Raw Milk, Citizens and Microbiology

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Abstract

Raw milk has both its high-minded supporters and detractors in high positions of power. No other food source seems to attract more effort to support and combat than milk straight from the ruminant. The government has always shown an interest in sugar substrates and in the modern day, milk, at the point of delivery from the cow, sheep or goat is hotly contested on both food freedom and public safety fronts. Raw milk is the *only food* that is banned from interstate commerce by the FDA under 21 C.F.R. § 1240.61 that has the effect of law dating back to 1987. Those who wish to consume raw milk are not on a crusade to overthrow grade A dairies; rather to be left alone to their own food choices as informed consumers and to assume their own risk, whilst those who oppose raw milk in any form, anywhere to anyone are well positioned to enforce that by regulatory statute. What is given to us first by our mothers and has been associated with agrarian civilizations for millennia is now wholly owned subsidiary of public policy.

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Personal choice for the modern individual is largely a matter of legal interpretation, and who is able to decide that may be the side that can most definitively plant their flag and enforce their will. It should not be assumed that those who wish to consume raw milk and raw milk products are on a crusade to make everyone do likewise, nor can it be assumed that those who are in positions of influence are inclined to allow such activities to be "taken at your own risk." In the middle of the fray is the question, "Who owns the person?" Proponents of raw milk often cite testimonials and positive personal sentiment bulked up with discussions of risk, historical perspective and pleas for personal freedom. Opponents of raw milk often cite regulatory enforcement burdens, public safety and a litany of disease vectors that have haphazardly formed modern dairy regulations as found. In the middle is the science, and that is worthy of discussion as this debate will not be decided strictly on the merits of its regulatory, economical and historical context. For proponents of raw milk to be heard, the following six points should be addressed: (1) scientifically credible evidence for raw milk does exist, and is worthy of consideration, (2) an unbiased definition of raw milk needs to be established so that both sides are not talking past each other, (3) the existence, function and benefit of commensals should be considered in the debate, (4) statistics for raw milk outbreaks are largely difficult to establish, (5) the "fee for service" model on the state level needs to be reevaluated so that all milk need not only be produced by large holding dairy operations by default and (6) the fact that agriculture is currently losing the pharmaceutical battle with bacteria is a serious concern and a fact that needs to be considered to allow small holding farmers and ranchers to be allowed into the market with informed consumers.

History of Food and American Government

The roots of personal and food freedom and the lengths to which “We the people” will go in America to ensure that, are part of the fabric in the history of the American experiment. The Founding Fathers were well versed in the Scottish Enlightenment with its deepest held beliefs rooted in Natural Law, which to them was self evident. The purpose of government was not to protect one from oneself, nor to provide a no fault society where matters of personal choice were without consequence when they trespassed on another's right to life, liberty or the pursuit of happiness; rather that these rights endowed by a Creator, were unalienable. These were neither the product of nor the domain of a government; rather they were the justification of the existence of the institution of government in order to protect those rights.

Food is that necessary carbon substrate of all life on earth, it is itself at the foundation for any society's existence therefore it is not any surprise that food has been pivotal to America's history. Unpopular acts from British Parliament known as the Sugar (and Molasses) Act and the Tea Act were cause enough for open rebellion of the colonies leading up to the Boston Tea Party (Kindig, 2014). Britain saw the colonies as a revenue measure to prop up the East India Tea Company which was neither a wholly private nor public business, rather it operated under both the color of law and a royal charter granting its existence. Furthermore, the impressment of American sailors on the high seas to serve on British ships (cited in the Declaration of Independence under grievances) which were largely “ruling the waves” to protect the financial interests of the crown not the least of which is dishonorably known to antiquity in part as the triangle trade. In this abhorrent venture, one of the legs of the triangle was sugar, molasses or the fermented form of rum from the colonies en route to Britain, while another and more deplorable leg was the forcible export of slaves from the African coast to the west in order to

trade for, of all things, sugar (Triangular trade, 2009). Following the American Revolution was the initial form of government known as the Articles of Confederation and after much discussion in the exchange of the Federalist (and Antifederalist) Papers was the formation of a Federal government under the US Constitution in 1789. One of the first tests of those new powers under the new Constitution of the Federal government, which was saddled with debt from fighting the Revolutionary War, was known as the Whiskey Rebellion (Kotowski, n.d.). Historically ironic, the Whiskey Rebellion was centered around said power to levy and enforce a tax by a newly established government on whiskey—fermented sugars. Milk, raw or pasteurized is characterized by its signature sugar known as lactose; a historical and somehow inevitable typecast for conflict in America.

Milk is not something that lends itself to a matter of subjective opinion; if it were so, there would not be a modern conflict of any real significance surrounding it. Objective information on milk complete with its date/time group of veridicality, what it is, how it can be produced, what its market price is, how much it can be subsidized for to maintain that price, what its published nutritional values are, how much of it you should drink of it per day to meet the serving size according to the food groups, food pyramid or MyPlate (depending on which date time group you referencing), etc. are cataloged in thousands of pages of documents and dozens of websites across at least two not totally separate entities of the government: the US Department of Agriculture (USDA)/the US Food and Drug Administration (FDA, which is part of the USDA) and the Centers for Disease Control and Prevention (CDC) under the Department of Health and Human Services. The local intersection between the citizen and all of that regulatory volume comes in the form of a county health inspector, a state livestock board or a milk control board among others which all sing the same song of how raw milk is implicitly bad (bordering on a

moral category) if not downright dangerous. A muted but detectable pressure can be characterized by the question, "and what responsible citizen would do such a thing?" A corollary to this party line is the lauding of the fact that mandatory pasteurization was one of the greatest achievements of public food health safety. Not content to just stop there, there are two sound bytes of interest from this camp that simultaneously capture all of this in a most succinct manner and beg the question of where science and public policy should meet:

1. "Drinking raw milk is like playing Russian Roulette with your health." John Sheehan, Director of Dairy and Egg Safety for the FDA's Center for Food Safety and Applied Nutrition (Wallace, 2007).

2. "Scientifically credible evidence for the health benefits of nonpasteurized dairy products beyond the benefits of those of otherwise equivalent pasteurized products is lacking" (Langer et al., 2012, p. 389).

Both of these claims will be evaluated throughout this paper comparatively with other research on the merits of science and not in the res ipsa loquitur sense of fiat public policy.

Pasteurization in America: When and Why

In the Journal of Environmental Health, a 2007 article titled, "A Legal History of Raw Milk in the United States" starts off with this fitting quote from the witty Winston Churchill, "There is no finer investment for any community than putting milk into babies" (Weisbecker, p. 62). The problems that necessitated milk pasteurization in communities precipitated upon the fact that babies were getting very sick from raw milk. A short exploration into when and why this happened illuminates the modern straight-jacket public health policy for milk. As the Industrial Revolution brought jobs to big cities, dense urban populations soon followed. America had not

yet produced an affordable automobile for the average person to buy, so horses were very common modes of transportation and livery in the big cities. As is quintessentially true in the natural order, when you have a lot of one thing, you have the potential for a lot of something else as an output or secondary effect. With a lot of horses came a lot of manure, and no real efficient way to remove this vector media. Likewise, the food stuffs such as dairy for all of these people in the cities needed to be produced, so the first unintended iteration of the now standard CAFO (Concentrated Animal Feeding Operation) was implemented by sheer necessity and pragmatism. What Allegheny and Appalachian farmers before the Whiskey Rebellion had figured out as a solution to the problem of getting grain to market, was magnified as a civic concern as cities began to grow and dairy cows needed to be fed.

In the natural order, carbon is not moved around a whole lot, it takes energy to do so and it is too valuable at the point where it can be recycled, so leaves that fall under the tree are meant to create duff to build top soil to nourish the tree and are not moved very far away intentionally. Likewise, a farmer can transport grain in bulk silage form over a mountain and unimproved roads to market or just distill it into whiskey which is easier to store, ship and is more valuable as a pay load per wagon trip. Breweries and distilleries in the big cities were still importing grain in order to manufacture beer and whiskey while dairy cattle needed grain to eat and available hay was ostensibly being fed to horses providing local motion. The output from the alcohol production (known as spent mash) became the feed for dairy operations in the cities because hay was likely not valuable enough to import to produce milk on the same economy of scale as grain to produce whiskey; what seemed like a perfect solution was actually a perfect storm.

Ruminants, cows one type of them, are most fortunate to be able to have a particular type of microorganisms colonizing their digestive tract. These co-dwelling bacteria, called

"commensals," bio-symbiotically produce the enzymes necessary to metabolize β glucosidic bonds that characterize the sugars in cellulose, where humans can only metabolize α glucosidic bonds found in starch (McMurry et al., 2013, p. 683). The spent mash being fed to urban cows, was nutritionally depleted and the milk produced from it was both low quantity (to which water was added) and poor quality (evident that it was blue in color). Moreover, what came to be known as "the Milk Problem" was exacerbated by the working conditions for dairy workers employed to collect the substandard milk and the cows forced to live in unimaginable filth (Weston A. Price Foundation, slide 56). The process that produced this milk is actually best captured in a New York Times article from 30 Apr 1874 describing the "adulteration" process:

> To remove the sky-blue color, and improve the flavor of the diluted article, [milk] dealers found it necessary to add a little molasses to sweeten it, salt to heighten its flavor, and annatto to improve its color. In addition to these substances, chalk, starch and the brains of different animals were frequently employed to improve the general appearance of the milk. Various kinds of gums were also used for the same purpose, and soda to correct any acidity which might arise from fermentation (Bad Milk, 1874).

Ultimately it was neither the root cause of the substandard quality of the fluid milk being passed off as the genuine article, nor the abhorrent conditions that the cows were living in that affected change to enforce pasteurization, it was that the lack of any accurate knowledge of of microbiology and pathogens was making "the business of putting milk into babies" a deadly one. "There were terrible outbreaks of typhoid fever, tuberculosis, diphtheria, and other diseases, resulting in thousands, including many children being killed" (Gumpert, 2015, p. 32). The process was ripe for reform, and the solution came from a technique used in the French wine industry.

The Historical, but Poorly Understood, Union of Microbiology and Law

When microbiology was in its infancy, Louis Pasteur was way out in front of this new science. Being known for successfully debunking abiogenesis, he is also justly credited with a life long career marked with scientific discovery in the microbe realm. Notable to history is his discovery that bacteria in beer and wine was the culprit for why it spoiled during shipping, and that these bacteria could be mitigated by heating the product to a certain temperature for a defined period to kill off just enough of the bacteria to prevent spoilage (Tortora et al., 2013, p. 8). The process bearing Louis Pasteur's name, later abandoned by the French wine industry because it changed the taste of the wine, was applied to milk as a fix for the symptomatic pathogens in milk and not the root cause, poor animal living conditions, poor diets and untreated water of questionable origins (a likely pathogen vector) being added to milk. The race to solve this huge public health concern was getting some legal muscle by 1914 when the Illinois Supreme Court had weighed in making pasteurization not just a good idea; but put forth a legal opinion that prompted it becoming the law first in Chicago which rippled across the country by 1920. The U.S. Public Health Service acting in 1939 to draft the Model Milk Health Ordinance and was actively promoting it for adoption at the local level (Weisbecker, 2007, p. 62)).

How Pasteurization Works

The efficacy of pasteurization is based on the denaturing of proteins through heat. What was intended to extend the life of beer and wine by reducing the live microbial load, works for milk in the same manner to prevent spoilage by influencing “the lag phase and generation time of different microorganisms, especially psychrotrophic bacteria, extending . . . shelf life” (Vianna et. al, 2012). The first commercial dairy pasteurizer was patented in Germany in 1893 (Gumpert,

2015, p. 33), unsurprisingly the science works in the same way today. In biology, proteins have to be coded for a precise way that they may be assembled in an exact manner in order to be folded in such an accurate way that the three dimensional shape they take is as defined as a key in a lock. All biochemical processes in living things depend on this truth. If a protein, whether it is in a bacteria cell wall, an immunoglobulin or a hormone, can be denatured, it will change not only in physical properties (shape, solubility, etc.) but will be *no longer be usable*. Consider the example of a skeleton key; its shape determines its function in three dimensional space. Take the same key and place it in a powerful press so that it is flat, and it may look recognizable, but its function is compromised and it will not actuate a lock. "Agents that cause denaturation include heat, mechanical agitation, detergents, organic solvents, extremely acidic or basic pH and inorganic salts (McMurry et al., 2013, p. 578). Alternatives to pasteurizing to do exist, but they work through different means to accomplish the same goal—the denaturing of proteins. There is some new research out of South Korea on the effects of high pressure (100-1000 MPa) and low temperature that can result in the same effects as pasteurization without the heat (Kim, Kim, Choi, Min & Kwak, 2008, p. 4176); nevertheless, the biochemistry is the same because energy is being added to the system. Similarly, out of Brazil some new research using CO_2 to treat raw milk to limit microbial growth in three ways:

> (1) the replacement of 0_2 by CO_2; (2) a pH reduction due to CO_2 dissolution and formation of carbonic acid; and (3) a direct effect on the metabolism of microorganisms, including changes in membrane fluidity, reductions in intracellular pH, and direct inhibition of metabolic pathways (Vianna et al., 2012, p. 4257).

The work being done to control microbes in the Brazilian research is being done with pH manipulation and the effects of redox chemistry on microbes.

For milk, the pasteurization, more specifically the denaturation of protein process is not selectable for just bacteria; rather *all proteins that can be denatured at a specified heat or pH range* are in fact altered. An Italian study detailing the effects of using a microwave oven to replicate a home pasteurization process in a domestic kitchen demonstrates that the nonuniform effects of a transverse microwave passing through three dimensional space of fluid milk in a container will not kill all of the bacteria because it is not heated uniformly (Tremonte, Tipaldi, Succi & Pannella, 2014, p. 3319).

Scientifically Relevant Points for a Proponent Position on Raw Milk

The following six points are critical to bring the understanding back to this debate in scientific terms regarding exactly what raw milk proponents are asking their government to allow. First, scientifically credible evidence does exist for raw milk as a food source. Secondly, the language of "raw milk" is not defined in the way that proponents are using it. Often it is commingled with milk that is produced to be pasteurized and is not fit to serve in an untreated form; doing so would be an unmitigated public health catastrophe. Third, conspicuous by its absence is the lack of any mention of commensal (aka "noble flora") bacteria living in what is referred to as "the biodome" in the human gut. The presumption that the consumers are sterile, ergo all food must be sterile is flawed at its base. Fourth, the statistics are dizzying for exactly what raw milk's track record is in pathogen outbreaks. The statistics are not easily obtained, and the agency keeping score has a strong opinion against raw milk. Fifth, the regulations are overtly biased to the large scale producers on a "fee for service" model that is neither in the public interest (particularly in Montana), nor does it favor the small producer and guarantees in perpetuity the pasteurization of raw milk by large producers who can absorb the associated costs by moving large volumes of dairy products. Lastly, agriculture is currently in an arms race with

microbes, and they are losing. The production of food from small holders that are close to the point of informed consumers needs to be taken seriously as a viable option for producing safe food.

Scientifically Credible Evidence for Raw Milk

International studies have corollary findings which are interesting in light of the American echo chamber between the CDC and USDA that touts, "There are no health benefits from drinking raw milk that cannot be obtained from drinking pasteurized milk that is free of disease-causing bacteria" (CDC, 2015, Raw Milk Questions and Answers). The United States has laid a marker on the table which can be enforced by law domestically, but fortunately for academic freedom, domestic regulations are not capable of making domestic policy compulsory belief abroad when it comes to empirical science. Among those who did not get the memo, Tremonte et al. leading a team of Italian researchers put on page one of their report in the abstract, "boiling causes a drastic reduction in the nutritional value of milk" (Tremonte et. al., 2014, p. 3314). A preliminary study out of Saudi Arabia is showing promising initial findings correlating the effects of raw camel milk on thymus and activation-regulated chemokine in autistic children in a double blind study comparing the effects with pasteurized milk (Bashir, Al-Ayadhi, 2014, p. 559). A comprehensive study out of the Alpine region of Southern Germany, Austria and Switzerland by Loss et al. cited these findings:

> Milk processing, such as heating, does not affect heat-stable caseins, whereas whey proteins, accounting for 18% of the total protein in cow's milk, are more sensitive to heat treatment and might influence the bioavailability of the proteins. Bovine whey contains

> proteins secreted by the mammary gland, such as β-lactoglobulin, α-lactalbumin, and lactoferrin, and from serum, such as IgG, serum albumin, and TGF-β (2011, p. 5).

Out of South Korea, a team of researchers out of the University of Seoul published a study that synthesized numerous other studies and collated their data to say that pasteurized milk could have up to a 66% loss in fat soluble vitamins A, D and E, a water soluble vitamin C loss of 50% while making others 38-80% less effective (Kim, Kim, Choi, Min & Kwak, 2008, p. 4181). While the CDC is quick to point out that raw milk is not a significant source of vitamin C, they do maintain their position, "Many studies have shown that pasteurization does not significantly change the nutritional value of milk and dairy products. All of the nutritional benefits of drinking milk are available from pasteurized milk without the risk of disease that comes with drinking raw milk" (CDC, 2015, Raw Milk Questions and Answers). Who is correct, and how can you tell?

The present discussion in this paper centers around science and the not contest over language, yet the flag planted by the CDC is rather clear, "Scientifically credible evidence for the health benefits of nonpasteurized dairy products beyond the benefits of those of otherwise equivalent pasteurized products is lacking" (Langer, Ayers, Grass, Lynch, Angulo & Mahon, 2012, p. 389). Is a "lack of science" to be equivocated with proof against? A better question is clearly, what evidence would the CDC be willing to accept? Not only is the above statement by the CDC bold and inflexible, with the rise of autism not just in the US but world wide, it is *positively tragic* save for two medical researchers out of Saudi Arabia (Bashir & Al-Ayadhi) who may be standing on the last bastion that is left of the scientific method and centuries of following the evidence where ever it leads. Among the apparent lack of "scientifically credible" evidence in the CDC's considerable blind spot is an acclaimed study out of southern Europe called the GABRIELA study which explores the connection between "farm" (raw) milk consumption on

childhood asthma and atopy (allergic [typically congenital] response measured with elevated IgE levels verified in the study with a fluorescence immunoassay). The study is comprehensive complete with serum samples, strict protocols for milk samples to be held at controlled temperatures, highly specified criteria for categorizing the study subjects demographics, geographical isolation and north of 8,000 children sampled and then those samples divided and cross examined against each other. Moreover, it has the names of twenty-seven PhD's and twenty-seven MD's on the study, which still may or may not yet qualify for substantive "scientifically credible evidence" per the CDC. The GABRIELA study directly challenges another statement by the CDC, "The process of pasteurization of milk has never been found to be the cause of chronic diseases, allergies, or developmental or behavioral problems" (CDC, 2015, Raw Milk Questions and Answers) with a more humble hypothesis, "The aim of the present analysis was to find biological components of cow's milk that might explain the protective effect of farm milk on childhood asthma and atopy" (Loss et al., 2011, p. 2). Presently, it is not wholly understood how the exact mechanism works, but a *definite link* is demonstrated in this European study between the whey proteins in "farm" (raw) milk (specifically: α-lactalbumin, β-lactoglobulin and BSA [Gumpert, 2015, p. 76]) and their affects on asthma and a weaker link to allergies (atopy) in children when compared to "shop" (pasteurized) milk does in fact exist according to their research. Consider the following evidence from Loss et al. In their 12 page study:

- Early exposure and daily consumption of farm milk showed a stronger inverse association with health outcomes in mixed milk drinkers. Because most exclusive farm milk drinkers were exposed to farm milk early in life with daily consumption, the power to detect the influence of frequency and age of first farm milk exposure was limited.

> Consumption of only boiled farm milk was not associated with any health outcome (2011, p. 4)

- Consumption of farm milk was also inversely related to food allergen sensitization (fx5) . . . . The associations of milk consumption and asthma were robust to adjustment for atopy and food allergen sensitization (2011, p. 4).

- Analyses . . . showed consumption of objectively assessed raw farm milk to be inversely associated with asthma . . . but not with atopy when compared with high heat–treated shop milk (2011, p. 4).

- Total fat content and total viable bacterial counts had no clear association with any of the analyzed health outcomes. No association was further found between these health outcomes and total protein content, somatic cell count, lactose levels, or microbiological subgroups. Yet increased levels of the whey proteins tended to be inversely associated with asthma but not with atopy (2011, p. 4).

Despite the meticulous data collection, synthesis and analysis of this single study, this rejoinder was offered in reply by a group of Canadian public health researchers who tentatively concluded, "raw milk may have protective association with allergy development . . . although this relationship is potentially confounded by other farming-related factors" (Gumpert, 2015, p. 75). This statement is cautious and less arrogant than their American counterparts and to the Canadian agency's credit certainly does not sound like they do not wish to be presented with the facts because they already have their mind made up. While the GABRIELA study does reference "hygiene hypothesis" by name (Loss et al., 2011, p. 5), the idea is gaining more acceptance in the west. Tortora et al. make this analysis, "for unknown reasons, asthma is

becoming a near epidemic, affecting about 10% of children in Western society, although they often outgrow it in time. It is speculated that lack of childhood exposure in the developed world to many infections, the so-called *hygiene hypothesis*, is a factor in the increase in the incidence of asthma" (2013, p. 530) Whether it is the confounded by "other farming-related factors" or implicitly the effects of raw milk itself, the GABRIELA study as well as another European study titled PARSIFAL by Waser et al. does put substantial emphasis on the fact that children raised on farms do demonstrate a higher level of health and resilience when it comes to asthma. Moreover, raw milk not only correlates with that marked increase in health, "farm" (raw) milk (by means of intact whey proteins) has been implicated as a cause of that uptick.

It is also important to mention the emphasis that raw milk proponents place on milk produced from grass fed, pasture rotated cows. Why is this important? The pathogen vector of *unpasteurized milk* is a serious concern, and there are not any proponents in print who would contest that fact. In the downloadable forms on the Minnesota Integrated Food Safety Center of Excellence, University of Minnesota, Minnesota Department of Health's website for the purpose of establishing a patient history for foodborne pathogens, "raw" or "unpasteurized" milk is listed as a line item question, typically towards the top of the list for the Campylobacter, Cryptosporidium, Salmonella and STEC as well as the CDC's Listeria interview form (n.d.) and for just cause as the risks for unpasteurized milk are real. However, the pathogen vector can be said to be "rate limited" in a healthy, grass-fed cow by design, while the CDC would disagree, "Disease-causing organisms can only be eliminated in milk through pasteurization or by adding chemicals to the milk . . . . Outbreaks of illness related to raw milk have been traced back to both grass-fed and grain-fed animals" (CDC, 2015, Raw Milk Questions and Answers). A proponent

organization for raw milk known as the Weston A. Price Foundation lists the following evidence for raw milk's built in safety mechanisms:

- Lactoperoxidase (2011, slide 5)
- Lactoferrin (2011, slide 6)
- Leukocytes, B-Lymphocytes, Macrophages, Neutrophils, T-Lymphocyes, Immunoglobulins (IgM, IgA, IgG1 & IgG2), Antibodies (2011, slide 7)
- Polysaccharides, Oligosaccharides, Medium-Chain Fatty Acids, Phospholipids and Spingolipids (2011, slide 9)
- Enzymes, (e.g. Complement & Lysozyme), Hormones & Growth Factors, Mucins, Fibronectin, Glycomacropeptide (2011, slide 10)
- Beneficial Bacteria (Lactobacilli and bifidus), B_{12} Binding Protein, Lactoglobulins (2011, slide 12)

The above list are *heat sensitive* lipids and protein structures which can be found listed in a side-by-side comparison in Figure 1 to show which are still effective before and after pasteurization. If any of the above items are in fact safety mechanisms in raw milk (the CDC denies this implicitly), then it is worth exploring some other testable effects of heat on proteins. The University of California Davis (UC Davis) points out that the test for pasteurization (if it indeed happened and to what effect) is verified by the test for the inactivation of alkaline phosphatase (UC Davis, n.d.). The inactivation or *denaturing* of the enzyme phosphatase is predictable and expected making this test very good science, because this enzyme (a protein) is most definitely affected by heat; the efficacy of the test depends on this fact. So if the very test used in industry

tests for the effect of an enzyme being inactivated (denatured by heat) during pasteurization, it becomes very difficult to reconcile this test mechanism with that with this narrow statement by the FDA, "The two major groups of milk protein are casein (about 80%) and whey proteins (about 20%). The protein quality of pasteurized milk is not different from that of raw milk" (FDA, 2014, Milk Proteins). As mentioned before, the GABRIELA study from Loss et al. *contests this fact directly*, by conferring the protective factors of raw milk directly by the lower fraction of whey proteins (2011, p. 5). If whey proteins are not heat stable at pasteurization temperatures, then not only are they *in fact definitely* denatured, but the FDA and CDC statements cannot be squared with this scientific fact rendering the parochial nature of their claims suspect to further explanation on their part.

What is Meant by "Raw Milk?"

To the point by John Sheenan that, "Drinking raw milk is like playing Russian Roulette with your health;" a delineation in the vocabulary is warranted. What is meant by "raw milk?" In commercial milk production, the redemption for this type of milk is undeniably in the pasteurization process because it is otherwise unfit for human consumption. A cow can be confined with hundreds of other cows in a small space, fed corn in a dark enclosure and not grass with the sun on her back in a rotated pasture, meanwhile she is given antibiotics prophylactically and she is never allowed to leave her confines has a life span that averages just 42 months (Weston A. Price Foundation, slide 110). If this milk is what is meant by "raw milk" then the regulators are talking right past the proponents, because *no one* is for drinking this milk any other way but heat treated, but clearly this is not all that is being missed. Quotes such as, "Raw milk is well-established as a vehicle for numerous infectious diseases" (Robinson, Scheftel & Smith, 2014, p. 39) are simply void of significance in the discussion. Furthermore, since they

are ill-defined, they show a clear bias in the “weight” of the reporting entity's chosen words making them neither meaningful nor helpful in the debate. Clearly large dairies are organized around the pasteurization and homogenization process when the “pre-pasturized” milk produced is “intended for processing” (Gumpert, 2015, p. 32) much less care needs to be taken to ensure that it is produced with low pathogen loads in a bulk tank silo with milk from thousands of cows from multiple farms. FDA regulation 21 C.F.R. § 1240.61 which bans the interstate commerce of raw milk (the only food to have such a ban) outlines the pasteurization standards: 63°C for 30 minutes, 72°C for 15 seconds or 89°C for 1 second with additional guidance for higher fat content or eggnog products (21 C.F.R. § 1240.61, 2015). As mentioned previously, these standards are meant implicitly *to denature many proteins, the good and the bad*; the higher the temperature, the faster the pasteurization process happens (read: “more throughput”).

What about organic milk? Due to the low demand for a given geographical distribution area, organic milk may have a significantly lower pesticide load, but the hopes of any benefits of raw milk are long since cooked away since it falls into the last category of ultra high temperature pasteurization (UHT: 138°C for 2 seconds [FDA, 2015, ULTRA-PASTEURIZATION]). In his book, *The Food Police*, Lusk maintains that UHT milk's taste precludes it from market demand in the United States which is why savvy marketing commercial dairies do not use the process, “I spent much of the last year in France, and most of the milk there was sold right off the unrefrigerated shelf—next to the laundry detergent. Why? Because it is ultra-high-temperature pasteurized. And you want to know something? It tastes terrible” (2013, p. 87). In truth, organic UHT milk is about as far away from raw milk as one can get.

The Existence and Benefits of the Microbiodome

Also conspicuous by its absence from any of the government studies publishing pathogenic outbreaks from or the dangers of "raw milk" (as stated, this is often a poorly defined term), is the existence of commensal bacteria in the gut of every human being. It is as though all people are considered "bug and germ free" and therefore everything that is produced for human consumption should also be sterile. Thompson and Manore would contest that in their book, *Nutrition, An Applied Approach*, "the human body is a lush microbial ecosystem containing about 100 trillion microorganisms (microscopic organisms such as bacteria) . . . [called the] human microbiodome" (2015, 32). A bit of truth in advertising goes a long way, consider the photo of a UHT chocolate milk carton provided to military personnel in Afghanistan (Figure 2), the bottom of the panel on the front of the carton reads (in Russian), "sterilized milk." To be sure, all bacteria in UHT milk has been neutralized in addition to anything good in it as well rendering the final product as white aqueous solution bearing calcium and caseins with vitamin D added. Paxson, in her journal article titled, *Post-Pasteurian Cultures: The Microbiopolitics of Raw-Milk Cheese in the United States*, moves the pasteurization conflict from the back burner to full boil when speaking of "Post-Pasteurians" in society, "dissenters who insist that not all bugs are bad, not only that microbes are a fact of life but that many also enhance human life. Resisting the hyperhygienic dream of Pasteurians" (2008, p. 15).

It would seem that some special pleading is involved here on behalf of the FDA and CDC on the measured vector of risk within the realm of microbiology. If the average person cannot see bacteria, then its existence and effects are probably best left to the experts, so it would seem. At the time of this writing, oysters can still be ordered raw at a bar, raw cookie dough can still be

sold and most diners in America will still serve eggs over easy—none of these "public health risks" have been made illegal.

The USDA will criticize those who hold raw milk as a nostalgic food, but they still to this day calculate the price of milk in the legislative tome known as the "Farm Bill" based on an antiquated formula from 1937 pricing milk originating from the then center of the dairy industry (during the 1930's) in Eau Claire, WI (Hurst, 1995, p. 48) regardless if the dairy is in Augusta, GA or Augusta, ME. Raw milk cheeses must be aged to a minimum of 60 days owing that time scale to an obscure government regulation dating back to WWII food standards for servicemen. The expertise bona fides are most noticeably advanced at the point of obscurity as Paxson points out, "Owing to categorical vagueness--and perhaps to the unctuous liminality of a supple cheese with guilt-inducing consumptive pleasure--the [FDA] warning has caused considerable confusion among the microbiopolitical players the FDA intends to serve: at-risk consumers" (2008, p. 23). While this seems proactive and perhaps a compassionate act of government by some standards, in a state like Montana where one can obtain a prescription for medical marijuana in order to roll it and smoke it to treat everything from anxiety to "certain lung diseases" (Medical Marijuana, n.d.) it would seem that there would be far more latitude given to informed adult consumers aware of bacteria who wish to purchase their raw milk products directly from a farmer. However, HB0245, the Montana House of Representatives bill that would have granted such farm direct sales for raw milk, was voted down in the 2015 session.

While the regulators are not going to leave all of the checking to the farmers, to be sure it is in the farmer's best interest to scrutinize their own milk. When cheese and milk is being sold direct to the customers, a farmer does not have a distributor or a 1-800 hot line with endless voice menu options (that have recently been changed) to hide behind. This cash on the bottle-

head, eye to eye contact sale is a strong safeguard to ensure that the milk is produced, collected, stored, bottled and sold in the best possible way to decrease pathogenic vectors. Paxson in her journal article writes about an interview she had with Vermont raw milk cheese farmers describing their autonomous verification practices, "[quoting Mateo, a farmer said] the bacteria count of the milk they make cheese from is generally lower than that of some pasteurized milk on supermarket shelves [verified by independent testing at farmer's expense] . . . To produce and maintain safe milk the Kehlers [farmers cited elsewhere in the journal article] never feed their cows silage (fermented corn) or fermented hay, notorious bacterial breeding grounds" (2008, p. 25). Every farmer's market vendor knows that sick or dead customers are not repeat customers, so the size of the distribution self regulates pathogenic outbreaks to a large extent compared to say 197,000 people sickened in 1987 outbreak of salmonellosis and 224,000 people sickened in 1994 also due to salmonellosis—both from pasteurized milk (Gumpert, 2015, p. 47).

Biology is not like physics where reductionism is king and works seamlessly in every circumstance. What it takes to maintain healthy homeostasis in a biological entity is not analogous to a two input see-saw where adding a variable to one side will affect one, and only one, output. Biological systems are more analogous to balancing a dinner plate on a chopstick where any number or gradient of one or more inputs can offset homeostasis. This distinction for grass-fed raw milk and raw milk products seems to have traction in the market with consumers who appreciate the microbiodome as evidenced by raw milk from grass-fed cows fetching very high retail premiums. Why is this so? The Swiss have a saying, "Winter Cheese is Boring Cheese," which speaks about the richness of the dairy product as a function of the diversified nutrient value in the pasture vegetation on which the ruminant is feeding. What makes cheese taste good, a cow healthy or the people who drink the raw milk from the grass-fed cow

microbiologically whole may not be reducible to one or even one dozen ingredients that can simply be enriched back into milk after it has been pasteurized. Rather this nuanced fact seems both intuitive in the serenity we sense when seeing cows on rotated pasture (low pathogen load) as opposed to in a CAFO (high pathogen load) and obvious in sky blue milk of nutritionally impoverished cows that lead to pasteurization becoming the one-size-fits-all law. The natural order which governs everything from physics to biology seem to have humble boundaries, and humanity's existence is optimal when we stay within those limits.

Statistics, Who is Keeping the Tally?

Clearly the position of the FDA and CDC is against raw milk, and one would expect to be able to get the score read once in a while. So just how many outbreaks have their been of "raw milk" (clarity needed for this term) in the last year? How many people have gotten sick, hospitalized or even died from raw milk? The answer is that no one is really sure and if there was ever room for improvement in scientific literacy, it is in the area of dairy statistics. The CDC and a not-for-profit entity called the Center for Science in the Public Interest seem to be the only two data bases with these records. The CDC's numbers have been quoted in several sources to be "2,384 illnesses, 284 hospitalizations and two [sic] deaths attributed to raw milk or raw milk products from 1998 through 2011" (Gumpert, 2015, p. 57). While these numbers are useful data points, they are difficult to verify and arrive at the same total in a repeatable manner. The reason is because the numbers are not cataloged annually, nor are they easily searchable. If one wanted to sleuth this out for themselves on the CDC data base, be patient and flexible, "you have to go through 787 pages of data, and manually locate the 'food vehicle' under one column and 'total ill' under another. . . . and the listings are often imprecise. Raw dairy illnesses can be identified as 'Milk, raw,' 'RAW MILK,' 'Goat milk, raw,' 'Cheese, unpasteurized,' 'Whole milk,

unpasteurized,' 'Queso fresco,' with no pasteurization status listed" (Gumpert, 2015, p. 59). So getting the score can be very difficult indeed, and if one asks where those numbers scale to all illnesses reported in one year, the answer can be very interesting. Gumpert gives the number of *reported* foodborne illnesses to be 15,000 per year (2015, p. 58) where the CDC gives a higher number at an *estimated* 48 million foodborne illnesses per year (CDC, 2014, CDC Estimates of Foodborne Illness in the United States)—clearly a range emerges in the data set. Using the advertised number of 2,384 illnesses in the fourteen year range given, the annual average would be 170.3 illnesses from raw milk every year—not a trivial number when the topic of people's health is concerned. However, additional comparison is warranted. Taking the lower number from Gumpert of 15,000 *reported* per year, the percentage of raw milk related foodborne illnesses is 1% (2,384 / 15,000 = 1%)—a significant number statistically or otherwise. Using the higher *estimated* number given by the CDC, the percentage of foodborne illnesses related to raw milk is 0.000004% (2,384 / 48,000,000 = 0.0000004%) which is statistically irrelevant past the point of even the most generous significant figure allowance.

Baselines are just hard to get in these data, because of something called "relative risk." Langer et al. who are in print with the indictment for raw milk saying that "scientifically credible evidence is lacking" offers this quote to quantify raw milk risk, "Therefore, the incidence of reported outbreaks involving nonpasteurized dairy products was ≈150× greater, per unit of dairy product consumed, than the incidence involving pasteurized products. If, as is probably more likely, <1% of dairy products are consumed nonpasteurized, then the relative risk per unit of nonpasteurized dairy product consumed would be even higher" (Langer et al, 2012, p. 389). Given the above calculations *with the CDC's own numbers*, this statement needs further clarification, qualification or retraction.

Given the connection established in the GABRIELA study by Loss et al. (2011) between asthma and raw milk, the Weston A. Price foundation has some interesting comparative figures, "About 5,500 people in the US die from asthma each year. About 1,250 people in the US die from food-borne pathogens from ALL sources (No deaths from raw milk). Thus, the risk of dying from asthma is over four times greater than the risk of dying from food-borne pathogens from ALL sources" (2011, slide 101). Statistically raw milk is safer that the trip to the farm by car to purchase it when the CDC's data are used.

"Consumption of raw milk is a high-risk behavior and will continue to cause morbidity and mortality until people stop consuming raw milk and raw milk products" (Jayarao, Donaldson, Straley, Sawant, Hegde & Brown, 2006, p. 2452). Even if raw milk were the "Russian Roulette" of your health *and the statistics ostensibly supported that claim*, the question emerges, "Who owns the person?" In the modern day of nationalized health care, the fiduciary responsibility of one's health clearly is in the public domain and cost actuarial tables making the parochial nature of the government's claims not just preventative measures for public health policy, but sound indemnity threat reduction. Paxson writes of the moral imperative of prophylaxis:

> The microbiopolitical regime of the FDA, working to protect the health of an eating population, is guided by a science-based governmentality [sic] similar in some ways to the biopolitics of, say, safe-sex campaigns. There are important differences. While prophylaxis and vaccination trade in communicable diseases, food poisoning although discomforting and occasionally lethal--is not contagious. But in their intimate, bodily yet social characters, food and sex, eating and eros, have much in common (2008, p. 26).

As unsavory as the analogy may be, the "Russian Roulette" narrative may be just the right amount of spin to put on the statistics, if the government were in the business of keeping the score now that the government is *also the one to bear* health care costs. 15,000 *reported* vs. 48,000,000 *estimated* is a large rounding error indeed. However, 48 million works out to be about 1 in 6 Americans, or the same number of odds you would presumably have in a six shot revolver used to play a hypothetical game of "Russian Roulette." Lusk in a good measure of irreverent humor said, "The food police unwittingly married George Orwell's two greatest works by bringing Big Brother onto Animal Farm" (2013, p.4).

Scale is convenient to the Regulator

If pasteurization is the cure, then a Socratic exploration into how the disease process starts and how it is transmitted (known as etiology and epidemiology) is warranted. "How does milk get contaminated? The CDC gives this answer:

> Milk contamination may occur from: Cow feces coming into direct contact with the milk , Infection of the cow's udder (mastitis), Cow diseases (e.g., bovine tuberculosis) , Bacteria that live on the skin of cows, Environment (e.g., feces, dirt, processing equipment), Insects, rodents, and other animal vectors, Humans, for example, by cross-contamination from soiled clothing and boots. Pasteurization is the only way to kill many of the bacteria in milk that can make people very sick (CDC, 2015, Raw Milk Questions and Answers).

All of the above list is good science, and hard to argue with—however, a question exists in that answer: "What does it cost to pasteurize?" Paxson cites the figure of $28,000 to have a small vat pasteurizer that would suit a small producer (2008, p. 24). If a farmer grossed $50,000 a year (an

attainable goal with the premiums netted with raw milk sales), just the equipment to render his/her product indistinguishable from all others on the supermarket shelf would be over half his/her salary for a year.

The costs to produce milk accumulate from there long before the first bottle of it can be sold in the State of Montana. The fee to purchase a license from the state is a mere $2.00, however the significant cost to have the inspectors come onto the farm is defined by regulation, "81-1-102. Duties and powers of department -- fees based on costs -- notice of rules and orders . . . . the department shall by rule establish all fees that it is authorized to charge, commensurate with costs as provided in 37-1-134" (*81-1-102*, 2014). This was cited in verbal testimony from opponents of raw milk during the Montana House and Human Services Committee hearing on 28 Jan 2015 in the context of small producers not being worth the cost/effort associated with regulators inspecting such a small operation when divided by the time available for just a few inspectors (Montana House of Representatives, Human Services Committee, 2015).

This "fee for service" model is paid for by the milk producer, which seems fair but is not scalable for the small producer when the cost associated are, "$2000 per trip" (Montana House of Representatives, Human Services Committee, 2015). When these costs can be made up on the volume of sales, then the CAFO producers are able to bear that cost at the expense of pathogenic loads in the pre-pasteurized milk. However, the original question of Socratic inquiry into why the milk needs to be pasteurized (as in it is unlawful not to do so) comes back to the fact that milk is mass produced in large holdings dairy operations that are able to feed subsidized corn to their short life cows. Any other scale for a dairy model (e.g. raw milk selling for $8-12 per gallon consumer direct sales) used to fund the cost of regulatory inspection is not affordable for the small holdings producer and not worth the trip for the regulator. Regulators are in the

business of maintaining a customer group to regulate—bigger is better and less work with fewer trips. Clearly, the mandate from former Agriculture Secretary to the Nixon Administration, Earl Butz, "Get big or get out" (Carlson, 2008) favors those who already are big enough to pay to play in the current system.

The reasons listed by the CDC for potential milk pathogens are all true, these things can happen, but they need not happen. While a thorough understanding of veterinary science is not explored here, it is a reasonable assumption that the alimentary canal and the mammary glands on a cow are separated physiologically whereby an enteric coliform need not get into the milk by default. Where there is risk, it likely can be mitigated by common sense, best practices and engineering controls so that milk collected can be free from coliforms (assuming that the milk is not intended to be pasteurized). Not surprisingly the FDA and CDC would disagree, "In fact, raw milk, no matter how carefully produced, may be unsafe. . . . Because even pasteurized milk contains low levels of nonpathogenic bacteria that can cause food to spoil, it is important to keep pasteurized milk refrigerated" (FDA, 2007, FDA and CDC Remind Consumers of the Dangers of Drinking Raw Milk). A distinction in the last part of that quote should be made in that raw milk will sour, and pasteurized milk will putrefy—because all of the enzymes are inactivated. A farmer who knows his cows is going to know when a cow has mastitis and separate her until she is well again, if for nothing else because he/she knows that is best for the animal. When the head count is in the hundreds of cows, that becomes more difficult to track and the "bomb proofing" of pasteurization becomes the gold standard weapon of last resort for dairy producers and the starting place to craft dairy regulations. When pasteurization is the reset that public health seemingly depends on, the process should be fail safe—but it is not. The point where the commingled milk from the silo exits the pasteurizer (heat exchanger) for the prescribed time

until it is on the table represents multiple points of failure from the failure of gaskets in the long routes of pipes that the milk must travel through before it reaches the bottle to "temperature abuses" when it is in the hands of the consumer.

Additionally, the myth is worth busting in that pasteurization does not kill off everything. A study out of New York by Huck, Hammond, Murphy, Woodcock & Boor explores the known microbes in pasteurized milk, "The presence of psychrotolerant Bacillus species and related spore formers (e.g., *Paenibacillus* spp.) in milk has emerged as a key biological obstacle in extending the shelf life of high-temperature, short-time pasteurized fluid milk beyond 14 d" (2007, p. 4872). These psychrotolerant spores are not the only hazards that follow the pasteurization process, Tomasula & Konstance followed the Foot-and-Mouth Disease virus (not a bacteria vector) from raw milk through the high temperature short time pasteurization process. Furthermore their research cites, "For milk at pH 6.7, 99.999% inactivation of the virus (5 $\log_{10}$ reduction) was achieved in 17 s at 72°C. At pH 7.6, FMDV was inactivated in 55 s at 72°C" (2004, p. 1116). It is noteworthy that these times are *much longer* than those prescribed by the FDA and their conclusions were that this was potentially a matter of "biosecurity" going as far to say that even colostrum should be pasteurized before feeding it to calves (2004, p. 1119). What makes colostrum so healthy for the calf is that it is very high in IgA immunoglobins—which are definitely susceptible to heat pasteurization; this would be analogous to declawing a barn cat.

The Microbes are Winning the Contest

With the present model of "produce the milk however, it can be cooked to cleanliness later" there is still a large dependence on antibiotics for prophylaxis. In short, there is just no other way to pack that many ruminants together in one enclosed feces packed space without

giving them antibiotics to keep pathogenic organisms in their systems at a manageable level. "Studies show that factory-farmed cattle have 300 times more pathogenic bacteria in their digestive tracts than cattle that are allowed to openly graze in pastures (Weston A. Price Foundation, slide 67). This most certainly creates an arms race between agriculture and microorganisms . . . and we are losing.

"Livestock growers use antibiotics in the feed of closely penned animals because the drugs reduce the number of bacterial infections and accelerate the animals' growth. Today, more than half the antibiotics used worldwide are given to farm animals" (Tortora et al, 2013, p. 583). This contest is a recent one, but the statistics are not in the producer's or consumer's favor. The prevalence of *Stapholococcus aureus* as a pathogenic crisis is a well documented medical problem. The contemporary definition of a *S. aureus* infection is "MRSA," or Methylin Resistant *S. Aureus*. In other words, the contemporary moniker is to describe *S. aureus* by what we know *does not work any longer*. The solution after methylin proved to be ineffective was vancomycin (from the word "vanquish") that was the next logical step in the arms race. "Vancomycin has been considered the last line of antibiotic defense for treatment of *Stapholococcus aureus* infections that are resistant to other antibiotics. The widespread use of vancomycin to treat MRSA has led to the appearance of vancomycin-resistant enterococci (VRE)" (Tortora et al., 2013, p. 569). This has serious implications for agriculture, because this superbug is an enteric—we may not have any more weapons left to fight this if we keep packing cattle together hoping to medicate or pasteurize our way out of a full blown microbiology food crisis.

Conclusion

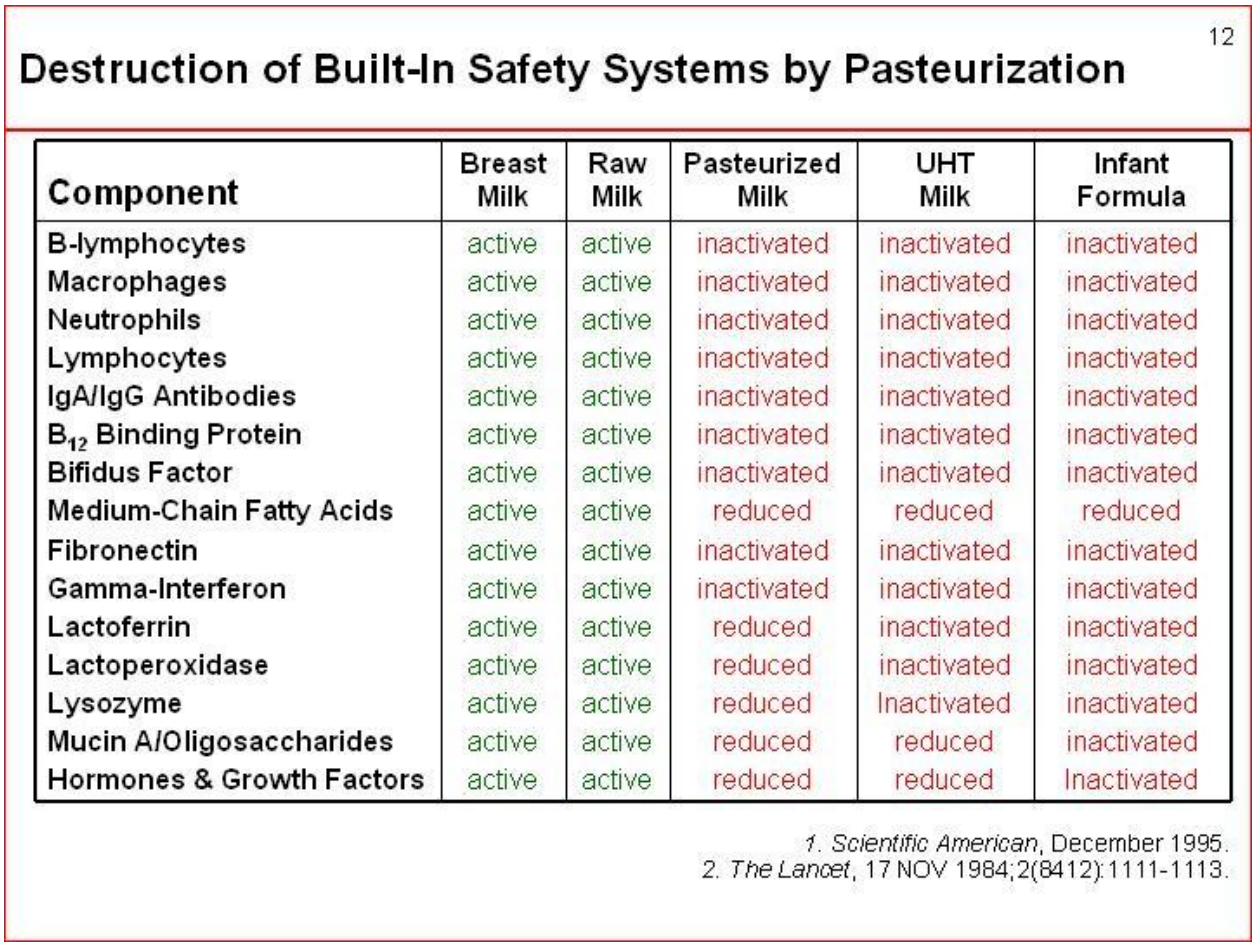
Raw milk is not without its risks, but they are manageable. The legislative bodies can enact laws such as, “The Wyoming Food Freedom Act (WFFA) [which legalizes] the production and sale within Wyoming of any food except meat products by a producer direct to the 'informed end consumer' is not subject to licensing or inspection” (Kennedy, 2015). Proponents of raw milk are not looking to overthrow grade A dairies, nor do they demand that raw milk be sold everywhere on every grocery store shelf, or that it be included in school lunches. The intent of raw milk production and sales is that it would be between “informed end consumers” who would seek out farmers to buy raw milk at their own risk.

Additionally, the language of “raw milk” and what its associated track record needs to be clarified and in some instances repudiated. The existence and benefits of the human microbiome need to be added into the balance of the discussion, or else it is incomplete to just speak of food as a sterile commodity. If the statistics of raw milk are to be used against raw milk, then they should be clarified to represent those cases that are congruent with the discussion. The current fee-for-service model for regulatory compliance favors large producers who are past the point of direct consumer sales and therefore must produce pasteurized milk commensurate with the scale required to produce such milk. This problem compounds itself and sets the bar higher than any small producer can reach to be serviced by inspectors. If public health and safety are the charter for inspectors, then a better model for small holdings dairy operations is needed.

Lastly, the silver bullet of antibiotics is no longer an option, last resort or otherwise. To reduce pathogenic loads, animal density must decrease. Joel Salatin, a farmer, author and innovator puts the antibiotic vs. pathogen problem in a most succinct way, “E. Coli, Salmonella,

Listeria, Bovine Spongiform Encephalopathy, Camphylobacter, MRSA, C. Diff, food allergies—all this is part of Nature saying, 'Enough!'" (Pantry Paratus, 2012). The 2013 World Almanac lists milk sales and consumption declining from 1910 to 2010 by almost 75% (Jannsen, p. 126). Large producers need subsidized grain to be profitable in order to feed grain and corn to dairy cattle to produce over the course of their short lives. This decline in commercial milk demand combined with market forces for local food and raw milk in particular favors small producers at the scale for direct consumer sales thus reconnecting consumers with their farmers bringing other economic possibilities into view (recycling manure to grow vegetables, laying hens, raising hogs for butcher, etc.). The future for food is promising, science and microbiology can certainly help, but not in the present debate under the current system status quo.

Figure 1:



12

Destruction of Built-In Safety Systems by Pasteurization

Component	Breast Milk	Raw Milk	Pasteurized Milk	UHT Milk	Infant Formula
B-lymphocytes	active	active	inactivated	inactivated	inactivated
Macrophages	active	active	inactivated	inactivated	inactivated
Neutrophils	active	active	inactivated	inactivated	inactivated
Lymphocytes	active	active	inactivated	inactivated	inactivated
IgA/IgG Antibodies	active	active	inactivated	inactivated	inactivated
B_{12} Binding Protein	active	active	inactivated	inactivated	inactivated
Bifidus Factor	active	active	inactivated	inactivated	inactivated
Medium-Chain Fatty Acids	active	active	reduced	reduced	reduced
Fibronectin	active	active	inactivated	inactivated	inactivated
Gamma-Interferon	active	active	inactivated	inactivated	inactivated
Lactoferrin	active	active	reduced	inactivated	inactivated
Lactoperoxidase	active	active	reduced	inactivated	inactivated
Lysozyme	active	active	reduced	Inactivated	inactivated
Mucin A/Oligosaccharides	active	active	reduced	reduced	inactivated
Hormones & Growth Factors	active	active	reduced	reduced	Inactivated

1. *Scientific American*, December 1995.
2. *The Lancet*, 17 NOV 1984;2(8412):1111-1113.

Note. From "Campaign for Real Milk," by the Weston A. Price Foundation, 2014, slide 12.

Figure 2:

Note. Photo taken by author.

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