"Ronald and Adamchak's clear, rational approach is refreshing, and the balance they present is sorely needed in our increasingly polarized world."—*Science*

TOMORROW'S TABLE

Organic Farming, Genetics, and the Future of Food

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Second Edition

The Mistrust of Science

Pam

> Scientific experimentation has proved immensely powerful. It has allowed us to nearly double our lifespan during the past century, to increase our global abundance, and to deepen our understanding of the nature of the universe. Yet scientific knowledge is not necessarily trusted. Partly, that's because it is incomplete. But even where the knowledge provided by science is overwhelming, people often resist it—sometimes outright deny it. Many people continue to believe, for instance, despite massive evidence to the contrary, that childhood vaccines cause autism (they do not); that people are safer owning a gun (they are not); that genetically modified crops are harmful (on balance, they have been beneficial); that climate change is not happening (it is).[1]
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> Atul Gawande, Reporter, *The New Yorker*

I've often wondered why so many people reject conclusions of trusted scientific institutions. Frequently, it is not irrationality or anti-science sentiment that drives this mistrust, as a recent conversation with a stranger made apparent.

I met Rebecca, curled up on the seat next to me, comfortable in furry boots, on the plane on the way back from Washington, D.C. She had a bright smile and blonde curly hair, wore a colorful scarf wrapped round her neck, and displayed a diverse assortment of jeweled rings on her fingers. She was an artist returning from sitting Shiva with her family after the death of her stepfather. I was returning from a meeting sponsored by the American Association for the Advancement of Science (AAAS). One of the discussions at the meeting centered on the similarities among the public responses to plant genetic engineering, climate change, and vaccines.[2] As I described the meeting, her gaze became intent. Her cheerful demeanor darkened.

"What do you think about vaccines?" she demanded.

I hesitated, choosing my words carefully. There is a broad scientific consensus that vaccines save lives, but I know that this conclusion remains controversial in some communities.

"I'm a scientist," I replied, "I vaccinated my children because the medical community recommends that children be vaccinated to protect them from diseases."

She nodded, her smile gone.

"I listened to my doctor, too," she said, "And now my child has a lifelong, incurable illness. Because of what I did, she will suffer her entire life."

Her response stunned me. I imagined the challenges her child must face and felt the sense of responsibility and guilt she must carry as a mother convinced she has made a poor choice for her child.

"What happened?" I asked.

"I delayed vaccination as long as possible, but my doctor kept pestering me and so when she was three, I had her vaccinated. A year later she was diagnosed with type 1 diabetes. Now my daughter is a statistic. She is one of those people that the medical community insists don't exist."

My heart lurched. "I am so sorry," I said. Type 1 diabetes is a grave disease that requires round-the-clock care to maintain healthy blood sugar levels. As far as I know, there is no way to prevent this disease, and it often appears when a child is young. In most people with type 1 diabetes, the body's own immune system mistakenly destroys cells in the pancreas that produce the insulin we all need to survive.

Rebecca's soft voice grew fierce. "The doctors said it wasn't because of the vaccine, but I know it was. She was healthy before the vaccination."

At that moment, I wondered if Rebecca was misinformed. Many people still believe the false claims made by actress Jenny McCarthy and former physician Andrew Wakefield that the administration of the measles, mumps, and rubella (MMR) vaccine causes autism and bowel disease.[3] Although their claims have long been discredited (Wakefield's medical license was revoked because of documented fraudulent claims and undisclosed conflict of interest), their anti-science campaigns have had devastating consequences. Many newspapers still promote their views, and in some areas of the world, parents hesitate or choose not to vaccinate their children, invoking a personal-belief exemption to skirt public school requirements.

The result has been a worldwide outbreak of measles and whooping cough. Marin County, California, recently experienced the largest outbreak of whooping cough in the nation.[4] Health care workers descended

into Marin to reeducate parents about the importance of vaccinating their children.[5] Even today, the notion that vaccines cause autism or other problems remains prevalent in some places, especially in certain liberal, highly educated, affluent communities like Marin County and Berkeley, where Rebecca lives.

"Did you hear that vaccines cause diabetes from the actress Jenny McCarthy?" I asked.

"No, I am not listening to her, I know she is a kook. I did my own research." Rebecca replied.

By that point, I was puzzled, I had not heard that the MMR vaccine caused type 1 diabetes, nor had anyone mentioned it at the AAAS meeting. Surely the vaccine would be banned if it caused such a terrible disease.

She noted my look of confusion and explained, "After my daughter was diagnosed, I did a lot of research. A study in Finland showed that after children were vaccinated there was a huge increase in diabetes." She elaborated with enough details to frighten any parent.

When I got home, I Googled "Finland, vaccines, diabetes." Up popped The National Vaccine Information Center (NVIC). Prominently displayed was the statement that "The introduction of . . . new vaccines in Finland [was] followed by a 62 percent rise in the incidence of diabetes in the 0 to 4 year old age group."[6]

The words used in the article were almost identical to what Rebecca had described. No wonder she was convinced that the vaccination caused diabetes in her daughter. I noticed though that the reported link between diabetes and the vaccination was not based on replicated scientific experiments.[7] In fact, the NVIC is not a scientific organization at all. It is an anti-vaccination advocacy group known to spread false information. New Yorker journalist Michael Specter described the NVIC as "the most powerful anti-vaccine organization in America" and reported that "its relationship with the US government consists almost entirely of opposing federal efforts aimed at vaccinating children."[8] The Institute for Science in Medicine, a non-profit educational organization dedicated to promoting high standards of science in all areas of medicine and public health, stated that "NVIC has the sort of name that sounds like a federal agency, one that [consumers] might mistake as a source of reliable information."[8]

The NVIC website, with its pseudoscience jargon, is targeted at people like Rebecca (see Box 8.1). It appears authoritative. It uses the same color scheme and general page layout as the National Institutes of Health, the nation's premier

medical research agency. It uses scientific-sounding studies to bolster its case. By citing discredited studies, the NVIC successfully manufactures uncertainty and stokes fear in consumers. This well-worn political strategy is widespread and effective in sowing doubt about scientific consensus on diverse subjects.[9–11] In Australia, the government revoked the tax-exempt charity status of an anti-vaccination advocacy group on the grounds that their fear-mongering misinformation about the danger of vaccines threatened public health, especially the health of children. It also required the group to change its name, from the Australian Vaccination Network to the Australian Vaccination-Skeptics Network, to make their perspective clear.[12]

BOX 8.1 **Five Hallmarks of Pseudoscience**

Surgeon and public-health researcher Atul Gawande summarizes five typical moves of pseudoscientists. "They argue that the scientific consensus emerges from a conspiracy to suppress dissenting views. They produce fake experts, who have views contrary to established knowledge but do not actually have a credible scientific track record. They cherry-pick the data and papers that challenge the dominant view as a means of discrediting an entire field. They deploy false analogies and other logical fallacies. And they set impossible expectations of research: when scientists produce one level of certainty, the pseudoscientists insist they achieve another."[1]

These websites are representative of hundreds of groups that are "grasping at the cultural authority of science, but also undermining it," according to Eric Conway, a historian at NASA's Jet Propulsion Laboratory at the California Institute of Technology in Pasadena.[11] Conway, co-author of *Merchants of Doubt* with Naomi Oreskes, exposed the tobacco industry's use of industry-funded pseudoscience and the manufactured uncertainty strategy to undermine the scientific consensus that smoking causes cancer. As Daniel Engber aptly remarked in *Slate,*[9] "The success of these programs shows how the public's understanding of science has devolved into a perverse worship of uncertainty, a fanatical devotion to the god of the gaps."

I recall Rebecca elaborating her story: "The scientists can believe vaccines work, but they don't have the experience I have had. They have not held their child white and stone cold in their arms. She almost died more than once." I grieved as I heard Rebecca describe her experiences. If her daughter had not been

treated immediately for low blood sugar, she could have fallen into a diabetic coma and died.

She continued, "Pharmaceutical companies and the government have given me no reason to trust them. Everyone can describe a bad experience where they were lied to or given false information, right?"

She is right. I recall some pharmaceutical scandals—Vioxx, for example. People used the Merck product for years before it was discovered that Vioxx increases the risk of heart attacks in some people.[13] The insidious part of the Vioxx episode was the possibility that Merck knew about this risk and hid it. This story damaged trust, not only in Merck, but also across the pharmaceutical industry.

The government also makes mistakes and can take a long time to correct them. A friend of mine, a well-traveled researcher, was mistakenly placed on a "no-fly" list years ago and still cannot get her name removed. She is subjected to searches every time she flies. It is not hard to understand why Rebecca felt her political and ethical concerns were not being addressed. Rebecca is representative of many consumers who generally trust in medical professionals and the scientific community but have little trust in pharmaceutical companies and the government.[14,15]

"Plus the whole system is rigged. You would not believe how much I pay for insulin. The pharmaceutical companies have too much control," she added.

Rebecca is not irrational or uneducated. She studied biology before becoming an investigative journalist, and later an artist. Her mother is an education professor. It is true that insulin is costly and just a few companies control the price. *The New York Times* reported in 2016 that, "in the United States, just three pharmaceutical companies hold patents that allow them to manufacture insulin. Together, these three companies made more than $12 billion in profits in 2014, with insulin accounting for a large portion."[16] Some patients have become so frustrated that they are trying to make a generic, cheaper insulin.[17] With more control, patients feel more powerful and less vulnerable.

Rebecca fits the profile of someone who hesitates or refuses to vaccinate her children. Such hesitators tend to be better educated and better paid than parents who do vaccinate.[14] What explains the fact that Rebecca, and many others, discount the scientific consensus that vaccines save lives?

According to Atul Gawande, "You can tell them that correlation is not causation. You can say that children get a vaccine every 2 to 3 months for the first couple years of their life, so the onset of any illness is bound to follow vaccination for many kids. You can say that the science shows no connection. But once an idea has got embedded and become widespread, it becomes very difficult to dig it out of people's brains—especially when

they do not trust scientific authorities. And we are experiencing a significant decline in trust in scientific authorities."[1] Many people do not realize that one of the first vaccines deployed eventually resulted in the eradication of smallpox, a horrible and deadly disease. Derek Koehler, a professor of psychology at the University of Waterloo, says that a lack of historical knowledge is not the main factor in rejecting science. Instead, he suggested that people have difficulty discerning a plausible argument. He found that simply reading comments from a single expert, despite the weight of many others contradicting a particular result, triggers a general sense of uncertainty, which colors perceptions.[18]

Even more insightful explanations for why some people discount the scientific consensus have emerged from a number of fields of research. Dan Kahan of Yale Law School has shown that we tend to see arguments the same way as others in the groups or tribes we associate with, based on general values and worldviews.[19] Nobel Laureate Daniel Kahneman demonstrated that our perceptions are mostly formed by subconscious mental shortcuts that lead us to jump to conclusions before reason even has a say.[20] Neuroscientists Joseph Ledoux and Liz Phelps, of New York University, and others have shown that feelings come first and carry more weight than conscious reason.[21] Slovic and others established that we filter information about risk through a number of psychological filters—fear factors—that cause us to feel the way we do about the facts, the evidence itself notwithstanding.[22]

"Whatever the cause," Koehler wrote, "the implications are worrisome. Government action is guided in part by public opinion."[18]

Part way into the flight, I became hungry and Rebecca offered me an orange. As I peeled my neighbor's offering, I flicked through the electronic menu on our high-tech flight. There was an impressive diversity to choose from. I settled on a veggie wrap with black rice, faro, and edamame dressed in a soy yuzu vinaigrette and a "sustainable, fresh, vegan, gluten-free, non-GMO" chocolate macaroon made with coconut oil.

That was a lot of labeling for a little cookie. I wondered whether it was appropriate to call a packaged processed cookie, especially one served on a plane, "sustainable and fresh." The "non-GMO" label was not informative. After all, the US Food and Drug Administration (FDA) already requires stringent labeling of foods that carry an ingredient found to be potentially harmful and has stated that there is no universal or logical definition of a GMO food (Box 8.2).

BOX 8.2 What Does a "Non-GMO" Label Mean?

What Is a GMO?

The US Food and Drug Administration (FDA) has concluded that there is no universal or logical definition of GMO food.[23] Everything we eat has been genetically improved in some manner. "Most foods do not contain entire organisms," the FDA notes.[24]

GMO Labeling Campaigns

The FDA does not support a mandatory GMO label because there is no nutritional need for more labeling.[25] The FDA already requires stringent testing of food products and labeling of those that carry an ingredient found to be potentially harmful (e.g., peanuts).

In addition to being safe to eat,[26] virtually every crop grown for human consumption has been genetically altered in some way. For example, bananas are sterile plants with artificially induced triple chromosomes; some varieties of California-certified organic rice were developed through radiation mutagenesis; and most cheeses are made with a genetically engineered enzyme.[27]

With a few exceptions (e.g., wild berries, game, chanterelles from the forest, live-caught pacific salmon), all the food we eat has been genetically altered in some manner. Each crop is different. It is not useful to group all GMOs together without regard to the purpose of the engineering, the needs of the farmer, or the social, environmental, economic, or nutritional benefits. A "GMO" label does not indicate whether the product has been sprayed with herbicides, because "non-GMO crops" are also typically sprayed with herbicides (albeit a different set of herbicides, which are typically more toxic and persist longer in the soil).[28] The exception to this is crops produced organically. Although organic farmers commonly use diverse types of pesticides, there are few herbicides registered for use directly on organic crops (see Box 5.2 in Chapter 5).[28] Instead, organic growers use tractor cultivation to till frequently, hand weeding, soil solarization, and other procedures to eliminate weeds.

Despite the lack of information provided by "GMO" labels, more than 50 countries require them, and more than a dozen US states have considered or are considering similar laws. For example, in 2013, voters in Washington defeated Initiative 522, a GMO labeling proposal by a vote of 54.8% to 45.2%. In 2012, California voters rejected a similar initiative, Proposition 37; it would have required labels on all foods made from GMOs. In 2014, Vermont governor Peter Shumlin signed a GMO labeling bill into law. This made Vermont the first US state to require mandatory GMO labeling. The bill went into effect July 1, 2016, but was superseded by Federal law later that year.

The Vermont law required labeling of foods (or extracted ingredients) that had been grown from seed genetically engineered with genes from other organisms (e.g., the Bt

gene derived from a bacterium). Yet, the Vermont bill, like the proposed California and Washington bills, contained a mishmash of exceptions. Cheese made with genetically engineered enzymes, red grapefruit developed through radiation mutagenesis, animals fed genetically engineered corn and soybeans, and insulin developed through genetic engineering were all exempted from labeling in the proposed laws. Crops sprayed with the Bt pesticide would not need a label, but crops genetically engineered to produce Bt would require a label.

The bills failed to note that the process of genetic engineering has been used safely in food and medicine for 40 years.[26] The bills did not mention that the planting of Bt corn in the United States has allowed corn farmers to reduce the amount of insecticides sprayed around the world or that planting of virus-resistant papaya saved the Hawaiian papaya industry.[29] None of the bills banned the planting of seeds developed by Monsanto or other corporations. In other words, these laws would not have provided consumers access to food that is more sustainable, more healthful, or less "corporate."

The claim that consumers have a "right to know" what is in their food is misleading. Many foods derived from genetically engineered crop varieties do not carry new genes or proteins. For example, sugar extracted from herbicide-tolerant sugar beets is chemically identical to sugar extracted from non-GMO or organic sugar beets. The herbicide-tolerant sugar beets are sprayed with glyphosate, which is classified as nontoxic by the EPA. NPR correspondent Dan Charles reported that for most farmers, planting non-GMO beets would mean going back to what they used to do, spraying their crop every 10 days or so with a "witches brew" of five or six different weedkillers. For example, non-GMO sugar beets are sprayed with paraquat, which is highly toxic to humans (see Box 2.2 in Chapter 2).[30,31] It makes sense to want to know what type of herbicide is being sprayed, but generic GMO labels do not provide that information. Consumers have the right not to be misled by a label that suggests there is something fundamentally different about food produced from crops developed through genetic engineering.

For these reasons, many scientists and farmers oppose generic labels. "Instead of providing people with useful information, mandatory GMO labels would only intensify the misconception that so-called Frankenfoods endanger people's health," stated the editors of *Scientific American*.[32] "Many people argue for GMO labels in the name of increased consumer choice. On the contrary, such labels have limited people's options. In 1997, a time of growing opposition to GMOs in Europe, the EU began to require them. By 1999, to avoid labels that might drive customers away, most major European retailers had removed genetically modified ingredients from products bearing their brand. Major food producers such as Nestlé followed suit. Today it is virtually impossible to find GMOs in European supermarkets."

What About the Farmers?

Many of Washington's canola, corn, and alfalfa farmers choose to grow genetically engineered crops, in part because of the cost savings and environmental benefits.[33] For this reason, most Washington farmers opposed Initiative 522.

Heather Hansen, Executive Director of Washington Friends of Farms and Forests, said the state's commodity growers (e.g., potatoes, wheat, canola, berries) would be hurt by Initiative 522, whether or not they grow genetically engineered crops, in part because of the new layer of bureaucracy it would add. Although Washington's large berry crops (primarily raspberries, blueberries, and strawberries) are not genetically engineered, growers would have been required to add GMO labels if the initiative had passed. That's because many growers pack their own berries and freeze them, adding a little sugar. The berries are not genetically engineered, but the sugar comes from genetically engineered sugar beets.[34]

The National Farmers' Federation in Australia believes that "responsible and strategic application of biotechnology within Australian agriculture can result in significant benefits for Australian farmers, the environment, consumers, and the Australian economy as a whole."[35] They urge the State governments to remove contradictory legislation and lift restrictions.[35] In Jackson County, Oregon, a ban on planting genetically engineered alfalfa angered farmers and triggered "right to farm" protests.[36]

It's Not About Your Health

The Washington state labeling initiative was the most expensive in state history. The No on 522 campaign set a record for fundraising, largely from out of state, bringing in $22 million in donations, according to *The Seattle Times*.[37] Just $550 came from Washington residents, according to the newspaper. The top five contributors were the Grocery Manufacturers Association, Monsanto, DuPont Pioneer, Dow AgroSciences, and Bayer CropScience. The largest donors to the pro-labeling campaign were California-based Dr. Bronner's Magic Soaps, the Organic Consumers Association, and the Center for Food Safety in Washington, DC, all identified by the nonprofit consumer awareness and medical watchdog group, *Quackwatch*, as "promoters of questionable health practices."[38,39]

In California, food and biotechnology companies amassed $46 million to defeat Prop 37, with Monsanto, the largest supplier of genetically engineered seeds, contributing $8.1 million.[40] The backers of Proposition 37 raised $9.2 million, mainly from the $35 billion organic food industry and nutritional supplement businesses. The top financial supporter of the initiative was Mercola Health Resources (see Box 8.3). These numbers make it clear that Proposition 37 was about large industries battling for market share, with much of the advertising aimed at spreading fear and misinformation. It was not about food safety or sustainable agriculture. It was difficult for consumers to access science-based information.

Spreading Misinformation

Misinformation about genetically engineered crops is fueled by the proliferation of groups claiming that foods made from these crops are dangerous. For example, during the runup to the vote on Initiative 522 in Washington State, the PCC Food Co-op in

Seattle sent flyers to customers falsely warning that GMOs cause allergies and autoimmune disease.[41] After the loss at the polls, the Seattle food co-op pledged to label genetically engineered foods in their stores by 2018.[42] They are not alone. Many stores and corporations have announced plans to go "GMO-free." For example, Whole Foods (larger than Monsanto in terms of total sales) has declared that within 5 years it will require labeling of all GMO foods sold in its stores.[43] Whole Foods also continues to sell highly profitable vitamin supplements as health remedies, even though some of those compounds can be harmful (see Box 8.3).

Many of the groups that demand GMO labeling and eventual elimination of GMOs[44] are supported by multinational corporations that would profit from such labels. For example, a slew of large corporations support the "Just Label It" campaign,[45] led by businessman Gary Hirshberg, managing director of the multinational corporation Stonyfield Europe, owned by Dannon Groupe. These companies often falsely claim that their own products are healthier than other products.[46–48]

Why We Should All Care About Science-Based Information

Why should consumers care about generic GMO labels? After all, any individual consumer can either pay heed to a label or ignore it. The reason is that marketing campaigns that discount science misinform consumers and harm the environment.

The focus on GMO labels often distracts stores from encouraging good nutritional and cost-effective choices for their customers. Like our own Co-op in Davis, the PCC Co-op in Seattle and Whole Foods sell arrays of herbal supplements, which are displayed prominently in the front of the store. The stores also prominently display organic produce and stow the cheaper conventional produce on small shelves in the back of the store. I noticed the other day that organically grown shallots cost $4.99/pound, whereas conventionally grown ones cost $2.99/pound. Few people in our well-off town are concerned that the prices for organic produce are often 50% higher than for conventional produce.

Transparency in Labeling

There is no evidence that Whole Foods can safeguard the food supply better than the FDA. In the last few years, Whole Foods has failed to address real food safety problems, endangering the health of their consumers.[49]

The main goal of a large corporation such as Whole Foods is to sell more of its products. If labels will drive huge profits, there is a strong financial incentive to use labels.[50,51] A. C. Gallo, president of Whole Foods, recently told *The New York Times*, "Some of our manufacturers say they've seen a 15 percent increase in sales of products they have labeled."[43]

The abundant use of "GMO-free" labels is starting to muddle the marketing campaigns of large corporations. For example, Chipotle began a campaign claiming that GMO cultivation hurts the environment. This claim contradicts the scientific evidence.[26] Without genetically engineered crops, it is estimated that agriculture's global environmental footprint would be substantially larger.[52] Compared with genetically engineered crops, Chipotle's non-GMO ingredients are more likely to have been sprayed with insecticides and more toxic herbicides.[53] Chipotle also continues to sell food produced using genetic engineering technology; for example, the meats are produced from livestock fed genetically engineered corn and soybeans, the cheese is made using genetically engineered chymosin (see Box 5.1 in Chapter 5), and the soft drinks carry sugars from genetically engineered corn or sugar beets. In 2015, because of these inconsistencies, Chipotle was sued for false advertising.[54] The plaintiff alleged that Chipotle had violated the Federal Food, Drug and Cosmetic Act through this misleading marketing and had tricked customers into paying extra for food that they falsely perceive to be more "natural" and therefore more healthy.

Cheerios and Grape-Nuts, produced by General Mills and Post, respectively, have also run into complications. Both companies started selling "GMO-free" cereals in 2014. This was an effort to give consumers a choice even though the company acknowledged on their website that GMO crops are safe to eat. But there were unintended consequences. The GMO-free versions of the cereals lacked certain vitamins. Vitamins are often produced with the use of genetically engineered bacteria[55]; furthermore, these bacteria feed on sugars, which are typically produced from corn or sugar beets that are genetically engineered.[56]

These stories give consumers cause to be skeptical about the current labeling trends. It is not in consumers' best interests to have massive corporations like Groupe Danon, Monsanto, Chipotle, and Whole Foods decide what is nutritious or safe. Whole Foods, a for-profit corporation, has been called "America's temple of pseudoscience" because some of the health remedies that it sells are so diluted that, "statistically speaking, they may not contain a single molecule of the substance they purport to deliver."[57]

Reaping greater profits is a perfectly legitimate goal for a corporation. But, as Steven Strauss, Distinguished Professor of Forest Biology at Oregon State University, has stated, "When science is subverted and distorted to advance a particular ideology or business interest, consumers are deprived of basic information and important benefits."

So how can consumers best gain information about how their food is grown? Consumers want transparency. In June 2016, a bipartisan agreement was reached in the US Senate to address this issue. The accord would require labeling of genetically engineered ingredients on packages via digital codes.[58] Ideally, such a label could indicate which ingredients were made using genetic engineering and, more importantly, for what purpose. If all products (not only those made from genetic engineering)

were labeled with digital codes, consumers could better shop and compare. They could know what types of pesticides had been applied to the crop. Some consumers may prefer to avoid foods that have been mutagenized with irradiation (including some certified organic produce). Some might prefer corn syrup produced from Bt corn if they knew that farmers growing the corn had reduced applications of chemical insecticides. They may prefer a genetically engineered virus-resistant papaya over its organic counterpart when they learn that the genetically engineered papaya likely carries tenfold less viral protein. I dream of the day when a simple scan from my smartphone would reveal all that went in to growing my apples and zucchini.

Perhaps these labels are intended to give consumers the idea that the treat is good for your health, which is a stretch. Each bite-size serving of the macaroon is 100 calories.

I doubt these labels are helpful to consumers. The journalist Timothy Egan put it plainly: "It's a public service to warn the less than 1 percent of the population who suffer from celiac disease that bakery products might contain something that could make them sick. But putting this label on things that have no connection is a cynical corporate play for clueless consumers who buy something simply because they think it's healthy. Red Bull boasts of being gluten-free. So is paint thinner."[59]

BOX 8.3 **The Herbal Supplement Industry**

The lack of regulation of the prosperous supplement industry provides a stark reminder of why reasonable regulations are needed for food and medicines. The supplement industry produced about $32 billion in revenue in 2012 and is projecting an increase to $60 billion in 2021.[60]

Dietary supplements now account for almost 20% of drug-related liver injuries that turn up in hospitals, up from just 7% a decade ago.[61] Many adults combine prescription drugs and supplements in ways that can lead to serious side effects.[62]

"It's really the Wild West," said Dr. Herbert L. Bonkovsky, Director of the Liver, Digestive and Metabolic Disorders Laboratory at Carolinas HealthCare System in Charlotte, NC. "When people buy these dietary supplements, it's anybody's guess as to what they're getting."

Americans spend an estimated $32 billion on dietary supplements every year, attracted by unproven claims that various pills and powders will help them lose weight, build muscle,

and fight off everything from colds to chronic illnesses.[63] About half of Americans use dietary supplements, and most of them take more than one product at a time.

The supplement business is largely unregulated. In recent years, critics of the industry have called for measures that would force companies to prove that their products are safe, genuine, and made in accordance with strict manufacturing standards before they reach the market.

But a Federal law enacted in 1994, the Dietary Supplement Health and Education Act, prevents the US Food and Drug Administration (FDA) from approving or evaluating most supplements before they are sold.[64] Usually, the agency must wait until consumers are harmed before officials can remove products from stores. Because the supplement industry operates on the honor system, studies show the market has been flooded with products that are adulterated, mislabeled, or packaged in dosages that have not been studied for safety.

The FDA estimates that 70% of dietary supplement companies are not following basic quality control standards that would help prevent adulteration of their products. Of about 55,000 supplements that are sold in the United States, only 170 (about 0.3%) have been studied closely enough to determine their common side effects, according to Dr. Paul A. Offit, the Chief of Infectious Diseases at the Children's Hospital of Philadelphia and an expert on dietary supplements.[65]

"When a product is regulated, you know the benefits and the risks and you can make an informed decision about whether or not to take it," he said. "With supplements, you don't have efficacy data and you don't have safety data, so it's just a black box."

A second trend emerged when Dr. Victor Navarro and his colleagues studied 85 patients with liver injuries linked to herbal pills and powders. Two-thirds were middle-aged women, on average 48 years old, who often used the supplements to lose weight or increase energy. Almost a dozen of those patients required liver transplantation, and three died.[61]

It was not always clear what the underlying causes of injury were in those cases, in part because patients frequently combined multiple supplements and used products with up to 30 ingredients, said Dr. Herbert Bonkovsky, an investigator with the network. One product that patients used frequently was green tea extract, which contains catechins, a group of potent antioxidants that reputedly increase metabolism. The extracts are often marketed as fat burners, and catechins are often added to weight-loss products and energy boosters. Most green tea pills are highly concentrated, containing many times the amount of catechins found in a single cup of green tea, noted Dr. Bonkovsky. In high doses, catechins can be toxic to the liver, and a small percentage of people appear to be particularly susceptible.

But liver injuries attributed to herbal supplements are more likely to be severe and to result in liver transplantation, according to Dr. Navarro. Unlike prescription drugs,

which are tightly regulated, dietary supplements typically carry no information about side effects. Consumers assume they have been studied and tested, but that is rarely the case. "There is this belief that if something is natural, then it must be safe and it must be good," he said.

There are a number of salesmen who have taken advantage of the absence of regulation. For example, Joseph Mercola, who markets a variety of controversial dietary supplements on his website, has been warned by the FDA to stop making illegal claims regarding his products' ability to detect, prevent, and treat diseases.[66,67] The medical watchdog site *Quackwatch* has criticized Mercola for making "unsubstantiated claims [that] clash with those of leading medical and public health organizations and many unsubstantiated recommendations for dietary supplements."[38] Ironically, Mercola has demanded more testing of crops made from genetic engineering despite the fact that genetically engineered crops are the most highly regulated crops on the market. Mercola has been the subject of criticism from the business, regulatory, medical, and scientific communities. A 2006 *BusinessWeek* editorial criticized Mercola's marketing practices as "relying on slick promotion, clever use of information, and scare tactics."[68]

Consumers deserve regulation of products that are potentially harmful, such as supplements, not ones that pose little danger, such as genetically engineered crops.

I had no illusions about this cookie, but my sweet tooth got the better of me. I bought the macaroon and bit into it. Chocolate flooded my mouth and my brain. It was so delicious and decadent that I recreated the recipe when I got home (Recipe 8.1).

I asked Rebecca what she thought about the "non-GMO" label. In the last 3 years, there has been a 237% increase in "GMO-free" labels.[69]

"I think corporations have too much control, and I don't trust the government regulators. I believe the food system is rigged to benefit the larger corporations," she replied. "I choose foods with the non-GMO label because it helps me avoid buying food from Monsanto."

Rebecca is not alone. Many consumers do not want to buy food that is derived from seeds produced by large corporations whom they see as dishonest.[26] But if you eat, it is hard to avoid seed companies. Monsanto, a major seed company, sells diverse kinds of seeds, many of which are not genetically engineered. Without increased public funding for plant breeding at nonprofit institutions, US and European farmers (including organic farmers, Chapter 5) will continue to buy their seeds from large seed companies.

Rebecca also might not be aware of the environmental costs associated with growing non-GMO crops. In 2014, Dan Charles from National Public Radio reported that the growing demand for foods labeled "non-GMO" has incentivized farmers in the southern United States to grow non-GMO corn.[70] Because some consumers are willing to pay for it, farmers can sell their non-GMO crops for 15% more than their conventional crops. Some of the profit gets eaten up by extra costs because farmers spend more money on chemical pesticides, many of which have harsher effects on the environment than those used with genetically engineered or organic crops. Researchers have also shown that there are higher levels of biodiversity in Bt crop ecosystems than in those sprayed with chemical insecticides.[26]

I recently had a chance to talk with Tom Muller, a partner of Muller Ranch, a farm of 8000 acres in Yolo County, California, who tells a similar story. Tom grows three types of alfalfa: certified organic, conventional, and herbicide tolerant.[71] He describes himself as a social moderate, a fiscal conservative, and a good steward of the land. He sells his alfalfa hay to five dairies in the Bodega Bay region, a coastal community 2 hours from Davis. Ninety-five percent of the dairies in the area are organic because farmers can sell organic milk for more than twice the cost of conventional milk. In the past, Tom grew about 50% organic alfalfa and 50% herbicide-tolerant alfalfa. But as the demand for organic alfalfa increased, Tom planted more of his acreage to the organic crop. He now grows 80 acres of organic alfalfa. The price he can get for organic alfalfa is $365 per ton, compared with $215 per ton for conventional or herbicide-tolerant alfalfa. But there is an unpleasant side effect of this profitable approach: Organic alfalfa is less nutritious because it is contaminated with weeds. To mitigate this problem, dairy ranchers supplement the organic alfalfa with corn syrup and cottonseed oil.

"The cows don't mind the weedy alfalfa too much," says Tom, "but horses can't eat it."

Although eating weedy hay can reduce milk production in cows, they usually don't get too sick because they are ruminants with specialized stomachs that allow them to more easily digest plants and weeds. In contrast, horses need clean hay to stay healthy. There are a number of weeds that are toxic to horses, including common groundsel and fiddleneck (*Amsinckia* species), which can cause liver failure and death in horses. Tom grows herbicide-tolerant, genetically engineered (aka "GMO") alfalfa for the nonruminants.

"The GMO alfalfa is much better for the horses than the organic hay," he says, "The GMO alfalfa is totally clean—no weeds at all."

Tom also grows conventional alfalfa ("non-GMO") to satisfy horse owners who demand it. This means that, instead of spraying glyphosate (classified as "nontoxic" by the EPA) once per season, he sprays the more toxic herbicides, such as Velpar, paraquat, Diuron, and 2-4-DB, twice a season (see Box 2.2 in Chapter 2). These herbicides, especially Velpar and Diuron, contaminate wells in the area and surface runoff.

"It is all about supply and demand," he tells me. Even though he much prefers growing herbicide-tolerant alfalfa, next year he will likely grow organic alfalfa for the dairy cows (which costs more, yields less, depletes the soil of macronutrients if manure is scarce, and is less nutritious) and non-GMO alfalfa for horses (which requires the application of more toxic compounds). That is what some consumers want.

"It does not make any sense," Tom says. "No one has a clue what farmers do."

RECIPE 8.1

Chocolate Macaroons

Ingredients

½ cup maple syrup
1 cup shredded coconut
1 cup freshly ground almonds*
½ cup coconut flour
½ cup raisins
2 oz 100% chocolate
½ cup sunflower oil
2 tsp vanilla
1 tsp salt

*Allergy warning: Manufactured in a facility with tree nuts

Preheat oven to 300°F. Form into balls and freeze for 10 minutes. Bake for 15 minutes.

In the summer of 2015, I sat with my family at a splintered picnic table under the smoky skies of the Sierra Nevada in South Lake Tahoe. The air smelled of vanilla and cedar from the trees nearby.

In California, it had been so long since we had a true winter that it felt like a large faucet in the sky had been turned off, as if a naughty child wanted to see what would happen to the biological beings below. It had been the worst drought in recorded history. The drought had damaged many of the Central Valley farms, which produce more than half of the fruits, nuts, and vegetables for the entire country. I worried about my big garden. The fruit trees, berries, and flowers need summer water to survive. Even though we have a water catchment system, we needed to pump supplemental water from the shrinking underground reservoirs to maintain the plants. And it was not only our tiny farm I worried about. Few people in the United States who eat California's nutritious produce remained untouched by the drought.

My sister-in-law, Jane, dressed in hiking pants, t-shirt, and frayed cotton Mary Jane Keds, brought me a cup of roasted barley tea with almond milk. Jane is a physician at the University of Washington in Seattle. As in California, Washington's forests were in trouble. She told us that they were experiencing the worst wildfire season in the history of the state. Even with 30,000 firefighters called out, there were still not enough people or equipment to battle the blazes.[72]

"How much evidence do people need that the climate is changing?" Jane asked.

My brothers Peter and Rick joined us at the table. Like all the Ronalds, their politics are progressive and their opinions unrestrained.

Rick replied, "That is the way people are. It does not matter what the evidence is, people make a decision based on an emotion and then gather information to back up that decision. The facts don't matter."

Peter said, "People pick and choose their science depending on their tribe."

The next morning, my dog Katie and I climbed onto my paddleboard, and pushed off into the glassy water of Emerald Bay in Lake Tahoe. With a depth of 1654 feet—in the United States, only Oregon's Crater Lake is deeper—the volume of water here could cover the entire state of California 14 inches deep. In some places, I could see massive stumps, the remains of trees that grew during a 200-year-long megadrought.[73] In the wetter years that followed, the stumps were submerged. It may be that someday trees will grow here once again. The current drought had hit hard, and the lake had dropped to its lowest level in years (Box 8.4).

BOX 8.4 **Agriculture and Climate Change**

After the energy sector, agriculture, deforestation, and other land use changes have been the second largest contributors to greenhouse gas emissions,[74] accounting for about 25% of global emissions. The changing climate will, in turn, affect agricultural production. Some agricultural areas, such as Bangladeshi rice fields, will flood more often, and other areas will be hotter and drier. New pest and disease outbreaks will occur.[75,76] According to the US Department of Agriculture, exposure to temperatures that are 1° to 4°C above optimal reduces vegetable yield, and temperatures more than 5° to 7°C above optimal can cause severe or total production loss. These data highlight the fact that agricultural activities are intimately connected to climate change. We cannot address one without addressing the other.

These are issues that the agricultural community is very concerned about. Farmers are already faced with dramatic changes to their operations. For example, in California, the acres devoted to cotton farming, a water-intensive venture, have decreased every year. Some agricultural economists predict that farmers will need to adopt alternative agricultural practices and economic activities and that some farmers will need to migrate away from locations where farming and livelihood become unfeasible.

The research community is seeking ways to use water more efficiently and to develop crop varieties that are resilient to stress. For example, the flood-tolerant rice varieties released by breeders at the International Rice Research Institute (see Chapter 1) are already helping farmers deal with the increased number of floods observed over the past few years. Through the Water Efficient Maize for Africa (WEMA) project, drought-tolerant corn could be available to farmers within the next 2 or 3 years.

Farmers planting herbicide-tolerant soybean, corn, cotton, and canola have been able to convert much of their operations to "no-till" production. In some regions of the world, this practice keeps more organic matter on the land between plantings and leaves the soil relatively undisturbed, reducing erosion.[33,77] Because tillage is reduced, greenhouse gas emissions resulting from burning of tractor fuel[78] or production of feed required for draught animals in smallholder systems is also reduced.[79,80] Reduced tillage also minimizes moisture loss, an increasingly important goal in the face of climate change. Because soils contain more carbon than all terrestrial vegetation and the atmosphere combined, no-till practices may mitigate climate change through carbon sequestration.[79,81,82]

According to the legal analysts Martha Marrapese and Keith A. Matthews and agricultural economists Richard Sexton and David Zilberman, higher-yielding and pest-resistant crops developed through genetic engineering have reduced the use of carbon-intensive inputs including fuels and other chemicals such as insecticides.[74]

Adoption of these genetically engineered crops can reduce fuel consumption by 19% on average.[83] Sexton and Zilberman reported that carbon emissions associated with production, packaging, and transport of agrochemicals could be reduced in the United States through the use of genetically engineered cotton in an amount equivalent to removing 23,000 cars from the road.

Marrapese and Matthews estimated that by the mid-21st century, the temperatures in California, one of the largest and most productive agricultural regions in the world that produces 50% of the nation's fruit, vegetables, and nuts, may exceed those optimal for the growth of these trees.[74]

I paddled back to the pier, tied up the paddleboard, and jumped in the lake to wash away my gloomy thoughts. Then I walked up the hill with Katie running beside me.

As I walked, it struck me that, whereas opposition to climate science is quite politically divided, the hesitation to use vaccines or consume crops developed through genetic engineering includes both liberals and conservatives.[84] But whatever the reason—political or not—rejection of the evidence-based conclusions of scientific institutions hinders our ability to tackle the perils associated with climate change (droughts, floods, and outbreaks of pests and diseases) and the challenges associated with feeding and nourishing a growing population.[75,76]

I joined Jane in the kitchen.

We admired the food my mother had already prepared for that night's meal: homemade lasagna, salad, fresh roasted eggplant, and plum tart. We had plenty to eat. It was almost impossible to imagine being hungry or that the hunger of others would affect us.

But I was discouraged. "No wonder there are so many new initiatives restricting what crops farmers can grow. None of us knows what it is like to be hungry, and few of us grow food. We cannot even imagine what it is like. People don't think about farmers much, especially farmers in less developed countries who grow only enough to feed themselves and their families."

Jane scowled, "We will feel it alright. Just wait."

I was startled by her response, "What do you mean?"

Jane said, "What do you think happens when a lot of hungry people see us eating and drinking? Conflict. It is not a stable world when a few have plenty of food and water and others cannot feed their children."

She is right. If there was any doubt, the December 2011 to March 2017 California drought and the 2008 food riots in Haiti and other parts of the world have made it clear.[85,86] Research showed that drought contributed to the Syrian uprising.[87]

Our friend Tommy arrived and joined the conversation. He had recently become a vegetarian and was distressed about the changing climate and the potential negative environmental impacts of growing animals. He heard us talking and interjected, "Monsanto is going to ruin the environment, and that's why we'd better stop genetic engineering while we still can."

"Tommy," I said, "Monsanto is not the only group that uses genetic engineering."

"Well, maybe not, but they control who does the research, and they are the ones that benefit," he said.

I explained that the work in my laboratory was funded by the National Science Foundation and other federal agencies, not by Monsanto. It had been more than 20 years since Monsanto funded a project in my lab.

"Do you want to get rid of publicly funded scientists, too?" I asked.

He answered, "I thought Monsanto funds all the plant research?"

I hear this often. But as far as I can tell, Monsanto is not dictating the research or opinions of any of my colleagues. In 2014, Monsanto's contributions to the entire UC Davis research budget amounted to less than one tenth of 1%. I explained this to Tommy, who looked puzzled. Facts don't necessarily have the power to change minds.

Later in the day, Jane, Rick, and I continued the conversation.

"The Earth has so many problems," I commented. "Why do people spend so much time challenging the scientific consensus on the safety of genetic engineering, the reality of climate change, or the usefulness of vaccines?"

Rick shrugged. "People are scared."

"I guess so." I added, "People are worried about the world's problems and want to do something to make it better."

"Besides, scientists make mistakes," Rick said. "They shouldn't be so sure they are right all the time. Scientists seem arrogant."

My brother Rick has paid attention to the antivaccine campaigns in his community of Marin County. "Many of my friends are afraid to vaccinate their children. You would feel the same if you were convinced that your

first child was autistic due to vaccinations. They are educated people. They are not crazy anti-science fundamentalists. You need to be more sympathetic. Why is it okay to force people to vaccinate? What if the scientists are wrong on this?"

Jane answered, "Of course individual scientists can be wrong. But the data on vaccines is not based on individual scientific opinion. It is a body of research that has been studied and validated for more than 200 years. The evidence is clear that vaccines save lives. The burden should be on the person making the poor choice. It is not ethical to expose unvaccinated children to the community."

"They want to choose their risks. It seems unfair to force them to vaccinate their kids," Rick said.

Jane was adamant, "If they had seen what I have seen, they would vaccinate their children immediately. Some of my patients have post-polio syndrome. Some have scarring from measles. I wish people would not so quickly believe what they see on the Internet."

"It is not only vaccinations they are afraid of," she added, "There are so many other medical issues that confuse patients. Every week I see patients who believe that they have a bladder disease because they urinate frequently. Most of the time, it is simply that they are drinking too much water. They read on the Internet that drinking water will keep your skin from aging. There is no scientific evidence for that."

I told Jane and Rick about a tragic story: "A friend of mine believed that it was important to drink large amounts of water during labor. She told me that she lost her baby because of drinking too much. It is because of a condition I had never heard of, called hyponatraemia.[88] It was just awful."

My friend was not anti-science; she was not uneducated. She was simply following the advice of her naturopathic adviser. In surveys of families in Michigan, Mark Largent, a Michigan State University professor, discovered that 92% of people got information about vaccines from their physicians, but 38% also got information from alternative practitioners.[15] Fewer than 4.5% of the participants read scientific studies. Many people tended to view human-made products as more risky than those they perceived as natural.[89] Mark argued that the medical community must work to educate alternative medical care providers because they influence the health care choices of many patients.

Jane said, "I get it that many people are scared and don't know where to get scientific information. They don't know they are putting their children at

risk. But what I don't get is why so many in Marin accept the science that the climate is changing but reject the science that vaccines and genetically engineered crops on the market are safe and effective (see Box 8.5). I am frustrated when I hear of people picking and choosing their science as if it were a fashion choice."

BOX 8.5 **GMO: What Is the Independent Scientific Consensus?**

The National Academies of Science released a report in 2016, confirming their earlier statements on genetically engineered crops.[26]

The same scientific organizations that most of us trust when it comes to the changes in climate state that the process of genetic engineering is no more risky than other methods of crop genetic improvement:

Organization	**Statement on Climate Change**	**Statement on GMOs**
American Association for the Advancement of Science	"The scientific evidence is clear: global climate change caused by human activities is occurring now, and it is a growing threat to society." (AAAS Board Statement on Climate Change, 2006)	"The science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe." (AAAS Board Statement on Labeling of Genetically Modified Foods, 2012)
American Medical Association	"Our AMA . . . supports the findings of the Intergovernmental Panel on Climate Change's fourth assessment report and concurs with the scientific consensus that the Earth is undergoing adverse global climate change and that anthropogenic contributions are significant." (Global Climate Change and Human Health, 2013)	"Our AMA recognizes that there is no evidence that unique hazards exist either in the use of rDNA (GE) techniques or in the movement of genes between unrelated organisms." "Bioengineered foods have been consumed for close to 20 years, and during that time, no overt consequences on human health have been reported and/or substantiated in the peer-reviewed literature." (Report of the Council on Science and Public Health, 2012)

Organization	Statement on Climate Change	Statement on GMOs
National Academies of Science (USA)	"The scientific understanding of climate change is now sufficiently clear to justify taking steps to reduce the amount of greenhouse gases in the atmosphere." (Understanding and Responding to Climate Change, 2005)	"Genetic engineering is one of the newer technologies available to produce desired traits in plants and animals used for food, but it poses no health risks that cannot also arise from conventional breeding and other methods used to create new foods." (Expert Consensus Report: Safety of Genetically Modified Foods, 2004) "An analysis of the U.S. experience with genetically engineered crops shows that they offer substantial net environmental and economic benefits compared to conventional crops. ... Generally, GE crops have had fewer adverse effects on the environment than non-GE crops produced conventionally." (Impact of Genetically Engineered Crops on Farm Sustainability in the United States, 2010)
World Health Organization	"There is now widespread agreement that the Earth is warming, due to emissions of greenhouse gases caused by human activity. It is also clear that current trends in energy use, development, and population growth will lead to continuing—and more severe—climate change." (Protecting Health from Climate Change, 2008)	"GM foods currently available on the international market have passed risk assessments and are not likely to present risks for human health. In addition, no effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved." (20 Questions on Genetically Modified Goods, 2013)

Organization	Statement on Climate Change	Statement on GMOs
European Commission	"There is unequivocal evidence that the Earth's climate is warming. . . . The consensus among climate experts is that it is extremely likely that the main cause of recent warming is the 'greenhouse' gases (GHGs) emitted by human activities, in particular the burning of fossil fuels—coal, oil and gas—and the destruction of forests." (Climate Change Fact Sheet, 2012)	"The main conclusion to be drawn from the efforts of more than 130 research projects, covering a period of more than 25 years of research, and involving more than 500 independent research groups, is that biotechnology, and in particular GMOs, are no more risky than conventional plant breeding technologies." (A Decade of EU-Funded GMO Research, 2010)
The Royal Society (UK)	"There is strong evidence that the warming of the Earth over the last half-century has been caused largely by human activity, such as the burning of fossil fuels and changes in land use, including agriculture and deforestation." (Climate Change: A Summary of the Science, 2010)	"A previous Royal Society report (2002) and the Government's GM Science Review (2003/2004) assessed the possibilities of health impacts from GM crops and found no evidence of harm. Since then no significant new evidence has appeared. There is therefore no reason to suspect that the process of genetic modification of crops should per se present new allergic or toxic reactions." (Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture, 2009)
International Science Academies: Joint Statement	"Climate change is real... there is now strong evidence that significant global warming is occurring. The evidence comes from direct measurements of rising surface air temperatures and subsurface ocean	"GM technology has shown its potential to address micro-nutrient deficiencies [in developing nations]. . . . GM technology, coupled with important developments in other areas, should be used to increase the production

Organization	Statement on Climate Change	Statement on GMOs
	temperatures and from phenomena such as increases in average global sea levels, retreating glaciers, and changes to many physical and biological systems. It is likely that most of the warming in recent decades can be attributed to human activities." (The Science of Climate Change, 2001)	of main food staples, improve the efficiency of production, reduce the environmental impact of agriculture, and provide access to food for small-scale farmers. . . . Decisions regarding safety should be based on the nature of the product, rather than on the method by which it was modified. It is important to bear in mind that many of the crop plants we use contain natural toxins and allergens." (Transgenic Plants and World Agriculture, 2000)

From Ryder, D. "Infographic: Climate Change vs. GMOs: Comparing the Independent Global Scientific Consensus." *Genetic Literacy Project*, July 8 2014.

Rick said, "Some people believe that children have died from vaccines, so they don't want to take that risk."

Jane frowned. "Vaccines have saved millions of lives, and there is no scientific evidence that a vaccine has ever killed anyone.[90,91] Those who *don't* vaccinate run the risk of losing their lives or spreading a deadly virus to an unvaccinated baby."

Rick said, "That may be true, but nothing is absolute, and it should not be presented that way by the scientific community. Anyway, it is a free country, so people should not be forced to vaccinate."

The discussion had become heated. It had moved beyond science and health and entered a realm that was clearly more about emotions than a dispassionate discussion of the facts. I was struck that maybe Rick felt that scientists

are unfeeling and not sympathetic to his community. I felt bad about this. I am not unsympathetic. I know, though, that the data are stark, and I am frustrated by the massive amount of misinformation about health and science.

The tendency of people to believe their peers is powerfully important and helps explain why our conversation had gotten emotional. Agreeing with one's peers demonstrates that you are a loyal member, deserving of the group's acceptance and its protection. As social animals, we have evolved to rely on our group to keep us safe. The instinct to agree with the views and values of your peers is rooted deep in in us. Arguing over those views and values challenges something important. But relying on your peer group and its thought leaders rather than relying on science drives much of the misinformation. Michael Specter points out that consumers have a tendency to trust anecdotes over peer-reviewed results, which may explain why today "the United States is one of the only countries in the world where the vaccine rate for measles is going down."[92] "It's understandable why people are drawn to anti-vaccine conspiracy theories," explained Rob Brotherton, an academic psychologist and author of *Suspicious Minds: Why We Believe Conspiracy Theories*, in an interview with journalist Olga Oksman.[93] "When people are dealing with some of the most important choices in their lives, like how to raise their children, and something unsettling happens, your brain will reach for explanations, for a sense of order." A person under those circumstances may have difficulty critically evaluating the evidence presented. The Internet, for example, has a disproportionate set of stories written by people who are convinced that vaccines are bad.

Jane said, "A few years ago, the US representative Michelle Bachman announced that the HPV vaccine causes mental retardation.[94] It's a complete fabrication, yet people believed it! Then, Sarah Palin came along and basically agreed with Bachmann.[95] It was awful. Parents are afraid to vaccinate because of this kind of fear mongering. My colleagues and I spend a *lot* of time every week explaining to parents that vaccinations are an important part of their children's health."

"I agree it is idiotic for politicians to scare people." Rick said, "But still, we need to balance individual choices with the greater good of society. When scientists and doctors talk to the public about vaccines and GMOs, it would be good for them to recognize that everyone wants a choice."

He continued, "I am just saying that even if it is clear that vaccinations benefit the community, that is not necessarily the way to go. Sure, vaccinations save lives, but that is only one factor in the equation. The father who refuses to

vaccinate his child may be making a poor health choice, but he is not wrong for wanting to protect his child based on the information he has."

Jane responded, "Making a poor health choice is not good parenting. In some ways, science has done too well and kept the bad consequences at bay. If more parents had seen a child die from measles, they would be the first in line asking that their kid be vaccinated. They would know the serious effects of not vaccinating."

"That's true," Rick said. "A big reason people are willing to make the choice not to vaccinate is that they don't see the risk of not vaccinating because vaccination has been so effective. No matter what you tell someone, if they have not seen anyone contract polio, they will not be too worried about it. And if they have seen the TV show with 15 reasonable-looking mothers swearing that a vaccination caused their child's severe illness, and have met two reasonable mothers who know one of those mothers, they are going to start thinking twice about vaccinations—but only because there is no perceived downside or risk."

"Anyway, I am not saying that it is a good move to *not* vaccinate," Rick continued. "I just think you are too hard on the people who think it is risky. Why shouldn't they be able to make their own choice?"[11]

Jane countered, "They should not be allowed to make their own choice about vaccines because they are endangering the lives of others when they send their unvaccinated kids to school.[96] If they don't vaccinate their children, they can choose to homeschool them."

"That is a reasonable solution," Rick agreed. "If people feel so strongly about not vaccinating, they can choose not to send their kids to public schools. They can keep them at home, or if they can afford it, they can send their kids to private school and set their own policies."

The compromise that Rick and Jane came up with is now the law in the state of California (Box 8.6). It allows for choice but at the same time ensures that the children in the public schools will all be vaccinated.

Rick has convinced me that parents who reject vaccines are not irrational. My plane companion Rebecca and many others believe that GMO seeds and vaccines are not properly regulated. They have heard many frightening stories from sources that they trust—their grocery stores (such as Whole Foods or the local co-op), their friends, family, coworkers, alternative health practitioners, and online forums. In this context, a decision to refuse vaccination or food labeled GMO is perfectly rational.

The problem is that people pick and choose their information. We can do that as never before in the modern media era. People select the information

BOX 8.6 **Vaccine Laws**

In the summer of 2015, Governor Jerry Brown of California signed one of the strictest school child vaccination laws in the country, eliminating personal and religious belief exemptions.[97] Children who are not vaccinated will not be permitted to attend public or private schools; homeschooling will be their only option.

"The science is clear that vaccines dramatically protect children against a number of infectious and dangerous diseases," Brown said in a signing statement. "While it's true that no medical intervention is without risk, the evidence shows that immunization powerfully benefits and protects the community."

The bill's author, Richard Pan, said, "The courts have been very clear that you don't have a right to spread a communicable disease, that there's a public interest in keeping our communities safe from disease."

The bill's passage has enhanced vaccination rates, but there will be some parents who are so anxious that they will remove their children from public schools and the public health system rather than vaccinate. This is not a goal the medical community wants to achieve.

A less authoritarian approach was adopted in Michigan. There, waivers are still allowed, but parents must go to the public health department and sit through a 30-minute education program. Preliminary results indicate a 30% reduction in waiver rates as compared to programs where no education was required.[15]

that fits their feelings and values and worldviews and reject anything that conflicts with them,[98] including science-based information. Feelings are an inescapable part of our perceptions, no matter how well informed we are. In fact, the more educated we are, and the more careful thinkers we are (two measures of "intelligence"), the better we are at distorting the facts into views that match our group's views.[99] Cognitive studies show that we don't like to work too hard to figure things out, so we don't access the scientific information that is available, which is why anecdotes carry more impact. Choosing information from trusted thought leaders of our tribe saves us work (Boxes 8.3 and 8.6).

There are still more cases than not in which science-based information prevails. For example, an increasing number of people have begun to accept what scientists concluded years ago, that the climate is changing, although only about half of Americans believe that human activity plays a role.[100] That may partly be due to the fact that more people are experiencing changes firsthand, in their local environments, including drought, record-breaking rains

and floods, and hurricanes. In California, the climate is changing before our eyes. None of us had ever experienced a drought like the one from 2012–2017. But undervaccination is different. Few people in the United States have yet suffered the consequences.

Jane remarked, "And it is the same with food in California. We have plenty of it. As long as a person can get the food they want at the price they want, why would they take a chance on eating a genetically engineered crop? It is different for papaya farmers in Hawaii who have seen that a viral infection can destroy their crop, or for eggplant farmers in Bangladesh who has seen the damage of insect infestation and the harmful effects of chemical insecticide sprays on their families. They already know that technology matters for the health of their farms and the health of their families. But for most of us in the cities, the controversy over GMO food won't become a non-issue until we are no longer able to buy our favorite foods."

I hope Jane is wrong. The scenario that controversy and rejection of useful technologies will continue until urban dwellers feel pain is grim. It may be that better access to science-based information on vaccines, plant genetics, food, and farming can help consumers and policy makers make environmentally sound decisions. But cognitive science reveals that we are subjective about how we get our information, what we trust and believe, and how we feel about the facts we get. Feelings are an inescapable part of our perceptions, no matter how well informed we are.[99] So, how can we move forward?

According to David Ropeik, "The lesson is that if we want to make the smartest possible choices about how to keep ourselves safe, we need to challenge ourselves to go beyond what instinctively feels right and try to blend our feelings with a careful, thoughtful consideration of what might actually do us the most good."[101]

CHAPTER 8: THE MISTRUST OF SCIENCE

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90. With any medicine, including vaccines, there is a chance of side effects. But these symptoms are usually mild (e.g., fever and headaches) and go away without treatment. In rare cases (estimated at <1 in 1 million doses), patients suffer a severe allergic reaction.
91. Contrary to popular belief, there has not been a verified instance of death or autism from a vaccination. And consider the dangers of *not* vaccinating your child with the tetanus,

diphtheria and pertussis (TDAP) vaccine. Tetanus kills about 1 of every 5 people who are infected. Diptheria can lead to breathing problems, paralysis, heart failure, and death. Pertussis (whooping cough) causes severe coughing spells, which can result in difficulty breathing, vomiting, and disturbed sleep. It can also lead to weight loss, incontinence, and rib fractures. Up to 2 of every 100 adolescents and 5 of every 100 adults with pertussis are hospitalized or have complications, which could include pneumonia or death.[102]

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96. Children in communities that have a high percentage of parents who don't vaccinate their children, like Marin County, are particularly susceptible to preventable diseases.[103,104] Measles has caused millions of deaths since its emergence thousands of years ago. In developed countries, 1 of every 1000 children infected with measles dies. In sub-Saharan Africa, it is even worse: 5% to 10% of children infected with measles die.[105] Measles-mumps-rubella (MMR) vaccine has saved many lives, yet it is also on the decline. In February 2014, there was an outbreak of measles in Disneyland.[104]; 110 Californians were infected, most of whom were not vaccinated. Of the unvaccinated children, 67% were not vaccinated because of the personal belief of their parents.
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CHAPTER 9: CONSERVING WILDLANDS

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