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| **Name:** |
| Kelsey Cho |
| **Group:** |
| 4B-2  |
| **Basic Science Question:** |
| What is the mechanism of fluoride? |
| **Report:** |
| Fluoride is as an agent frequently used in many oral health products to reduce the incidence of dental caries. Fluoride reduces the incidence of dental caries mainly by inhibiting the demineralization and enhancing the remineralization of teeth. In order to more fully understand the mechanism in which fluoride is able to prevent dental caries, one must understand the components of teeth, namely enamel and dentin. Enamel and dentin are made up of inorganic material, organic material, and water (Bašić et al., 2013, 181). Caries mostly affect the mineral/inorganic component of enamel and dentin, known as hydroxyapatite. Hydroxyapatite is crystallized calcium phosphate (Bašić et al., 2013, 181). According to the National Center for Biotechnology Information, caries are defined as the “localized destruction of the tooth surface initiated by decalcification of the enamel, followed by enzymatic lysis of organic structures and leading to cavity formation” (NCBI, 1965-1966). More specifically, decalcification/demineralization occurs when bacteria located on the teeth ferment carbohydrates into acids that ultimately dissolve the hydroxyapatite crystals of the mineralized portion of teeth. The subsequent leeching of calcium and phosphate from the tooth can cause the formation of a cavity through collapse of tooth structure (Bašić et al., 2013, 182). One mechanism of action that fluoride has in order to inhibit caries formation is to inhibit this demineralization of tooth structure. It has been shown that fluoride in solution (like saliva) adsorbs to the surface of teeth and replaces the hydroxyl ions in hydroxyapatite to form fluorapatite. (Bašić et al., 2013, 183). Fluorapatite has a lower solubility than hydroxyapatite, which ultimately prevents dissolution of the mineralized component of teeth by acid (Bašić et al., 2013, 182). Another mechanism by which fluoride reduces the incidence of caries is that it enhances remineralization. Remineralization occurs when the calcium and phosphate that leech from the tooth during demineralization reabsorb into the tooth and rebuild the damaged hydroxyapatite crystals (Bašić et al., 2013, 183). Fluoride that is adsorbed to partially demineralized hydroxyapatite crystals attracts calcium ions to speed up the remineralization process (Bašić et al., 2013, 183). It is also worth noting that this remineralization also gives the tooth increased resistance (termed “acquired resistance”) to acidic degradation of tooth structure in the future (Bašić et al., 2013, 183).High fluoride concentrations (such as in toothpaste and professional gels/varnishes) are also associated with the formation of a compound called calcium fluoride on the enamel surface (Bašić et al., 2013, 184). In low pH environments, (such as with acid producing cariogenic bacteria) the calcium fluoride on the enamel surface dissolves, releasing calcium and fluoride ions into the oral environment (Bašić et al., 2013, 184). This ultimately serves a reservoir of fluoride ions on the enamel that can be released and used in acidic and cariogenic situations for the prevention of caries via the inhibition of demineralization and the enhancement of remineralization of tooth structure (Bašić et al., 2013, 184).Lastly, one controversial mechanism of fluoride in the prevention of caries is that it is antimicrobial. More specifically, fluoride can inhibit metabolism in bacteria. In an acidic environment, fluoride can diffuse into cariogenic bacteria as hydrogen fluoride (Bašić et al., 2013, 185). Hydrogen fluoride dissociates into hydrogen and fluoride ions within the cytoplasm of bacteria to acidify its cytoplasm (Bašić et al., 2013, 185). This acidification in turn inhibits the enzymes responsible for carbohydrate metabolism within bacteria (Bašić et al., 2013, 185). While it makes sense that an antimicrobial function of fluoride would prevent caries by killing cariogenic bacteria, it is important to note that there is still no general consensus that this mechanism directly prevents caries (Bašić et al., 2013, 185).Overall, fluoride is an agent that is commonly used in many oral health products in order to prevent the formation of dental caries. The prevention of dental caries can be attributed to two main mechanisms of fluoride: the inhibition of demineralization and the enhancement of mineralization. Fluoride can also create a natural reservoir of fluoride ions that is released in acidic conditions in order to inhibit caries formation through this inhibition of demineralization and enhancement of remineralization. Lastly, despite the controversy, fluoride’s antimicrobial properties should also be taken into consideration when evaluating fluoride’s possible mechanisms of action against caries formation. |
| **References:** |
| Bašić K, Peroš K, Rošin-Grget K, Sutej I,. The cariostatic mechanisms of fluoride. Acta Med Acad. 2013 Nov;42(2):179-88. doi: 10.5644/ama2006-124.85. PMID: 24308397.NCBI (National Center for Biotechnology Information). 1965-1966. Dental Caries [Internet]. [Cited 10 November 2020.] Available from https://www.ncbi.nlm.nih.gov/mesh/68003731 |