

W.D. Miller and his Contributions to Dental Science

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Willoughby Dayton Miller (1853–1907) was the first dentist in history with a thorough training in the natural sciences. He had studied mathematics and physics at the University of Ann Arbor, Michigan from 1871 to 1875 and intended to follow additional courses in Europe.

While he studied in Edinburgh, his bank went bankrupt and he lost nearly all his money. Miller then travelled to Berlin where he continued his studies, but in his difficult financial situation he had to earn money. It was not easy for Miller to find a job, but he was lucky to make the acquaintance of an American dentist, Frank Abbot, living and practicing in Berlin, and Miller asked him for help. Dr. Abbot found him a job as a translator, and in addition asked Miller to give lessons to his wife and daughter. How much the ladies learned from Miller in the natural sciences is not known. However, an important side effect of the lessons was that Miller soon became engaged, and determined to marry, Miss Caroline Abbot. Moreover, Miller began to like his future father-in-law's profession and, supported by this generous man, returned to the United States to study dentistry.

In Spring 1879 Miller graduated as Doctor of Dental Surgery from the Philadelphia Dental College. Returning to Berlin he assisted in the office of his father-in-law and continued his studies of natural and medical sciences, especially microbiology. The latter had achieved enormous progress under the stimulating influence of Robert Koch whose methods appealed to the research-minded dentist. He worked hard and the dental problems he tackled were solved with a critical sense of logic, a thoroughness and a versatility of methods which is amazing even to the sophisticated research worker of the late 20th century.

Between 1881 and 1907 Miller published 164 scientific articles in

German, American and English journals. Of the few books he wrote, the most famous one was first published in German in 1889, under the title 'Die Mikroorganismen der Mundhöhle'. Better known internationally and more often cited is the English version of this book which has been reprinted in the present edition. 'The Micro-Organisms of the Human Mouth' was published in Philadelphia a year after the German original. The American edition of 1890 is not only better known nowadays than the German edition, but its text had been partly revised besides being translated, and a whole new chapter (III) was added by the author. Several reasons seem to justify a new edition of this book. First of all, it is so extremely rare that it is nearly inaccessible, although no part of it is obsolete. To say the least, it is a unique document of the first major attempt to solve a number of unsolved dental problems in a scientific way. The etiology of dental caries for which the book is most famous, is only one of them. Miller was an outstanding histopathologist, and the results of his investigations of carious dentine and of infections of the pulp, for their time, were a step from the Stone Age to Modern Science. The vicinity of Miller's small laboratory to the institute of Robert Koch obviously explains the keen interest of the Professor of Dentistry not only in oral but also in general microbiology. Miller's methods of determination and differentiation of strains were as versatile as his very limited facilities would permit (his research laboratory measured about 30 square feet). Miller's limitations were compensated for by his awareness of the pitfalls, and he knew that an oral microbiologist must not rely on morphology: '. . . the form of a fungus alone by no means always entitles us to draw conclusions as to its specific character'. Miller's self-critical attitude also becomes apparent when he refers to his great many attempts 'to cultivate the supposed bacterium of greenstain, but so far without success', or when he questions the validity of an earlier success in isolating from the mouth 'the bacterium of brick-colored deposit': 'My present opinion however, is that the one I obtained is not the one I have been seeking' (p. 91 and 92). Few scientists will know that Miller did not claim the 'chemico-parasitical' explanation of the caries process to be his own invention, although in retrospect he deserves full credit for the caries theory bearing his name: '. . . in the decay of the hard tooth-structures 'two factors have always been in operation: (1) the action of acids, and (2) the action of germs'. 'This theory — which for the sake of distinction may be called the septic — is rather an amplification of the chemical theory than a contradiction of it. Most probably the work of decalcification is entirely performed by the action

of acids, but these acids are, we think, secreted by the germs themselves . . .' (p. 134). This is not a citation from Miller, but Miller's citation of Milles and Underwood (Transact. Int. Med. Congr. 1881) to whom Miller gives ample credit.

Miller's comprehension for the possibilities of caries prevention, derived from his ideas of the etiology of caries, was remarkably clear and would have credibility had it been written yesterday: '. . . it must be apparent that there are four ways by which we may counteract or limit the ravages of this disease. We may endeavour (1) by hygienic measures to secure the best possible development of the teeth; (2) by repeated, thorough, systematic cleansing of the oral cavity and the teeth, to so far reduce the amount of fermentable substances as to materially diminish the production of acid, as well as to rob the bacteria of the organic matter necessary to their rapid development; (3) by prohibiting or limiting the consumption of such foods or luxuries, which readily undergo acid fermentation, to remove the chief source of the ferment products injurious to the teeth; (4) by the proper and intelligent use of antiseptics to destroy the bacteria, or at least to limit their number and activity' (p. 223).

What Miller wanted to say by mentioning as a possibility the 'proper and intelligent use of antiseptics' is elaborated in his book in great detail and is worth serious consideration by all those working on this problem today: 'If a very thorough mechanical cleansing has not preceded the antiseptic, its action upon the centers of decay will be equal to little more than zero' (p. 225 and 226). This remark is only one of the many warnings Miller gave as limitations to his general idea. Needless to say, Miller knew from his own investigations that even under optimum conditions not more than a temporary reduction of microbial counts was to be expected after the application of antiseptics.

One of the most interesting facettes of the book is Miller's misconception about the etiologic role of plaque. This is the more surprising since Miller nearly always was right with the interpretation of what he observed, if he was able to observe it. His failure to recognize the importance of plaque, and his persistence in denying it is perhaps explained by his clinical experience being inferior to that of his famous colleagues and opponents G.V. Black and J.L. Williams.

There is no doubt that Miller paid some attention to aggregates on the surface of teeth, because he states that he isolated 'more than one hundred different kinds of bacteria from the *juices and deposits* in the mouth' (p. 68; emphasis supplied by the editor). Nevertheless, Miller

remained reluctant, and from his many experiments, when using bacteria-containing saliva for acid production in vitro, he seemed to believe in the cariogenic effect of free acid in the oral cavity.

Under the impression of the evidence accumulated by Black and Williams, Miller in 1902 published an article on 'The Presence of Bacterial Plaques on the Surface of the Teeth, and Their Significance', in *Dental Cosmos* 44, 425–446; May (No. 5) 1902. He begins by defending himself and citing quotations from his earlier writings in which he had pointed at the presence of 'masses of bacteria' in a 'matrix' on the tooth surface — but the matrix he refers to is the enamel cuticle which is 'thickened and invaded by masses of bacteria'. Miller then enlarges on Williams' opinion that all softening of enamel in the caries process 'is due to the action of acids, and chiefly or wholly to the acids excreted by bacteria in situ'. Miller continues: 'Others, in commenting upon his communication, have, it seems to me, gone rather farther than Williams himself, and the view seems now to be rather prevalent that the bacteria coating the surface of the enamel cover or invest themselves with a gelatinous substance, underneath which they produce their acids directly in contact with the enamel, and that only acids produced beneath those films and protected from dissipation in the saliva by the films are responsible for the beginning of caries. Acids distributed in the saliva have no influence in causing caries'. Miller then goes on citing Black: 'Caries of the teeth has its beginning when the conditions of the mouth are such that microorganisms causing caries form gelatinous plaques, by which they are glued to the surface of the teeth'. Miller's lack of appreciation of these views culminates in the comment 'I am not convinced that the nature of this film has been determined with sufficient clearness, or whether its significance and importance may not have been somewhat overrated'.

From this statement it is obvious that Miller did not think of extracellular formation of polysaccharide as a specific factor in the cariogenic environment of the teeth. As a matter of fact Miller, in his book (pages 19, 22 and 23), did mention dextran formation as one of the metabolic activities bacteria may exert on carbohydrates, and he described the example of *Leuconostoc mesenteroides* in the molasses of sugar factories; this was mentioned, however, solely for the purpose of giving — as introduction — a complete systematic survey of what Miller called the 'vital manifestations of microorganisms'.

Miller's lack of recognition of the importance of plaque, and his experimenting in vitro with incubation mixtures of oral fluid and different carbohydrates explains why he considered starch to be more

cariogenic than sucrose. In a mixture of saliva and bacteria where there is no diffusion barrier, and where incubation for hours blurs the details of the degradation, addition of starch as substrate may result in formation of more acid than addition of sucrose. Miller thought that 'sugar, being readily soluble, is soon carried away or so diluted with the saliva as to be rendered harmless, whereas amylaceous matter (i.e. starch; edit.) adheres to the teeth for a greater length of time and consequently manifests a more continued action than sugar' (p. 207). Miller, however, adds a – presumably personal – communication saying that 'Busch, on the contrary, is of the opinion that 'baker caries' is due rather to the inhalation of sugar-dust than to that of flour-dust' (p. 207).

In spite of all limitations, Miller's 'Micro-Organisms of the Human Mouth' is highly rewarding reading matter; every page of it reflects stimulating ideas of a sparkling, creative mind – one of the greatest in dental science we ever had.