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Review

The controversial contribution to dental research made by Albert Schatz-
Co-discoverer of streptomycin

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ABSTRACT

In addition to being co-discoverer of the antibiotic streptomycin the American microbiologist and soil scientist, Albert Schatz did ground breaking dental research. His major contribution is the Proteolysis–Chelation theory, but he also did research on fluoridation where he emphasised the overlooked involvement of so-called paradoxical effects. His research led him to become an active supporter of anti-fluoridation campaigns. The following article discusses Schatz's important and largely overlooked contribution to dentistry.

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1. Introduction

Albert Schatz is now widely recognized as the co-discoverer of the anti-tuberculosis antibiotic streptomycin (Wainwright, 1991). As we shall see in this paper, Schatz also made important, if controversial contributions, to research in dentistry, particularly in relation to the proteolysis–chelation theory. He also conducted extensive research and became an important figure in the worldwide campaign against the fluoridation of drinking water. Here I

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discussed the largely ignored work and show that, in addition to making a seminal contribution to research into antibiotics, Schatz also did ground breaking and provocative work on dental research (Fig. 1).

Born in Norwich, Connecticut on February 2, 1920, Albert Israel Schatz grew up in Passaic, New Jersey. In 1938, he enrolled in the College of Agriculture at Rutgers State University of New Jersey. Here, he received a Bachelor of Science degree with the highest class ranking in Soil Science in 1942 and then immediately began a PhD program in Soil Microbiology at Rutgers under the supervision of Selman A. Waksman. Five months later, Schatz was drafted as a bacteriologist in the Medical Detachment of the Air Force, stationed in army hospitals in Florida.

Schatz's contribution to dentistry, which was mainly done in association with his uncle, J.J. Martin who was a practising dentist, is generally ignored, largely because it is centred on two controversial aspects, namely the Proteolysis–Chelation theory of dental

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Fig. 1. Albert Schatz, co-discover of streptomycin and pioneer of dental research.

decay and the debate over the impact of drinking water fluoridation. While the Theory is often given passing reference in textbooks on dentistry (Rajendram and Sivapathasundharam, 2009), his views on drinking water fluoridation, when mentioned in the standard dental literature, are generally summarily dismissed; his highly active approach to this subject however, made him something of a hero amongst anti-fluoridation campaigners.

2. The Proteolysis-Chelation theory

Schatz and co-workers first suggested the Proteolysis-Chelation theory in 1955. Chelation occurs when metal ions are complexed through coordinated covalent bonds which leads to the formation of poorly dissociated and/or weakly ionized compounds. Chelation is independent of the pH of the medium. The proteolysis-chelation theory suggests that dental caries is caused when the organic components of enamel are attacked by bacteria; the resulting breakdown products possess chelating properties which lead to the dissolution of the enamel-minerals even at the neutral/alkaline pH; secondary chelators, such as mucopolysaccharides, lipids and citrates may also be involved. The theory also suggests that there also occurs a simultaneous microbial degradation of organic component by both proteolysis and the dissolution.

Schatz stated that when he began work on caries in 1953, he was surprised to discover how acid was unequivocally declared to be the cause of tooth decay; a fact which, he claimed, had never actually been proved. He suggested that dental researchers seemed to be unaware that the anions and un-dissociated molecules of certain acids could also decalcify enamel and dentine, just as hydrogen ions do, but by an entirely different mechanism; that is by forming chelates and other complexes. The Acid Theory claims that tooth decay is due to decalcification which is attributed almost entirely to the action of hydrogen ions. The chelation theory, on the other hand takes into account a wide variety of agents, including acidic, neutral and alkaline compounds which form calcium chelates under acidic and non-acidic conditions.

The Proteolysis-Chelation theory suggests the involvement of two actions which are interrelated actions: firstly an enzymatic attack on organic constituents, followed by a more or less simultaneous demineralisation brought about by substances arising endogenously from the degradation of the organic constituents; these being able to complex calcium, Schatz looked upon enamel, not as a mineral structure, but as being essentially organic, like bone and dentine.

Although, as has already been mentioned, Schatz's Proteolysis Chelation Theory is mentioned in textbooks, it is not generally accepted and many younger dental practitioners and researchers have probably never been taught about the alternative to the Acid Theory of dental decay.

3. Schatz and anti-fluoridation

Schatz actively campaigned against fluoridation of drinking water; his approach was heretical, often sarcastic and direct and,

not surprisingly, his acerbic criticism of pro-fluoridation researchers did nothing to gain him support from scientists and public health administrators. He was, and still is, however, widely admired amongst anti fluoridation campaigners and was an active speaker and campaigner on the subject. Most of his experimental work on fluoridation was conducted while he was working in Chile. Schatz claimed that fluoridation was not only ineffective in preventing caries it caused cancer and was killing undernourished people in Chile. Not surprisingly, his views were widely criticised, notably by Brown (1992) and Mitchell (1992) in letters to the *New Zealand Journal of Medical Journal*.

Schatz was criticised for selecting the Chilean communities for study in a biased manner and also for publishing his work in a non-existent scientific journal. Schatz responded by emphasizing that the communities which had been used in the Chilean study were actually chosen by the National Health Service of Chile, so that the demographic data used by him was extracted taken from official government reports. Schatz also claimed that Brown and Mitchell also ignored data obtained by Briner and Carmona (Briner and Calmona, 1966). This data showed that fluoridation of water in the Curico region of Chile produced a 244% increase in fluoride-related deaths compared with results found in non-fluoridated San Fernando, and 288% more such deaths than in Chile as a whole. Schatz also claimed that Brown and Mitchell, as well as others obscured the real issue. This has led to respectable scientists and other professional researchers being blackballed and not allowed to publish their criticism of fluoridation in dental and medical journals.

Schatz admitted that his work on fluoridation in Chile was by necessity published in an obscure journal, but pointed out that, he had tried to increase its readership by forwarding a copy to a) every dental and medical officer in the Pan-American Health Organization and the National Health Service of Chile and b) to professors in the faculties of medicine, dentistry and pharmacy in the University of Chile, Shortly afterwards, fluoridation was discontinued in Chile, a decision which he claimed resulted directly from the data which he presented. Schatz responded to the claim that he had fabricated the journal in which the Chilean fluoridation work was published (i.e. the *Journal of Arts, Science, and Humanities*) of the Anthony University) was libellous He rightly pointed out that the copyright and date of publication was readily verifiable by directing an inquiry to the Library of Congress, Copyright Office, Washington, D.C. He also pointed out that copies of the paper could also be ordered from the Copyright Office of the Library of Congress.

In 1978 a public rebuttal of Schatz's claims was issued by The Division of Dental Health of US dept of Health, Education and Welfare. Schatz was working at Temple University and a statement from the Health Science Center of this University on Dec 8, 1972 affirmed its support for fluoridation by claiming that "The charges made by Dr Schatz including the studies in cities, have been examined and found to be of insufficient substance to alter the position of the recognized scientific and professional communities which endorse this proven public health measure"

In the 1978, the rebuttal, the US Department of Health Center for Disease Control in Atlanta released a statement about Schatz's claims of a connection between fluoridation and increased mortality stating bluntly that the results were not valid. They reported that Schatz's paper "Increased Death Rates in Chile Associated with Artificial Fluoridation of Drinking Water" had been reviewed and that: a) No relationship could be established between fluoridation and mortality rates in Chile from the information provided, b) the paper contains numerous errors of interpretation and analysis, c) demographic information recognizing as impacting on mortality rates and therefore valid epidemiological research is not provided nor analysed. The press release claimed that the control community of San Fernando had a significantly lower rate of infant deaths

when compared with Curico (fluoridated) prior to the introduction of fluoridation in 1953, and the same observation applies to the neonatal death rates. Once again, it was claimed that Schatz based his arguments on invalid data originating from the false premise that the two communities were comparable prior to the introduction of fluoridation in 1953. Both in terms of infant and neonatal mortality, San Fernando was not, the rebuttal claimed, a good control for Curico since the rates were not initially comparable. Dr. Schatz attributes solely to fluoridation 35 deaths per 10,000 persons per year. The criticism continued that the results were based on the claimed untenable assumption that the only difference between Curico and San Fernando was the use of fluoride. The public statement went further by discrediting Schatz's view that fluorine and fluoride are both carcinogenic. It ended with the positive assertion that: "Water fluoridation for the purpose of dental caries prophylaxis poses no hazard relevant to cancer causation."

4. Schatz's emphasis on paradoxical effects in dentistry

Schatz claimed that many researchers were, in relation to the effectiveness of fluoridation in relationship to deaths and cancers, overlooking an important phenomenon referred to by him as "paradoxical effects". As a result of this phenomenon, a high dose of a chemical may paradoxically cause less damage than a lower one (Schatz et al., 1964); paradoxical effects he pointed out are not isolated phenomena but are occur widely and are of relevant to the biochemistry and physiology of organisms over a wide variety of conditions. Schatz claimed that most researchers think only in linear dose relationships and so tend to attribute any observed deviations to experimental error or variability. For example, paradoxical effects can be produced by radiation, temperature, mutagenic and carcinogenic chemicals, fluoride, steroid hormones, dextran, detergents, trace metals, herbicides, fungicides, insecticides, germicides, antibiotics, drugs and a wide variety of other agents.

Schatz and Martin (1964) claimed that as the fluoride concentration is increased over a thousand-fold range, the extent of inhibition rises may approach 100% and then subsequently falls, and that the occurrence of paradoxical effects with low level fluoridation (in addition to low level radiation exposure) indicates that no threshold level exists below which fluoride and radiation are harmless. Schatz claimed that researchers are often blinded by the continued pursuit of the "linear dose relationship" and the "cancer paradigm." His finding of a cluster of infant deaths at very low fluoride levels, suggested to Schatz that the relationship between fluoride concentration and sudden infant death syndrome is not linear, but paradoxical.

Schatz further emphasised that research claiming to prove the safety of fluoridation has not involved very low concentrations of the element at which paradoxical effects may occur as follows: (1) individuals vary significantly in their ability to take up fluoride, (2) there is considerable individual variation in relation to terms of response, (3) it has been unjustifiably assumed that there is a consistent threshold level (i.e. the one part per million maintained in drinking water, below which fluoridation is assumed to be safe). Schatz claimed that the occurrence of paradoxical effects at very low levels of fluoride means that there is no threshold level below which even low-level fluoridation is safe.

Paradoxical effects often occur in complex systems which are influenced by variations in conditions which occur within the same

system and so may not always appear at very low concentrations. However, a linear dose–response always appears at higher concentrations which, in the case of fluoride, begin at one part per million. The relationship between fluoride concentration and sudden infant death syndrome may therefore be linear and/or paradoxical, depending on the concentration range of fluoride and a number of other variables. This variability can lead to results being irreproducible, a feature which is characteristic of paradoxical effects.

Schatz pointed out that statistical analysis of experimental data often hides paradoxical effects. Statistical methods are too frequently used to determine where a straight line should be drawn between scattered points, leading to the assumption that straight lines are the correct outcome and that deviations caused by paradoxical effect-irregularities have too frequently been attributed to experimental variation or errors.

5. Conclusion

The main scientific contribution of Albert Schatz was obviously the role he played as co-discoverer of streptomycin, an antibiotic which, as it happens, has never been widely been use in dentistry. Schatz's considered that his dental research was of equal significance to his work on antibiotics and he also applied his broad knowledge of soil microbiology to the dental-related question of the microbial degradation of keratin (Schatz et al. 1955, 1956). These contributions to dentistry were certainly both novel and provocative, but his work never entered the mainstream. As pointed out in the Introduction, Schatz's proteolysis chelation theory, although often mentioned in passing in dental textbooks (Rajendram and Sivapathasundharam, 2009) it has not been accepted as a serious alternative to the acid theory of tooth decay. Similarly, his work on fluoridation has been widely criticised and roundly dismissed by public health authorities. Despite this, Schatz continues to be widely quoted by anti-fluoridation authors (Groves, 2001) and among anti-fluoridation activists, with whom, he remains something of a hero.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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