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Milk For Lunch:
The History and Health of Milk in School Lunches

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Humans are the only creatures that drink another mammal's milk, especially as adults. Nowhere is this more true than the United States, where milk has become an integral part of the American diet. Dairy, especially milk, is served at nearly every meal and hailed as an important staple of our diet, particularly for children. Milk comes with heavy associations of health, athleticism, purity, and motherhood. Some of these associations are the result of modern marketing campaigns, while others have their roots in the millennia old traditions of bovine domestication throughout western civilization. At the center of each of these are the general oddity of milk consumption and the general lack of introspection that is given towards milk and the bizariness of the dairy industry. The American public has in recent decades begun to reject gluten, refined sugars, processed meat, and has embraced a variety of health fads, some founded in legitimate health science, some not. This desire to seek an informed relationship with healthy fresh food, in feeling if not fact, has also been directed at dairy in recent years. The increasing prominence of the vegan movement, the availability of nut-based alternatives to dairy milk, anxiety over antibiotics and growth hormones, and the rising enthusiasm for local and raw milk, have all had a deep impact on the American milk industry. However, with the exception of veganism, very few of the consumer driven trends in dairy have questioned the actual claims to health and fitness that milk enjoys, and even these have generally been reactionary in nature, or a result of a lack of interest in dairy as a product rather than a rejection of its cultural claims of being a prerequisite for wellness. How did milk become

such a dietary staple, mandated by school lunches and food stamp programs, and what health impact does it actually pose?

To answer questions about the incorporation of milk as a dietary staple and widespread multibillion dollar industry, it is necessary to examine the history of milk. The history of milk is a lengthy one, with the first “cow” likely having been domesticated more than 10,000 years ago.¹ Such an ancient history makes tracing the historical impact of dairy dubious at best, likely more suited for the realms of archaeology and genetic anthropology than history. What we do know is that approximately 10,500 years ago, wild ancestors of modern cows seem to have been domesticated in the Fertile Crescent. Thanks to the work of geneticists, it seems likely that domestication of cows occurred two, possibly three times in the area now referred to as the Near East. A third domestication may have occurred more recently in Africa, while yaks were also domesticated in what is today China. Once cattle were domesticated, it is suggested that the mutations or genes for lactose tolerance were selected for, and today 35% of the world is lactose intolerant as adults, the greatest concentration of whom are of Near Eastern or Western descent. With cheese, milk, and butter now viable food sources, cows would have become an even more central aspect of life for early nomadic tribes, leading them to roam in search of pastures for their cows, driving both human and bovine migration. Archaeological evidence has suggested that in approximately 5000 BC. the first nomadic tribes who kept cattle began to move

¹ Amelie Scheu et al., "The Genetic Prehistory of Domesticated Cattle from Their Origin to the Spread across Europe," *BMC Genetics*, 2015.

into the southeastern reaches of Europe.² From this point the spread of cattle continued, inseparably tied to the proliferation of these first nomadic tribes who eventually settled into towns, which became cities, kingdoms, and eventually established nation-states.

The creation of nation-states in the West and the military and economic conflicts that arose between them would eventually become a driving force in the spread of dairy. When Christopher Columbus arrived in the Americas for his second voyage in 1493, he brought the first cattle the continents had ever seen. The cattle Columbus brought with him formed the basis for what would eventually become the iconic longhorn breeds. These first Spanish cows encountered a generally hospitable environment, generally devoid of predators, with only drought and high temperatures to limit their spread. These first cattle likely adapted quickly to the new environment, allowing their population to explode into semi-wild herds that remained relatively untethered for the next 200 years as they expanded into North America, spreading with them what the Spanish, and later the puritans saw, as a civilizing influence and mark of western dominance.³

When the other European countries began their own imperialist expansions into the new world, colonists brought with them their home countries' own distinctive breeds, making America not just a proverbial melting pot of peoples but also of cows. As the colonies expanded, so did the demand for old world cattle, generally considered superior and more "pure". The European

² Amelie Scheu et al., "The Genetic Prehistory of Domesticated Cattle."

³ G. A. Bowling, "The Introduction of Cattle into Colonial North America," *Journal of Dairy Science*, July 19, 2010

colonies in North America continued to import cattle from other European colonies with purer and more plentiful stock, as well as from Europe.⁴ The mass importation of cattle continued into the early 17th century until the colonies' bid for independence broke down relationships with Europe. At this point, cattle had already become just as much of an established part of the new world as it was the old. Cattle would have been an integral part of daily life in the early United States, and a familiar part of most people's lives during this agriculturally dominated part of United States history. Indeed, the need for space for farmland, as well as cattle grazing land, was a driving force in the expansion westward for poor farmers. The United States government, which initially attempted to restrain westward expansion to some extent, eventually embraced the spread of cattle as a way to erase Native American culture both by forcing them to give up nomadic lifestyles in order to raise cattle and grow crops, and by using cows as a form of environmental competition to buffalo⁵.

In a gross oversimplification and abbreviation of history, cattle spread from sea to shining sea on the American continent. Although the country would not reach a grand total of 50 full states until 1959 when Hawaii and Alaska were admitted to the union, the United States was effectively a unified nation of cattle from coast to coast.⁶ From the arrival of cows in the colonies until the eve of World War I, the role of dairy cows in society stayed relatively stagnant. The average cow belonged to a farmer of relatively little means and was part of a family farm rather than a dairy. Farms would have had a one to four cows, a few

⁴ G. A. Bowling, "The Introduction of Cattle into Colonial North America."

⁵"US History II (American Yawp)," Lumen.

⁶ Hawaii Statehood Admissions Act, 1959.

other assorted animals, and would have grown a variety of crops.⁷ The average farm was largely a subsistence affair. Crops grown would largely have gone to feeding the farm's occupants, its animals would have grazed or eaten hay during the winter months, while what very little extra farmers had would have been used in barter or sold in order to purchase necessities that could not be produced on the farm. The cow would have been a valuable resource, providing milk and more easily storable milk by-products, which could be sold for some scant income or traded.⁸

Like much of agricultural life, the nature of dairying was fundamentally altered by the changes accompanying the American Industrial Revolution during the second half of the 19th century. The increase in industrial factories brought with them an explosion in the American populace's concentration into cities and urban environments. The country as a whole would not become predominantly urban until after World War II, but in the western and eastern United States, an urban majority had emerged by the early part of the 20th century.⁹ Concentration of workers in cities had two important effects for the dairy industry. First, it created a class of workers separated from their subsistence farms who now had the wages to purchase the food they could no longer grow. Separation of a wage-earning public from their traditional farms provided the opportunity for dairying to become more widely professionalized as the demand for milk in urban centers exploded. Secondly, and perhaps just as important for the development of the

⁷ Carolyn Dimitri, "The 20th Century Transformation of U.S. Agriculture and Farm Policy," June 2005.

⁸ Dimitri, "The 20th Century Transformation of U.S. Agriculture and Farm Policy."

⁹ Leah Boustan and Owen Hearey, "URBANIZATION IN THE UNITED STATES, 1800-2000," 2013.

professional milk industry, it created greater distances that milk had to be transported, as dairies were forced out of the city landscape. This distance between consumer and supplier would eventually shape milk into “the definitive health crisis” of the late 19th and early 20th centuries.¹⁰

Greater distances between milk and consumers creates for the milk industry the unique and all-important risk of spoilage and contamination. Grains can be stored, meat can be dried or salted, but fluid milk in its raw form offers no such preservation options. Milk’s high content of fat, sugar, and protein, which makes it appealing as a food source for humans and the young of mammalian species, also makes it an ideal bacterial culture, especially during the warm summer months. The contamination of milk was not just a matter of sour tasting breakfast cereal and a stomach ache, as it is now, but often resulted in serious sickness and death. Milk transmitted tuberculosis, scarlet fever, and typhoid, which helped lead to milk’s association with infant mortality and illness.¹¹ Perhaps unsurprisingly, when temperature and therefore bacterial milk contamination increased during the summer months, so too did infant mortality, showing a direct relationship with milk consumption. The danger milk posed was so serious that Anthropological studies have cited better milk sanitation as one of the largest factors in lowering infant mortality by 50% between 1900 and 1920.¹²

¹⁰ Sally McMurry, *The Impact of Sanitation Reform on the Farm Landscape in U.S Dairying, 1890-1950* (Buildings and Landscapes 20, 2013), 23.

¹¹ McMurry, *The Impact of Sanitation Reform*, 23-26.

¹² Sarah Komisarow, *Public Health Regulation and Mortality: Evidence from early 20th Century Milk Laws*, (Journal of Health Economics, 56, 2017), 126,127.

Perhaps somewhat ironically, at the same time that milk was increasingly separated from its consumers, and therefore increasingly dangerous, it was also being increasingly marketed as a food for children. As more mothers and young women entered the workforce, medical professionals became convinced that the city would be too mentally and physically taxing for women and compromise the safety of their breast milk and even their ability to produce breast milk. The “American Association for Study and Prevention of Infant Mortality” claimed that “The Wear and tear of modern life, with its demands upon the mothers nervous system....made it impossible for the human race to offer its progeny the sustenance intended by nature.”¹³ As an alternative to breast milk, some physicians pushed urban woman to use cow’s milk and new lines of cow’s milk based infant formula, thereby expanding infant exposure to contaminated milk.

Initially small farmers whose land had been enveloped by the expanding cities attempted to capitalize on the new urban milk markets by operating as urban dairies. These local dairies, or swill dairies as they came to be known, were a source of consternation for the milk-drinking populace and health officials alike. Frustrations with farm animals in urban environments were not limited to cows; indeed, many city planning decisions and laws in New York City were driven by the need to cope with a substantial population of free roaming pigs. Swill dairies in New York and other cities posed problems similar to those caused by barnyard animals in an urban environment, namely stench, a large amount of animal waste, and the animals’ eventual carcasses, which were often left rotting

¹³ Kendra Smith – Howard, *Pure and modern milk: an environmental history since 1900*. (Oxford: Oxford University Press, 2017), 12-20.

on the side of the road.¹⁴ Swill dairies carried with them, however, a unique threat. Cows in these urban dairies were being fed the refuse from breweries and kept in squalid conditions. The dietary and spatial abuse of these urban cattle was reflected in the quality of their milk, resulting in a Sinclairian style expose in the *New York Times*. The expose revealed that cows were often incredibly ill, with rotting teeth and festering sores, producing milk described as a “bluish, white compound of true milk, pus and dirty water... .” The already inedible-sounding product of swill dairies might then be cut with flour, eggs, or sawdust, in order to give it the white color commonly associated with milk. Perhaps unsurprisingly given the ingredients and quality, swill milk was implicated in the death of more than 8,000 infants in New York alone.¹⁵ Eventually public outrage over the expose forced the passage of some of the country's first food safety laws. In the debate and public media discussion surrounding milk purity regulations, the voice of Robert Hartley rose to prominence.

Robert Hartley was a member of the temperance movement, who as early as the 1840s was also writing about the dangers emerging in milk production. Hartley, as a member of the temperance movement, was concerned with the welfare of the poor and the moral character of society. Though his blasting of the swill milk was topically important for the time in which he was writing, his seeming veneration for milk likely had an even greater long-term impact. Hartley seemed to regard milk as a perfect food, capable of not only nourishing the body

¹⁴ Smith-Howard, *Pure and Modern Milk*, 13-17.

¹⁵ New York Times "How we Poison our Children," May 13 1858.

but also the spirit.¹⁶ In his lengthy 1842 article on milk, Hartley claimed that milk had been “made essential by infinite wisdom” to the existence of humans and animals. His near supernatural regard for dairy lead him to suggest that a safe supply of clean milk could cure illness both physical and moral.¹⁷ At the same time that Hartley demanded reform in the milk industry, his exaltation of its benefits insured that milk would continue to enjoy popularity while strengthening its nearly magical associations with purity and health. By the turn of the century, swill dairies had been banned from major cities while railroads had facilitated the movement of increasingly professionalized dairy farms further from their markets. Further distance from cities increased the risks that milk imported to the city posed, even with the introduction of refrigerated rail cars.¹⁸ Though swill milk had been banned, the early 20th century milk industry continued to grapple with a changed industrial landscape and health challenges, as sanitation reform eventually directed its attention towards the rural dairy farm in the aftermath of World War I.

With the arrival of World War I, the place of the cow, as a standard accessory to the normal workings of family subsistence farming, began to be further uprooted. War carried with it the patriotic duty to serve, an influx in government spending, and the need for vast quantities of raw material, which in the case of the dairy industry meant butter, cheese, and most importantly condensed milk. Condensed milk was a valuable wartime asset, reportedly used

¹⁶ Bee Wilson, "The Swill Is Gone," *The New York Times*, September 29, 2008.

¹⁷ Richard A. Meckel, *Save the Babies: American Public Health Reform and the Prevention of Infant Mortality 1850-1929* (Michigan: University of Michigan Press, 1998).

¹⁸ Meckel, *Save the Babies: American Public Health Reform*.

by the Tartars as early as the 13th century. It was cheap, high in calories and protein, containing more than a thousand calories in a can, and most importantly it was incredibly easy to safely store and transport. Indeed the Borden milk company began its position of dominance in the dairy market, shortly after the invention of dairy condensing by Gail Borden Jr., by supplying Union soldiers with condensed milk. The same wartime boom in dairy that helped give the Borden company its start would be seen to an even greater extent and effect during World War I. Actual statistics on the demand for dairy during World War I are difficult to come by, but it was significant enough that dairy farmers were able to procure a flat price on fluid milk for the duration of the war.¹⁹

Flat pricing on milk was significant because it was outside the normal classified milk system which milk dealers used. Milk dealers, such as Borden, bought raw milk from farmers by the hundredweight and processed it to sell to stores either as fluid milk, cheese, cream, or other milk by-products. Different prices were awarded based upon the intended use of the milk purchased. Grade A milk was used for fluid milk consumption and fetched a higher price than grade B milk, which could be used in the production of milk by-products. Farmers were then paid a blended price at the end of the month based upon the amount of milk purchased and used for grade A and B purposes.²⁰ Farmers took issue with this system because it was generally suspected that milk dealers and middlemen between farmers and dealers often lied about the percentage of milk used for fluid milk in order to bring down prices. The blended price system also

¹⁹ Erba and Novakovic, *The Evolution of Milk Pricing and Government intervention in Dairy Markets*, 5-7.

²⁰ Novacovic and Eric, *The Evolution of Milk Pricing*, 9-12.

introduced more volatility into the milk market because payments to farmer per hundredweight would fluctuate widely based upon that month's fluid milk sales.²¹

Following World War I, the blended pricing of milk was generally reinstated into the milk markets, while farmers found their limited bargaining power weakened both by post-war market realities and new sanitation initiatives. The boom in milk demand during war time promoted strong business for farmers and a focus on maximizing milk production to meet the elevated demand. With the war over, the demand for dairy evaporated, falling back to its pre-war levels, leaving the dairy market saturated with professionalized dairy farms with insufficient markets. The glut of cheap milk left dairy farmers largely at the financial mercy of a few large dairy processors, the Borden company, Sheffield Dairy farms, Nestle, and large unionized dairy farm collectives, which acted as subsidiaries of the large companies with which they held contract.²²

Low milk prices, costly sanitation reforms, and monopolization had already pushed many small farmers to the edge of ruin, when in 1929 the Great Depression began. A year later heavy droughts in the West lead to the infamous Dust Bowl. During this time period the largest producers of commercial milk were in New York, New England and Wisconsin, areas relatively unaffected by the Dust Bowl itself. These same areas were, however, still subject to a series of punishing droughts that pushed many already struggling dairy farmers into subsistence levels. In a New York Milk Board presentation to the Governor, it was stated that "...dairymen could not possibly meet their most pressing obligations.

²¹ Novacovic and Eric, *The Evolution of Milk Pricing*, 9.

²² Novacovic and Eric, *The Evolution of Milk Pricing*, 9.

Even the bare necessities of life could not be secured by many farm families, and many dairymen were threatened with the loss of the farms and homes in which their meager lifetime savings were invested.”²³ In New York, it was estimated that a third of farmers were unable to make federal loan payments.²⁴ Eyewitness accounts from dairy farms claimed that many farmers were “destitute of suitable clothing, shoes, and other present-day necessities of life.”²⁵ In a memoir, an Iowan farmer recalls that when you foreclosed on a man’s farm or horse, “you just convicted his family to starvation.”²⁶

With such levels of destitution on farms, it is perhaps unsurprising that attempts at foreclosure were common and often resulted in upwellings of rural violence and frustration. Other midwestern farmers shared stories of tar and feathering judges, attempting to hang tax collectors, as well as efforts to seize munitions stashes.²⁷ In New York, dairy farmers lead protests against low milk prices in a series of strikes, the most significant of which occurred in 1937 and 1939. The 1937 strike was so destructive and violent that it reportedly brought New York closer to martial law than any time since the Civil War. The 1939 strike was generally credited as being a peaceful triumph for labor, but even this comparatively peaceful strike saw protesters run over by trucks, cars flipped on the side of the road, barns burned down, and multiple instances of milk

²³ Kriger Website New York State, Milk Control Board, *Report of the Milk Control Board to the Governor and the State Legislature*(Albany: J.B. Lyons, March, 1934), 3.

²⁴ Thomas Kriger, "Syndicalism and Spilled Milk: The Origins of Dairy Farmer Activism in New York State, 1936–1941," *Labor History* 38, no. 2-3 (1997): 269,270,

²⁵ Kriger, *Syndacalism and Spilled Milk*, 269, 270.

²⁶ Terkel Studs, *Hard Times: An Oral History of the Great Depression*,(Random House Books, 1970), 215,225.

²⁷ Studs, *Hard Times*, 215,225.

processing facilities being stormed by armed farmers who dumped out thousands of gallons of milk. In Wisconsin the violence was perhaps even more dramatic. Throughout the Great Depression there was a period of intense violence, including riots and the frequent bombing of cheese and cream processing facilities and even police stations. In the Wisconsin riot of 1939, police and militia clashed with rioting farmers, using tear gas and bayonets in attempts to subdue the farmers. The militia and police were eventually driven back when their own tear gas was thrown back at them. Strikes and political activity during the Depression managed to make minor changes, but failed to largely shift the structure of the monopolized dairy industry. Instead it would take World War II to overhaul the industry, propelling American dairy production further along its seemingly industrial trajectory.

Just like with World War I, the new global conflict brought with it increased demand for dairy, transformative technologies, and paradigm shifts within the world of American dairy. In the first year of World War II alone the federal government demanded the production of over a million cans of evaporated milk, over 250,000 pounds of butter, and 200,000,000 pounds of powdered milk.²⁸ News publications at the time called this boom in wartime dairy production the “most formidable challenge in its history,” which would provide dairy farmers with “the most tremendous opportunity” the industry had ever experienced.²⁹ In New York there was a 20% increase in fluid milk production alone and a 50-cent increase in prices per hundredweight. Initially

²⁸ New York Times, “DAIRIES ARE HARD HIT,” Sept 13, 1942.

²⁹ New York Times, “DAIRIES ARE HARD HIT,” Sept 13, 1942.

these increases in prices were likely warmly welcomed by farmers and may have helped to end the worst of the widespread dairy riots from the previous decade. However, as the war continued the shape of American dairy began to change. The increase in dairy prices eventually clashed with an explosion in the costs of both labor and grain, two key components for the running of a dairy farm. The combined costs of food and labor ruined many small farmers or drove them out of the industry. In Chicago, during the autumn of 1942, it was reported that dairy farms were being bought out by larger competitors on a daily basis and that an expected 1,700 regional farms would be out of business by the end of the year.³⁰ During the early to middle period of the 20th century the number of dairy farms in New York alone fell by nearly 100,000 while the value per acre of dairy farms approximately doubled.³¹ This trend of increasing value in dairy farm acreage with a decrease in the total number of farms during a time of increased production suggests that larger farms were able to take advantage of the increased demand by consolidating smaller farms and using technology to increase output. Small dairy farmers, unable to afford the high wartime costs of maintaining or upgrading a farm, saw attractive opportunities elsewhere. Farmhands increasingly found new urban-based opportunities in manufacturing. A southern farmhand summarised this sentiment when reflecting on the war, “Who is going to plow a mule for fifty cents a day when you can drive down to Lejeune or Fort Bragg and you’d make seven dollars and twenty cents a day?”³²

³⁰ New York Times, “DAIRIES ARE HARD HIT,” Sept 13, 1942.

³¹ “New York Agricultural Census: Cows Milked and Dairy Products 1920 to 1954,” (USDA, 1954).

³² Lauch Fairthcloth, *Southern Oral History Program*, Wilson Library University of North Carolina at Chapel Hill, July 16th, 1966.

For the rural worker, the wartime boom in manufacturing provided a new more appealing economic option. Meanwhile smaller farmers who didn't wish to part with their farm but were unable to finance a dairy operation found comparatively easy money by raising pork.³³ As more small dairy farms were bought out, or switched to alternate industries, the larger farms were left able to take increasing advantage of wartime economies of scale.

When World War II ended, so too did many of the subsidies and flat rate pricing that farmers had enjoyed for the interim of the war. Though many price support programs ended, the concept of governmental purchase of milk as a price support was maintained and became a pillar of subsequent milk policy.³⁴ The government's ability to purchase milk at parity was eventually legally established in the 1949 Agricultural Act. A ramification of this governmental support was not just the further entanglement of government and dairy, but the act also necessitated the limiting of dairy imports. Had dairy been allowed to be freely imported into the United States, it would have undercut the abilities of American farmers to support themselves in the face of cheaper imports and left the federal government with the legal responsibility to support world dairy prices by buying the vast majority of more expensive domestic milk.³⁵ World War II had brought with it greater dairy consolidation and interdependence with the federal government in legal and practical ways that would shape dairy well into the 21st century. The war had also, however, been accompanied by radical technological

³³New York Times, "DAIRY FARMERS TO GET SUBSIDIES," Sep 26, 1943.

³⁴ Novacovic and Eric, *The Evolution of Milk Pricing*, 10.

³⁵ Novacovic and Eric, *The Evolution of Milk Pricing*, 10.

and scientific shifts that would aid in the reshaping of milk and dairy production into something further afield from its subsistence roots.

The end of World War II and the later half of the 20th century brought with it the transformative technologies of antibiotics, artificial insemination, and effective pasteurization and storage techniques. These technologies, which we shall examine individually, provided the dairy industry with what it needed to become a truly industrial proposition. Pasteurization and antibiotics represent two sides of the same coin, and largely ended the century-long struggle with insuring safely consumable dairy products. The discovery of penicillin was made by Sir Alexander Fleming in the late 1920s. It would not however be until the 1940s that penicillin would be successfully isolated, beginning its tenure at the forefront of the anti-bacterial revolution. The importance of antibiotics was quickly recognized by veterinarians and dairy farmers alike who saw it as an important tool against mastitis, the main pathogenic adversary of the dairy farmer of the time. In 1945, a farmer nicely summarized this sentiment, almost prophetically stating that the “dairy farm is costing too much . . . Mastitis and slow breeding are the main loss of milk production, so do all you can to control these.”³⁶ Antibiotics presented a way to control mastitis and were eventually adopted as a weapon to prevent it from even taking root. Though we often think of antibiotic resistance and chemical contamination as a 21st century concern, dairy farming served as an early warning about the double-edged sword that antibiotics provide. As early as the 1940’s veterinarians were cautioning about

³⁶ Kendra Smith-Howard, "Antibiotics and Agricultural Change: Purifying Milk and Protecting Health in the Postwar Era," *Agricultural History* 84, no. 3 (2010): 330,331.

proper usage of antibiotics³⁷. Veterinarians were, however, expensive, and as farms expanded and became larger, calling in an expensive specialist for a single sick cow became an even less appealing option. Compounding the issue were pharmaceutical companies themselves. A veterinarian's professional diagnosis and treatment may have been expensive, and preventative practices would always be time consuming. Antibiotics, on the other hand, were cheap and relatively easy to administer. Rather than consulting veterinarians, many farmers simply began indiscriminately treating ill and healthy cows with antibiotics. Within a decade of the inception of antibiotics, "officials estimated that half of the two hundred four tons of antibiotics used for veterinary treatment were directed towards treating mastitis." This scattershot approach eventually evolved into farmers feeding cattle ever more complex cocktails of antibiotics regardless of the state of health of their cows. It was better to prevent any sickness from taking off than to risk losing cows or capital to illness. Despite the initial success of antibiotics, a decade later researches still concluded that "mastitis...is probably as far from satisfactory control and elimination, as it has ever been in the history of modern dairying."³⁸ To this day the incidence of mastitis is reportedly anywhere from 15% to 32%, while antibiotic resistant bacteria remains a constant threat.³⁹

Going hand in hand with the widespread use of antibiotics as a tool in increasing dairy safety during the later half of the 20th century was widespread adoption of both more effective pasteurization and sterile storage technologies.

³⁷ Smith-Howard, "Antibiotics and Agricultural Change," 330.

³⁸ Smith-Howard, "Antibiotics and Agricultural Change," 334.

³⁹ "Determining Cause and Incidence Rate of Clinical Mastitis in Dairy Cattle," Determining Cause and Incidence Rate of Clinical Mastitis in Dairy Cattle | Animal & Food Sciences.

Pasteurization itself was not a new idea, having been invented in the 1860s by Louis Pasteur. As early as 1908 Chicago legally required all milk sent into the city to be pasteurized, and by 1924 the Michigan required all milk to be pasteurized, making it the first state to come into compliance with the 1924 Milk Pasteurization Ordinance (POM) recommended by the federal government.^{40 41} However, it would not be until the 1960s that all 50 states adopted pasteurization laws that either met the POM or exceeded its expectations. Today the sale of unpasteurized milk, minus some state exemptions for certified raw milk, is illegal both within states and across state lines.⁴² During the end of this period of statewide adoption of pasteurization, significant advances in packaging and refrigeration technologies were also introduced into the industry, and in some cases the home. Pasteurization, which had been practiced to some degree (even if not always effectively or correctly) for most of the 20th century, was theoretically capable of killing the pathogens within milk. However, in the absence of sanitary/aseptic packaging techniques and widespread refrigeration during the first part of the century, pasteurization had proven unable to prevent milk-related illness. Part of this was simply because even if milk was purified of bacteria during its processing, there was no effective way to prevent contamination further along the its journey from producer to consumer. Even though refrigeration technology was present by 1900, it would not be widespread until

⁴⁰ "Pasteurization," International Dairy Foods Association.

⁴¹ "State Milk Laws," NCLS.

⁴² "State Milk Laws," NCLS.

some time during World War II.⁴³ Consumers began adopting refrigeration, and farmers increasingly were encouraged to adopt refrigeration systems as opposed to simple cooling concrete baths for storage purposes. Between refrigeration on the producer and consumer ends of the supply chain, milk now posed significantly less of a health risk. Between consumer and producer, the processors, who handled pasteurization and packaging, filled in the sanitation gaps. In 1933 and 1940 the precursors to the cardboard and plastic polyurethane packaging we are familiar with today were respectively introduced.⁴⁴ By the latter half of the century, the supply chain of safe milk was completed by the gradual expansion of the PMO to outline detailed sanitary guidelines for processing facilities and the 1957 discovery that prior pasteurization temperatures had not been sufficient to eradicate the pathogenic *Coxiella Burnetii*.⁴⁵⁴⁶ Later in the 1960s and 70s ultra high temperature (UHT) truly aseptic packaging would be introduced. These alternate processing and storage processes allow milk to be stored in boxes unrefrigerated for several months, but due to its less palatable taste, UHT milk is generally only popular in countries where refrigerators are less common. Through the incorporation of antibiotics as well as safer processing and transport, milk faded from a preeminent public health crisis to a hardly thought about dietary staple. Today milk is implicated in

⁴³ Jonathan Rees, *Refrigeration Nation : A History of Ice, Appliances, and Enterprise in America*. (Studies in Industry and Society. Baltimore: Johns Hopkins University Press, 2013),163,164,165.

⁴⁴"USDA GUIDELINES FOR THE SANITARY DESIGN AND FABRICATION OF DAIRY PROCESSING EQUIPMENT," 2001.

⁴⁵"Milk Facts." Heat Treatments and Pasteurization | MilkFacts.info.

⁴⁶USDA GUIDELINES FOR THE SANITARY DESIGN AND FABRICATION OF DAIRY PROCESSING EQUIPMENT," 2001.

only 16% of all foodborne illness, as opposed to 25% a century earlier. While this is perhaps not a massive percentage drop, the fatality rates and incidence in comparison to the population as a whole is substantially lower than it was during the 1900s.

At around the same time that antibiotics and new sanitation techniques were providing a powerful, though flawed, tool to fight cattle disease, new artificial insemination techniques were answering another one of farmers' frustrations, slow breeding. Artificial insemination (AI) was scientifically proposed in papers as early as the 17th century but did not become widely successful in trials until the late 19th century. Up until the early to mid 20th century, use of AI was largely performed by co-operatives of early adopters or for research techniques; however, revolutions in both semen preservation and selection allowed AI to be more widely adopted during the middle of the 20th century.⁴⁷ Widespread use of AI and knowledge of genetics have allowed the milk production of dairy cows to explode over the past half century.⁴⁸ In 1931 the average milk production per dairy cow was approximately twelve pounds per day.⁴⁹ Almost three decades later in 1959, the production of milk per cow had risen to 19.4 pounds of milk produced daily per cow.⁵⁰ With the introduction of recombinant bovine growth hormones during the 1970s and the continuation of selective breeding programs, milk production has reached new highs. Bovine

⁴⁷ R. H. Foote, "The History of Artificial Insemination: Selected Notes and Notables¹," *American Society of Animal Science*, 2002.

⁴⁸ M. Georges, D. Nielsen, and M. Mackinnon, "Mapping Quantitative Trait Loci Controlling Milk Production in Dairy Cattle by Exploiting Progeny Testing," *Genetics*, February 1995.

⁴⁹ "Milk Production on December 1st," December 18, 1931.

⁵⁰ "Milk Production December 11th." December 11, 1959.

growth hormone slows the natural decrease of mammary gland cells of cows in peak milk production and decreases the amount of feed required to produce a gallon of milk. Early trials showed growth hormone capable of increasing milk production by nearly 20% over a short trial, while reducing the required feed by around 30%.⁵¹ Today a single dairy cow produces approximately 60 to 70 lbs of milk per day, a near 600% increase in production per cow.⁵² Perhaps not surprisingly, the introduction of growth hormones into the United States dairy market coincided with the tenure of Earl Butz, whose infamous agricultural slogan “get big or get out” encapsulated the history of both American agriculture and dairy.

Cows have been a part of human history for thousands of year, likely playing enabling roles in the establishment of permanent settlements as a reliable source of food and labor. The importance of the cow has not diminished, continuing both symbolically and literally as a cornerstone of agriculture into the current age. Within the United States, the admittedly brief existence of the dairy cow and its relationship with humans has undergone some of the most intense changes since domestication first occurred. For the dairy farmer, these changes been a difficult history of professionalization, marginalization, and recently industrialization. For the American consumer, the history of dairy has been coupled largely with the increasingly urban landscape and the health challenges posed by these structural changes. Dairy farms have changed from small family-owned herds to thousand-cow, factory-farmed super herds. Not only have the

⁵¹ L.J Machlin, "Effect of Growth Hormone on Milk Production and Feed Utilization in Dairy Cows," May 1973.

⁵² John Ferreira, "National Agricultural Statistics Service Milk Report," March 20, 2018.

structures of farms changed, but the cows themselves have been altered by the forward march of technology, now just as much of a product of the sciences as the chemicals and plastics adopted to combat milk-borne diseases. With the broad history of American dairy production outlined, the question for the 21st century now becomes what benefits and risks does this supposedly “perfect food” actually hold? Who consumes milk, and how has it become a de facto, unquestioned, part of the diet of millions of American children?

To understand how dairy became integral to the current American diet, it is first necessary to dive back into the realm of the historical. The national school lunch program was formally passed into law in 1946 by President Harry Truman; eight years later the country saw the passage of the 1954 Special Milk Program, which cemented the place of dairy in American schools.⁵³ The impact and content of both programs will be discussed later, but their passage was not unprecedented. Milk’s involvement in U.S. public relief projects traces back to the social reform movements of the 20th and late 19th century. The first of these food programs was created by the Children's Aid Society of New York in 1853, which aimed to provide free lunches to orphans attending its vocational school.⁵⁴ For the duration of the 19th century, free lunches and programs of the sort were generally run by independent charities, which were often lead by women of the temperance movement.⁵⁵ Similar charitable organizations went out of their way to insure the health of mothers and infants in the increasingly industrialized

⁵³ Gordon W. Gunderson, "National School Lunch Program (NSLP)," Food and Nutrition Service.

⁵⁴ "A History of Innovation," Children's Aid.

⁵⁵ Janet Poppendieck, *Free for All: Fixing School Food in America* (Berkeley: Univ Of California Press, 2011), 44.

urban centers. As already mentioned, such reformers and early activists, inspired by Robert Hartley's writings on the benefits of cow's milk, began to set up Milk Stations in American cities. These Milk Stations attempted to distribute clean milk to sick and destitute infants.⁵⁶ In 1904 with the publishing of the book *Poverty* by Robert Hunter, concern over poverty and malnutrition among poor children reached a wider audience.⁵⁷ Inspired partially by concerns about societal struggles with industrializations, and partially by attempts to reform the increasingly compulsory American school system, activists and charities increasingly began to offer free or reduced price lunches during school hours.⁵⁸ These reformers believed that widespread malnourishment had negative impacts on both infant mortality, academic success, and future prospects as a citizens. By 1912 the New York Association for Improving the Condition of the Poor served 600,000 meals a year across the country in 40 different states.⁵⁹ In 1914 the New York School Lunch Association, described as an "organization of women," served three-cent lunches to over 170,000 students in New York.⁶⁰ Menus for these specific lunches included cheese sandwiches as well as the occasional ice cream sandwich. Menus in similar programs included the choice of fluid milk or cocoa.⁶¹ During this early section of the 20th century, it was eventually realized that school meal programs were highly successful in helping children, but that the

⁵⁶ Save the Babies: American Public Health Reform and the Prevention of Infant. Meckel 92.

⁵⁷ Gordon W. Gunderson, "National School Lunch Program (NSLP)," Food and Nutrition Service.

⁵⁸ Gordon W. Gunderson, "National School Lunch Program (NSLP)," Food and Nutrition Service.

⁵⁹ Lynne Olver, "The Food Timeline: School Lunch History," The Food Timeline: School Lunch History,

⁶⁰ THREE-CENT SCHOOL LUNCHESES: What has been done for New York children The Christian Science Monitor (1908-Current file); Aug 29, 1914; ProQuest Historical Newspapers: The Christian Science Monitor (1908-1999) pg. 8

⁶¹ Rose Mary Swartz. 1874-1941, *Feeding the Family* (Place of Publication Not Identified: Hardpress, 2013), pg. 154-157.

programs were also unable to be run for organizational and financial reasons on a large scale by the small charitable organizations that had created them. As such, school lunch programs were increasingly turned over to the control of school boards and state legislatures.⁶² The increasing involvement of governmental and bureaucratic organizations in school lunches was further compounded and made possible by World War I, which brought with it both a new variety of canned nonperishables, as well as the large scale management strategies whose development had been necessitated by the need to feed a modern army.⁶³

Increasing involvement of the federal government brought with it both increased ability to sustain large scale meal programs, but also brought with it new political interests. As part of the New Deal of the 1930s, Roosevelt oversaw the creation of the Surplus Marketing Agency (SMA). The goal of the SMA was to insure stable agricultural prices by purchasing surplus product with government money. The SMA also marked a departure from previous agricultural theory in that it sought to procure favorable market conditions and increased productivity through technology and education as opposed to trying to achieve large degrees of small-farm ownership.⁶⁴ This shift in thought would end up favoring larger landowners and help further drive the rise of industrialized farming during the 20th century.⁶⁵ In many ways the SMA's desire to increase productivity through new sciences took agricultural down an analogous path as dairy during the 20th century characterized by increased consolidation, rising technological costs,

⁶² Gordon W. Gunderson, "National School Lunch Program (NSLP)," Food and Nutrition Service.

⁶³ Levine, Susan. *School Lunch Politics : The Surprising History of America's Favorite Welfare Program*, Princeton University Press, 2008. 48.

⁶⁴ Levine, "School Lunch Politics", 48.

⁶⁵ Levine, "School Lunch Politics",48.

boom bust price cycles, and exploding productivity that left small farmers unable to effectively compete.

The increasingly municipally run school lunch programs proved the perfect place for the SMA to put its theories into practice. The children served by lunch programs were a politically safe place to dispose of excess farm commodities, increasing their popularity among both rural farmers and urban populations. By 1940 over 5 million children were being fed through some involvement with SMA donations to school programs.⁶⁶ Some proponents of the SMA's distribution of surplus foods claimed that it helped raise market prices and productivity while it increased "farmers' income over and over the value of quantity removed from the market."⁶⁷ The economic claims of SMA's supporters were heavily contested, but there could be no doubt that the School Lunch program was massively successful from a social perspective, not just because of its political popularity, but also in its ability to drive demand for foods children would not have otherwise have encountered. These early school lunch programs were in effect starting with children to create an Americanized national diet. As one commentator noted, "Foods once disliked but now popular include carrots and peas and peanut butter sandwiches. A child can be taught to eat all foods except those forbidden by religion."⁶⁸ Introducing new foods was not, however,

⁶⁶ Levine, "School Lunch Politics",50.

⁶⁷ Levine, "School Lunch Politics",50.

⁶⁸ <http://www.foodtimeline.org/foodschoools.html> "Autumn Brings Back the School-Day Lunches," Edda Morga, *New York Times*, October 3, 1937 (p. G16)

an easy task; it reportedly took three years to popularize Spanish rice, and seven years to popularize wheat bread over white bread.⁶⁹

There was, however, a limit to the willingness of children to adopt foods especially when the need to dispose of excess food began to eclipse the actual needs of students. Today critics of school lunch programs often suggest that donation programs flood schools with undesirable food that students neither want or need. In the context of today's schools this claim is open for debate and will be further examined for validity later; however, in the 1930s it was certainly true. Schools reportedly received massive quantities of eggs, apples and other more unusual foods such as grapefruit or olives. The Department of Agriculture was quick to suggest that eggs were a healthy alternative to other protein sources. While eggs may perhaps be a healthy option, students were served hard boiled eggs for days at a time and “revolted” at their future presence in meals.⁷⁰ Similarly there was such an overabundance of apples that students left them in the toilets rather than eat them, while they chose to use the grapefruit to play ball with due to their unfamiliarity with the fruit.⁷¹ While the federal government had eagerly extended its New Deal policies into the realm of school lunches, milk remained absent from these government programs on a national level, though this would soon change.

Chicago, which had the most robust of the municipally-run school meal programs, would also be the first to incorporate milk as a concrete part of school-

⁶⁹ "Autumn Brings Back the School-Day Lunches," Edda Morga, *New York Times*, October 3, 1937 (p. G16)

⁷⁰ Levine, "School Lunch Politics", 50.

⁷¹ Levine, "School Lunch Politics", 50,51.

provided nutrition with federal support. In 1940 Chicago began a federally subsidized program in 15 schools providing free or one-cent milk to low-income students. Schools would purchase the milk from farmers, the one-cent fee would go to cover costs, and the federal government would cover the remaining cost, usually amounting to a little less than one cent.⁷² Not only did schools receive reimbursement and expanded buying options through economies of scale, they also began receiving the spiritual predecessors to today's "Got Milk" campaign. Posters and educational materials were provided to lunchrooms and classrooms as part of the program, provided by the Chicago Milk Foundation.⁷³ Such educational materials were supposed to supplement and provide additional nutritional knowledge that was considered generally lacking in students.⁷⁴ During the early 19th century doctors and "health experts" recommended that children drink a quart of milk a day, while adults were recommended an entire pint.⁷⁵ While today such blatant advertising, which still exists within classrooms, may spark some ire, during the period of malnutrition and food scarcity in post-Depression America, the perceived need for both nutritional intake and education was very real.

The Chicago program was widely considered a massive success. Not only was it expanded within Chicago, but the program spread to 11 other large cities within the year.⁷⁶

⁷² Gordon Gunderson "National School Lunch Program (NSLP)." Food and Nutrition Service.

⁷³ Angela Cylkowski, "Teaching of Nutrition in Chicago Public Schools," *Ulletin of the Polish Institute of Arts and Sciences in America* 3 (1945): 491.

⁷⁴ Cylkowski, "Teaching of Nutrition in Chicago Public Schools," 491

⁷⁵ New York Times, "SAYS TWO CONCERNS PRICE ALL OUR MILK," March 14, 1939.

⁷⁶ Gordon W. Gunderson, "National School Lunch Program (NSLP)," Food and Nutrition Service.

Five years later the school milk program was brought onto the national stage through its incorporation into the 1946 National School Lunch Program. The School Lunch program was pushed through Congress as a hotly contested measure, both as a matter of wartime national security, but also as part of an effort to revamp the popular ASA program. The military-minded were concerned about losing potential soldiers to malnutrition. The educationally-oriented charities sought to alleviate social ills and refocus school lunches on the nutritional needs of children rather than agricultural markets. Farmers, on the other hand, were already looking to the post-war future. The surplus of agricultural and dairy products may have dried up at the start of the war, but the agricultural sector was already planning ways to support prices in post-war America. The Dairymen's League as well as other agricultural organizations began to heavily lobby Southern Democrats for the expansion of surplus programs, the chief of which was the school lunch programs.⁷⁷ Despite heavy debate about socialism, racial segregation, and the role of states, the desire for both agricultural supports and well-fed children won out, allowing the act to pass into law under the 79th U.S. Congress.⁷⁸

The act stated that "it is hereby declared to be the policy of Congress, as a measure of national security, to safeguard the health and well-being of the Nation's children and to encourage the domestic consumption of nutritious

⁷⁷ Levine, "School Lunch Politics", 71.

⁷⁸ Levine, "School Lunch Politics", Chapter 4.

agricultural commodities... .”⁷⁹ The act declared that donations should not unnecessarily shape student meals and that nutritional benchmarks should be met in preference to agricultural surplus donations. Actual administration and implementation was left to the states, but participating states would have to match the funds given by the federal government and provide at least one of three nutritionally satisfactory lunch varieties mandated by the federal government.⁸⁰ Much to the boon of the dairy industry, all three lunch varieties incorporated a mandated half pint of milk.⁸¹ The 1946 lunch program had successfully provided a reliable surplus market for increasingly industrialized dairy farmers while also insuring the legal entrenchment of milk as part of school lunches and a healthful diet.

The 1946 act continued in relatively the same form, small budgetary and administrative changes notwithstanding, until the 1960s. The 1950s had seen the continuation of the 1946 act relatively intact, minus scuffling over finances and funding sources, which were often tied to civil rights-based political conflict. The one change of note to school lunch programs during the 50s was the 1954 Special Milk Program, which was passed as a separate entity from the school lunch plans. The Special Milk Program expanded the milk reimbursements available, and had the net consequence of adding an additional 400 million half pints of milk to schools across the country.⁸²

⁷⁹ "H.R. 9680 (83rd): An Act to Provide for Continued Price Support for Agricultural Products to Augment the Marketing and Disposal of Such Products to Provide for Greater Stability in the Products of Agriculture and for Other Purposes," GovTrack.us, 1954

⁸⁰ Levine, "School Lunch Politics", chap 4.

⁸¹ Gunderson "National School Lunch Program (NSLP)." Food and Nutrition Service.

⁸² Levine, "School Lunch Politics", 87.

In 1966 the national school lunch program underwent its first overhaul since its enactment, becoming modified by the 1966 Child Nutrition Act. This addition to the 1946 law significantly expanded the school lunch program, increasing funding, the schools eligible, as well as extending meal reimbursement to cover breakfast programs. The driving force behind this sudden increase in funding for school lunches was two fold. Firstly, it was the result of the “discovery” of poverty and hunger within the United States.⁸³ Urban middle-class citizens, enjoying the post-war prosperity, were shaken to learn about the very real presence of malnutrition and food scarcity around the country. Southern conservatives also supported increased school lunch program spending, though for different reasons. By passing farm legislations they hoped to keep the control of the school lunch programs in the hands of the USDA. As part of the negotiations to procure funding, the Special Milk Program was added as a permanent fixture of the national school lunch program, further ingraining milk as part of a healthy lunch and tool to fight malnutrition.

Following the passage of the 1966 Child Nutrition Act, activism and concern about both poverty and child nutrition continued to expand the school lunch program, though often in unintended ways. Concern about the actual amount of needy children being reached, and a continuation of the War on Hunger allowed the school lunch program to soar to new heights. More children than ever before were being served free or reduced priced lunches, approaching

⁸³ Poppendieck, Janet. *Free for All : Fixing School Food in America*, University of California Press, 2010. ProQuest Ebook Central, 52-56.

nearly 20 million participants by the end of the 1960s.⁸⁴ Activist and political efforts to ensure that low-income children received free lunch had unforeseen consequences. The school lunch program was increasingly becoming what was considered to be an entitlement program. As one historian characterized it, “Put simply, as the number of free meals soared, the number of paying children precipitously declined.”⁸⁵ With the school lunch program increasingly becoming an entitlement program, whose limited funds focused on targeting poor children, the quality of school lunches decreased. The politicians and activists who were focused on health, rather than poverty, increasingly advocated for universal school lunch.⁸⁶ Unable to secure sufficient funding, the vision of a universal nutritional lunch failed to come to fruition and the concern with insuring the quality of school lunches continued to spiral. The focus had shifted from the “nutritionally needy” to the “financially needy,” though neither group was by any means mutually exclusive.⁸⁷ The change of focus of the school lunch program left school districts across the country in financial crises, unable to pay for lunch. Budgetary concerns as well as associations with poverty resulted in the FDA loosening its regulatory requirements on school lunches. Perhaps unsurprisingly, laxer regulations saw the encroachment of soda, vending machines, fast food corporations, and for-profit corporate lunch providers into

⁸⁴ Poppendieck, “Free for All,” 56.

⁸⁵ Poppendieck, “Free for All,” 57.

⁸⁶ Levine, “School Lunch Politics”, 133-135.

⁸⁷ Levine, “School Lunch Politics”, 135.

Chicago Tribune, August 10, 1977 (p. C12)

[NOTE: Read the original document: [The National School Lunch Program Is It Working?/GAO.](#)

schools.⁸⁸ At the same time modifications to school lunch laws, in reactions to large amounts of food waste, increasingly allowed students to pick and choose foods rather than taking the entire lunch. As cafeterias were left with soggy piles of green beans they turned to familiar fast food fare such as french fries and pizza to maintain participation.⁸⁹

Pioneering the revolution in the fast food school lunch was Las Vegas, where a local businessman had negotiated the permissibility of fortified foods as part of an effort to rescue the school system from budget deficits. The program, which had offerings such as vitamin-fortified milkshakes containing the required 8 ounces of milk in a school lunch, was a wild success and signaled widespread acceptance of fortified foods and food substitutions as acceptable cafeteria commodities.⁹⁰ Under President Ronald Reagan in the 1980s, this foray into nutritional substitution reached new heights as massive budget cuts and loosened regulations allowed for further “McDonaldization” of school lunch programs.⁹¹ During this time period, milk was still offered as a mandated part of school lunches, though some schools found loopholes, ie: milkshakes. The increase in heavily processed food and “competitive foods” (such as those served in vending machines and snack bars not comprising the federally mandated school lunch) showed no overall harm to the food industry. Potatoes sold for french fries serve the agricultural market just as well as more wholesome baked potatoes. The dairy

⁸⁸ Levine, “School Lunch Politics”, chapter 8.

⁸⁹ Poppendieck, “Free for All,” 59.

⁹⁰ Poppendieck, “Free for All,” 59.

⁹¹ Poppendieck, “Free for All,” 62-65.

industry was, however, beginning to glimpse a crisis. The encroachment of soda into schools meant that milk was simultaneously becoming one of the most healthy beverage options in the cafeteria and the most under consumed, though it still remained a required part of the meal. Though milk was still decades off from its current low rates of consumption, its place as a nutritional and lunchtime darling was receding in the face of sodas and fruit juices.

The 1990s and ascension of President Bill Clinton carried with it further damages to both the school lunch program and milk's position in it. Though milk faced increasing competition in the 1980s, at the same time the massive growth in the surplus production of cheese and butter meant that these two staples had been unloaded onto schools as donations, where they found ample uses in pizza and other fatty dishes. The 1990s and Clinton's administration, however, brought deepening concerns with the deficit, obesity, and American fat consumption. Widely publicized studies of school lunches found them to be almost comically out of proportion to the USDA recommended macronutrient profiles for a meal. In addition, school lunches were also found to be grossly high in sodium and to lack micronutrients that were deemed part of a healthy diet.⁹² Spurred by concerns about obesity, legislation was passed that required school lunches to actually coincide with USDA nutrient recommendations. Reform was not, however, accompanied by large-scale restructuring, so heavily processed food, competing snacks, soda, and nutritionally fortified foods like pizza and french fries continued as staples of school lunches. French fries and fortified

⁹² Poppendieck, "Free for All," 59.

pizza were not the only school foods that continued to garnish school lunch trays into the 21st century. Milk remained, but now offered in a wide variety of flavored and skim options and bearing the familiar and catchy “Got Milk” slogan.

The 2008 election of President Barack Obama resulted in the “Healthy, Hunger-Free Kids Act” of 2010. This new act, a result of a perceived obesity epidemic and concern about the health of students across the country, was aimed at reversing some of the worst trends in school lunches that had been emerging since the 70s and 80s. The act expanded funding, mandated a greater degree of lunches be made of fruits and vegetables, revamped the “Food Pyramid” by turning it into “My Plate,” and gave the USDA greater ability to police nutritional content of lunches served.⁹³ One notable aspect of the act for dairy products is that it limited milk to nonfat options and suggested dairy make up a side during meals rather than a main aspect of the main course, which was reserved for grains and vegetables. The act, which was soon to be repealed, was widely criticized in the years immediately after its passage for increasing the quantity of food waste and decreasing school lunch enrollment. The act, however, was found to have little long term impact on participation or food waste, and was found to generally increase the amount of micronutrients and vegetables consumed.⁹⁴

Over the past century dairy has undergone significant shifts in both its methods of production as a business, and the ways in which it is consumed by the American public. The dairy cow has shifted from being an integral part of small

⁹³ "Healthy Hunger-Free Kids Act," USDA Food and Nutrition Service.

⁹⁴ N. Vaudrin et al., "Impact of the 2010 US Healthy, Hunger-Free Kids Act on School Breakfast and Lunch Participation Rates Between 2008 and 2015.," *American Journal of Public Health*, January 2018.

family farms, to constituting the sole focus of massive industrial enterprises comprised of thousands of cows and complex technologies. The increasing technological and administrative complexity that characterized 20th-century dairy was accompanied by consolidation and massive rises in production as well as efficiency. Despite the increased availability of dairy at increasingly low prices, the 20th century and the new millenia has been characterized by steadily decreasing levels of dairy consumption.⁹⁵ Dairy markets have, to a debatable extent, compensated for decreased consumption by further inserting themselves into federal school lunch programs. which grew out of charitable hunger relief efforts during the early 1900s. No longer tainted by the threat of disease, milk has in many ways continued to enjoy its status as a perfect food, a status that advertisements emphasize in cafeterias across America as milk competes with increasingly popular sodas and juices. However, it must be examined, to what extent are milk's claims to being the healthy, nutritionally superior choice, actually founded in fact?

To answer questions and gain better understanding on the benefits or risks posed by milk, it is first necessary to examine questions that may seem simple. What exactly is milk? According to the Handbook of Food Chemistry, on a physical level, milk is broadly described as "a heterogeneous mixture which can be defined as a complex chemical substance in which fat is emulsified as globules, major milk protein (casein), and some mineral matters in the colloidal state and lactose together with some minerals and soluble whey proteins in the form of true

⁹⁵ "Healthy Hunger-Free Kids Act," USDA Food and Nutrition Service.

solution.”⁹⁶ A reader without scientific background may now find themselves asking what this jumble of words actually means. To answer that it is necessary to break this description of milk down into its component parts. A “heterogeneous mixture” simply refers to a mixture that is not uniform in its parts that can often be separated from each other. This description of milk becomes more descriptive when it goes on to describe milk’s components as “colloidal,” an “emulsion” and other parts as a “true solution.” The milk fat, casein protein, and some minerals exists as a colloid, meaning that they are microscopically dispersed through milk as distinct particles rather than truly being dissolved. An emulsion is a specific type of colloid, referring to two liquids existing as a mixture of a continuous phase and dispersed phase. A helpful example presents itself in the case of a few oil droplets floating in water. The water (the continuous phase) does not truly dissolve the oil; even when shaken up, the oil just becomes more dispersed (the dispersed phase), existing as distinct droplets within the water. In short, this description is simply saying that fat and casein exist as separate dispersed substances, while lactose and whey protein are actually dissolved within the water that makes up a majority of milk.

If the percentage of the composition of each of these macro-ingredients is examined, the breakdown is as follows: Milk is roughly 87.5% water, 3.9% fat, 3.4% protein, 4.8% carbohydrate, and up to 0.8% minerals.⁹⁷ The specifics of each of these larger components will now be examined and broken down into

⁹⁶ Bhavbhuti M. Mehta, "Chemical Composition of Milk and Milk Products," SpringerLink, January 01, 1970.

⁹⁷ "THE CHEMISTRY OF MILK," Dairy Processing Handbook, March 17, 2016.

their constituents. To begin the discussion of milk's chemical profile, a brief discussion of the structure of water is necessary. A single water molecule represented by the chemical symbol H_2O is two hydrogen atoms each bonded to an oxygen atom through a single polar "covalent" bond. The "polar" aspect means that the bond is unequal, the oxygen hogging the hydrogen's negative electrons, pulling them closer to the oxygen end of the molecule, making it in turn more negative. The chemical mechanisms behind this are unnecessary to describe in further detail, but suffice it to say that the water molecule acts somewhat like a magnet with a positive and negative end. The oxygen becomes slightly negative while the hydrogens both become slightly positive. The slightly positive hydrogen atoms in water molecules are somewhat attracted to the partially negative oxygen atom of other water molecules. It may be helpful to think of the interaction between two water molecules as two bar magnets, with the south pole of one magnet weakly attracted to the north pole of the other, though each magnet remains indivisible. This weak bond of attraction between slightly negative oxygens and hydrogens of separate water molecules generally constitutes what is called a "hydrogen bond," though there are other intermolecular forces simultaneously at play.

The formation of hydrogen bonds and water's highly polar nature are important for understanding solubility and the general appearance of milk as well as milk processing. Within milk the soluble components--proteins and carbohydrates and minerals--become dissolved in the continuous phase. To understand solubility, it perhaps helps to think of the soluble components as a

jumble of paper clips on a table with many bar magnets. Some of the paper clips will be pulled apart by the magnets. Paper clips that are chained together, will remain chained together, though they will still be pulled out of the jumble by their attraction to the magnets. If, however, rubber balls, analogous to milk's insoluble components, were added into the mix, the magnets would have no effect on them and the physical presence of the paper clips and magnets might actually push the rubber balls together. Though more complex than needed for the current discussion of solubility and the properties of water, it is worth noting that additional molecular forces and maximization of entropy and minimization of enthalpy also govern solvation and behavior within a solvent.

With a brief overview of the chemical nature of water and solubility complete, we can now examine the non-water components of milk, the most plentiful and possibly most evolutionarily important of which is carbohydrates. Though there are exceptions to the rule, a carbohydrate is a relatively self-definitional term, describing a hydrated carbon, meaning a carbohydrate contains carbon, hydrogen, and oxygen in a 1:2:1 ratio. In biochemistry, a carbohydrate is a somewhat more specific category essentially synonymous with five to six carbon "saccharides" (derived from the Latin word for sugar). Using this slightly more specific definition of carbohydrate, which is the usual dietary and biochemical definition, a carbohydrate is any of the basic monosaccharides or combination of them. The relevant six- and five-carbon monosaccharides, meaning a single saccharide or "sugar," typically includes glucose, galactose, and fructose. Various combinations of these monosaccharides can form the aptly

named “disaccharides,” composed of two joined monosaccharides, as well as longer chains of monosaccharides, such as glycogen (an energy storage molecule) and cellulose (the tough fibrous material of leaves).

In milk the primary carbohydrate found is lactose, which is of both nutritional and evolutionary importance. Lactose, originally discovered in milk, hence its name, is a disaccharide, composed of a glucose monosaccharide joined to galactose monosaccharide through a beta 1 - 4 glycosidic bond. The terminology may be intimidating, but it is relatively straightforward. The 1 and the 4 simply are indicating that the bond, termed a glycosidic bond, exists between the first carbon of glucose and the fourth carbon of galactose. Meanwhile the “beta” indicates the spatial orientation of this bond in relation to other structural components of the monosaccharides. Existing as the counterpart to “beta” glycosidic bonds are also “alpha” glycosidic bonds. Alpha glycosidic bonds are found in things like starch or glycogen and are easily broken down by humans as a source of energy, which is why high-starch foods like potatoes provide plentiful and easily digestible energy. Beta glycosidic bonds, however, cannot be naturally digested by humans and are found in things such as cellulose and lactose, explaining why we cannot subsist on tree bark or grass.

If humans cannot digest beta glycosidic bonds, then how can we drink milk? This process of milk digestion and metabolism will be addressed in further detail later, but at its root the ability of some humans to digest milk is due to the continued presence of the enzyme lactase into adulthood. Lactase is an enzyme present in some human populations that is responsible for the

breakdown of lactose's beta glycosidic bond, splitting lactose into its digestible monosaccharide components. There are multiple genes and mutations highly associated with possession of lactase into adulthood, the most prominent of these being the T/C - 13910 substitution mutation lying near the gene coding for the lactase enzyme.⁹⁸ This mutation is thought to have emerged at some point within the past 20,000 years and faced significant selection pressures that made it widespread among some groups beginning five to ten thousand years ago.^{99 100} Separate mutations associated with lactase persistence into adulthood have also been theorized to have emerged in multiple populations separately, some as early as the past 2000 years in some African populations.¹⁰¹ The global prevalence of lactose persistence (LP) is approximately 35% and varies geographically, with the highest LP being found in northern Europe where LP can be found in upwards of 80% of the adult population, and the lowest percentages being found in East Asian countries such as Japan.¹⁰² With the multiple instances of selection for varieties of LP associated mutations, it stands to reason that a variety of factors have driven the rise in prominence of LP in humans. Theories explaining the rise of LP and the human consumption of milk are equally varied. Some suggest that the extra calories alone were enough to drive LP's spread, other theories suggest

⁹⁸ A. C. Bulhões et al., "Correlation between Lactose Absorption and the C/T-13910 and G/A-22018 Mutations of the Lactase-phlorizin Hydrolase (LCT) Gene in Adult-type Hypolactasia.," *Brazilian Journal of Medical and Biological Research = Revista Brasileira De Pesquisas Medicas E Biologicas.*, November 2007.

⁹⁹ Pascale Gerbault, Anke Liebert, and Yuval Itan, "Evolution of Lactase Persistence: An Example of Human Niche Construction," *Philosophical Transactions of the Royal Society B: Biological Sciences*, March 27, 2011.

¹⁰⁰ T. Bersaglieri, P. C. Sabeti, and N. Patterson, "Genetic Signatures of Strong Recent Positive Selection at the Lactase Gene.," *American Journal of Human Genetics.*, June 2004.

¹⁰¹ Pascale, "Evolution of Lactase Persistence."

¹⁰² Pascale, "Evolution of Lactase Persistence."

that drinking cow's milk may have helped provide resistance from malaria, and other theories suggest that milk could have served as a valuable source of hydration in arid environments.¹⁰³ Theories attempting to explain LP in northern European populations have also suggested that the success of LP mutations in the Global North is largely due to milk's ability to enhance calcium absorption, which would be advantageous in environments with little sunlight.¹⁰⁴ Sunlight is necessary for the de novo synthesis of vitamin D in humans. Vitamin D is in turn required for adequate calcium absorption, and milk serves as a source of both vitamin D and calcium, a fact advertisers love to share. Though a variety of explanatory factors likely account for the rise of LP in humans, one variable is consistent. Populations that historically herd domesticated cattle are the ones with the largest amounts of LP. LP is too recent of a mutation to have become so widespread solely through genetic drift or chance, suggesting that as humans exercised unnatural selection pressures of breeding and domestication upon cows, they were in turn shaping both our society, culture, and very genome.¹⁰⁵

While carbohydrates found within milk may be the most historically and evolutionarily discussed macromolecules within milk, they are not the only important macromolecules. The second most common macromolecule within milk is protein. Milk is approximately 3.3% protein, and generally contains 8 grams of protein in a single 8-ounce glass.¹⁰⁶ Frequent consumers of protein-

¹⁰³ Pascale, "Evolution of Lactase Persistence."

¹⁰⁴ Gebhard Flatz, "LACTOSE NUTRITION AND NATURAL SELECTION," *The Lancet*, September 17, 2003.

¹⁰⁵ Bersaglieri, Patterson, "Genetic Signature of Strong Recent Selection."

¹⁰⁶ Milk Composition," Milk Facts.

supplemented foods such as protein shakes are likely already unknowingly familiar with the two groups of milk proteins, whey and casein protein, both of which are the bases of popular health supplements. Milk protein is generally 18% whey protein, which is dissolved in the water-based portion of milk, and 82% casein protein, which is dissolved in the aforementioned fat globules.

Before examining the differences between these two proteins slightly closer, it is first necessary to conduct a quick discussion of the nature of proteins. Proteins are involved in essentially all aspects of life, and they form one of the central tenets in the “central dogma” of molecular biology, which states that genetic information in the form of DNA is transcribed into RNA, which is then translated into proteins. Most people are familiar with DNA and the concept that our genetic code is what makes us each human and unique. Proteins are in many ways the end product of our DNA, providing the visible and mechanical manifestations of our genetic code. Proteins help make up everything to the easily visible, such as our fingernails, to the invisible, such as enzymes and the cellular machinery that allows individual cells in our bodies to communicate and survive.

Proteins are evidently important, but what exactly are they? At a basic level the answer is surprisingly simple given the level of complexity that proteins can achieve. Proteins are simply folded and often interconnected chains of amino acids. An amino acid is a carboxylic acid, a hydrogen, an amino group, and an R group connected to a carbon. Understanding the chemical nature and interactional mechanisms of these individual components is not necessary,

suffice it to say that the amino group and carboxylic acid are capable of interacting to join amino acids into the chains that eventually become proteins.

There are 22 amino acids involved in the construction of proteins, whose structure is identical except for the R-group, which is unique to each amino acid. It is this unique R group that gives each amino acid its unique identity and chemical properties. Different R groups make certain amino acids charged, partially charged, hydrophobic, hydrophilic acidic, and imbue amino acids with varieties of other properties that contribute to the complex functionality of proteins. Much like a Lego set, there are a limited number of shapes/colors in the set, but the pieces can be combined and repeated to create a near infinite amount of structures.

Within the human body, 20 of these 22 amino acids are used in the production of proteins. Of these 20 amino acids, nine of them are considered “essential,” meaning the human body cannot produce them, and thus they must be obtained through one’s diet. Cow's milk contains all nine of the essential amino acids, and 18 amino acids in total.¹⁰⁷ Within milk, whey protein is primarily composed of the two proteins alpha-lactalbumin and beta-lactoglobulin. Alpha-lactalbumin comprises approximately 20% of whey proteins and is comparatively high in the sulfur-containing amino cysteine, which allows for the formation of strong bonds within the protein.¹⁰⁸ Alpha-lactalbumin is also involved with the transport of calcium and zinc, and is of particular importance

¹⁰⁷ Saima Rafiq, Nuzhat Huma, and Imran Pasha, "Chemical Composition, Nitrogen Fractions and Amino Acids Profile of Milk from Different Animal Species," July 2016.

¹⁰⁸ E. A. Permyakov and L. J. Berliner, "Alpha-Lactalbumin: Structure and Function.," FEBS Letters., May 19, 2000.

because it is highly involved in regulating the actual production of milk and may possess anti-cancer properties.¹⁰⁹ ¹¹⁰ Beta-lactoglobulin, on the other hand, is of particular uniqueness because it, unlike other bovine milk proteins, is not also found in human milk and is the protein involved in relatively rare allergic reactions to milk.¹¹¹ Beta-lactoglobulin is not, however, just an allergy-causing nuisance, it is involved in the transportation of vitamin A and immunoglobulins that fight pathogenic infection. ¹¹² Beta-lactoglobulin is also a relatively delicate protein that loses its three-dimensional structure at high temperatures and high levels of acidity, making it crucial in milk processing. When you heat milk on the stove, the sticky film that forms on the surface is coagulated beta-lactoglobulin.¹¹³

With an overview of the soluble proteins out of the whey (pun intended), this brief discussion of milk protein can be brought to a close after a glance at the comparatively complex nature of casein proteins. Casein proteins exist within the emulsive phase of milk, forming micelles much like fat particles do in water. A micelle can be thought of as a sphere of molecule, which is generally given its molecular orientation and stability by an interplay of intermolecular forces, predominantly molecular affinity for water. For example, if you and ten of your friends were all wearing large winter coats and hats but no socks, how would you arrange yourselves around a fireplace? You wouldn't want your faces by the fire and would probably orient your faces away from the fire, but in order to warm

¹⁰⁹ Permyakov and Berliner, Alpha-Lactalbumin”

¹¹⁰ "LALBA Lactalbumin Alpha [Homo Sapiens (human)] - Gene - NCBI," National Center for Biotechnology Information.

¹¹¹ Milk Composition," Milk Facts.

¹¹² Milk Composition," Milk Facts.

¹¹³ "Major Milk Proteins," Milk Composition & Synthesis Resource Library.”

your toes you would want to keep your feet near the fire. This represents low and high affinity respectively. Certain structural components of molecules may have high affinity for water and orient themselves towards it, while other components of the molecule may have low affinity for water, and seek to avoid it. By congregating the components with low affinity for water their interactions with water is minimized while maximising the exposure of the components with high affinity to water, resulting in a spherelike micelle. The various components of casein protein similarly act to form micelles. Casein is made up of a variety of casein types, α_{s1} , B, K, and α_{s2} , listed in order of prevalence.¹¹⁴ Alpha and beta caseins are largely hydrophobic (have a low affinity for water) and are found within the center of micelles. K caseins, on the other hand, are found on the outside of the micelle due to molecular components that are more fond of water.¹¹⁵ Casein is also of note because it acts as the main transporter of calcium and phosphate in milk, as well as being structurally vulnerable to acidity. The physical characteristics of casein, namely its aggregation in acidic conditions, is what allows for the formation of the milk curd which is key in the processing of yogurt and other milk products.

The final macronutrient of chemical interest, and of particularly heavy debate within the world of diet and marketing, is fat. Fat, often the object of vilification by media and advertisements, is actually part of a larger group of chemical structures called lipids. A lipid is generally considered to be “any of a

¹¹⁴Mohd Younus Bhat, Tanveer Ali Dar, and Laishram Rajendrakumar, "Casein Proteins: Structural and Functional Aspects," Casein Proteins: Structural and Functional Aspects | IntechOpen, September 07, 2016.

¹¹⁵ Bhat, Rajendrakumar, "Casein Proteins."

group of organic compounds that are insoluble in water but soluble in organic solvents.”¹¹⁶ While this statement might be somewhat confusing at first, it is perhaps helpful to think of rinsing olive oil, a lipid, off of a plate. The oil will not dissolve in water, so just rinsing the plate will leave behind the olive oil. This same olive oil, however, would be soluble if you washed your plate with some sort of dish detergent. With such an amorphous definition it should come as little surprise that lipids include a large variety of molecules, chief among which are triglycerides, phospholipids, steroids, sphingolipids, and terpenes. Within the body these various lipids serve a wide range of functions including cell signaling, bodily odor production, hormonal effects, and cell membrane integrity. Dietary “fat” more specifically refers to triglycerides and fatty acids.¹¹⁷ A fatty acid is simply a carbon chain bound to a carboxylic acid group. In depth chemical explanation is not necessary, suffice it to say that the carbon chain is what causes fats to be hydrophobic.

A fatty acid may be either saturated or unsaturated, terms doubtlessly familiar to even the occasional purveyor of nutritionally related news stories or nutrient labels. Media coverage often focuses on these two categories, calling them “good” or “bad” fats, and providing examples such as butter as saturated and olive oil as unsaturated. What however do the terms “saturated” and “unsaturated” actually mean? A saturated fatty acid is simply a fatty acid whose carbon chain is completely “saturated” with hydrogens. The straight carbon chain covered with hydrogens provides a large surface area for weak intermolecular

¹¹⁶ AD Smith, Oxford Dictionary of Biochemistry and Molecular Biology. Oxford University Press; Oxford: 2000.

¹¹⁷ "Facts on Fats: Dietary Fats and Health," Facts on Fats - Dietary Fats and Health: (EUFIC).

forces to act, so collections of saturated fatty acids with long carbon chains often exist as solids at room temperatures. Unsaturated fatty acids, on the other hand, contain carbons which may be double bonded to each other at one or more locations. A carbon can typically only form four bonds, so double bonding to an adjacent carbon means that each of the carbons involved will have one less hydrogen bonded, making them “unsaturated” by hydrogen. The double bond also introduces a kink into the chain of carbons, disrupting its straight orientation, and thereby reducing the packing of adjacent fatty acids. Less ability to exist in close proximity in space to other fatty acids reduces the effect of intramolecular forces, allowing these fatty acids to be more spread out and fluid, often existing as liquids at room temperature, such as oils.

When unsaturated fatty acids are named they are often referred to by the position and number of the double bonds present. The two essential dietary fatty acids, which your body cannot produce and therefore must obtain through the diet are good examples of fatty acid terminology. These two fatty acids are omega-6 linoleic, and omega-3 alpha linolenic acids. The “omega” followed by a number is in reference to the last carbon in the carbon chain, and its relative position to the first double bond in the carbon chain. For example, omega-3 fatty acids have a double bond 3 carbons away from the end of the carbon chain, starting the count on the omega carbon. The number and orientation of double bonds can add further complexity to the naming process, and conveys additional dietary considerations. Chemical discussion of the naming procedure and properties is superfluous, though it may be of interest that the term “trans-fats” is

in reference to the way the double bond is oriented in space, while “mono and polyunsaturated fats” reference the presence of one vs. multiple double bonds in the chain.

Within milk there are over 400 different fatty acids, though the vast majority of milk fat is made up of less than 20 of these various fatty acids.¹¹⁸ The primary fatty acid within milk is palmitic acid, making up 26% of the total fatty acid content.¹¹⁹ Worth noting is also butyric fatty acid, which is responsible for making milk “rancid” when it becomes broken off from its glycerol backbone.¹²⁰

Whole milk may contain a massive abundance of fatty acids; however, 98.3% of the fat in milk exists as triglycerides. A triglyceride is made from a glycerol backbone and three fatty acids. Glycerol is a molecule made up of three carbons joined with three alcohols in an orientation that allows for three fatty acids to be joined to the alcohols. Mixing and matching a variety of fatty acids attached to a glycerol allows for an immense variety of possible triglycerides with a variety of chemical and physical properties. In milk processing, it is the differences in both melting points and densities of these various triglycerides and fatty acids that is of particular importance.

Composed of shorter carbon chains, and with fewer oxygens and other slightly heavier atoms, fats are generally less dense than fats or carbohydrates. It is this comparatively lower density that allows for the creation of skim and 2% milk. “Skim milk,” as it is called in the United States, is also more aptly referred to as “skimmed milk” in many European countries. “Skim” or “skimmed” milk is

¹¹⁸ "Milk Composition." Milk Facts.

¹¹⁹ "Milk Lipids - Chemical Properties." Milk Lipids - Chemical Properties | Food Science.

¹²⁰ "Milk Lipids - Chemical Properties." Milk Lipids - Chemical Properties | Food Science.

named after its production process, which involves literally “skimming” the fat off the surface of milk. When left for an extended period of time, unhomogenized milk will form a cream layer as the phases of milk slowly separate out. It is the presence and thickness of the cream layer or line that historically served as a marker for good milk, and part of the reason why farmers opposed efforts for pasteurization. Pasteurization as well as homogenization of milk disrupts the formation of the cream line, hence early adopters of pasteurization feared that their milk would be disregarded as an inferior product. Commercial skimming of milk has a long history, and control of the fat content of milk as well as its other chemical properties, is crucial for the production of butter, cream, and other milk by products.¹²¹ The skimming of milk first became industrialized in 1877 with the invention of the milk centrifuge by a German engineer, which was later improved by the Swedish engineer Gustav de Laval.¹²² The centrifugal separator that Laval finalized spun milk at high speeds; the denser “milk” was forced to the bottom of a drum, while the less dense “cream” or milk fat, was forced to the top and flowed into a separate storage container.¹²³ Though initially used for the industrial production of heavy cream, this same basic principle allows for the separation of fat from milk that allows for the creation of 2% and skim milk.¹²⁴

Fat free and reduced fat milk are both the most popular varieties of fluid milk and are increasingly a source of nutritional debate. In 2016 there was around 5 billion dollars worth of skim milk sold, accounting for more than 50% of

¹²¹ P. A. Cant and K. R. Palfreyman, "Milkfat Products," (*New Zealand Dairy Research Institute*).

¹²² Bylund Gosta. "Dairy Processing Handbook," 1995, 91.

¹²³ Gosta. "Dairy Processing Handbook," 92.

¹²⁴ Gosta. "Dairy Processing Handbook," 110.

total fluid milk sales.¹²⁵ Perhaps in reaction to American avoidance of fat, and marketplace preferences for fat-reduced foods, there has been increased scrutiny directed towards skim milk.¹²⁶ Much of the scrutiny surrounding skim milk stems from studies which suggest difference in the rates of cancer and diabetes associated with drinking different milk varieties. The other large debate between the two is centered largely around differences in vitamin content. It only takes a simple internet search to find a near infinite number of popular health and fitness websites heatedly debating the difference in vitamin contents between milk and decrying artificial vitamin fortification (despite no evidence that synthetic vitamins are harmful).

Vitamins are a broad class of organic compounds that animals require in limited amounts and must be acquired through the diet. There is usually considered to be 13 vitamins, 9 of which are water soluble and 4 of which are fat soluble. Milk is generally considered a good source of B vitamins, A vitamins, and vitamin D. Vitamin A and D are, however, fat soluble vitamins. This raises concern because skimming milk to produce 2% and fat free milk removes these crucial vitamins that are dissolved in the cream. Because skimming milk removes these vitamins, skim milk is fortified, with synthetic forms of these same vitamins. Vitamin fortification has been a hugely successful public health initiative within the industrialized world responsible for the eradication of many diseases. Despite the widespread success of fortification in a variety of foods, there is now concern that people, especially children, may be receiving harmful

¹²⁵ "Refrigerated Milk Sales by Category U.S., 2016 | Statistic." Statista.

¹²⁶ Samantha Olson, "Whole vs. Skim Milk For Heart Health: New Dietary Guidelines May Revert Back To Whole Milk," Medical Daily, October 12, 2015.

amounts of some vitamins and minerals.¹²⁷ Knowing the general chemical nature of biomolecules may be interesting, but how exactly do we know what to eat? How many carbohydrates, proteins, fats, and vitamins and minerals do we actually need?

General suggestions for dietary guidelines and restrictions have an ancient history rooted in religious and food safety practices. This being said, modern dietary recommendations centered around insuring a healthful life have a slightly shorter history than one might expect. The first government published recommendations for a healthful diet were published in 1894 as part of a USDA farmers bulletin. At this time the existence of vitamins and minerals was not yet known, yet this did not stop the bulletin from perhaps prophetically proclaiming that “...The evils of overeating may not be felt at once, but sooner or later they are sure to appear perhaps in an excessive amount of fatty tissue, perhaps in general debility, perhaps in actual disease.”¹²⁸

By 1916, this early bulletin was followed by the first ever USDA nutrition guide, *Food for Young Children*, by Caroline Hunt. This handbook sought to lay out food requirements and meal planning for families, emphasizing five basic food groups: milk and meat, cereals, vegetables and fruits, fats and fatty foods, and sugars.¹²⁹ Interest in establishing scientifically grounded nutritional requirements continued to gain traction in the early 20th century as social reformers increasingly fought for school lunch programs that put children's

¹²⁷ "Keep the Multi, Skip the Heavily Fortified Foods." The Nutrition Source. April 19, 2016.

¹²⁸ Etta Saltos, "Chapter 2," in *Dietary Recommendations and How They Have Changed Over Time*, by Carole Davis (USDA/ERS), 34.

¹²⁹ Carole Davis and Etta Saltos *Dietary recommendations and how they have changed in our time* pg 34

nutritional needs over the market needs of farmers.¹³⁰ Driven in part by Depression Era concern for children's well-being, and then by World War II national security concerns, the USDA released the first set of Recommended Dietary Allowance (RDA) guidelines as part of the 1943 wartime nutrition guide.¹³¹

The RDA's, which are still used today in an updated form, are the recommended daily allowance of a nutrient. More specifically the RDA is the estimated daily average intake of a nutrient needed to meet the needs of 98% of a given gender, age, and weight group.¹³² The RDA's of 1943 were more generally marketed to the public as "The Basic Seven" food groups. Newspapers at the time suggested that people consume "green and yellow vegetables; oranges, tomatoes grapefruit...milk and milk products (such as cheese); meat, poultry, fish or eggs (or dried beans, peanuts, or peanut butter); flour and cereals; and butter or fortified margarine (vitamin A added)."¹³³ In 1956 these seven, rather undefined, food groups were trimmed down to the catchier "Basic Four" of milk, meat, fruits and vegetables, and grains.¹³⁴

The basic four continued to be the foundation of nutritional education in the United States until the 1970s and 80s, when concerns about dietary chronic diseases began to emerge.¹³⁵ The issue according to one USDA official was that "The glory of the basic four was its simple grouping of foods, but it was never

¹³⁰ Levine, "School Lunch Politics", 52

¹³¹ Caroline Davis and Elta Saltos, Dietary Recommendations, pg 35.

¹³² DRI handbook pg 9

¹³³ "To Demonstrate The Basic Seven." April 2, 1943.

¹³⁴ Caroline Davis and Elta Saltos, Dietary Recommendations, pg 36.

¹³⁵ Caroline Davis and Elta Saltos, Dietary Recommendations, pg 35.

intended to be a guide to a total diet...it was merely a foundation.”¹³⁶ Late 20th century anxiety about the shape of the American diet was finally manifested in the recommendations to avoid excess calories, fat and cholesterol, salt, and sugar, thereby marking the shift in industrial dietary standards into a policy of avoidance as well as consumption.¹³⁷ Despite this recommendations to limit portion size at meals, Red Cross recommendations still made sure to suggest that young children “have the equivalent of two cups of milk a day.”¹³⁸

Specificity and increasing attention on what not to eat continued into the end of the 20th century and start of the 21st century. The 1990s saw a new emphasis on mindful and enjoyable eating in moderation, as well as the introduction of the controversial and beloved Food Pyramid. The Food Pyramid advocated for a basic diet of grain-based products as well as vegetables, meat, and dairy, as secondary dietary staples. The Food Pyramid , in an era of obesity concerns, was subsequently updated to reflect exercise (featuring a hiking figure), and was replaced with MyPlate in 2011. MyPlate is the current general dietary educational standard and advocates for a greater emphasis on fruits and vegetables, and was less than enthusiastically described by a prominent dietician as “better than the pyramid, but that’s not saying a lot.”¹³⁹

MyPlate, much like its predecessors, presents itself much like an advertisement for healthy eating. Its logo is a colorful symbol of a plate divided up into 4 different colors representing proteins, vegetables, grains, and fruit. It

¹³⁶ Haddix, Carol. "Four Basic Food Groups Grow Up With the Times." July 24, 1985.

¹³⁷ Caroline Davis and Elta Saltos, *Dietary Recommendations*, pg 35.

¹³⁸ Carol. "Four Basic Food Groups Grow Up With the Times."

¹³⁹ William Neuman, "Nutrition Plate Unveiled, Replacing Food Pyramid," *The New York Times*, June 02, 2011.

also contains a blue colored circle off to the side representing a separate serving of a dairy product.¹⁴⁰ The actual dairy page of MyPlate contains colorful infographics extolling the benefits of dairy, largely as a source of calcium, and recommends consuming three cups of fat-free or reduced fat milk (or equivalent dairy products) per day.¹⁴¹ Interestingly, these recommendations also include calcium fortified soy milk as an option for dairy. Further examination of MyPlate dietary recommendations prove relatively sparse in nutritional guidelines with the exception of advice to limit sodium, saturated fats, and sugar, as well as to limit calories to specific intake levels dependent on age and activity level.¹⁴² Given this low level of information that is geared towards the general population, it is necessary to turn towards additional sources when determining dietary needs.

The Reference Dietary Intakes (RDI), are jointly issued by the National Academy of Sciences, the Institute of Medicine, and the Food and Nutrition Board. The RDI is a comprehensive set of recommendations laying out the most up-to-date dietary recommendations.¹⁴³ The RDIs include the RDA, the adequate intake value (similar to a less established RDA), as well as the tolerable upper limit value which measures toxic intake levels.¹⁴⁴ The RDIs, unlike MyPlate, is less concerned with assigning serving sizes of specific food groups and instead simply prescribes recommended nutrient and caloric intake levels, though it does

¹⁴⁰ "What My Plate All About." USDA.

¹⁴¹ "All about the Dairy Group." Choose MyPlate. November 03, 2017.

¹⁴² "What My Plate All About." USDA.

¹⁴³ "Nutrient Recommendations: Dietary Reference Intakes (DRI)." NIH Office of Dietary Supplements.

¹⁴⁴ "Nutrient Recommendations: Dietary Reference Intakes (DRI)." NIH Office of Dietary Supplements.

contain similar recommendations for limiting certain fats, added sugars, and sodium.¹⁴⁵ The RDIs suggest that children between the ages of 4 and 18 receive their daily calories in the form of 25-35% fat, 45-65% carbohydrates, and 10-30% protein.¹⁴⁶ In addition, and of interest to discussions of milk, the RDIs also suggest receiving a daily intake of 1300 mg of calcium and 600 IU of vitamin D.¹⁴⁷ RDI analysis of sample populations found that calcium and vitamin D intakes were below the RDA for essentially all age groups and populations with the exception of women over 50, whose supplement use may actually put some women at risk of surpassing the tolerable upper limit for intake.¹⁴⁸ This same analysis concluded by stating that a large amount of the population may be at risk of vitamin D deficiency complications, but that greater scientific consensus on appropriate assessment of deficiency was desperately needed.¹⁴⁹ The author did, however, note that while clinical determination of deficiency was relatively unstandardized, there was still strong evidence that calcium and vitamin D were necessary for skeletal health.

With these dietary recommendations in mind, how then does milk stack up? One cup of skim milk provides approximately 80 calories and 12 grams of carbohydrates, 0.2 grams of fat, 8 grams of protein, 100 IU of vitamin D, and 300

¹⁴⁵"Nutrient Recommendations: Dietary Reference Intakes (DRI)." NIH Office of Dietary Supplements.

¹⁴⁶ DRI essential guide 70-82

¹⁴⁷ Catharine Ross and Christine Taylor, "Read "Dietary Reference Intakes for Calcium and Vitamin D" at NAP.edu," National Academies Press: OpenBook, 2011, 9.

¹⁴⁸ Catharine Ross and Christine Taylor, "Read "Dietary Reference Intakes for Calcium and Vitamin D" at NAP.edu," National Academies Press: OpenBook, 2011, 10.

¹⁴⁹ Catharine Ross and Christine Taylor, "Read "Dietary Reference Intakes for Calcium and Vitamin D" at NAP.edu," National Academies Press: OpenBook, 2011, 14.

milligrams of calcium.¹⁵⁰ For a somewhat active male child between the ages of 9 and 13 the daily caloric needs are between 1,800 and 2,200 calories.¹⁵¹ If said child consumes the recommended three servings of non-fat milk per day, then even when using the lower caloric value, the servings of milk only account for 13% of his daily calories. Three servings of fat-free milk also would provide 17% of the higher RDA for protein as well as 69% of daily calcium intake and half of the recommended vitamin D. The contribution to daily caloric intake is higher for whole and 2% milk, with whole milk providing 24% of daily calories due to an extra 8 grams of fat per serving, 3 of which are saturated fat. According to the American Heart Association, only 5 to 6% of total calories should come from saturated fat.¹⁵² This means that three servings of whole milk provides 75% of recommended saturated fat intake and 35% of the upper RDA for total fat intake. It is worth mentioning, that while fat has been historically portrayed negatively, polyunsaturated fats are part of a healthy diet. Saturated fats, on the other hand, have been strongly linked to incidence of cardiovascular disease.¹⁵³ With such a seeming wealth of dietary guidelines, that have broadly focused on similar themes since their inception, why has America seen an explosion of childhood obesity, and how do school lunches and milk factor into this worrisome trend?

America's adult male and female overweight population has only increased marginally since 1960, hovering at about 40% and 25% respectively. What has

¹⁵⁰ "Milk Composition." Milk Facts.

¹⁵¹ "Parent Tips: Calories Needed Each Day." We Can! 2010.

¹⁵² Etta Saltos, "Chapter 2," in *Dietary Recommendations and How They Have Changed Over Time*, by Carole Davis.

¹⁵³ Frank M. Sacks et al., "Dietary Fats and Cardiovascular Disease: A Presidential Advisory From the American Heart Association," *Circulation*, January 01, 2017,

changed since then is the percentage of obese individuals, categorized by a BMI (kg/m²) above 30. Since the 1960s obesity rates have shot from just over 10% in men to around 30%. In women the same trend is seen with increases from approximately 25% to almost 40%.¹⁵⁴ At some point during the 1980s obesity statistics take on an even more concerning characteristic as adolescents increasingly began to be classified as obese.¹⁵⁵ Today obesity rates among children and young adults are approximately 17%.¹⁵⁶ The only silver lining is with the exception of the 12- to 19-year-old demographic, in which obesity rates have remained stable over the past decade.¹⁵⁷

Increases in obesity are concerning, especially among children, due to strong associations with negative long-term health outcomes. Obesity is attributed as the cause of an estimated 300,000 deaths per year, is strongly associated with development of type 2 diabetes, increases risk of cardiovascular disease, cancer, stroke, mental health issues, and is found to negatively impact overall quality of life.¹⁵⁸ This does not account for the financial burden of obesity-related health care costs, which are estimated to be 75 billion, 302 million of which are a direct result of complications from childhood obesity. Similarly childhood obesity is also strongly predictive of future health outcomes and

¹⁵⁴ "Overweight & Obesity Statistics." National Institute of Diabetes and Digestive and Kidney Diseases. August 01, 2017.

¹⁵⁵ Anderson, P., & Butcher, K. (2006). Childhood Obesity: Trends and Potential Causes. *The Future of Children*, 16(1), 49.

¹⁵⁶ Overweight & Obesity Statistics." National Institute of Diabetes and Digestive and Kidney Diseases.

¹⁵⁷ Cynthia L. Ogden, "Prevalence of Obesity in the United States, 2011-2012," JAMA, February 26, 2014.

¹⁵⁸ <https://www.sciencedirect.com/science/article/pii/S0303720709003645>

morbidity.¹⁵⁹ Given the public health costs and personal risks associated with obesity, especially as a child, it should come as little surprise that much attention has been given to determining the causes of the “obesity epidemic” both at home and abroad where obesity rates are also beginning to soar. At the individual level, childhood obesity is found to be largely the result of genetics, maternal BMI, as well as environmental and behavioral factors.¹⁶⁰ On the broader scale of public health, the recent trends in childhood obesity are attributed to the intersection of high calorie “convenience foods”, consumption of more pre-prepared fast food, increased reliance on cars, and increases in sedentary activities such as video games and TV.¹⁶¹ Of particular interest is the strong correlation between sugar sweetened beverages (SSB), such as sodas, and obesity.¹⁶² SSB consumption is implicated in increases in negative cardiovascular outcomes and development of type 2 diabetes, regardless of weight gain.¹⁶³ Given the clear costs of obesity, it is of little surprise that school lunches, and milk’s mandated spot within them, have again become the site of controversy.

Assessing the successes of school lunch reform, and the benefits they provide both academically and nutritionally, is less than a straightforward task. A wide variety of factors such as differences in food offerings, a la carte options, student participation, and student demographics contribute to the complexity of

¹⁵⁹ <https://www.karger.com/Article/Abstract/63462>

¹⁶⁰ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3056648/>

¹⁶¹ Patricia M. Anderson and Kristin F. Butcher 39

¹⁶² Vasanti S Malik, Matthias B Schulze, Frank B Hu; Intake of sugar-sweetened beverages and weight gain: a systematic review—, *The American Journal of Clinical Nutrition*, Volume 84, Issue 2, 1 August 2006, Pages 274–288.

¹⁶³ Vasanti S. Malik et al., "Sugar Sweetened Beverages, Obesity, Type 2 Diabetes and Cardiovascular Disease Risk," *Circulation*, March 23, 2010.

assigning a verdict on the presence of milk in schools and children's diet, though milk is undoubtedly a better option than SSB. The 2008 USDA report on school lunches constructs the difficulties facing school lunches as a “trilemma,” consisting of the conflicting needs to provide low cost meals that satisfy nutritional requirements, while also maintaining student participation.

In the actual lunchroom, hitting nutrient goals is relatively easy, at least according to nutritionists. What cafeteria workers instead largely struggle with is the “calorie floor vs fat ceiling conundrum.”¹⁶⁴ This is the struggle to meet minimum calorie requirements while satisfying minimum fat limits, a conflict that is frequently resolved by adding larger amounts of sugar to meals, often through fat-free desserts, fruit juices, or flavored milk.¹⁶⁵ In 2003 chocolate milk was estimated to account for 75% of the added sugars consumed as part of the plate lunch.¹⁶⁶ The presence of added sugars in school lunches is of concern, especially in light of studies suggesting that diets high in added sugars are more harmful for health outcomes than diets similar in intake of more complex carbohydrate sources.¹⁶⁷ A 2009 analysis of students who started kindergarten at the same BMI found that eating school lunches was strongly predictive of larger amounts of weight gain, which was attributed to higher calorie content found in school lunches in comparison to packed lunches. The caloric difference was

¹⁶⁴ Poppendieck, “Free for All,” 93.

¹⁶⁵ Poppendieck, “Free for All,” 94.

¹⁶⁶ Johanna T. Dwyer, Paul Michell, and Claire Cosentino, “Fat-sugar See-saw in School Lunches: Impact of a Low Fat Intervention,” 434.

¹⁶⁷ D. Giugliano et al., “More Sugar? No, Thank You! The Elusive Nature of Low Carbohydrate Diets,” *Endocrine*.

estimated to be an average of about 40 calories.¹⁶⁸ Longer term analysis of the school lunch program has also concluded that it has been ultimately ineffective in producing adults physically fit enough for military service, and that it no longer provides short term benefits to participants.¹⁶⁹ The USDA report attributed the findings of the 2009 study as a result of the unaccounted-for effects of poverty. The same USDA report also recognized research among higher income students that reported non-significant weight gain attributed to school lunches.¹⁷⁰

Debate about the effects of school lunches is made more complex by the presence of several studies contradictory to the findings already discussed. A separate 2009 study found that students who ate at home, as opposed to eating school lunches, ate more overall calories. Not only did students eating at home consume more calories, but a larger portion of these came from added sugars and other “empty calories.”¹⁷¹ Similar studies comparing packed lunches to school lunches found that packed lunches contained more saturated fat, more sugar, while providing less fiber and calcium.¹⁷² It was also found that school lunch consumption was associated with larger fruit and vegetable intake than packed lunches among lower socioeconomic groups¹⁷³. The USDA report, however,

¹⁶⁸ Diane Whitmore Schanzenbach, "Do School Lunches Contribute to Childhood Obesity?" *Journal of Human Resources* 44, no. 3 (2009).

¹⁶⁹ Peter Hinrichs, "The Effects of the National School Lunch Program on Education and Health," *Journal of Policy Analysis and Management* 29, no. 3 (2010): 503.

¹⁷⁰ "National School Lunch Program (NSLP)." Food and Nutrition Service.

¹⁷¹ Ronette R. Briefel and Phillip M. Gleason, "Consumption of Low-Nutrient, Energy-Dense Foods and Beverages at School, Home, and Other Locations among School Lunch Participants and Nonparticipants," 2009.

¹⁷² Alisha R. Farris, "Nutritional Comparison of Packed and School Lunches in Pre-Kindergarten and Kindergarten Children Following the Implementation of the 2012-2013 National School Lunch Program Standards," *Journal of Nutrition Education and Behavior* 46, no. 6 (2014).

¹⁷³ Ramona Robinson-O'Brien, Teri Burgess-Champoux, and Jess Haines, "Associations Between School Meals Offered Through the National School Lunch Program and the School Breakfast

suggests that this difference is largely due to the classification of potato products as vegetables.¹⁷⁴ The amount of salad bars and other healthy options is found to have increased since 2008 and subsequent changes to nutritional requirements. Increases in options such as salad bars and fresh foods, however, have primarily been concentrated among wealthy school districts.¹⁷⁵ Despite disparities in funding, it still appears that the school lunch program provides significant benefits to low income students by increasing nutrient intake and providing large positive boosts to academic performance.¹⁷⁶

With this background in mind, assessing the role of milk within school lunches becomes a matter of evaluating both milk's comparative and inherent health impacts . Establishing milk's comparative health benefits is a relatively straightforward and easy task. It should come as little shock that milk appears to be better as a lunch option than other beverages such as soda. It is estimated that switching milk out for SSB could decrease the prevalence of obesity and improve the profile of school lunches.¹⁷⁷ Similarly, the substitution of milk or water, but not fruit juice, for SSB is strongly associated with reductions in body fat

Program and Fruit and Vegetable Intake Among Ethnically Diverse, Low-Income Children," *The Journal of School Health*, October 2010.

¹⁷⁴ "National School Lunch Program (NSLP)." Food and Nutrition Service.

¹⁷⁵ Lindsey Turner et al., "Improvements and Disparities in Types of Foods and Milk Beverages Offered in Elementary School Lunches, 2006â€"2007 to 2013â€"2014," *Preventing Chronic Disease* 13 (2016): 6.

¹⁷⁶<http://web.a.ebscohost.com/ehost/detail/detail?vid=0&sid=bbd908c1-31e2-45a6-97b7-da9d0ca503b6%40sessionmgr4006&bdata=JnNpdGU9ZWlhvc3QtbGl2ZSZyY29wZT1zaXRl#AN=122072468&db=bth>

¹⁷⁷ Travis Smith, "DO SCHOOL FOOD PROGRAMS IMPROVE CHILD DIETARY QUALITY?" *American Journal of Agricultural Economics*, March 2017.

development.¹⁷⁸ On the other end of the spectrum, consumption of SSBs was found to largely account for the higher caloric intake among children who chose to drink them, and as previously mentioned are strongly predictive of obesity.¹⁷⁹

Critics of Obama era nutrition requirements for school lunches often claim that by eliminating SSBs and flavored milks, policy makers risked increasing food waste. The concern for milk specifically is that mandated unflavored skim milk is likely to end up in the trash rather than a student's belly. Fears about milk waste due to changing school lunch rules, or the banning of flavored milks in some school districts, is relatively unsubstantiated in the long term. It was found that removal of chocolate milk from cafeterias resulted in a 10% decrease in milk sales, accompanied by a near 30% increase in fluid milk waste.¹⁸⁰ Initial increases in food waste were found to disappear after two years, however, and participation in school lunches actually increased during this same time period.¹⁸¹ Other studies also determined there were minimal long-term decreases in student participation.¹⁸² It was also found that milk consumption levels returned to normal after two years in schools that replaced chocolate milk with unflavored

¹⁷⁸ M. Zheng, A. Rangan, and N. J. Olsen, "Substituting Sugar-sweetened Beverages with Water or Milk Is Inversely Associated with Body Fatness Development from Childhood to Adolescence.," *Nutrition* (Burbank, Los Angeles County, Calif.), January 2015.

¹⁷⁹ K. C. Mathias, M. M. Slining, and B. M. Popkin, "Foods and Beverages Associated with Higher Intake of Sugar-sweetened Beverages," 2018.

¹⁸⁰ Andrew S. Hanks, David R. Just, and Brian Wansink, "Chocolate Milk Consequences: A Pilot Study Evaluating the Consequences of Banning Chocolate Milk in School Cafeterias," *SSRN Electronic Journal*, 2014.

¹⁸¹ Marlene Schwartz, "New School Meal Regulations Increase Fruit Consumption and Do Not Increase Total Plate Waste," *Childhood Obesity*, July 2015.

¹⁸² Donna B. Johnson, "Effect of the Healthy Hunger-Free Kids Act on the Nutritional Quality of Meals Selected by Students and School Lunch Participation Rates," January 4, 2016.

milk.¹⁸³ Interestingly, it was found that preference for unflavored milk was highly dependent on the presence of fruit juices. On days when fruit juice was offered, there was far lower selection of plain milk.¹⁸⁴

Given the strong evidence for the negative health outcomes associated with SSB such as sodas, fruit juice, and to a lesser extent flavored milk, it comes as little surprise that unflavored milk is a comparatively superior option. Obama era lunch reforms are sufficiently far in the past to assess their effects on lunch rooms. Though the reforms initially depressed participation and increased waste, these trends seem to have been short term, and the changes have over all increased nutrient intake. The role of milk as a tool in fighting obesity and improving the quality of school lunches appears clear. If the options are SSBs or milk, policy should clearly prioritize unflavored milk, and restrict SSB alternatives in order to induce student milk consumption. Given the negative impact that a la carte options, snack bars, and vending machines have on school lunch participation, it may also be worth investigating their removal. Many vending machines now are required to sell diet sodas in schools. Artificial sweeteners, though they contain zero calories themselves, have shown little ability to actually reduce the total calories being consumed throughout the day from other sources.¹⁸⁵ This may, however, have more to do with the dietary

¹⁸³ Marlene B. Schwartz et al., "Student Acceptance of Plain Milk Increases Significantly 2 Years after Flavored Milk Is Removed from School Cafeterias: An Observational Study," *Journal of the Academy of Nutrition and Dietetics*, 2017.

¹⁸⁴ Schwartz, "New School Meal Regulations Increase Fruit Consumption and Do Not Increase Total Plate Waste."

¹⁸⁵ Meghan B. Azad, Ahmed M. Abou-Setta, and Bhupendrasinh F. Chauhan, "Nonnutritive Sweeteners and Cardiometabolic Health: A Systematic Review and Meta-analysis of Randomized Controlled Trials and Prospective Cohort Studies," *Canadian Medical Association Journal* 189, no. 28 (2017).

choices made by soda drinkers, who may make less healthy food selections independent of SSB intake. At the very least vending machines, as well as lunches, should primarily seek to offer water and milk in preference to soda or juice as a way of combating both obesity and nutritional deficiency.

While milk is clearly nutritionally superior to lunchtime alternatives laden with added sugars, its independent claims to health require further investigation. The internet is full of clickbait articles and web pages, often published by vegan and alternative medicine groups, that raise the alarms relating milk to cancer and other negative health outcomes. Often cited by these sources are vague references to epidemiological studies examining areas of the world with a low incidence of colorectal and breast cancer. One such study examining Japan, Bolivia, India, and Mongolia did find strong correlation between high concentrations of cattle and cancer rates. It was found that in general countries with low levels of dairy consumption, and more importantly, low levels of beef consumption, experienced lower levels of cancer.¹⁸⁶ The exception to this rule was Mongolia, in which the consumption of barbecued meat is high, but milk consumption is relatively low. Interestingly, the researchers concluded that relationships between dairy consumption and cancer is likely related to the type of cow being used. All of the countries studied were found to primarily herd the lower milk producing zebu cattle rather than the bos

¹⁸⁶ Harald Zur Hausen, "Dairy Cattle Serum and Milk Factors Contributing to the Risk of Colon and Breast Cancers," *International Journal of Cancer*, February 20, 2015, section goes here, accessed April 08, 2018.

taurus varieties favored in western nations.¹⁸⁷ It was hypothesized that consumption of bovine products of bos taurus origins may transmit forms of a virus similar to hepatitis. This hypothesis received marginal support from the isolation of what appeared to be intact DNA viruses in dairy products.¹⁸⁸ The results of research linking milk to colorectal cancer should, however, be taken with a large grain of salt. The epidemiological research done was incredibly broad and left plenty of room for confounding variables such as lifestyle, environment, and other dietary choices. For example, people in India may have low beef consumption, but they also likely have higher consumption of minimally processed vegetables which is independently associated with lower cancer rates. Similarly, how are we to know that rising colorectal cancer rates in Japan are due to increased dairy consumption? Increased colorectal disease may be related to beef intake, but it is also likely attributable to a variety of factors, such as increases in sedentary lifestyles and the greater presence of western style fast foods. The studies discussed above, while interesting, should not be interpreted as definitive evidence of dairy consumption causing cancer. Correlation does not mean causation, a point carefully stated by the authors of the studies, but frequently missed by the media.

In another case of misinterpretation of scientific research, it has recently been suggested that milk may in fact be bad for bones, due to acidification of the

¹⁸⁷ Hausen, "Dairy Cattle Serum and Milk Factors Contributing to the Risk of Colon and Breast Cancers"

¹⁸⁸ Hausen, "Dairy Cattle Serum and Milk Factors Contributing to the Risk of Colon and Breast Cancers"

body and calcium leaching caused by phosphates.¹⁸⁹ Perhaps not surprisingly, these scientific interpretations spread by pop-news and anti-vaccination groups have little basis in scientific fact. While dairy may have some minor effect on urine acidity, there is no effect on the blood or body's acidity, which must be kept within a tight range to prevent a swift death. It also does not appear that phosphate intake has any negative effects on calcium retention. Similarly, differences in osteoporosis rates among high and low dairy-consuming countries are ultimately attributable to differences in resistance activity, i.e manual labor.¹⁹⁰ With the last urban health myth dispelled, it is time to actually examine what existent scientific literature says about milk.

Scientific studies surrounding calcium intake and bone health have been relatively middle of the road in their portrayal of milk, unlikely to please the dairy industry or its critics. Meta analysis examining the recent literature on dairy consumption found that “increasing calcium intake from dietary sources or by taking calcium supplements produces small non-progressive increases in BMD (bone mineral density), which are unlikely to lead to a clinically significant reduction in risk of fracture.”¹⁹¹ Examining the difference between milk consumption and supplement intake also found both to be equally beneficial.¹⁹² Despite the overstated benefits of dairy for bone health, researchers have still

¹⁸⁹T. R. Fenton, "Milk and Acid-base Balance: Proposed Hypothesis versus Scientific Evidence.," National Center for Biotechnology Information, 2011.

¹⁹⁰ Fenton, "Milk and Acid-base Balance: Proposed Hypothesis versus Scientific Evidence."

¹⁹¹V. Tai, W. Leung, and A. Grey, "Calcium Intake and Bone Mineral Density: Systematic Review and Meta-analysis.," *BMJ (Clinical Research Ed.)*, September 29, 2015.

¹⁹²Tara S. Rogers, Marjorie G. Garrod, and Janet M. Peerson, "Is Bone Equally Responsive to Calcium and Vitamin D Intake from Food vs. Supplements? Use of ⁴¹calcium Tracer Kinetic Model," *Bone Reports*, December 2016.

concluded that milk is a crucial part of school lunches. This was largely because school age children are undergoing large amounts of bone growth, and are likely to be calcium deficient, making milk a valuable source for this demographic.¹⁹³

Beyond bone health, the research continues to build in favor of milk as part of a healthy diet. It would appear that while milk has limited effects on bone health for adults, it perhaps conveys greater benefits in the struggles against obesity and cardiovascular disease. A 12-year study of men consuming dairy found that those who consumed greater amounts of milk fats were less likely to become obese regardless of starting BMI.¹⁹⁴ Similarly, studies examining Latino children, who are one of the groups most affected by obesity, found strong correlation between higher consumption of milk fats and lower obesity risk. This same study, however, acknowledges that maternal BMI and single-parent homes were likely confounding variables, and also saw less consumption of any milk by the most obese children.¹⁹⁵ Even more limited studies, examining rat models, found that full-fat dairy intake aided in fat loss.¹⁹⁶ Rat models have also been used in the production of mechanistic models involving calcium, though none have yet been proposed explaining the mechanisms behind higher fat intake. Calcium models propose that calcium intake is involved in the regulation of fat cells' (adipocytes) fat storage abilities, and that increased calcium intake prevents

¹⁹³ K. Uenishi, "Milk, Dairy Products and Bone Health.Milk Intake and Bone Acquisition in Junior High School and High School Students.," *Clinical Calcium*, January 01, 2018.

¹⁹⁴ Sara Holmberg and Anders Thelin, "High Dairy Fat Intake Related to Less Central Obesity: A Male Cohort Study with 12 Years' Follow-up," *Scandinavian Journal of Primary Health Care*, June 2013.

¹⁹⁵ Amy L. Beck et al., "Full Fat Milk Consumption Protects against Severe Childhood Obesity in Latinos," *Preventive Medicine Reports*, December 2017.

¹⁹⁶ Sarah Trottier, "Exercise and Dairy Protein Interactions in the Treatment of Obesity," April 1, 2017.

fat absorption.¹⁹⁷ Possibly lending greater support to this theory are studies on milk intake and insulin resistance. Among overweight adults it was found that those who consumed more dairy were far more less likely to develop insulin resistance or cardiovascular disease, even when consuming similar macronutrient profiles.¹⁹⁸ However promising, the results of these studies are somewhat limited by a smaller amount of research that fails to support the positive associations between milk consumption and fat loss. Examination of total calcium intake was, by one group of researchers, found to have little to no effect on the progression of BMI in children from the ages of 13 to 21.¹⁹⁹ In a more experimentally based study on calcium intake and weight loss over the course of 25 weeks, evidence was found supporting a non-significant relationship between calcium intake and weight loss. Although the authors did notice a correlation, they did note that it was non-significant and minor, though consistent with mechanistic theory.²⁰⁰

Given the large amount of inconclusive and sometimes contradictory evidence, how can milk's inherent health value be properly evaluated? It is perhaps helpful to turn once again to history and to consult a 1965 speech presented by Dr. Bradford Hill, a professor of medical statistics. In his speech he

¹⁹⁷ Michael B. Zemel, "Regulation of Adiposity and Obesity Risk By Dietary Calcium: Mechanisms and Implications," Taylor and Francis Online, December 17, 2017.

¹⁹⁸ Mark A. Pereira, "Dairy Consumption, Obesity, and the Insulin Resistance Syndrome in Young Adults," JAMA, April 24, 2002.

¹⁹⁹ Tiago Marajubo and Carla Lopes, "Dairy Products and Total Calcium Intake at 13 Years of Age and Its Association with Obesity at 21 Years of Age," Nature, 2018

²⁰⁰ SUE A. SHAPSES, Stanley Heshka, and STEVEN B. HEYMSFIELD, "Effect of Calcium Supplementation on Weight and Fat Loss in Women," The Journal of Clinical Endocrinology and Metabolism, February 2004.

advocated for different correlational standards within the the field of health care. As an example he presents the case of an experimental drug for treating morning sickness. If said drug shows even the slightest evidence of being dangerous, then it should not be used, given that its recipient is likely to survive without it. The standard of proof, he argues, must be much higher before we advocate that people stop doing things that bring them joy.²⁰¹ He concludes his argument by stating, “All scientific work is liable to be upset or modified by advancing knowledge. That does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time.”²⁰² The first part of his argument, on relative standards of proof, can provide guidance on milk. The research presented raises some concerning possibilities about dairy from cows of European evolutionary origins. However, this research is in its infancy, and it does not provide adequate evidence that millions of dairy lovers should stop consuming a food they enjoy. Indeed, much of the evidence runs in the opposite direction. It would appear that milk fat and calcium intake may provide some sort of protection against development of obesity, cardiovascular disease, and insulin resistance. But then again, this evidence suggests that any such effects are likely small and may also have more to do with general lifestyle choices correlated with milk drinking. For example, subjects drinking more milk may be generally more health conscious, may drink less soda, and may come from families that are more attentive to food choices. Considering the evidence for milk’s, likely exaggerated, health benefits and the

²⁰¹ Austin B. Hill, Sir, "The Environment and Disease: Association or Causation?" *Section of Occupational Medicine*, 1965.

²⁰² Hill, "The Environment and Disease: Association or Causation?."

even slimmer evidence that milk poses a danger, it seems clear that more definitive research is needed. Until the time when that research builds a stronger body of evidence, milk is here to stay from a dietary standpoint. At best milk helps fight obesity, at worst it provides protein and vitamins, even though it falls far short of being the cure-all it was historically hailed as.

The differing standards of proof raised by Dr. Bradford Hill do raise an important closing point. While it is important to insure a higher standard of proof when asking people to give up things they enjoy, this does not mean that powerful evidence should be ignored. Demands for unassailable proof, and the propensity for scientific knowledge to be inherently imperfect and subject to change, leaves scientific knowledge open to exploitation. The misrepresentation of correlational studies and the meaning of scientific “theory” has allowed tobacco and fossil fuel industries to thrive well after a wealth of evidence had been accumulated condemning them. A similar example is present in the foods we eat. In Congress there has been strong resistance to including environmental impact information in diet guidelines, as well as pushback on recommendations to limit meat intake.²⁰³ This is despite strong evidence that our “western diets” and low levels of physical activity are causal factors in a large number of negative health outcomes, as well as being environmentally taxing. Demanding unassailable evidence set in stone poses the risk of becoming consumed with media exacerbated fears over which foods cause cancer and will help us shed pounds. Mark Bittman and Dr. David Katz summarized this point well in their

²⁰³ Maggie Fox, "Can We Eat Butter and Salt? House Members Question Diet Guidelines," NBCNews.com, October 7, 2015

New York Times article, “The Last Conversation You’ll Ever Need to Have about Eating Right,” in which they argue that we all know the fundamentals of eating well, but become distracted by fads and media stories.

”We don’t know, because the study to prove that any *one* diet is “best” for human health hasn’t been done, and probably can’t be. So, for our health, the “best” diet is a theme: an emphasis on vegetables, fruits, whole grains, beans, lentils, nuts, seeds, and plain water for thirst. That can be with or without seafood; with or without dairy; with or without eggs; with or without some meat; high or low in total fat.”²⁰⁴

With this statement in mind, it is clear that true dietary and lifestyle changes are necessary for America at large, but that dairy remains a healthful, or at least not harmful, part of this change within the school lunch system.

²⁰⁴ Mark Bittman and David Katz, "The Last Conversation You’ll Ever Need to Have About Eating Right," *Grub Street*, March 18, 2018.

Conclusion

Cow's milk has enjoyed an understated, but crucial, role in the story of human civilization. Even within the United States milk has been both symbolically and nutritionally important. It has been a dietary staple that has undergone radical change during the past 150 years, and in many ways milk has held a mirror to the larger societal, technological, and dietary changes in America. During the rural to urban shift, milk was a definitive public health crisis that provided a foil to wider anxieties about city life. At the same time that milk, and cities themselves, became object for concern, milk was also demonstrating the way forward as a progenitor of American welfare programs. From the first charity milk pantries, to the establishment of mandated school lunches, milk has been inseparable from conceptions of children's health, despite now resolved threats of disease. School milk and lunch programs have born out these sentiments, and have seemingly provided a great boon to American school children. Even today, though their effects are more limited, our imperfect school lunches continue to provide tangible benefits to students, especially the least fortunate. Within the framework of modern school lunches, the place of milk becomes more clear. Milk is not the perfect cure-all food it was hailed as during the 19th and early 20th century. Nor does milk appear to be the nutritional boogeyman that alarmist dietary articles would have us believe. Milk cannot prevent obesity and disease on its own, but it also appears unlikely to cause either. Indeed, it is just a food. Until such time that new dietary research or

environmental concerns suggest otherwise, milk, and its storied past, is here to stay.

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