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INTRODUCTION

I was attending a primate meeting in Lyons, France, in 1968. I had made a presentation on the use of primates in dental research, and during a break, a "senior" man, with gray hair, slightly balding, and wearing wire-rimmed spectacles, introduced himself: "I am Henry Klein," he said. "Do you know who I am?" I said, erroneously as it turned out, "Yes. I know your work. You have published on the prevalence of dental caries in captive primates." "No," he replied, "I am Henry Klein, the DMF Klein." (Klein in fact had published papers on the prevalence of caries in Rhesus monkey.)

Henry Klein's introduction struck a chord, not very loudly at first. We conversed for a considerable time, and I learned a great deal about dental research in the USA during the 1940s and 1950s. When I returned home to the Royal College of Surgeons of England and examined the published literature, I realized the prodigious contribution of this person to our understanding of the epidemiology of dental caries, the importance of fluoride, the familial occurrence of dental caries, and indeed his contribution to research into caries in animals.

EARLY CAREER

Clearly, before any measurement of the extent of disease can be carried out, it is essential to arrive at a reasonably accurate method of determining, and more importantly expressing, the prevalence and perhaps subsequently the incidence of the disease. In the 1930s, when considerable attention was being focused on fluorosis and dental caries, there was not a readily usable quantifiable method of expressing this relationship (McClure, 1970). Klein, with his collaborator Palmer, introduced the term DMF in the 1930s. In the same paper (which included data on the prevalence of caries in 8000 native Americans), they noted that "responsibility for the low caries attack rates in the southwestern area may be the result of the

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drinking of fluoride waters." They noted, further, that "The conclusion was inescapable because the data made possible comparison of DMF rates in endemic and non-endemic fluorosis areas." Henry Klein, with his colleagues, conducted some of the largest epidemiological studies ever in the United States and was the first to generate meaningful data on the true extent of the disease. The most well-known are perhaps those conducted in Hagerstown (MD), where over 4000 children were examined. Klein and colleagues noted huge differences in surface susceptibility to caries and teeth mortality rates. They noted that, *per* 100 boys aged 6 years, 25 carious teeth were present with 35 carious surfaces. In the same community in 15-year-olds, 668 carious teeth were present with 1435 caries lesions (Klein and Palmer, 1938)...clearly a most serious situation.

FLUORIDE—MOTTLED ENAMEL

When I met Henry Klein, he had left the United States, resigned from the Public Health Service, and was working as a consultant for a company based in Paris. I asked him why he had left the United States. He proceeded to tell me the history, from his perspective, of fluorides, mottled teeth, and the prevalence of dental caries in the United States during the decade spanning the 1930s. He earnestly believed that the credit for making the association between mottled enamel and a lower prevalence of caries was denied him by his superiors; indeed, he pointed out, many of them considered that any fluoride exposure was harmful to teeth, and some had even taken out patents on means to remove fluoride from water.

The relationship between excessive fluoride ingestion and mottled teeth had long been established before the concept that fluoride in drinking water was associated with low levels of dental caries (Dean and Elvove, 1935). It is important to point out, I believe, that, according to Klein, the current acceptable level of 1 ppm F in the drinking water was originally established on the basis of what was esthetically acceptable, and not on the preventive aspect of fluoride. It was one of those fortunate acts of nature that 1 ppm F in drinking water provided almost the optimum prophylactic and esthetic outcome. Indeed, Klein (1972), citing Dean and Elvove (1935), noted: "Late in 1933 an investigation was begun to determine what constitutes a permissible amount of F in a domestic water supply...Amounts not exceeding one point *per* million expressed in terms of fluorine are of no public health significance."

When he (Klein) pointed out their fallacies with his data, they embraced the concept as their own (Dean, 1938). It is certainly true that Klein's name does not feature as prominently in the history of fluoride as his contributions appear to warrant (McClure, 1970).

I believe that it is worthy of note that, in an additional series of epidemiological studies, he noted that teeth already present in the mouth derived considerable protection from the introduction of water fluoridation. Furthermore, he noted that newly erupted teeth appeared to derive even more protection against caries than did those present in the mouth before fluoridation. He concluded that children did not have to be born into a fluoridated area to derive benefits and observed that the longer children had resided in a fluoridated area, the greater the protection against caries. Thus started the controversy over the systemic effect vs. the topical effect of fluoride that continues today.

When Klein told me his story, I was intrigued and urged him to write his account of fluoridation and have it published. He informed me that he had already prepared a written account but did not believe that he could ever get it published because it would be so controversial. In subsequent meetings, I continued to urge him to publish, and he continued to display considerable reticence, and at one point he sent his manuscript to me with the request that I publish it under my name. I of course declined, and eventually I persuaded him to send it to the *Journal of the Irish Dental Association*. The editor, Walter Allwright, was delighted to receive it, and it was published in that journal (*J Irish Dent Assoc* 18:9-21, 1972) under the title "Dental Caries Inhibition By Fluorine—The Historical Perspective". It is an intriguing account of fluoride and should be read by all who have even a slight interest in "Cariology" (Klein, 1972).

BELATED RECOGNITION

Around that time, I was collaborating with the National Institute of Dental Research. I related the story to Jim Carlos, who was Director of the National Caries Program. Following some discussion, we thought that it would be appropriate to nominate Henry Klein to receive the IADR's H. Trendley Dean Award. We were delighted when the committee accepted our nomination. We were even more delighted and surprised when Henry Klein came to the IADR General Session in 1972 (in Las Vegas) and accepted the award named for a person whom he regarded as his nemesis.

PIONEER CARIOLOGIST

Henry Klein's contributions to dental research were not restricted to his observations on the effects of fluoride or to the development of indices to express prevalence of dental caries. In a whole series of masterly papers, he drew attention to the familial aspects of dental caries and pointed out that the prevalence and distribution of caries in children follow that of the mother more so than that of the father, and that the prevalence of caries was significantly higher in siblings who had elevated levels of caries, compared with those whose siblings experienced low levels of caries (Klein, 1946). Furthermore, if both parents had experienced elevated levels of caries, the likelihood of children having a high caries score was even more enhanced. Thus, he had developed the concept of

maternal "transmission" of caries many decades before it was shown experimentally. This series of studies was carried out in 1150 families (5400 persons) of Japanese ancestry who were interned at the Colorado River Relocation Center. They had been relocated from the city of Los Angeles and elsewhere in Southern California.

It is noteworthy that the DMF scores were as high as 6.6 for 15-year-old children from high-caries parents compared with fewer than half that score in children from low-scoring parents.

It is clear that Klein was a thoughtful and careful opportunist, and his ability to gather some extraordinary epidemiological data from "captive populations" was quite remarkable. In today's ethically sensitive climate, one wonders whether such an approach would pass muster.

Dr. Klein's research interests also encompassed laboratory studies and investigations into caries in animals. As early as 1929, he stated that enamel was permeable to fluoride, clearly based on his observation that enamel readily adsorbed fluoride, which of course helped to explain one of his most important observations, that teeth which erupted into a fluoridated environment derived greater protection than those already present when first exposed to fluoride.

Klein's research interests also explored the incidence of caries among siblings. He also pointed out the fallacy then in vogue that girls were more susceptible to caries than are boys; the alleged differences were readily explained by differences in timing of eruption. He was also among the first to draw attention to the influence of macro-economic factors on the prevalence of caries.

Henry Klein was a true "Cariologist", long before the term became 'fashionable'. He studied with great success the many facets of this ubiquitous disease, and his manifold observations, though infrequently recognized, provide the basis for many current hypotheses. Indeed, at the IADR meeting held in Chicago in 1934, he presented two papers on the incidence of caries in Rhesus monkeys and a description of macroscopic caries in wild rats.

He certainly initiated the debate on whether the protective effect of fluoride resulted from teeth being exposed topically or through systemic administration.

Klein (1929) was probably the first in the dental field to carry out an evidence-based analysis of the dental literature. He read all of the available literature pertaining to nutrition and oral health concerning the period 1912-1928, and classified the papers based on scientific merit as judged by well-controlled experiments, adequate data, and appropriate analysis. Klein concluded that the number of poor papers far outnumbered the combined totals of excellent or mediocre papers. Perhaps matters of science have not changed a great deal.

LASTING LEGACY

It is apparent from the data published during the 1930s and 1940s that the dental health of the population in the United States was in a deplorable state. Certainly Klein's ability to express the prevalence of dental caries in simple quantifiable terms enabled the Congress of the United States to comprehend the burden of poor oral health being borne by the population. There is little doubt that this realization of the Nation's poor oral health helped in no small way in the development of the

National Institute of Dental Research. It has been said that NIDCR is the house that fluoride built. Then surely Henry Klein is one of its neglected cornerstones.

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