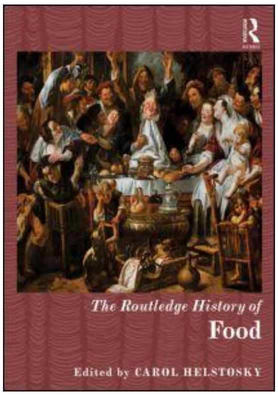

The Routledge History of Food

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Industrializing Diet, Industrializing Ourselves

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INDUSTRIALIZING DIET, INDUSTRIALIZING OURSELVES

Technology, food, and the body, since 1750

Chris Otter

> Previously food and factories had nothing to do with each other, but now many artificial processes have been interposed between man and the plants and animals from which his food is derived … *We do not know what has been added to or taken away from our food.* Mummified preparations are vividly dyed to simulate the green freshness of plants, the red or yellow of fruit juices, the golden colour of butter and eggs.
>
> R.H.A. Plimmer and Violet G. Plimmer, *Food and Health*, 1925

During the twentieth century, anxieties about the "industrialization" of food have been expressed in various ways. The mysterious processes interposing between producer and consumer have been regarded with suspicion. Nothing, perhaps, embodies humanity's increasing detachment from "nature" more than the increasingly synthetic, artificial nature of food. Foodstuffs, the Plimmers suggested, bear little resemblance to the plants and animals from which they are derived. Food systems themselves disturb ecologies and devour energy. This chapter provides a schematic overview of the history of food industrialization and of the unease that it generated.

The Industrial Revolution was a globally transformative process. It was also a vital phase in world food history. The transition from an "organic" economy, powered by renewable but unreliable energy sources, to a "mineral" economy driven by non-renewable but energy-dense fossil-fuels, enabled food systems to expand in scale.[1] Steam and internal combustion engines liberated food distribution from the constraints of wind, water and animal power. This allowed industrializing nations to outsource food production and concentrate on manufacturing, something particularly true in Britain:

> The British Isles are but the center of a vast industrial system which ramifies to the corner of the earth … England produces only a very small part of its food supply. Owing no doubt to its gradual development of the machine-technique, the surplus which the machine made possible had gone in large part to maintain higher competitive standards of living … In short the national food supply rests upon the double contingency of production in foreign countries and the shipping available for bringing the food to British ports.[2]

Supply chains were extended and increasingly reliant upon mineral energy. Food became more processed than at any previous point in human history, with manufacturers creating food products.[3] Expanded food systems funnelled primary products to processing centers – factories, mills, dairies – where raw materials (sugars, oils) were refined and often sold to food manufacturers who combined the processed materials in order to create a finished product. Food production became mechanized and its organization was a crucial part of the story of the rise of managerial capitalism.[4]

The ensuing foodstuffs – bottled sauces, wrapped bread, chicken nuggets, candy bars, fish sticks, TV dinners – have certain defining characteristics. They tend to be highly durable, particularly when combined with refrigeration systems. They are energy-dense, providing intense bursts of calories. They often contain significant levels of fat and low levels of fibre. They are the archetypal foodstuffs of the nutrition transition: a shift towards a high-calorie diet rich in animal proteins, refined carbohydrates and fats which began in the west in the eighteenth century and which has since globalized.[5]

Since the nutrition transition is linked in complicated ways with the epidemiologic transition and the rise of "lifestyle" or "mismatch" diseases (diabetes, heart disease and so forth), the industrialization of diet is inseparable from the industrialization of the human body.[6] Some of the effects of this industrialization are positive (increased disease resistance, longer life expectancy) and some are negative (obesity). The effect on other living bodies has been even more profound. Wheat, corn, cattle and chickens have become significantly different as a consequence of selection, feeding and hybridization, making the industrialization of food a major event in "evolutionary history."[7]

Before beginning, a brief caveat is in order. It would be highly misleading to regard the industrialization of food as a purely "modern" phenomenon. Industrialization is not wholly synonymous with fossil fuels. Long-distance trade in foodstuffs has existed for millennia (witness spices moving from Han China to Rome, for example). Food processing is hardly modern: milling and food preservation (drying, salting, smoking), for example, have long histories.

Agriculture and industrialization

In *The Agrarian Question* (1899), Karl Kautsky declared that "the revolutionising of agriculture is setting in train a remorseless chase."[8] Kautsky wrote during a period of great transformation in agricultural technology. The invention of the mechanical (but still horse-powered) reaper by Obed Hussey (1833) and Cyrus McCormick (1834) transformed American agriculture: by 1864, almost 100,000 harvesters were being manufactured annually.[9] Agricultural machinery was thus "at the centre of the US industrial revolution" (see Figure 12.1).[10] By 1865, 80 percent of American wheat was harvested by machine: these technologies slowly permeated European agriculture thereafter.[11]

The industrialization of agriculture fundamentally altered the energy basis of world food production. When Kautsky wrote, fossil fuels had yet to truly pervade agriculture, but this began to change with the invention of steam- and oil-powered tractors and combine harvesters.[12] Gasoline-driven tractors were developed in the United States in 1889, and the appearance of functional power-take-off shafts amplified their appeal in the twentieth century.[13] Tractorization took off first in the United States and has spread globally since 1945. It was essential to what Cochrane and Ryan described as "a massive transference of cheap fossil fuels into agriculture" between World War II and 1973.[14]

Fig 15—American thrasher at work. Outfits of this general character can thrash one or two thousand bushels in a day, blow the straw off into great piles, and move themselves to the next farm after supper (International Harvester Co)

Figure 12.1 Steam thresher. From J. Russell Smith, *The World's Food Resources* (New York: Henry Holt, 1919)

The transition to a mineral economy, then, was as much an agricultural as a manufacturing phenomenon. Farming began drawing on the "accumulated wealth" of the earth's "subterranean forest" of coal and oil.[15] Land could now be used largely for food production, and the intimate spatial connection between urban areas and their agrarian hinterlands was shattered. The labor requirements of agriculture were correspondingly reduced. A mineralized agrarian economy could allow one-fiftieth of the labor force to produce food, while in organic economies, this figure could be as high as four-fifths.[16] Fossil fuels drove pumps which drained land, powered factories making farm tools, and provided raw materials for the manufacture of pesticides. As Howard Odum famously said, "industrial man no longer eats potatoes made from solar energy, now he eats potatoes partly made of oil."[17]

Perhaps the most significant fossil fuel input came with the invention of synthetic nitrate fertilizer by Fritz Haber in 1909. The ensuing Haber–Bosch process broke the limits of an organic fertilizer system built around manure and legumes, by relying upon mineral energy. Since 1945, natural gas has been used to manufacture nitrates in much of the world, while coal predominates in China.[18] The global use of synthetic fertilizers rose by nearly 250 percent between 1966 and 1986.[19] Vaclav Smil regards this technological achievement as the greatest of the twentieth century: "the single most important change affecting the world's population – its expansion from 1.6 billion people in 1900 to today's 6 billion – would not have been possible without the synthesis of ammonia."[20]

Hybridization and selection of crops has also contributed to this process. The first International Conference on Hybridization and Cross-Breeding was held in London in 1899.[21] The amount of hybrid corn grown on American farms rose dramatically in the mid-twentieth century.[22] New wheat varieties like Red Fife and Marquis came to dominate American and Canadian wheat farming (see Figure 12.2). Taken cumulatively, this amounted to a "biological revolution" in American agriculture.[23] Such crops were designed with various attributes in mind: yield, disease resistance, capacity to resist drought, and photoperiodicity. Global agricultural statistics can be unreliable, but it has been estimated that world food production has risen eighteen-fold between 1750 and 2000.[24]

Chicken

In 1901, J.A. Hobson observed that "weaving, baking, brewing, and a great number of home industries of last century have now become definite branches of industry."[25] The emergence of large-scale processing has been one of the most significant dimensions of food industrialization. The basic characteristics of food processing involve the transformation of raw materials into a more technologically-mediated product, often involving the

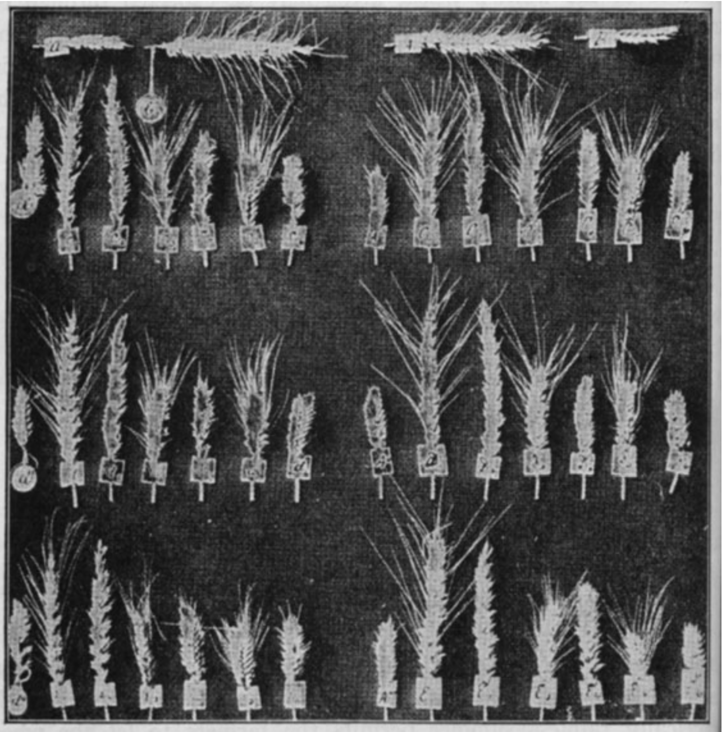

FIG. 23.—An experiment in plant breeding, cross-bred wheat showing gre
variation in offspring of hybrids.

ab, = parents.
a′ a″ a‴ = offspring of ab cross.
c_1c_2 etc., d_1d_2 etc., e_1e_2 etc. } = offspring of a′ a″ a‴.
BA = parents same variety as ab but crossed the other way.
A′A″A‴ = hybrid offspring of BA cross
C_1C_2, D_1D_2, E_1E_2 } etc. = offspring of hybrids A′A″A

Figure 12.2 Crossbred wheat. From J. Russell Smith, *Industrial and Commercial Geography* (New York: Henry Holt, 1926) accentuation of palatability and storability.[26] The twentieth-century tendency has been towards large-scale, heavily-capitalized operations, which has driven industry concentration: in 1947, there were around 42,000 food manufacturing companies in the United States, a number reduced by over one-half by 1977.[27]

Meat production, for example, has gone from being a generally small-scale, local operation to something much greater in size, scope and complexity. In Cincinnati, or "Porkopolis," dead pigs were hung from a rotating wheel upon which they were cleaned and gutted: thus was born the "disassembly line."[28] The meat industry was an early example of large-scale, industrialized food production.[29] The division of labor has become almost exquisitely specialized, as Timothy Pachirat has memorably described.[30] Slaughtering times have accelerated: in the early 1970s, the fastest slaughtering lines killed 179 cattle per hour; today, the figure is around 400.[31] Such speed demands the geographical concentration or "urbanization" of livestock through the formations of industrial feedlots with most inputs ultimately reliant upon oil.[32]

Chicken provides a particularly cogent example of this process: "chicken, an afterthought on American farms before World War II, has been transformed into the most studied and industrialized animal in the world."[33] Before 1930s, American chicken production was a largely incidental product of egg production, taking place on small farms scattered across the country.[34] In 1925, the average American consumed around half a pound of chicken annually; by 1995, this figure was 70 pounds.[35]

Certain aspects of chicken industrialization were evident in the early twentieth century. In Britain, birds were fattened in coops (seven feet long by eighteen inches wide).[36] Fattening began after around four months, with funnel crammers being used. In their authoritative guide to the British meat industry, Leighton and Douglas observed that "funnel cramming is done by inserting the nozzle of a specially made funnel into the gullet of the bird and then pouring in the food, which is made of the consistency of cream. This method is quicker than hand cramming, but great care must be taken not to choke the bird."[37] They concluded rather unconvincingly that "after the first few feeds the birds seem to welcome the appearance of the crammer at feeding time."[38] Some tubes ran straight into the chicken's stomach.[39] The use of incubators to regulate the temperature for hatching chicks became normal; the chicken's environment was becoming enclosed and regulated.

Geneticists analyzed the characteristics of this particularly plastic animal. William Bateson published the first scientific paper on chicken inheritance in 1902.[40] The map of the chicken genome has been relentlessly charted ever since.[41] Sewall Wright's development of mating systems analysis in the 1930s and 1940s enabled poultry breeders to better predict improvements, and by the 1940s, quantitative genetics was being utilized.[42] "Chicken of Tomorrow" contests, held in postwar America, were also genetically significant. By the early 1950s, most commercial American broiler chickens were descended from "Chicken of Tomorrow" prize winners.[43] The industry was soon organized around such hybrids: chicken engineering was underway.[44] These chickens were exceptionally efficient meat producers. In 1940, chickens required over four pounds of feed for every pound of weight gained; by the late 1980s, this amount had practically halved.[45] Antibiotics were added to feed as growth-promoters from the 1950s. Today's Cornish Cross chickens are specifically bred for their capacity for rapid growth: they represent the "pinnacle of industrial chicken breeding."[46] Today's broiler chickens reach market weight at forty-two days.

These animals are enfolded in an integrated, artificial, bounded landscape, in which light and heat are judiciously regulated. The American broiler industry became concentrated in western Arkansas, northern Alabama and northern Georgia.[47] These complexes became increasingly vertically integrated, with everything from hatching to processing undertaken within the same facility, with every part of the chicken utilized, including slaughterhouse waste being recycled as animal feed. Tyson, the world's most successful chicken company, was largely responsible for creating vertical integration, bringing previously dissociated elements of the industry together into one smoothly interconnected system.[48] This allowed chicken to be branded far more successfully than other forms of meat.[49] Such branding was facilitated by the invention of heavily processed types of chicken which bear little relation to the form of the original animal (nuggets, strips, patties), the sale of which has dramatically increased in the past three decades.[50]

Such intense industrialization is, perhaps, reaching its biological limits. The use of antibiotics is generating resistant strains of pathogen, and foodborne microbes like salmonella easily spread within poultry production ecologies.[51] Attempts to engineer perfect broiler chickens with high breast meat yields have produced several unintended biological consequences, from musculoskeletal problems to immunodeficiency. The metabolic stress placed on these animals has generated rising mortality rates.[52] Like cattle feedlots, intense systems of poultry production produce large volumes of fecal material, which can create ecological problems. In America's Delmarva Peninusula, 1.5 billion pounds of manure are produced annually, which is more than the waste from a city of four million people.[53] Excessive nitrogen and phosphorus are causing eutrophication in local water systems.[54]

White bread

The white sliced bread loaf has been one of the most vilified twentieth-century foodstuffs. "There is no crime that I know of that in my judgment equals the crime of the white-flour man," intoned one early twentieth-century crusader, "unless it is that of the man who bricks up his chimneys and compels his family to breathe over and over again the air that has been devitalised, out of which the oxygen has been burned by the stove."[55] White wheat bread has long been a status food, but only since the nineteenth century has it been democratized, and this democratization has catalyzed eulogy and discontent in equal measure.

Traditional milling used numerous techniques (stones, pestles, querns, handmills) to crush the whole grain. Bran was either left in the flour or sieved out. These industries were, to adopt Lewis Mumford's parlance, "eotechnic": they relied on human, animal, wind or water power.[56] In the nineteenth century, roller milling transformed the flour-making process. The first successful mill using rollers rather than stones was built by Sulzberger (a Zurich engineer) in 1834 and, although stone mills remained initially predominant, roller milling reached the United States and Central Europe after 1860, with Minneapolis and Budapest becoming centers of the global milling industry.[57]

Roller milling proceeded in several stages. First, various machines – sieves, magnets, aspirators, cylinders, washers – were used to clean the grain, and to remove stones and other impurities. Then, rather than being ground in one single operation, wheat was first broken and then reduced. Breaking wheat necessitated the use of spiral grooved rollers which crushed rather than fully ground the wheat.[58] The aim here was not to produce flour, but to remove as much bran as possible from the grain, which was then sifted and either re-broken or sent to another machine, the purifier. Purifiers removed bran flakes from middlings (as these intermediate products were often known), and hence made "a higher grade of flour than was ever known before."[59] The middlings were then *reduced* to flour by smooth rollers.[60]

Such a short summary of the complex milling process cannot do it justice. Indeed, as one commentator noted, a diagram was perhaps far superior "in conveying to the practical mind a deal of information which but for the flow sheet would necessitate the adoption of the exhausting and cumbrous plan of verbal or more probably detailed written information" (see Figure 12.3).[61] Flour emerged from roller mills in many clearly differentiated

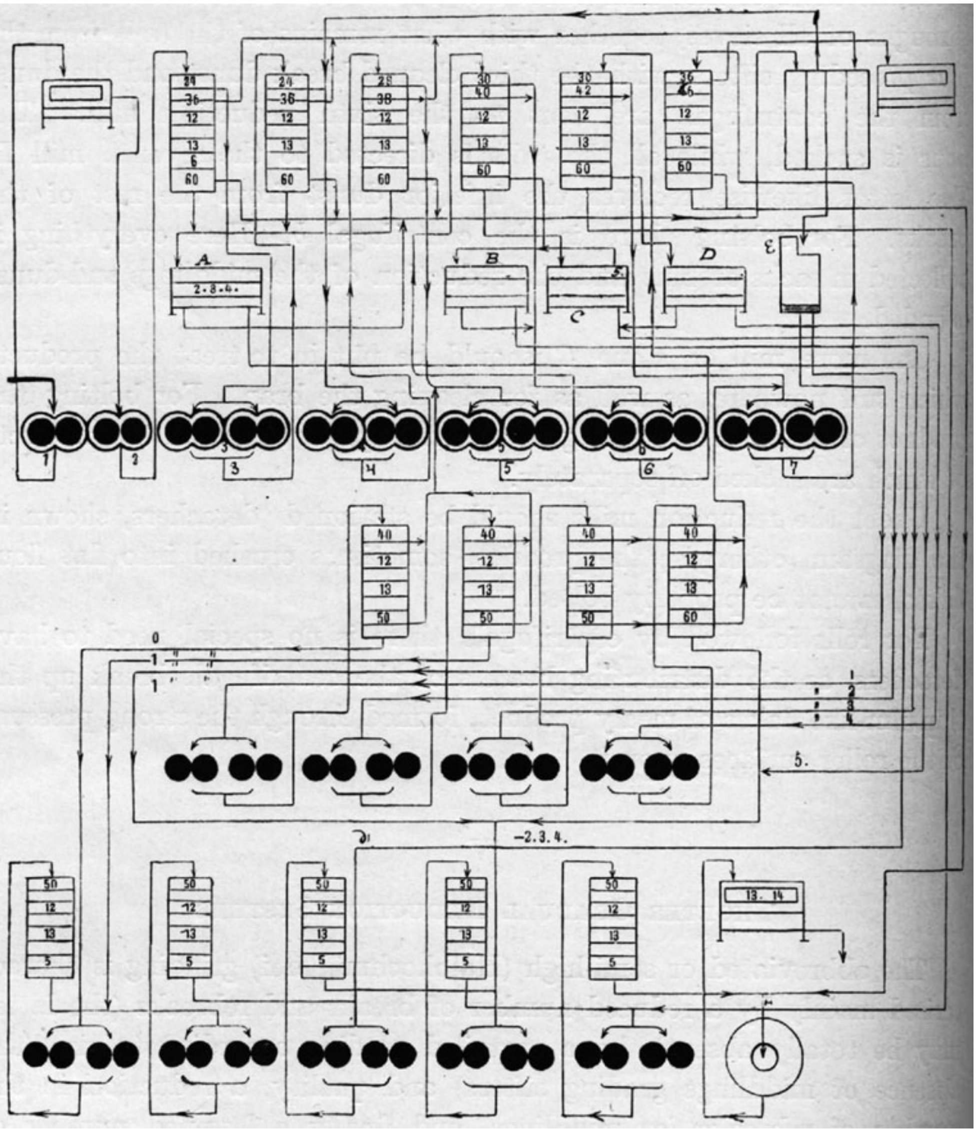

Figure 12.3 German abridged high milling. From Peter Kozmin, *Flour Milling: A Theoretical and Practical Handbook of Flour Manufacture for Millers, Millwrights, Flour-Milling Engineers, and Others Engaged in the Flour-Milling Industry*, trans. by M. Falker and Theodor Fjelstrup (London: G. Routledge & Sons, 1917)

and perfectly calibrated streams. It could then be blended into mixtures for particular purposes, and it was regularly bleached to accelerate the process of whitening, using chemicals like chlorine and nitrogen peroxide.[62] In 1914, the American Supreme Court ruled that bleaching was legitimate, and the practice has remained legal ever since.[63]

Mechanization appeared to be taking command: "milling, which was in ancient times a very simple process but a very laborious one, has now become a very complex process but one accomplished with comparatively little labour."[64] Mills themselves were large, multistoried buildings.[65] Fires were something of a hazard in early roller mills. One milling textbook documented 363 fires in twenty-two years, caused by sparks, fans, lights and inattentive workmen.[66] Engine rooms could be isolated from the rest of the mill, while automatic sprinklers were being installed in mills by the later nineteenth century.[67] According to William Voller, manager of the Albert Flour Mills in Gloucester, "the automatic sprinkler now dominates the entire field of flour mill insurance."[68]

Roller milling also engendered an energy transition in flour production. Early steam-driven flour mills used traditional millstones. The Albion Flour Mill, on the south bank of the Thames, was equipped with a steam engine in 1786 by Boulton and Watt. The mill burned down in 1791 and a rejoicing crowd watched the flames.[69] The progress of steam milling was rather slow in the following decades: some early German mills (for example at Stettin, Munich and Leipzig) deployed steam power.[70] Kanefsky estimated that in 1870, two-thirds of all horsepower available for British grain milling was produced by watermills, but he noted the decline in their numbers thereafter.[71] In 1865, William Stanley Jevons observed that "wind-cornmills still go on working until they are burnt down, or out of repair; they are then never rebuilt, but their work is transferred to steam-mills."[72] In 1933, windmills had largely fallen into disuse in Britain.[73] Milling was gravitating to large ports, where large milling companies controlled much of the trade.

A similar story is evident for baking. "The advent of machinery in the bakery has caused a revolution in bread baking," declared Harry Snyder, professor of Agricultural Chemistry at the University of Minnesota in 1930.[74] This revolution was quite dramatic, given the condition of baking in the mid-nineteenth century. In *Capital*, Marx described the English baking industry as "archaic" and "pre-Christian."[75] Despite the advent of biscuit-making technologies for navies, bakeries generally remained small-scale and frequently rather squalid institutions in Britain and the United States. As late as 1890, 90 percent of American bread was baked at home.[76]

The technological reform of the bakery was, however, underway by this date. By 1900, most British bakehouses had dough-kneaders and other forms of machinery were gradually being adopted.[77] Practical dough dividers, which split dough into precise sizes, entered the marketplace in 1896.[78] Oven designs proliferated, with the steam-pipe oven viewed by William Jago and his son, William C. Jago, overlords of British scientific baking, as particularly significant.[79] Sanitary concerns led to the development of wrapping. Wrapped bread first appeared in 1895, and the first reliable wrapping machine was built in 1913. By the 1920s, commercial bread was almost universally wrapped.[80] The first factory-produced sliced bread emerged in 1928 from the Chillicothe Baking Company in Missouri.[81] The mass-produced, sliced, wrapped white bread loaf had arrived, and it sold spectacularly well: it was a pure, streamlined loaf for an industrial age.[82]

This mass-produced industrial bread loaf required accelerated fermentation. Traditional techniques for breadmaking were laborious and time-consuming, but the development of the "straight" method, in which flour, salt, yeast and water were mixed simultaneously, reduced dough-making times to a few hours. The process could be shortened through the addition of more yeast and malt extract: such short processes became more popular in England, "and are almost universally used in machine or automatic bakeries."[83] Such technologies relied upon standardized, compressed yeast.[84] Baking was further accelerated by the development of the Do-Maker process in 1953, which allowed dough to be made in a few minutes by injecting a liquid ferment directly into the flour.[85] This system utilized a central control panel, allowing feed rates and desired dough viscosity to be pre-set, with meters showing the amount of ingredients entering the mixer, enabling rapid adjustments to be made.[86] By the early 1960s, "almost all bakery engineers are now attempting to do something on these lines."[87] The Do-Maker process has since all but disappeared, but it stimulated more successful technological developments like the Chorleywood Baking Process, or CBP (developed in England in 1961), which also combined mixing and dough development in a single integrated procedure.[88] The CBP was extremely fast and allowed the use of low-quality wheat to produce very cheap white bread: it has been adopted in Australasia and South Africa.[89]

Breadmaking was becoming almost a subdivision of engineering (the term "bakery engineer" was emerging into industry parlance).[90] The direct interaction with dough through touch and smell retreated, to be replaced by numerous gauges and instruments, from thermometers and clocks to farinographs and extensometers. There were profound transformations in plant personnel, with the production manager becoming responsible for a large bakery's production.[91] A complex division of labor typified bakery organization: workers were employed as dough-makers, dividers, or oven clearers, for example.[92] Cereal chemists oversaw the addition of various additives, such as milk, sugar and malt. Emulsifiers like soy flour and lecithin were increasingly used to soften bread and retard staleness by the 1960s.[93]

Mobility and durability

Archetypal industrial foods, like the chicken nugget and white sliced bread, were designed to be mobile and durable. They were easily packed and stacked. Chicken nuggets were engineered to move from freezer to plate in as little time as possible, while white bread was engineered to remain soft for far longer than traditional bread. Mobility and durability were not simply engineered into foods themselves: they were also properties of food infrastructures which had been liberated from the limits of organic power systems. Furthermore, the development of mechanical refrigeration, canning and chemical preservatives decreased the perishability of raw and processed foodstuffs. As a result, networks of food provision became longer and consumers in affluent parts of the world could consume many foods year-round, increasingly in a "fresh" condition.[94]

Food was hardly immobile before the development of a fossil fuel economy. Cattle were driven over significant distances: from Hungary to Italy, for example, or from Scotland to London.[95] The emergence of the railroad and steamship, however, substantially increased the ambit of regular trade in foodstuffs. They enabled the opening up of New World and European colonial territories. Railroads were integral to the development of Canadian wheat, for example: they funneled wheat from prairie elevators to major inspection points, whereupon the grain was exported. The protectionist National Policy encouraged railway construction in the later nineteenth century.[96] The result was the Canadian Pacific Railroad, "the spine of Canada."[97] In truth, it was more like a conveyor belt. South Asian wheat was also channeled into the world market by a huge rail network. Telegraphy combined with railroads to distribute information about prices and goods. American meat packing companies, for example, depended on railways and telegraphs. Distribution houses wired orders to central offices in Chicago, which monitored and controlled flows of orders to packing plants, and the meat which came from them.[98]

In the later nineteenth century, steamships carried live animals from North and South America to European markets, an arrangement which tended towards cruelty and which also enabled the intercontinental transfer of epizootics like foot and mouth disease. The development of mechanical refrigeration ultimately solved this problem. In the United States, experiments with refrigerator cars began in 1857.[99] These early systems relied on natural ice, and icing stations became a recognizable part of American railroad infrastructure (see Figure 12.4). Numerous patents were awarded after 1867 for refrigerated meat trucks.[100] The modernized refrigerator car, complete with refillable ice bunkers, appeared in 1881, designed by Andrew Chase for Gustavius Swift.[101]

Contemporaneous experiments produced functional systems of mechanical refrigeration, using various principles. Ultimately, the vapor compression machine triumphed. In the mid-1850s, Alexander Twining in Cleveland, Ohio, and James Harrison, in Australia, received patents for, and constructed, small ether machines which marked the beginning of

Figure 12.4 Loading ice into refrigerated trucks. The Post-Intelligencer Collection, Museum of History & Industry

the commercial application of compression refrigeration. The vapor compression machine was greatly refined by the German engineer Carl von Linde, who conceptualized it as a steam engine in reverse, using thermodynamic theory to calculate its efficiency.[102] His machines, introduced into German breweries from 1874, became globally popular, and made ammonia the most popular refrigerant.[103] In the brewing industry, the rise of refrigeration aided the formation of large-scale capitalist enterprises.[104]

Refrigeration also allowed the shipment of dead meat rather than live animals. In October 1875, Timothy Eastman sent frozen meat from New York to London. The carcases were simply suspended from hooks in the hold, and the circumambient temperature around them maintained at freezing by a combination of ice and fans.[105] A more sophisticated success came in 1877, when the S.S. *Paraguay* sailed from Buenos Aires to Le Havre, using an ammonia compression refrigeration machine. The frozen meat reportedly arrived in excellent condition.[106] The adoption of technologies which kept meat in a chilled rather than frozen condition greatly assisted the rise of the Argentinean meat industry, and Britain became the center of the world's frozen and refrigerated meat trade (see Figure 12.5). Commentators reflected on the overcoming of problems of distance: "refrigeration … made possible the concentration of killing and dressing, distance now being no object, as districts hundreds of miles from the packing house could be served with meat as easily as the district in the immediate vicinity of the plant."[107]

Fishing underwent industrialization in the nineteenth century with the development of the steam trawler. In 1883, there were 181 steam trawlers operating from British ports: in 1901, there were 1,573.[108] Early efforts to equip these ships with mechanical refrigeration equipment met with mixed success. It was not until the 1920s that refrigerating machines were installed on American vessels to help chill fish.[109] The first fully-equipped freezer ship was the *Karmoy* (1915), but this appears to have been rather unsuccessful.[110] Clarence Birdseye drew on such techniques when he introduced industrial flash freezing in 1924, and frozen fish became hugely popular thereafter. The process allowed fish to be frozen without causing any cellular damage, banishing some of the suspicions surrounding marketing of the commodity.[111] This very perishable product could now be transported over significant distances: "the low temperature to which the product is cooled allows it to be shipped in corrugated cardboard cartons protected by more of the cardboard, for considerable distances without refrigeration."[112]

Since 1945, there has been a great expansion in production of frozen fish, particularly through integrating freezing technologies into the trawlers themselves: in the 1960s, giant factory trawlers were built in Japan and the USSR.[113] Marketing frozen fish presented certain problems: early efforts to sell "fishbricks" which could be cut into any desirable shape were unsuccessful, not least because grocery stores lacked requisite display cases.[114] The fish stick, launched by Birds Eye in 1953 following three years of research, was the solution.[115] It required almost no effort to cook, and replicated the taste of fresh fish more successfully than the canned product. Fish sticks have since become a globally successful industrial food. In the 1960s, for example, they were introduced into West Germany, and became immediately popular.[116] Like the chicken nugget, the fish stick is a processed, industrialized food, designed for mobility and durability: the product's animal origin is dissembled, making it particularly popular with children.

Temperature control has pervaded most branches of food production. After 1945, freeze-drying was used for the production of instant coffee and dried soups.[117] The first frozen French fries date from 1946, but the real pioneer of this industry was J.R. Simplot,

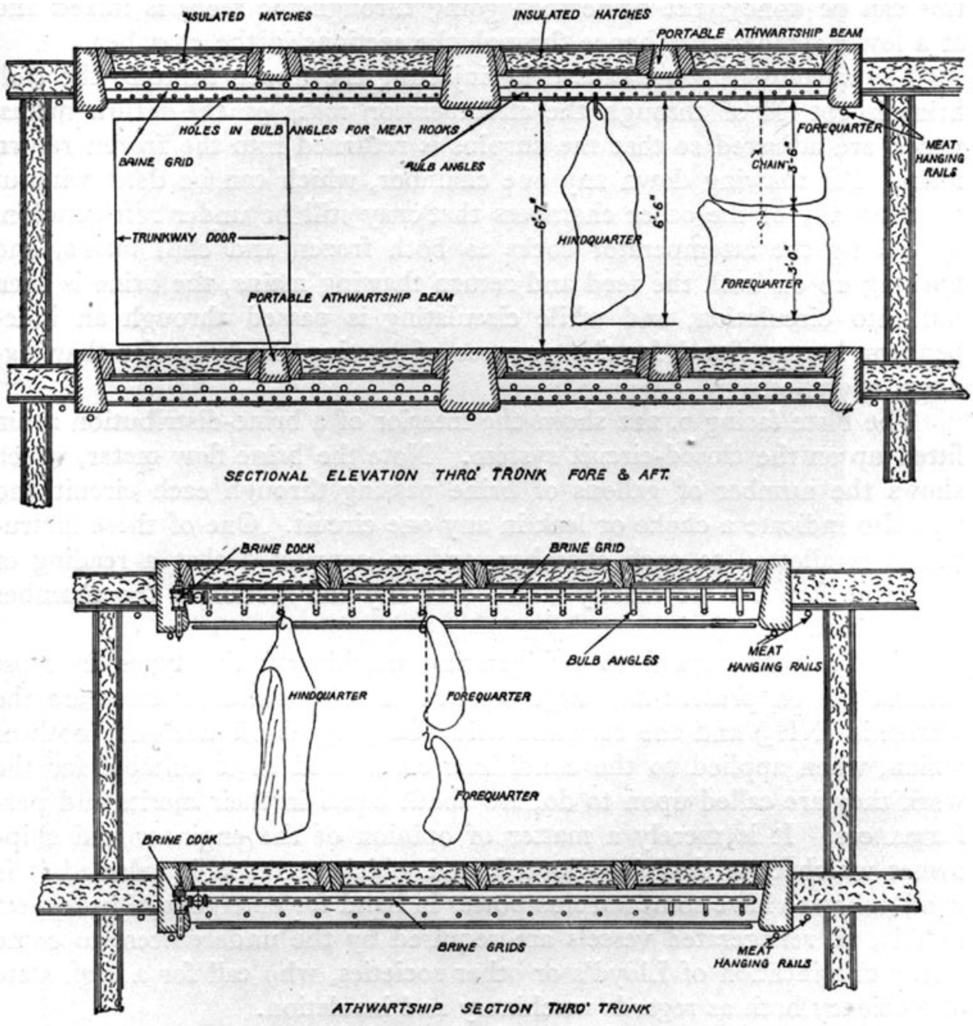

Fig. 6.—Sections through Modern Steamer for carrying Chilled Beef

Figure 12.5 Beef refrigeration equipment. From Joseph Raymond, "Transport of Refrigerated Meat by Sea," in *The Frozen and Chilled Meat Trade*, vol. II (London: Gresham, 1929)

who began supplying McDonald's in 1966. As Eric Schlosser notes, French fries "have become the most widely sold foodservice item in the United States."[118] The 1948 invention of frozen concentrated orange juice transformed the Florida orange industry: in 1943–4, Florida produced 46.2 million boxes of oranges, a figure doubling to ninety-three million by 1956–7.[119] These developments have been assisted by the rise of refrigerated road transport (see Figure 12.6) and, on a more global scale, containerization, which has been vital to the transferrable transportation system.[120] The first carriage of containers by sea came in 1956 (from New York to Houston) and containers were soon sent internationally.[121] Containers with their own internal refrigeration systems made the system increasingly integrated.[122]

Figure 12.6 Insulated motor van. From J.T. Critchell and J. Raymond, *History of the Frozen Meat Trade* (London: Constable and Company, 1912)

The cold chain was completed with the development of the cold store. Such buildings, mainly used for fruit, were spreading in the United States from 1870.[123] By 1904, the United States boasted 620 public cold-storage warehouses, with a combined capacity of 102,500,000 cubic feet.[124] During the twentieth century, the cold chain has been greatly refined, not least through scientific comprehension of the effect of temperature, humidity and atmospheric chemistry on various foodstuffs, or controlled atmospheric storage. There were many experiments on the impact of refrigeration and novel gaseous environments for fruit: controlled atmospheric storage thrived after 1945 (see Figure 12.7).[125] Cold chains now regulate the entire aeriform milieu of food, not merely its temperature. Within cold chains, average temperatures plummeted. In the interwar period, American cold stores were usually around minus 20 degrees Celsius, but by the 1970s, they were frequently minus 30, with some Japanese stores as low as minus 55 degrees Celsius. This trend abated in the 1970s, perhaps due to rising energy prices, although some containers can maintain temperatures of minus 60 degrees Celsius, for tuna, sea urchins and swordfish for Japan's sushi market.[126]

Industrialized food systems, then, are characterized by distended transportation networks which move raw materials (including animal feedstuffs) to processing hubs – roller mills, concentrated feeding systems – often located in periurban zones or ports. These hubs are characterized by a high degree of mechanization, a highly sophisticated division of labor, and significant fossil-fuel inputs. Throughout these food systems, temperature control has promised a reduction of waste and a balancing of gluts and dearths through the equalization of supply. Such technological developments have not just affected food distribution: they have had very real impacts on the history of finance. Storage (temperature-controlled or otherwise), unified world markets, and real time price signals (whether coming through telegraphic or fibreoptic cables) have combined to encourage speculation in the form of futures or hedging.

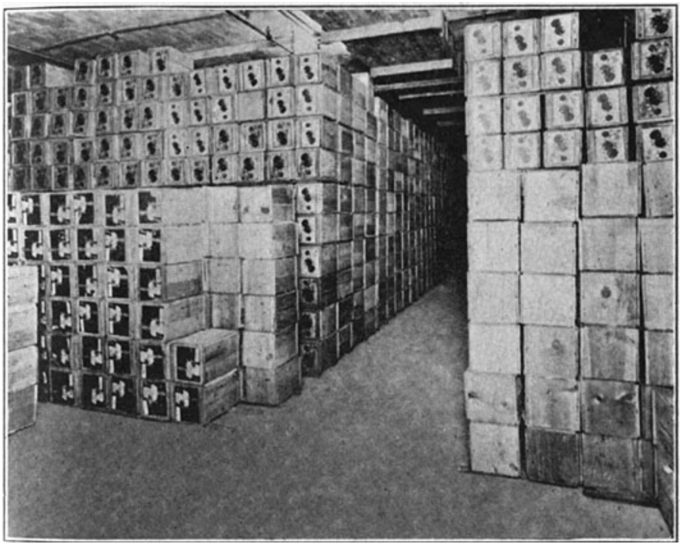

Figure 12.7 Boxed apples. From W.P. Hedden, *How Great Cities are Fed* (New York: D.C. Heath, 1929)

Canning, memorably described as "anxiety in its absolute state" by the sociologist Giralmo Sineri, was another vital technology of mobility and durability.[127] In 1919, the economic geographer J. Russell Smith argued that "canning, more than any other invention since the introduction of steam, has made possible the building up of towns and communities beyond the all too narrow bounds of varied production."[128] Canning originated with the metal cannisters used by the eighteenth-century Dutch navy and the early nineteenth-century bottling techniques of a French confectioner, Nicolas Appert.[129] Metal cans were soon adopted, and the first food-canning works was developed at Bermondsey in London in 1812. The metal's cost meant that early tin cans were largely used for specific customers like explorers or navies, for whom the preservation of food was particularly important. One early explorer to utilize canned products was Otto von Kotzebue, who used them on his three-year voyage to the Bering Strait and South Seas in 1815–18.[130]

The commercial development of canning followed quickly. The French canned sardine industry developed from 1824, when Joseph Colin opened the first fish cannery.[131] Canned food developed in the United States during and following the Civil War, which introduced large numbers of soldiers to canned produce, particularly pork and beans, and sweetened condensed milk. Gail Borden opened his first large condensing plant at the start of the Civil War, and supplied it to troops. In 1860, five million cans of food were being produced annually in America: by 1870, this number was thirty million.[132] America was now producing far more canned food than any other nation on earth. In 1899 Elbridge Amos Stuart, an Indiana grocer, developed a technique for producing canned evaporated milk, which he called "Carnation."[133] H.J. Heinz, who began selling pickles and sauerkraut in the 1870s, soon turned to canning and began selling baked beans and macaroni and cheese. In 1897, an employee of Campbell's, the chemist John Dorrance, pioneered a method of condensing soup: within a year, vegetable, tomato, chicken, oxtail and consommé soup were on sale.[134]

From the 1850s, cans were made of steel, and plated with tin. Inventors, meanwhile, attempted to find ways to eliminate soldering, most notably the New Yorker Max Ams, whose 1896 double seam, when combined with automatic machinery, greatly increased the speed of can production.[135] Seamless cans were replacing soldered ones by the early twentieth century. Early cans were made of thick metal, and could be huge: one 1815 can weighed 17 pounds 12 ounces. Such cans could only be opened with a hammer and chisel. In 1858, Ezra Warner received a patent for a can opener with large curved blade which could be maneuvered around the edge of the can.[136] Bull's head tin openers were sold with cans of bully beef in the 1860s.[137] The first wheeled can opener, designed to preclude the jagged, dangerous edges which early openers created, was patented by William Lyman in 1870.[138] In 1894, F.C. Busch designed a scored top which could be removed without an opener: this was the first attempt to create something akin to a contemporary ring pull.[139]

The tin can was not the only receptacle to revolutionize the storage and distribution of food. The milk bottle, pioneered in the United States and France in the 1870s, became a ubiquitous article in early twentieth-century Britain, which developed a distribution system built around a peculiarly British electric vehicle, the milk float. By the 1940s, well over one hundred million milk bottles were produced in Britain annually.[140] Packaging, meanwhile, became globally ubiquitous. Ralph Borsodi rather grandly claimed that "the elevator made the skyscraper possible; the package has made the kitchenette home possible."[141] Later in the century, plastic bottles, tetrapaks and aluminium foil proliferated. American food industries spent nearly two billion dollars on plastic packaging in 1972.[142]

Synthetic food

Food processing quickly became a scientific enterprise. Manufacturers of chilled, canned and packaged food began to employ chemists to provide quality control of their products. The American Can Company established a laboratory in 1906, and the National Canners' Association of the United States began investigations in 1910.[143] Crosse and Blackwell's Bermondsey factory had bacteriological and analytical departments, and a technical research centre, by 1939.[144] Such laboratories were soon involved in debates about safety thresholds for additives or particular chemical components of food. In 1920, for example, Samuel Prescott founded the Coffee Research Laboratory at MIT. In order to test the effects of caffeine, rabbits were force-fed coffee: humans, results suggested, would have to simultaneously drink 150–200 cups of coffee to die.[145]

Food production thus became heavily quantified. In collaboration and sometimes in competition with government laboratories, industry negotiated legal limits of preservatives. British Ministry of Health regulations of 1927 outlined the amount of preservatives permitted for different foods: in jam, for example, forty parts per million of sulphur dioxide were allowed.[146] Other forms of scientific preservation were developed. Food irradiation techniques, involving the application of small doses of radiation to food to kill microorganisms, were pioneered in the early twentieth century.[147] In 1956, Victor Cohn predicted that by 1975, "we may have replaced the refrigerator and freezer … with an ordinary storage cabinet filled with atomic-ray-preserved food."[148] Irradiation remains legal, but by the end of the 1990s, only about 0.002 percent of fruit, vegetables, and poultry consumed in the United States were irradiated.[149]

Irradiation is, at least at this point in history, a minor story in the history of the industrialization of food. Fortification and chemical manipulation are not. From vitaminized margarine and milk in the late 1920s to the later twentieth-century rise of "nutraceuticals," food manufacturers have increasingly engineered foodstuffs to produce very calculated qualities: appearance, durability, texture, and flavor. By 1987, the European Union had approved around 380 such additives.[150] The resulting foods are "convenient" in the sense that they are durable, bacteria-resistant, require limited preparation and often necessitate little mastication. The earliest convenience foods replaced simple meals or parts of more complex meals: bottled sauces, bouillon cubes, pancake mixes, packaged cereals.[151] After 1945, entire preprepared multi-part meals became available: the TV dinner was pioneered in 1953, following a turkey glut.[152]

Some social context is necessary here. Ready meals appeared along with increasing numbers of women entering the workforce, and they were often interpreted in explicitly gendered ways:

> without ready prepared meals, boil-in-bag packs, instant coffee and mashed potato, and many other items, our present industrial life, with one out of every three married women engaged in occupations outside the home, would be difficult if not impossible.[153]

The industrialized kitchen was clearly part of this order. In higher-class homes, fossil-fuel-driven motors powered electric ovens and kitchen implements, thus largely eradicating the need for servants. Domestic refrigeration extended the cold chain into the home. Such technologies were democratized over the twentieth century, at uneven rates: domestic technologies permeated the American home well before the European, and they permeated urban homes before rural ones. The rise of supermarkets, to which customers (usually women) drove, integrated food purchasing into an increasingly automobilized culture and agglomerated foodstuffs in giant "consumption factories" rendering the dispersed topography of traditional retailing increasingly obsolete.[154] The supermarket, where foods were concentrated in large, fossil-fuel-powered buildings, mirrored the food-production hubs in other parts of the food system.

The rise of TV dinners, fortified bread and instant mashed potatoes coincided with renewed concerns about global population growth, which had been largely allayed since the invention of synthetic nitrates. John Boyd Orr thought that conventional farming could feed 5–6 billion, but beyond this it might be necessary to "call in the chemists, who can synthesize nearly all the constituents of food except the mineral elements, of which there is no shortage."[155] Chemists had, in fact, been doing this for some time. Synthetic flavorings were developed from the later nineteenth century: synthetic oil of almonds, for example, was made from toluene, a coal tar product.[156]

In 1879 Constantin Fahlberg, working at Johns Hopkins University, derived saccharin from coal tar. Fahlberg's achievement seemed almost alchemical: saccharin was 300 times as sweet as sugar yet contained no calories. Despite some initial unease about deriving a dietary constituent from a fossil fuel, saccharin was soon being used in various products, including syrup, jam and chocolate.[157] In the later twentieth century, synthetic sweeteners proliferated: cyclamate (now banned in the United States), sucralose, aspartame and stevia.[158] They allowed consumers to keep eating while striving to lose weight, and they were marketed from 1950s as "guilt-free sites of indulgence."[159] Jean Nidetch of Weight Watchers made artificially sweetened food central to weight-conscious diets.[160] In the United States, the consumption of sweeteners rose by 150 percent between 1975 and 1984.[161]

In vitro meat might be a very recent innovation, but the idea of synthetic meat dates from at least the same time as saccharin. In 1895, the sanitarian Benjamin Richardson predicted that in the future, "the chemist should be able to prepare from the vegetable world foods which would be identical in all important features, including flavour, with animal food."[162] Four years later, John Harvey Kellogg launched protose, a canned meat substitute made of nuts.[163] Winston Churchill speculated that in the future, synthetic meat would be produced.[164] Anton Metternich, in *Die Wüste droht* (*The Threat of the Desert*, 1947), apparently "devoted an entire chapter to synthetic liverwurst."[165] In very recent years, the use of foetal bovine serum or stem cells has promised a realization of the visions of Richardson and Churchill. As a possible alternative to "test tube" meat, Adam Shriver has proposed the genetic engineering of animals "with a reduced or completely eliminated capacity to suffer."[166]

Synthetic utopianism has not been limited to laboratory-produced meat. J.B.S. Haldane thought that cellulose would be a vital feedstock for food production: "when – not if – we can separate the cellulose-splitting enzymes from those which break up the sugar further, we shall be in a position to convert wood pulp or hay quantitatively into human food," making hunger a thing of the past.[167] Reality and fantasy became hard to distinguish. The American Chemical Society's 1951 meeting saw untrammelled optimism: "mankind will be producing synthetic foods from sunlight, water, ammonia, and the carbon dioxides in the air."[168] Yeast and algae have been mooted as solutions to the world food problem. They have also been utilized to produce single-cell proteins (SCPs). In the 1960s and 1970s, various companies developed techniques to produce such edible biomass. The Soviets, for example, were producing 1.1 million tonnes of SCPs by the end of the 1970s.[169] British Petroleum ultimately launched its single-cell proteins as animal feed.[170] In 1972, John Gow, head of ICI's food and agriculture research division, claimed that one square mile could produce enough protein for the whole world, generating water, CO_2 and heat as waste products.[171] Single-cell protein cultivation has been described as "the first attempt in the history of mankind to produce proteinaceous food and feedstuffs without the aid of agriculture."[172] Mycoproteins, meanwhile, are also used for human food products: Quorn, for example, was launched in 1985.[173]

The industrial eater

> No field within the entire scope of mechanization is so sensitive to mishandling as that of nutrition. Here mechanization encounters the human organism (whose laws of health and disease are still incompletely known). The step from the sound to the unsound is nowhere so short as in the matter of diet.[174]

In *The Omnivore's Dilemma*, Michael Pollan reflected on another key feedstock of the food manufacturing system – corn: "it takes a certain kind of eater – an industrial eater – to consume these fractions of corn, and we are, or have evolved into, *that* supremely adapted creature: the eater of processed food."[175] What is true for corn is true for soy, or wheat. Most of today's consumers – at least in the west – ingest large amounts of processed, pre-prepared and fast food, which is a chemically heterogeneous, engineered product composed of "fractions" of different ingredients, listed on the sides of food packages. In this final section, I will reflect on the "industrial eater" and the discontents surrounding "industrial eating."

The industrial eater is, in many ways, palpably better fed than the pre-industrial eater. Human height, for example, has risen significantly in all parts of the world passing through the nutrition transition, and improved nutrition (including maternal nutrition) is demonstrably a significant factor in this change.[176] Average body size has increased by 100 percent since 1800, part of what some scholars call "technophysio evolution," a term meaning historical bodily transformations whose causes are primarily environmental, not genetic.[177] Debates over transformation in calorific intake during industrialization continue to rage, but the majority of research does suggest that by the end of the nineteenth century, per capita calorific intake was rising in Europe. Most people in Britain, for example, were adequately fed. The most recent research suggests figures of 3,165 calories for skilled workers and 2,700 calories for poor workers around 1900.[178] This ensured "sufficient energy for sustained work" for most of the working population, although "a substantial minority" still had energy intakes which "were incompatible with sustained physically demanding work."[179] Without such calorific levels, it is doubtful that anything like an Industrial Revolution could have happened. Despite the persistence of massive social disparities and endemic food insecurity, this process has globalized. In 1969/71, world per capita food consumption was 2,411 calories: thirty years later it was 2,789 calories.[180]

The industrialization of diet coincides rather neatly with what James Riley has called the "democratization of survival to old age" caused by changed mortality patterns.[181] There are many reasons for this epidemiologic transition, not least improvements in public health systems. Improved nutrition, however, has clearly played a vital role in producing bodies capable of resisting opportunistic infections and endemic diseases like tuberculosis.[182] Vitamin and mineral deficiencies are extremely rare for consumers of fortified foods. Public health techniques and nutrition are not mutually exclusive: the pasteurization of milk and construction of infant feeding centres, for example, combined both strategies.

Despite these clear dietary improvements, the industrialization of diet raised many anxieties. George Orwell, for example, grumbled that:

> in the highly mechanised countries, thanks to tinned food, cold storage, synthetic flavouring matters, etc., the palate is a dead organ … Look at the factory-made, foil-wrapped cheese and "blended" butter in any grocer's; look at the hideous rows of tins which usurp more and more of the space in any food-shop, even a dairy; look at a sixpenny Swiss roll or a twopenny ice-cream; look at the filthy by-product that people will pour down their throats under the name of beer. Wherever you look you will see some slick machine-made article triumphing over the old-fashioned article that still tastes of something other than sawdust.[183]

Historians have often concurred, referring, for example, to the "abysmal dietary situation of the 19th-century industrialization period."[184] These commentators have generally utilized two forms of critique: an Orwellian approach which assails the taste of processed food, and a more medical critique which argues that an industrialized diet increased morbidity during a period of mortality decline. In practice, these two lines of attack are difficult to disentangle, and it is, in turn, hard to separate either from a broader, more moral, critique of the effect of technology and "progress" on the human mind and body.

Early twentieth-century commentators also remarked on changing mortality patterns, pointing out that diseases like cancer were increasing in incidence in the most economically advanced parts of the world.[185] Diet was often posited as a cause of this transformation. "To make radical dietary changes in one hundred to one hundred and fifty years is to court disaster" complained Melvin Page, who blamed sugar and refined wheat flour for humanity's degeneration.[186] These were the foods of sedentary, urbanized populations, unknown to Paleolithic peoples or contemporary societies who had yet to industrialize. Thus was born the idea that the industrialization of diet led humanity away from the foods we had evolved to eat, something underpinning contemporary appeals to Paleo diets and also more profound ruminations on so-called "mismatch diseases."[187] Industrial food was blamed for various ailments, including appendicitis, diverticular disease, varicose veins, deep vein thrombosis, haemorrhoids, gall stones, coronary heart disease, obesity and hiatus hernia.[188] Nonwestern peoples did not suffer from such afflictions, and neither did most wild mammals (pets and livestock were a different story). Critiques of human progress invariably had a dietary dimension: witness the critique of the western diet in Nazi Germany.[189]

The industrial diet, critics proclaimed, was deficient in fibre. This produced constipation, which "seems always to have ridden with civilization, a most unnecessary passenger," which in turn catalyzed various crazes, from wholemeal bread and yoghurt to abdominal surgery.[190] Gastric ulcers, dyspepsia, diverticulitis and appendicitis were all blamed, at one time or another, on industrialized food. Archaeological evidence has shown demonstrable lack of tooth decay in Paleolithic skeletons, which suggests a clear link between the Neolithic revolution, dietary transformation and the decline of dental health.[191] Such empirical data suggested that tooth decay might be the archetypal disease of civilization, a kind of insidious mass morbidity causing misery without death: "dental caries is, unquestionably, the most common of all diseases affecting civilised mankind."[192]

More striking, perhaps, has been the rise in obesity. An industrial food system, combined with the replacement of much human labor by machines, has produced a historically-novel combination of plenty and sedentarism which in turn has allowed human bodies to grow in size. Orwell argued that technological advances were threatening to create a "paradise of little fat men."[193] Wherever the western dietary model (and heavy fossil-fuel consumption) is adopted, people grow bigger. In Chinese cities, for example, the prevalence of childhood obesity rose from 1.5 percent in 1989 to 12.6 percent in 1997.[194] In South Korea, the decline of a traditional diet, rich in vegetables and rice, and its replacement with a more western-style diet, has led to a rise in obesity levels.[195] The media began evoking the idea of "epidemic obesity" in 1987.[196] Scholars soon concurred, although there has been thought-provoking critique of the concept.[197] What is undeniable is that industrialization has created an environment within which humans have become substantially bigger. Rates of coronary heart disease, meanwhile, began rising among men in the 1920s and rose dramatically across the twentieth century.[198]

The health consequences of industrialized food are complex and ambivalent. On the one hand, rising human heights, life expectancy, disease resistance and micronutrient intake are clear positives related in various ways to dietary shifts. On the other hand, the slew of "mismatch diseases" caused by radical dietary and technological change must be viewed as a significant, and negative, unintended consequence of the industrialization of food. Dietary change can thus be used to support metanarratives of either progress or decline: the most satisfactory solution is probably to evoke both simultaneously.

The industralization of diet is, finally, inseparable from industrialization per se, and is thus deeply interconnected with recent global environmental history. There is insufficient space here to chart these developments, but it is worth noting that right from the beginning of the industrialization of food, romantics and socialists produced what might be termed eco-critique of dietary change. Marx, for example, noted that:

> [a]ll progress in capitalist agriculture is a progress in the art, not only of robbing the labourer, but of robbing the soil … Capitalist production therefore, develops technology, and the combining together of various processes into a social whole, only by sapping all the original sources of wealth – the soil and the labourer.[199]

Similarly, the advent of synthetic nitrate fertilizers was immediately attacked by organic farmers concerned about damage to the soil.[200] By the 1930s, soil erosion was regarded as a major consequence of the intensification and globalization of agriculture.[201] Today, the list of environmental problems caused by global food system has expanded to include concerns as diverse as the genetic homogenization of crops and livestock, pollution, eutrophication and food miles. Doris Grant, railing against the ecological and biological consequences of industrial bread, urged housewives to regard home-made bread as "the first line of defence for the housewife and her family against our present-day unnatural and dangerous environment."[202]

Conclusion

> Before our food reaches the table it is poisoned in the soil, disinfected, bleached, softened, dyed, tinned, bottled, packaged, fortified, irradiated, thickened, frozen, flaked, sprayed, embalmed, flavored, extended, emulsified, gassed, deodorized, stabilized, hydrolized, polished, neutralized, or subjected to atomic fall-out.[203]

The fish stick was a mere eight years old when Doris Grant penned these hyperbolic words. She thus wrote at the precise historical juncture when industrial foods were becoming hegemonic and normal in the west. Industrial foods were mass-produced, standardized, wrapped, durable and mobile. They were gustatorily anodyne and predictable: they were easy to prepare. Industrial foods relied on vast global systems to supply the raw materials and energy required for processing. These raw materials were, with the exception of fish, increasingly selected and even genetically modified to facilitate durability and processing. Fish populations themselves have been decimated by industrial trawling.[204] The industrialization of food, then, is a dramatic chapter in the history of life on earth.

Our contemporary dietary patterns have been irrevocably shaped by the industrialization of food. The nutrition transition was powered by fossil fuels and provided the dietary surplus necessary to power the Industrial Revolution.[205] It has also quite clearly produced the most reliable stream of calories ever seen on earth. It has boosted maternal health, human height, human weight, and (to some degree) human life expectancy. Fortified food has greatly reduced the incidence of deficiency diseases in the west. It has, perhaps, rectified some of the biological damage caused by the Neolithic revolution, which Jared Diamond famously called "the worst mistake in the history of the human race."[206]

Yet such optimism must be tempered. Industrialized food has brought with it a litany of morbidities – type 2 diabetes, obesity, constipation, food allergies – which have transformed our bodies in negative ways. Industrialized food has become so omnipresent as to be practically inescapable. Organic food, for example, is often held up as a rejection of food industrialization, but organic food has itself been industrialized: Michael Pollan has used the term "industrial organic" to describe this process.[207] Exclusive dining experiences and fast-food restaurants alike rely upon fossil fuel-powered systems. Like most other aspects of our lives, our diets have become inseparable from the mineral economy, which has generated concerns about food security as well as anxieties about ecological collapse.[208] Industrialized food is, in its current manifestation, a transient phase in food history which will disappear along with fossil-fuel society at some unknown date in the future.

Notes

1 E. Wrigley, *Continuity, Chance, and Change: The Character of the Industrial Revolution in England* (Cambridge: Cambridge University Press, 1990).

2 Walter Hamilton, "The Requisites of a National Food Policy," *Journal of Political Economy*, 26:6, June 1918, 620.

3 John Connor, Richard Rogers, Bruce Marion and Willard Mueller, *The Food Manufacturing Industries: Structure, Strategies, Performance, and Policies* (Lexington, MA: Lexington Books, 1985), p. 4.

4 Alfred Chandler, *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, MA: Belknap, 1977), pp. 348–50.

5 Barry Popkin, "The Nutrition Transition and its Health Implications in Lower-Income Countries," *Public Health Nutrition*, 1:1, 1998, 5.

6 See, for example, Daniel Lieberman, *The Story of the Human Body* (New York: Allen Lane, 2013), esp. pp. 209–92.

7 E. Russell, *Evolutionary History: Uniting History and Biology to Understand Life on Earth* (Cambridge: Cambridge University Press, 2011).

8 Karl Kautsky, *The Agrarian Question*, trans. Pete Burgess [1899] (Winchester, MA: Zwan Publications, 1988), p. 297.

9 John H. Perkins, *Geopolitics and the Green Revolution: Wheat, Genes, and the Cold War* (Oxford: Oxford University Press, 1997), p. 50.

10 Charles Post, "The Agrarian Origins of US Capitalism: The Transformation of Northern Agriculture Before the Civil War," *Journal of Peasant Studies*, 22:3, 1995, cited in Michael Watts and David Goodman, "Agrarian Questions: Global Appetite, Local Metabolism: Nature, Culture, and Industry in *Fin-de-siècle* Agro-food Systems," in David Goodman and Michael Watts (eds), *Globalizing Food: Agrarian Questions and Global Restructuring* (New York: Routledge, 1997), p. 16.

11 Giovanni Federico, *Feeding the World: An Economic History of Agriculture, 1800–2000* (Princeton: Princeton University Press, 2005), p. 100.

12 J.R. McNeill, *Something New Under the Sun: An Environmental History of the Twentieth-Century World* (New York: Norton, 2001), pp. 217–18.

13 Federico, *Feeding the World*, p. 92.

14 Willard Cochrane and Mary Ryan, *American Farm Policy, 1948–1973* (Minneapolis: University of Minnesota Press, 1976), p. 5.

15 Rolf Sieferle, *The Subterranean Forest: Energy Systems and the Industrial Revolution* (Cambridge: White Horse Press, 2001), p. 42.

16 Wrigley, *Continuity, Chance, and Change*, p. 72.

17 Howard Odum, *Environment, Power, and Society* (New York: Wiley-Interscience, 1971), p. 116.

18 Vaclav Smil, *Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production* (Cambridge, MA: MIT Press, 2004), pp. 116–18.

19 Paul Josephson, *Resources under Regimes: Technology, Environment, and the State* (Cambridge, MA: Harvard University Press, 2005), p. 168.

20 Smil, *Enriching the Earth*, p. xiii.

21 Noel Kingsbury, *Hybrid: The History and Science of Plant Breeding* (Chicago: University of Chicago Press, 2009), p. 151.

22 Federico, *Feeding the World*, p. 97.

23 A. Olmstead and P. Rhode, "Biological Innovation in American Wheat Production: Science, Policy, and Environmental Adaptation," in S. Shrepfer and P. Scranton (eds), *Industrializing Organisms: Introducing Evolutionary History* (London: Routledge, 2004), p. 71.

24 James Belich, *Replenishing the Earth: The Settler Revolution and the Rise of the Anglo-World, 1783–1939* (Oxford: Oxford University Press, 2009), p. 3.
25 J.A. Hobson, *The Social Question* [1901] (Bristol: Thoemmes, 1996), p. 40.
26 Connor *et al.*, *Food Manufacturing Industries*, 41.
27 Connor *et al.*, *Food Manufacturing Industries*, 405.
28 William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York: Norton, 1991), pp. 228–9.
29 Richard Perren, *Taste, Trade and Technology: The Development of the International Meat Industry since 1840* (Aldershot: Ashgate, 2006), p. 1.
30 Timothy Pachirat, *Every Twelve Seconds: Industrialized Slaughter and the Politics of Sight* (New Haven: Yale University Press, 2011).
31 Amy Fitzgerald, "A Social History of the Slaughterhouse: From Inception to Contemporary Implications," *Human Ecology Review*, 17:1, 2010, 62.
32 Michael Pollan, *The Omnivore's Dilemma: A Natural History of Four Meals* (New York: Penguin, 2006), p. 72.
33 Steve Striffler, *Chicken: The Dangerous Transformation of America's Favorite Food* (New Haven: Yale University Press, 2005), p. 15.
34 William Boyd and Michael Watts, "Agro-Industrial Just-in-Time: The Chicken Industry and Postwar American Capitalism," in David Goodman and Michael Watts (eds), *Globalizing Food: Agrarian Questions and Global Restructuring* (New York: Routledge, 1997), p. 195.
35 Boyd and Watts, "Agro-Industrial Just-in-Time," p. 192.
36 Gerald Leighton and Loudon Douglas, *The Meat Industry and Meat Inspection* (London: The Educational Book Company, 1910), 5 vols, V, p. 1451.
37 Leighton and Douglas, *Meat Industry*, V, p. 1462.
38 Leighton and Douglas, *Meat Industry*, V, p. 1463.
39 Roger Horowitz, *Putting Meat on the American Table: Taste, Technology, Transformation* (Baltimore: Johns Hopkins University, 2006), p. 106.
40 William Boyd, "Making Meat: Science, Technology, and American Poultry Production," *Technology and Culture*, 42:4, October 2001, pp. 652–3.
41 J. Bitgood, "The Genetic Map of the Chicken and Availability of Genetically Diverse Stocks," in Robert Etches and Ann Gibbins (eds), *Manipulation of the Avian Genome* (Boca Raton: CRC Press, 1993), p. 61.
42 Boyd, "Making Meat," 656.
43 Boyd, "Making Meat," 657.
44 Boyd, "Making Meat," 658.
45 Striffler, *Chicken*, p. 16.
46 Pollan, *Omnivore's Dilemma*, p. 171.
47 Peter Atkins and Ian Bowler, *Food in Society: Economy, Culture, Geography* (London: Arnold, 2001), p. 83.
48 Striffler, *Chicken*, p. 39.
49 Striffler, *Chicken*, p. 25.
50 Shai Barbut, *Poultry Products Processing: An Industry Guide* (Boca Raton: CRC Press, 2002), p. 289.
51 J.H. McCoy, "Trends in Salmonella Food Poisoning in England and Wales 1941–72," *Journal of Hygiene*, 74, 1975, 277.
52 Boyd, "Making Meat," 661–2.
53 Boyd, "Making Meat," 643.
54 Boyd, "Making Meat," 644.
55 Mr. Perky, cited in R. Russell, *Strength and Diet: A Practical Treatise with Special Regard to the Life of Nations* (London: Longmans, Green, & Co, 1905), p. 347.
56 Lewis Mumford, *Technics and Civilization* [1934] (Chicago: University of Chicago Press, 2010), pp. 107–50.
57 Peter Kozmin, *Flour Milling: A Theoretical and Practical Handbook of Flour Manufacture for Millers, Millwrights, Flour-Milling Engineers, and Others Engaged in the Flour-Milling Industry*, trans. M. Falker and Theodor Fjelstrup (London: G. Routledge & Sons, 1921), pp. 34, 38.
58 Kozmin, *Flour Milling*, p. 217.
59 C.O. Swanson, *Wheat Flour and Diet* (New York: The Macmillan Company, 1928), p. 60.
60 Swanson, *Wheat Flour and Diet*, p. 89.

61 William R. Voller, *Modern Flour Milling: A Text-Book for Millers and Others Interested in the Wheat and Flour Trades*, 3rd edn (Gloucester, England: s.n., 1897), 336.
62 Kozmin, *Flour Milling*, 480.
63 Aaron Bobrow-Strain, *White Bread: A Social History of the Store-Bought Loaf* (Boston: Beacon Press, 2012), 66–8.
64 Swanson, *Wheat Flour and Diet*, 102.
65 Kozmin, *Flour Milling*, p. 561.
66 Voller, *Modern Flour Milling*, pp. 433–5.
67 Voller, *Modern Flour Milling*, p. 436.
68 Voller, *Modern Flour Milling*, p. 440.
69 Christian Petersen, *Bread and the British Economy, c.1770-1870*, ed. Andrew Jenkins (Aldershot: Scolar Press, 1995), pp. 60–2.
70 Kozmin, *Flour Milling*, p. 37.
71 John Kanefsky, "Motive Power in British Industry and the Accuracy of the 1870 Factory Return," *Economic History Review*, New Series, 32:3, August 1979, 372.
72 W.S. Jevons, *The Coal Question: An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of our Coal-mines*, 3rd edn, revised [1906] (New York: A.M. Kelley, 1965), p. 178.
73 On the windmill's decline, see Richard Hills, *Power from Wind: A History of Windmill Technology* (Cambridge: Cambridge University Press, 1994), pp. 215–32.
74 Harry Snyder, *Bread: A Collection of Popular Papers on Wheat, Flour and Bread* (New York: Macmillan, 1930), p. 109.
75 Karl Marx, *Capital: A Critique of Political Economy* (London: Lawrence and Wishart, 1954), I, p. 237.
76 Bobrow-Strain, *White Bread*, p. 23.
77 John Burnett, *Plenty and Want: A Social History of Diet in England from 1815 to the Present Day* (London: Scolar, 1979), p. 141.
78 William Jago and William C. Jago, *The Technology of Bread-Making, Including the Chemistry and Analytical and Practical Testing of Wheat, Flour, and Other Materials Employed in Bread-Making and Confectionery* (London: Simpkin, Marshall, Hamilton, Kent, & Co., Limited, 1911), p. 646.
79 Jago and Jago, *Technology of Bread-Making*, p. 659.
80 Aaron Bobrow-Strain, "White Bread Bio-politics: Purity, Health, and the Triumph of Industrial Baking," *Cultural Geographies*, 15, 2008, 28.
81 Bobrow-Strain, *White Bread*, p. 55.
82 Bobrow-Strain, "White Bread Bio-politics," 31.
83 D.W. Kent-Jones and E.F. Mitchell, *The Practice and Science of Breadmaking* (Liverpool: The Northern Publishing Co. Ltd., 1962), p. 106.
84 James Grant, *The Chemistry of Breadmaking* (London: Edward Arnold, 1912), p. 155.
85 Bobrow-Strain, *White Bread*, pp. 69–70; Kent-Jones and Mitchell, *Practice and Science of Breadmaking*, p. 126.
86 Kent-Jones and Mitchell, *Practice and Science of Breadmaking*, p. 129.
87 Kent-Jones and Mitchell, *Practice and Science of Breadmaking*, p. 130.
88 Stanley Courvain and Lisa Young, *Technology of Breadmaking*, 2nd edn (New York: Springer, 2007), pp. 38–9.
89 W.P. Edwards, *The Science of Bakery Products* (Cambridge: Royal Society of Chemistry, 2007), p. 174.
90 James Tobey, "Baking Technology and National Nutrition," *Scientific Monthly*, 49:5, November 1939, 464.
91 Edmund Bennion, *Breadmaking: Its Principles and Practice*, 4th edn (London: Oxford University Press, 1967), p. 297.
92 Bennion, *Breadmaking*, pp. 300–1.
93 Bennion, *Breadmaking*, pp. 52, 158.
94 Susanne Freidberg, *Fresh: A Perishable History* (Cambridge, MA: Belknap, 2009).
95 Karl Appuhn, "Ecologies of Beef: Eighteenth-Century Epizootics and the Environmental History of Early Modern Europe," *Environmental History*, 15:2, April 2010, 268–87.
96 Carl E. Solberg, *The Prairies and the Pampas: Agrarian Policy in Canada and Argentina, 1880–1930* (Stanford: Stanford University Press, 1987), p. 13.
97 Agnes Cameron, "The Empire of Larger Hope," *Metropolitan Magazine*, XXVI:III, June 1907, p. 298.

98 Chandler, *Visible Hand*, pp. 391–402.
99 Oscar Anderson, *Refrigeration in America: A History of a New Technology and its Impact* (Princeton: Princeton University Press, 1953), p. 35.
100 Richard Perren, *Taste, Trade and Technology: The Development of the International Meat Industry since 1840* (Aldershot: Ashgate, 2006), p. 50.
101 Chandler, *Visible Hand*, p. 299.
102 Mikael Hård, *Machines are Frozen Spirit: The Scientification of Refrigeration and Brewing in the 19th Century: A Weberian Interpretation* (Boulder: Westview, 1994), p. 122.
103 Barry Donaldson and Bernard Nagengast, *Heat and Cold: Mastering the Great Indoors: A Selective History of Heating, Ventilation, Air-Conditioning and Refrigeration from the Ancients to the 1930s* (Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1994), pp. 131–2.
104 Hård, *Machines are Frozen Spirit*, p. 187.
105 Perren, *Taste, Trade and Technology*, p. 48.
106 Perren, *Taste, Trade and Technology*, p. 49.
107 D. Anthony and W. Blois, *The Meat Industry: A Text-Book for Meat Traders and Others Engaged in the Various Branches of the Meat Industry* (London: Baillière, Tindall & Cox, 1931), p. 49.
108 Ian Simmons, *An Environmental History of Great Britain: From 10,000 Years Ago to the Present* (Edinburgh: Edinburgh University Press, 2001), p. 162.
109 Anderson, *Refrigeration in America*, p. 175.
110 *Ice and Refrigeration*, 49:6, December 1915, p. 333.
111 Freidberg, *Fresh*, pp. 249–53.
112 C. Robert Moulton, *Meat Through the Microscope: Applications of Chemistry and the Biological Sciences to Some Problems of the Meat Packing Industry* (Chicago: University of Chicago Press, 1929), p. 32.
113 Roger Thévenot, *A History of Refrigeration Throughout the World* (Paris: International Institute of Refrigeration, 1979), pp. 316, 320.
114 Paul Josephson, “The Ocean’s Hot Dog: The Development of the Fish Stick,” *Technology and Culture*, 49:1, January 2008, 45.
115 Josephson, “Ocean’s Hot Dog,” 48.
116 Burghard Cielsa and Patrice Poutrus, “Food Supply in a Planned Economy: SED Nutrition Policy Between Crisis Response and Popular Needs,” in Konrad Jarausch (ed.), *Dictatorship as Experience: Towards a Socio-Cultural History of the GDR* (New York: Berghahn, 1999), p. 154.
117 Thévenot, *History of Refrigeration*, p. 322.
118 Eric Schlosser, *Fast Food Nation: What the All-American Meal is Doing to the World* (New York: Penguin, 2002), p. 115.
119 Alissa Hamilton, *Squeezed: What You Don’t Know About Orange Juice* (New Haven: Yale University Press, 2009), pp. 23–4.
120 Thévenot, *History of Refrigeration*, p. 341. See also Shane Hamilton, *Trucking Country: The Road to America’s Walmart Economy* (Princeton: Princeton University Press, 2008); Marc Levinson, *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger* (Princeton: Princeton University Press, 2006).
121 Levinson, *The Box*, p. 1.
122 Richard Woodman, *The History of the Ship: The Comprehensive Story of Seafaring From Earliest Times to the Present Day* (London: Conway Maritime Press, 1997), p. 325.
123 Thévenot, *History of Refrigeration*, p. 90.
124 Anderson, *Refrigeration in America*, p. 128.
125 A. Keith Thompson, *Controlled Atmosphere Storage of Fruits and Vegetables*, 2nd edn (Cambridge, MA: CABI, 2010), p. 3.
126 Thévenot, *History of Refrigeration*, 331; Flemming Jessen, Jette Nielsen and Erling Larsen, “Chilling and Freezing of Fish,” in Ioannis Boziaris (ed.), *Seafood Processing: Technology, Quality and Safety* (Oxford: Wiley, 2014), p. 52.
127 Giralmo Sineri, cited in Massimo Montanari, *Food is Culture*, trans. Albert Sonnenfeld (New York: Columbia University Press, 2006), p. 15.
128 J. Russell Smith, *The World’s Food Resources* (New York: Henry Holt, 1919), p. 408.
129 Stuart Thorne, *The History of Food Preservation* (Totowa: Barnes and Noble Books, 1986), pp. 25–9.
130 Thorne, *History of Food Preservation*, p. 43.

131 Sue Shephard, *Pickled, Potted, and Canned: How the Art and Science of Food Preserving Changed the World* (New York: Simon & Schuster, 2000), p. 241.

132 Richard Osborne Cummings, *The American and His Food: A History of Food Habits in the United States*, revised edn (Chicago: University of Chicago Press, 1941), p. 69.

133 Shephard, *Pickled, Potted, and Canned*, p. 151.

134 Daniel Sidorick, *Condensed Capitalism: Campbell Soup and the Pursuit of Cheap Production in the Twentieth Century* (Cornell: Cornell University Press, 2009).

135 Thorne, *History of Food Preservation*, p. 99.

136 Henry Petroski, *The Evolution of Useful Things: How Everyday Artifacts – From Forks and Pins to Paper Clips and Zippers – Came To Be As They Are* (New York: Vintage, 1994), p. 187.

137 Shephard, *Pickled, Potted, and Canned*, p. 245.

138 Petroski, *Evolution of Useful Things*, pp. 188–9.

139 Thorne, *History of Food Preservation*, p. 105.

140 Arthur Guy Enock, *This Milk Business: A Study from 1895 to 1943* (London: H.K. Lewis, 1943), p. 195.

141 Ralph Borsodi, *The Age of Distribution: A Study of the Economy of Modern Distribution* [1927] (New York: Arno Press, 1976), p. 229.

142 Connor *et al.*, *Food Manufacturing Industries*, p. 32.

143 Thorne, *History of Food Preservation*, p. 151.

144 Michael French and Jim Phillips, *Cheated Not Poisoned? Food Regulation in the United Kingdom, 1875–1938* (Manchester: Manchester University Press, 2000), p. 28.

145 Larry Owens, "Engineering the Perfect Cup of Coffee: Samuel Prescott and the Sanitary Vision at MIT," *Technology and Culture*, 45:4, 2004, 799.

146 Edwin Jordan, *Food-Poisoning and Food-Borne Infection*, 2nd edn (Chicago: University of Chicago Press, 1931), p. 93.

147 James Spiller, "Radiant Cuisine: The Commercial Fate of Food Irradiation in the United States," *Technology and Culture*, 45:4, October 2004, 743; Edward Josephson, "An Historical Review of Food Irradiation," *Journal of Food Safety*, 5, 1983, 163–5.

148 Victor Cohn, *1999: Our Hopeful Future* (Indianapolis: Bobbs-Merrill, 1956), cited in Warren Belasco, *Meals to Come: A History of the Future of Food* (Berkeley: University of California Press, 2006), p. 200.

149 Spiller, "Radiant Cuisine," 759–60.

150 Atkins and Bowler, *Food in Society*, p. 215.

151 Ruth Schwartz Cowan, "The Industrial Revolution in the Home," in Donald MacKenzie and Judy Wajcman (eds), *The Social Shaping of Technology*, 2nd edn (Buckingham: Open University Press, 1999), p. 286.

152 Raj Patel, *Stuffed and Starved: The Hidden Battle for the World Food System* (Brooklyn: Melville House Publishing, 2007), pp. 263–4.

153 A. Holmes (director of the British Food Manufacturing Industries Research Association), *Guardian*, July 8, 1968, cited in Christopher Driver, *The British at Table 1940–1980* (London: Chatto & Windus, 1983), p. 144.

154 Patel, *Stuffed and Starved*, p. 220.

155 John Boyd Orr, *The White Man's Dilemma: Food and the Future* (London: George Allen and Unwin, 1953), 79, cited in Belasco, *Meals to Come*, p. 43.

156 James Grant, *Confectioners' Raw Materials: Their Sources, Modes of Preparation, Chemical Composition, the Chief Impurities and Adulterations, their More Important Uses and Other Points of Interest* (London: Edward Arnold & Co., 1926), p. 93.

157 "Substitutes for Sugar," *British Medical Journal*, May 10, 1902, 1171.

158 For an authoritative history, see Carolyn De La Peña, *Empty Pleasures: The Story of Artificial Sweeteners from Saccharin to Splenda* (Chapel Hill: University of North Carolina Press, 2010).

159 De La Peña, *Empty Pleasures*, pp. 6, 11.

160 De La Peña, *Empty Pleasures*, p. 132.

161 De La Peña, *Empty Pleasures*, p. 177.

162 Benjamin Ward Richardson, responding to H.F. Lester, "The Progress of the Abattoir System in England," *Journal of the Society of Arts*, March 22, 1895, 437.

163 Karen Iaccobo and Michael Iaccobo, *Vegetarian America: A History* (Westport: Praeger, 2004), p. 126.

164 Simon Fairlie, *Meat: A Benign Extravagance* (White River Junction: Chelsea Green Publishing, 2010), p. 227.

165 Joachim Radkau, *Nature and Power: A Global History of the Environment*, trans. Thomas Dunlap (Cambridge: Cambridge University Press, 2008), p. 319.

166 Adam Shriver, "Knocking Out Pain in Livestock: Can Technology Succeed Where Morality Has Stalled?" *Neuroethics*, 2:3, November 2009, cited in Fairlie, *Meat*, 229.

167 J.S. Haldane, "Enzymes," in *Possible Worlds and Other Papers* (New York: Harper & Brothers, 1928), p. 53.

168 "Sunny Side of the Street," *Life*, September 10, 1951; cited in Belasco, *Meals to Come*, p. 3.

169 Robert Bud, *The Uses of Life: A History of Biotechnology* (Cambridge: Cambridge University Press, 1993), p. 135.

170 Bud, *Uses of Life*, p. 136.

171 Driver, *The British at Table*, p. 138.

172 Horst Doelle, *Microbial Process Development* (River Edge: World Scientific Development, 1994), p. 205.

173 Bud, *Uses of Life*, p. 137.

174 Siegfried Giedion, *Mechanization Takes Command: A Contribution to Anonymous History* (New York: Norton, 1969) p. 169.

175 Pollan, *Omnivore's Dilemma*, p. 90.

176 Roderick Floud, Kenneth Wachter and Annabel Gregory, *Height, Health and History: Nutritional Status in the United Kingdom, 1750–1980* (Cambridge: Cambridge University Press, 1990), p. 135.

177 Roderick Floud, Robert Fogel, Bernard Harris and Sok Chul Hong, *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700* (Cambridge: Cambridge University Press, 2011).

178 Ian Gazeley and Andrew Newell, "Urban Working-Class Food Consumption and Nutrition in Britain in 1904," *IZA Discussion Paper No. 6988*, November 2012, 22.

179 Gazeley and Newell, "Urban Working-Class Food Consumption," 23.

180 John Kearney, "Food Consumption Trends and Drivers," *Philosophical Transactions of the Royal Society: Biological Sciences*, 365:1554, September 27, 2010, 2794.

181 James Riley, *Rising Life Expectancy: A Global History* (Cambridge: Cambridge University Press, 2001), p. x.

182 John Butterly and Jack Shepherd, *Hunger: The Biology and Politics of Starvation* (Hanover, New Hampshire: Dartmouth College Press, 2010), p. 217; Peter Lunn, "Nutrition, Immunity and Infection," in R. Schofield, D. Reher and R. Bideau (eds), *The Decline of Mortality in Europe* (Oxford: Clarendon, 1991), p. 137.

183 George Orwell, *The Road to Wigan Pier* (Harmondsworth: Penguin, 1962), p. 179.

184 Carole Shammas, "The Eighteenth-Century English Diet and Economic Change," *Explorations in Economic History*, 21:3, July 1984, 267.

185 E.g. Frederick Hoffman, *The Mortality From Cancer Throughout the World* (Newark: The Prudential Press, 1915).

186 Melvin Page, *Degeneration, Regeneration* (St. Petersburg, FL: Biochemical Research Foundation, 1949), cited in J.I. Rodale, *Sugar: The Curse of Civilization*, 2nd edn (Berkhamsted: The Rodale Press, 1967), p. 20.

187 For a fascinating analysis of the phenomenon of mismatch, see Lieberman, *Story of the Human Body*.

188 Denis Burkitt, "Some Diseases Characteristic of Modern Western Civilization," *British Medical Journal*, February 3, 1973, 274–5.

189 Robert Proctor, *The Nazi War on Cancer* (Princeton: Princeton University Press, 1999), pp. 120–72.

190 C.C. Furnas and S.M. Furnas, *Man, Bread and Destiny* (New York: Reynal and Hitchcock, 1937), p. 273. See also James Whorton's magisterial study of costiveness, *Inner Hygiene: Constipation and the Pursuit of Health in Modern Society* (Oxford: Oxford University Press, 2000).

191 Richard Steckel, Jerome Rose, Clark Larsen and Phillip Walker, "Skeletal Health in the Western Hemisphere from 4000 B.C. to the Present," *Evolutionary Anthropology*, 11, 2002, 146.

192 C. Doswell Wallis, "Some Thoughts on the Prevention of Dental Disease and Irregularity," at the Manchester Conference on the Prevention of Diseases of the Teeth, May 15, 1920, cited in

Charles Hecht (ed.), *The Gateway to Health: Prevention of Diseases of the Teeth* (London: St. Catherine Press, 1921), p. 299.
193 Orwell, *Road to Wigan Pier*, p. 169.
194 Patel, *Stuffed and Starved*, pp. 270–1.
195 Barry Popkin, *The World is Fat: The Fads, Trends, Policies, and Products that are Fattening the Human Race* (New York: Avery, 2009), p. 99.
196 Sander Gilman, *Fat: A Cultural History of Obesity* (Cambridge: Polity Press, 2008), p. 16.
197 Barry Popkin and Collen Doak, "The Obesity Epidemic is a Worldwide Phenomenon," *Nutrition Reviews*, April 1998, 106; Michael Gard and Jan Wright, *The Obesity Epidemic: Science, Morality and Ideology* (London: Routledge, 2005).
198 Ina Zweiniger-Bargielowska, "Slimming Through the Depression: Obesity and Reducing in Interwar Britain," in Derek Oddy, Peter Atkins and Virginie Amilien (eds), *The Rise of Obesity in Europe: A Twentieth Century Food History* (Farnham: Ashgate, 2009), p. 179.
199 Marx, *Capital*, I, pp. 474–5.
200 Perkins, *Geopolitics and the Green Revolution*, p. 216.
201 Donald Worster, *Dust Bowl: The Southern Plains in the 1930s* (New York: Oxford University Press, 1979).
202 Doris Grant, *Your Bread and Your Life* (London: Faber & Faber, 1961), p. 15.
203 Grant, *Your Bread and Your Life*, p. 61.
204 Callum Roberts, *The Unnatural History of the Sea* (Washington: Island Press, 2007), pp. 163–302.
205 This is one of the many theses in Sidney Mintz's extraordinary *Sweetness and Power: The Place of Sugar in Modern History* (New York: Penguin, 1986).
206 Jared Diamond, "The Worst Mistake in the History of the Human Race," *Discover Magazine*, May 1987, pp. 64–6.
207 Pollan, *Omnivore's Dilemma*, pp. 134–84.
208 Dale Pfeiffer, *Eating Fossil Fuels: Oil, Food and the Coming Crisis in Agriculture* (Gabriola Island: New Society Publishers, 2006).