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WAITING FOR THE INVISIBLE HAND:

Market Power and Endogenous Information in the Modern Market for Food

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WAITING FOR THE INVISIBLE HAND: MARKET POWER AND ENDOGENOUS INFORMATION IN THE MODERN MARKET FOR FOOD[1]

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ABSTRACT: In many ways, the modern market for food exemplifies the economist's conception of perfect competition, with many buyers, many sellers, and a robust and dynamic marketplace. But over the course of the last century, the U.S. has witnessed a dramatic shift away from traditional diets and toward a diet comprised primarily of processed brand-name foods with deleterious long-term health effects. This, in turn, has generated increasingly urgent calls for policy interventions aimed at improving the quality of the American diet. In this paper, we ask whether the current state of affairs represents a market failure, and—if so—what might be done about it. We review evidence that most of the nutritional deficiencies associated with today's processed foods were unknown to nutrition science at the time these products were introduced, promoted, and adopted by American consumers. Today more is known about the nutritional implications of various processing technologies, but a number of forces—including consumer habits, costly information, and the market power associated with both existing brands and scale economies—are working in concert to maintain the status quo. We argue that while the current brand-based industrial food system (adopted and maintained historically as a means of preventing competition from small producers) has its advantages, the time may have come to consider expanding the system of quality grading employed in commodity markets into the retail market for food.
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Introduction

Americans don't eat well. That is to say, the typical American diet is characterized by an excess of added sugars and other refined carbohydrates (blamed by a growing chorus of experts for epidemic levels of obesity and diabetes) and hydrogenated oils (similarly blamed for epidemic levels of heart disease), and by a dearth of beneficial nutrients such as dietary fiber, essential fatty acids, and various micronutrients (Pollan 2008). This hasn't always been the case, of course. Some 150 years ago, American households found sustenance in locally produced, freshly prepared, traditional meals—and the many "diseases of civilization" seen today were virtually unknown (Levenstein 1988, Taubes 2007).

This modern transformation of the American diet was driven by a variety of market forces, many of which have been beneficial: improvements in transportation infrastructure, agricultural productivity, and food processing technology have resulted in food products that are convenient and relatively inexpensive. Indeed, in light of the robust national market for food—with its many buyers and sellers and near-universal availability of a wide selection of products—it is tempting to view the U.S. market for food as exemplifying the virtues of a competitive market. While it may be true that the Western diet has unfortunate consequences for long-term health, why can't we presume that consumers have weighed these costs against the many benefits—price, taste, convenience, etc.—in choosing to consume it? This is an important question, given the ongoing public policy debate over what—if anything—should be done about the current epidemic of diet-related disease.

This question—in short, whether the nutritional *quality* of the modern American diet should be viewed as the natural outcome of an efficient market—is the subject of this

essay. The answer we propose is somewhat novel in that we do not emphasize the usual sources of market failure, such as federal subsidies to agriculture or the moral hazard associated with health insurance.[3] Rather, we will argue that the market outcome we observe is the product of a costly information problem, which has been exacerbated historically by a number of key policy decisions.

The costly information problem we study stems from the changes in nutritional quality induced by food processing. These changes collectively constitute a "problem," we argue, because i) they are not (costlessly) observable to the individual consumer, either before or after consumption, and ii) though producers of processed foods often possess information about processing and nutritional quality that might help consumers make informed purchasing decisions, they cannot credibly convey this information to (and indeed may have incentive to conceal it from) consumers. To the extent that these conditions hold, processed foods can therefore be characterized as *credence* goods (Darby and Karni 1973). It is well known that credence goods can lead to market breakdown.[4] In what follows we argue that a powerful confluence of facts gleaned from the history and current nature of food processing, nutrition science, and food policy appear to imply that the size of this particular market breakdown is large, and is unlikely to be rectified without policy intervention.

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[3] While these "usual sources" of market failure in the market for food are sometimes mentioned in both the popular press and the scientific literature, their impacts are thought to be small. Alston *et al*. (2008), for instance, argue persuasively that U.S. agricultural subsidies, though large, result in only very small distortions of the retail market. Rashad and Markowitz (2007) and Smith *et al*. (2007) provide estimates of the moral hazard effect of health insurance on health outcomes (obesity or weight gain); both find it to be negligible.

[4] For a recent review of the literature on credence goods, see Dulleck and Kerschbamer (2006). The market breakdown to which we refer resembles the "lemons" market described by Akerlof (1970), in that only low quality products are traded.

This essay proceeds as follows: We begin with a brief review of the current state of knowledge in nutrition science, with special attention to the relationships between modern food processing technologies and various measures of nutritional value. We then proceed to examine the historical transformation of the American diet, with special attention to the lack of available information about the nutritional qualities of novel food products at the time they were introduced. This leads us to a consideration of the—somewhat formidable—forces that might prevent a market-based response to new information. We conclude with a look at the historical developments that led to the modern dominance of proprietary brand-name food products, and ask how they might inform policy responses to today's diet-related public health problems.

Effects of Food Processing on Nutritional Quality

The effects of particular dietary constituents on human health are both more complicated—and less well-understood—than the popular conception of nutrition would suggest. Consider, for instance, the historical (but still ongoing) debate over dietary causes of obesity, diabetes, and heart disease. While much of this debate has taken place at the level of macronutrients (protein/carbohydrate/fat), or the even more reductive "calories in vs. calories out,"[5] it is becoming increasingly clear that macronutrient *quality* is the most important dietary determinant of health outcomes. At the same time, a pattern is emerging: nutritional quality has been linked repeatedly to food processing technologies. To

[5] This last perspective has been a favorite in economic studies of obesity, which have tended to focus on the influence of changes in (various measures of) the implicit "price of a calorie" on body weight (e.g., Cutler *et al*. 2003, Chou *et al*. 2004).

illustrate some of the critical subtleties of these findings, we consider first the so-called "glycemic hypothesis."

Refined Carbohydrates and the Endogeneity of Caloric Intake

Proponents of the glycemic hypothesis suggest that, rather than fats or sugars or calories, the most important dietary determinant of a number of chronic diseases (including obesity and diabetes) is *carbohydrate quality*, where quality is measured by blood sugar response in the minutes and hours following ingestion. Experimental studies have demonstrated that following consumption of refined carbohydrates[8], human subjects experience a predictable sequence of physiological events: first, blood sugar levels rise dramatically; followed by a proportional increase in circulating levels of insulin, which in turn induces a number of physiological changes that have the collective effect of bringing blood sugar back into the normal range. In extreme cases, this sequence of events can lead paradoxically to a period of *low* blood sugar many minutes or hours after the meal, during which the subject typically reports feelings of hunger or cravings for sweets. The strength of the glycemic response can vary from person to person, and no simple formula predicts the glycemic effect of a particular food, though it is known to vary with fiber content, particle size, preparation method, chewing speed, and even the combination of foods included in the meal (Ludwig 2002). Nevertheless, this physiological response has been documented

[8] *Refined carbohydrates* are generally understood to include sugar- or starch-containing foods such as sugar, flour, and white rice that have been machine-processed to make them more easily digestible (Taubes 2007).

repeatedly in both animal and human studies, and chronic consumption of low-quality (i.e., high-glycemic index) carbohydrates has been shown in large epidemiological studies to be associated with insulin resistance (diabetes) and obesity (Willet *et al*. 2002).

This phenomenon, is remarkable in part because it represents a clear example of the endogeneity of dietary intake with respect to dietary quality (i.e., the consumption of high-glycemic index foods appears to cause people to eat more, *ceteris paribus*). More importantly, a consumer who lacks schooling in the endocrinology of digestion might not correctly attribute his feelings of hunger to the carbohydrate meal ingested hours earlier, not to mention the possibility that it might be related to the development of diabetes many years later.[9] It also represents an instance in which food processing technologies appear to degrade nutritional quality: refined white flour, for instance, with its small particle size and lack of fiber (Table 1), tends to induce a stronger glycemic response than simple stone ground whole grain flour (Ludwig 2002).

Hydrogenated Oils, Omega-3 Fatty Acids, and Blood Lipids

Dietary fat, as one might expect, is also considerably more complicated than popularly understood. Although dietary fat has long been blamed as a leading cause of obesity and heart disease, there is now a growing consensus that *total* dietary fat intake has little

[9] In their pioneering study of credence goods, Darby and Karni (1973) note that "Credence qualities arise whenever a good is utilized…in combination with other goods of uncertain properties to produce measurable output." This seems to us an apt description of the consumer's diet problem, in which many inputs (i.e., foods) contribute to a single output (i.e., health). Note that the greater the time lag between consumption and illness, the more difficult it will be to link consumption of any particular food to health outcomes. In numerous "natural experiments" in which traditional food cultures have been suddenly displaced by the Western diet, the onset of diabetes typically follows within 18-22 years (Diamond 2003).

demonstrable effect on health outcomes.[10] Rather, the strongest evidence from both clinical and epidemiological studies now points to *trans*-fatty acids—found in many margarines and vegetable shortenings—is the form of dietary fat most conducive to heart disease.[11] And again, *trans*-fats are primarily a product of industrial food processing: nearly all *trans*-fats in the American diet are the product of the partial hydrogenation of vegetable oils, a process that generates a chemically stable, low-cost substitute for lard and butter (Unnevehr and Jagmanaite 2008).

Another side effect of hydrogenation that has been attracting attention of late is the selective destruction of omega-3 fatty acids. While there is widespread scientific agreement that human health is harmed by current levels of *trans*-fats in the U.S. food supply, there is also a growing body of evidence suggesting that health outcomes would be improved if omega-3s were *more* widely consumed. Omega-3 fatty acids are one of two types of polyunsaturated essential fatty acids (the other being omega-6), distinguished by their chemical structures. Both are essential components of the diet (i.e., they are necessary to sustain human life, and neither can be synthesized by the human body from other compounds), and are thought to affect blood lipids in a way that *decreases* the risk of heart disease (Mensink *et al*. 2003). But omega-3 fatty acids are thought to be uniquely effective in preventing cardiac deaths (GISSI 1999, Leaf 2007, Yokoyama *et al*. 2007),

[10] Taubes (2007) provides an excellent review of the scientific debate over the dietary causes of obesity, diabetes, and heart disease, which has been conducted historically on the basis of surprisingly weak evidence. Nevertheless, a consensus emerged—and was for a time incorporated into official U.S. dietary guidelines encouraging consumers to "eat sparingly" of fats and oils—because of a desire to convey a simple message to consumers, and perhaps also for reasons of political economy (Nestle 2007).

[11] *Trans*-fats have the singular ability to increase low density lipoproteins (the "bad cholesterol") while decreasing high density lipoproteins (the "good cholesterol") in the bloodstream. Epidemiological estimates suggest that eliminating *trans*-fats from the U.S. food supply could prevent between 6 and 19 percent of heart attacks and related deaths (Mozaffarian *et al*. 2006).

which makes it particularly unfortunate that they are in such short supply in the modern diet. While the pre-industrial ratio of omega-6 to omega-3 in the diet is thought to be on the order of 1:1, the modern ratio is around 11:1 (Eaton *et al*. 1997).[12] The reasons for this are related to the nature of omega-3s. They are found primarily in fish and green plants but also some nuts and seeds, and, most significantly, omega-3 fatty acids are more susceptible to oxidation and spoilage than their omega-6 counterparts. For this reason, vegetable oils (such as soybean oil) containing significant amounts of omega-3s are not well-suited for use in mass-marketed processed foods (which often require long-term storage without refrigeration), and are typically hydrogenated and used as shortening (Allport 2006). In other words, the shortage of omega-3s in the American diet appears to be yet another unfortunate—and apparently deadly—side effect of modern food processing technology.

Food Processing and the Consumer

Carbohydrate quality and fatty acid composition, while perhaps the most important contemporary examples of the impact of modern food processing on long-term health outcomes, are, nevertheless, only examples. It is not difficult to come up with others, however. For instance, heat treatment is widely used to eliminate food-borne pathogens, but it can dramatically reduce levels of valuable micronutrients in canned foods (Table 1), and (along with homogenization) negatively affects the flavor and other nutritional properties of fresh milk (Schmid 2003). Similarly, the milling of grains entails the isolation and removal of the (vitamin- and essential-fatty-acid-rich) germ and (fiber-rich)

[12] Some researchers argue that the *ratio* of these two types of fats is more important than absolute intakes, implying that a reduction in omega-6 might be beneficial under current circumstances (see Allport 2006 for an extended discussion). Others, however, have failed to detect such an effect in epidemiological studies (Mozaffarian *et al*. 2005, Willett 2007).

bran so that the (carbohydrate-rich) endosperm can be ground into white flour (Davidson and Passmore 1963). It is tempting to conclude that there is some generality to this phenomenon. Perhaps this should not be surprising: the substances modern nutrition science has identified as problematic—refined carbohydrates, *trans*-fats, vitamin-deficient fruits and vegetables, etc.—were novel when first introduced, in the sense that (with rare exceptions) they are not found in nature. Minimally processed traditional diets, on the other hand, have sustained human life for thousands of years, enough time for deleterious health effects to be eliminated either by changes in local food cultures or by genetic adaptation of the consuming population.[13]

The growing scientific consensus that food processing technology may be the root cause of many of the so-called "diseases of civilization" has led some public health advocates to call broadly for a return to minimally processed, traditionally prepared foods (Willet 2005, Pollan 2008).[14] What this position ignores, of course, are the many real benefits of modern food production technologies. By altering food in ways that improves its longevity and uniformity and—at least with respect to food-borne pathogens—safety, retail products can be marketed on a national or international scale. This allows producers to take advantage of economies of scale and the efficiencies of comparative advantage.

[13] Examples of the latter are described by Flatz (1987; on genetic adaptation to lactose) and Diamond (2003; on the relative tolerance for refined carbohydrates among peoples of European descent).

[14] The call to "opt out" of the market for processed food has been made most plainly by bestselling author Michael Pollan (2008), who issues, for example, the following admonitions: "Don't eat anything your great grandmother wouldn't recognize as food," "Avoid food products containing ingredients that are a) unfamiliar, b) unpronounceable, c) more than five in number, or that include d) high-fructose corn syrup," "Shop the peripheries of the supermarket and stay out of the middle," and "Get out of the supermarket whenever possible." The last point constitutes (by its explicit endorsement of local farmer's markets) a condemnation not only of processed food, but industrial agriculture in general. While Pollan does not analyze the information-based causes of the problem that are the focus of our study, it is hard to imagine a clearer declaration of a "lemons"-style market breakdown.

Indeed, it might be argued that consumers see these benefits, in the form of lower prices and convenience and (perhaps) taste, and—having weighed them against the possibility of negative health effects—have decided that the benefits exceed the costs.[15] It is to this question—i.e., whether current American dietary practice can be viewed as the efficient outcome of a free market—to which we now turn our attention.

Hidden Quality and the History of American Food

As noted above, unregulated markets may fail to support trade in high-quality goods when *credence* qualities are present. A necessary condition for a processed food to constitute a credence good is that quality must be *unobservable* to the consumer, even after consumption. In one sense, this is obviously true of many of the nutritional qualities discussed in the previous section: quantification (or even verification of the presence) of trans-fats, or omega-3s, or vitamins lies beyond the limits of human sensory perception, requiring laboratory analysis (or a credible claim on the label—more on this later) too costly to be feasible for individual consumers.[16] But even if this problem were overcome—if consumers could, for example, reliably infer nutrient content from information on food labels—quality could be viewed as unobservable for another reason: nutrition science is complex (our discussion of current knowledge in the previous section, though necessarily simplified, may serve to illustrate), and the fixed cost of learning the long-term health implications of dietary choices (not to mention the time required to

[15] This point is often made more or less explicitly in economic studies of obesity (e.g., Cutler *et al*. 2003, Chou *et al*. 2004, Finkelstein and Zuckerman 2008).

[16] The same logic applies to glycemic effects: human perception of blood sugar levels is limited to extreme highs and lows, as demonstrated by the longstanding practice of external blood sugar monitoring in the treatment of diabetes (Cox *et al*. 1985).

compare labels in the grocery store) could act as an effective barrier to fully informed decisions. Nevertheless, it is possible to imagine that in spite of these barriers, consumers are able, on average (perhaps by imitation of informed consumers) to effectively weigh the costs and benefits of eating processed foods. In what follows we discuss the historical conditions under which many of today's most widely consumed food products were adopted, and consider the implications for the efficiency with which the market has facilitated the trade-offs inherent in dietary choice.

Consider first the history of canning (Figure 1). Invented by Nicolas Appert in 1802 to facilitate export and greatly expanded in the 1870s when new methods of packing under steam pressure large-scale canning and pickling feasible[18], it was the 1920s before the effects of canning on vitamin content began to become clear (Levenstein 1988).[19] Similarly, Gail Borden was awarded the U.S. patent for unsweetened condensed milk in 1856, a development historians now blame for the outbreak of "infantile scurvy" (now known to be caused by Vitamin C deficiency) in the last decades of the 19th century, a

[18] The H.J. Heinz Company was among the first to take advantage of the new technology, soon claiming to produce "57 Varieties" of preserved foods. Heinz invested aggressively in advertising and promotion of its brands, including a popular display at the 1893 Chicago World's Fair (where more than one million attendees receive free samples and a green metallic Heinz pickle charm), a six-story-tall electrically illuminated sign (the first of its kind) in New York, and the opening of the Heinz Pier in Atlantic City in 1899). Another large player entered the scene in 1898, when J.T. Torrance developed a new method of condensing soups (making canned soups less bulky) and founded the Joseph P. Campbell Company, maker of Campbell's Soups (Levenstein 1988).

[19] Indeed, the very existence of vitamins was unknown prior to their discovery by Funk in 1912.

period during which the use of condensed milk (in which most Vitamin C is destroyed by heat during processing) as food for infants increased dramatically (Jay *et al*. 2005, Kiple and Ornelas 2000).

During this same period, technological advances (in the form of the roller mill) made white flour affordable for ordinary Americans (Davidson and Passmore 1963). This newfound industrial efficiency of milling[20] facilitated introduction of the "Uneeda Cracker" by the National Biscuit Company (known today as Nabisco) in 1899, and the aggressive (and ultimately successful) campaigns by the Post and Kellogg's companies a few years later to convince Americans to give up the traditional egg- and meat-based breakfast in favor of cereals made from highly processed grains. That the consequences of these new products for human health were unknown at the time is underscored by the fact that the accompanying ad campaigns aggressively promoted them as *more* healthy and—the existence of microorganisms having been recently discovered—hygienic than traditional foods.[21,22]

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[20] White flour (as compared to whole grain flour) facilitates mass distribution of baked goods because the absence of essential fatty acids eliminates the possibility of rancidity, and (along with other nutritional changes) makes the product less palatable to rodents (Davidson and Passmore 1963).

A similar message was disseminated by the American Sugar Refining Company (the "sugar trust") in the 1880s, which successfully convinced the public that brown sugar was unsafe to eat. Between 1880 and 1915, per capita consumption of white granulated sugar doubled (Levenstein 1988). The "refinement" of brown sugar to white entails the removal of molasses and thus virtually all nutritionally valuable vitamins and minerals (Table 1).

[22] Processing was not, strictly speaking, the only means by which nutritional quality was (inadvertently) diminished for the sake of industrial efficiency. Iceberg lettuce (a new variety introduced in 1903, the virtues of which included being "virtually indestructible" and thus suitable for long-distance shipment by train; see Levenstein 1988), for example, is—we now know—nutritionally inferior to heritage varieties such as Romaine by virtually any measure (Table 1). More generally (and more recently), Davis *et al*. (2004) examined changes in nutrient content for 43 fruits and vegetables between 1950 and 1999 and—noting significant drops in the levels of several nutrients—suggested that trade-offs between yield and nutrient content may be responsible.

Fortunately, once the source of the "diseases of malnutrition" caused by micronutrient deficiency was identified, the problem was largely resolved by replacing key nutrients after processing. However, even this has been a slow process. The first federal standard for the sale of "enriched" white flour was not issued until 1941, and it was amended as recently as 1998 to include folic acid (a dearth of which can cause birth defects) (CDC 2004).

In other cases health effects have taken even longer to discern. For instance ,the hydrogenation of vegetable oils for use in shortening and margarine was developed in Germany in 1903, leading to a 1910 U.S. patent for (and 1911 introduction of) Crisco, but the first studies demonstrating the effect of *trans*-fats on blood lipids (and thus, presumably, heart disease) were not published until the early 1990s (Mensink and Katan 1990, Zock and Katan 1992, Judd *et al*. 1994), and the scientific consensus was not strong enough to warrant a new product labeling requirement until 2006 (Figure 2) (Unnevehr and Jagmanaite 2008).

Omega-3 fatty acids present an even more difficult problem. Though the shift away from omega-3s probably began with the advent of agrarian societies, it has almost certainly been accelerated (as noted above) by the switch to industrially processed foods in the early 1900s. The first reports suggesting any nutritional significance of the omega-3 family of fatty acids were not published until the 1970s (indeed the "omega" nomenclature for distinguishing omega-3 from omega-6 fatty acids was not even proposed until 1964), and though their putative role in the prevention of cardiac deaths was first reported in 1999, these findings were not replicated until 2007 (see above). Because of the inherent

instability of omega-3s, it is not clear whether this nutrient can ever easily be incorporated into processed foods (Allport 2006).

The lag between the introduction of new processing technologies and discovery of the nutritional changes may have been slow in the cases of heat treatment and hydrogenation, but nothing compares with the problem posed by refined carbohydrates (Figure 3). Though millers have been creating ever-whiter flour (and rice processors ever-whiter rice) for thousands of years, the effects of refined carbohydrate on heart disease and body weight remain controversial even today. Indeed, while many researchers and practitioners have pointed to dietary carbohydrates (or more precisely, the *quality* of dietary carbohydrates) as a likely cause of heart disease and obesity over the past century, in recent decades they have been more or less relegated to the fringes of scientific discourse, at least until Ludwig's influential review article appeared in the *Journal of the American Medical Association* in 2002 (Taubes 2007). And even if this debate is resolved in favor of the glycemic hypothesis, it will remain true that glycemic effects are difficult to measure, making it difficult to see how the consumer could easily gauge the tradeoffs between particular products in the grocery store.

Current food processing technologies were originally adopted in part because they improved the efficiency with which products could be delivered to consumers. But if the large food processors introduced (and consumers adopted) novel foods in the absence of information about long-term health effects, we might expect that new information about these health effects would induce, at the margin, a "market correction"—,with consumer demand shifting toward a more traditional diet comprising less highly processed foods.

The next section considers some of the forces that appear to be working against such a correction.

Waiting for the Invisible Hand

> *Most of the poisons introduced into our food supply act slowly and indefinitely, and their results can seldom be traced to the source. There is therefore no particular compulsion upon producers to eliminate them.* --Arthur Kallet (1934, p. 31)

The first barrier to a "market correction" is the problem of search costs. As noted in the previous section, the consumer's search for information about the links between diet and health is costly, because time and literacy are required to understand the scientific evidence, because in many cases there remains disagreement between experts, and because information about nutrients or extent of processing are not found on food labels in an accessible form. This necessarily implies that there will be an implicit bias toward the *status quo* diet, even when new information becomes available—and that the larger the search costs, the smaller will be the response to new information (Schmalensee 1982).[23] That this diet was originally adopted when it was generally thought to be *healthier* than traditional dietary practice suggests strongly that consumers, given the chance to start anew and make the choice all over again, would give less weight to cost and convenience—and more weight to long-term health effects—than is reflected in current dietary practice.

A second barrier standing between consumers and a healthier diet stems from the endogenous provision of information about product quality. It is impossible to fully

[23] As an alternative our "costly search" nomenclature, this reluctance of the consumer to change his diet can be captured more concisely with a single word: *habit*. While this descriptor may be more consistent with the subjective reports of consumers, we emphasize the search framework because it suggests environmental parameters—such as the opportunity cost of time, education, and ease of access to information—upon which the strength of habits might be expected to depend. Our use of the term "habit" in the remainder of this essay should be viewed in this light. For more extended discussions of the proposition that habits might be an optimal response to costly search, see, e.g., Becker 1996, Smith 2004, or Smith and Tasnádi 2007.

characterize the reluctance (or inability) of consumers to adjust to new findings in nutrition science without addressing the predominance of commercial marketing messages. Consumer habits, after all, are presumably associated with particular foods, and more precisely—when it comes to the industrially processed foods that dominate the modern American diet—to proprietary brand names. It is well known that brands can play a useful role in markets for differentiated products (such as brand name foods), allowing producers to send credible signals (via costly advertising) about product quality. While this costly signaling mechanism cannot directly convey information about *credence* qualities (in which quality is never observable), it can support trade with respect to *experience* qualities (in which quality is observable, but only after initial consumption), perhaps including food products that can be trusted not to induce food poisoning or other deleterious short-term health effects.[24] In the resulting equilibrium, sellers of products of (observably) high quality goods gain monopoly power, higher prices, and increased profits, which can justify and sustain large advertising budgets (Nelson 1970, Milgrom and Roberts 1986).

Advertising has played a critical role in the marketing of newly developed brand-name food products since the earliest days (around the turn of the 19th century) of the expansion of the U.S. retail foods market to a national scale (see, e.g., footnote 18), and it continues to do so today (Elitzak 2001). This is an important observation because it underscores a key asymmetry in the market for food that parallels the findings of nutrition science: while

[24] Evidence in support of the notion that brands signal food safety can be found in the fact that most major food safety incidents are attributable not to particular brands, but rather to commodity-level inputs. The U.S. Centers for Disease Control and Prevention (CDC), for instance, reported four occurrences of food contamination or adulteration in 2008 that warranted nationwide alerts, three of which (dairy, jalapeño peppers, and peanut butter) occurred at the commodity level. The fourth might be considered the exception that proves the rule: a *salmonella* outbreak was traced back to cereal products marketed under the *Malt-O-Meal* label, which are promoted as low-cost (and less-advertised) alternatives to the major national brands (CDC 2009).

firms have a private incentive to invest in the promotion of processed (brand-name) foods, minimally processed (and thus, evidently, healthier) traditional foods are necessarily *non-proprietary*, so that no individual seller (of carrots, or lettuce, or tomatoes…) can fully recover benefits that might accrue from their promotion (including, but not limited to, campaigns to educate consumers about the health benefits of consuming such a diet). And while there have been efforts to address this asymmetry with federal nutrition education campaigns and mandatory grower participation in marketing programs, these have been dwarfed by private investments in brand name advertising. Consumers Union (2005), for instance, estimates that total expenditures on the widely touted California and federal "5-a-day" program (advising consumers to eat a minimum of five servings of fruits and vegetables each day) in 2004 were less than 0.1% of comparable expenditures on advertising by commercial sellers of foods and beverages over the same time period. Gallo (1999) uses a broader measure of public expenditures—all U.S. Department of Agriculture expenditures on nutrition education, evaluation, and demonstrations in 1997—that still adds up to less than 5% of advertising expenditures by food manufacturers.[25]

Today's popular brand-name foods represent valuable profit streams for their producers, and it should not be surprising that these firms would be reluctant to alter product formulations in response to emerging scientific evidence on health outcomes, especially when such changes will almost certainly increase production costs, and might

[25] The relationship between commercial and non-commercial food advertising expenditures appears to be largely unchanged since the publication of Gallo's study. Total expenditures by federal commodity checkoff programs in 2004 (excluding cotton), for instance, added up to approximately $594 million (Wilde 2006). Again, this was just 5% of the $11.3 billion spent on advertising by just the largest commercial purveyors of foods and beverages in the same year (Endicott 2005).

even be harmful with respect to consumer demand (if flavor or appearance are noticeably affected).

It might be argued that under these conditions new entrants should be attracted to enter the market with new, healthier products. This mechanism is, unfortunately, hindered by the credence problem. In the absence of standards or certifications (providing clearly agreed-upon definitions of terms and units of measure, for instance, for qualities of interest to the consumer) that would facilitate the communication of product-specific quality information to the consumer, sellers of high-quality foods will be unable to command a price premium.

This reluctance to change on the part of food manufacturers, together with engrained consumer habits, make it hard to argue that the market has reached—or will reach anytime soon—something approaching a "full information" equilibrium, reflecting optimal trade-offs between cost, convenience, and health outcomes. In the next section we examine the history of America's dominant brand-based model for marketing foods and beverages, consider implications for possible alternatives to the persistent information-based market failure evident in the current food system.

Is Branding Efficient?

> *The product of the large, nationally advertising…canners is for the most part of mediocre quality; and this must be so, since the scale of their output does not permit them to select from the best…The companies have naturally resisted efforts to have all cans carry a grade mark indicating the quality of the contents. Imagine the effect on Del Monte advertising and prices, for example, of B and C grade marks on Del Monte cans.* --Arthur Kallet (1934, pp. 31-32)

Utilizing a system of brand names to convey information about product quality is appealing because—while it cannot solve the credence qualities problem—it leaves decisions about the minutia of product design and promotion to the market participants

most informed about these matters. But in the retail market for food, a case can be made that our predominantly brand-based system *exacerbates* the credence problem, because of the unfortunate (though in some sense predictable) historical coincidence of processing innovations with deleterious long-term health effects. Even if this were not the case, brands come with inherent inefficiencies, as prices are distorted upward by market power. Money spent on commercial food advertising provides a lower bound on the social welfare cost of branded foods (or, if you will, the cost of providing the limited quality information conveyed by food advertisements), and these expenditures are not trivial: $26 billion in 2000, or 4% of the $660 billion consumers spent on food—up from $7.3 billion or 2.7% of consumer expenditures in 1980 (Elitzak 2001).

There is nothing prohibiting sellers from providing specific product quality information, of course. But as noted above, quality claims in the absence of third-party standards or verification are typically either not credible or too costly for the typical consumer to decipher. Given this difficulty, and in light of the extraordinary expenditures currently devoted to brand advertising, it seems prudent to ask whether a better system of grading or certification for processed foods might be warranted. Such policies, properly implemented, promote competition by effectively converting what had been (unobservable) credence qualities into *search* qualities (in which quality is known by the

consumer before purchase) (Nelson 1970). It is unrealistic, however, to expect producers to support movement in this direction. Once again, history serves to illustrate.

Today's brand-based food economy has not always been seen as an inevitable outcome. In the early 1930s, when concerns about inconsistent quality in canned foods (including the notorious case of a druggist whose patent medicine killed seventy-three people in seven states; his only punishment under existing law was a two-hundred-dollar fine), Congress considered updating the 1906 Food and Drug Act to include a quality grading system. Such a system would have established standards with respect to process and content for canned foods, resulting in federal "grades" (A, B, C, etc.) that could be placed on food labels by manufacturers who meet the standards. Though the large food processors of the time had initially supported a weaker measure that would have labeled substandard fare "Below U.S. Standard, Low Quality but Not Illegal" they came out strongly against more specific grading of high-quality foods, reportedly both because the proposed penalties for false and misleading advertising would preclude the use of extravagant health claims in marketing new products, and because proposed federal quality grading would diminish the importance of large advertising budgets and brand names (thus making it easier for smaller producers to gain market share) (Kallet 1934). Another important voice speaking in opposition to these regulations was that of the mass circulation magazines (by the mid-1930s, the food industries had become their largest advertisers). The editorial boards of both *Good Housekeeping* magazine and *Ladies Home Journal* were forced into embarrassing reversals after initially expressing support for the bill. A

weakened version of the bill (the *Food, Drug, and Cosmetic Act* of 1938) that did not include a strong grading system was eventually passed (Schlink 1935, Levenstein 1993).

A similar debate played out (mostly at the state and local levels) over the pasteurization of milk. Pasteurization ensures that fresh milk can be stored under refrigeration for extended periods of time without spoilage, and can prevent food-borne disease. But pasteurization is not the only option: milk can also be made safe by a combination of careful attention to hygiene during production and rapid distribution to the consumer. Shortly after the advent of commercial pasteurization in 1890, the Certified Milk movement was founded by H.I. Coit, who advocated against pasteurization because of its impact on both taste and nutritional value—though the latter claim was relatively unfounded at the time (Jay *et al*. 2005). Nevertheless, local laws requiring pasteurization were enacted in many localities, beginning with New York City in 1910 (Levenstein 1988). The debate over whether to require pasteurization (as opposed to certification) to ensure the safety of fresh milk continued into the late 1930s, when a public relations campaign sponsored by large milk producers succeeded in establishing a widespread belief that raw milk is never safe to drink. Many states subsequently banned the sale of unpasteurized milk completely, making pasteurization the norm for interstate commerce (Schmid 2003).[27]

[27] This episode underscores the importance of scale technologies in conveying market power upon producers. Nevertheless, brand names played an important role: the largest national players in the dairy industry at the time (controlling large shares of most urban markets) were the National Dairy Products Company (later re-named *Kraft*) and the Borden Company (Till 1938). Note that the policy outcome (mandatory pasteurization) eliminates potential competition from niche producers of high-quality product (raw milk produced under sanitary conditions).

Another important development in the history of American food came in 1973, when the Food and Drug Administration issued a regulation repealing the 1938 "imitation" rule prohibiting substantial changes to traditional foods without explicit notice (via the printing of the word "IMITATION" on the label). The move was endorsed by a coalition of large food processors, who presumably hoped to benefit from the sale of reformulated versions of traditional foods. This seemingly minor regulatory change has been blamed by some as leading to the dramatic subsequent rise in diet-related illness (Pollan 2008).[28]

Despite the ultimate predominance of branding as the primary means of communicating product quality to the American consumer, it seems reasonable—especially in light of the historical role evidently played by industry in the decision to rely on brands—to reconsider whether an expanded system of certification, quality grading, and/or labeling standards for processed foods might well generate a net gain in market efficiency. That such policies might generate a Pareto improvement is easy to establish in theory, and depends on such factors as the cost and accuracy of monitoring, the extent to which standards are relevant to the concerns (including health outcomes) of consumers, and the impact of implementation on producer market power (Caswell and Padberg 1992, Crespi and Marette 2001, Masters and Sanogo 2002, Raynaud *et al*. 2005). Moreover, certification is already widely employed in the U.S. for organic production, and quality standards exist for seventy vegetables, and twenty-two fruits, and grading is used for red meats, fowl, and eggs (Dimitri *et al*. 1996).

[28] Ironically, the change was also supported by the American Heart Association, on the grounds that it would facilitate the reformulation of many foods to reduce levels of saturated fat. Another implication, however, was that flavor-enhancing additives could now—more than ever—be used to make the presence of low-quality ingredients more palatable (or less perceptible) to the consumer. There are currently more than 3,000 additives used in processed foods sold in the U.S. (FDA 2009).

Toward a More Efficient Market for Processed Foods

> *Consumption is the sole end and purpose of all production; and the interest of the producer ought to be attended to only so far as it may be necessary for promoting that of the consumer.*
> --Adam Smith (1776, p. 159)

> *…the restoration of biological normality by the removal of an abnormal exposure (e.g., stopping smoking, controlling air pollution, moderating some of our recently-acquired dietary deviations); here there can be some presumption of safety.* --Geoffrey Rose (1985, p. 38)

Placed in historical context, it becomes apparent that the modern American epidemic of diet-related chronic illness is at least in part the product of a fundamental failure of the market to deliver high quality foods to the consumer. Nevertheless, we see reason for optimism. The desire of the consumer for a healthy diet, and the willingness of industry to respond, was vividly demonstrated by the recent implementation of the *trans*-fat labeling requirement. This rule has resulted in an *en masse* re-formulation of virtually every *trans*-fat-containing food product on the market (Unnevehr and Jagmanaite 2008).. That this transformation took place nearly a century after the widespread adoption of partially hydrogenated vegetable oils is a lesson that should not be lost in future efforts to remedy the credence quality problem with processed food products. We would propose two broad principles for such efforts.

First, any new food policies should take seriously the words of Adam Smith, and place the interests of the consumer first. We mean this not in the focus group, ask-them-what-they-like-to-eat sense, but rather in the spirit of revealed preference, taking to heart the evidence that people have always gravitated toward healthy foods when convinced they were so. It also implies, importantly, that the interests of large producers should not be given first—nor even, perhaps, last—priority when implementing new regulations. If an efficient market is the goal, then priority should be placed on revealing (in an easily

accessible manner) to consumers product qualities that are most likely to be conducive to long-term good health, and if the interests of producer groups are addressed at all, policy should be aimed at encouraging the participation of *small* producers, in order that rigorous competition might occur across the "quality" spectrum.[29]

Second, food policy should be conservative, as suggested by epidemiologists Peter Cleave (1956) and (later) Geoffrey Rose (1985), who emphasized the dangers of adopting population-level public health policies that might have unanticipated negative effects. By conservative, we mean what Rose meant: when the scientific questions are unresolved, err on the side of what is natural. There is no reason food standards could not be developed that inform the consumer, in effect, of the *extent of processing*—how far removed this product is, if you will, from the foods your great grandmother ate. This would restore competition for a dimension of dietary quality that is currently largely unobservable, and allow consumers to choose something other than "opting out" of the market for processed foods. This is not a particularly radical idea, as it can be viewed as merely reinstating a (perhaps more sophisticated) version of the 1938 "imitation" rule requiring that consumers be given notice when a food product is produced in an unconventional manner. But the implications for public health could be profound.

[29] Evidence that much of existing food policy appears designed to exclude competition from small producers is not limited to the few American examples we reference above. Reardon *et al*. (2001) argue that the strategic use of grades and standards as anticompetitive tools for excluding small producers (often by requiring large capital investment) is widespread in developing countries. This phenomenon is, of course, not unique to the food industry (Stigler 1971).

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Tables and Figures

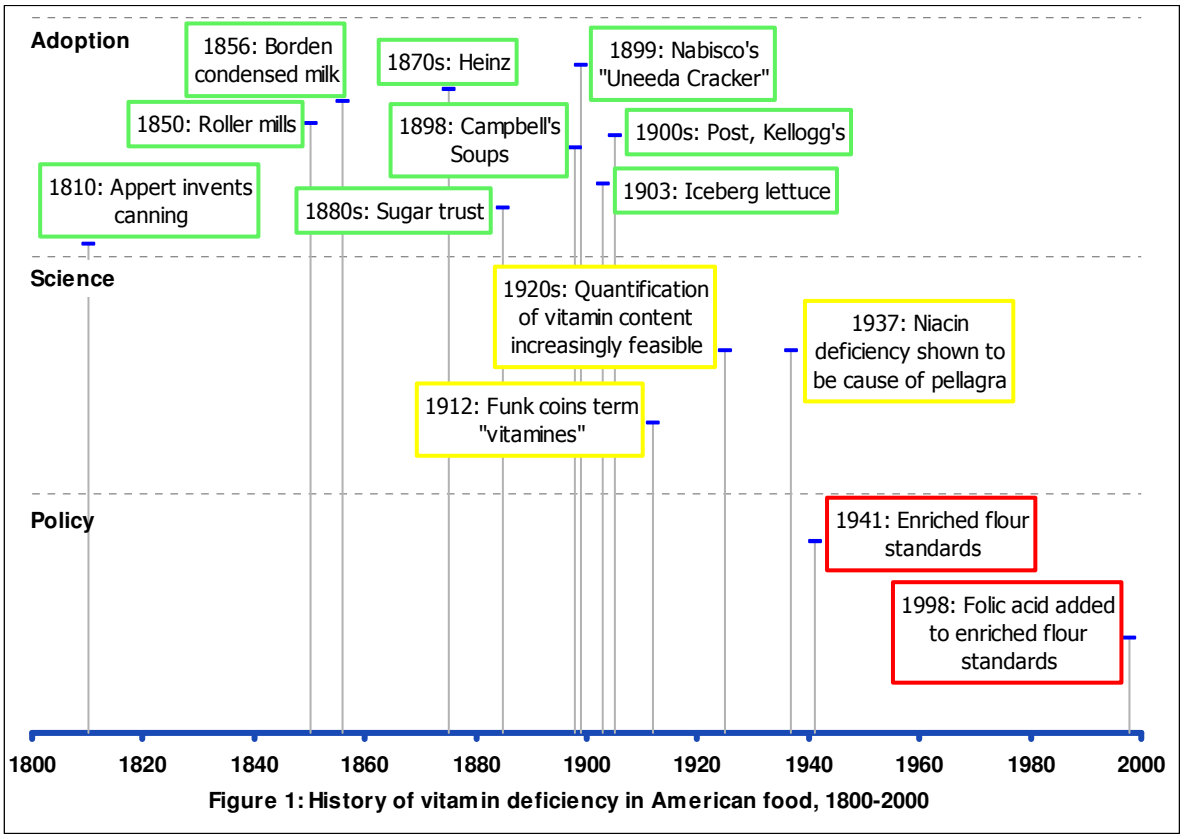

Figure 1: History of vitamin deficiency in American food, 1800-2000

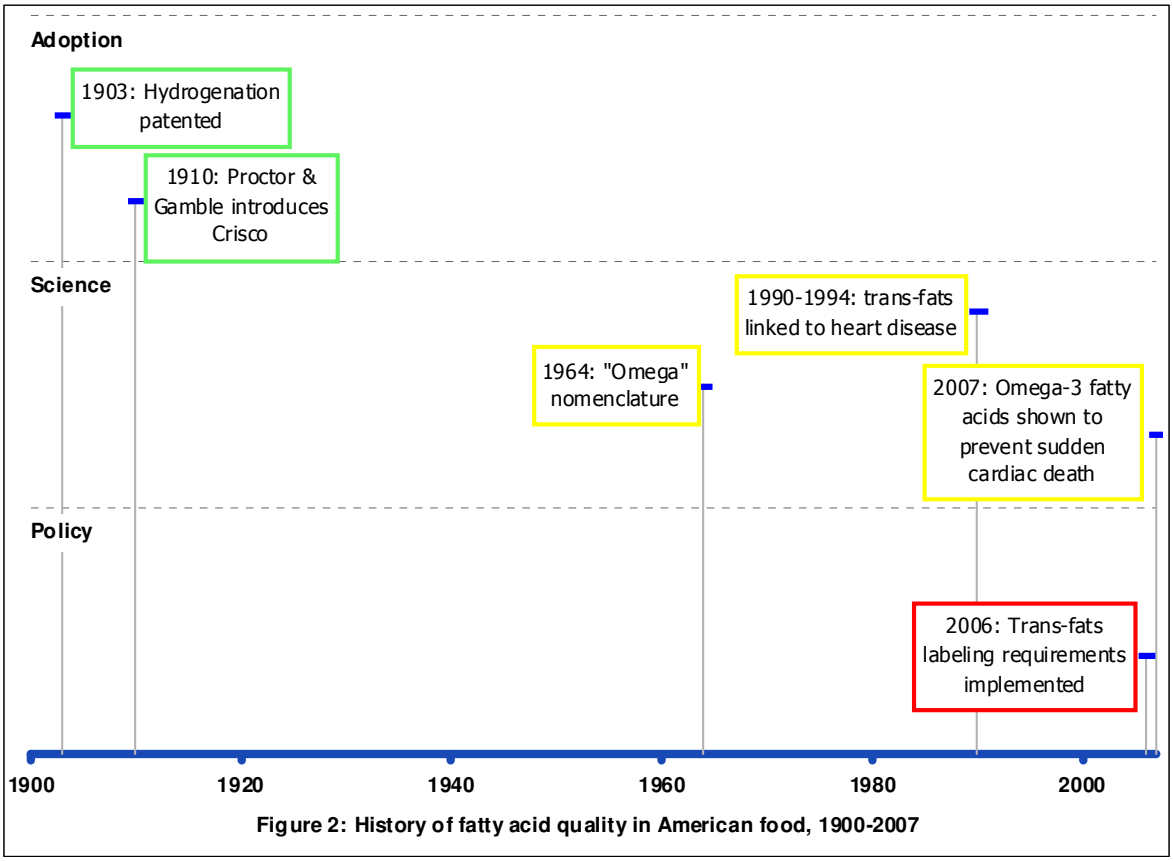

Figure 2: History of fatty acid quality in American food, 1900-2007

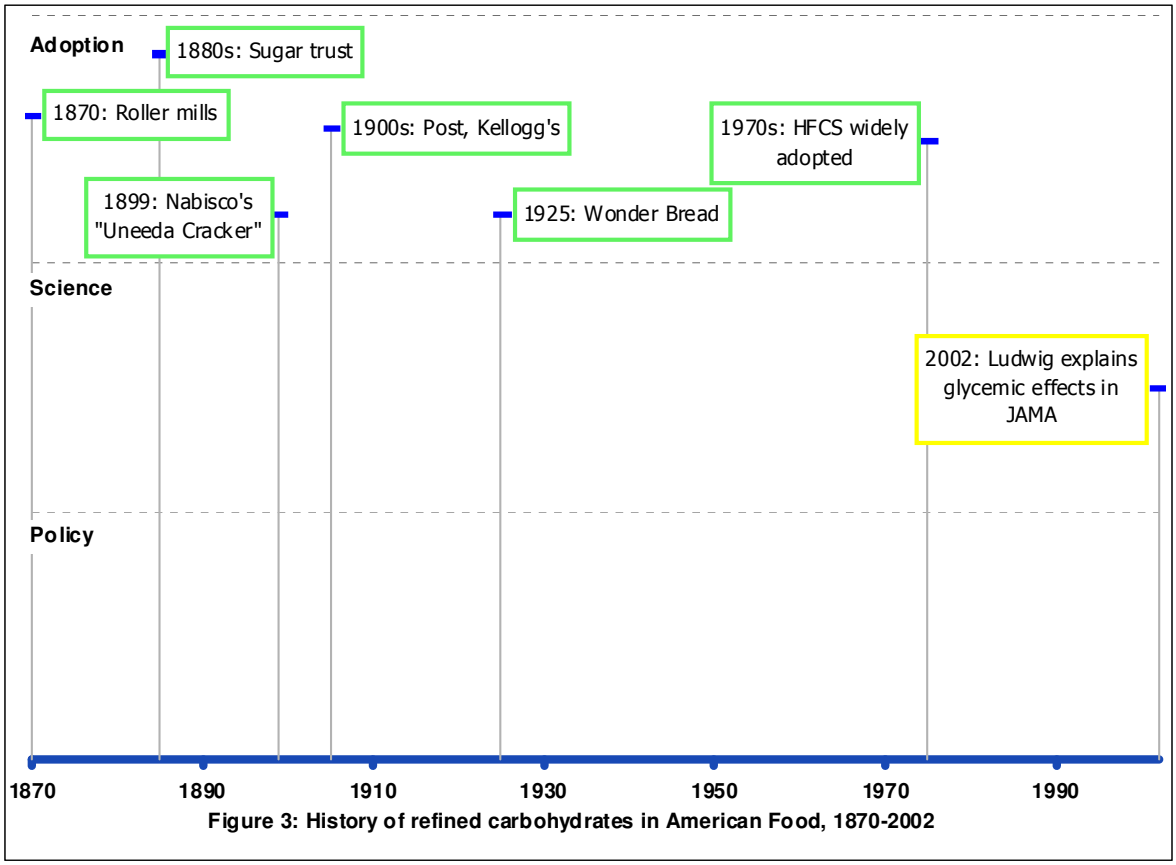

Figure 3: History of refined carbohydrates in American Food, 1870-2002

Table 1: Food Processing and Nutrition

Processed Food	Changes in nutritional quality induced by processing
White Sugar (relative to brown)*	98.8% decrease in calcium
	98.8% decrease in iron
	98.5% decrease in potassium
	100.0% decrease in niacin
Iceberg Lettuce (relative to Romaine)*	43% decrease in fiber
	58% decrease in iron
	35% decrease in zinc
	88% decrease in vitamin C
	63% decrease in riboflavin
	61% decrease in niacin
	43% decrease in vitamin B-6
	79% decrease in folate
	94% decrease in beta-carotene
Canned Tomatoes (relative to fresh)*	27% decrease in vitamin C
	84% decrease in beta-carotene
	2760% increase in sodium
Dried Tomatoes (relative to fresh) (dry wt.)*	27% decrease in vitamin C
	71% decrease in folate
Fresh Tomatoes grown in 1999 (relative to 1950)**	17% decrease in vitamin C
	43% decrease in vitamin A
	55% decrease in calcium
	25% decrease in iron
Canned Apples (sweetened, drained, relative to fresh)*	29% decrease in fiber
	91% decrease in vitamin C
	47% decrease in thiamine
	62% decrease in riboflavin
	20% decrease in niacin
	19% decrease in beta-carotene
	200% increase in sodium
	44% increase in sugar
White Flour (relative to whole wheat flour)*	78% decrease in fiber
	70% decrease in iron
	73% decrease in thiamine
	81% decrease in riboflavin
	80% decrease in niacin
	87% decrease in vitamin B-6
	41% decrease in folate
	63% decrease in monounsaturated fatty acids
	47% decrease in polyunsaturated fatty acids
Enriched White Flour (relative to whole wheat flour)*	78% decrease in fiber
	63% decrease in monounsaturated fatty acids
	47% decrease in polyunsaturated fatty acids
White Rice (relative to brown rice)*	56% decrease in iron
	83% decrease in thiamine
	63% decrease in niacin
	72% decrease in vitamin B-6
	55% decrease in folate
	81% decrease in monounsaturated fatty acids
	84% decrease in polyunsaturated fatty acids
Beef (grain-fed, relative to grass-fed)***	38% decrease in omega-3 fatty acids
	78% increase in omega-6:omega-3 ratio

Sources:
*USDA 2008 and authors' calculations
**Davis *et al*. 2004 and authors' calculations
***French *et al*. 2000 and authors' calculations

Table 2: Notable Events in the History of American Food, 1800-2007

Year	Event
1810	"Canning" (heating and sealing food in an airtight container) developed by Nicolas Appert. Napolean needed to feed a travelling army and offered a prize of 12,000 francs in 1800 to anyone who could create foods to feed his army. After some 15 years of experimentation, Appert was awarded the prize in 1810 (Jay *et al*. 2005)
1837	Pasteur shows that the souring of milk is caused by microorganisms (Jay *et al*. 2005)
1856	U.S. Patent for unsweetened condensed milk awarded to Gail Borden. (Jay *et al*. 2005)
1860	Pasteur shows that heating destroys undesirable organisms in wine and beer (Jay et al. 2005)
1869	First refrigerated box car of fresh fruit shipped east from California. In the following decade, newly established rail networks facilitate delivery of hothouse produce to large cities. New longer-lasting peach variety ships from Georgia to northern cities. (Levenstein 1988).
1870	Advent of roller mills makes white flour affordable for working class households (Davidson and Passmore 1963).
1870s	New technique of packing under steam pressure makes large-scale canning and pickling feasible. The H.J. Heinz Company is among the first to take advantage of the new technology, soon claiming to produce "57 Varieties" of preserved foods. Heinz invests aggressively in advertising and promotion of its brands, including a popular display at the 1893 Chicago World's Fair (where more than one million attendees receive free samples and a green metallic Heinz pickle charm), a six-story-tall electrically illuminated sign (the first of its kind) in New York, and the opening of the Heinz Pier in Atlantic City in 1899 (Levenstein 1988).
1875-1900	Reports of "infantile scurvy" (now known to be caused by Vitamin C deficiency) become increasingly common. Observers have since noted that the use of evaporated and condensed milk (in which most Vitamin C is destroyed by heat during processing) as food for infants increased dramatically over this period of time (Kiple and Ornelas 2000).
1879	Gustavus Swift develops system that allows beef to be fattened and slaughtered in Chicago, then shipped east in refrigerated railroad cars, fresh, dressed, and cheaper than beef on the hoof (Levenstein 1988, p. 31). By the mid-1880s, it was said that the "Golden Age of American Beef" had arrived (Levenstein 1988).
1880s	Newly arisen competitive market for refined sugar spawns formation of a "sugar trust" (the American Sugar Refining Company), which uses market power to eliminate competition and maintain higher prices. The trust also successfully convinces the public that brown sugar is unsafe to eat. Between 1880 and 1915, per capita consumption of white granulated sugar doubles (Levenstein 1988).
Late 1880s	Rail used for daily delivery of fresh milk, fruits, and vegetables to exurban areas of Middle Atlantic and Great Lakes states. Milk sold from American farms rises from 2 billion pounds per year in 1870 to more than 18 billion in 1900 (Levenstein 1988).
1890	Commercial pasteurization of milk begins (Jay *et al*. 2005)
	Experiments in which chickens are fed polished rice provide the first evidence that beriberi is a disease of malnutrition. Beriberi had become widespread in Southeast Asia after the introduction of the steam-powered rice mill in 1870 (Kiple and Ornelas 2000).

Table 2, continued

Year	Event
1891	Federal meat inspection law passed with support from the large meat packers, pre-empting more restrictive state-specific rules (Levenstein 1988, p. 38)
1893	Certified Milk movement started by H.I. Coit in New Jersey (Jay *et al*. 2005)
1898	J.T. Torrance develops method of condensing soups, making canned soups less bulky; founds Joseph P. Campbell Company, maker of Campbell's Soups (Levenstein 1988).
1899	National Biscuit Company (a.k.a. Nabisco) introduces the "Uneeda Cracker." Nabisco eventually captured 70 percent of the market, via a series of mergers of large manufacturers, replacement of generic cracker barrels with sanitary-looking packages, and an aggressive sales and advertising campaign (Levenstein 1988).
1900	Food processing industry accounts for 20 percent of U.S. manufacturing. Of the top four sectors of the industry—meat packing, flour milling, sugar refining, and baking—only baking (with the exception of cracker-baking) is not dominated by a few large corporations (Levenstein 1988).
1900s	Post, and then Kellogg's, invest heavily in national advertising campaigns, which succeed in convincing American consumers to switch from meat-based breakfasts to packaged products made from highly processed grains. Health and hygiene are among the most prominent messages included in these ads as reasons for the switch (Levenstein 1988).
1903	Iceberg lettuce introduced. Called "virtually indestructible," the new variety can be shipped long distances without bruising or wilting (Levenstein 1988).
	German chemist Wilhelm Norman files a patent for the "conversion of unsaturated fatty acids…into saturated compounds" by hydrogenation (Allport 2006).
1906	The *Meat Inspection Act* and the *Pure Food and Drug Act* (new, tougher federal meat inspection and food labeling laws establishing the Food and Drug Administration) are enacted, partly in response to the publication of Upton Sinclair's *The Jungle.* H.J. Heinz and other large canners initially oppose, then support the legislation when it becomes clear that federal oversight is needed to assuage consumer fears about the safety of processed foods (Levenstein 1988).
1907	The first systematic description of *pellagra* (a disease now known to be caused by niacin deficiency) is published in the *Journal of the American Medical Association*. Within months, thousands of cases are diagnosed, mostly among the poor in southern states where the diet consists primarily of cornmeal and generally lacks milk or meat (Kiple and Ornelas 2000).
1910	Procter & Gamble develops and patents a new vegetable shortening to compete with lard and butter in home cooking. The patent application stated that "This invention is a food product consisting of a vegetable oil, preferably cottonseed oil, partially hydrogenised, and hardened to a homogenous white or yellowish semi-solid closely resembling lard. The special object of the invention is to provide a new food product for a shortening in cooking…" By 1912, *Crisco* was being widely advertised as "An absolutely new product—a scientific discovery which will affect every kitchen in America" (Schisgall 1981)
	New York City Board of Health issues an order requiring the pasteurization of milk (Jay *et al*. 2005). Many other cities follow suit a few years later (Levenstein 1988).

Table 2, continued

Year	Event
1912	Funk discovers the existence and critical nutritional role of "vitamines" in food (Funk 1912). In the following decade, several individual nutrients are identified, and their importance to human health is gradually established. (Levenstein 1993).
1914	In *U.S. v. Lexington Mill and Elevator Company*, the Supreme Court issues its first ruling on food additives. It ruled that in order for bleached flour with nitrite residues to be banned from foods, the government must show a relationship between the chemical additive and the harm it allegedly caused in humans. The court also noted that the mere presence of such an ingredient was not sufficient to render the food illegal (http://www.fda.gov/opacom/backgrounders/miles.html, accessed 11/19/08). Reports of the successful treatment of pellagra by dietary modification are published (Kiple and Ornelas 2000).
1915	Billboard campaign (sponsored by flour millers) encourages consumers to "Eat More Wheat" (Levenstein 1988).
1923	Procter & Gamble begins radio advertising of Crisco, sponsoring "Crisco Cooking Talks," in which various speakers read recipes that call for the use of Crisco (Schisgall 1981).
1925	Continental Baking acquires Wonder Bread, transforming it into a national brand. (http://www.wonderbread.com, accessed 2/9/09)
1928	Elmer McCollum, the most widely known nutrition researcher in the U.S., warns that white flour has been deprived of most of its vitamin content. In 1930 McCollum is hired by General Mills to promote its consumption; in 1934 he appears on a heavily-promoted Betty Crocker radio special to assure the public that white flour promotes good health (and weight loss); in 1935 he writes a well-publicized letter to Congress denouncing "the pernicious teachings of food faddists who have sought to make people afraid of white-flour bread" and provides the canning industry with a statement assuring the public nutrition science supported "the high favor of canned goods among consumers." In 1938, McCollum received an award from the Grocery Manufacturers Association for his contributions to knowledge of food (Schlink 1935, Levenstein 1993).
1929	Clarence Birdseye sells his method of flash-freezing foods to General Foods. The subsequent stock market crash and events that follow limit the size of the frozen food market until after World War II (Levenstein 1993).

Table 2, continued

Year	Event
1930-1938	In response to concerns about inconsistent quality in canned foods (including the notorious case of a druggist whose patent medicine killed seventy-three people in seven states; his only punishment under the existing law was a two-hundred-dollar fine), Congress considers updating the 1906 Food and Drug Act. The large food processors strongly oppose the bill (after initially supporting a measure that would label substandard fare "Below U.S. Standard, Low Quality but Not Illegal"), reportedly both because the proposed penalties for false and misleading advertising would preclude the use of extravagant health claims in marketing new products, and because proposed federal quality grading would diminish the importance of large advertising budgets and brand names (thus making it easier for smaller producers to gain market share). Another important voice speaking in opposition to these regulations is that of the mass circulation magazines (by the mid-1930s, the food industries had become their largest advertisers). The editorial boards of both *Good Housekeeping* magazine and *Ladies Home Journal* are forced into embarrassing reversals after initially expressing support for the bill. A weakened version of the bill (the *Food, Drug, and Cosmetic Act* of 1938) that does not include these measures eventually passes (Schlink 1935, Levenstein 1993).
1930-1939	Procter & Gamble expands radio advertising of Crisco with the popular "Sisters of the Skillet" program. Two large radio networks (formed by National Broadcasting Company and the Columbia Broadcasting System) now cover dozens of cities. The campaign continues through the Great Depression, and sales of Crisco triple between 1933 and 1939. Procter & Gamble maintains Crisco's dominant market share throughout the 20th century, in part by continually improving its formulation in response to pressure from competing products (Schisgall 1981).
1937	Niacin (then called nicotinic acid) shown to be the critical limiting nutrient in a study of blacktongue (the canine equivalent of pellagra) in dogs (Kiple and Ornelas 2000).
1939	The American Medical Association recommends "restoring" processed foods with nutrients to bring them back to their "high natural levels" (Levenstein 1993).
Late 1930s	After years of debate over whether to require pasteurization (as opposed to certification) to ensure the safety of liquid milk, a public relations campaign sponsored by large milk producers (including most prominently the National Dairy Products Company—later re-named Kraft—and the Borden Company) succeeds in convincing the public that raw (unpasteurized) milk can never be safe to drink. Many states subsequently pass laws banning the sale of raw milk; as a result, pasteurization quickly becomes the norm for interstate commerce (Schmid 2003).
1941	Enriched flour standards established by federal government. Because many states subsequently require enrichment of refined flour, the practice quickly becomes the norm for interstate commerce (Levenstein 1993).
1941-1953	The proportion of household income spent on food increases—in apparent contradiction of Engel's Law—from 22% to 26%. *Fortune* magazine declares that "Of all the violent upheavals that have shaken and transformed the American market, none (has) been bigger, or more baffling, than those affecting food," going on to explain that the biggest change is the now-ubiquitous presence of processed foods in American kitchens: "One out of five home-made cups of coffee drunk in the U.S. today is made from a soluble preparation. In many supermarkets you can now buy a complete turkey dinner, frozen, apportioned, packaged. Just heat and serve" (Levenstein 1993).

Table 2, continued

Year	Event
1949-1959	Thanks to frozen concentrated orange juice, Swanson's heat-and-serve "TV dinners," self-service chest freezers in supermarkets, and newly affordable home freezers, consumer expenditures on frozen foods increase 2700 percent. During this period (dubbed "the Golden Age of Food Processing"), food chemists also develop over four hundred new additives for use in processing and preserving food. Innovations included food coloring, the flavor-enhancer monosodium glutamate (MSG) and strawberry-flavored Jell-O. The trade-off between taste and production efficiency in processed foods is widely acknowledged in trade publications, though rarely mentioned in consumer magazines (*Better Homes and Gardens* featured a "These Foods are News!" column from 1959 to 1961) (Levenstein 1993).
1950	The *Oleomargarine Act* requires prominent labeling of colored oleomargarine, to distinguish it from butter. The Delaney Committee starts congressional investigation of the safety of chemicals in foods and cosmetics, laying the foundation for the 1954 *Miller Pesticide Amendment*, the 1958 *Food Additives Amendment* (requiring manufacturers of new food additives to establish safety; the *Delaney proviso* prohibits the approval of any food additive shown to induce cancer in humans or animals), and the 1960 *Color Additive Amendment*. Upon passage of the 1958 Act, the deputy commissioner of the Food and Drug Administration tells the New York State Bar convention that the FDA intends to use its new authority primarily to *reassure the public about the safety of processed foods* (Levenstein 1993; http://www.fda.gov/opacom/backgrounders/miles.html, accessed 11/19/08).
1950s	*Kraft Television Theater*, an immensely popular live television drama, features commercials for such products as Miracle Whip, Kraft marshmallows, Kraft caramels, Velveeta, and Cheese Whiz; convenience is emphasized (one recipe for "Cheese Rabbit," a quick one-dish dinner, consists of a jar of Cheese Whiz mixed with a can of kidney beans, onion, pepper, margarine, ketchup, and Worcestershire sauce) (Levenstein 1993).
1951	Herbert Dutton shows that linolenic acid (an omega-3 fatty acid) is the cause of the off flavors and odors in soybean oil, leading to the expanded use of partial or selective hydrogenation to eliminate this fat (Allport 2006). Coast-to-coast transmission of television broadcasting becomes possible; Procter & Gamble's award-winning nighttime drama "Fireside Theater" (later re-named "The Jane Wyman Show") transmitted by 94 stations. Crisco is featured prominently, along with various soap products (Schisgall 1981)
1958	704 chemicals are now commonly added to foods (Levenstein 1993). The FDA publishes in the Federal Register the first list of substances generally recognized as safe (GRAS). The list contains nearly 200 substances (http://www.fda.gov/opacom/backgrounders/miles.html, accessed 11/19/08).
1959	The H.J. Heinz Company publishes the *Heinz Handbook of Nutrition*, which warns that "discussions of modern methods of food manufacture inevitably highlight partial losses of a number of valuable nutrients during processing…while the large number of advantages are ignored or taken for granted." The advantages listed include processed infant food, which provides "essential nutrients seldom supplied before when they were needed most" (Levenstein 1993).
1964	Ralph Holman proposes the "omega" system for naming the different families of fatty acids; prior to this (and for several years after) most analysis of dietary fat neglected to distinguish between the various forms of fatty acids (Allport 2006).

Table 2, continued

Year	Event
1966	*Fair Packaging and Labeling Act* requires all consumer products in interstate commerce to be "honestly and informatively labeled," with the FDA enforcing provisions on foods, drugs, cosmetics, and medical devices (http://www.fda.gov/opacom/backgrounders/miles.html, accessed 11/19/08).
1967	Trout raised with corn oil as the only fat in their diet develop a shock syndrome and suffer a high mortality. Trout are the first animal to be recognized as requiring omega-3 fatty acids (Allport 2006).
1973	FDA issues regulations repealing the 1938 "imitation" rule prohibiting substantial changes to traditional foods without explicit notice on the label. The move is supported by the American Heart Association (because it would facilitate the reformulation of many foods to reduce levels of saturated fat) and the food processing lobby (Pollan 2008).
1974-1975	High sugar prices (1974) and expiration (1975) of the patented production process for high fructose corn syrup (HFCS) spawn a dramatic shift away from sucrose (sugar) as the caloric sweetener of choice in processed foods (http://www.hfcs55.com/hfcs-in-usa/, accessed 2/7/09).
1976	The *Vitamins and Minerals Amendments* ("Proxmire Amendments") stop FDA from establishing standards limiting potency of vitamins and minerals in food supplements or regulating them as drugs based solely on potency (http://www.fda.gov/opacom/backgrounders/miles.html, accessed 11/19/08).
1977	A U.S. Senate committee chaired by George McGovern issues *Dietary Goals for the United States*, which call for decreased consumption of red meat and dairy products. These industries express outrage, and the goals are rewritten to say "choose meats, poultry, and fish that will reduce saturated fat intake" (Pollan 2008).
1982	Ralph Holman and his colleagues report that the neurological symptoms of a patient living on a total parenteral nutrition formula are caused by a deficiency of omega-3 fatty acids. Omega-3s come to be recognized as essential for humans (as well as trout), but it's thought to be almost impossible to make someone deficient in this widespread nutrient (Allport 2006).
1989	Dennis Hoffman is the first of a number of investigators to find significant differences in the visual and mental acuity of infants raised on formulas with and without omega-3 fatty acids (Allport 2006).
1990	*Nutrition Labeling and Education Act* requires all packaged foods to bear nutrition labeling and all health claims for foods to be consistent with terms defined by the Secretary of Health and Human Services. The law preempts state requirements about food standards, nutrition labeling, and health claims and, for the first time, authorizes some health claims for foods. The food ingredient panel, serving sizes, and terms such as "low fat" and "light" are standardized; the requirement is implemented in 1992. (http://www.fda.gov/opacom/backgrounders/miles.html, accessed 11/19/08).
1990-1994	Three studies demonstrating the effect of trans-fats on blood lipids (and thus, presumably, heart disease) published (Mensink and Katan 1990, Zock and Katan 1992, Judd et al. 1994).

Table 2, continued

Year	Event
1996	The *Food Quality Protection Act* amends the Food, Drug, and Cosmetic Act, eliminating application of the Delaney proviso to pesticides (http://www.fda.gov/opacom/backgrounders/miles.html, accessed 11/19/08).
1998	Folic acid added to enriched flour standards (CDC 2004).
1999	First published report suggesting that omega-3 fatty acids can prevent sudden cardiac death (GISSI 1999).
2002	David Ludwig publishes article in *Journal of the American Medical Association* (JAMA) reviewing evidence that refined carbohydrates are a likely cause of chronic diseases such as obesity, diabetes, and heart disease.
2003	To help consumers choose "heart-healthy" foods, the Department of Health and Human Services announces that FDA will require food labels to include *trans*-fat content, the first substantive change to the nutrition facts panel on foods since the label was changed in 1993. The rule goes into effect in January 2006 (http://www.fda.gov/opacom/backgrounders/miles.html, accessed 11/19/08).
2004	Passage of the *Food Allergy Labeling and Consumer Protection Act* requires the labeling of any food that contains a protein derived from any one of the following foods that, as a group, account for the vast majority of food allergies: peanuts, soybeans, cow's milk, eggs, fish, crustacean shellfish, tree nuts, and wheat (http://www.fda.gov/opacom/backgrounders/miles.html, accessed 11/19/08).
2007	Omega-3 fatty acids shown to prevent sudden cardiac death (Leaf 2007, Yokoyama *et al.* 2007).