WHY TEETH ARE SUSCEPTIBLE TO CARIES? AN EVOLUTIONARY PERSPECTIVE

The question 'why we evolved to have dental caries?" was posed to me during the 2017 ORCA meeting with the challenge to share my answer to the broader community of cariologists. This manuscript is my response to the challenge and is centered on the premise of the question, evolution.

The reason why we humans experience dental caries can be thought as a consequence of the process of evolution. Within this process, is the concept of natural selection, which was discovered by Charles Darwin[1] and Alfred Russel Wallace[2]. The idea was championed in Charles Darwin's widely known book "On the Origin of Species."[3] By natural selection, our teeth became a mineralized structure that is susceptible to dissolution under acidic conditions. The mineralized structure is the result of a balanced act that is not perfect and is dictated by the behavior of charged particles near a semi-permeable membrane that can lead to an uneven distribution of minerals since different charged substances might be unable to pass the membrane, creating uneven electrical charges (the Gibbs-Donan effect).[4] This phenomenon potentially explains a variation of individual susceptibility to dental caries that innate, and adds to other factors such as influences of diet, quality of saliva, and oral hygiene behaviors.

One misconception regarding natural selection is that we are evolving to get more fit, and that means we are becoming better. Before talking about teeth specifically, let us think about two different organs. Bone, as an example, evolved to be a mineralized and though structure, but it is not unbreakable. It does not need to be. Under regular circumstances, the mineral density of bone in humans is sufficient for humans to survive and sustain their mobility. Bones will break if one falls from a certain height but the number of these events was not often enough to impact survival of our species and favor the ones that can survive long falls. From the bone metabolism standpoint, we seldom survived past young adult life and the consequences of ageing and osteopenia were never an issue. Another interesting organ is the brain. Human brains are unique in many ways and have evolved to accommodate complex cultural and linguistic abilities and other more advanced cognitive functions. Hence, the brain has a sophisticated ability to deduce cause, agency, and intent, therefore it can anticipate danger and formulate associations of predictive value that helped us survive.[5] The consequence of this ability to deduce cause is that humans now have a need to deduce cause. Fulfilling this need by anecdotal explanations that carry an emotional component are favored by many in contrast to information based on current evidence, which often needs to be processed and is not readily available to be used. Hence, superstitious and supernatural explanations of the natural world and the origin of the universe satisfy many people, despite some having college level education.

Back to teeth, human teeth evolved through natural selection to allow humans to obtain nutrients from solid foods, which allowed brain and other organs to become more sophisticated. Roots and raw vegetables required a powerful tool to be broken down and the human stomatognathic system can generate forces as strong as 350 lb.[6] While most other vertebrate species simply replace dentitions when they break, mammals have at most two generations of teeth, so fracture is not desirable. Human teeth, like of the other mammals, have composite structures and complex arrangements of mineralized matter that have evolved to resist fracture.[7] To make teeth harder, the easy solution was using calcium, which is the third most abundant metal in Earth's crust (fifth most common element), after iron and aluminum. Calcium reacts slowly with water but dissolves readily in dilute or concentrated acids. Individuals with softer teeth (less calcium content) probably had difficulties in gaining satisfactory levels of nutrition, had more fractures, and were less likely to survive and individuals with harder teeth were probably more successful. The ultimate consequence of this process was hard teeth rich in calcium but highly susceptible to acidic solutions. This was never an issue to humans until their diet dramatically changed with the introduction of refined sugars. Sugars provided bacteria in the biofilm with a "new" readily source of energy and that boosted the production of acids on top of tooth surfaces. The harder tooth, which evolved to be able to handle a raw diet, was not built to resist to low pH environments lasting long times and dental caries experience exploded in humans.

The increase in disease prevalence allowed for the observation of population patterns in which certain individuals appear to be more susceptible to the disease, whereas certain individuals appear to be resistant. Therefore, we believe it is worth defining the biological parameters, including genomic variation, that determine why certain individuals are more or less susceptible to dental caries. After working on this topic for more than a decade,[8,9] we realized this effort has been hampered by poor definitions of disease affection. Our latest approach has been to rethink how the phenotype can be defined and look for ways that patterns of disease progression can be used to understand the biological component modulating the host affected by dental caries.[10] We envision that one day we will use genomic information to decide how often individuals should be seen by the dentist, if they are more susceptible to demineralization, or if certain restorative treatments are more likely to fail.[11-13] Dental caries prevention may be tailored to the ones that will benefit the most and treatment will be centered to individual needs guided by biological predictors that can be defined at chairside.

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