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INTRODUCTION

The 1 August 1988 issue of *Chemical & Engineering News* contained an article that caused a sensation in the long-running controversy over fluoridation. "Fluoridation of Water," a special report written by associate editor Bette Hileman,[1] surveyed the arguments both for and against the measure.

Fluoridation is the addition of the element fluorine—called "fluoride" when in an ionized form—to public water supplies as a measure to help prevent tooth decay in children. Hileman's article outlined the standard view that fluoridation greatly reduces tooth decay, but also presented criticisms of this view. It described evidence both for and against claims that fluoridation may be involved in health problems, such as kidney disease, hypersensitive reactions, and cancer. It also recounted some of the methods used in the ardent promotion of fluoridation.

Hileman had not been involved in the fluoridation debate which has raged for decades. In writing the article, she studied the issue and consulted both supporters and opponents of fluoridation.

The ideas in her article were not new, and most of the evidence had been canvassed repeatedly in other forums. Why, then, did it cause such an impact? The reason is that never before

had such a major scientific publication presented both sides to the debate in such an extensive treatment. In particular, never before in recent decades had a major professional association, such as the American Chemical Society which publishes *Chemical & Engineering News*, given the scientific criticisms of fluoridation such credibility.[2]

In the English-speaking countries at least, fluoridation has long been virtually untouchable for "serious scientists." Opponents of fluoridation have been categorized as cranks, usually right-wing, and akin to those who think the earth is flat.[3] In most dental, medical, and scientific journals, the arguments against fluoridation are given little space and little credence.

The *Chemical & Engineering News* article represented a dramatic contrast to the usual dismissal of antifluoridation views. The article generated news stories around the country and overseas, and led to a large volume of correspondence in later issues. Not surprisingly, opponents of fluoridation were delighted with the article; supporters were dismayed. More significantly, many correspondents congratulated Bette Hileman and *Chemical & Engineering News* for raising both sides of the issue for public discussion.

A BRIEF HISTORY

The use of fluoride to prevent tooth decay was promoted by various individuals in Europe in the 1800s.[4] But the key events on the road to fluoridation occurred later and in the United States.

Frederick McKay, a dentist, first noticed staining of teeth in his Colorado patients in 1901. The colors ranged from white, yellow, and brown to black. In serious cases, there was also pitting of the enamel. Unlike most others who had noticed this mottling, McKay was intrigued by it and, over the next three decades, he pursued its origins. He noticed that, whereas people who had lived in a particular community from birth had stained teeth, newcomers to the district did not. Further investigation convinced McKay that water supplies were responsible.

It was not until 1931 that chemical analysis provided an answer to what was causing the discoloration: fluoride. H. V. Churchill, chief chemist at the Aluminum Company of America, supervised tests on water samples and, with McKay's help, established a connection between fluoride in drinking water and

mottled teeth. At about the same time, researchers M. C. Smith, E. M. Lantz, and H. V. Smith in Arizona were able to produce mottling in the teeth of rats by feeding them fluoride. Also in the same year, H. Velu reported the fluoride-mottling link based on work in Morocco and Tunisia.

McKay had long observed that mottled teeth, although unsightly, seemed to be more resistant to decay. Discovery of the fluoride connection finally stimulated the United States Public Health Service (USPHS) to investigate the issue. Led by H. Trendley Dean, USPHS scientists (mainly dentists) carried out surveys of decay in towns with different fluoride levels and also carried out experiments with animals.

A range of levels of fluoride led to the severe mottling observed by McKay and others. Severe mottling was widespread at five parts per million (ppm) and above, but less common at lower concentrations.[5] Investigators looked to see if there was a concentration which avoided most mottling while providing the benefits of reduced tooth decay. The level judged to be optimal in this regard was 1.0 ppm.

Only a small fraction of water supplies have high levels of fluoride naturally. Most have less than 0.2 ppm, a concentration too small to provide much impact on decay. In 1939, it was first proposed to add fluoride to waters which naturally have low fluoride levels. Fluoride would be added to bring the concentration to about 1.0 ppm.

The proposal struck a chord with a small number of dentists and public health officials in the United States who began campaigning vigorously for fluoridation. Many others were more cautious, including national health administrators and USPHS scientists who were still studying the dental effects of fluoride. In 1945, the first of a number of trials was begun. In these studies, two cities with similar characteristics were selected. Both had low natural levels of fluoride in the water. One city had fluoride added to its water supply, while the other's water remained unfluoridated. Rates of tooth decay in the cities were monitored by periodic examination of children's teeth.

The first study involved Grand Rapids, Michigan, where water was fluoridated in 1945. The water supply in control city, Muskegon, also in Michigan, remained unfluoridated. In the same year and in New York State, Newburgh's water was fluoridated, while Kingston served as the control. Other important early studies involved fluoridation of the water supplies in Evanston, Il-

linois, and Brantford, Ontario. Oak Park, Illinois, and Sarnia, Ontario, served as the respective controls.

At the time, it was thought that fluoride acted by being incorporated into the growing enamel of children's teeth. Hence, it would take quite a few years to see the full effect of fluoridation. The trials were planned to last ten or fifteen years. But after only a few years, the reported reductions in tooth decay were quite striking.

The proponents of fluoridation—in particular, a few enthusiastic advocates such as Wisconsin dentist John G. Frisch and Wisconsin dental administrator Francis Bull—were impatient with delay. Their lobbying was aimed especially at administrators in the USPHS, the most influential body in the public health field. H. Trendley Dean, whose work helped lay the ground for fluoridation, was not a supporter of rapid implementation, preferring to wait for the full results of the fluoridation trials. Along with others, his view was influential in maintaining the USPHS's cautious stand throughout the 1940s.

The high-pressure tactics of Frisch, Bull, and others eventually won out. The top administrators of the USPHS apparently overruled Dean,[6] and, in 1950, the USPHS endorsed fluoridation. Shortly afterward, two key professional bodies—the American Dental Association (ADA) and the American Medical Association (AMA)—also expressed support.

In the United States, however, decisions concerning public water supplies are made at the level of states, cities, or towns. The USPHS endorsement did not force any community to fluoridate, but it did provide vital authoritative backing for local individuals and groups that pushed for it.

The endorsements by the USPHS, ADA, and AMA were based on the claim that fluoridation resulted in massive reductions in tooth decay, typically quoted as 50 to 60 percent, with no associated health risks, and at little cost to the community. At the time, dental decay was widespread, and many dentists felt unable to cope with it. Many people had all their teeth removed at an early age due to decay. In this environment, fluoridation was an attractive proposition. During the 1950s, a large number of communities moved to fluoridate their waters.

But almost as soon as the push for fluoridation began in the 1940s, a vocal and persistent opposition arose. In many communities where fluoridation was proposed, there were local individuals and groups that claimed that it was dangerous. The op-

ponents typically claimed that it caused certain health problems in some people, and that it was "compulsory mass medication" and, therefore, unethical as well as an abuse of government power.

This basic configuration of proponents and opponents has persisted from the 1940s until today. The arguments on each side have remained essentially the same. The proponents assert that fluoridation massively reduces tooth decay rates, has no proven adverse consequences for health (except negligible mottling of teeth, which is only of cosmetic concern), and is the cheapest and most effective way of getting fluoride to all members of the population. The opponents say that the benefits are overrated, that there are a variety of proven or possible adverse health consequences (including skeletal fluorosis, intolerance reactions, and cancer), and that fluoridation is unethical because it is compulsory medication with an uncontrolled individual dosage.

Although the arguments have remained much the same, the fortunes of fluoridation have waxed and waned. The population drinking fluoridated water in the United States greatly expanded during the 1950s, but the opposition caused local reverses and stopped many proposals. Since the 1960s, the fraction of the U.S. population served by water supplies with added fluoride has increased only gradually, and now hovers at about one half.[7]

From the United States, the message about fluoridation was sent around the industrialized world. Dental and medical authorities, after investigation, usually endorsed the measure. In several countries—especially Australia, Canada, Ireland, and New Zealand—the pattern has been similar to that of the United States: there has been widespread adoption of fluoridation in the face of strenuous opposition. On the other hand, in Britain, only one in ten people drinks fluoridated water. In continental Western Europe, the measure was greeted even more cautiously by government bodies, and fluoridation is found in only a few localities. Only in the Netherlands did a sizable fraction of the population ever receive fluoridated water, and that program was terminated in the 1970s. By contrast, several Eastern European governments have introduced fluoridation on a more substantial scale, although it is far from universal.

In nonindustrialized societies, fluoridation is not usually a feasible proposition. In some countries, tooth decay was not much of a problem as long as the diet remained sufficiently traditional. But as the diet became Westernized, with large amounts of refined and sugary foods, tooth decay became a serious problem. The

main obstacle to fluoridation in nonindustrialized countries is a lack of centralized public water supplies. Often, water is obtained from private wells which are not suitable for fluoridation. There are some exceptions, such as urban Singapore which is entirely fluoridated.[8]

Table 1
Percentage of the Population Served by Water Supplies with Added Fluoride in Selected Countries in the Late 1980s.[a]

66	Australia	0	Lebanon
0*	Austria	0	Netherlands
0	Belgium	50	New Zealand
21	Brazil	0	Norway
36	Canada	7	Papua New Guinea
10	Chile	0*	Philippines
21	Czechoslovakia	3	Poland
0	Denmark	0*	Portugal
10	Fiji	0	Romania
2	Finland	100	Singapore
0	France	0	South Africa
20	East Germany	0	Sweden
0	West Germany	3	Switzerland
0	Greece	0	Thailand
0	India	0	Turkey
0	Iran	15?	U.S.S.R.
66	Ireland	9	United Kingdom
20	Israel	49	United States
0	Japan	0	Zimbabwe

*Greater than zero but less than 0.5 percent.
[a]For details see the appendix.

The proponent case has had no dramatic developments since 1950. The early promoters of fluoridation—including prominent figures such as H. Trendley Dean, John G. Frisch, and Francis Bull—have been followed by many others, such as Frank J. McClure, Ernest Newbrun, Herschel S. Horowitz, and Brian Burt. Other countries have their own lists of prominent proponents, including Douglas Jackson, John J. Murray, and Andrew J. Rugg-Gunn in Britain, and Noel Martin, Lloyd Carr, and Graham Craig in Australia.

The proponents refer to an accumulating body of data supporting the efficacy of fluoride in preventing tooth decay. They have also produced critiques on claims of hazards.

Compared to the proponents, it is easier to single out opponents among scientists around the world. George Waldbott was undoubtedly the most prestigious opponent in the United States from the 1950s until his death in 1982. Others have been Frederick Exner, Albert Burgstahler, and John Lee. These critics have concentrated on the health hazards of fluoridation, including allergic and intolerance reactions.

In the mid 1970s, John Yiamouyiannis and Dean Burk joined the debate when they made dramatic claims about a link between fluoridation and cancer, and, since then, this issue has been a continuing and contentious one. Yiamouyiannis is the most prominent opponent who is a scientist in the United States today.

Another side to the opponents' case is a critique of the evidence that fluoridation enormously reduces tooth decay. Waldbott, Exner, and others introduced this point, but the earliest comprehensive critique was presented by Philip Sutton, an Australian dental researcher, in 1959. In the 1980s, the critique of the size of benefits was taken up by John Colquhoun in New Zealand; Mark Diesendorf, Australia; John Yiamouyiannis, United States; and Rudolf Ziegelbecker, Austria. These individuals rank among the world's leading opponents of fluoridation who are scientists.[9]

The fluoridation debate has been such a bitter one that it is virtually impossible to say anything on the topic which cannot be questioned by one side or the other, or both. This applies to the history of fluoridation as much as to anything else. The abbreviated account I have given is largely the picture as presented by the proponents of fluoridation[10]. Some opponents have emphasized other events in the history, and given a different complexion to the whole account. I will have occasion to return to some events which have been the subject of debate. Suffice it to say that the selection of historical events as significant and the interpretation of motives are influenced by the stance of those making the selections and interpretations.

Analyzing the fluoridation controversy

The confrontation between expert proponents and opponents of fluoridation is a central focus in this book. By contrast, most social scientists have treated fluoridation as scientifically beyond dispute and have ignored natural scientists who are opponents.

These social scientists have focused on the popular opposition to fluoridation and tried to explain it by factors such as ignorance, political conservatism, alienation, and confusion. This approach exempts the scientific aspects of fluoridation from scrutiny. The resulting analyses of the controversy are one-sided, usually serving the proponents by implicitly denigrating the opponents.

To analyze the fluoridation controversy, I prefer to use instead what can be characterized as a power picture of science.[11] Instead of treating science solely as a search for truth, science is analyzed as is any other social activity, such as advertising or transportation. In this picture, science is something which people do which serves some interests in society more than others, epecially the interests of scientists themselves and of other groups with money and power enough to fund research and apply results.

Power is involved in all aspects of the practice of science, even in the daily processes by which scientists make decisions about what is valid knowledge. What is counted as knowledge depends on getting agreement from other scientists, and this may involve funding, status, or persuasive ability.

Fluoridation is a good topic in which to examine the dynamics of science and power because the opposition, while far from entirely successful, has not been totally submerged. The profluoridationists have been largely successful in maintaining their views as dominant among key groups in English-speaking countries, and this helps reveal the processes by which orthodoxy is established and perpetuated. But this insight is made possible by the persistence of a minority opposition, which ensures that the exercise of power in science is, to some extent, brought out into the open.

Furthermore, the issue has been a public one, and this means that many of the arguments for and against fluoridation have been spelled out with exceptional clarity. Internal disputes within the scientific community about theories of chemical catalysis, for example, do not generate very much accessible material for analysis. Finally, fluoridation combines technical, political, and ethical dimensions in a potent mixture.

In using the power picture of science to analyze fluoridation, I employ a variety of concepts and approaches. One is the idea of a "resource" or "tool." Various elements—including slogans, claims of scientific knowledge, publications (Hileman's article, for example), professional prestige, authoritative endorsements, community organizations, governments, and the mass media—have been used as resources in the struggle over fluoridation.

Another important concept is interest. For example, scientists have an interest in obtaining publishable results, establishing a good reputation, and having a good job. Corporate executives have an interest in increasing sales and profits, and also in protecting their executive status and privileges.

The idea of "social structure" or "social institution" is also valuable. For example, capitalism is a way of organizing work based on private property and the purchase of labor power. This results in patterned sets of relationships between people, such as the employer-employee relationship.

Rather than try to analyze fluoridation by using a single unified theoretical picture, I prefer to approach it at a series of different levels, using the concepts already mentioned where appropriate. I have selected parts of the controversy which highlight the interacting roles of knowledge and power.

Chapters 2 through 6 can be seen as a series of examinations of the fluoridation debate, and each shows the exercise of power on a successively larger scale. Each chapter reveals a power dynamic which casts a different light on the preceding chapters.

In chapter 2, I examine the arguments raised by scientists who support or oppose fluoridation in relation to benefits, risks, individual rights, and decision making. This can be considered to be an analysis at the level of intellectual debate, although, even here, the role played by other factors can be observed. In detailing the arguments, chapter 2 also sets the stage for the later analysis.

Proponents and opponents line up in an almost completely predictable fashion on the entire range of arguments, from science to ethics. Chapter 3 probes this remarkable coherency of viewpoints, which can be explained as a product of the polarizing nature of the fluoridation debate itself: the partisans develop their coherent views in order to make a solid case in the "rough-and-tumble" of public debates and campaigns. This analysis at the level of social psychology suggests that the scientific arguments outlined in chapter 2 have been shaped, directly or indirectly, by the requirements of public fluoridation debates.

Chapter 4 turns to the struggle for credibility, which involves obtaining authoritative backing and attacking the credibility of those on the other side. This means going far beyond attacking the credibility of scientific statements, which would constitute part of an intellectual dispute. Rather, the attack is on the credibility of individuals as scientists and as honest, sensible, and upstanding citizens. This is a level involving every possible use of rhetoric

against the reputations of individuals as a tool in a struggle for authority. The existence of systematic attempts to undermine the credibility of individuals as people—rather than the credibility of their arguments, and to gain support on the basis of authority—shows the limitations of dealing only with arguments and views as in chapters 2 and 3.

Another exercise of power has been control over publication, research funding, and professional accreditation. In all these areas there are examples of the overt use of the power of the dental profession against antifluoridationists. Chapter 5 examines this side of the controversy by placing it in the context of the dental profession's support for fluoridation. This analysis at the level of professional power shows that the debate over scientific knowledge about fluoridation has involved more than language. It is not solely an intellectual dispute, nor a verbal duel for authority and credibility, as treated in chapters 2 to 4. Rather, the material basis for scientific communication, scientific research, and professional advancement—namely, publications, research grants, and accreditation—have been used as tools in the struggle.

Moving beyond a focus on individual researchers and partisans, chapter 6 looks at the role of industrial corporations, whose interests may have shaped the context of the fluoridation debate. This analysis, at the level of corporate power, suggests that the issue of fluoridation might not have arisen in the form that it took—or even become an issue at all—had the historical configuration of corporate interests and the dental profession been different.

Proceeding from chapter 2 through to chapter 6, the focus changes from the exercise of power at the level of individuals and arguments to the role of power at the large scale of social structures. All levels are required for a full picture. The large-scale, structural perspectives provide the context for detailed disputation; without these wider contexts, the debate might be imagined to be proceeding on the basis of fact and logic alone. But the structural perspectives do not tell the story by themselves. Rather, they provide a framework for and an influence on debate. Even so, only a detailed examination can tell what arguments are actually developed and deployed.

In chapter 7, I attempt to draw out some implications of the analysis. How *should* the debate be resolved? *Can* the debate be resolved? In retrospect, how could the proponents and the opponents have improved their strategies? I conclude that there is no

simple answer to any of these questions. In confronting the fluoridation debate, one also confronts—implicitly or explicitly—basic issues about the organization of society.

A basic theme in my analysis is that it is impossible to separate the scientific and power dimensions of the fluoridation issue. In order to assess the scientific work on fluoridation, it is necessary to understand the wider social context—the careers of key individuals, the commitment of the USPHS and the ADA, and the potential of corporate support or hostility. All of these can influence what scientific research is done or not done, the predisposition of researchers to obtain particular types of results, and the assessment of contrary findings. The body of research relating to fluoridation, and the common evaluations made of it, cannot be separated from the wider power dimensions of the controversy.

Conversely, it is impossible to understand fully the power dimensions of the controversy without assessing the scientific issues. The common view that fluoridation is scientifically beyond question, as well as the minority view that it is scientifically indefensible, eliminate the possibility of understanding how scientific knowledge claims are embedded in power struggles. Assessing the struggles over scientific knowledge is essential to a full understanding of wider power dimensions.

It is not my task in this analysis to either support or oppose fluoridation. So far as I am concerned, that is a side issue. My interest is in the analysis of scientific knowledge as it is used and shaped in the course of a bitter public dispute. In developing my analysis, I have benefitted greatly from a handful of writers who have analyzed the issue without assuming that fluoridation is scientifically correct.[12]

Chapter 8 deals with the social analysis of the fluoridation controversy. I briefly describe standard approaches in previous studies, contrast my own approach with them, and defend my formal agnosticism about fluoridation. I also recount a potential difficulty encountered by those studying contemporary controversies: the involvement of the researcher, reluctant or otherwise, directly in the controversy.

In this book I present one way of looking at the issue of fluoridation. It is certainly not the only way. It is my hope that, in selecting some perspectives not often given attention previously, some will see this issue in a new light.

When I circulated the first draft of this book to a range of individuals for comment, I also invited them to write responses to

my text. Edward Groth III took up this offer, and I am greatly pleased to have his insightful essay as part of this book. It deals with how to assess the scientific evidence on fluoridation. It is highly appropriate that Groth's views should be represented here, since his pioneering work on the fluoridation controversy has received insufficient attention.[13]