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Optimizing nature: Invoking the "natural" in the struggle over water fluoridation

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Abstract

For the past seventy years, a host of scientific and public health bodies in the United States have strongly endorsed the practice of adding fluoride compounds to public water supplies as a prophylactic against dental caries. Throughout that period, a constant undercurrent of skepticism and outright opposition has slowed the adoption of the practice in the United States and limited its spread to just a handful of countries around the world. One of the attractions of water fluoridation is its affordability: the fluoride compounds are sourced from the phosphate and aluminum industries, for whom they would otherwise constitute an annoying toxic waste disposal problem. Despite this, proponents have nonetheless succeeded in shaping a narrative that casts fluoridation as "natural" or at least mimicking nature. I demonstrate how fluoridationists were able to persuasively argue that adding a pollutant to the water supply was safe and natural. In the process, I examine how environmental historians and historians of science approach topics such as fluoridation. I suggest that as a result of the influence of science and technology studies and an ontological turn toward hybridity, the two subdisciplines are becoming increasingly convergent.

Keywords

Environmentalism, moral authority of nature, pollution, public health, water fluoridation

While Florida's tourism promoters prefer their state be associated with sunshine, from a geological and economic perspective, it could just as accurately be known as the Phosphate State. The so-called Bone Valley of central Florida contains some of the largest phosphate deposits in the world, thereby supplying global agriculture with one of its most important commodities: synthetic fertilizer. In the process, the mining industry leaves behind a scarred landscape denuded of vegetation and pocked with vividly colored

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waste disposal ponds that one popular science magazine described as "beautiful pools of pollution."[1] In order to manufacture fertilizer, phosphate rock is crushed and refluxed with sulfuric acid, in the process releasing highly toxic hydrogen fluoride and silicon tetrafluoride gases. Prior to the 1970s, these pollutants were vented into the atmosphere, scorching nearby vegetation and causing crippling skeletal fluorosis in livestock in the vicinity of fertilizer plants. The industry's emissions gave central Florida some of the most noxious air pollution in the country. During the 1960s, however, complaints by farmers and ranchers eventually forced reluctant manufacturers to invest in pollution abatement scrubbers that converted toxic vapors into fluorosilicic acid (FSA), a dangerous but more containable liquid waste.[2]

The U.S. National Institute for Occupational Safety and Health (NIOSH) cautions that FSA, an inorganic fluoride compound, has dire health consequences for any worker that comes into contact with it. Breathing its fumes causes severe lung damage or death and an accidental splash on bare skin will lead to burning and excruciating pain. In short, NIOSH sternly warns: "AVOID ALL CONTACT!" Not surprisingly, FSA's volatility "may be hazardous in the environment," particularly to aquatic organisms. In addition to its potent toxicity, it is highly reactive: it interacts negatively with metals, producing a flammable hydrogen gas, while also eating through glass and attacking concrete.[3] Fortunately, it can be contained in high-density cross-linked polyethylene storage tanks. It is in such tanks—or in rubber-lined bulk containers—that fluorosilicic acid has for the past half century been transported from Florida fertilizer factories to water reservoirs throughout the United States. Once there, it is drip-fed into drinking water. This is a practice that the American Dental Association and numerous scientists and public health officials describe as "the precise adjustment of the existing naturally occurring fluoride levels in drinking water to an optimal fluoride level … for the prevention of dental decay."[4]

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1. J. Henry Fair and Michael Tenneson, "Beautiful Pools of Pollution," *Discover*, June 29, 2010, <http://discovermagazine.com/galleries/zen-photo/p/phosphate-mining> (May 22, 2017).
2. Scott H. Dewey, "The Fickle Finger of Phosphate: Central Florida Air Pollution and the Failure of Environmental Policy, 1957-1970," *Journal of Southern History* 65:3 (1999): 565–603. Dewey points out that state regulators were largely ineffectual and generally sided with industry. Only once federal regulators intervened in the wake of the 1970 National Environmental Policy Act was industry forced to adopt abatement measures. For a broader and more polemical (but also powerful and convincing) exposé of fluoride pollution and its links with water fluoridation, see Christopher Bryson, *The Fluoride Deception* (New York: Seven Stories Press, 2004).
3. Centers for Disease Control, International Chemical Safety Card 1233, October 27, 2004 <www.cdc.gov/niosh/ipcsneng/neng1233.html> (May 22, 2017).
4. American Dental Association, Fluoride Facts, 2005, <www.ada.org/~/media/ADA/Member%20Center/FIles/fluoridation_facts.ashx> (May 22, 2017). Fluorosilicic acid has been the main fluoridation compound in the United States since 1968. Prior to that it was sodium fluoride, a similarly toxic waste product produced in powder form by the aluminum industry. Fluorosilicic acid's advantage was that it was a liquid and therefore easier to mix into water. It was also cheaper and more abundant. In recent years, China has become an increasingly significant supplier of fluorosilicic acid. A recent study showed that the levels of

The key phrase is "naturally occurring fluoride." While the process described above might strike the average person as being about as "natural" as adding tetraethyl lead to gasoline or spraying DDT across the landscape, community water fluoridation (CWF) proponents have nonetheless relied heavily on the argument that adding a toxic waste product to drinking water, far from constituting an insidious form of pollution, is in fact the mere optimization of a naturally existing compound. Most fluoridation advocates probably have little interest in whether or not CWF is "natural" or "artificial." The main thing, from their perspective, is that it works. Drinking fluoridated water changes tooth enamel in a way that makes children's teeth more resistant to decay, although to what extent—and at what cost to human and environmental health—is a matter of debate. Nevertheless, regardless of their personal views about CWF's "naturalness," fluoridationists' ability to plausibly describe the practice as natural has allowed them to claim what Lorraine Daston and Fernando Vidal refer to as "the moral authority of nature": a "trick that consists in smuggling certain items … back and forth across the boundary that separates the natural and the social," thereby imparting "universality, firmness, even necessity—in short, authority—to the social." This rhetorical ploy constitutes a key component in CWF's widespread—though far from universal—acceptance among the general population in the handful of countries that have adopted it.[5]

Fortunately for CWF advocates, the discovery of fluoride's efficacy as a caries prophylactic was inextricably linked with drinking water from the very beginning. This conferred a far greater degree of plausibility to fluoridationists' claims of "naturalness" than if fluoride's dental benefits had been discovered via experimentation in a laboratory. Furthermore, the CWF consensus crystalized in the early 1950s, more than a decade before the publication of *Silent Spring* and the rise of modern environmentalism. Changing ideas of what could be considered "natural"—and to what degree it mattered—would have made CWF a much harder sell in the 1970s than was the case at mid-century. CWF, therefore, was the result of two vital contingencies: the fact that fluoride was sometimes naturally present in drinking water, although rarely at the "optimal" level, and its implementation at a time when scientific reductionism was still largely unchallenged by the holistic ontology of environmentalism, the emergence of which contracted the scope of what could plausibly be defined as "natural."

Unpacking nature is no walk in the park. In his list of keywords, Raymond Williams described it as "perhaps the most complex word in the language."[6] Peter Coates, the author of a broad cultural history of nature, divides the term's meaning into five overlapping categories: places unmodified by people; the collective phenomena of the universe; an essence or principle that informs the workings of the world; a source of authority

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metal contaminants, such as arsenic and lead, in various fluoride sources varied from batch to batch, thereby creating a regulatory blind spot. See Phyllis J. Mullenix, "A New Perspective on Metals and Other Contaminants in Fluoridation Chemicals," *International Journal of Occupational and Environmental Health* 20 (2014): 157–66.

5. Lorraine Daston and Fernando Vidal, "Introduction," in Lorraine Daston and Fernando Vidal (eds.), *The Moral Authority of Nature* (Chicago: University of Chicago Press, 2004), pp. 1–20, 3.
6. Raymond Williams, *Keywords: A Vocabulary of Culture and Society* (Oxford: Oxford University Press, 1976), p.184.

governing human affairs; and the conceptual opposite of culture.[7] In its adjectival form, one could add that "natural" is also the conceptual opposite of "artificial." It is this latter meaning that CWF proponents evoke most directly, but clearly their use of the term "natural" cuts across several other categories as well. Since fluoride compounds are part of the collective phenomena of the universe—mostly forged in the molten heat of volcanoes—they are as independent from human artifice as lava or coral. They would exist in water whether humans were present or not. Thus, adding them to drinking water is no more unnatural than adding a little extra ascorbic acid to orange juice, a practice which merely optimizes a substance that occurs naturally in oranges.

Describing something as "natural," however, is never a neutral act regardless of who is doing the describing. As historian of science Anne Harrington notes, "there is nothing 'natural' about the political imperatives people at different times hear in nature. We are both creators and consumers of the stories we ask the natural world to tell us about how we should live our lives."[8] In Western culture, Daston and Vidal point out, there has been a strong tendency "to create experts in the natural—at first physicians and natural philosophers in the early modern period, and later scientists." Scientists have thus become relied upon as knowledgeable and "disinterested interpreters of nature's verdicts."[9] Bruno Latour further argues that all modern politics has been underpinned by theories of nature, with scientists as the ultimate arbiters of the natural order and the proper basis for human conduct within it. The moral authority of nature is thus adjudicated by putatively objective scientists whose competing pronouncements serve to bolster political ideologies and social policy.[10]

Natural scientists, however, are not the only class of experts whose construal of nature shapes politics. Historians, too, offer narratives that purport to explain how societies have diverged from or have been shaped by nature. A famous instance is Frederick Jackson Turner's frontier thesis, which viewed American success as a product of a society forced to constantly tame the wilderness. The process of frontier expansion forged a tough and self-reliant national character, as well as extending Jeffersonian democracy, with its dependence on small independent yeomen, across the continent. Environmental historians in particular have attempted to describe the role and place of nature in human life. Initially inspired by the holistic ontology of ecosystem ecology, early environmental historians tended to view nature as an ordered nonhuman realm with its own inherent values and a kind of wisdom that resulted from millions of years of evolutionary history.[11]

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7. Peter Coates, *Nature: Western Attitudes since Ancient Times* (Berkeley: University of California Press, 1998), p.3.
8. Anne Harrington, *Reenchanted Science: Holism in German Culture from Wilhelm II to Hitler* (Princeton: Princeton University Press, 1996), p.206.
9. Daston and Vidal, "Introduction," p.7 (note 5).
10. Bruno Latour, *The Politics of Nature: How to Bring the Sciences into Democracy* (Cambridge: Harvard University Press, 2004).
11. For a useful overview of Turner's role in the evolution of environmental history in the United States, see Mark Schiffhauer, "From Wilderness to Environment: The Role of 'Nature' in Western American Historiography from Frederick Jackson Turner to Donald Worster and the New Western History" (Doctoral Dissertation, Phillipps Universität, Marburg, 2008).

From the perspective of historians of science, who also claim expertise in explaining and historicizing nature, environmental historians often seemed naïve, trusting that certain biological sciences—and the models of nature they offer—constitute accurate descriptions of how the natural world functions, thereby providing them with key benchmarks for analyzing humans' environmental impact over time. This privileging of the natural sciences—particularly ecology—means that environmental history risks becoming what environmental historians Sverker Sörlin and Paul Warde call a mere "epiphenomenon in the study of nature," one that convinces neither natural nor social scientists of its importance.[12] Historian of science Graham Burnett offers similar sentiments: "environmental historians are inclined to deploy as historical *explanans* some of the very findings that historians of science consider *explanandum*. This tends to frustrate the historian of science." Nevertheless, Burnett admits, his own tribe has an "exaggerated preoccupation with treating 'nature' as endlessly and ineluctably constituted by human discourse or practices," a view that "can (not wholly unreasonably) strike the practicing environmental historian as either sophomoric, paranoiac, quixotic, or downright nuts."[13] Even as he was writing these words, however, Burnett's observation was already out of date. Beginning in the 1990s, environmental historians, under the influence of poststructuralism and science and technology studies, started to view nature as a cultural construct.[14] While some scholarship, particularly that of U.S. environmental historians, maintains a spirit of 1970s environmental advocacy and a (perfectly understandable given the state of the world) tendency toward declensionist narratives, hybridity and complexity have increasingly become the discipline's dominant leitmotif, particularly in the environmental history of disease and health.[15]

12. Sverker Sörlin and Paul Warde, "The Problem of the Problem of Environmental History: A Re-Reading of the Field," *Environmental History* 12 (2007): 107–30, 115.
13. D. Graham Burnett, *The Sounding of the Whale: Science and Cetaceans in the Twentieth Century* (Chicago: University of Chicago Press, 2012), pp.8–9.
14. The most influential volume of constructivism in environmental history is William Cronon (ed.), *Uncommon Ground: Toward Reinventing Nature* (New York: W. W. Norton, 1995). It spawned numerous critiques, notably Michael Soulé and Gary Lease (eds.), *Reinventing Nature?: Responses to Postmodern Deconstruction* (Washington, DC: Island Press, 1995) and Eileen Crist, "Against the Social Construction of Nature and Wilderness," *Environmental Ethics* 26 (2004): 5–24.
15. For an excellent summary of these historiographic developments and what they mean for the discipline, see Paul Sutter, "The World with Us: The State of American Environmental History," *Journal of American History* 100:1 (2013): 94–119. For examples of how science and technology studies have influenced environmental history, see Dolly Jørgensen, Finn Arne Jørgensen, and Sara Pritchard (eds.), *New Natures: Joining Environmental History with Science and Technology Studies* (Pittsburgh: University of Pittsburgh Press, 2013). Examples of environmental histories that embrace hybridity, particularly when related to human health, include Gregg Mitman, *Breathing Space: How Allergies Shape Our Lives and Landscapes* (New Haven: Yale University Press, 2007); Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley: University of California Press, 2006); Nancy Langston, *Toxic Bodies: Hormone Disruptors and the Legacy of DES* (New Haven: Yale University Press, 2010); Brett Walker, *Toxic Archipelago: A History of Industrial*

The history of CWF has a different narrative arc and moral trajectory from topics that environmental historians of disease and health usually tackle. Scholars like Linda Nash, Brett Walker, and Nancy Langston generally look to industrial causes of illness—be they pollution, environmental contamination, or medication that has proved to be damaging—and explore the way it has affected the environment and human health. Usually there is a clear villain, such as DDT, lead, or mercury. The question is rarely whether any of these substances are beneficial to human health, but rather, what degree of harm they cause. Fluoride, on the other hand, is the story of an industrial pollutant that came to be seen by many as a medical miracle. Thus, the official CWF history contains no mention of careless or nefarious industrial interests socializing the cost of pollution while pocketing the profit of production. Rather, the fluoride waste generated by industry is rhetorically reconstituted as a useful commodity, a "co-product" of aluminum or phosphate production. It is then used in a government approved practice to improve human health. Fluoride, whether in the form of FSA or sodium fluoride, is classified by the Environmental Protection Agency as a dangerous toxic waste except when it is drip-fed into drinking water, at which point it is transformed into a preventative agent in the service of public health.

From the perspective of CWF advocates, fluoride's public health history is like a crime story with a twist: after following a trail of clues for many years, detectives finally catch their chief suspect and put him on trial. But it soon turns out that he has redeeming qualities that far outweigh the crime with which he was originally charged. The indefatigable private eye in this case was Frederick McKay, a Massachusetts-born dentist and enthusiastic amateur epidemiologist. After completing his training at the University of Pennsylvania School of Dentistry, McKay moved to Colorado Springs in 1901 to establish his first practice. He soon became perplexed by the unsightly tea-colored stains that discolored many of his patients' teeth, a condition that he was unable to find in the dental literature. McKay began calling it Colorado stain or brown stain, and nobody understood why many residents of this particular region suffered from it while those in neighboring counties did not. The brown stains usually appeared during childhood and marked the teeth for life. In the summer of 1909, McKay and some colleagues inspected the mouths of 2,945 Colorado Springs children and discovered that 87.5% suffered from the condition. It would take McKay and others another two decades to solve the mystery.[16]

Disease in Japan (Seattle: University of Washington Press, 2010); and, on fluoridation in particular, Christopher Sellers, "The Artificial Nature of Fluoridated Water: Between Nations, Knowledge, and Material Flows," *Osiris* 19 (2004): 182–200. Another prominent environmental historian, Martin Melosi, has written about fluoridation from the perspective of water policy and engineering history. See *Precious Commodity: Providing Water for America's Cities* (Pittsburgh: University of Pittsburgh Press, 2011).

16. Donald R. McNeil, *The Fight for Fluoridation* (New York: Oxford University Press, 1957), p.6. McNeil's book was based on his University of Wisconsin doctoral dissertation. However, far from being a detached historian, McNeil was an ardent fluoridationist who worked as a fluoride consultant for the American Dental Association and the Public Health Service. His work was written with the close cooperation of McKay and other early fluoridation advocates and constitutes a kind of semi-official history of CWF. For evidence of McNeil's close association with the ADA, see the file "ADA Correspondence, 1960-63,"

Upon further investigation, McKay determined that the Colorado Springs area was not unique; there were pockets of brown stain throughout the country in places such as west Texas, South Dakota, and northwest Arkansas. McKay began to conduct an informal epidemiological study. He examined the local diet, soil conditions, and air quality, but eventually decided that the culprit had to be the water. "The evidence is so conclusive," he wrote in 1927 to the Public Health Service (PHS) in Washington, DC, "that it is futile to discuss it further from any other standpoint."[17] Despite testing numerous samples, however, he could not find anything unusual in the local water supply, which was clear, odorless, and agreeable to the taste. Nevertheless, he became increasingly convinced that some as yet undetected trace element in the water was responsible for the dental lesions. Notwithstanding his inability to prove his theory, McKay nonetheless lobbied Colorado Springs to change its water supply, which it did in 1925. The town of Oakley, Idaho, which suffered similar problems, also agreed to change its water supply in 1925, inviting McKay to testify as an expert witness. He personally examined all the town's school children and found that 100% suffered from some degree of brown stain. Several years later he returned to Oakley and reported that among children raised on the new water supply, brown stain was virtually nonexistent.[18]

A big step toward solving the mystery of brown stain occurred in 1931, when nervous chemists at the Aluminum Company of America (ALCOA) began to examine the water in Bauxite, Arkansas, an ALCOA company town established to house bauxite miners and their families. The principle ore of aluminum, bauxite was vital to ALCOA's production process. In 1909, the town's growing population necessitated a new water supply, and ALCOA dug three deep wells to access the ample groundwater. In a few years, children in Bauxite began to be afflicted with brown stain. Initially, this was of no great concern to ALCOA. By the late 1920s, however, the company was fending off charges that its aluminum cookware was slowly poisoning the population. ALCOA's chief chemist, H. V. Churchill, was concerned that any link between aluminum and brown stain would be a public relations disaster, so in 1930 he tested Bauxite's water supply using the most advanced spectrographic equipment available at the time. The tests showed that the groundwater had unusually high levels of fluorine—fifteen parts per million (ppm)—a result, he wrote McKay, "so unexpected in water that a new sample was taken with extreme precautions," but showed the same outcome. "There are many ways in which this fluoride content of water might function and it is conceivable that it might play an important part" in mottled enamel, Churchill reported. He asked McKay, who had visited

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Box 1, Donald R. McNeil Papers, State Historical Society of Wisconsin Archives. Another triumphalist account written by a participant in early fluoridation work is Frank J. McClure, *Water Fluoridation: The Search and the Victory* (Bethesda, MD: U.S. Department of Health, Education, and Welfare, 1970).

17. McKay to Grover A. Kampf, March 29, 1927, file 27, box 2, H. Trendley Dean Papers, National Library of Medicine, Bethesda, Maryland.
18. F. S. McKay, "Mottled Enamel: A Fundamental Problem in Dentistry," *Dental Cosmos* 67 (1925): 847–60; F. S. McKay, "Mottled Enamel: The Prevention of its Further Production through a Change of Water Supply at Oakley, Idaho," *Journal of the American Dental Association* 20 (1933): 1137–49; McNeil, *Fight for Fluoridation*, pp.21–2 (note 16).

Bauxite several years before as part of his tour of brown stain regions, to send "with minimum publicity" water samples from other endemic areas. All had unusually high levels of fluorine, an element that was not tested for in standard water analyses of the day. Soon thereafter, animal experimentation by scientists at the University of Arizona firmly established a causal relationship between fluorine consumption and stained teeth. McKay was thrilled to finally learn the identity of the mysterious element, while Churchill was no doubt relieved that it was fluorine, rather than aluminum, which appeared to cause the staining.[19]

Fluoride compounds, Churchill pointed out, occur naturally in soil and water, particularly "in the vicinity of volcanic activity and in those localities where hot or warm springs are encountered."[20] But nature doesn't always have the best interests of humans in mind. In that sense, fluoride was "natural" in the same way as arsenic, mosquitos, and cholera. While McKay and Churchill were busy revealing fluoride's undesirable effect on teeth, a young Danish scientist, Kaj Roholm, was investigating the impact of industrial fluoride on overall human health. In 1930, a dense layer of polluted fog settled over the Meuse Valley, a heavily industrial area in eastern Belgium, killing sixty people and sickening thousands. After lengthy and careful investigation, Roholm determined that gaseous fluoride compounds were responsible. Roholm also investigated fluoride intoxication among cryolite workers in Copenhagen, as well as the impact of fluoride pollution on animals living downwind of factories, particularly aluminum smelters, which Roholm identified as emitters of large quantities of fluoride gases.[21] In the mid 1930s, whether natural or anthropogenic, fluoride compounds were nothing but bad news for human and environmental health.

Just as fluoride's negative image was beginning to crystalize in the minds of scientists and public health officials, however, a countervailing discourse was simultaneously forming. Ironically, it also stemmed from the work of Frederick McKay. Brown stain's dental disfigurement was unsightly and undoubtedly caused significant psychological problems for many who suffered from it. Oddly enough, however, as far as McKay could tell, it did not actually compromise the strength or physical health of teeth. On the contrary, people living in endemic brown stain regions seemed to suffer less from dental caries—cavities that require either filling or removing teeth—than the general population. In 1928, McKay informally collaborated with a group of investigators from

19. Churchill to McKay, January 20, 1931. Box 1, Aluminum Company of America Correspondence (discovery of fluoride, 1927–47), State Historical Society of Wisconsin Archives; McNeil, *Fight for Fluoridation*, pp.26–8 (note 16).
20. Churchill to McKay. In its pure form, fluorine is one of the least stable elements on the periodic table. Fortunately, nature has kept fluorine in check by binding it with other elements, forming various salts known as fluorides. It is these fluoride compounds, such as sodium fluoride and FSA, that are used in water fluoridation.
21. Kaj Roholm, *Fluorine Intoxication. A Clinical Hygienic Study with a Review of the Literature and some Experimental Investigations* (London: H. K. Lewis & Co., 1937). Roholm has the unique distinction of being revered by both fluoridation proponents and skeptics. Proponents argue that his careful studies helped them determine a safe level of fluoride consumption, while opponents claim he was the first toxicologist to alert the world to the true dangers posed by fluoride compounds.

the University of Michigan dental school who were surveying a small town in Illinois where children were known to have high rates of mottling. The survey indicated that dental caries rates were surprisingly low, a fact that took on a new significance once the causal relationship between fluoride compounds and brown stain had been established.[22]

The man who played the most important role in transforming fluoride's medical image from tooth disfigurer to a potential prophylactic against dental caries was H. Trendley Dean. A St. Louis dentist who had joined the Army Dental Corps in World War I, Dean went on to become a key figure in public health dentistry. In 1930, he was appointed chief scientist of the newly established Dental Research Section of the National Institutes of Health, and then in 1948 became the first director of the National Institute of Dental Research. Dean was quick to realize that solving the mystery of mottled enamel, though useful, was of secondary importance compared to the broader public health implications of dental caries. In a letter to the U.S. Surgeon General in 1932, Dean repeated McKay's earlier observation that "individuals in an endemic [brown stain] area show a lesser incidence of caries than individuals in some nearby non-endemic areas. Consequently, the study of mottled enamel may disclose some lead applicable to the vastly more important problem, dental caries."[23] Once it became clear that fluoride was the cause of brown stain—which Dean would soon label dental fluorosis—Dean shifted the focus of his research, and that of the government's health bureaucracy, from eliminating fluorosis to combating caries.

Dental caries was perceived as one of America's most widespread health problems in the early twentieth century. Since dentists were comparatively few and dental surveys virtually nonexistent, it is difficult to know just how pervasive the condition was and to what extent, if at all, it had gotten worse over time. Nonetheless, dentists themselves were convinced that it had reached epidemic proportions, a perception that appears to have been borne out by military fitness records. These show that in 1916, for example, one third of potential recruits failed their health exam due to caries-related problems.[24] Few things motivate a government's concern about the welfare of its citizens more than problems with military recruitment. Not surprisingly, therefore, funds began to flow toward dental research, both from government sources and from corporate foundations. Many dentists and medical scientists were convinced that Americans' diets, particularly their fondness for refined flour and sugar, were largely to blame. But changing people's dietary habits, which involved taking on deeply entrenched and politically powerful agricultural and industrial interests, as well as attempting to modify people's taste preferences, seemed to be an insurmountable obstacle. No wonder, then, that Dean and others were excited by the discovery of fluoride's impact on teeth.

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22. R. W. Bunting, Mary Crowley, Dorothy G. Hard, and Margaret Keller, "Further Studies of the Relation of B. Acidophilus to Dental Caries," *Dental Cosmos* 70 (1928): 1002.
23. Dean to U.S. Surgeon General, February 6, 1932, box 2 (35), Dean Papers. More detailed biographical information about Dean can be found in Box 1 of the same collection.
24. Alyssa Picard, *Making the American Mouth: Dentists and Public Health in the Twentieth Century* (New Brunswick, NJ: Rutgers University Press, 2009), p.2.

During the 1930s, Dean, McKay, and colleagues from the Public Health Service and various university dental schools set about trying to demonstrate fluoride's connection to both dental fluorosis and reduced rates of caries. Embarking on a succession of epidemiological studies in towns which had fluoride-rich water supplies, Dean was able to gradually zero in on a ratio that appeared to offer considerable protection against caries while causing limited and barely discernable fluorosis. The magic number, he determined, was one part per million (1ppm). As the studies continued, Dean and his colleagues published a series of articles that would become the scientific bedrock of fluoridation.[25] Thus, although water containing precisely 1ppm fluoride existed almost nowhere, it nonetheless came to be seen—and, for many, remains to this day—the optimal level of fluoride in drinking water. Drinking water containing less than this amount was increasingly deemed "fluoride deficient."[26]

Dean's studies revealed that throughout most of the United States, particularly in the heavily populated eastern states, natural fluoride levels were far lower than 1ppm. Thus, the majority of the nation's population exhibited little mottling, but had high rates of caries. Nevertheless, Dean himself did not advocate artificially augmenting the level of fluoride in drinking water, at least not during the 1930s. A cautious and methodical researcher, he felt that many years of further investigation would be required before such a prospect could be contemplated. Even the American Dental Association, subsequently CWF's most steadfast advocate, was reluctant to endorse the idea. However, some dental researchers were less circumspect. Although others must surely have discussed the possibility, Gerald J. Cox, a biochemist who worked at both the dental school and the Mellon Institute for Industrial Research at the University of Pittsburgh, appears to have been the first person to specifically recommend artificial water fluoridation in the pages of a scientific journal.[27]

Despite being far more cautious about fluoride than some of his colleagues, Dean nonetheless began to explore the possibility of testing artificial fluoridation in a handful of carefully chosen communities. In early 1943, he appeared on the popular radio program *Adventures in Science*. While it was too early to make a definitive judgment, he

25. Some of the most influential articles include: H. Trendley Dean and Elias Elvove, "Some Epidemiological Aspects of Chronic Endemic Dental Fluorosis," *American Journal of Public Health* 26 (1936): 567–75; H. Trendley Dean, "Chronic Endemic Dental Fluorosis," *Journal of the American Medical Association* 107 (1936): 1269–72; Dean and McKay, "Production of Mottled Enamel Halted by a Change in the Common Water Supply," *American Journal of Public Health* 29 (1939): 590–96.
26. For useful narrative accounts of Dean's so-called "shoe leather surveys," see McNeil, *Fight for Fluoridation*, chapter 2 (note 16) and R. Allan Freeze and Jay H. Lehr, *The Fluoride Wars: How a Modest Public Health Measure Became America's Longest-Running Political Melodrama* (Hoboken, NJ: John Wiley & Sons, 2009), pp. 98–102. High levels of naturally occurring fluoride are responsible for endemic skeletal fluorosis in certain parts of the world, particularly in India and China. This debilitating disease, which manifests with similar symptoms to advanced arthritis, has a devastating effect on those afflicted with it. See Sellers, "Artificial Nature" (note 15).
27. Gerald J. Cox, "New Knowledge of Fluorine in Relation to Dental Caries," *Journal of the American Water Works Association* 31 (1939): 1926–30.

warned, it was nonetheless clear that fluoride had tremendous potential as a caries prophylactic. In addition to vast improvements in dental health, fluoridation would have a profound effect on dentistry as a whole. "If it should be found possible to more than halve the dental decay in a community by a simple adjustment of the chemical composition of the public water supply," he told host Watson Davis, "then there would need to be a reorientation of the problem of dental needs, the future distribution of dental practitioners, the type of dentistry they will be called upon to practice and other as yet unforeseen developments."[28] While at first glance it would seem that fluoridation—if it indeed lived up to its promise—might drastically reduce the need for dentists, Dean and others believed that it would actually benefit the profession in two key ways. First, it would boost the prestige of dentistry, thus bolstering a profession that had always suffered status anxiety due to a perception that it was not quite as serious or important as medicine. Second, it would free dentists to move beyond their primary function as fillers of teeth, allowing them to instead concentrate on more technically challenging and lucrative forms of dental work, such as orthodontics, which better suited the entrepreneurial, individualist, fee-for-service culture of American dentistry.[29]

After consulting with colleagues at the University of Michigan, Dean selected the towns of Grand Rapids and Muskegon to participate in a fifteen-year fluoridation trial. Both cities drew their water, which had virtually no natural fluoride, from Lake Michigan. In January 1945, with the enthusiastic cooperation of city officials, Grand Rapids began adding sodium fluoride to its water supply while Muskegon remained fluoride free. But not everyone was prepared to wait fifteen years. In the mid 1940s, a small group of activist dentists, mostly in Wisconsin, began agitating for immediate CWF. Chief among them was John Frisch, a Madison dentist and prominent member of the Wisconsin State Dental Society. Frisch had been following McKay and Dean's work closely throughout the 1930s. In his mind, Dean's publications had firmly established that water containing around 1ppm fluoride was both efficacious and completely safe in the fight against dental caries. Artificial fluoride, he was convinced, was no different from natural fluoride, and endless trials and experiments would merely condemn another generation of children to the pain and misery of caries. So certain was Frisch of fluoride's safety and efficacy, that he began to add it to his home water supply so that he could monitor any changes in his children's dental health.[30]

While the Grand Rapids trial was in its infancy, Frisch and his colleagues began to promote fluoridation throughout Wisconsin. In 1947, after two years of fierce campaigning

28. Transcript from Dean's appearance on *Adventures in Science*, January 16, 1943, in box 3 (24), Dean Papers.
29. Picard, *American Mouth*, pp.140, 159 (note 24). Many have pointed out the tension between the ADA's tireless and vociferous support of fluoridation and its longstanding opposition—just as tireless and vociferous—to any government efforts to institute universal dental or health care. Picard's formulation is particularly pithy: "The ADA claimed that government could not be trusted to provide health insurance no matter how badly the public wanted it, but should be trusted to fluoridate the water no matter how vigorously the public opposed it" (Picard, *American Mouth*, p.139 (note 24)).
30. McNeil, *Fight for Fluoridation*, pp.52–3 (note 16).

and politicking, they finally convinced officials in Madison, the state capital and home of its flagship university, to fluoridate the town's water supply. To allay skeptical members of the public, for whom fluoride was primarily an ingredient in rat poison, Frisch began to increasingly invoke fluoride's "naturalness." "The dental profession," he declared in 1946, "is imitating nature as closely as it can." One only had to look to Green Bay, "where people have been drinking fluorine water with sodium fluoride supplied to it by nature for over one hundred years, and no deleterious effect of any nature has occurred in that locality."[31] Frisch, who had been corresponding with Frederick McKay for several years, traveled to Colorado to help McKay with a dental survey in the town of Salida, whose water supply was naturally fluoridated at 1.3 ppm. Salida, they wrote, "is a very fortunate community in that nature has provided the city with water containing an ideal amount of fluorine."[32] It was therefore, they repeated for emphasis, among those lucky cities that "nature has endowed … with a water supply that … contain(s) an ideal amount of fluorine."[33]

Frisch and his fellow Wisconsin fluoridation advocates saw themselves as descendants of early twentieth-century Wisconsin progressivism, a political movement that promoted an interventionist government guided by well qualified experts.[34] While the Michigan trials continued, with dozens of dental researchers descending on the state to prod and probe children's teeth for signs of caries, Frisch and his acolytes barnstormed Wisconsin, convincing community after community to add fluoride to its water supply. Their goal was to have fifty communities fluoridated by 1950, a target they duly reached. The result was that by mid-century, Wisconsin had more than triple the number of fluoridated towns than the rest of the United States combined.[35] While these numbers were quite remarkable given the rising grassroots opposition to fluoridation, Frisch would not be satisfied until every citizen in America, or for that matter the world, could enjoy the benefits of fluoride compounds in their drinking water. Thus, he grew alarmed when technical problems with the fluoride injection equipment, along with concerns about adequate fluoride supplies, threatened to slow the pace of adoption. This prompted him to write to ALCOA, which produced large quantities of highly toxic sodium fluoride waste as part of its production process. "The demand for this material," he informed them, "will soon reach astronomical proportions."[36] If Frisch had any qualms about the "naturalness" of ALCOA's sodium fluoride, he managed to suppress them. But it seems

31. "Present Status of Fluorine as a Prevention to Decay of the Teeth in the State of Wisconsin." Statement by the Fluorine Committee of the Wisconsin State Dental Society, October 31, 1946, Box 1, John G. Frisch Correspondence, 1931–47, State Historical Society of Wisconsin.
32. Frisch and McKay, "Report of the Recent Dental Survey of the Salida School Students," 1947 (no exact date), Correspondence 1947, July–December, Box 1, Frisch Correspondence.
33. Frisch press statement from the State Dental Hygienist Convention, October 1948. Correspondence, 1948, October–December, Box 1, Frisch Correspondence.
34. For more on Wisconsin progressivism, see Nancy C. Unger, *Fighting Bob Lafollette: The Righteous Reformer* (Chapel Hill, NC: University of North Carolina Press, 2000). For progressivism more broadly, see Michael McGerr, *A Fierce Discontent: The Rise and Fall of the Progressive Movement in America, 1870-1920* (New York: Free Press, 2003).
35. McNeil, *Fight for Fluoridation*, p.63 (note 16).
36. Wisconsin State Dental Society to Aluminum Company of America, June 27, 1949, Correspondence, 1949, May–August, Box 3, Frisch Correspondence.

unlikely that he did. The fact that he mocked a skeptical dentist in Massachusetts for having "peculiar ideas about tetra-ethyl lead being taken out of the gasoline because 'the vapor poisons the atmosphere'"[37] suggests that Frisch's scientific views were in tune with mid twentieth-century views encapsulated by the popular slogan "better living through chemistry," a phrase that reflected the incautious scientific optimism of the era.[38]

The Wisconsin fluoridationists' most important victory, however, occurred at the federal level. By 1950, the trial in Grand Rapids was yielding very positive results. In fact, officials in Muskegon grew increasingly agitated. From their perspective, the town's ongoing status as the control city meant their citizens' dental health was being sacrificed on the altar of Dean's scientific cautiousness. They would indeed begin fluoridation in 1951, thus severely compromising Dean's fifteen-year study in the eyes of fluoridation skeptics. Meanwhile, Frisch and his colleague, Frank Bull, the State Dental Director of Wisconsin, began to lobby the United States Public Health Service to endorse CWF. With anti-fluoridationist influence growing—they had already defeated several CWF drives in Wisconsin—Frisch and Bull were concerned that by the time Dean's Grand Rapids trial was completed, fluoridation might be politically dead. Dean stuck to his guns, but cracks soon began to appear at the PHS. CWF advocates argued that the Grand Rapids data would merely verify what Dean's 1930s studies had already proved: that water containing 1ppm fluoride was safe and effective. By failing to endorse the practice immediately, the PHS was ensuring that another generation of Americans would suffer from dental ill health, as well as giving anti-fluoridationists time to defeat one of the nation's most promising public health practices while it was still in its infancy. The PHS caved in to the pressure remarkably quickly, endorsing fluoridation in June 1950 and strongly supporting the practice thereafter. The move had a cascading effect: within months, the American Dental Association, the American Water Works Association, the American Medical Association, and a host of other high-profile government bureaus and professional bodies all gave fluoridation their stamp of approval.[39]

For Frisch, the PHS endorsement represented a monumental victory for dental public health. For others, it also represented new economic opportunities. In 1951, for example, the trade journal *Chemical Week* enthusiastically proclaimed the coming "Water Boom for Fluorides." "The market potential," the author gushed, "has fluoride chemical makers goggle-eyed." Furthermore, there was no reason to be concerned that antifluoridationists would be able to suppress demand: "Any apathy or opposition on the part of the public is made up for by the USPHS's zeal in drumming up the program." In sum, "it all adds

37. Frisch to E. E. Edwards, August 6, 1951, Correspondence, 1951, July–September, Box 4, Frisch Correspondence.
38. Lawrence C. Rubin, "Merchandising Madness: Pills, Promises, and Better Living through Chemistry," *The Journal of Popular Culture* 38:2 (2004): 369–83; Michelle Mart, *Pesticides, a Love Story: America's Enduring Embrace of Dangerous Chemicals* (Lawrence, Kansas: University Press of Kansas, 2015); David Kinkela, *DDT and the American Century: Global Health, Environmental Politics, and the Pesticide that Changed the World* (Chapel Hill: University of North Carolina Press, 2011).
39. Freeze and Lehr, *Fluoride Wars*, pp.112–15 (note 26); McNeil, *Fight for Fluoridation*, chapter 4 (note 16).

up to a nice piece of business on all sides, and many firms are cheering the USPHS and similar groups on as they plump for the increasing adoption of fluoridation."[40] As one might expect, such articles were seized upon by fluoridation skeptics as evidence that the motives of CWF advocates were far from pure. ALCOA's involvement in discovering fluoride in water only deepened their skepticism. Frederick Exner, a Seattle radiologist and prominent antifluoridationist, summarized the putative economic motivations behind fluoridation, weaving together a convoluted narrative involving collusion between government, fluoride emitting industries such as ALCOA, the renowned Kettering Lab in Cincinnati, and numerous other entities that could plausibly, if somewhat tenuously, be connected with fluoridation.[41]

The whole fluoridation story, in fact, leant itself remarkably well to conspiracy theorizing: Andrew W. Mellon, a founder of ALCOA and one of its major stockholders, was the U.S. Treasury Secretary from 1921–32, when the PHS was still a division of the Treasury Department. Gerald Cox worked at the Mellon Institute, of which Andrew Mellon was the founder. Trendley Dean, critics charged, was "ordered" to study fluoride in the hope that dental mottling could be linked to naturally occurring fluoride far from industry, thereby deflecting attention from the health effects of industrial fluoride pollution. Oscar Ewing, who oversaw the USPHS when it endorsed fluoridation, was a former high-ranking lawyer at ALCOA who had been sent to Washington DC to help ward off law suits against industrial fluoride pollution. ALCOA was also a major supplier of sodium fluoride, the most commonly used compound in the early years of fluoridation. CWF conveniently converted a difficult to dispose of waste product into a profitable commodity. As the company noted in its advertisements, "ALCOA sodium fluoride is particularly suitable for the fluoridation of water supplies. … If your community is fluoridating its water supply—or is considering doing so—let us show you how ALCOA sodium fluoride can do the job for you."[42] Fluoride's transmogrification from toxic waste to public health miracle, skeptics argued, suited American industry all too well.[43]

While the PHS endorsement was certainly a major public relations victory for fluoridationists, it by no means guaranteed the spread of CWF. Neither the PHS nor any other

40. "Water Boom for Fluorides," *Chemical Week*, July 7, 1951, p.14.
41. Frederick Exner, "Fluoridation, Part III," *Northwest Medicine* 54 (1955): 1255–6. The critique was further elaborated in one of the early bibles of antifluoridationism: Frederick Exner, George Waldbott, and James Rorty, *The American Fluoridation Experiment* (New York: Devin-Adair, 1955), chapter 4.
42. Advertisement in the *Journal of the American Water Works Association*, 43 (1950): 6.
43. Bryson, *Fluoride Deception*, pp.43–4, 126–7 (note 2). Bryson argues that the need to create a clean image for fluoride was a vital part of the fluoridation story, particularly once the atomic weapons industry started emitting large quantities of fluoride pollution. Freeze and Lehr, on the other hand, dismiss this as largely coincidental. See *Fluoride Wars*, chapter 6 (note 26). If there was any conspiracy in the fluoridation story, it is more likely to involve the subtler form that environmental historian Paul Hirt calls "a conspiracy of optimism," a "general cultural tendency … to assume the optimistic regarding our ability to control nature and resolve social problems with environmental engineering." See Paul Hirt, *A Conspiracy of Optimism: Management of the National Forests since World War II* (Lincoln: University of Nebraska Press, 1994), p.xlviii.

federal or state body had the power to mandate nationwide CWF. Instead, the decision was left up to cities and towns throughout the nation. It was a situation that played into the hands of fluoridation skeptics, who had more influence over local referenda than over federal or state government agencies. Scientists and dental researchers like Trendley Dean were flabbergasted and appalled by the array of charges hurled at them from an assortment of activists that spanned the gamut from skeptical doctors and dentists to unhinged anti-communist zealots. Citizens throughout the nation, these objectors charged, would soon be forced to drink water containing rat poison or industrial pollution. What could be more unnatural?[44]

Dean was unhappy that the PHS had caved in so quickly to Frisch and the other CWF crusaders, thereby undermining his carefully planned fifteen-year trial. Nonetheless, once he realized that a growing antifluoridation movement might jeopardize the future of a very promising public health policy, he quickly dropped his misgivings and joined the battle. In 1952, after fierce lobbying from skeptics, the U.S. House Select Committee to Investigate the Use of Chemicals in Food and Cosmetics decided to hold hearings on fluoridation. Dean and others felt confident that the committee would demolish the antifluoridationist claims. They were therefore surprised and disappointed by its final report, which acknowledged that fluoride was effective against dental caries but nonetheless urged communities to "err on the side of caution" when considering fluoridation.[45] Continued antifluoridationist lobbying culminated in 1954 with the introduction of a bill that threatened to outlaw CWF altogether. Submitted by Roy Wier, a Democrat from Minnesota, H.R. 2341 was designed "to protect the public health from the dangers of fluorination of water." The stakes could not have been higher: had the bill passed, it would have made it illegal for any government agency at any level to introduce fluoride into its water supply.[46]

By 1954, Trendley Dean had retired from his position as director of the National Institute of Dental Research and was working as the Secretary of the Council on Dental

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44. This is not the place to discuss the anti-fluoridationist movement in any depth, a digression which would require another article altogether. For those interested in the topic, a huge collection of documents and paraphernalia, from considered critiques of the Grand Rapids trials to bizarre claims about government mind control, can be found in numerous archives throughout the nation. The richest and most complete collection is at the University of Massachusetts Archive in Amherst. Michael Dolan, a biologist and antifluoridationist, has convinced many of the most high-profile antifluoridationists of the past half century to donate their papers to the collection, which comprises dozens of boxes of material. For a useful, albeit rather condescending, summary of the movement, see Freeze and Lehr, *Fluoride Wars* (note 26). For a more sympathetic overview, see Brian Drake, *Loving Nature, Fearing the State: Environmentalism and Antigovernment Politics before Reagan* (Seattle: University of Washington Press, 2013), chapter 2, and Catherine Carstairs, "Debating Water Fluoridation Before Dr. Strangelove," *American Journal of Public Health* 105:8 (2015): 1559–69.
45. For an overview of the report from a pro-fluoridation perspective, see J. Roy Doty and W. Philip Fair, "An Analysis of the Delaney Committee Report on the Fluoridation of Drinking Water," *Journal of the American Dental Association* 45:3 (1952): 351–6.
46. Fluoridation of water. Hearings before the Committee on Interstate and Foreign Commerce, House of Representatives, Eighty-Third Congress, second session, on H.R. 2341. A bill to protect the public health from the dangers of fluorination of water. May 25, 26, 27, 1954.

Research of the American Dental Association. With over two decades of crucial involvement in fluoride and dental health issues and a list of forty-six scientific papers on the subject, Dean was fluoridation's star witness at the H.R. 2341 hearings. He began his testimony by offering the committee members a potted history of the fluorine–dental caries relationship and the extensive epidemiological studies that proved that at 1ppm, fluoride offered significant protection against caries while causing very little dental fluorosis. "Obviously," he continued, "the next step would be an attempt to duplicate this purely natural phenomenon by adjusting the chemical composition (fluoride) of a public water supply to conform to that where Nature itself has provided such outstanding evidence of protection against the attacks of dental caries." Allaying fears that fluoridation constituted mass medication without the consent of the targeted population, Dean insisted that fluoridation was neither a treatment nor a cure for caries. Rather, "Fluorine simply prevents the decay from developing." "In short," he declared in a final appeal to the moral authority of nature, "fluoridation of public water supplies simulates a purely natural phenomenon—a prophylaxis which Nature has clearly outlined in those communities that are fortunate enough to have about one part per million of fluoride naturally present in the public water supply."[47]

Wier's bill languished with the adjournment of the 83rd Congress, as did antifluoridationists' best chance of ending the practice. Subsequently, Dean's naturalization of water fluoridation became the standard language of government agencies, the American Dental Association, and countless water authorities throughout the United States and other nations that adopted CWF. Far from constituting a form of alchemical sleight of hand by which industrial pollution was converted into mass medication, adding sodium fluoride—and subsequently fluorosilicic acid—to drinking water was merely a case of optimizing nature: a slight tweak to adjust a chemical benefit that "Nature has clearly outlined."

Naturalizing fluoride clearly brought peace of mind to those who might otherwise have been skeptical of water fluoridation. Dr. Benjamin Spock, the celebrity pediatrician who authored the bestseller *The Commonsense Book of Baby and Child Care* and who became a prominent spokesman for fluoridation, is a good example. Spock conceded that this support ran counter to his general suspicion of chemical additives: "I've always been against the pollution of the diet by the addition of salt and sugar, additives and preservatives to foods consumed by adults as well as children … And I've always been against the imposition of regulations on people in an arbitrary, undemocratic manner." Spock also admitted that he was a fluoridation skeptic in the 1940s, but by the late 1950s he had become chairman of a national committee to educate the public and public officials about the value and safety of fluoridation. "What particularly allayed my early doubts about adding a chemical to the public water supplies," he later told readers, "was learning that fluoride has always occurred naturally in water supplies, in various concentrations ranging from seven parts per million in some regions of the Southwest to a mere twentieth of a part per million in some regions of the Northeast. It is a natural, though varying, ingredient in water."[48]

47. Testimony of Dr. H. Trendley Dean before the House Committee of Interstate and Foreign Commerce with Respect to H.R. 2341, May 27, 1954. Underlining in original.
48. Benjamin Spock, "The Truth About Fluoridation," *Redbook Magazine*, September 1980, p.51.

Like much of modern science-driven health policy, fluoridation is the product of scientific reductionism, a mode of thought that increasingly replaced older, holistic ways of understanding nature. Throughout the nineteenth century, technological breakthroughs allowed scientists to focus on and manipulate organisms at the cellular level. The reductionist science of the laboratory identified diseases and promised cures; it split apart and recombined molecules into useful new materials and products. Given their efficaciousness, it is not surprising that reductionist values and assumptions became increasingly pervasive to the point of seeming self-evident. In a time of rapid industrial expansion and growing consumerism, they offered a form of science that was on the one hand practical and result-oriented, but which also promised insight into the most fundamental levels of life and matter.[49] The rise of the germ theory of disease, for example, emphasized experimental medicine and detailed scientific research over more amorphous explanations of disease. As a result, Stephen Kunitz notes, "Disease specificity became increasingly possible, and with it the possibility of disease-specific interventions that would be applicable in all places among all people, regardless of topography, climate or culture."[50]

From the perspective of CWF, a pertinent example of reductive thinking is what the Australian historian of science Gyorgi Scrinis calls "nutritionism." As scientists began to isolate various nutrients in the late nineteenth and early twentieth centuries, they systematically decontextualized them from the broader dietary patterns and social relations in which they are embedded. "This single-nutrient reductionism," Scrinis argues, "often ignores or simplifies the interactions among nutrients within foods and within the body," a practice that frequently involves "the premature translation of a statistical association between single nutrients and diseases into a deterministic or causal relationship according to which single nutrients are claimed to cause, or at least increase the risk of, particular diseases."[51] While fluoride is not technically a nutrient, it is clear that fluoridation scientists nonetheless operated within the nutritionally reductive paradigm that Scrinis describes, isolating a particular compound and insisting that it would largely solve a problem—dental caries—that was the product of myriad dietary and social forces. Although their language was slightly different, perceptive analysts of fluoridation politics during the 1950s understood this dynamic, even if they generally sided with the reductionists. Charles Metzner, a public health economist at the University of Michigan, for example, explained that the opposition of some dentists to fluoridation was due to the fact that they "defensively accept 'naturalistic' as opposed to medical views on food and drugs."[52]

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49. Charles Rosenberg, "Holism in Twentieth Century Medicine," in C. Lawrence and G. Weisz (eds.), *Greater than the Parts: Holism in Biomedicine, 1920–1950* (New York: Oxford University Press, 1998), pp.335–55, 336.
50. Stephen Kunitz, *The Health of Populations: General Theories and Particular Realities* (New York: Oxford University Press, 2007), p.11.
51. Gyorgi Scrinis, *Nutritionism: The Science and Politics of Dietary Advice* (New York: Columbia University Press, 2013), p.6. Not surprisingly, fluoridation also has much in common with the history of food fortification, a practice far more widespread in the United States than elsewhere. See Mark Lawrence, *Food Fortification: The Evidence, Ethics, and Politics of Adding Nutrients to Food* (Oxford: Oxford University Press, 2013).
52. Charles Metzner, "Some Possible Reasons Why Public and Professional Acceptance of Water Fluoridation Has Been Slow." Address delivered at the World Health Organization in Geneva, July 3, 1957. Copy found in the Trendley Dean Papers, Box 5:18.

Scientific reductionism, however, never obliterated older worldviews. Holistic thinking persisted into the twentieth century, taking on a variety of forms depending on the academic discipline or social milieu that embraced it: it was sometimes metaphysical, tending toward spiritualism or vitalism, while at other times it was resolutely materialist and Darwinian. At the most general level, holism is both a worldview and a sensibility. It insists that everything in the universe is interconnected and interdependent and that the world can be properly understood only by focusing on the way that its constitutive parts interact with the constituted whole. From a historian's perspective, as Christopher Lawrence and George Weisz usefully point out, "Holism is essentially relational; it constitutes a rhetorical claim made in opposition to other approaches that are characterized as excessively narrow or reductionist in focus."[53]

Among the most steadfast opponents of CWF were practitioners of alternative medicine—particularly chiropractors—and natural food advocates (or "food faddists," as fluoridationists dismissively called them).[54] In the 1950s, these groups held what might be called a proto-environmental worldview: they embraced a holistic sensibility that was critical of scientific reductionism, but was not yet informed by the ecological concepts that would characterize environmentalism.[55] As Christopher Sellers notes in his study of antifluoridationism on Long Island, New York, in the 1950s, "it is striking how, without any Carsonian appeal to ecology, Manhasset's antifluoridationists worried about environmental ramifications of fluoridation that ranged beyond the faucets on which its advocates fixated."[56] By the time environmentalism started to gain political traction in the 1960s and 1970s, however, fluoridation enjoyed enormous support among the scientific and policy elite in the Anglo-American world. Nonetheless, there were a few critics

53. C. Lawrence and G. Weisz, "Medical Holism: The Context," in *Greater than the Parts*, p.1–22, 2 (note 50). Other useful sources on twentieth century scientific holism include Mitchel Ash, *Gestalt Psychology in German Culture, 1890–1967: Holism and the Quest for Objectivity* (Cambridge: Cambridge University Press, 1995); Harrington, *Re-enchanted Science* (note 8); Kristine Alster, *The Holistic Health Movement* (Tuscaloosa: University of Alabama Press, 1989); Frank Golley, *A History of the Ecosystem Concept in Ecology: More than the Sum of the Parts* (New Haven, CT: Yale University Press, 1993); Betty Jean Craige, *Laying Down the Ladder: The Emergence of Cultural Holism* (Amherst: University of Massachusetts Press, 1992).
54. For a useful history of chiropractic and its commitment to holism, see Holly Folk, *The Religion of Chiropractic: Populist Healing from the American Heartland* (Chapel Hill: University of North Carolina Press, 2017). For health food and organic farming, see Warren J. Belasco, *Appetite for Change: How the Counterculture took on the Food Industry* (New York: Pantheon, 1989). For health food advocates' opposition to fluoridation, see Drake, *Loving Nature*, chapter 2 (note 45).
55. For more on the history of holistic thought prior to modern environmentalism, see Frank Zelko, "'A Flower is your Brother!': Holism, Nature, and the (non-ironic) Enchantment of Modernity," *Intellectual History Review* 23:4 (2013): 517–36. For a broader history of holistic thought in the United States, see Linda Sargent Wood, *A More Perfect Union: Holistic Worldviews and the Transformation of American Culture after World War II* (New York: Oxford University Press, 2010).
56. Sellers, "Artificial Nature," p.197 (note 15).

who employed a holistic ecological discourse to challenge the practice. Geoffrey Dobbs, a forest botanist at the University College of North Wales, for example, criticized public health officials for their reductionist worldview:

> But of course, the public health officials who promote and defend fluoridation so passionately do not view the matter in … broad terms. Usually they are neither statisticians nor ecologists, but are entirely concerned with the extremely narrow and specialized purpose to which pollution of the entire water supply is merely incidental. They are unduly impressed by percentage figures for caries reduction, and unimpressed by the inconclusive evidence of injury among the population at large, without realizing the impossibly massive investigations which would be necessary to produce conclusive proofs. They therefore feel justified in defending the public health against an increase in environmental pollution which is being promoted by the Health Department—a shocking reversal of roles … And so we see the unhappy spectacle of public health official and industrialists standing shoulder to shoulder in defense of environmental pollution, against those who take a wider ecological view of it.[57]

In the wake of *Silent Spring*, a number of fluoridation skeptics wrote to Rachel Carson in the hope of enlisting her support. But although she was sympathetic, Carson had enough on her plate with DDT, and illness left her with little time or energy for a new cause.[58] Paul Ehrlich also exhibited cautious skepticism: "The scientific evidence supporting the efficacy and safety of mass fluoridation at the generally recommended level … is not as good as it ought to be," he wrote in 1977. "Fluorides have been shown to concentrate in food chains, and evidence suggesting a potential for significant ecological effects is accumulating." Ehrlich's main source was the doctoral dissertation of one of his students, Edward Groth, who criticized the lack of research on fluoride pollution and the impact of fluoridation on waterways and freshwater food chains.[59] Ralph Nader was also cautiously skeptical:

> [T]here are better ways – more comprehensive ways – to cut down the dental caries in the subject population of attention without exposing 80 or so percent of the population to it. One of

57. Geoffrey Dobbs, "Concerning the Control, and the Defense, of Environmental Pollution." The article was originally published in the *Journal of the Soil Association* (1969) and reprinted in the *National Fluoridation News* (1970), p.2, a defunct antifluoridation newsletter published by Ethel Fabian in Hempstead, New York. My copy is from the Public Records Office of Victoria (Australia), Fluoridation of Water Supply: 45/020/00066, City of Caulfield File.
58. Drake, *Loving Nature*, p.53 (note 45). For the connection between antifluoridationism and environmentalism in Canada, see Catherine Carstairs and Rachel Elder, "Expertise, Health, and Popular Opinion: Debating Water Fluoridation, 1945-1980," *Canadian Historical Review* 89:3 (2008): 345–71, and Carstairs, "The Environmental Critique of Water Fluoridation," *Scientia Canadensis*, 38:1 (2015): 1–21.
59. Paul R. Ehrlich, Anne H. Ehrlich, and John P. Holdren, *Ecoscience: Population, Resources, Environment* (San Francisco: W. H. Freeman, 1977), p.575. Edward Groth III, "Two Issues of Science and Public Policy: Air Pollution Control in the San Francisco Bay Area and Fluoridation of Community Water Supplies," (PhD Dissertation, Stanford University, 1973).

> the principles of ecology is you do not intrude new elements into an ecological pattern unless you have an awfully good reason to and unless the benefits far outweigh the costs.[60]

But for the most part, the criticism from environmentalists was hesitant and carefully worded, and no major environmental organization made fluoridation a primary target.[61]

The fact that CWF is practiced in only a small number of countries strongly indicates that its adoption is only partly dependent on scientific consensus. Throughout the world most scientific elites—and dentists in particular—seem to generally share the PHS and American Dental Association view of fluoridation. Despite this, few governments have seen fit to adopt it. In some cases, such as in the Netherlands and Sweden, it is clear that antifluoridationists used the same playbook as their American counterparts, but successfully.[62] In the United States, antifluoridationists came close to ending CWF in the 1950s and have persuaded hundreds of small communities to refrain from—or in some cases, end—fluoridation. The fact that approximately two-thirds of Americans nonetheless drink artificially fluoridated water owes more to politics and historical contingency than to the triumph of rational science and enlightened policy. Regardless of its scientific merit, if fluoride's dental efficacy had been discovered in the course of laboratory studies on rat poison instead of via analysis of drinking water, it undoubtedly would have faced greater resistance. Also, CWF benefited from good timing. If in 1980 scientists had proposed adding the toxic waste of the fertilizer industry to drinking water in order to slightly reduce levels of dental caries, they would have faced a unified and politically powerful environmental movement and a population inculcated with environmental values. Neither circumstance seems propitious for garnering the moral authority of nature.[63]

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60 Interview with Nader from *Let's Live Magazine*, June 1971: <www.slweb.org/nader.html> (June 9, 2017).

61 Dental researchers such as Howard Pollick, from the University of California San Francisco, insist that fluoridation not only presents no ecological hazards, but is in fact environmentally friendly: "since the chemicals used for water fluoridation are co-products of the manufacture of phosphate fertilizers, and the raw material used is a natural resource (rocks excavated for their mineral content), water fluoridation could accurately be described as environmentally friendly, as it maximizes the use made of these natural resources, and reduces waste." "Water Fluoridation and the Environment: Current Perspective in the United States," *International Journal of Occupational Environmental Health* 10:3 (2004): 343–50, 348.

62 Hans C. Moolenburgh, *Fluoride: The Freedom Fight* (Edinburgh: Mainstream Publishing Company, 1987). Moolenburgh was a Dutch physician and leader in the fight against CWF in his home country. For the Swedish case, see Jonatan Samuelsson, "Lex Norrköping: The Norrköping Water Fluoridation Trials 1952-1962 and the Passing of the 1962 Water Fluoridation Act" (Masters Thesis, Umea Universitat, 2015).

63 The countries in which the majority of people drink artificially fluoridated water are Australia (80%), Brunei (95%), Chile (70%), Guyana (62%), Hong Kong (100%), the Irish Republic (73%), Israel (70%), Malaysia (75%), New Zealand (62%), Singapore (100%), and the United States (64%). Based on figures from the British Fluoridation Society, 2012, <http://fluoridealert.org/content/bfs-2012/> (June 11, 2017). Israel briefly stopped fluoridation in 2014 due to the opposition of then Health Minister Yael German, but restarted again two years later when a new minister was appointed. *Jerusalem Post*, March 21, 2016, <www.jpost.com/Business-and-Innovation/Health-and-Science/Fluoride-to-again-be-added-to-drinking-water-448720> (June 11, 2017).

The history of CWF provides rich possibilities for environmental historians and historians of science. For the latter, the forging of a scientific consensus around CWF offers much material for detailed explorations of the sociopolitical context in which scientists practice and the worldviews and habits of mind that inform their research and results. In other words, as Steven Shapin puts it, one should study fluoride science "as if it were produced by people with bodies, situated in time, space, culture, and society, and struggling for credibility and authority." CWF's history also offers a classic example of the construction of expertise and what sociologist Thomas Gieryn calls "boundary-work."[64] In the case of CWF, dental researchers early on established themselves as experts on fluoride's effect on human health and asserted their expertise against skeptical scientists, lay critics or environmentalists who questioned the practice, preventing them from publishing in important scientific journals and successfully stigmatizing them as cranks and quacks.

Environmental historians' predilection for focusing on ecological relationships and material flows also offers a vital dimension to the CWF story, tracing fluoride's path through various production processes and into ecosystems, food chains, and human bodies. Environmental historians certainly need to continue to heed the warnings of historians of science: to remain cognizant of the fact that the science that guides their historical interpretations is itself subject to historicization and should not be used unproblematically. For historians of science, on the other hand, environmental history serves as a reminder that issues like fluoridation are more than staging grounds for competing scientific discourses and appeals to the moral authority of nature: they also leave a mark on the material world that itself influences the history of both humans and their environment.

Despite these rather minor differences, however, it seems fair to say that historians of science and environmental historians are now largely on the same page. We all more or less agree that nature is a cultural construct, that all environments are hybrid, and that the experts who purport to explain nature—whether shamans, natural philosophers, scientists, or historians—are always influenced by their cultural milieu and sociopolitical context. Nevertheless, as environmental historian Paul Sutter points out, the field's "commitment to hybridity, however productive, also feels transitional," failing to offer analytical or normative clarity. "If all environments are hybrid," Sutter asks, "what are the useful distinctions to be made within that category? What counts as damage in hybrid environments? Are some hybridities better than others?"[65]

Obviously, the answers to such questions are not merely academic. An interpretative framework that emphasizes hybridity cannot help but favor culture over nature. In dissolving the boundary between them, it encourages and potentially exonerates a broader array of human interventions while disarming skepticism toward practices such as water

64. Steven Shapin, *Never Pure: Historical Studies of Science as if It Was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority* (Baltimore: Johns Hopkins University Press, Second Edition, 2010). Thomas Gieryn, *Cultural Boundaries of Science: Credibility on the Line* (Chicago: University of Chicago Press, 1999).

65. Sutter, "The World with Us": 96–7 (note 15).

fluoridation, genetic manipulation, and geoengineering. In a world where all human activity is as "natural" as bison grazing or plankton photosynthesizing, almost anyone can appeal to the moral authority of nature. Environmental historians and historians of science can act as a check on hybridity's tendency toward moral relativism. Since historicism treats all constructs and ideologies equally, hybridity should, and no doubt will, be subject to the same probing examination and deconstructive analysis as the dichotomy between nature and culture that it helped demolish. It is hard to know exactly what a post-hybridity epistemology might look like, although it would not be surprising to see the reemergence of some form of ecological holism, one that accepts the analytical insights of hybridity while curbing its potential to justify or downplay anthropogenic change. How would water fluoridation be evaluated through this new lens? Although one can never be sure, it is hard to imagine that the current widespread equanimity toward the practice would continue.

Author's note

After this article was written, a shorter, popular version was published on a history website produced by Ohio State University. See "Toxic Treatment: Fluoride's Transformation from Industrial Waste to Public Health Miracle," *Origins* 11:6 (2018).

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