corn a day and reaches a weight of twelve hundred pounds, he will have consumed in his lifetime the equivalent of thirty-five gallons of oil—nearly a barrel.

So this is what commodity corn can do to a cow: industrialize the miracle of nature that is a ruminant, taking this sunlight- and prairie grass-powered organism and turning it into the last thing we need: another fossil fuel machine. This one, however, is able to suffer.

Standing there in the pen alongside my steer, I couldn't imagine ever wanting to eat the flesh of one of these protein machines. Hungry was the last thing I felt.Yet I'm sure that after enough time goes by, and the stink of this place is gone from my nostrils, I will eat feedlot beef again. Eating industrial meat takes an almost heroic act of not knowing or, now, forgetting. But I left Poky determined to follow this meat to a meal on a table somewhere, to see this food chain at least that far. I was curious to know what feedlot beef would taste like now, if I could taste the corn or even, since taste is as much a matter of what's in the head as it is about molecules dancing on the tongue, some hint of the petroleum. "You are what you eat" is a truism hard to argue with, and yet it is, as a visit to a feedlot suggests, incomplete, for you are what what you eat eats, too. And what we are, or have become, is not just meat but number 2 corn and oil.

FIVE

THE PROCESSING PLANT

Making Complex Foods

(18,000 KERNELS)

1. TAKING THE KERNEL APART: THE MILL

One of the truly odd things about the 10 billion bushels of corn harvested each year is how little of it we eat. Sure, we grind some of it to make cornmeal, but most of the corn we eat *as* corn—whether on the cob, flaked, or baked into muffins or tortillas or chips—comes from varieties other than number 2: usually sweet corn or white corn. These uses represent a tiny fraction of the harvest—less than a bushel per person per year—which is probably why we don't think of ourselves as big corn eaters. And yet each of us is personally responsible for consuming a ton of the stuff every year.

Much of the rest of that per capita ton does enter our bodies, but not before it has been heavily processed, broken down into simple compounds either by animals like steer 534 or a processing plant, and then reassembled either as beef, chicken, or pork, or as soft drinks, breakfast cereals, or snacks. What doesn't pass through the gut of a food animal to become meat will pass through one of America's twenty-five

"wet mills" on its way to becoming one of the innumerable products food science has figured out how to tease from a kernel of corn. (These mills are called wet to distinguish them from the traditional mills where corn is simply ground into dry meal for things like tortillas.)

About a fifth of the corn river flowing out from the elevators at the Iowa Farmers Cooperative travels to a wet milling plant, usually by train. There it diverges into a great many slender branching tributaries, only to converge much later on a plate or in a cup. For what the wet mill does to a bushel of corn is to turn it into the building blocks from which companies like General Mills, McDonald's, and Coca-Cola assemble our processed foods.

The first rough breakdown of all that corn begins with the subdivision of the kernel itself: Its yellow skin will be processed into various vitamins and nutritional supplements; the tiny germ (the dark part nearest the cob, which holds the embryo of the potential future corn plant) will be crushed for its oil; and the biggest part, the endosperm, will be plundered for its rich cache of complex carbohydrates.

This oversized packet of starch is corn's most important contribution to the industrial food chain: an abundance of carbohydrate molecules in long chains that chemists have learned to break down and then rearrange into hundreds of different organic compounds—acids, sugars, starches, and alcohols. The names of many of these compounds will be familiar to anyone who's studied the ingredient label on a package of processed food: citric and lactic acid; glucose, fructose, and maltodextrin; ethanol (for alcoholic beverages as well as cars), sorbitol, mannitol, and xanthan gum; modified and unmodified starches; as well as dextrins and cyclodextrins and MSG, to name only a few.

To watch the stream of corn coming off of George Naylor's farm proceed to divide, subdivide, and ultimately branch off into a molecule of fructose destined to sweeten a soda is not as easy as following it to a feedlot into a cut of meat. For one thing, the two companies who wet mill most of America's corn (Cargill and ADM) declined to let me watch them do it. For another, the process is largely invisible, since it takes place inside a series of sealed vats, pipes, fermentation tanks, and filters. Even so, I would have liked to follow my bushel of corn through ADM's plant in Decatur, Illinois (the unofficial capital of corn processing in America), or to Cargill's mill in Iowa City (the likely destination of the train I saw being loaded at the elevator in Farnhamville), but the industrial food chain goes underground, in effect, as it passes through these factories on its path to our plates.

The closest I got to following corn through a mill was at the Center for Crops Utilization Research at Iowa State University, in Ames, forty-five miles from the farmers cooperative elevator in Farnhamville. After my visit to George Naylor's farm, I spent a couple of days on the Ames campus, which really should be called the University of Corn. Corn is the hero of the most prominent sculptures and murals on campus, and the work of the institution is dedicated in large part to the genetics, culture, history, and uses of this plant, though the soybean, Iowa's second crop, gets its share of attention too. The Center for Crops Utilization Research is charged with developing new uses for America's corn and soybean surplus, and to this end operates a scaled-down wet milling operation, a Rube Goldberg contraption of stainless steel tubes, pipes, valves, vents, drying tables, centrifuges, filters, and tanks that Larry Johnson, the center's director, was more than happy to show me.

To hear Johnson describe it, the wet milling process is essentially an industrial version of digestion: A food is broken down through a series of steps that includes the application of physical pressure, acids, and enzymes. The order of the steps is different in industrial digestion—the acids come before the mechanical chewing, for instance—but the results are much the same: A complex food is reduced to simple molecules, mostly sugars.

"First we separate the corn into its botanical parts—embryo, endosperm, fiber—and then into its chemical parts," Johnson explained as we began our tour of the plant. When a shipment of corn arrives at the mill, it is steeped for thirty-six hours in a bath of water containing a small amount of sulphur dioxide. The acid bath swells the kernels and frees the starch from the proteins that surround it.

After the soak, the swollen kernels are ground in a mill. "By now the

germ is rubbery and it pops right off," Johnson explained. "We take the slurry to a hydroclone"—basically a centrifuge for liquids—"where the germ floats off. After it's dried, we squeeze it for corn oil." Corn oil can be used as a cooking or salad oil, or hydrogenated for use in margarine and other processed foods: Atoms of hydrogen are forced into the fat molecules to make them solid at room temperature. (Though originally designed as a healthy substitute for animal fats, medical researchers now think these trans fats are actually worse for our arteries than butter.)

Once the germ has been removed and the kernels crushed, what's left is a white mush of protein and starch called "mill starch." To draw off as much of the protein as possible, the mill starch undergoes a progressively finer series of grindings and filterings and centrifuges. The extracted protein, called gluten, is used in animal feed. At each step more fresh water is added—it takes about five gallons to process a bushel of corn, and prodigious amounts of energy. Wet milling is an energy-intensive way to make food; for every calorie of processed food it produces, another ten calories of fossil fuel energy are burned.

At this point the process has yielded a white slurry that's poured out onto a stainless steel table and dried to a fine, superwhite powder—cornstarch. Cornstarch comprised wet milling's sole product when the industry got its start in the 1840s. At first the laundry business was its biggest customer, but cooks and early food processors soon began adding cornstarch to as many recipes as they could: It offered the glamour of modernity, purity, and absolute whiteness. By 1866, corn refiners had learned how to use acids to break down cornstarch into glucose, and sweeteners quickly became—as they remain today—the industry's most important product. Corn syrup (which is mostly glucose or dextrose—the terms are interchangeable) became the first cheap domestic substitute for cane sugar.

I remember an elementary school science experiment in which we were instructed to chew—and chew and chew—a cracker until the slurry of starch turned suddenly sweet on our tongues.The teacher explained that the enzymes in our saliva had broken the long starch molecules into shorter molecules of glucose. Much the same process—it's called "enzyme hydrolysis"—revolutionized corn refining in the 1940s. As enzymes replaced acids, refiners were able to produce progressively sweeter sweeteners from corn. Yet none were quite as sweet as sugar (or, to be more precise, sucrose). That threshold wasn't crossed until the late 1960s, when Japanese chemists "broke the sweetness barrier," in the words of the Corn Refiners Association's official history of high-fructose corn sweetener. They discovered that an enzyme called glucose isomerase could transform glucose into the much sweeter sugar molecule called fructose. By the 1970s the process of refining corn into fructose had been perfected, and high-fructose corn syrup—which is a blend of 55 percent fructose and 45 percent glucose that tastes exactly as sweet as sucrose—came onto the market. Today it is the most valuable food product refined from corn, accounting for 530 million bushels every year. (A bushel of corn yields thirty-three pounds of fructose.)

But if the pipe marked "HFCS" leads to the fattest spigot at the far end of a corn refinery's bewildering tangle of pipes and valves, it is by no means the only spigot you'll find back there. There are dozens of other "output streams." At various points along its way through the mill some portion of the thick white slurry of starch is diverted to another purpose or, in the refiner's jargon, another "fraction." The starch itself is capable of being modified into spherical, crystalline, or highly branched molecules, each suitable for a different use: adhesives, coatings, sizings, and plastics for industry; stabilizers, thickeners, gels, and "viscosity-control agents" for food.

What remains in the slurry is "saccharified"—treated with enzymes that turn it into dextrose syrup. A portion of this dextrose is siphoned off for use as corn syrup; other fractions are recruited to become sugars like maltodextrin and maltose. The largest portion of the corn syrup stream is piped into a tank where it is exposed to glucose isomerase enzymes and then passed through ion exchange filters, emerging eventually as fructose. Now what's left of the dextrose stream is piped into a fermentation tank, where yeasts or amino acids go to work eating the sugars, in several hours yielding an alcoholic brew. This itself is frac-

tionated into various alcohols, ethanol chief among them, our gas tanks being the ultimate destination of a tenth of the corn crop. The fermented brew can also be refined into a dozen different organic and amino acids for use in food processing or the manufacture of plastic.

And then that's about it: There's no corn left, and not much of anything else either, except for some dirty water. (Though even some of this "steep water" is used to make animal feeds.) The primary difference between the industrial digestion of corn and an animal's is that in this case there is virtually no waste at the end of it.

Step back for a moment and behold this great, intricately piped stainless steel beast: This is the supremely adapted creature that has evolved to help eat the vast surplus biomass coming off America's farms, efficiently digesting the millions of bushels of corn fed to it each day by the trainload. Go around back of this beast and you'll see a hundred different spigots, large and small, filling tanker cars of other trains with HFCS, ethanol, syrups, starches, and food additives of every description. The question now is, Who or what (besides our cars) is going to consume and digest all this freshly fractionated biomass—the sugars and starches, the alcohols and acids, the emulsifiers and stabilizers and viscosity-control agents? This is where we come in. It takes a certain kind of eater—an industrial eater—to consume these fractions of corn, and we are, or have evolved into, that supremely adapted creature: the eater of processed food.

2. PUTTING IT BACK TOGETHER AGAIN: PROCESSED FOODS

The dream of liberating food from nature is as old as eating. People began processing food to keep nature from taking it back: What is spoilage, after all, if not nature, operating through her proxy microorganisms, repossessing our hard-won lunch? So we learned to salt and dry and cure and pickle in the first age of food processing, and to can, freeze, and vacuum-pack in the second. These technologies were blessings, freeing people from nature's cycles of abundance and scarcity, as well as from the tyranny of the calendar or locale: Now a New Englander could eat sweet corn, or something reminiscent of it, in January, and taste a pineapple for the first time in his life. As Massimo Montanari, an Italian food historian, points out, the fresh, local, and seasonal food we prize today was for most of human history "a form of slavery," since it left us utterly at the mercy of the local vicissitudes of nature.

Even after people had learned the rudiments of preserving food, however, the dream of liberating food from nature continued to flourish—indeed, to expand in ambition and confidence. In the third age of food processing, which begins with the end of World War II, merely preserving the fruits of nature was deemed too modest: The goal now was to improve on nature. The twentieth-century prestige of technology and convenience combined with advances in marketing to push aside butter to make shelf space for margarine, replace fruit juice with juice drinks and then entirely juice-free drinks like Tang, cheese with Cheez Whiz, and whipped cream with Cool Whip.

Corn, a species that had been a modest beneficiary of the first two ages of food processing (having taken well to the can and the freezer), really came into its own during the third. You would never know it without reading the ingredient label (a literary genre unknown until the third age), but corn is the key constituent of all four of these processed foods. Along with the soybean, its rotational partner in the field, corn has done more than any other species to help the food industry realize the dream of freeing food from nature's limitations and seducing the omnivore into eating more of a single plant than anyone would ever have thought possible.

In fact, you would be hard-pressed to find a late-model processed food that isn't made from corn or soybeans. In the typical formulation, corn supplies the carbohydrates (sugars and starches) and soy the protein; the fat can come from either plant. (Remember what George Naylor said about the real produce of his farm: not corn and soybeans but "energy and protein.") The longer the ingredient label on a food, the more fractions of corn and soybeans you will find in it. They supply the

essential building blocks, and from those two plants (plus a handful of synthetic additives) a food scientist can construct just about any processed food he or she can dream up.

A FBW YEARS AGO, in the days when "food security" meant something very different than it does today, I had the chance to visit one of the small handful of places where this kind of work is done. The Bell Institute, a leafy corporate campus on the outskirts of Minneapolis, is the research-and-development laboratory for General Mills, the sixth-largest food company in the world. Here nine hundred food scientists spend their days designing the future of food—its flavor, texture, and packaging.

Much of their work is highly secretive, but nowhere more so than in the cereals area. Deep in the heart of the heart of the Bell Institute, down in the bowels of the laboratory, you come to a warren of windowless rooms called, rather grandly, the Institute of Cereal Technology. I was permitted to pass through a high-security conference room furnished with a horseshoe-shaped table that had a pair of headphones at every seat. This was the institute's inner sanctum, the cereal situation room, where General Mills executives gather to hear briefings about new products.

The secrecy surrounding the successor to Cocoa Pebbles struck me as laughable, and I said so. But as an executive explained to me, "Recipes are not intellectual property; you can't patent a new cereal. All you can hope for is to have the market to yourself for a few months to establish your brand before a competitor knocks off the product. So we're very careful not to show our hand." For the same reason, the institute operates its own machine shop, wlitre it designs and builds the machines that give breakfast cereals their shapes, making it that much harder for a competitor to knock off, say, a new marshmallow bit shaped to resemble a shooting star. In the interests of secrecy, the food scientists would not talk to me about current projects, only past failures, like the breakthrough cereal in the shapes of little bowling pins

and balls. "In focus group the kids loved it," the product's rueful inventor told me, "but the mothers didn't like the idea of kids bowling their breakfast across the table," Which is why bowling pin cereal never showed up in your supermarket.

In many ways breakfast cereal is the prototypical processed food: four cents' worth of commodity corn (or some other equally cheap grain) transformed into four dollars' worth of processed food. What an alchemy! Yet it is performed straightforwardly enough: by taking several of the output streams issuing from a wet mill (corn meal, corn starch, corn sweetener, as well as a handful of tinier chemical fractions) and then assembling them into an attractively novel form. Further value is added in the form of color and taste, then branding and packaging. Oh yes, and vitamins and minerals, which are added to give the product a sheen of healthfulness and to replace the nutrients that are lost whenever whole foods are processed. On the strength of this alchemy the cereals group generates higher profits for General Mills than any other division. Since the raw materials in processed foods are so abundant and cheap (ADM and Cargill will gladly sell them to all comers) protecting whatever is special about the value you add to them is imperative.

I think it was at General Mills that I first heard the term "food system." Since then, I've seen in the pages of *Food Technology*, the monthly bible of the food-processing industry, that this term seems to be taking over from plain old "food." Food system is glossier and more high-tech than food, I guess; it also escapes some of the negative connotations that got attached to "processed food" during the sixties. It's probably as good a term as any when you're describing, as that magazine routinely does, new edible materials constructed from "textured vegetable protein," or a nutraceutical breakfast cereal so fortified with green tea, grape seed extract, and antioxidants that it's not even called a cereal but a "healthy heart system."

Exactly what corn is doing in such food systems has less to do with nutrition or taste than with economics. For the dream of liberating food from nature, which began as a dream of the eaters (to make it less

perishable), is now primarily a dream of the feeders—of the corporations that sell us our food. No one was clamoring for synthetic cheese, or a cereal shaped like a bowling pin; processed food has become largely a supply-driven business—the business of figuring out clever ways to package and market the glut of commodities coming off the farm and out of the wet mills. Today the great advantages of processing food redound to the processors themselves. For them, nature is foremost a problem—not so much of perishable food (though that's always a concern when your market is global) as of perishable profits.

Like every other food chain, the industrial food chain is rooted at either end in a natural system: the farmer's field at one end, and the human organism at the other. From the capitalist's point of view, both of these systems are less than ideal.

The farm, being vulnerable to the vicissitudes of weather and pests, is prone to crises of over- and underproduction, both of which can hurt business. Rising raw material prices cut into profits, obviously enough. Yet the potential boon of falling raw material prices—which should allow you to sell a lot more of your product at a lower price—can't be realized in the case of food because of the special nature of your consumer, who can eat only so much food, no matter how cheap it gets. (Food industry executives used to call this the problem of the "fixed stomach"; economists speak of "inelastic demand.") Nature has cursed the companies working the middle of the food chain with a recipe for falling rates of profits.

The growth of the American food industry will always bump up against this troublesome biological fact: Try as we might, each of us can eat only about fifteen hundred pounds of food a year. Unlike many other products—CDs, say, or shoes-—there's a natural limit to how much food we can each consume without exploding. What this means for the food industry is that its natural rate of growth is somewhere around 1 percent per year—1 percent being the annual growth rate of the American population. The problem is that Wall Street won't tolerate such an anemic rate of growth.

This leaves companies like General Mills and McDonald's with two options if they hope to grow faster than the population: figure out how to get people to spend more money for the same three-quarters of a ton of food, or entice them to actually eat more than that. The two strategies are not mutually exclusive, of course, and the food industry energetically pursues them both at the same time. Which is good news indeed for the hero of our story, for it happens that turning cheap corn into complex food systems is an excellent way to achieve both goals.

BUILDING PROCESSED FOOD out of a commodity like corn doesn't completely cushion you from the vicissitudes of nature, but it comes close. The more complex your food system, the more you can practice "substitutionism" without altering the taste or appearance of the product. So if the price of hydrogenated fat or lecithin derived from corn spikes one day, you simply switch to fat or lecithin from soy, and the consumer will never know the difference. (This is why ingredient labels says things like "Contains one or more of the following: corn, soybean, or sunflower oil.") As a management consultant once advised his food industry clients, "The further a product's identity moves from a specific raw material—that is, the more processing steps involved—the less vulnerable is its processor" to the variability of nature.

In fact, there are lots of good reasons to complicate your product—or, as the industry prefers to say, to "add value" to it. Processing food can add months, even years, to its shelf life, allowing you to market globally. Complicating your product also allows you to capture more of the money a consumer spends on food. Of a dollar spent on a whole food such as eggs, $0.40 finds its way back to the farmer. By comparison, George Naylor will see only $0.04 of every dollar spent on corn sweeteners; ADM and Coca-Cola and General Mills capture most of the rest. (Every farmer I've ever met eventually gets around to telling the story about the food industry executive who declared, "There's money to be made in food, unless you're trying to grow it.") When Tyson food scientists devised the chicken nugget in 1983, a cheap bulk commodity—chicken—overnight became a high-value-added product, and most of

the money Americans spend on chicken moved from the farmer's pocket to the processor's.

As Tyson understood, you want to be selling something more than a commodity, something more like a service: novelty, convenience, status, fortification, lately even medicine. The problem is, a value-added product made from a cheap commodity can itself become a commodity, so cheap and abundant are the raw materials. That lesson runs straight through the history of a company like General Mills, which started out in 1926 as a mill selling whole wheat flour: ground wheat. When that product became a cheap commodity, the company kept ahead of the competition by processing the grain a bit more, creating bleached and then "enriched" flour. Now they were adding value, selling not just wheat but an idea of purity and health, too. In time, however, even enriched white flour became a commodity, so General Mills took another step away from nature—from the farm and the plants in question—by inventing cake mixes and sweetened breakfast cereals. Now they were selling convenience, with a side of grain and corn sweetener, and today they're beginning to sell cereals that sound an awful lot like medicines. And so it goes, the rushing stream of ever cheaper agricultural commodities driving food companies to figure out new and ever more elaborate ways to add value and so induce us to buy more.

When I was in Minneapolis I spoke to a General Mills vice president who was launching a new line of organic TV dinners, a product that at first blush sounded like an oxymoron. The ingredient list went on forever, brimming with additives and obscure fractions of corn: maltodextrin, corn starch, xanthan gum. It seems that even organic food has succumbed to the economic logic of processing. The executive patiently explained that selling unprocessed or minimally processed whole foods will always be a fool's game, since the price of agricultural commodities tends to fall over time, whether they're organic or not. More food coming off the farm leads to either falling profits—or more processing.

The other problem with selling whole foods, he explained, is that it will always be hard to distinguish one company's corn or chickens or apples from any other company's. It makes much more sense to turn

the corn into a brand-name cereal, the chicken into a TV dinner, and the apples into a component in a nutraceutical food system.

This last is precisely what one company profiled in a recent issue of *Food Technology* has done. TreeTop has developed a "low-moisture, naturally sweetened apple piece infused with a red-wine extract." Just eighteen grams of these apple pieces have the same amount of cancer-fighting "flavonoid phenols as five glasses of wine and the dietary fiber equivalent of one whole apple." Remember the sixties dream of an entire meal served in a pill, like the Jetsons? We've apparently moved from the meal-in-a-pill to the pill-in-a-meal, which is to say, not very far at all. Either way, the message is: We need food scientists to feed us. Of course, it was fortified breakfast cereal that first showed the way, by supplying more vitamins and minerals than any mere grain could hope to. Nature, these products implied, was no match for food science.

The news of TreeTop's breakthrough came in a recent *Food Technology* trend story titled "Getting More Fruits and Vegetables into Food." I had thought fruits and vegetables were already foods, and so didn't need to be gotten into them, but I guess that just shows I'm stuck in the food past. Evidently we're moving into the fourth age of food processing, in which the processed food will be infinitely better (i.e., contain more of whatever science has determined to be the good stuff) than the whole foods on which they're based. The food industry has gazed upon nature and found it wanting—and has gotten to work improving it.

Back in the seventies, a New York food additive manufacturer called International Flavors & Fragrances used its annual report to defend itself against the rising threat of "natural foods" and explain why we were better off eating synthetics. Natural ingredients, the company pointed out rather scarily, are a "wild mixture of substances created by plants and animals for completely non-food purposes—their survival and reproduction." These dubious substances "came to be consumed by humans at their own risk."

Now, thanks to the ingenuity of modern food science, we had a choice. We could eat things designed by humans for the express purpose of being eaten by people—or eat "substances" designed by natu-

ral selection for its own purposes: to, say, snooker a bee or lift a wing or (eek!) make a baby. The meal of the future would be fabricated "in the laboratory out of a wide variety of materials," as one food historian wrote in 1973, including not only algae and fungi but also petrochemicals. Protein would be extracted directly from petroleum and then "spun and woven into 'animal' muscle—long, wrist-thick tubes of'filet steak.'" (Come to think of it, agribusiness has long since mastered this trick of turning petroleum into steak, though it still needs corn and cattle to do it.)

All that's really changed since the high-tech food future of the sixties is that the laboratory materials out of which these meals will be constructed are nominally natural—the relative prestige of nature and modern chemistry having traded places in the years since the rise of environmentalism. And besides, why go to the trouble and expense of manufacturing food from petroleum when there is such a flood of cheap carbon coming off the farm? So instead of creating foods whole cloth from completely synthetic materials, the industry is building them from fortified apple bits, red-wine extract, flavor fractions derived from oranges, isoflavones from soy, meat substitutes fashioned from mycoprotein, and resistant starches derived from corn. ("Natural raspberry flavor" doesn't mean the flavor came from a raspberry; it may well have been derived from corn, just not from something synthetic.) But the underlying reductionist premise—that a food is nothing more than the sum of its nutrients—remains undisturbed. So we break down the plants and animals into their component parts and then reassemble them into high-value-added food systems.The omnivore's predilection to eat a variety of species is tricked by this protean plant, and even the biological limit on his appetite is overcome.

Resistant starch, the last novelty on that list of ingredients, has the corn refiners particularly excited today. They've figured out how to tease a new starch from corn that is virtually indigestible. You would not think this is a particularly good thing for a food to be, unless of course your goal is to somehow get around the biological limit on how much each of us can eat in a year. Since the body can't break down resistant starch, it slips through the digestive track without ever turning into calories of glucose—a particular boon, we're told, for diabetics. When fake sugars and fake fats are joined by fake starches, the food industry will at long last have overcome the dilemma of the fixed stomach: whole meals you can eat as often or as much of as you like, since this food will leave no trace. Meet the ultimate—the utterly elastic!—industrial eater.

FOURTEEN

THE MEAL

Grass *Fed*

Before I left the farm Friday, 1 gathered together the makings for that evening's dinner, which I'd arranged to cook for some old friends who lived in Charlottesville. I had originally thought about filling a cooler with Polyface meat and bringing it home with me to California to cook there, but decided it would be more in keeping with the whole local food chain concept to eat this particular meal within a leisurely drive of the farm where it had been grown. After all, it was the sin of flying meat across the country that had brought me to Swoope in the first place, and I hated for Joel to think that an entire week of his instruction had left me unimproved.

From the walk-in, I picked out two of the chickens we had slaughtered on Wednesday and a dozen of the eggs I'd helped gather Thursday evening. I also stopped by the hoop house and harvested a dozen ears of sweet corn. (In consideration of my week's labors, Joel refused to accept payment for the food, but had I paid for it, the chicken would have cost $2.05 a pound, and the eggs $2.20 a dozen—prices that compare very favorably with Whole Foods's. This is not boutique food.)

On the way into Charlottesville, I stopped to pick up a few other ingredients, trying as best as I could to look for local produce and preserve the bar code virginity of this meal. For my salad, I found some nice-looking locally grown rocket. At the wine shop I found a short, chauvinistic shelf of Virginia wines, but here I hesitated. How far could I take this local conceit before it ruined my meal? I hadn't had a sip of wine all week and was really looking forward to a decent one. I'd read somewhere that wine-making in Virginia was "coming into its own," but isn't that what they always say? Then I spotted a Viognier for twenty-five bucks—the priciest Virginia wine I'd ever seen. I took this as a sign of genuine confidence on somebody's part, and added the bottle to my cart.

I also needed some chocolate for the dessert I had in mind. Fortunately the state of Virginia produces no chocolate to speak of, so I was free to go for the good Belgian stuff, panglessly. In fact, even the most fervent eat-local types say it's okay for a "foodshed" (a term for a regional food chain, meant to liken it to a watershed) to trade for goods it can't produce locally—coffee, tea, sugar, chocolate—a practice that predates the globalization of our food chain by a few thousand years. (Whew . . .)

During the week I'd given some thought to what I should make; the farm's varied offerings certainly gave me plenty of choices. Working backward, I knew I wanted to make a dessert that would prominently feature Polyface eggs, having heard so much from the chefs about their magical properties. A chocolate souffle, since it calls for a certain degree of magic, seemed the obvious choice. For a side dish, sweet corn was a no-brainer; there'd be kids at the table and no one had tasted corn yet this summer. But what meat to serve? Because it was only June, Polyface had no fresh beef or pork or turkey; Joel wouldn't begin slaughtering beeves and turkeys till later in the summer, hogs not till the fall. There was frozen beef and pork in the walk-in, last season's, but I preferred to make something fresh. Rabbit seemed risky; I had no idea whether Mark and Liz liked it, and the chances that their boys would eat bunny were slim. So that had left chicken, the animal with which I'd been

most intimate this week. Which, truth to tell, left me feeling vaguely queasy. Was I going to be able to enjoy eating chicken so soon after my stint in the processing shed and gut-composting pile?

That queasiness perhaps explains the multistep preparation I finally settled on. When I got to Mark and Liz's house, there were still several hours before dinner, which meant there was enough time for me to brine the chicken. So I cut each of the two birds into eight pieces and immersed them in a bath consisting of water, kosher salt, sugar, a bay leaf, a splash of soy sauce, a garlic clove, and a small handful of peppercorns and coriander seeds. My plan was to slow roast the chicken pieces on a wood fire, and brining—which causes meat to absorb moisture and breaks down the proteins that can toughen it on the grill—would keep the chicken from drying out.

But the brining (like the carving of the birds into pieces) promised to do something else, too, something for me as much as the meat: It would put a little distance between the meal and Wednesday's kill, certain aromas of which were still lodged in my nostrils. One of the reasons we cook meat (besides making it tastier and easier to digest) is to civilize, or sublimate, what is at bottom a fairly brutal transaction between animals. The anthropologist Claude Levi-Strauss described the work of civilization as the process of transforming the raw into the cooked—nature into culture. For these particular chickens, which I had personally helped to kill and eviscerate, the brining would make a start on that transformation even before the cooking fire was lit. Both literally and metaphorically, a saltwater bath cleanses meat, which perhaps explains why the kosher laws—one culture's way of coming to terms with the killing and eating of animals—insist on the salting of meat.

After a few hours, I removed and rinsed the chicken pieces, and then spread them out to dry for an hour or two, so that the skin, now slightly waterlogged, would brown nicely. Since Mark and Liz had a gas barbecue, I'd have to simulate my wood fire. So I snipped a couple of twigs off their apple tree, stripped the leaves, and placed the twigs on top of the grill, where the green wood would smolder rather than burn. I turned the gas down low and, after rubbing a little olive oil on the chicken pieces, arranged them on the grill among the apple branches, leaving some room to add the corn later.

While the chicken roasted slowly outside, I got to work in the kitchen preparing the souffle with Willie, Mark and Liz's twelve-year-old. While Willie melted the chocolate in a saucepan, I separated the eggs. The yolks were a gorgeous carroty shade of orange and they did seem to possess an unusual integrity; separating them from the whites was a cinch. After adding a pinch of salt, I began beating the egg whites; within minutes they turned from translucent to bright white and formed soft, rounded peaks, which is when Julia Child says to begin adding sugar, and to turn the beater on high. Now the egg whites rapidly doubled in volume, then doubled again, as billions of microscopic air pockets formed amid the stiffening egg proteins. When the heat of the oven caused these air pockets to expand, the souffle would rise, assuming everything went according to plan. Once the egg whites formed a stiff, spiky snowscape, I stopped. Willie had already blended the yolks into his melted chocolate, so we now gently folded that thick syrup into my egg whites, then poured the airy, toast-colored mixture into a souffle dish and put it aside. I could see why pastry chefs in Charlottesville swore by Polyface eggs: What Joel had called their "muscle tone" made baking with them a breeze.

Willie and I brought the corn out on the deck to shuck. The ears were so fresh that the husks squealed as you peeled them back. I mentioned to Willie that our entire meal would be a celebration of the chicken—not only the eponymous entree, which we could smell sweetly roasting on the grill, but the souffle with its half-dozen eggs, and even this corn, which I explained had grown in a deep bed of composted chicken manure. Probably not the sort of detail you'd want to mention on a menu, but Willie agreed there was something pretty neat about the alchemy involved, how a plant could transform chicken crap into something as sweet and tasty and golden as an ear of corn.

Golden Bantam, the corn in question, is an heirloom variety introduced in 1902, long before the hybridizers figured out how to amp up the sweetness in sweet corn. This momentous change in the genetics of

our corn is an artifact of an industrial food chain, which demands that vegetables be able to endure a cross-country road trip after picking so that they might be available everywhere the year round. This was a particular problem for corn, the sugars of which begin turning to starch the moment it is picked. So in the early sixties the breeders figured out a way to breed in extra copies of the genes responsible for producing sugars. But something was lost in the translation from local to cosmopolitan corn: The kernels lost much of their creaminess, and the specific taste of corn was overwhelmed by a generic, one-dimensional sweetness. The needs of a long industrial food chain might justify such a trade-off, but when you can eat corn picked a few hours before dinner, there's no reason for it. Unless of course an industrial diet of easy sugars has dulled your taste for the earthy sweetness of corn, now that it has to compete with things like soda.

I HAD MADE pretty much the same meal on several occasions at home, using the same basic foodstuffs, yet in certain invisible ways this wasn't the same food at all. Apart from the high color of the egg yolks, these eggs looked pretty much like any other eggs, the chicken like chicken, but the fact that the animals in question had spent their lives outdoors on pastures rather than in a shed eating grain distinguished their flesh and eggs in important, measurable ways. A growing body of scientific research indicates that pasture substantially changes the nutritional profile of chicken and eggs, as well as of beef and milk. The question we asked about organic food—is it any better than the conventional kind?—turns out to be much easier to answer in the case of grass-farmed food.

Perhaps not surprisingly, the large quantities of beta-carotene, vitamin E, and folic acid present in green grass find their way into the flesh of the animals that eat that grass. (It's the carotenoids that give these egg yolks their carroty color.) That flesh will also have considerably less fat in it than the flesh of animals fed exclusively on grain—also no surprise, in light of what we know about diets high in carbohydrates. (And

about exercise, something pastured animals actually get.) But all fats are not created equal—polyunsaturated fats are better for us than saturated ones, and certain unsaturated fats are better than others. As it turns out, the fats created in the flesh of grass eaters are the best kind for us to eat.

This is no accident. Taking the long view of human nutrition, we evolved to eat the sort of foods available to hunter-gatherers, most of whose genes we've inherited and whose bodies we still (more or less) inhabit. Humans have had less than ten thousand years—an evolutionary blink—to accustom our bodies to agricultural food, and as far as our bodies are concerned, industrial agricultural food—a diet based largely on a small handful of staple grains, like corn—is still a biological novelty. Animals raised outdoors on grass have a diet much more like that of the wild animals humans have been eating at least since the Paleolithic era than that of the grain-fed animals we only recently began to eat.

So it makes evolutionary sense that pastured meats, the nutritional profile of which closely resembles that of wild game, would be better for us. Grass-fed meat, milk, and eggs contain less total fat and less saturated fats than the same foods from grain-fed animals. Pastured animals also contain conjugated linoleic acid (CLA), a fatty acid that some recent studies indicate may help reduce weight and prevent cancer, and which is absent from feedlot animals. But perhaps most important, meat, eggs, and milk from pastured animals also contain higher levels of omega-3s, essential fatty acids created in the cells of green plants and algae that play an indispensable role in human health, and especially in the growth and health of neurons—brain cells. (It's important to note that fish contain higher levels of the most valuable omega-3 s than land animals, yet grass-fed animals do offer significant amounts of such important omega-3s as alpha linolenic acid—ALA.) Much research into the role of omega-3 s in the human diet remains to be done, but the preliminary findings are suggestive: Researchers report that pregnant women who receive supplements of omega-3 s give birth to babies with higher IQs; children with diets low in omega-3 s exhibit more behavioral and learning problems at school; and puppies eating diets high

in omega-3 s prove easier to train. (All these claims come from papers presented at a 2004 meeting of the International Society for the Study of Fatty Acids and Lipids.)

One of the most important yet unnoticed changes to the human diet in modern times has been in the ratio between omega-3 and omega-6, the other essential fatty acid in our food. Omega-6 is produced in the seeds of plants; omega-3 in the leaves. As the name indicates, both kinds of fat are essential, but problems arise when they fall out of balance. (In fact, there's research to suggest that the ratio of these fats in our diet may be more important than the amounts.) Too high a ratio of omega-6 to omega-3 can contribute to heart disease, probably because omega-6 helps blood clot, while omega-3 helps it flow. (Omega-6 is an inflammatory; omega-3 an anti-inflammatory.) As our diet—and the diet of the animals we eat—shifted from one based on green plants to one based on grain (from grass to corn), the ratio of omega-6 to omega-3 has gone from roughly one to one (in the diet of hunter-gatherers) to more than ten to one. (The process of hydrogenating oil also eliminates omega-3s.) We may one day come to regard this shift as one of the most deleterious dietary changes wrought by the industrialization of our food chain. It was a change we never noticed, since the importance of omega-3s was not recognized until the 1970s. As in the case of our imperfect knowledge of soil, the limits of our knowledge of nutrition have obscured what the industrialization of the food chain is doing to our health. But changes in the composition of fats in our diet may account for many of the diseases of civilization—cardiac, diabetes, obesity, etc.—that have long been linked to modern eating habits, as well as for learning and behavioral problems in children and depression in adults.

Research in this area promises to turn a lot of conventional nutritional thinking on its head. It suggests, for example, that the problem with eating red meat—long associated with cardiovascular disease—may owe less to the animal in question than to that animal's diet. (This might explain why there are hunter-gatherer populations today who eat far more red meat than we do without suffering the cardiovascular consequences.) These days farmed salmon are being fed like feedlot cattie, on grain, with the predictable result that their omega-3 levels fall well below those of wild fish. (Wild fish have especially high levels of omega-3 because the fat concentrates as it moves up the food chain from the algae and phytoplankton that create it.) Conventional nutritional wisdom holds that salmon is automatically better for us than beef, but that judgment assumes the beef has been grain fed and the salmon krill fed; if the steer is fattened on grass and the salmon on grain, we might actually be better off eating the beef. (Grass-finished beef has a two-to-one ratio of omega-6 to -3 compared to more than ten to one in corn-fed beef.) The species of animal you eat may matter less than what the animal you're eating has itself eaten.

The fact that the nutritional quality of a given food (and of that food's food) can vary not just in degree but in kind throws a big wrench into an industrial food chain, the very premise of which is that beef is beef and salmon salmon. It also throws a new light on the whole question of cost, for if quality matters so much more than quantity, then the price of a food may bear little relation to the value of the nutrients in it. If units of omega-3s and beta-carotene and vitamin E are what an egg shopper is really after, then Joel's $2.20 a dozen pastured eggs actually represent a much better deal than the $0.79 a dozen industrial eggs at the supermarket. As long as one egg looks pretty much like another, all the chickens like chicken, and beef beef, the substitution of quantity for quality will go on unnoticed by most consumers, but it is becoming increasingly apparent to anyone with an electron microscope or a mass spectrometer that, truly, this is not the same food.

OKAY, but what about to someone equipped with a more or less standard-issue set of human taste buds? How different does a pastured chicken actually taste? It certainly smelled wonderful when I raised the lid on the barbecue to put the corn on. The chicken was browning nicely, the skin beginning to crisp and take on the toasty tones of oiled wood. The corn, on which I'd rubbed some olive oil and sprinkled salt and pepper, would take only a few minutes—all it needed was to heat

up and for a scattering of kernels to brown. The browning of the chicken skin and the corn looked similar but in fact it owed to completely different chemical reactions, reactions that were contributing to their flavors and smells. The corn was caramelizing, as its sugars broke apart under the heat and formed into hundreds of more complicated aromatic compounds, giving a smoky dimension to the corny sweetness. Meanwhile, the chicken skin was undergoing what chemists called the Maillard reaction, in which carbohydrates in the chicken react in dry heat with certain amino acids to create an even larger and more complicated set of compounds that, because they include atoms of sulfur and nitrogen, give a richer, meatier aroma and taste to the meat than it would otherwise possess. This, at least, is how a chemist would explain what I was seeing and smelling on the grill, as I turned the corn and chicken pieces and felt myself growing hungrier.

While the corn finished roasting, I removed the chicken from the grill and set it aside to rest. A few minutes later I called everyone to the table. Ordinarily I might have felt a little funny serving as both dinner host and guest, but Mark and Liz are such close friends it seemed perfectly natural to be cooking for them in their home. That's not to say I didn't feel the cook's customary preprandial apprehension, compounded in this instance by the fact that Liz herself is such a good cook, and holds very definite opinions about food. I certainly hadn't forgotten the time she'd wrinkled her nose and pushed away a Polyface steak I'd served her. Grass-fed beef is flavored by the pastures it grows on, usually but not always for the best. It had tasted fine to me.

I passed the platters of chicken and corn and proposed a toast. I offered thanks first to my hosts-cum-guests, then to Joel Salatin and his family for growing the food before us (and for giving it to us), and then finally to the chickens, who in one way or another had provided just about everything we were about to eat. My secular version of grace, I suppose, acknowledging the various material and karmic debts incurred by this meal, debts which I felt more keenly than usual.

"At the beginning of the meal," Brillat-Savarin writes in his chapter "On the Pleasures of the Table" in *The Physiology of Taste*, "each guest eats steadily, without speaking or paying attention to anything which may be said." And so we did, aside from a few sublingual murmurs of satisfaction. I don't mind saying the chicken was out of this world. The skin had turned the color of mahogany and the texture of parchment, almost like a Peking duck, and the meat itself was moist, dense, and almost shockingly flavorful. I could taste the brine and apple wood, of course, but also the chicken itself, which more than held its own against those strong flavors. This may not sound like much of a compliment, but to me the chicken smelled and tasted exactly like chicken. Liz voiced her approval in similar terms, pronouncing it a more chickeny chicken. Which is to say, I suppose, that it chimed with that capitalized idea of Chicken we hold in our heads but seldom taste anymore. So what accounted for it? The grass?The grubs? The exercise? I know what Joel would have said: When chickens get to live like chickens, they'll taste like chickens, too.

The flavors of everything else on the table had a similarly declarative quality: the roasted corn and lemony rocket salad, and even the peachy Viognier, all of them tasting almost flamboyantly themselves, their flavors forming a bright sequence of primary colors. There was nothing terribly subtle about this meal, but everything about it tasted completely in character.

Everyone was curious to hear about the farm, especially after tasting the food that had come off it. Matthew, who's fifteen and currently a vegetarian (he confined himself to the corn), had many more questions about killing chickens than I thought it wise to answer at the dinner table. But I did talk about my week on the farm, about the Salatins and their animals. I explained the whole synergistic ballet of chickens and cows and pigs and grass, without getting into specifics about the manure and grubs and composted guts that made the whole dance work. Thankfully all of that, the killing cones, too, had retreated to the mental background for me, chased by the smoky-sweet aromas of the meal, which I found myself able to thoroughly enjoy.

The unexpectedly fine wine helped too, as did the fact that the dinner table conversation drifted off as it will do, from my Paris Hilton ad-

ventures as a farmhand to Willie's songwriting (he is, mark my words, the next Bob Dylan), Matthew's summer football camp, Mark and Liz's books-in-progress, school, politics, war, and on and on, the topics spiraling away from the table like desultory rings of smoke. Being a Friday late in June, this was one of the longest evenings of the year, so no one felt in a rush to finish. Besides, I'd just put the souffle in to bake when we sat down, so dessert was still a ways off.

In his chapter Brillat-Savarin draws a sharp distinction between the pleasures of eating—"the actual and direct sensation of a need being satisfied," a sensation we share with the animals—and the uniquely human "pleasures of the table." These consist of "considered sensations born of the various circumstances of fact, things, and persons accompanying the meal"—and comprise for him one of the brightest fruits of civilization. Every meal we share at a table recapitulates this evolution from nature to culture, as we pass from satisfying our animal appetites in semisilence to the lofting of conversational balloons. The pleasures of the table begin with eating (and specifically with eating meat, in Brillat-Savarin's view, since it was the need to cook and apportion meat that first brought us together to eat), but they can end up anywhere human talk cares to go. In the same way that the raw becomes cooked, eating becomes dining.

All such transformations were very much on my mind that evening, coming at the end of a week of farmwork that had put me in much closer touch with the biology of eating than the art.The line from composting chicken guts to gastronomy is almost unimaginably long, but there is a line. While we talked and waited for the souffle to complete its magic rise, the smell of baking chocolate seeped out of the kitchen and filled the house. When at last I told Willie the time had come to open the oven, cross your fingers, I saw his smile blossom first, then the great crown of souffle puffing out from the cinched white waist of its dish. Triumph!

Here was the most improbable transformation of all. There's something wondrous about any souffle, how a half dozen eggs flavored by nothing more than sugar and chocolate can turn into something so

ethereally Other. Souffle, "to blow," comes from the Latin word for breath, of course, in recognition of the air that a souffle mostly is. But souffle has a spiritual sense, too, as in the breath of life (in English the word "spirit" comes from breath), which seems fitting, for isn't the souffle as close as cookery ever comes to elevating matter into spirit?

This particular souffle was good, not great; its texture was slightly grainier than it should be, which makes me think I may have beaten the eggs a little too long. But it tasted wonderful, everyone agreed, and as I rolled the rich yet weightless confection on my tongue, I closed my eyes and suddenly there they were: Joel's hens, marching down the gangplank from out of their Eggmobile, fanning out across the early morning pasture, there in the grass where this sublime bite began.