Industrial Diets

According to science fiction shows like Star Trek, food in the future will be produced by replicators. All you have to do is walk up to a machine that looks like a microwave and command it to produce something you desire like "Tea, Earl Grey, hot" or "macaroni and cheese" and, voila, the atoms necessary to make the dish will be assembled in just the right way. This fantasy of future food is actually not that far off from the way many people sustain themselves today and makes the differences between Paleolithic and agricultural era diets seem fairly trivial. Even though farmers neither hunt nor gather they do at least grow and process their food. How about you? Did you grow or raise anything you ate today? In fact, did you even have to process it? The average American or European consumes about a third of all meals outside the house, and when we cook, we mostly unwrap, combine, and heat different ingredients. I love to cook, but the most intensive work I usually do is to peel a carrot, dice an onion, or grind stuff in a food processor.

From a physiological perspective, the Industrial Revolution changed our diets as much if not more than the Agricultural Revolution. As chapter 8 reviewed, by switching from hunting and gathering to herding and cultivating, the first farmers increased the amount of food they could obtain, but at a cost. Farmers not only must work hard, but the food they produce is less diverse, less nutritious, and less certain than what a hunter-gatherer eats. By using machines to produce, transport, and store food in the same way we do textiles and cars, the Industrial Revolution abated some of these trade-offs and magnified others. These shifts began in the nineteenth century, but they intensified after World War 2, especially in the 1970s, as gigantic industrial corporations took over the business of making and producing food from small-scale farmers. In much of the developed world, the food we eat is now as industrial as the cars we drive and the clothes we wear.

The biggest change brought about by the industrial food revolution is that food producers (one cannot really call them farmers) have figured out how to grow and manufacture as cheaply and efficiently as possible exactly what people have desired for millions of years: fat, starch, sugar, and salt. The result of their ingenuity is a superabundance of inexpensive calorie-dense food. Consider sugar. The only really sweet food a hunter-gatherer can eat is honey, which usually requires walking many miles to find a hive, climbing the tree, smoking out the bees, and then bringing the honeycomb back. Sugarcane became a crop in the Middle Ages, and its cultivation accelerated during the eighteenth century, largely by using slaves to produce massive quantities in plantations. With the end of slavery in the late nineteenth century, industrial methods were

applied to sugar production, and modern farmers now use specialized tractors to plant enormous fields of domesticated sugarcane and sugar beets, which have been bred to be as sweet as possible. Other machines are used to irrigate the plants and to make and spread fertilizers and pesticides, which increase yields and minimize crop losses. Once grown, these supersweet plants are harvested and processed by yet more machines to extract the sugar, which is then packaged and shipped all over the world by ships, trains, and trucks. The availability of sugar increased even more dramatically in the 1970s when chemists devised a method to transform cornstarch into a sugary syrup (high fructose corn syrup). About half the sugar Americans consume now derives from corn. After adjusting for inflation, a pound of sugar today costs one-fifth what it did one hundred years ago.' Sugar has become so superabundant and so cheap that the average American consumes more than 200 pounds (45 kilograms) a year. Perversely, some people now pay extra money to buy foods made with less sugar.

Unless you have a garden or go to farmers' markets, the chances are that most of what you eat - including free-range eggs and organic lettuce - was grown industrially, often with the support of government subsidies to keep quantities abundant and prices low. Between 1985 and 2000, when the purchasing power of a U.S. dollar decreased by 59 percent, the price of fruits and vegetables doubled, fish increased by 30 percent, and dairy remained about the same; in contrast, sugars and sweets became about 25 percent less expensive, fats and oils declined in price by 40 percent, and soda became 66 percent less expensive. At the same time, portion sizes ballooned. If you were to walk into an American fast-food restaurant in 1955 and order a hamburger and fries, you'd consume about 412 calories, but today for the same price (in inflation-adjusted dollars) the same order would have double the amount of food, totaling 920 calories. Soda consumption in the United States has more than doubled since 1970, now averaging more than 150 liters (about 40 gallons) per year. According to U.S. government estimates, bigger and more calorie-dense portions have caused the average American to consume about 250 more calories per day in 2000 than in 1970, a 14 percent increase.

Industrial food may be inexpensive, but its production exacts a significant toll on the environment and on the health of workers. For every calorie of industrial food you eat, approximately 10 calories of fossil fuel were spent to plant, fertilize, harvest, ship, and process the food before it got to your plate. Further, unless the food was organic, massive quantities of pesticides and inorganic fertilizers were used, polluting water supplies and sometimes poisoning workers. The most extreme and disturbing type of industrial food is meat. Because humans have craved meat perhaps more than anything else (except possibly honey) for millions of years, there is a strong incentive to produce cheap, plentiful meat, especially beef, pork, chicken, and

turkey. Satisfying this craving, however, was a challenge until recently, keeping meat consumption modest. Despite having domesticated animals, early farmers generally ate less meat than hunter-gatherers, because animals are more valuable alive for their milk than dead for their flesh and because farm animals require lots of land and labor, especially if one has to make and store hay to feed them during the winter. Food industrialization altered this equation dramatically by employing new technologies and economies of scale. Most of the meat Americans and Europeans eat is grown in giant facilities called concentrated animal feeding operations (CAFOs). CAFOs are huge fields or barns where hundreds to thousands of animals are fed grain (usually corn) in crowded conditions. The animals respond just as we do to being fed an abundance of starch without exercising: they get fat. They also have high rates of disease because concentrated animal wastes and high animal densities promote infectious diseases, and because species such as cows have digestive systems adapted for grass rather than grain. As a result, the animals require endless administrations of antibiotics and other medicines to keep their chronic diarrhea under control and to prevent them from dying (the antibiotics also increase weight gain). CAFOs also generate copious quantities of pollution. Do the economic benefits of industrially producing so much low-quality inexpensive meat outweigh the costs to human health and the environment?

The other major shift in human diet since the industrial food revolution is how foods are increasingly modified and processed to increase their desirability, convenience, and storability. Millions of years of struggling to get enough food probably explains why people consistently prefer processed foods with low fiber and high concentrations of sugar, fat, and salt. In turn, manufacturers, par-ents, schools, and anyone else who sells or provides food are happy to give us what we want, and an entire new profession of food engineers has been created to design new processed foods that are appealing, inexpensive, and have a long shelf life. If your supermarket is anything like mine, more than half the foods for sale are substantially processed and more ready to eat than most "real food." I spent years as a parent trying to limit people's efforts to serve these processed foods to my daughter. Instead of giving her an apple, she'd be given a fruit roll, a fruit-flavored candy ludicrously marketed as a substitute for fruit that has the same number of calories and vitamin C, but without the fiber or any other nutrients.

Processing food by grinding it into tiny particles, removing fiber, and increasing its starch and sugar content changes how our digestive systems function. When you eat something, you have to expend some energy to digest it, to break the molecules down and transport the nutrients from your gut to the rest of your body. (You can feel and measure the energy cost of digestion by how much your body temperature rises after eating a meal.) This cost is significantly

reduced—by more than 10 percent—when you eat more highly processed foods that have smaller particle sizes." If you grind up a steak into hamburger or a handful of peanuts into peanut butter, your body will extract more calories per gram of food with less cost. Your gut digests the food using enzymes, proteins that bind to the surface of food particles and break them down. Small particles have more surface per unit mass, so smaller particles are digested more efficiently. In addition, processed foods with less fiber, such as white flour and white rice, require fewer steps and less time to digest, causing blood sugar levels to rise more quickly. Such foods (termed high glycemic foods) are quickly and easily broken down, but our digestive systems are not well adapted to the rapid swings in blood sugar levels they cause. When the pancreas tries to produce enough insulin that fast, it often overshoots, causing elevated levels of insulin, which then causes blood sugar levels to plunge below normal, making you hungry. Such foods promote obesity and type 2 diabetes. So just how much has industrialization changed what individuals eat? One should mistrust simplistic characterizations of diets, both today and in the past, because there was no single diet eaten by hunter-gatherers or farmers, just as there is no single modern Western diet. Even so, table 5 compares reasonable approximations of a typical, generalized hunter-gatherer diet with estimates of what a typical modern American eats, and with U.S. government recommended daily allowances (RDAs). Compared to foragers, people who eat industrial diets consume a relatively high percentage of carbohydrates, especially sugars and refined starches. Industrial diets are also comparatively low in protein, high in saturated fats, and exceedingly low in fibre. Finally, despite manufacturers’ abilities to load foods with calories, industrial diets contain low quantities of most vitamins and minerals, with the obvious exception of salt.

In short, the invention of agriculture caused the human food supply to increase in quantity and deteriorate in quality, but food industrialization multiplied this effect. Over the last hundred years, people have developed many technologies to produce orders of magnitude more food that is usually nutrient poor but calorie rich. Since the Industrial Revolution began about twelve generations ago, these changes have enabled us to feed more than an order of magnitude more people and to feed them more. Although approximately 800 million people today still face shortages of food, more than 1.6 billion people are overweight or obese.

TABLE 5. Comparison of Standard Hunter-Gatherer and American Diets, and the U.S. Government Recommended Daily Allowances (U.S. RDA)

Data are averaged for males and females.

Item	Hunter-gatherer	Average American	U.S. RDA
Carbohydrate (% daily energy)	35–40%	52%	45–65%
Simple sugars (% daily energy)	2%	15–30%	<10%
Fat (% daily energy)	20–35%	33%	20–35%
Saturated fat (% daily energy)	8–12%	12–16%	<10%
Unsaturated fat (% daily energy)	13–23%	16–22%	10–15%
Protein (% daily energy)	15–30%	10–20%	10–35%
Fiber (g/day)	100 g	10–20 g	25–38 g
Cholesterol (mg/day)	>500 mg	225–307 mg	<300 mg
Vitamin C (mg/day)	500 mg	30–100 mg	75–95 mg
Vitamin D (IU/day)	4,000 IU	200 IU	1,000 IU
Calcium (mg/day)	1,000–1,500 mg	500–1,000 mg	1,000 mg
Sodium (mg/day)	<1,000 mg	3,375 mg	1,500 mg
Potassium (mg/day)	7,000 mg	1,328 mg	580 mg

Modern American dietary data is from http://www.cdc.gov/nchs/data/ad/ad334.pdf, and the hunter-gatherer diet estimates are based on M. Konner and S. B. Eaton (2010). Paleolithic nutrition: 25 years later. *Nutrition in Clinical Practice* 25: 594–602.