn starch that glues the thing together, the corn flour in the batter that coats it, and the corn oil in which it gets fried. Much less obviously, the leavenings and lecithin, the mono-, di-, and triglycerides, the attractive golden coloring, and even the citric acid that keeps the nugget "fresh" can all be derived from corn.

To wash down your chicken nuggets with virtually any soft drink in the supermarket is to have some corn with your corn. Since the 1980s virtually all the sodas and most of the fruit drinks sold in the supermarket have been sweetened with high-fructose corn syrup (HFCS)—after water, corn sweetener is their principal ingredient. Grab a beer for your beverage instead and you'd still be drinking corn, in the form of alcohol fermented from glucose refined from corn. Read the ingredients on the label of any processed food and, provided you know the chemical names it travels under, corn is what you will find. For modified or unmodified starch, for glucose syrup and maltodextrin, for crystalline fructose and ascorbic acid, for lecithin and dextrose, lactic acid and lysine, for maltose and HFCS, for MSG and polyols, for the caramel color and xanthan gum, read: corn. Corn is in the coffee whitener and Cheez Whiz, the frozen yogurt and TV dinner, the canned fruit and ketchup and candies, the soups and snacks and cake mixes, the frosting and gravy and frozen waffles, the syrups and hot sauces, the mayonnaise and mustard, the hot dogs and the bologna, the margarine and shortening, the salad dressings and the relishes and even the vitamins. (Yes, it's in the Twinkie, too.) There are some forty-five thousand items in the average American supermarket and more than a quarter of them now contain corn. This goes for the nonfood items as well: Everything from the toothpaste and cosmetics to the disposable diapers, trash bags, cleansers, charcoal briquettes, matches, and batteries, right down to the shine on the cover of the magazine that catches your eye by the checkout: corn. Even in Produce on a day when there's ostensibly no corn for sale you'll nevertheless find plenty of corn: in the vegetable wax that gives the cucumbers their sheen, in the pesticide responsible for the produce's perfection, even in the coating on the cardboard it was shipped in. Indeed, the supermarket itself—the wallboard and joint compound, the linoleum and fiberglass and adhesives out of which the building itself has been built—is in no small measure a manifestation of corn.

And us?

2. CORN WALKING

Descendants of the Maya living in Mexico still sometimes refer to themselves as "the corn people." The phrase is not intended as metaphor. Rather, it's meant to acknowledge their abiding dependence on this miraculous grass, the staple of their diet for almost nine thousand years. Forty percent of the calories a Mexican eats in a day comes directly from corn, most of it in the form of tortillas. So when a Mexican says "I am maize" or "corn walking," it is simply a statement of fact: The very substance of the Mexican's body is to a considerable extent a manifestation of this plant.

For an American like me, growing up linked to a very different food chain, yet one that is also rooted in a field of corn, not to think of himself as a corn person suggests either a failure of imagination or a triumph of capitalism. Or perhaps a little of both. It does take some imagination to recognize the ear of corn in the Coke bottle or the Big Mac. At the same time, the food industry has done a good job of persuading us that the forty-five thousand different items or SKUs (stock keeping units) in the supermarket—seventeen thousand new ones every year—represent genuine variety rather than so many clever re-arrangements of molecules extracted from the same plant.

You are what you eat, it's often said, and if this is true, then what we mostly are is corn—or, more precisely, processed corn. This proposition is susceptible to scientific proof: The same scientists who glean the composition of ancient diets from mummified human remains can do the same for you or me, using a snip of hair or fingernail. The science works by identifying stable isotopes of carbon in human tissue that bear the signatures, in effect, of the different types of plants that originally took them from the air and introduced them into the food chain. The intricacies of this process are worth following, since they go some distance toward explaining how corn could have conquered our diet and, in turn, more of the earth's surface than virtually any other domesticated species, our own included.

Carbon is the most common element in our bodies—indeed, in all living things on earth. We earthlings are, as they say, a carbon life form. (As one scientist put it, carbon supplies life's quantity, since it is the main structural element in living matter, while much scarcer nitrogen supplies its quality—but more on that later.) Originally, the atoms of carbon from which we're made were floating in the air, part of a carbon dioxide molecule. The only way to recruit these carbon atoms for the molecules necessary to support life—the carbohydrates, amino acids, proteins, and lipids—is by means of photosynthesis. Using sunlight as a catalyst the green cells of plants combine carbon atoms taken from the air with water and elements drawn from the soil to form the simple organic compounds that stand at the base of every food chain. It is more than a figure of speech to say that plants create life out of thin air.

But corn goes about this procedure a little differently than most other plants, a difference that not only renders the plant more efficient than most, but happens also to preserve the identity of the carbon atoms it recruits, even after they've been transformed into things like

Gatorade and Ring Dings and hamburgers, not to mention the human bodies nourished on those things. Where most plants during photosynthesis create compounds that have three carbon atoms, corn (along with a small handful of other species) make compounds that have four: hence "*C-4*," the botanical nickname for this gifted group of plants, which wasn't identified until the 1970s.

The *C-4* trick represents an important economy for a plant, giving it an advantage, especially in areas where water is scarce and temperatures high. In order to gather carbon atoms from the air, a plant has to open its stomata, the microscopic orifices in the leaves through which plants both take in and exhaust gases. Every time a stoma opens to admit carbon dioxide precious molecules of water escape. It's as though every time you opened your mouth to eat you lost a quantity of blood. Ideally, you would open your mouth as seldom as possible, ingesting as much food as you could with every bite. This is essentially what a *C-4* plant does. By recruiting extra atoms of carbon during each instance of photosynthesis, the corn plant is able to limit its loss of water and "fix"—that is, take from the atmosphere and link in a useful molecule significantly more carbon than other plants.

At its most basic, the story of life on earth is the competition among species to capture and store as much energy as possible—either directly from the sun, in the case of plants, or, in the case of animals, by eating plants and plant eaters. The energy is stored in the form of carbon molecules and measured in calories. The calories we eat, whether in an ear of corn or a steak, represent packets of energy once captured by a plant. The *C-4* trick helps explain the corn plant's success in this competition: Few plants can manufacture quite as much organic matter (and calories) from the same quantities of sunlight and water and basic elements as corn. (Ninety-seven percent of what a corn plant is comes from the air, three percent from the ground.)

The trick doesn't yet, however, explain how a scientist could tell that a given carbon atom in a human bone owes its presence there to a photosynthetic event that occurred in the leaf of one kind of plant and not another—in corn, say, instead of lettuce or wheat. The scientist can do this because all carbon is not created equal. Some carbon atoms, called isotopes, have more than the usual complement of six protons and six neutrons, giving them a slightly different atomic weight. C-13, for example, has six protons and seven neutrons. (Hence "C-13.") For whatever reason, when a *C-4* plant goes scavenging for its four-packs of carbon, it takes in more carbon 13 than ordinary—*C-3*-plants, which exhibit a marked preference for the more common carbon 12. Greedy for carbon, *C-4* plants can't afford to discriminate among isotopes, and so end up with relatively more carbon 13. The higher the ratio of carbon 13 to carbon 12 in a person's flesh, the more corn has been in his diet—or in the diet of the animals he or she ate. (As far as we're concerned, it makes little difference whether we consume relatively more or less carbon 13.)

One would expect to find a comparatively high proportion of carbon 13 in the flesh of people whose staple food of choice is corn—Mexicans, most famously. Americans eat much more wheat than corn—114 pounds of wheat flour per person per year, compared to 11 pounds of corn flour. The Europeans who colonized America regarded themselves as wheat people, in contrast to the native corn people they encountered; wheat in the West has

always been considered the most refined, or civilized, grain. If asked to choose, most of us would probably still consider ourselves wheat people (except perhaps the proud corn-fed Midwesterners, and they don't know the half of it), though by now the whole idea of identifying with a plant at all strikes us as a little old-fashioned. Beef people sounds more like it, though nowadays chicken people, which sounds not nearly so good, is probably closer to the truth of the matter. But carbon 13 doesn't lie, and researchers who have compared the isotopes in the flesh or hair of North Americans to those in the same tissues of Mexicans report that it is now we in the North who are the true people of corn. "When you look at the isotope ratios," Todd Dawson, a Berkeley biologist who's done this sort of research, told me, "we North Americans look like corn chips with legs." Compared to us, Mexicans today consume a far more varied carbon diet: the animals they eat still eat grass (until recently, Mexicans regarded feeding corn to livestock as a sacrilege); much of their protein comes from legumes; and they still sweeten their beverages with cane sugar.

So that's us: processed corn, walking.

3. THE RISE OF *ZEA MAYS*

How this peculiar grass, native to Central America and unknown to the Old World before 1492, came to colonize so much of our land and bodies is one of the plant world's greatest success stories. I say the *plant* world's success story because it is no longer clear that *corn's* triumph is such a boon to the rest of the world, and because we should give credit where credit is due. Corn is the hero of its own story, and though we humans played a crucial supporting role in its rise to world domination, it would be wrong to suggest we have been calling the shots, or acting always in our own best interests. Indeed, there is every reason to believe that corn has succeeded in domesticating us.

To some extent this holds true for all of the plants and animals that take part in the grand co-evolutionary bargain with humans we call agriculture. Though we insist on speaking of the "invention" of agriculture as if it were our idea, like double-entry bookkeeping or the lightbulb, in fact it makes just as much sense to regard agriculture as a brilliant (if unconscious) evolutionary strategy on the part of the plants and animals involved to get us to advance their interests. By evolving certain traits we happen to regard as desirable, these species got themselves noticed by the one mammal in a position not only to spread their genes around the world, but to remake vast swathes of that world in the image of the plants' preferred habitat. No other group of species gained more from their association with humans than the edible grasses, and no grass has reaped more from agriculture than *Zea mays*, today the world's most important cereal crop.

Corn's success might seem fated in retrospect, but it was not something anyone would have predicted on that day in May 1493 when Columbus first described the botanical oddity he had encountered in the New World to Isabella's court. He told of a towering grass with an ear as thick as a man's arm, to which grains were "affixed by nature in a wondrous manner and in form and size like garden peas, white when young." Wondrous, perhaps, yet this was, after all, the staple food of a people that would shortly be vanquished and all but exterminated.

By all rights, maize should have shared the fate of that other native species, the bison, which was despised and targeted for elimination precisely because it was "the Indians' commissary:" in the words of General Philip Sheridan, commander of the armies of the West. Exterminate the species, Sheridan advised, and "[t]hen your prairies can be covered with speckled cattle and the festive cowboy." In outline Sheridan's plan was the plan for the whole continent: The white man brought his own "associate species" with him to the New World—cattle and apples, pigs and wheat, not to mention his accustomed weeds and microbes—and wherever possible helped them to displace the native plants and animals allied with the Indian. More even than the rifle, it was this biotic army that did the most to defeat the Indians.

But corn enjoyed certain botanical advantages that would allow it to thrive even as the Native Americans with whom it had coevolved were being eliminated. Indeed, maize, the one plant without which the American colonists probably would never have survived, let alone prospered, wound up abetting the destruction of the very people who had helped develop it. In the plant world at least, opportunism trumps gratitude. Yet in time, the plant of the vanquished would conquer even the conquerors.

Squanto taught the Pilgrims how to plant maize in the spring of 1621, and the colonists immediately recognized its value: No other plant could produce quite as much food quite as fast on a given patch of New World ground as this Indian corn. (Originally "corn" was a generic English word for any kind of grain, even a grain of salt—hence "corned beef"; it didn't take long for *Zea mays* to appropriate the word for itself, at least in America.) The fact that the plant was so well adapted to the climate and soils of North America gave it an edge over European grains, even if it did make a disappointingly earthbound bread. Centuries before the Pilgrims arrived the plant had already spread north from central Mexico, where it is thought to have originated, all the way to New England, where Indians were probably cultivating it by 1000. Along the way, the plant—whose prodigious genetic variability allows it to adapt rapidly to new conditions—made itself at home in virtually every microclimate in North America; hot or cold, dry or wet, sandy soil or heavy, short day or long, corn, with the help of its Native American allies, evolved whatever traits it needed to survive and flourish.

Lacking any such local experience, wheat struggled to adapt to the continent's harsh climate, and yields were often so poor that the settlements that stood by the old world staple often perished...Planted, a single corn seed yielded more than 150 fat kernels, often as many as 300, while the return on a seed of wheat, when all went well, was something less than 50: 1. (At a time when land was abundant and labor scarce, agricultural yields were calculated on a per-seed-sown basis.)

Corn won over the wheat people because of its versatility, prized especially in new settlements far from civilization. This one plant supplied settlers with a ready-to-eat vegetable and a storable grain, a source of fiber and animal feed, a heating fuel and an intoxicant. Corn could be eaten fresh off the cob ("green") within months after planting, or dried on the stalk in fall, stored indefinitely, and ground into flour as needed. Mashed and fermented, corn could be brewed into beer or distilled into whiskey; for a time it was the

only source of alcohol on the frontier. (Whiskey and pork were both regarded as "concentrated corn," the latter a concentrate of its protein, the former of its calories; both had the virtue of reducing corn's bulk and raising its price.) No part of the big grass went to waste: The husks could be woven into rugs and twine; the leaves and stalks made good silage for livestock; the shelled cobs were burned for heat and stacked by the privy as a rough substitute for toilet paper. (Hence the American slang term "corn hole.")

"Corn was the means that permitted successive waves of pioneers to settle new territories," writes Arturo Warman, a Mexican historian. "Once the settlers had fully grasped the secrets and potential of corn, they no longer needed the Native Americans." Squanto had handed the white man precisely the tool he needed to dispossess the Indian. Without the "fruitfulness" of Indian corn, the nineteenth-century English writer William Cobbett declared, the colonists would never have been able to build "a powerful nation." Maize, he wrote, was "the greatest blessing God ever gave to man."

Valuable as corn is as a means of subsistence, the kernel's qualities make it an excellent means of accumulation as well. After the crop has supplied its farmer's needs, he can go to market with any surplus, dried corn being the perfect commodity: easy to transport and virtually indestructible. Corn's dual identity, as food and commodity, has allowed many of the peasant communities that have embraced it to make the leap from a subsistence to a market economy. The dual identity also made corn indispensable to the slave trade: Corn was both the currency traders used to pay for slaves in Africa and the food upon which slaves subsisted during their passage to America. Corn is the protocapitalist plant.

4. MARRIED TO MAN

But while both the new and the native Americans were substantially dependent on corn, the plant's dependence on the Americans had become total. Had maize failed to find favor among the conquerors it risked extinction, because without humans to plant it every spring, corn would disappear from the earth in a matter of a few years. The novel cob-and-husk arrangement that makes corn such a convenient grain for us renders the plant utterly dependent for its survival on an animal in possession of the opposable thumb needed to remove the husk, separate the seeds, and plant them.

Plant a whole corncob and watch what happens: If any of the kernels manage to germinate, and then work their way free of the smothering husk, they will invariably crowd themselves to death before their second set of leaves has emerged. More than most domesticated plants (a few of whose offspring will usually find a way to grow unassisted), corn completely threw its lot in with humanity when it evolved its peculiar husked ear. Several human societies have seen fit to worship corn, but perhaps it should be the other way around: For corn, we humans are the contingent beings. So far, this reckless—seeming act of evolutionary—faith in us has been richly rewarded.

It is tempting to think of maize as a human artifact, since the plant is so closely linked to us and so strikingly different from any wild species. There are in fact no wild maize plants, and teosinte, the weedy grass from which corn is believed to have descended (the word is

Nahuatl for "mother of corn"), has no ear, bears its handful of tiny naked seeds on a terminal rachis like most other grasses, and generally looks nothing whatsoever like maize. The current thinking among botanists is that several thousand years ago teosinte underwent an abrupt series of mutations that turned it into corn; geneticists calculate that changes on as few as four chromosomes could account for the main traits that distinguish teosinte from maize. Taken together, these mutations amounted to (in the words of botanist Hugh Utis) a "catastrophic sexual transmutation": the transfer of the plant's female organs from the top of the grass to a monstrous sheathed ear in the middle of the stalk. The male organs stayed put, remaining in the tassel.

It is, for a grass, a bizarre arrangement with crucial implications: The ear's central location halfway down the stalk allows it to capture far more nutrients than it would up top, so suddenly producing hundreds of gigantic seeds becomes metabolically feasible. Yet because those seeds are now trapped in a tough husk, the plant has lost its ability to reproduce itself—hence the catastrophe in teosinte's sex change. A mutation this freakish and maladaptive would have swiftly brought the plant to an evolutionary dead end had one of these freaks not happened to catch the eye of a human somewhere in Central America who, looking for something to eat, peeled open the husk to free the seeds. What would have been an unheralded botanical catastrophe in a world without humans became an incalculable evolutionary boon. If you look hard enough, you can still find teosinte growing in certain Central American highlands; you can find maize, its mutant offspring, anywhere you find people.

5. CORN SEX

Maize is self-fertilized and wind-pollinated, botanical terms that don't begin to describe the beauty and wonder of corn sex. The tassel at the top of the plant houses the male organs, hundreds of pendant anthers that over the course of a few summer days release a superabundance of powdery yellow pollen: 14 million to 18 million grains per plant, 20,000 for every potential kernel. ("Better safe than sorry" or "more is more," being nature's general rule for male genes.) A meter or so below await the female organs, hundreds of minuscule flowers arranged in tidy rows along a tiny, sheathed cob that juts upward from the stalk at the crotch of a leaf midway between tassel and earth. That the male anthers resemble flowers and the female cob a phallus is not the only oddity in the sex life of corn.

Each of the four hundred to eight hundred flowers on a cob has the potential to develop into a kernel—but only if a grain of pollen can find its way to its ovary, a task complicated by the distance the pollen has to travel and the intervening husk in which the cob is tightly wrapped. To surmount this last problem, each flower sends out through the tip of the husk a single, sticky strand of silk (technically its "style") to snag its own grain of pollen. The silks emerge from the husk on the very day the tassel is set to shower its yellow dust.

What happens next is very strange. After a grain of pollen has fallen through the air and alighted on the moistened tip of silk, its nucleus divides in two, creating a pair of twins, each with the same set of genes but a completely different role to perform in the creation of the kernel. The first twin's job is to tunnel a microscopic tube down through the center of the silk thread. That accomplished, its clone slides down through the tunnel, past the husk, and into the

waiting flower, a journey of between six and eight inches that takes several hours to complete. Upon arrival in the flower the second twin fuses with the egg to form the embryo—the germ of the future kernel. Then the first twin follows, entering the now fertilized flower, where it sets about forming the endosperm—the big, starchy part of the kernel. Every kernel of corn is the product of this intricate ménage-à-trois; the tiny, stunted kernels you often see at the narrow end of a cob are flowers whose silk no pollen grain ever penetrated. Within a day of conception, the now superfluous silk dries up, eventually turning reddish brown; fifty or so days later, the kernels are mature. *

*My account of the sex life of corn is drawn from Betty Fussell's *The Story of Corn* (1992) and Frederick Sargent's *Corn Plants* (1901).

The mechanics of corn sex, and in particular the great distance over open space corn pollen must travel to complete its mission, go a long way toward accounting for the success of maize's alliance with humankind. It's a simple matter for a human to get between a corn plant's pollen and its flower, and only a short step from there, to deliberately crossing one corn plant with another with an eye to encouraging specific traits in the offspring. Long before scientists understood hybridization, Native Americans had discovered that by taking the pollen from the tassel of one corn plant and dusting it on the silks of another, they could create new plants that combined the traits of both parents. American Indians were the world's first plant breeders, developing literally thousands of distinct cultivars for every conceivable environment and use.

Looked at another way, corn was the first plant to involve humans so intimately in its sex life. For a species whose survival depends on how well it can gratify the ever-shifting desires of its only sponsor, this has proved to be an excellent evolutionary strategy. More even than other domesticated species, many of which can withstand a period of human neglect, it pays for corn to be obliging—and to be so quick about it. The usual way a domesticated species figures out what traits its human ally will reward is through the slow and wasteful process of Darwinian trial and error. Hybridization represents a far swifter and more efficient means of communication, or feedback loop, between plant and human; by allowing humans to arrange its marriages, corn can discover in a single generation precisely what qualities it needs to prosper.

It is by being so obliging that corn has won itself as much human attention and habitat as it has. The plant's unusual sexual arrangements, so amenable to human intervention, has allowed it to adapt to the very different worlds of Native Americans (and to their very different worlds, from southern Mexico to New England), of colonists and settlers and slaves, and of all the other corn-eating societies that have come and gone since the first human chanced upon that first teosinte freak.

But of all the human environments to which corn has successfully adapted since then, the adaptation to our own—the world of industrial consumer capitalism; the world, that is, of the supermarket and fastfood franchise—surely represents the plant's most extraordinary evolutionary achievement to date. For to prosper in the industrial food chain to the extent it has, corn had to acquire several improbable new tricks. It had to adapt itself not just to

humans but to their machines, which it did by learning to grow as upright, stiff-stalked, and uniform as soldiers. It had to multiply its yield by an order of magnitude, which it did by learning to grow shoulder to shoulder with other corn plants, as many as thirty thousand to the acre. It had to develop an appetite for fossil fuel (in the form of petrochemical fertilizer) and a tolerance for various synthetic chemicals. But even before it could master these tricks and make a place for itself in the bright sunshine of capitalism, corn first had to turn itself into something never before seen in the plant world: a form of intellectual property.

The free corn sex I've described allowed people to do virtually anything they wanted with the genetics of corn except own them—a big problem for a would-be capitalist plant. If I crossed two corn plants to create a variety with an especially desirable trait, I could sell you my special seeds, but only once, since the corn you grew from my special seeds would produce lots more special seeds, for free and forever, putting me out business in short order. It's difficult to control the means of production when the product you're selling can reproduce itself endlessly. This is one of the ways in which the imperatives of biology are difficult to mesh with the imperatives of business.

Difficult, but not impossible. Early in the twentieth century American corn breeders figured out how to bring corn reproduction under firm control, and to protect the seed from copiers. The breeders discovered that when they crossed two corn plants that had come from inbred lines—from ancestors that had themselves been exclusively self-pollinated for several generations—the hybrid offspring displayed some highly unusual characteristics. First, all the seeds in that first generation (F-1, in the plant breeder's vocabulary) produced genetically identical plants—a trait that, among other things, facilitates mechanization. Second, those plants exhibited heterosis, or hybrid vigor—better yields than either of their parents. But most important of all, they found that the seeds produced by these seeds did not "come true"—the plants in the second (F-2) generation bore little resemblance to the plants in the first. Specifically, their yields plummeted by as much as a third, making their seeds virtually worthless.

Hybrid corn now offered its breeders what no other plant at that time could: the biological equivalent of a patent. Farmers now had to buy new seeds every spring; instead of depending upon their plants to reproduce themselves, they now depended on a corporation. The corporation, assured for the first time of a return on its investment in breeding, showered corn with attention—R&D, promotion, advertising—and the plant responded, multiplying its fruitfulness year after year. With the advent of the F-1 hybrid, a technology with the power to remake nature in the image of capitalism, *Zea mays* entered the industrial age and, in time, it brought the whole American food chain with it.

TWO: THE FARAI

1. ONE FARMER, 129 EATERS

To take the wheel of a clattering 1975 International Harvester tractor, pulling a spidery eight-row planter through an Iowa cornfield during the first week of May, is like trying to steer a boat through a softly rolling sea of dark chocolate. The hard part is keeping the thing

on a straight line, that and hearing the shouted instructions of the farmer sitting next to you when you both have wads of Kleenex jammed into your ears to muffle the diesel roar. Driving a boat, you try to follow the compass heading or aim for a landmark on shore; planting corn, you try to follow the groove in the soil laid down on the previous pass by a rolling disk at the end of a steel arm attached to the planter behind us. Deviate from the line and your corn rows will wobble, overlapping or drifting away from one another. Either way, it'll earn you a measure of neighborly derision and hurt your yield. And yield, measured in bushels per acre, is the measure of all things here in corn country.

The tractor I was driving belonged to George Naylor, who bought it new back in the mid-seventies, when, as a twenty-seven-year-old, he returned to Greene County, Iowa, to farm his family's 470 acres. Naylor is a big man with a moon face and a scraggly gray beard. On the phone his gravelly voice and incontrovertible pronouncements ("That is just the biggest bunch of bullshit! Only the *New York Times* would be dumb enough to believe the Farm Bureau still speaks for American farmers!") led me to expect someone considerably more ornery than the shy fellow who climbed down from his tractor cab to greet me in the middle of a field in the middle of a slate-gray day threatening rain. Naylor had on the farmer's standard-issue baseball cap, a yellow chamois shirt, and overalls—the stripy blue kind favored by railroad workers, about as un-intimidating an article of clothing as has ever been donned by a man. My first impression was more shambling Gentle Ben than fiery prairie populist, but I would discover that Naylor can be either fellow, the mere mention of "Cargill" or "Earl Butz" supplying the transformational trigger.

This part of Iowa has some of the richest soil in the world, a layer of cakey alluvial loam nearly two feet thick. The initial deposit was made by the retreat of the Wisconsin glacier ten thousand years ago, and then compounded at the rate of another inch or two every decade by prairie grasses—big bluestem, foxtail, needlegrass, and switchgrass. Tall-grass prairie is what this land was until the middle of the nineteenth century, when the sod was first broken by the settler's plow. George's grandfather moved his family to Iowa from Derbyshire, England, in the 1880s, a coal miner hoping to improve his lot in life. The sight of such soil, pushing up and then curling back down behind the blade of his plow like a thick black wake behind a ship, must have stoked his confidence, and justifiably so: It's gorgeous stuff, black gold as deep as you can dig, as far as you can see. What you can't see is all the soil that's no longer here, having been blown or washed away since the sod was broken; the two-foot crust of topsoil here probably started out closer to four.

The story of the Naylor farm since 1919, when George's grandfather bought it, closely tracks the twentieth-century story of American agriculture, its achievements as well as its disasters. It begins with a farmer supporting a family on a dozen different species of plants and animals. There would have been a fair amount of corn then too, but also fruits and other vegetables, as well as oats, hay, and alfalfa to feed the pigs, cattle, chickens, and horses—horses being the tractors of that time. One of every four Americans lived on a farm when Naylor's grandfather arrived here in Churdan; his land and labor supplied enough food to feed his family and twelve other Americans besides. Less than a century after, fewer than 2 million Americans still farm—and they grow enough to feed the rest of us. What that means is that Naylor's grandson, raising nothing but corn and soybeans on a fairly typical Iowa farm, is so astoundingly productive that

he is, in effect, feeding some 129 Americans. Measured in terms of output per worker, American farmers like Naylor are the most productive humans who have ever lived.

Yet George Naylor is all but going broke—and he's doing better than many of his neighbors. (Partly because he's still driving that 1975 tractor.) For though this farm might feed 129, it can no longer support the four who live on it: The Naylor farm survives by the grace of Peggy Naylor's paycheck (she works for a social services agency in Jefferson) and an annual subsidy payment from Washington, DC. Nor can the Naylor farm literally feed the Naylor family, as it did in grandfather Naylor's day. George's crops are basically inedible—they're commodities that must be processed or fed to livestock before they can feed people. Water, water, everywhere and not a drop to drink: Like most of Iowa, which now imports 80 percent of its food, George's farm (apart from his garden, his laying hens, and his fruit trees) is basically a food desert.

The 129 people who depend on George Naylor for their sustenance are all strangers, living at the far end of a food chain so long, intricate, and obscure that neither producer nor consumer has any reason to know the first thing about the other. Ask one of those eaters where their steak or soda comes from and she'll tell you "the supermarket." Ask George Naylor whom he's growing all that corn for and he'll tell you "the military-industrial complex." Both are partly right.

I came to George Naylor's farm as an unelected representative of the Group of 129, curious to learn who, and what, I'd find at the far end of the food chain that keeps me alive. There's no way of knowing whether George Naylor is literally growing the corn that feeds the steer that becomes my steak, or that sweetened my son's soft drink, or supplied the dozen or so corn-derived ingredients from which his chicken nugget is constructed. But given the complexly ramifying fate of a bushel of commodity corn, the countless forking paths followed by its ninety thousand kernels as they're dispersed across the nation's sprawling food system, the odds are good that at least one of the kernels grown on the Naylor farm has, like the proverbial atom from Caesar's dying breath, made its way to me. And if not me, then certainly you. This Iowa cornfield (and all the others just like it) is the place most of our food comes from.

2. PLANTING THE CITY OF CORN

The day I showed up was supposed to be the only dry one all week, so George and I spent most of it in the cab of his tractor, trying to get acquainted and get his last 160 acres of corn planted at the same time; a week or two later he'd start in on the soybeans. The two crops take turns in these fields year after year, in what has been the classic Corn Belt rotation since the 1970s. (Since that time soybeans have become the second leg supporting the industrial food system: It too is fed to livestock and now finds its way into two-thirds of all processed foods.) For most of the afternoon I sat on a rough cushion George had fashioned for me from crumpled seed bags, but after a while he let me take the wheel.

Back and forth and back again, a half a mile in each direction, planting corn feels less like planting, or even driving, than stitching an interminable cloak, or covering a page with the same sentence over and over again. The monotony, compounded by the roar of a diesel engine well past its prime, is hypnotic after a while. Every pass across this field, which is almost but not quite dead flat, represents another acre of corn planted, another thirty thousand seeds tucked into

one of the eight furrows being simultaneously etched into the soil by pairs of stainless steel disks; a trailing roller then closes the furrows over the seed.

The seed we were planting was Pioneer Hi-Bred's 34H31, a strain that the catalog described as "an adaptable hybrid with solid agronomics and yield potential." The lack of hype, notable for a seed catalog, probably reflects the fact that 34H31 does not contain the "Yield-Gard gene," the Monsanto-developed line of genetically engineered corn that Pioneer is currently pushing: The genetically modified 34B9S, on the same page, promises "outstanding yield potential." Despite the promises, Naylor, unlike many of his neighbors, doesn't plant GMOs (genetically modified organisms). He has a gut distrust of the technology ("They're messing with three billion years of evolution") and doesn't think it's worth the extra twenty-five dollars a bag (in technology fees) they cost. "Sure, you might get a yield bump, but whatever you make on the extra corn goes right back to cover the premium for the seed. I fail to see why I should be laundering money for Monsanto." As Naylor sees it, GMO seed is just the latest chapter in an old story: Farmers eager to increase their yields adopt the latest innovation, only to find that it's the companies selling the innovations who reap the most from the gain in the farmer's productivity.

Even without the addition of trans genes for traits like insect resistance, the standard F-1 hybrids Naylor plants are technological marvels, capable of coaxing 150 bushels of corn from an acre of Iowa soil. One bushel holds 56 pounds of kernels, so that's slightly more than ten thousand pounds of food per acre; the field George and I planted that day would produce 1.5 million pounds of corn. Not *bad* for a *day's* work sitting down, I thought to myself that afternoon, though of course there'd be several more days of work between now and the harvest in October.

One way to tell the story of this farm is by following the steady upward arc in the yield of corn. Naylor has no idea how many bushels of corn per acre his grandfather could produce, but the average back in 1920 was about twenty bushels per acre—roughly the same yields historically realized by Native Americans. Corn then was planted in widely spaced bunches in a checkerboard pattern so farmers could easily cultivate between the stands in either direction. Hybrid seed came on the market in the late the 1930s, when his father was farming. "You heard stories," George shouted over the din of the tractor. "How they talked him into raising an acre or two of the new hybrid, and by god when the old corn fell over, the hybrid stood straight up. Doubled Dad's yields, till he was getting seventy to eighty an acre in the fifties." George has doubled that yet again, some years getting as much as two hundred bushels of corn per acre. The only other domesticated species ever to have multiplied its productivity by such a factor is the Holstein cow.

"High yield" is a fairly abstract concept, and I wondered what it meant at the level of the plant: more cobs per stalk? more kernels per cob? Neither of the above, Naylor explained. The higher yield of modern hybrids stems mainly from the fact that they can be planted so close together, thirty thousand to the acre instead of eight thousand in his father's day. Planting the old open-pollinated (nonhybrid) varieties so densely would result in stalks grown spindly as they jostle each other for sunlight; eventually the plants topple in the wind. Hybrids have been bred for thicker stalks and stronger root systems, the better to stand upright in a crowd and withstand mechanical harvesting. Basically, modern hybrids can tolerate the corn equivalent of city life, growing amid the multitudes without succumbing to

urban stress.

You would think that competition among individuals would threaten the tranquility of such a crowded metropolis, yet the modern field of corn forms a most orderly mob. This is because every plant in it, being an F-1 hybrid, is genetically identical to every other. Since no individual plant has inherited any competitive edge over any other, precious resources like sunlight, water, and soil nutrients are shared equitably. There are no alpha corn plants to hog the light or fertilizer. The true socialist utopia turns out to be a field of F-1 hybrid plants.

Iowa begins to look a little different when you think of its sprawling fields as cities of corn, the land, in its own way, settled as densely as Manhattan for the very same purpose: to maximize real estate values. There may be little pavement out here, but this is no middle landscape. Though by any reasonable definition Iowa is a rural state, it is more thoroughly developed than many cities: A mere 2 percent of the state's land remains what it used to be (tall-grass prairie), every square foot of the rest having been completely remade by man. The only thing missing from this man-made landscape is ... man.

3. VANISHING SPECIES

A case can be made that the corn plant's population explosion in places like Iowa is responsible for pushing out not only other plants but the animals and then finally the people, too. When Naylor's grandfather arrived in America the population of Greene County was near its peak: 16,467 people. In the most recent census it had fallen to 10,366. There are many reasons for the depopulation of the American Farm Belt, but the triumph of corn deserves a large share of the blame—or the credit, depending on your point of view.

When George Naylor's grandfather was farming, the typical Iowa farm was home to whole families of different plant and animal species, corn being only the fourth most common. Horses were the first, because every farm needed working animals (there were only 225 tractors in all of America in 1920), followed by cattle, chickens, and then corn. After corn came hogs, apples, hay, oats, potatoes, and cherries; many Iowa farms also grew wheat, plums, grapes, and pears. This diversity allowed the farm not only to substantially feed itself—and by that I don't mean feed only the farmers, but also the soil and the livestock, but to withstand a collapse in the market for anyone of those crops. It also produced a completely different landscape than the Iowa of today.

"You had fences everywhere," George recalled, "and of course pastures. Everyone had livestock, so large parts of the farm would be green most of the year. The ground never used to be this bare this long." For much of the year, from the October harvest to the emergence of the corn in mid-May, Greene County is black now, a great tarmac only slightly more hospitable to wildlife than asphalt. Even in May the only green you see are the moats of lawn surrounding the houses, the narrow strips of grass dividing one farm from another, and the roadside ditches. The fences were pulled up when the animals left, beginning in the fifties and sixties, or when they moved indoors, as Iowa's hogs have more recently done; hogs now spend their lives in aluminum sheds perched atop manure pits. Greene County in

the spring has become a monotonous landscape, vast plowed fields relieved only by a dwindling number of farmsteads, increasingly lonesome islands of white wood and green grass marooned in a sea of black. Without the fences and hedgerows to slow it down, Naylor says, the winds blow more fiercely in Iowa today than they once did.

Corn isn't solely responsible for remaking this landscape: It was the tractor, after all, that put the horses out of work, and with the horses went the fields of oats and some of the pasture. But corn was the crop that put cash in the farmer's pocket, so as corn yields began to soar at mid-century, the temptation was to give the miracle crop more and more land. Of course, every other farmer in America was thinking the same way (having been encouraged to do so by government policies), with the inevitable result that the price of corn declined. One might think falling corn prices would lead farmers to plant less of it, but the economics and psychology of agriculture are such that exactly the opposite happened.

Beginning in the fifties and sixties, the flood tide of cheap corn made it profitable to fatten cattle on feedlots instead of on grass, and to raise chickens in giant factories rather than in farmyards. Iowa livestock farmers couldn't compete with the factory-farmed animals their own cheap corn had helped spawn, so the chickens and cattle disappeared from the farm, and with them the pastures and hay fields and fences. In their place the farmers planted more of the one crop they could grow more of than anything else: corn. And whenever the price of corn slipped they planted a little more of it, to cover expenses and stay even. By the 1980s the diversified family farm was history in Iowa, and corn was king. (Planting corn on the same ground year after year brought down the predictable plagues of insects and disease, so beginning in the 1970s Iowa farmers started alternating corn with soybeans, a legume. Recently, though, bean prices having fallen and bean diseases having risen, some farmers are going back to a risky rotation of "corn on corn.")

With the help of its human and botanical allies (i.e., farm policy and soybeans), corn had pushed the animals and their feed crops off the land, and steadily expanded into their paddocks and pastures and fields. Now it proceeded to push out the people. For the radically simplified farm of corn and soybeans doesn't require nearly as much human labor as the old diversified farm, especially when the farmer can call on sixteen-row planters and chemical weed killers. One man can handle a lot more acreage by himself when it's planted in monoculture, and without animals to care for he can take the weekend off, and even think about spending the winter in Florida.

"Growing corn is just riding tractors and spraying," Naylor told me; the number of riding and spraying days it takes to raise five hundred acres of industrial corn can probably be counted in weeks. So the farms got bigger, and eventually the people, whom the steadily falling price of corn could no longer support anyway, went elsewhere, ceding the field to the monstrous grass.

Today Churdan is virtually a ghost town, much of its main street shuttered. The barbershop, a food market, and the local movie theater have all closed in recent years; there's a cafe and one sparsely stocked little market somehow still hanging on, but most people drive the ten miles to Jefferson to buy their groceries or pick up milk and eggs when they're getting gas at

the Kum & Go. The middle school can no longer field a baseball team or put together a band, it has so few students left, and it takes four local high schools to field a single football team: the Jefferson-Scranton-Paton-Churdan Rams. Just about the only going concern left standing in Churdan is the grain elevator, rising at the far end of town like a windowless concrete skyscraper. It endures because, people or no people, the corn keeps coming, more of it every year.

I've oversimplified the story a bit; corn's rapid rise is not quite as self-propelled as I've made it sound. As in so many other "self-made" American successes, the closer you look the more you find the federal government lending a hand—a patent, a monopoly, a tax-break-to our hero at a critical juncture. In the case of corn, the botanical hero I've depicted as plucky and ambitious was in fact subsidized in crucial ways, both economically and biologically. There's a good reason I met farmers in Iowa who don't respect corn, who will tell you in disgust that the plant has become "a welfare queen."

The great turning point in the modern history of corn, which in turn marks a key turning point in the industrialization of our food, can be dated with some precision to the day in 1947 when the huge munitions plant at Muscle Shoals, Alabama, switched over to making chemical fertilizer. After the war the government had found itself with a tremendous surplus of ammonium nitrate, the principal ingredient in the making of explosives. Ammonium nitrate also happens to be an excellent source of nitrogen for plants. Serious thought was given to spraying America's forests with the surplus chemical, to help out the timber industry. But agronomists in the Department of Agriculture had a better idea: Spread the ammonium nitrate on farmland as fertilizer. The chemical fertilizer industry (along with that of pesticides, which are based on poison gases developed for the war) is the product of the government's effort to convert its war machine to peacetime purposes. As the Indian farmer activist Vandana Shiva says in her speeches, "We're still eating the leftovers of World War II."

Hybrid corn turned out to be the greatest beneficiary of this conversion. Hybrid corn is the greediest of plants, consuming more fertilizer than any other crop. For though the new hybrids had the genes to survive in teeming cities of corn, the richest acre of Iowa soil could never have fed thirty thousand hungry corn plants without promptly bankrupting its fertility. To keep their land from getting "corn sick" farmers in Naylor's father's day would carefully rotate their crops with legumes (which add nitrogen to the soil), never growing corn more than twice in the same field every five years; they would also recycle nutrients by spreading their cornfields with manure from their livestock. Before synthetic fertilizers the amount of nitrogen in the soil strictly limited the amount of corn an acre of land could support. Though hybrids were introduced in the thirties, it wasn't until they made the acquaintance of chemical fertilizers in the 1950s that corn yields exploded.

The discovery of synthetic nitrogen changed everything—not just for the corn plant and the farm, not just for the food system, but also for the way life on earth is conducted. All life depends on nitrogen; it is the building block from which nature assembles amino acids, proteins, and nucleic acid; the genetic information that orders and perpetuates life is written in nitrogen ink. (This is why scientists speak of nitrogen as supplying life's quality, while

carbon provides the quantity.) But the supply of usable nitrogen on earth is limited. Although earth's atmosphere is about 80 percent nitrogen, all those atoms are tightly paired, non-reactive, and therefore useless; the nineteenth-century chemist Justus von Liebig spoke of atmospheric nitrogen's "indifference to all other substances." To be of any value to plants and animals, these self-involved nitrogen atoms must be split and then joined to atoms of hydrogen. Chemists call this process of taking atoms from the atmosphere and combining them into molecules useful to living things "fixing" that element. Until a German Jewish chemist named Fritz Haber figured out how to turn this trick in 1909, all the usable nitrogen on earth had at one time been fixed by soil bacteria living on the roots of leguminous plants (such as peas or alfalfa or locust trees) or, less commonly, by the shock of electrical lightning, which can break nitrogen bonds in the air, releasing a light rain of fertility.

Vaclav Smil, a geographer who has written a fascinating book about Fritz Haber called *Enriching the Earth*, pointed out that "there is no way to grow crops and human bodies without nitrogen." Before Fritz Haber's invention the sheer amount of life earth could support—the size of crops and therefore the number of human bodies—was limited by the amount of nitrogen that bacteria and lightning could fix. By 1900, European scientists recognized that unless a way was found to augment this naturally occurring nitrogen, the growth of the human population would soon grind to a very painful halt. The same recognition by Chinese scientists a few decades later is probably what compelled China's opening to the West: After Nixon's 1972 trip the first major order the Chinese government placed was for thirteen massive fertilizer factories. Without them, China would probably have starved.

This is why it may not be hyperbole to claim, as Smil does, that the Haber-Bosch process (Carl Bosch gets the credit for commercializing Haber's idea) for fixing nitrogen is the most important invention of the twentieth century. He estimates that two of every five humans on earth today would not be alive if not for Fritz Haber's invention. We can easily imagine a world without computers or electricity, Smil points out, but without synthetic fertilizer billions of people would never have been born. Though, as these numbers suggest, humans may have struck something of a Faustian bargain with nature when Fritz Haber gave us the power to fix nitrogen.

Fritz Haber? No, I'd never heard of him either, even though he was awarded the Nobel Prize in 1920 for "improving the standards of agriculture and the well-being of mankind." But the reason for his obscurity has less to do with the importance of his work than the ugly twist of his biography, which recalls the dubious links between modern warfare and industrial agriculture. During World War I, Haber threw himself into the German war effort, and his chemistry kept alive Germany's hopes for victory. After Britain choked off Germany's supply of nitrates from Chilean mines, an essential ingredient in the manufacture of explosives, Haber's technology allowed Germany to continue making bombs from synthetic nitrate. Later, as the war became mired in the trenches of France, Haber put his genius for chemistry to work developing poison gases—ammonia, then chlorine. (He subsequently developed Zyklon B, the gas used in Hitler's concentration camps.) On April 22, 1915, Smil writes, Haber was "on the front lines directing the first gas attack in military history." His "triumphant" return to Berlin was ruined a few days later

when his wife, a fellow chemist sickened by her husband's contribution to the war effort, used Haber's army pistol to kill herself. Though Haber later converted to Christianity, his Jewish background forced him to flee Nazi Germany in the thirties; he died, broken, in a Basel hotel room in 1934. Perhaps because the history of science gets written by the victors, Fritz Haber's story has been all but written out of the twentieth century. Not even a plaque marks the site of his great discovery at the University of Karlsruhe.

Haber's story embodies the paradoxes of science: the double edge to our manipulations of nature, the good and evil that can flow not only from the same man but the same knowledge. Haber brought a vital new source of fertility and an awful new weapon into the world; as his biographer wrote, "It's the same science and the same man doing both." Yet this dualism dividing the benefactor of agriculture from the chemical weapons maker is far too pat, for even Haber's benefaction has proven decidedly to be a mixed blessing.

When humankind acquired the power to fix nitrogen, the basis of soil fertility shifted from a total reliance on the energy of the sun to a new reliance on fossil fuel. For the Haber-Bosch process works by combining nitrogen and hydrogen gases under immense heat and pressure in the presence of a catalyst. The heat and pressure are supplied by prodigious amounts of electricity, and the hydrogen is supplied by oil, coal, or most commonly today, natural gas-fossil fuels. True, these fossil fuels were at one time billions of years ago created by the sun, but they are not renewable in the same way that the fertility created by a legume nourished by sunlight is. (That nitrogen is actually fixed by a bacteria living on the roots of the legume, which trades a tiny drip of sugar for the nitrogen the plant needs.)

On the day in the 1950s that George Naylor's father spread his first load of ammonium nitrate fertilizer, the ecology of his farm underwent a quiet revolution. What had been a local, sun-driven cycle of fertility, in which the legumes fed the corn which fed the livestock which in turn (with their manure) fed the corn, was now broken. Now he could plant corn every year and on as much of his acreage as he chose, since he had no need for the legumes or the animal manure. He could buy fertility in a bag, fertility that had originally been produced a billion years ago halfway around the world.

Liberated from the old biological constraints, the farm could now be managed on industrial principles, as a factory transforming inputs of raw material—chemical fertilizer—into outputs of corn. Since the farm no longer needs to generate and conserve its own fertility by maintaining a diversity of species, synthetic fertilizer opens the way to monoculture, allowing the farmer to bring the factory's economies of scale and mechanical efficiency to nature. If, as has sometimes been said, the discovery of agriculture represented the first fall of man from the state of nature, then the discovery of synthetic fertility is surely a second precipitous fall. Fixing nitrogen allowed the food chain to turn from the logic of biology and embrace the logic of industry. Instead of eating exclusively from the sun, humanity now began to sip petroleum.

Corn adapted brilliantly to the new industrial regime, consuming prodigious quantities of fossil fuel energy and turning out ever more prodigious quantities of food energy. More than half of all the synthetic nitrogen made today is applied to corn, whose hybrid strains

can make better use of it than any other plant. Growing corn, which from a biological perspective had always been a process of capturing sunlight to turn it into food, has in no small measure become a process of converting fossil fuels into food. This shift explains the color of the land: The reason Greene County is no longer green for half the year is because the farmer who can buy synthetic fertility no longer needs cover crops to capture a whole year's worth of sunlight; he has plugged himself into a new source of energy. When you add together the natural gas in the fertilizer to the fossil fuels it takes to make the pesticides, drive the tractors, and harvest, dry, and transport the corn, you find that every bushel of industrial corn requires the equivalent of between a quarter and a third of a gallon of oil to grow it—or around fifty gallons of oil per acre of corn. (Some estimates are much higher.) Put another way, it takes more than a calorie of fossil fuel energy to produce a calorie of food; before the advent of chemical fertilizer the Naylor farm produced more than two calories of food energy for every calorie of energy invested.

From the standpoint of industrial efficiency, it's too bad we can't simply drink the petroleum directly, because there's a lot less energy in a bushel of corn (measured in calories) than there is in the half gallon or so of oil required to produce it. Ecologically this is a fabulously expensive way to produce food—but "ecologically" is no longer the operative standard. As long as fossil fuel energy is so cheap and available, it makes good economic sense to produce corn this way. The old way of growing corn—using fertility drawn from the sun—may have been the biological equivalent of a free lunch, but the service was much slower and the portions were much skimpier. In the factory time is money, and yield is everything.

One problem with factories, as compared to biological systems, is that they tend to pollute. Hungry for fossil fuel as hybrid corn is, farmers still feed it far more than it can possibly eat, wasting most of the fertilizer they buy. Maybe it's applied at the wrong time of year; maybe it runs off the fields in the rain; maybe the farmer puts down extra just to play it safe. "They say you only need a hundred pounds per acre. I don't know. I'm putting on up to two hundred. You don't want to err on the side of too little," Naylor explained to me, a bit sheepishly. "It's a form of yield insurance."

But what happens to the one hundred pounds of synthetic nitrogen that Naylor's corn plants don't take up? Some of it evaporates into the air, where it acidifies the rain and contributes to global warming. (Ammonium nitrate is transformed into nitrous oxide, an important greenhouse gas.) Some seeps down to the water table. When I went to pour myself a glass of water in the Naylor's kitchen, Peggy made sure I drew it from a special faucet connected to a reverse-osmosis filtration system in the basement. As for the rest of the excess nitrogen, the spring rains wash it off Naylor's fields, carrying it into drainage ditches that eventually spill into the Raccoon River. From there it flows into the Des Moines River, down to the city of Des Moines—which drinks from the Des Moines River. In spring, when nitrogen runoff is at its heaviest, the city issues "blue baby alerts," warning parents it's unsafe to give children water from the tap. The nitrates in the water bind to hemoglobin, compromising the blood's ability to carry oxygen to the brain. So I guess I was wrong to suggest we don't sip fossil fuels directly; sometimes we do.

It has been less than a century since Fritz Haber's invention, yet already it has changed earth's

ecology. More than half of the world's supply of usable nitrogen is now man-made. (Unless you grew up on organic food, most of the kilo or so of nitrogen in your body was fixed by the Haber-Bosch process.) "We have perturbed the global nitrogen cycle," Smil wrote, "more than any other, even carbon." The effects may be harder to predict than the effects of the global warming caused by our disturbance of the carbon cycle, but they may be no less momentous. The flood of synthetic nitrogen has fertilized not just the farm fields but the forests and the oceans too, to the benefit of some species (corn and algae being two of the biggest beneficiaries), and to the detriment of countless others. The ultimate fate of the nitrates that George Naylor spreads on his cornfield in Iowa is to flow down the Mississippi into the Gulf of Mexico, where their deadly fertility poisons the marine ecosystem. The nitrogen tide stimulates the wild growth of algae, and the algae smother the fish, creating a "hypoxic," or dead, zone as big as the state of New Jersey—and still growing. By fertilizing the world, we alter the planet's composition of species and shrink its biodiversity.

5. A PLAGUE OF CHEAP CORN

The day after George Naylor and I finished planting his corn, the rains came, so we spent most of it around his kitchen table, drinking coffee and talking about what farmers always talk about: lousy commodity prices; benighted farm policies; making ends meet in a dysfunctional farm economy. Naylor came back to the farm at what would turn out to be the good old days in American agriculture: Corn prices were at an all-time high, and it looked as though it might actually be possible to make a living growing it. But by the time Naylor was ready to take his first crop to the elevator, the price of a bushel of corn had dropped from three dollars to two dollars, the result of a bumper crop. So he held his corn off the market, storing it in the hope that the price would rebound. But the price kept falling all through that winter and into the following spring and, if you factor in inflation, it has pretty much been falling ever since. These days the price of a bushel of corn is about a dollar beneath the true cost of growing it, a boon for everyone but the corn farmer. What I was hoping George Naylor could help me understand is, if there's so much corn being grown in America today that the market won't pay the cost of producing it, then why would any farmer in his right mind plant another acre of it?

The answer is complicated, as I would learn, but it has something to do with the perverse economics of agriculture, which would seem to defy the classical laws of supply and demand; a little to do with the psychology of farmers; and everything to do with farm policies, which underwent a revolution right around the time George Naylor was buying his first tractor. Government farm programs once designed to limit production and support prices (and therefore farmers) were quietly re-jiggered to increase production and drive down prices. Put another way, instead of supporting farmers, during the Nixon administration the government began supporting corn at the expense of farmers. Corn, already the recipient of a biological subsidy in the form of synthetic nitrogen, would now receive an economic subsidy too, insuring its final triumph over the land and the food system.

Naylor's perspective on farm policy was shaped by a story his dad used to tell him. It takes place during the winter of 1933, in the depths of the farm depression. "That's when my father hauled corn to town and found out that the price of corn had been ten cents a bushel the day before, but on that day the elevator wasn't even buying." The price of corn had fallen to zero. "Tears always

came to his eyes when he recounted the neighbors losing their farms in the nineteen twenties and thirties," Naylor told me. America's farm policy was forged during the Depression not, as many people seem to think, to encourage farmers to produce more food for a hungry nation, but to rescue farmers from the disastrous effects of growing too much food—far more than Americans could afford to buy.

For as long as people have been farming, fat years have posed almost as stiff a challenge as lean, since crop surpluses collapse prices and bankrupt farmers who will be needed again when the inevitable lean years return. When it comes to food, nature can make a mockery of the classical economics of supply and demand—nature in the form of good or bad weather, of course, but also the nature of the human body, which can consume only so much food no matter how plentiful the supply. So, going back to the Old Testament, communities have devised various strategies to even out the destructive swings of agricultural production. The Bible's recommended farm policy was to establish a grain reserve. Not only did this insure that when drought or pestilence ruined a harvest there'd still be food to eat, but it kept farmers whole by taking food off the market when the harvest was bountiful.

This is more or less what New Deal farm programs attempted to do.

For storable commodities such as corn, the government established a target price based on the cost of production, and whenever the market price dropped below that target, the farmer was given a choice. Instead of dumping corn onto a weak market (thereby weakening it further), the farmer could take out a loan from the government—using his crop as collateral—that allowed him to store his grain until prices recovered. At that point, he sold the corn and paid back the loan; if corn prices stayed low, he could elect to keep the money he'd borrowed and, in repayment, give the government his corn, which would then go into something that came to be called, rather quaintly, the "Ever-Normal Granary." Other New Deal programs, such as those administered by the Soil Conservation Service, sought to avert overproduction (and soil erosion) by encouraging farmers to idle their most environmentally sensitive land.

The system, which remained in place more or less until shortly before George Naylor came back to the farm in the 1970s, did a fairly good job of keeping corn prices from collapsing in the face of the twentieth century's rapid gains in yield. Surpluses were held off the market by the offer of these "nonrecourse loans," which cost the government relatively little, since most of the loans were eventually repaid. And when prices climbed, as a result of bad weather, say, the government sold corn from its granary, which helped both to pay for the farm programs and smooth out the inevitable swings in price.

I say this system remained in place "more or less" until the 1970s because, beginning in the 1950s, a campaign to dismantle the New Deal farm programs took root, and with every new farm bill since then another strut was removed from the structure of support. Almost from the start, the policy of supporting prices and limiting production had collected powerful enemies: exponents of laissez-faire economics, who didn't see why farming should be treated differently than any other economic sector; food processors and grain exporters, who profited from overproduction and low crop prices; and a coalition of political and business

leaders who for various reasons thought America had far too many farmers for her (or at least their) own good.

America's farmers had long been making political trouble for Wall Street and Washington; in the words of historian Walter Karp, "since the Civil War at least, the most unruly, the most independent, the most republican of American citizens have been the small farmers." Beginning with the populist revolt of the 1890s, farmers had made common cause with the labor movement, working together to check the power of corporations. Rising agricultural productivity handed a golden opportunity to the farmers' traditional adversaries. Since a smaller number of farmers could now feed America, the moment had come to "rationalize" agriculture by letting the market force prices down and farmers off the land. So Wall Street and Washington sought changes in farm policies that would loose "a plague of cheap corn" (in the words of George Naylor, a man very much in the old rural-populist mold) on the nation, the effects of which are all around us—indeed, in us.

6. THE SAGE OF PURDUE

Earl "Rusty" Butz, Richard Nixon's second secretary of agriculture, probably did more than any other single individual to orchestrate George Naylor's plague of cheap corn. In every newspaper article about him, and there were scores, the name of Earl Butz, a blustering, highly quotable agricultural economist from Purdue University, is invariably accompanied by the epithet "colorful." Butz's plainspoken manner and barnyard humor persuaded many people he must be a friend to the farmer, but his presence on the board of Ralston Purina probably offered a more reliable guide to his sympathies. Though chiefly remembered outside agriculture for the racist joke that cost him his job during the 1976 election, Butz revolutionized American agriculture, helping to shift the food chain onto a foundation of cheap corn.

Butz took over the Department of Agriculture during the last period in American history that food prices climbed high enough to generate real political heat; his legacy would be to make sure that never happened again. In the fall of 1972 Russia, having suffered a series of disastrous harvests, purchased 30 million tons of American grain. Butz had helped arrange the sale, in the hopes of giving a boost to crop prices in order to bring restive farmers tempted to vote for George McGovern into the Republican fold. The plan worked all too well: The unexpected surge in demand, coinciding with a spell of bad weather in the Farm Belt, drove grain prices to historic heights. These were the corn prices that persuaded George Naylor he could make a go of it on his family's farm.

The 1972 Russian grain sale and the resulting spike in farm income that fall helped Nixon nail down the farm vote for his reelection, but by the following year those prices had reverberated through the food chain, all the way to the supermarket. By 1973 the inflation rate for groceries reached an all-time high, and housewives were organizing protests at supermarkets. Farmers were killing chicks because they couldn't afford to buy feed, and the price of beef was slipping beyond the reach of middle-class consumers. Some foods became scarce: horse meat began showing up in certain markets. "Why a Food Scare in a Land of Plenty?" was a headline in *U.S. News and World Report* that summer. Nixon had a consumer

revolt on his hands, and he dispatched Earl Butz to quell it. The Sage of Purdue set to work reengineering the American food system, driving down prices and vastly increasing the output of American farmers. What had long been the dream of agribusiness (cheaper raw materials) and the political establishment (fewer restive farmers) now became official government policy.

Butz made no secret of his agenda: He exhorted farmers to plant their fields "fencerow to fencerow" and advised them to "get big or get out." Bigger farms were more productive, he believed, so he pushed farmers to consolidate ("adapt or die" was another of his credos) and to regard themselves not as farmers but as "agri-businessmen." Somewhat less noisily, Butz set to work dismantling the New Deal farm regime of price supports, a job made easier by the fact that prices at the time were so high. He abolished the Ever-Normal Granary and, with the 1973 farm bill, began replacing the New Deal system of supporting prices through loans, government grain purchases, and land idling with a new system of direct payments to farmers.

The change from loans to direct payments hardly seems momentous—either way, the government pledged to make sure the farmer receives some target price for a bushel of corn when prices are weak. But in fact paying farmers directly for the shortfall in the price of corn was revolutionary, as its proponents surely must have understood. They had removed the floor under the price of grain. Instead of keeping corn out of a falling market, as the old loan programs and federal granary had done, the new subsidies encouraged farmers to sell their corn at any price, since the government would make up the difference. Or, as it turned out, make up some of the difference, since just about every farm bill since has lowered the target price in order, it was claimed, to make American grain more competitive in world markets. (Beginning in the 1980s, big buyers of grain like Cargill and Archer Daniels Midland (ADM) took a hand in shaping the farm bills, which predictably came to reflect their interests more closely than those of farmers.) Instead of supporting farmers, the government was now subsidizing every bushel of corn a farmer could grow—and American farmers pushed to go flat out could grow a hell of a lot of corn.

7. THE NAYLOR CURVE

It's not at all clear that very many American farmers know exactly what hit them, even now. The rhetoric of competitiveness and free trade persuaded many of them that cheap corn would be their salvation, and several putative farmers' organizations have bought into the virtues of cheap corn. But since the heyday of corn prices in the early seventies, farm income has steadily declined along with corn prices, forcing millions of farmers deeper into debt and thousands of them into bankruptcy every week. Exports, as a percentage of the American corn harvest, have barely budged from around 20 percent, even as prices have fallen. Iowa State University estimates that it costs roughly \$2.50 to grow a bushel of Iowa corn; in October 2005 Iowa grain elevators were paying \$1.45, so the typical Iowa farmer is selling corn for a dollar less than it costs him to grow it. Yet the corn keeps coming, more of it every year.

How can this possibly be?

George Naylor has studied this question, and he has come up with a convincing answer. He's often asked to speak at meetings on the farm crisis, and to testify at hearings about farm policy, where he often presents a graph he's drawn to explain the mystery: He calls it the Naylor Curve. ("Remember the Laffer curve? Well, this one looks a little like that one, only it's true.") Basically it purports to show why falling farm prices force farmers to increase production in defiance of all rational economic behavior.

"Farmers facing lower prices have only one option if they want to be able to maintain their standard of living, pay their bills, and service their debt, and that is to produce more." A farm family needs a certain amount of cash flow every year to support itself, and if the price of corn falls, the only way to stay even is to sell more corn. Naylor says that farmers desperate to boost yield end up degrading their land, plowing and planting marginal land, applying more nitrogen—anything to squeeze a few more bushels from the soil. Yet the more bushels each farmer produces, the lower prices go, giving another turn to the perverse spiral of overproduction. Even so, corn farmers persist in measuring their success in bushels per acre, a measurement that improves even as they go broke.

"The free market has never worked in agriculture and it never will.

The economics of a family farm are very different than a firm's: When prices fall, the firm can layoff people, idle factories, and make fewer widgets. Eventually the market finds a new balance between supply and demand. But the demand for food isn't elastic; people don't eat more just because food is cheap. And laying off farmers doesn't help to reduce supply—You can fire me, but you can't fire my land, because some other farmer who needs more cash flow or thinks he's more efficient than I am will come in and farm it. Even if! go out of business this land will keep producing corn."

But why corn and not something else? "We're on the bottom rung of the industrial food chain here, using this land to produce energy and protein, mostly to feed animals. Corn is the most efficient way to produce energy, soybeans the most efficient way to produce protein." The notion of switching to some other crop Naylor gruffly dismisses. "What am I going to grow here, broccoli? Lettuce? We've got a long-term investment in growing corn and soybeans; the elevator is the only buyer in town, and the elevator only pays me for corn and soybeans. The market is telling me to grow corn and soybeans, period." As is the government, which calculates his various subsidy payments based on his yield of corn.

So the plague of cheap corn goes on, impoverishing farmers (both here and in the countries to which we export it), degrading the land, polluting the water, and bleeding the federal treasury, which now spends up to \$5 billion a year subsidizing cheap corn. But though those subsidy checks go to the farmer (and represents nearly half of net farm income today), what the Treasury is really subsidizing are the buyers of all that cheap corn. "Agriculture's always going to be organized by the government; the question is, organized for whose benefit? Now it's for Cargill and Coca-Cola. It's certainly not for the farmer."

Early that afternoon, after George and I had been talking agricultural policy for longer than I ever thought possible, the phone rang; his neighbor, Billy, needed a hand with a balky corn

planter. On the drive over Naylor told me a little about Billy. "He's got all the latest toys: the twelve-row planter, Roundup Ready seed, the new John Deere combine." George rolled his eyes. "Billy's in debt up to his eyeballs." George believes he's managed to survive on the farm by steering clear of debt, nursing along his antique combine and tractor, and avoiding the trap of expansion.

A blockish fellow in his fifties, with a seed cap perched over a graying crew cut, Billy seemed cheerful enough, especially considering he'd just blown his morning fiddling with a broken tractor cable. While he and George were working on it I checked out the shed full of state-of-the-art farm equipment and asked him what he thought about the corn he was planting—corn genetically engineered to produce its own pesticide. Billy thought the seed was the greatest. "I'm getting 220 bushels an acre on that seed," he boasted. "How's that compare, George?"

George owned he was getting something just south of two hundred, but he was too polite to say what he knew, which was that he was almost certainly clearing more money per acre growing less corn more cheaply. But in Iowa, bragging rights go to the man with the biggest yield, even if it's bankrupting him.

In a shed across the way I noticed the shiny chrome prow of a tractor trailer poking out and asked Billy about it. He explained he'd had to take on long—distance hauling work to keep the farm afloat. "Have to drive the big rig to pay for all my farm toys," he chuckled.

George tossed me a look, as if to say, kind of pathetic, isn't it?

Poignant seemed more like it, to think what this farmer had to do to hold on to his farm. I was reminded of Thoreau's line: "Men have become the tools of their tools." And I wondered if Billy gave much thought, in those late-night hours rolling up the miles on Interstate 80, to how he got to this point, and about who he was really working for now. The bank? John Deere? Monsanto? Pioneer? Cargill? Two hundred and twenty bushels of corn is an astounding accomplishment, yet it didn't do Billy nearly as much good as it did those companies.

And then of course there's the corn itself, which if corn could form an opinion would surely marvel at the absurdity of it all—and at its great good fortune. For corn has been exempted from the usual rules of nature and economics, both of which have rough mechanisms to check any such wild, uncontrolled proliferation. In nature, the population of a species explodes until it exhausts its supply of food; then it crashes. In the market, an oversupply of a commodity depresses prices until the surplus is either consumed or it no longer makes sense to produce any more of it. In corn's case, humans have labored mightily to free it from either constraint, even if that means going broke growing it, and consuming it just as fast as we possibly can.