

ECOLOGIES

For her advocacy of small producers and raw-milk cheese, Marie-Christine Montel has become a minor celebrity within the cheese world. Her research is an inspiration to a generation of technically curious cheesemakers: she is the cheese geek's cheese geek. When American cheesemaker Mateo Kehler talks about the on-site laboratory that he and his brother Andy have set up at the Cellars at Jasper Hill in Vermont, he jokes that "there is already a lab coat hanging up here with Marie-Christine's name on it."

So there was great excitement when Montel was invited to deliver a presentation on her work with the Salers producers and their *gerles* at the 2015 American Cheese Society conference in Providence, Rhode Island. The annual conference is the single largest gathering of North American cheesemakers, importers, and sellers. There are educational sessions, industry briefings, and plenty of swag. Delegates wear intricately color-coded badges to denote their status, with categories ranging from members of the press to senior attendees, who are labeled "Aged to Perfection." At the 2015 meeting, twelve hundred people packed into the Rhode Island Convention Center to learn, gossip, and do business.

When it came time for Montel's presentation, a large audience crowded into the seminar room. But as they heard the tale of the *gerles* and saw the experimental data, they sat unmoved. The elegance of the microbiology, the revalorization of ancient cheesemaking techniques, and the implications for understanding and enhancing their own cheeses were lost on the crowd. Instead, in the question and answer session at the end, it became clear that the research on *gerles* had seemed irrelevant to the majority of the audience. What most people wanted was advice on potential pathogens and handling issues with public health officials.

The audience had not been ready for her message, had not been primed for a world where microbial biodiversity could be the defining goal of good dairy farming. It was, said Montel afterward, as if she were “from a different planet.” It was true. She might as well have delivered a lecture on unicorn ranching. Despite our frustration, we could recognize and appreciate the concerns of the audience. Their problems were intimately familiar: this was the dairy world in which Bronwen’s family had lived for over a century.

YOUR GREAT-GRANDFATHER’S HERD

A decade earlier, amid the cocktail chatter at our wedding in London, two dairy industries collided. Many of our guests were Bronwen’s colleagues from Neal’s Yard Dairy in London, a company that has come to emblemize the revival of British farmhouse cheese. Seated next to the company’s sales director was Bronwen’s uncle Eddie. We always thought of Eddie as a car enthusiast ex-NASA engineer, but he was also a farmer, fighting a last stand to maintain the viability of the California dairy that had been founded by Bronwen’s great-grandfather.

At the time, Eddie’s farm in California was comfortably larger than any dairy operation in the United Kingdom. However, even with thousands of cattle, the farm was too small to prosper amid the vicissitudes of the American market for liquid milk. Despite milking high-yielding cows twenty-four hours a day, life was a struggle. But this was not a consequence of his poor management or lack of business savvy; rather, he was the prisoner of a market that was beyond his control.

Bronwen’s great-grandfather, Fred Imsand, was a Swiss emigrant to California at the turn of the twentieth century. From a dairying family, he found work at a dairy while he romanced the chambermaids of San Francisco. He survived the 1906 earthquake by the simple expedient of standing in an empty lot during his milk-delivery run, and in the ensuing chaos he made his way to San Bernardino in Southern California, where through a combination of savings, resourcefulness, and gruff charm he acquired a farm of his own, Meadowbrook Dairy.

The dairy of Fred’s era was diversified and complete. Beyond the cows and their milk, the family farmed chickens and pigs, smoked their own hams, and sold produce from their orchard. Yet Bronwen’s grandparents eventually rebelled against the unremitting toil of this system, embracing the progres-

sive promise of scale, mechanization, and specialization. By the late 1950s, the dairy was a successful local business, with a fleet of milk trucks and—as the Inland Empire grew into Eisenhower-era suburban comfort—five little dairy drive-thrus.

Fred had started out with a herd of twenty Holstein cows, but Bronwen's grandfather Eddie Sr. recognized the direction that the milk market was going and made every effort to expand the business. In this environment, Bronwen's mother's involvement in the dairy as a young woman was restricted to some light bookkeeping as she studied for her medical school exams; a loathing for calves' liver is the only legacy of her upbringing on a dairy farm.

By the early 1970s, as supermarkets began to dominate retail sales, Eddie Sr. decided to concentrate solely on producing liquid milk and abandoned direct-to-consumer sales completely. With that decision came expansion: by the time Bronwen's mother graduated from college, the herd numbered just under four hundred cows. It was ultimately a question of pragmatism, and decisions were made in order to survive. Eddie Sr. had spent a year studying at the University of California, Davis, in the 1930s before the worsening economic climate of the Great Depression demanded that he return to work on the farm, and at each stage of Meadowbrook Dairy's expansion, he looked to the experts at UC Davis—one of the major American centers for industrial agricultural research—for advice. Each decision he made was based on progressive mainstream ideas about best practice.

The pace at which Meadowbrook Dairy grew mirrors trends in dairy farming within the United States at large. We can see these changes reflected most starkly in US Department of Agriculture statistics. From 1970 to 2006, average herd size leapt from just 19 cows to 120 cows per farm. Hidden within the arithmetic mean is an even more significant change: small dairy farms are disappearing rapidly. The smallest class of farm, those with fewer than thirty cows, might still constitute nearly 30 percent of all dairy operations, but together this bottom third represents only 2 percent of all cows and 1 percent of milk production. In contrast, between 2000 and 2006, the number of farms with more than two thousand cows doubled. In 2006, almost a quarter of all milk production—and the majority in the western United States—took place at these megadairies.¹

Europe is also seeing a steady consolidation of the dairy industry and growth of herd size. The number of registered dairy producers in the United Kingdom dropped by more than half from 1998 to 2013. From 2008/9 to 2012/13, the only UK dairy farms growing in size were those producing more

than two million liters of milk a year; based on average milk yields, the average herd size of these farms was approximately three hundred cows.² With milk prices at historic lows, milk production at dairies with more than two thousand cows is becoming more widespread. Where the United States has led, Europe is following.

Change came rapidly to Meadowbrook. A sudden series of family bereavements led to a swift generational succession, and in 1978, at age twenty-seven, Bronwen's uncle Eddie took full responsibility. It was a tough time. The suburban expansion of San Bernardino was about to swallow the dairy, and strategic decisions had to be made. Again, the advice of the dairy extension program at UC Davis proved critical. Resisting a possible move to the San Joaquin Valley, Eddie relocated the entire operation fifty miles north across the San Gabriel Mountains to El Mirage. While the high desert did not afford lush pastures, a new five-hundred-acre alfalfa ranch provided vertical integration. The dairy's systems were pared down for maximum efficiency, and an anaerobic digester was installed that converted manure into electricity. Again, scale increased. At its peak, the new operation was milking 2,200 cows, but life was still a struggle.

For this most mainstream of dairies, there was no sense that processing the milk on the farm or attempting to produce a unique product could add anything to the sustainability of the operation. When family members talk about the dairy, their pride is palpable, but each commercial decision and each stage of growth is explained and rationalized as the inevitable consequence of market conditions. Over the more than thirty years Eddie spent running the farm, he was beaten down by a commodity market that he could not control. His is a common stoicism: "Every farmer goes through periods of up and down; it's a cyclic business as far as profit and loss go. It's never been a business where you can count on a percentage of margin."

The farm's milk contract paid according to total solids—the number of pounds of butterfat and protein that the herd could produce—so the system was optimized for maximum production with maximum efficiency. In this model of dairy farming, controlling feed costs is everything, and Eddie was forced to become increasingly sophisticated at supplementing the silage and hay that he made himself with cheaply available commodity by-products. Technology helped. Eventually, it was simply a question of entering the details of the almond hulls, cottonseed, or citrus pulp into the computer to get the appropriate balance for a nutritionally optimized total mixed ration.

To this extent, Meadowbrook Dairy was the diametric opposite of Guy Chambon's operation. The entire conceit of Chambon's *Salers Tradition* is to

have cows who will thrive in a place where they will eat interesting food—hence the painstaking twice-daily milking in the pastures on the top of a mountain—and then let the cheese make itself, with a little help from the *gerles*. Uniqueness is fundamental. Taken together, these farming and cheese-making practices, from the choice of the cussed and archaic Salers breed to the maintenance of the biodiversity of the mountainside pastures and the microbial biofilms on the wooden *gerles*, make for the production of something that could not be achieved anywhere else. In contrast, Meadowbrook Dairy tacitly accepted that their output would be blended with milk from many other sources and that the route toward commercial sustainability was through efficiency and growth. Instead of keeping cows in a place where they would eat interesting food, Meadowbrook kept its cows where space was cheap and then fed them carefully calculated inputs to keep costs down and yields up.

When none of his children expressed any interest in dairy farming, Eddie ultimately took the opportunity to divest himself of the business. When we talk with him now, his sense of relief is clear, even if it is bittersweet: “We ended up taking this as a time we could slow down and keep the [alfalfa] farm out in Inyokern, and we donated the land to the water district. It was an opportunity that comes along only once or twice in a lifetime.”

Although the cheesemakers attending Montel’s presentation at the American Cheese Society conference almost certainly operated on a smaller scale than thousand-cow dairies, the mentality with which Eddie worked would have been familiar to them. It is true in much of Europe as well, where the scale might be smaller still but the same pressures toward consolidation, volume, and efficiency are being felt. For Bronwen, this too is familiar. When she was a teenager, she and her family had managed, by following received notions of best practice, to domesticate industrial dairying.

INDUSTRIAL WRIT SMALL

Unlike her mother, Bronwen did not grow up on a dairy farm. Visits to her cousins at Meadowbrook Dairy brought exotic new experiences, like the opportunity to climb mountains of fuzzy cottonseed feed, but the dairy and its evolution registered only vaguely on her consciousness. Her parents settled several hours further south in eastern San Diego County, in the foothills of the Cuyamaca Mountains. With hot, dry summers and mild winters, the

area was dominated by chaparral and horse fancy. Surrounded by equestrianism, Bronwen soon became obsessed by the desire to own a horse.

And so as she began junior high school, Bronwen joined the local 4-H club along with her best friend Melody; it seemed more exciting than the Girl Scouts, and it would give her the chance to make a halter for the horse of her dreams. But Melody, whose family owned a billy goat called Buck Rogers, also convinced Bronwen to sign up for the dairy goat group. At the first meeting, she was exposed to the vision of baby goats frolicking in fresh straw, and all thoughts of horses were immediately banished. Bronwen's parents recognized a modified win when they saw one, and within days a goat pen was being constructed in the backyard.

When Bronwen's parents, a musicologist and a physician, bought a house with land, they had no intention of dabbling in domestic dairying; they simply needed space where they could practice the violin without the neighbors complaining. Music loomed large in their lives—they had first met as teenagers playing in the same orchestra—and distance from other neighbors allowed assiduous practice to be combined with the odd hours of the work schedule at the hospital. While Bronwen's mother had been raised on the dairy farm and her father's family had dabbled in semisuburban farming when he was young, they had no firsthand knowledge of animal husbandry. Jerry Belanger's book *Raising Milk Goats the Modern Way* (Garden Way Publishing, 1975) would be their homesteading bible.

The goats, Natasha and Ginger, were to play a major role in the life of Bronwen's family for the next six years. They grew into glossy, glorified pets, but a vague sense of paranoia surrounded their management. Their pen sat within a two-and-a-half acre goat smorgasbord packed with sumac, foxtails, eucalyptus, manzanita, and native sages. This type of Mediterranean scrubland is one of the classic environments for goat foraging, a way of exploiting marginal land that has been practiced for thousands of years.

The goat book, however, suggested otherwise, claiming that a diet foraged from the native chaparral was poor in nutritional value and would lead to malnourished goats and problems with worms. The family deemed it much safer to buy in a mixture of hay, fermented alfalfa with molasses, and vitamin-enriched, grain-based goat chow for them to eat. In an area famous for its raging wildfires, with strict requirements for brush control, the goats looked on quizzically every summer as Bronwen's father scoured the property with a weed whacker and the family raked and bagged up the fallen weeds to take to the local dump. Ironically, within the world of forestry management, goat

grazing is now regarded as one of the most effective weed management solutions for fire prevention; it is also inexpensive, nontoxic, and nearly carbon neutral.³ At its headquarters in Mountain View, California, Google now uses goats for just this purpose.

Then there was the question of sex. There was no mistaking when the goats came into heat: the sex-starved animals would stand on the big rock in the middle of the pen and bleat loudly and incessantly. Were it not for this habit, they would likely have been bred only a couple of times. But as it was, they got their way year after year. When it came time to breed them, they were loaded into the back of the family's dusty Chevrolet Suburban and whisked off to the goat breeder's for a quickie with the buck. Bronwen's father remembers setting aside his Messiaen program notes on a day when the rest of the family was gone, the kids all at school, and "driving the goat off to get nailed."

When the baby goats arrived, the family kept the females or gave them to other members of the 4-H club who wished to found their own goat dynasties, but their sentimental approach to animal husbandry left them in a quandary when it came to the boys. The first set of kids were both, tragically, male. They were sent off at a tender age to "eat grass" in a friend's backyard. Another male kid followed; we learned in researching this book that he ended up as the main course at a family friend's Easter celebration. Had Bronwen known the truth at the time, she would have been beside herself, but it highlights a perennial problem for sentimental domestic dairy farmers: males. Unless you are prepared to eat them, they have no value. Bronwen's reservations about eating her pets were not remarkable. When we talked with Jeannette Beranger, senior program manager for the Livestock Conservancy in the United States, it became clear that many sentimentalists dabble in homesteading with rare breeds. Beranger launched into an anecdote about an enthusiastic couple with whom she worked who could not bear to see any of their males killed or eaten. The couple had the capital to keep them, ultimately tending a separate paddock of forty lost boys. Without those resources, even the ethically consistent lacto-vegetarian will eat veal.

In the case of Bronwen's goats, the kids were taken off their mothers immediately and raised on the bottle, making it possible both to collect the milk and to domesticate the kids. Bronwen's mother recalled, "We pasteurized the milk because we hadn't done all the tests. . . . There was some kind of goat virus, I think." The cautionary tales of tuberculosis, brucellosis, John's disease, and caprine arthritis encephalitis were enough to convince her it was the

right move. The family purchased a two-gallon, red-and-silver kitchen-countertop pasteurizer. To prevent any potential goat viruses from being transmitted, the baby goats drank pasteurized milk from their bottles too.

The family drank the pasteurized goat's milk with their meals, and Bronwen's parents tolerated a few of her failed attempts at making goat's milk fudge, but at almost two gallons per day, the goats were pumping out more milk than the family could ever use. The deep-freezer in the garage began to fill up with plastic containers full of goat's milk. Bronwen decided that it was time to make cheese.

She ordered a kit from the goat-supply catalog, and a collection of small silver foil packets, a vial of beige-colored liquid, and what looked like a set of plastic drinking cups with holes in them arrived in the mail. Bronwen had always enjoyed cooking, and the enclosed recipe was straightforward enough: warm the pasteurized milk, add the powdered bacteria and a few drops of the liquid enzyme, let the mixture sit overnight, and then spoon the resulting substance into the molds and let it drain. She followed the instructions with great care, scrupulously dipping all of the equipment in boiling water before using it for fear that bacteria other than those in the powder might make their way into the mix. Visions of giving the entire family explosive diarrhea were pushed to the back of her mind.

The following evening, she presented her finished fresh goat cheese to the rest of the family. It was an off-white substance with a gelatinous texture and a sour flavor. Her mother spread a thin layer on a cracker and ate it quickly. Her father, likely having similar thoughts about imminent gastrointestinal consequences, suggested that he would "try some later." Her younger brother and sister snickered and hid, too squeamish to go near it. While nobody was struck down, it was not a distinguished or delicious food. Hardly having begun, Bronwen's first foray into cheesemaking was over. Soon after, her mother found an animal rescue shelter that accepted donations of pasteurized goat milk, and the problem of freezer space was neatly solved.

In an environment ripe with potential for integrated goat husbandry, Bronwen's family had exactly replicated the practices of industrial dairying. The difference was that at Meadowbrook Dairy, the cows had not even had the option of grazing diverse pastures. Bronwen's teenage goat rearing demonstrated the obsession with absolute control that characterizes intensive agriculture: the brush was cleared by hand rather than by the grazing goats, and cheesemaking was driven by the contents of a packet. If there were no commodity by-products in the goats' ration, it was because the goats were in

a luxurious confinement. But the aim, encouraged by 4-H advisors and the wisdom of the manuals, was to remove the animals and their milk from the purportedly dangerous natural world and then precisely to control the inputs that were reintroduced to the system. There was no other way to imagine farming and absolutely no other way to imagine cheesemaking.

MAKING AGRICULTURE WORK

In this context, it is perhaps unsurprising that Bronwen never contemplated life as a dairy farmer. Instead, she followed a more recent family tradition and embarked on a path toward a career as a physician. However, just as she was about to head off to medical school, nagging doubts about the decision prompted a desire for some time for reflection. Two years as a Peace Corps health volunteer in Senegal provided that time. Living and working in a village of Fulani herders in the north of the country reawakened her curiosity about dairying: the rangy Senegalese cows were nothing like her uncle's buxom Holsteins, and that in itself was intriguing. What were the differences in the relationships between the people, the animals, and the land?

On her return from the Peace Corps, Bronwen searched for a path that would provide her with an opportunity to address these questions. She made cheese on a small dairy farm in New Jersey and then completed a master's degree in anthropology at Oxford, which allowed for a more formal study. At Oxford, Bronwen's thesis on the relationship between Protected Designation of Origin legislation and tradition gave her the chance to meet and interview the key players in the British artisan dairy industry. This is also where Francis enters the story: Bronwen's thesis was the topic of the paper that she was presenting at the Oxford Symposium on Food & Cookery on the occasion that we first met. Ours is, for good or ill, a relationship founded on European Union food law.

The academic study of cheese and culture was one thing—as we have seen with the relationship between Salers and Cantal in the Auvergne, appellation regulations are a manifestation of the politics and commercial realities of a region rather than a scholarly attempt at defining authenticity—but with a couple of months left on her student visa, Bronwen had the opportunity to start work at Neal's Yard Dairy, a London-based retailer, wholesaler, and exporter of the cheeses of Britain and Ireland. Within a year, she had become their cheese buyer, and she suddenly had the opportunity to collaborate with

the best cheesemakers in the United Kingdom, to taste thousands of cheeses—indeed, every batch of production—and select the best for the company’s customers, and to understand the inner struggles and frustrations of artisan cheesemakers. As a job, it was part stock control, part technical guide, and part therapist.

While Bronwen worked buying cheese in London and visiting cheesemakers throughout the United Kingdom, our dinner table conversation became driven by her experiences. It was a tense time. Never quite fights, but always on the verge of a rumbling marital discord, these conversations highlighted the differences in our backgrounds. Unlike Bronwen, Francis has no family heritage in dairying. A city boy who liked to eat, he was so disheartened by the food on offer at his college that he set about teaching himself to cook. What started as a hobby soon became all-consuming, and by the time he graduated he had determined that he wanted to write about food.

His university experience shaped him in another way too: thanks to the mysteries of the room ballot, he spent his second year living next door to Sir John Plumb, the octogenarian former Master of the college. Never married, Sir John had led one of the great twentieth-century lives. He spent the war codebreaking at Bletchley Park and then, as an academic historian, managed successfully to combine scholarly rigor with the literary flair to sell books. The mentor to a generation of historians of the eighteenth century, Sir John’s commercial success had allowed him to indulge his love of high living. Along the way, he had accumulated an impressive wine collection, and as he approached his ninetieth birthday—and in the context of a tense relationship with the student body of the college—one of his greatest delights was “serving nineteen year olds wines that they will never again be able to taste.”

For Francis, at that stage very much the ingénue, the opportunity to taste these wines was a formative experience. It was not so much the wines themselves as an introduction to a world that he had never contemplated might exist. Wine had always been just another alcoholic beverage to him, something that quenched a thirst and provided social lubrication. But these wines were different. Yes, the flavors were haunting, but so too were the questions that they inspired. *How* were the wines different? *Why* were they different? For a lifelong Londoner with precious little experience of growing anything, these were the first faltering steps in trying to explain differences in flavors in terms of the practice of agriculture.

When, after spending five years as a line cook and eighteen months as a fishmonger, Francis started to write about food, it was to these questions that

he kept returning. Wine was the lens through which to explore food and culture. And, to the detriment of domestic harmony, it provided a framework to ask uncomfortable questions about the cheese industry. Questions that seemed absurd when applied to cheese appeared self-evident in the context of wine, where an entire industry was already grappling with the consequences of the relationship between farming practices and flavor. It rapidly became our shared passion. When we were both given the opportunity to work a harvest with friends who produced wine in Burgundy, France, we leapt at the chance.

The vineyards of Burgundy are a UNESCO World Heritage Site. Or rather, the system of *climats*, the precisely defined small parcels of vineyards on the slopes just south of the city of Dijon, is a World Heritage Site. These *climats* are the result of the interplay of natural conditions and over a millennium of interaction with human civilization: a combination of the viticultural decisions of medieval monks and the cultural consequences of the lack of primogeniture under the Napoleonic code has created a heavily codified system in which producers might own only tiny parcels in any given vineyard. The home of Pinot Noir and Chardonnay, this is the emotional center of the world for many wine lovers and natural territory for the obsessive: it is a region where even a small producer might make twenty different wines each year and where vineyard and producer share equal billing on the label.

The thriving wine trade in Burgundy was in stark contrast to the struggling Anglo-Saxon dairy industry. The wines themselves were gorgeous, but even more striking was that this was a region where farmers were basking in commercial success: in Burgundy, small-scale agriculture offers material rewards, and farmers with tiny holdings become international celebrities. It was not always this way. Old-timers still watch their backs nervously, unsure how long these good times will last. They remember when, even as late as the 1970s, a grand domaine did not provide enough income to support a family. But now that the world has discovered a taste for their wines, the best Burgundian producers are plowing the money back into their work in the vineyard.

The market for the wines of Burgundy explicitly values the work of the farmer-producer: wines made from bought-in grapes have less value, even when they are from the same appellations and vinified by the same winemakers. Burgundians recognize that value is created in the vineyard, and this has given them a route map for how aspirational producers might improve their fortunes. Embracing sustainable viticulture, eschewing systemic fungicides and synthetic fertilizers, and paying new attention to soil microbiology and

genetic diversity of the vines in the vineyard make for wines that are snapped up by a prowling international band of merchants and importers who are all on the lookout for the next rising star. Dropping yields is standard practice, and winemaking itself has become an exercise in sensitively shepherding the ferments rather than aggressively forcing them along.

Good practice makes good wines and is rewarded in the marketplace because it can be tasted by discerning and passionate consumers. In a region on the very northerly margins of successful red wine production, every small accumulation of incremental advantage in the vineyard is vital, and so a great domaine shares its success among its farmworkers. “Good” wine tastes good. Giddy with the experience of the harvest, we could not but wonder: Why can’t cheese be like this? It is another primary agricultural product that can be processed at the farm. Yet Anglo-Saxon dairy farmers lack the road map, the path to take to improve their cheese. It was the search for that path that took us to the mountains of the Auvergne and our encounter with Dr. Marie-Christine Montel.

BIODIVERSITY MATTERS

The Anglo-Saxon world lacks anything like Montel’s INRA cheese laboratory at Aurillac. With its eight full-time members of staff, augmented by visiting students and academics, the laboratory is a fully equipped center of excellence in microbiology with a dedicated test creamery downstairs that is capable of making tiny batches of individual cheeses for experiments. The local cheese industry association has offices at the front of the building: the dialogue between practitioners and scientists is physically built into the space. In her office, Montel even has a tiny wooden model *gerle* that she uses as a wastepaper basket.

In an effort to start a conversation between cheesemakers and scientists in the English-speaking world, Bronwen organized a conference, the Science of Artisan Cheese, with the help of Neal’s Yard Dairy. Hosted by Cheddar producer Jamie Montgomery, the conference was first held in 2012. It was a heady time. Organizing the presentations and liaising with the scientists reignited within Bronwen the spark of her teenage-scientist self, and she felt the desire to learn more about cheese in a rigorous environment. And so with Neal’s Yard Dairy generously granting her a two-month sabbatical, she made her way to the Dutton Lab at Harvard University.

Dr. Rachel Dutton has a talent for addressing big questions. As a PhD candidate working in the laboratory of Dr. Jon Beckwith at Harvard Medical School, she was dissatisfied with their choice of bacterium. Beckwith had spent forty years addressing the fundamental problems of biology through the study of *Escherichia coli*. In a world of discrete specialization, Beckwith's was an *E. coli* lab. But Dutton was curious to work with other bacteria, ones about which nothing was known. Within the hierarchies of the academic world, in theory Dutton should have stopped there: the humble PhD student is a vehicle for his or her supervisor's work, striving at the coal face to advance knowledge one experiment at a time. Not Dutton. She set about gradually winning over other members of the lab with her conviction that an alternative bacterium would be a compelling direction of study. After many meetings, Beckwith decided to give her a chance, and then her results swiftly convinced him that her ideas had merit. By the time Dutton left to establish her own laboratory, the entire Beckwith lab had moved over to the study of *Mycobacterium smegmatis* as a model for tuberculosis, based on Dutton's idea.

Straight out of her doctoral program, Dutton was awarded a Bauer Fellowship at Harvard's Center for Systems Biology. It was an ideal fit. The Bauer Fellowships are designed to provide young researchers operating in interdisciplinary fields the chance to establish their own small laboratories for five years. They are self-consciously broad in the range of scholars that they attract, and the center employs everyone from microbiologists to mathematicians to engineers, all of whom are devoted to developing new experimental and analytical methods for solving biological problems. In Dutton's case, her lab was to study real world interactions in complex microbial communities. Their model system? Cheese.

It was a great insight. Cheese rinds are ideal for a microbiologist looking to work on microbial communities. Unlike the anaerobic microbes of the human digestive tract, the communities on cheese rinds are easy to culture in the lab. They are also reproducible, and samples are readily available; Dutton first met Bronwen at the Slow Food Cheese festival in Brà, Italy, where she had gone to collect as many cheese samples as possible. Lastly, the communities are just complex enough that their interactions are interesting without being so overwhelming that developing serious experiments becomes impossible.

Dutton hired smart too. Her first postdoc, Dr. Benjamin Wolfe, is a mycologist of relentless intellectual curiosity and married to one of Boston's top chefs. Amid the funky smells coming from the thousand or so experimental

cheese communities that they created and stashed in cupboards, on the top of shelves, and in the wine-cooler “cave” that they constructed, Dutton, Wolfe, and the rest of the lab team steadily teased apart microbial interactions using miniature “cheeses” made from freeze-dried curd. At the same time, they developed a reputation within the wider food world as the point of reference for questions of microbiology; an early interaction with David Chang of the Momofuku restaurant group brought them to the attention of chefs. (Wolfe would go on to write a successful regular column on food microbes for Chang’s magazine, *Lucky Peach*.) They were the microbiology lab that you went to not because you were worried about pathogens and safety but because you wanted to learn about the good microbes. Soon, food industry figures like Chad Robertson of Tartine Bakery in San Francisco and food writer Harold McGee were taking note. Dutton had become, in the words of the *New York Times*, “For Gastronomists, a Go-To Microbiologist.”⁴

When Bronwen arrived at the lab in January 2014, she was astounded. The Center for Systems Biology takes interdisciplinary collaboration seriously: the facilities are open-plan, with shared space and equipment. Lunchtime meetings encourage the cross fertilization of ideas, and lab members are regularly recruited as subjects for each other’s studies. The team in the next bay was studying the trillions of organisms that make up the human gut microbiome and how they affect drug metabolism and nutrition. Using themselves as guinea pigs, they had just completed a study, published in *Nature*, showing how changes in diet cause an immediate and pronounced shift in the balance of the gut microbial community.

Bronwen’s years in the cheese industry had conditioned her to look at cheese microbiology from a quality assurance standpoint and instilled in her a love of supposedly sterile surfaces and an obsession with “avoiding contamination.” In the Dutton lab, she learned that the world looks very different from a microbe’s point of view and that health depends more on balanced ecologies than on obsessive protection from contact with the enemy. Any organism, even cheesemaking workhorses such as *Lactococcus lactis* and *Geotrichum candidum*, has the capacity to cause serious or even fatal disease if it gains a foothold in the wrong place.⁵ But as Montel demonstrated in her study on the *gerles*, robust microbial communities are formidable tools. Guy Chambon’s Salers is a cheese made in a porous wooden bucket in a room with a muddy floor. Pathogens never get a look in.

Healthy microbial communities may be invisible, but they are not subtle; they are powerful in ways that we are only beginning to fathom. They—and

cheese, by extension—lie at the center of a revolution in our understanding of the world around us and what it means to be healthy. The human skin microbiome differs between individuals, and some skin communities, like some cheese rinds, are capable of repelling pathogens, while others invite them.⁶ There is a growing body of evidence supporting the hypothesis that everything from the anticancer effects of cruciferous vegetables to mood and anxiety levels are mediated by communities of gut microorganisms. And it seems that it is not the number of microbes present but rather the composition of their communities that is crucial to their effects and their resilience.⁷

Dutton and Wolfe’s lab mates demonstrated brilliantly that species representing only a tiny proportion of the overall community in a certain set of circumstances can be catapulted into starring roles when their environment changes. In their experiment, the team bravely traded in their normal diet for a five-day protein fest of meat, cheese, eggs, and pork cracklings. The microbial communities in their guts immediately became enriched with an entirely different set of species specialized in digesting all-you-can-eat barbecue (hold the sauce). These altered gut communities returned to baseline soon after the subjects of the study went back to a normal diet.⁸

Human evolution takes millions of years, but microbes respond to a change of environment in a matter of days. Thus, the flexibility of the microbiome allows humans to adapt rapidly to radically different and highly specialized environments. In his book *Missing Microbes* (2014), Dr. Martin Blaser makes the case that the diversity within the human microbiome allows this rapid specialization to take place. Without “contingency microbes”—the understudies waiting patiently in the wings for their call to take center stage—once-harmless environmental stimuli may prove catastrophic for the host. When it was first described in the late-nineteenth century, the bacterium *Helicobacter pylori* could be found in the stomachs of all members of the population. As a result of more aggressive sanitation practices and the bacterium’s sensitivity to ubiquitous antibiotics, *H. pylori* is now present in the stomachs of less than 6 percent of Americans born after 1995.⁹ And evidence is accruing that while *H. pylori* can have detrimental health effects, it also affects the immune response, conferring protection against allergies and asthma. How many of our “modern plagues,” from asthma to obesity, are linked to faltering microbiomes sapped of their diversity?

Mirroring the multiple scales of farming across which cheese is made, from the microbial to the mammalian, exactly the same message about the importance of diversity comes from Dr. Paul M. VanRaden, a cattle geneticist. As

he puts it, “preserving genetic variation is the key to adapting to different definitions of perfection.”¹⁰ Biodiversity is essential to future-proofing the cattle population. VanRaden is no fringe radical. He is the US Department of Agriculture research geneticist employed to study the economic value of genetic traits in cows. He spends his time perfecting the statistical models to help improve—by which he means boost the economic return from—the national and international dairy herd.

The scientific community is also slowly appreciating the importance of biodiversity in arable farming systems. Studying corn farms across the Northern Great Plains of the United States, Dr. Jonathan Lundgren and Dr. Scott Fausti demonstrated that biodiversity “performs critical ecosystem functions that cannot be replaced indefinitely by technology such as pesticides and herbicides.” Lundgren and Fausti identified all of the insect species in the plant foliage for fifty-three different corn farms. They found that more biodiverse cornfields had fewer pests. Most intriguingly, it was not simply the number of species and the abundance of individual insects that correlated with pest abundance. Rather, it was the balance of species within these communities that seemed to be connected with lower pest populations.¹¹ Just as with the microbial communities of the wooden *gerles* and the human gut, it was the strength and resilience of the ecological network that predicted the health of the system.

What makes cheese unique is its capacity to link the biodiversity of these three different worlds: flora, fauna, and microbiota. Moreover, cheese has the capacity to do this in a form that the consumer can *taste*. The uniqueness of Guy Chambon’s Salers—the reason that it is a product worth hunting down and worth the extra cost—is in the unique experience that it offers. It relies on the diverse mountain flora, but to exploit those interesting—and otherwise entirely marginal—pastures, Chambon must use a rare breed of cow that has the genetic traits not just to survive but also to prosper on the mountainside. His processing of the milk follows suit: there is no pasteurization to destroy the native microbial communities, nor is there any inoculation of starter cultures other than contact with the biofilms in the *gerles*. In the rounded depth of flavor of the cheese, we as consumers can experience the totality of his farming system. When it comes to biodiversity, cheese is the essential food, the tool that allows the consumer to trust, but verify.