Introduction

A NUMBER OF YEARS AGO, I went to the supermarket and bought an overflowing armful of cereal boxes and cookie packages. I'd started writing about the food industry for the *New York Times* not long before, and I'd decided to test whether those expiration dates printed on packages actually meant anything. I'd always wondered what happened to food after the expiration dates passed. Would the cookies turn green or taste like old shoes? Would bugs crawl out of the cereal? I tucked the boxes and crinkly bags away in my kitchen for nearly a year. The dates printed on the packages came and went, and when I opened them, the results were fairly unremarkable: my cereal and cookies looked and tasted perfectly normal, almost as if I'd just bought them.

I started wondering how long other foods would last. My experiment expanded—frozen dinners, kids' lunches, loaves of bread, processed cheese, hot dogs, pudding, and Pop-Tarts. I brought home samples of fast-food burgers, fries, chicken sandwiches, and chicken nuggets. At the time I was working from home, and I had to keep everything out of reach of our two young sons, who were

never able to understand why they couldn't eat just one Oreo or have a taste of a Pop-Tart.

I worried that my work area might succumb to some sort of awful infestation. I pictured fruit flies or those tiny worms that get into the forgotten bag of flour in the back corner of the top cabinet. But none of this happened. Much of my collected food stubbornly refused to decay, even after as many as six years—far beyond expiration dates.

I wondered what had happened to this food to make it so eternal, so unappealing to the mold and bacteria that normally feast on ignored leftovers and baked goods. It seemed to me that the dates printed on the package had little to do with true "expiration." What did those dates actually mean? How was it possible that foods that seemed perfectly edible could be immune to natural processes of decomposition? What were we actually feeding our kids?

Around our house, my experiments were regarded as little more than mildly amusing, sort of weird, and definitely gross. My food collection was a funny little hobby. Until the guacamole incident.

On a Fourth of July trip out of town in 2011, my husband had returned from the grocery store with a tub of "fresh guacamole." "They made an announcement over the loudspeaker that they had just made it over at the deli, so I went and got some," he said proudly.

The container had a haphazardly applied sticker on it, indicating that it very well could have been "made fresh" by one of the store's white-coated deli workers. But there was something unusual about the ingredients: Hass avocados, salt, ascorbic acid, citric acid, xanthan gum, amigum, text-instant, tomatoes, yellow onion, jalapeño, cilantro.

I was knee-deep in research on food additives, but I'd never heard of amigum or text-instant. I went to the store and bought another tub, tucking it into our fridge at home and figuring I'd look into those strange ingredients later. Mostly I forgot about it. Then, nine months later, my mom, who lives with us in Boulder, Colorado, announced she'd tried some of the guacamole. We'd just had a birthday party for one of our boys, and I'd bought some dips from Whole Foods. I hoped that was what she was referring to, but I was pretty sure all of it was gone.

My mom had tried the other guacamole, the Fourth of July stuff, of course. "It was a little spicy," she declared.

My food museum was nauseating, but it had never occurred to me that it could actually sicken anyone. I was concerned because, as an older person, my mom has a higher risk of contracting a life-threatening food-borne illness. Mom assured me everything would be fine; she is nothing if not an unrelenting optimist. Amazingly, though, she was right. Not even an intestinal rumbling. She'd only tried a little, thank God.

Some people probably would have looked at that tub of green goop and not eaten any of it. It was brown around the edges and didn't look particularly fresh. But others might have done exactly what my mom did, and mistaken it for something edible. Even homemade guacamole tends to darken after a few days, and what my mom ate had none of the red flags that help guide us in our decisions about whether or not to consume something. There was no mold and no bad smell.

Like so much of the food we eat today, this immortal guacamole was not what it seemed. It had, in fact, been prepared—or assembled—by those deli workers, but not according to any recipe you'd use at home. It didn't look like a processed food, but that's

exactly what it was. Along with the usual avocados, tomatoes, and onions, this guacamole had corn. Or corn manipulated beyond recognition so that it had been transformed into preservatives you can't taste, smell, or see. And then there was that "text-instant," as well as "amigum"—an ingredient that, I later learned, was even more bizarre than I could have imagined.

And that is the story of so much of our food, it turns out. Although my mother instilled in me a healthy skepticism of processed foods growing up, allowing me very limited access to what she called "gooped-up" food, I had no idea just how tremendously technical our food production had become until my food experiments impelled me to take a closer look. What started as an earnest attempt to understand the true meaning of labeling on the packages of the foods so many of us eat became a larger journey that brought me inside the curious, intricate world of food science and technology, a place where food isn't so much cooked as disassembled and reassembled. Over the last century, such complex modes of production have ushered in a new type of eating, what we call processed food.

Considering our vast and bewildering cornucopia of modern food choices, it's easy to forget that most of the items lining the inner aisles of the supermarket and the substances offered on fast-food menu boards simply didn't exist a century ago. The avalanche of prefabbed, precooked, often portable food into every corner of American society represents the most dramatic nutritional shift in human history. If we really are what we eat, then Americans are a different dietary species from what we were at the turn of the twentieth century. As a population, we ingest double the amount of added fats, half the fiber, 60 percent more added sugars, three and a half times more sodium, and infinitely greater quantities of corn and soybean ingredients than we did in 1909.

The trouble with this wholesale remaking of the American meal is that our human biology is ill equipped to handle it. The way our bodies metabolize food is stuck somewhere in the Stone Age, long before the age of Cheez Whiz, Frosted Flakes, and Classic Chick'N Crisp fried in vegetable oil. Our many novel and high-tech manipulations of food destroy much of its essential geography, resulting in all sorts of unintended consequences. When we start taking food apart and industrially processing it, it often stops making biological sense.

Processed food is even more ubiquitous than we think it is, in part because many products are designed to look as if they're not really processed at all. Subway's "fresh" sandwiches and the center aisles at Whole Foods, for instance, can both be quite perplexing. What are boxes of General Mills's Cascadian Farm's Fruitful O's and Cinnamon Crunch, if not Froot Loops and Cinnamon Toast Crunch by other names? Whole Foods co-founder John Mackey once acknowledged that some of what his stores sell is a "bunch of junk." And Subway's bread is not much more fresh and its meat no more whole than the bags of chips sitting up at the register. In total, some 70 percent of our calories come from this sort of (ultra) processed food. As an industry, this amounts to $850 million a year.

And yet many foods that some might call processed in fact are not. At one point during my research, I attended an industry conference where the keynote discussion sought to tackle the merits of food processing. The example most often cited was pasteurized milk. Thank goodness for food scientists, the argument went, who save Americans from countless outbreaks of campylobacter and *E. coli*. Yes, thank goodness, but pasteurized milk, let's be clear, is not a processed food. Nor are frozen peas, canned beans, washed and boxed spinach, bags of baby carrots, packages of aged cheese, or boxes of raw, frozen ground beef shaped into hamburgers.

At one point in time these products undoubtedly would have been heralded as newfangled creations. But today they barely register on the processing continuum and are not included in that 70 percent figure, which comes from a rigorous analysis done by the Brazilian nutrition scientist Carlos Monteiro. As a general rule—in a universe of tens of thousands of foods, there are always exceptions—a *processed food* is something that could not be made, with the same ingredients, in a home kitchen. Your home kitchen.

I've written this book with the core belief that it's important to understand what we're eating. Some people won't want to know and would rather just keep eating all their favorite foods in peace, and this book isn't for them. But for those who believe in the virtues of a health-promoting diet for themselves and their families, few things are more important to understand than what happens to our food before it gets to our plates—whether it's arrived from the farm reasonably intact or has had a long, multibranched journey through the nutritionally devastating food-processing industrial complex.

The aging guacamole notwithstanding, my mom, who read food labels with a discriminating eye long before it was fashionable, still does her best to avoid "gooped-up" food. She cooks most of what she eats and continues to survey ingredients (although apparently not if the food is already in the fridge). But her diet isn't one of deprivation. She eats meat and dairy and plenty of butter. She's never been lactose-free, sugar-free, caffeine-free, or fat-free. Nor does she have any plans to go gluten-free: the woman eats more bread than anyone. The only organizing principle of her diet is that she predominantly consumes things she would have recognized as food growing up in the thirties in Nova Scotia. She doesn't eat fast food; there was none back then. And she's never owned a microwave; they weren't available until the seventies.

It seems to have worked well for her. In her early eighties, she's in near-perfect health, with no chronic conditions and no prescriptions to fill, something that, if you ask her, she will attribute in no small part to what she eats. "What you put into your body matters, Melanie," she told me more than once while I was in college, eating Pop-Tarts and pizza for dinner. "Just because it's edible doesn't mean it's good for you."

As hard as it was to acknowledge at the time, she was on to something.

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Weird Science

Eight percent of U.S. kids have food allergies. Luckily very little of what they eat is technically food.

—Stephen Colbert

On a swampy day in New Orleans, 15,000 people streamed into the Morial Convention Center, an immense structure on the banks of the Mississippi. Food scientists, chemists, research and development chiefs, marketing executives, salespeople, professors, and students, they wore badges attached to ribbons strung around their necks and hauled around thick packets of information in free shoulder bags festooned with company logos. Old acquaintances greeted one another with backslaps and squeals of delight. For three days in mid-June, the convention center, just upriver from the elegant plantation homes and leafy throughways of the Garden District, hummed with a low roar of chatter.

An annual event since 1940, the Institute of Food Technologists' yearly meeting, known as IFT, is the country's largest and most anticipated gathering in the processed food industry. There are few locations better suited to a celebration of food than New Orleans. The town's luscious aromas are an indelible a part of its character, with New Orleans's contributions to the national diet including crayfish bisque, jambalaya, po' boys, spicy red beans and rice, oysters Rockefeller, shrimp remoulade, trout amandine, and shrimp cooked every which way. These carnal, spicy foods have evolved from a rich brew of diverse populations and prompted the novelist Tom Robbins to write, "The minute you land in New Orleans, something wet and dark leaps on you and starts humping you like a swamp dog in heat, and the only way to get that aspect of New Orleans off you is to eat it off."

There was lots to eat at IFT, but not the standard New Orleans fare. IFT isn't the Fancy Food Show. You'll find no morel mushrooms, Italian fruit vinegar, or Hawaiian honey. And it isn't Aspen's Food & Wine Classic with its melted-cheese master class. Dedicated to the latest advances in food science, it's a conference where the idea of eating seemed to take on a curious notional quality, a place where food isn't plant or animal but a *matrix* or *application*.

The conference opened with a video entitled "Day in the Life of a Food Scientist," featuring both a NASA food scientist talking about how she confects space meals and scientists at Disney making new kids' snacks with cartoon characters. Michael Specter, author of the book *Denialism: How Irrational Thinking Hinders Scientific Progress, Harms the Planet, and Threatens Our Lives,* delivered the keynote address. He spoke about how science—food and otherwise—is often misunderstood by the public. Afterward, a panel discussion explored "Changing the Image of Food Science in the Marketplace."

The conference's main event was held in an immense exposition hall, where nine hundred companies that supply ingredients for processed food had set up booths to showcase their new products. The largest installations featured colorful banners suspended from the ceiling, plush carpets, comfy couches, counters with bar stools, and small kitchens. One company had driven a truck into the hall to serve as its cooking station. Another hung a giant saltshaker from the rafters at an angle, as if it were about to unleash a snowstorm on the crowd below. Along the perimeter, rows of more modest setups extended as far as the eye could see.

As I wandered the floor, I noted strange banners that advertised "cheese application needs" and "emulsified meat systems." A company selling milk powders declared, "At Marron Foods, people eat, sleep, and drink agglomeration." Another firm boasted about "meat enhancement." At one booth, I asked a twenty-something sales rep for a dairy ingredient company whether it was difficult to explain to his friends what he does for a living. "I tell them that I'm building milk backwards," he said, grinning.

It was, I thought, an apt description of the basic blueprint for processed food. The companies in the convention center disassemble food (usually corn, soybeans, wheat, or milk) into hundreds of different ingredients, which manufacturers such as Kraft, Pepsi, General Mills, ConAgra, Tyson, and Sysco then construct into the packaged foods we buy at grocery stores and fast-food restaurants. Some of the ingredients on display were ordinary and familiar—I saw a company selling vanilla extract and another displaying dried fruit. Many others were novel creations designed to perform highly specialized functions: monk fruit extract to replace sugar, specialized yeast extracts to lower salt, algae-based flour to reduce fat.

Many ingredients I'd never envisioned myself eating, but probably have—inner pea fiber, microparticulated whey protein con-

centrate, corn fiber designed to be dissolved into clear beverages. I saw a company selling a substance made from castor oil and added to chocolate to lower costs. A Chinese firm was offering promotional samples of synthetic fruit flavoring. And there was plenty of that old standby, xanthan gum, the slimy coating produced by fermentation of the bacteria *Xanthomonas campestris* with corn syrup.

Although IFT is a conference about processed food, no one who goes there refers to it that way. For those who work in the industry, the term is vague and prosaic, if not pejorative. The term doesn't capture the complexity and breadth of their business. To articulate accurately the sophistication of manufactured food—whether a frozen dinner, package of lunch meat, cereal bar, or Egg McMuffin—a much more precise and technical language is preferred. This opaque vernacular was on display on the convention center's upper level, where a three-day lineup of meetings and panels was under way. Some were accessible to nonscientists, like one entitled "Reducing Sodium in Foods: Implications for Flavor and Health." Others required substantial translation. A dairy-food scientist from a company called TIC Gums gave a talk called "Texturing Alternatives for All-Natural Dairy Products Using Synergistic Hydrocolloids," and a rep from a scientific standards organization held forth on "Developing a Compendial HPLC Procedure for Steviol Glycosides."

Even with superhuman levels of energy, visiting even a fraction of the small city of booths and exhibits would require more than the three full days. At every turn, a smiling person offered a tray of mouthwatering samples or motioned toward a counter lined with treats. Having eaten my way around the floor, I remarked to one of the reps in the IFT pressroom that I was going to cut myself off. "Are you feeling okay?" she asked, a bit worried. I wasn't sure what she meant. "Some of these things are really new and they don't always agree with people. I had some problems last year."

Cheaper Ingredients

I tasted a blueberry muffin baked with something called Flav-R-Bites that were moist and sweet and tasted a lot like blueberries. As I chewed, a sales rep from Cereal Ingredients split open a muffin to show me what his product looked like inside. "Like a lot of food, it's about eye appeal. You want it to look just like blueberries."

Actual berries are quite expensive. Flav-R-Bites consist of flour, sugar, starch, flavorings, and just six percent blueberry solids, but enough so that the word "blueberry" can appear on the label. Such substitutions help keep raw material costs low and ensure an endless and affordable national supply of blueberry muffins, scones, and bagels. The nuggets also have a much longer shelf life; with bona fide blueberries, you get maybe a few days of longevity. Cereal Ingredients had dozens of nuggets on display in every imaginable flavor and color. Lined up in glass jars, they shimmered.

Over at the other end of the expo hall, I wandered into National Starch's installation, one of the show's biggest and most prominent. Founded back in 1890 in Bridgewater, New Jersey, the company provides food starches to customers such as General Mills, Nestlé, Kellogg's, and McDonald's. National Starch's products first ushered in the era of frozen meals in the fifties. Without modified starches, the sauces in TV dinners would have been a goopy, oily mess and the meat dry and rubbery. Today, the company's starches, which are made from corn, tapioca, and potatoes, still add structure to sauces and moisture to meat. They also give yogurts and puddings the sort of thickness you can plant a spoon into, provide frozen food with "freeze-thaw stability," and, perhaps

most important, help lower production costs for food products of all stripes.

These altered starches do this very well, apparently. According to an ambitious campaign National Starch ran a number of years ago, its starches, which were branded with the trademarked name "Starchology," can mimic a variety of more traditional food ingredients. "The tomato is feeling insecure," read one trade magazine ad. "Starchology can squeeze 40% out of vegetable solids. It's tough for the tomato but terrific for you." Another ad targeted manufacturers laboring under the unnecessary burden of buying real butter: "Butter is feeling left out. Starchology can help you replace fat with savings." As an added bonus, these food-simulating starches could be identified on package labels by the everyday, reassuring words "cornstarch" or "flour." There was no need to indicate that these starches had been altered in labs, either by chemicals or through a heating and cooling process. The company explained that "Wholesome, consumer-friendly ingredients enhance your products and give them a 'made-at-home' feel while withstanding typical food processing conditions."

You might think that having a product contain actual tomatoes or real blueberries would be a good thing. But when processed food is concerned, fruits and vegetables cause problems since they contain water, which can cause spoilage or ice crystals when products are frozen—not to mention that these whole-food ingredients are expensive for food manufacturers. All businesses must be mindful of how operating costs affect the bottom line, and food companies may be under a greater burden than most, since American grocery shoppers and fast-food eaters have become deeply attached to the idea of inexpensive food. The amount we pay for our food has declined dramatically over the last six decades, from 20.6 percent of disposable income in 1950 to now 9.8 percent.

This is lower than at any other time in our history and less than any other country. Most food companies dread the idea of raising prices, since it's certain to be followed by some degree of customer defection.

For IFT 2011, National Starch—which merged in 2012 with a starch and high-fructose corn syrup maker named Corn Products and renamed itself Ingredion—had found an ideal food with which to exhibit the cost-cutting benefits of its starch technology: Greek yogurt. Sales of this yogurt, which is thicker and higher in protein than standard varieties, had catapulted to a quarter of all yogurt sales in just four years, taking big manufacturers like Dannon and General Mills, which owns the Yoplait brand, by complete surprise. Everyone was looking to take advantage of this booming market, yet cost was an issue. To develop its characteristic thickness, Greek yogurt must be strained in $10-million machines—one of the reasons that containers of Greek yogurt can cost twice as much as regular yogurt.

To solve this problem, National Starch devised a prototype Greek yogurt that could be manufactured at a fraction of the cost. The cheaper solution, served in clear plastic cups and lined neatly along a counter in the convention hall, was "Greek-style" yogurt made with its Novation Indulge 3340 tapioca starch and milk protein concentrate supplied by another company. The yogurt was topped with berries, or "superfruits," as the industry has taken to calling them, and it was thick and creamy, with a slightly pasty texture. According to my taste buds, it tasted exactly like Greek yogurt. Paul Petersen, National Starch's tall, slim, New Zealand-born global marketing director for texture products, wandered over to ask if I had any questions.

"How's your starch being used in the yogurt? As a thickener?" I asked.

"It's a texturing system," he said. "We don't like to use the term 'thickeners,' since that implies tough and clumpy. It binds with moisture to give that creamy texture people eating Greek yogurt expect."

"But would those people feel shortchanged if they knew they weren't eating real Greek yogurt?" I asked.

Petersen looked at me as if I'd missed the point entirely. "There's no standard or rule of identity for Greek yogurt, so there is no real thing," he said.

He was right. The Food and Drug Administration maintains regulations for what can go into roughly two hundred eighty different foods—rules that don't include newer products like Greek yogurt. There's no standard for Greek yogurt any more than there are regulations for what constitutes a Greek salad. "And don't forget," Petersen said, "this yogurt is going to cost much less than the traditional Greek yogurts."

In fact, it already did. "Greek yogurts" containing National Starch's thickeners and added milk protein concentrate were on the market, and they cost less. Safeway's store brand Lucerne had one, as did Yoplait. However, several months after IFT, a General Mills food scientist told me that this was one cost-cutting move that hadn't quite turned out as hoped. Yoplait Greek yogurt wasn't selling particularly well because customers perceived it to be less authentic than other brands. "The Greek people who work here think it's terrible," she added. The company was considering going back to the drawing board to do actual straining, she said. As of the fall of 2012, General Mills seemed to be still testing the benefits of this new authenticity. Some packages of Yoplait Greek yogurt were made with milk protein concentrate; others weren't.

After finishing my "Greek yogurt," I moved on to National Starch's light cucumber ranch dip, made with their Precisa Cling

20 starch. Petersen explained what was happening here: "You want the dip to cling to the vegetables but not to have the consistency of snot." I tried some. The dip formed a nice, tight ball around my baby carrot, nothing close to a drippy homemade veggie dip situation. I wiggled it a little and, as advertised, the dip clung.

White Powders

I suppose I never realized it would be someone's job to negotiate the fine line between sturdy and snotty veggie dips. Or to measure moisture and fat "cook-out" in hamburgers, as a rep at International Fiber Corporation (IFC) put it. "The demo is amazing," he told me as an enormous poster of a thick hamburger dangled over his head. The company's oat fiber, he explained, helps prevent burgers from shrinking when they're cooked, making them juicier and allowing less meat to be used for that quarter pounder. One of IFC's ingredients—at the time *isolated oat product,* now *cellulose* (made from tree pulp)—is among the purported nonbeef substances in Taco Bell's taco meat that prompted a much-publicized 2011 lawsuit. The suit, which accused Taco Bell of using less than the required level of meat in its tacos, was withdrawn just two months after it was filed. But not before Taco Bell's CEO Greg Creed had a chance to go on *Good Morning America* to talk to George Stephanopoulos, who asked him, "What's an isolated oat product?" Creed was forced to admit he had no idea.

The people who go to IFT every year don't consider any of this as odd. Not even a little. It's their job to sell isolated oat substances and cheaper yogurt ingredients. It's how they pay their mortgages and clothe their families. And beyond that, a lot of people in the food industry quite like their jobs; formulating a new snack bar or frozen dessert can yield the same pleasures as solving a really

challenging puzzle. When I asked one food scientist whether he thought the average person would find IFT perplexing, he replied, "Not everyone can eat fresh vegetables." The world needs processed food, he argued—though he admitted he needed it less than most. He told me he likes to shop at farmer's markets and plants a garden every spring.

Perhaps my most surreal moment at IFT came at a large, circular encampment erected by Tate & Lyle, a $4.3 billion British agribusiness that got its start selling sugar in the 1800s. The company now makes a range of ingredients, including starches and various sugar substitutes, such as Splenda. I walked onto a thick, gray carpet and bellied up to a makeshift bar to sample a small dish of vanilla parfait topped with a single raspberry. A sales rep wearing a seafoam-green shirt emblazoned with a Tate & Lyle logo explained that this parfait was already being sold at some supermarkets as a dip for fruit. She said it was made with two different types of Tate & Lyle's corn-based starches and sweetened with its crystalline fructose, also made from corn. "The starches work as a kind of glue that binds everything together," she explained.

Under a sign that read "Our ingredients, your success," I tasted the contents of my parfait cup. It was smooth and sweet, but oddly bland and indistinct. I was at a loss to figure out what exactly I was eating. "What's in it?" I asked. "You know, the primary ingredient."

The rep looked at me with a puzzled, blank stare. She turned to her colleague, who also had no idea. After a few moments, she said, "It's a cultured dairy product."

"So it's yogurt?"

"Um, it's not yogurt." She paused. "It's a powdered product probably. You'd add water to it. But it's definitely cultured dairy. That's where you're getting the tangy flavor."

I wasn't getting much of a tangy flavor, but that was beside the point. The parfait wasn't food so much as the chosen delivery system for several edible powdered ingredients, which, I was coming to realize, were everywhere.

If you strip away the food freebies and colorful backdrops of plump fruits and juicy burgers, IFT stands as a grand festival of neutral-hued powders. Crystalline fructose and modified starches are white, as are Splenda and monk fruit extract. Yeast extracts, enzymes, preservatives such as BHT and citric acid, dough conditioners like ammonium sulfate and sodium stearoyl lactylate, and many flavorings are sold as beige powders. Soy protein is a pale yellow powder, and dairy proteins are closer to white. A lot of synthetic vitamins are white powders—and, of course, that yogurt-esque ingredient in my parfait. The food industry relies heavily on these dried, finely pulverized materials because they're cheap and convenient to ship, and because they last much longer than anything with moisture in it.

You probably don't think of your lunch as being constructed from powders, but consider the ingredients of a Subway Sweet Onion Chicken Teriyaki sandwich. Of the 105 ingredients, 55 are dry, dusty substances that were added to the sandwich for a whole variety of reasons. The chicken contains thirteen: potassium chloride, maltodextrin, autolyzed yeast extract, gum Arabic, salt, disodium inosinate, disodium guanylate, fructose, dextrose, thiamine hydrochloride, soy protein concentrate, modified potato starch, sodium phosphates. The teriyaki glaze has twelve: sodium benzoate, modified food starch, salt, sugar, acetic acid, maltodextrin, corn starch, spice, wheat, natural flavoring, garlic powder, yeast extract. In the fat-free sweet onion sauce, you get another eight: sugar, corn starch, modified food starch, spices, salt, sodium benzoate, potassium sorbate and calcium disodium EDTA. And finally, the Italian white bread has twenty-two: wheat flour, nia-

cin, iron, thiamine mononitrate, riboflavin, folic acid, sugar, yeast, wheat gluten, calcium carbonate, vitamin D2, salt, ammonium sulfate, calcium sulfate, ascorbic acid, azodicarbonamide, potassium iodate, amylase, wheat protein isolate, sodium stearoyl lactylate, yeast extract and natural flavor.

If you were to make this sandwich at home with a basic chicken breast and fresh bread made with minimal ingredients, it would contain only a handful of these things. Mass-scale food processing, however, requires an entirely different system of assembly, one fraught with often conflicting expectations. Manufactured food needs not only to taste good, for instance, but also to withstand the wear and tear of processing. It has to look and taste exactly the same every time. It also has to have a long shelf life, be produced cheaply and efficiently, and on top of all that, it would be nice if it could be marketed as healthy. Modified food starches and sugars are what allow Subway to boast that its Sweet Onion Chicken Teriyaki sandwich has only 4.5 grams of fat.

Such prerequisites present food manufacturers and ingredient companies with no shortage of brain-bending problems, which is one of the reasons the people who decide to become food scientists find their work so fascinating.

Food Science U

Steve Smith is strolling the halls of Purdue University's expansive $28 million Philip E. Nelson food science building, and each time someone approaches, he flashes a wide, gap-toothed grin and pitches his steaks. "Salisbury steaks," he says, "We've got Salisbury steaks downstairs." As head of the food science department's sensory testing lab, he does this sort of thing all the time. Every day except Fridays, Smith oversees two taste tests, each of which

requires at least one hundred people to sit at a basement computer and answer questions about two similar but different food items that emerge from a sliding panel in the wall. A heavyset guy with salt-and-pepper hair and a matching mustache, Smith has the sort of unflappable enthusiasm and easy likability that make this job look effortless.

At least, he does most days. Today he's having trouble rounding up the last few volunteers for the Salisbury steaks, which isn't all that surprising. When was the last time you went out to a restaurant and ordered Salisbury steak? The hunks of meat Steve Smith is hawking are made by a Cincinnati-based foodservice company called AdvancePierre and sold to school and hospital cafeterias. An earlier tasting from the same company featured a sodium-reduced burger and had many more takers, including me. Many of the taste tests sell themselves. "People love it when we have cookies or french fries or smoothies," Smith says. "Next week, we have Mrs. Fields's carrot cake and donuts. I'm not expecting any problems with those."

I'd come to Purdue just several weeks after fall classes had started up to understand how one gets into the business of being a food scientist. Located in West Lafayette, Indiana, Purdue is one of only thirty-eight universities around the country that offer undergraduate and graduate degrees in the field. Although there are no rankings for food science the way there are for medicine, law, and business, a tally of leading schools would include Purdue in the top five. The school has an exceptionally productive and collaborative relationship with the food industry. Large manufacturers and ingredient makers have helped create labs and contribute to student scholarships. Their employees appear regularly on the leafy, picturesque campus to give talks to students and interview them for jobs and internships, a process that was already in full swing by mid-September.

During my visit, the university hosted its Industrial Roundtable, an annual career fair held on the campus's central outdoor quad. There I met Purdue graduates who are now role models for current students. Rodney Green, a Purdue PhD, works at ConAgra on Hunt's canned tomato products and Van Camp's baked beans. His colleague Kirsten Fletter devises new varieties of Slim Jim, Banquet frozen food and Orville Redenbacher popcorn. Jessica Schroeder got a masters degree in 2007 and is now a food scientist for Pepsi's Tropicana beverages, developing the lower-calorie line of Trop50 juices. "It's got stevia, the natural sweetener, in it," she said, proudly hoisting a bottle from a table lined with PepsiCo products. Lynn Choi Perrin, a senior scientist at General Mills, oversees Pillsbury Toaster Strudels, Totino's individual frozen pizza, and Fruit Roll-Ups. Also on the quad were reps from Kraft, Nestlé, french fry maker McCain Foods, and the flavor company Sensient Technologies.

Even though millions of people have consumed the fruits—or fruitlike substances—of their labor, the careers of people like Perrin and Schroeder are unfamiliar to most. Parents dream of their kids one day becoming doctors, lawyers, software moguls, famous athletes, and—until recently, perhaps—Wall Street investment bankers. Nobody imagines their children as food scientists, unless maybe they're food scientists themselves. "A lot of people think it has something to do with cooking," one scientist lamented. Purdue professor Lisa Mauer told me a story about her well-meaning mother-in-law once giving her a cookbook in which to store class notes, a cute but ironic gesture, since much of the field's research ultimately affords us the convenience of never needing to cook.

Like processed food itself, the discipline of food science is a relatively recent phenomenon. The first department began in 1918 at the University of Massachusetts at Amherst with remarkably

simple, practical food processing goals: to preserve fruit. Local farmers complained to the university's horticulture department that they were losing money on lower-quality fruits and other leftover product that couldn't be sold at markets. In response, the department head directed one of his botany professors, Walter Chenoweth, to set up a lab dedicated to the study of methods for fruit preservation. Chenoweth protested he knew nothing about the subject, but somehow this only made him seem more qualified for the job.

The practice of basic canning had been around a long time. Companies like Heinz, Campbell's, Borden, and Van Camp were successfully selling containers of jellies, horseradish, ketchup, condensed soups, and milk. Homemakers, too, used heated and airtight glass jars as a way to preserve nature's seasonal bounty. But the food shortages of World War I had sparked new interest in preservation, and there was still much to be learned about the chemistry of the process. Chenoweth spent the remaining years of his life acquiring this knowledge and sharing it with others. He hosted regular seminars for homemakers on how to apply scientific principles to their canning—how to avoid improper packing, prevent air pockets from forming, avoid sealing a jar too tightly, and apply just the right amount of heat.

Over the next four decades, several land-grant universities, which were set up by Congress with mandates to teach practical science, followed UMass into the food science future. Most of these programs were geared toward finding new ways to boost the consumption of crops grown within the state. Kansas State University focused on meat processing and wheat. The University of Wisconsin at Madison devoted itself to dairy. And the University of Illinois specialized in products from soybeans. Eventually these programs were expanded to include a broader range of studies,

ultimately becoming more and more elaborate. By the fifties, it wasn't so much about food as "foodstuffs." One textbook in 1953 was entitled *Foodstuffs: Their Plasticity, Fluidity and Consistency.*

Loving Food

Notwithstanding the inverse relationship between food science and cooking, many of the Purdue students and former students I talked to said they were inspired to study food science explicitly because they like to prepare their own food. What about cooking school, I wondered? Nobody had seriously considered this, as most were driven by a greater affinity to science than art. Jenn Farrell, a senior from Indianapolis, described cooking as her "stress relief." Most evenings, when she returns to her apartment after working in the sensory lab, running the Food Science Club, and taking classes in ingredient technology and food analysis, she whips up meals from "whatever's lying around in the fridge." Chicken will go into the oven with a medley of vegetables and a sauce she's put together. Baking, she said, is her favorite activity. On weekends, she's likely to make banana bread from a coveted recipe handed down from her grandmother. "It's the best banana bread you've ever had," she crowed.

Farrell hadn't heard of food science until her high school organic chemistry teacher mentioned it to her during her junior year. The teacher suggested she might want to consider going to college to study something like chemical engineering, but that didn't interest her. When she mentioned her fascination with cooking and food, he gave her a newspaper article detailing the top five up-and-coming careers. Food science was one of them. The field immediately struck Farrell as an ideal way to leverage her passion for food into a career without having to deal with the mania

and weird hours of restaurant life. "The next thing I knew, I was at Purdue taking Food Science 101," she said.

Farrell now works in Chicago for a company called Leahy IFP, a maker of canned fruit, boxed juices, pancake syrup, and margarita mixes. She got the job, a post in the research and development department, in the spring of her senior year and started working a few weeks after graduation.

Food science is booming. All of Purdue's 2012 graduates either were hired by the food industry or went on to further study. A poster in the hall of the food science building highlighted each of the companies that had offered full-time jobs or internships to students the year before, in 2011: Kellogg, Heinz, Cargill, Pepsi, Kraft, Morgan Foods, General Mills, Nestlé, Sara Lee, ConAgra, Maplehurst Bakeries, Sensient, Leprino Foods (cheese), Kerry Ingredients, McCain Foods, and AmeriQual (military meals). Suzanne Nielsen, the gracious, gray-haired, food science department head—a woman who could easily be mistaken for an English professor on her way over to teach a class on Chaucer—said that since the department was formed in 1982, they've seen 100 percent job placement for American students (those from other countries can have a harder time finding industry jobs, since employee work visas are a hassle companies would rather not deal with). This means that within six months of graduation, all those who wanted a job found one, even in years when the broader job market was in disarray.

It's no coincidence that the head of the department and the most recent president of the undergraduate Food Science Club are both female. The chemical and aeronautical engineering departments at Purdue and just about everywhere else remain boys' clubs, but food science has evolved to be predominately female. Nationally, women now account for 65 percent of students, though this

was a long time in the making. Founded in 1939, IFT didn't have its first female president until 1997; fifty-seven men had previously occupied the job. The increasing numbers of women entering the field in the eighties caused then-president Theodore Labuza to worry that this influx of estrogen might "convert the industry into one which is female dominated, like nursing or teaching, and reduce the salary levels in the process." He wondered nervously, "Should more males be recruited into the field?"

International students, too, are overrepresented in food science, with roughly one fifth of those studying it coming from other countries, mostly China and India. Foreign food scientists are more likely to land jobs at universities and government agencies such as the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA). Others return to their home countries.

Purdue's heavily female, heavily international food science students don't just study how to make your hamburgers juicier and dips creamier. Food scientists do the important job of figuring out how to reduce harmful bacteria in food. They analyze the way food behaves in all kinds of situations and they measure all the stuff that's in it. They've looked at ways to increase vitamin D levels in mushrooms, at how microwave cooking affects the carotenoid content of chilaca chili peppers, and at what allergens are present in mangoes. Spend time with food scientists, and you'll learn all kinds of fascinating things about food: that you can make cranberry juice clear by changing its pH and that using fat-free dressing on a salad can prevent you from absorbing many of the vegetables' healthy (fat-soluble) phytochemicals.

At the same time, food science programs are charged with grooming students to engineer the next McDonald's snack wrap or design a new kind of prepackaged lunch. There's a mock corporate boardroom at Purdue—to give students experience presenting to people seated around intimidatingly large, well-lacquered tables. There's also a pilot plant where students can construct foods using scaled-down versions of some of the same machines that companies install in their factories. During an undergraduate food processing class I attended, the professor informed students they would be using the plant the following week to make hot dogs. The announcement was greeted mostly with squeals of delight, along with a few groans of disgust. "If you have a weak stomach for meat and fat—because that's what hot dogs are—then come talk to me," she advised.

"The industry was there at the table when we started," said Philip Nelson, the department founder and building's namesake. Nelson, who's in his seventies and was visiting campus from his house on a lake in northern Michigan, recalled, "I hired a former executive vice president from Campbell's Soup as a mentor to help me and to figure out how to work with food companies. We established programs they said they needed, like carbohydrate research." He called the food industry one of Purdue's "customers" and said that serving its needs was on par with serving the needs of students.

Many of the students I talked to acknowledged, with varying degrees of candor, that it isn't always easy to endorse wholeheartedly an industry that churns out billions of dollars worth of Hot Pockets, Doritos (some of which come from a plant twenty-five miles from campus), Little Debbie snack cakes, sugary drinks, and chicken wings that aren't wings. But like the food scientists at IFT, they said that precooked and fast food is crucial in a hectic world. By and large, they said they'd like to work toward replacing unhealthy ingredients such as sodium and unpronounceable chemicals with healthier options like fiber and whole grains. Jenn

Farrell did an internship at a flavor company, where she helped soup and sauce manufacturers cut back sodium levels by using yeast extracts and hydrolyzed vegetable protein. Like Yan, a PhD student from Shanghai, told me she's been developing a new kind of starch that will digest more slowly, possibly serving as a replacement for white flour in bakery foods. "People are busy and there's a need for these products, but we can help people make better choices by providing healthier foods," she declared.

Creating healthier processed food is a noble goal. If future scientists like Yan and Farrell can engineer a way out—find salt, sugar, and fat replacements, use more nutritious ingredients—everybody wins. The processed food industry can grow its sales, while America shrinks its waistline and health-care expenditures. We can have our Little Debbies and eat them too.

But can we really?

It was technology, after all, and an unbridled belief in its utility for the food industry that helped get us into this mess in the first place. When applied to food, scientific innovation hasn't always been a good thing. And nobody knew that better than a Purdue chemistry professor who strolled the streets of West Lafayette some 130 years ago.

2

The Crusading Chemist

When Americans think of consumer advocates, the names Ralph Nader or Esther Peterson or Eliot Spitzer may jump to mind. But Harvey W. Wiley, M.D., was the original.

—The Food and Drug Administration

In the fall of 1902, just as the nation's first wave of urban migration tipped the population of our capital to 280,000, a dozen men gathered in a basement along what is now Independence Avenue. They were dressed in dark suits and sat expectantly around two dining tables covered in white linens. The meal they ate had been prepared by trained chefs, served on elegant china—and laced with poison. Everyone at the table was aware of this fact, but no one knew that the specific poison was borax, a naturally occurring mineral known to cause skin reactions, respiratory irritation, and various forms of gastrointestinal distress.