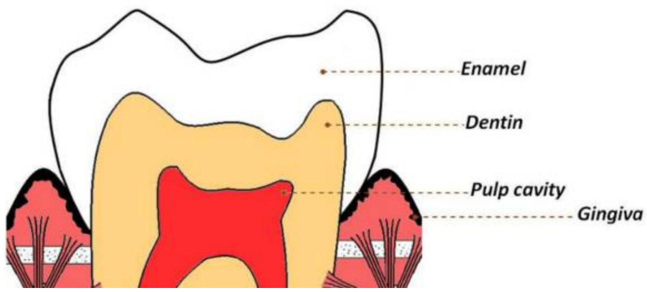
Hydroxyapatite vs Fluoride Toothpastes

Tooth Structure Basics: Enamel is the layer of tissue that covers the crown of the tooth (the tooth's outermost layer). The layer just inside the enamel is referred to as Dentin, and it makes up the bulk of the tooth's crown and roots. Both Enamel and Dentin have a structural makeup with very high concentrations of calcium phosphates. The enamel structure is composed of prisms of very large crystals (much larger than those crystal prisms that make up bone structure).

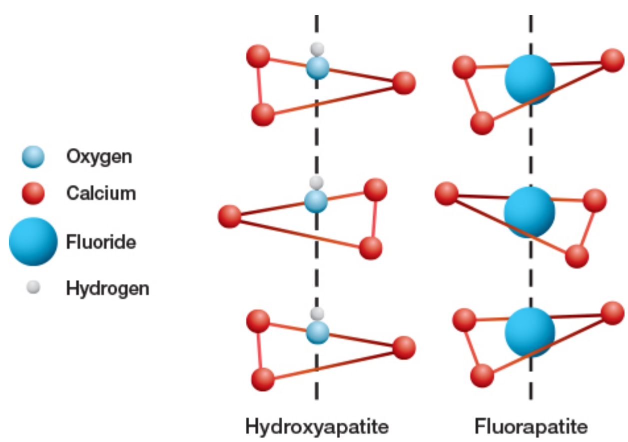


Below the enamel is the dentin, which is also largely inorganic. Dentin is the main building material of the tooth, forming most of the roots and the crown. The crystals (actually called "apatite" crystals) that make up enamel are much larger than those that make up dentin, and the apatite crystals that build dentin are much larger than those found in bone.

Apatite molecules are phosphate minerals. When combined with calcium and either hydroxyl groups or fluoride groups, they become calcium phosphates (Hydroxyapatite and Fluorapatite, respectively).

What on earth does all that mean? Basically, there are a couple of naturally occurring molecules that the body uses to build a tooth, and once broken down, to rebuild that same tooth.

The structure of these two molecules is very similar, with their interior representing a noticeable difference. The interior structure of each molecule is occupied by either a hydroxyl group (O and H), or a fluoride group (F). In part, owing to its larger molecule, the fluorapatite (the molecule containing fluoride) is considered more durable and more resistant to breaking down by the oral bacteria that cause cavities.



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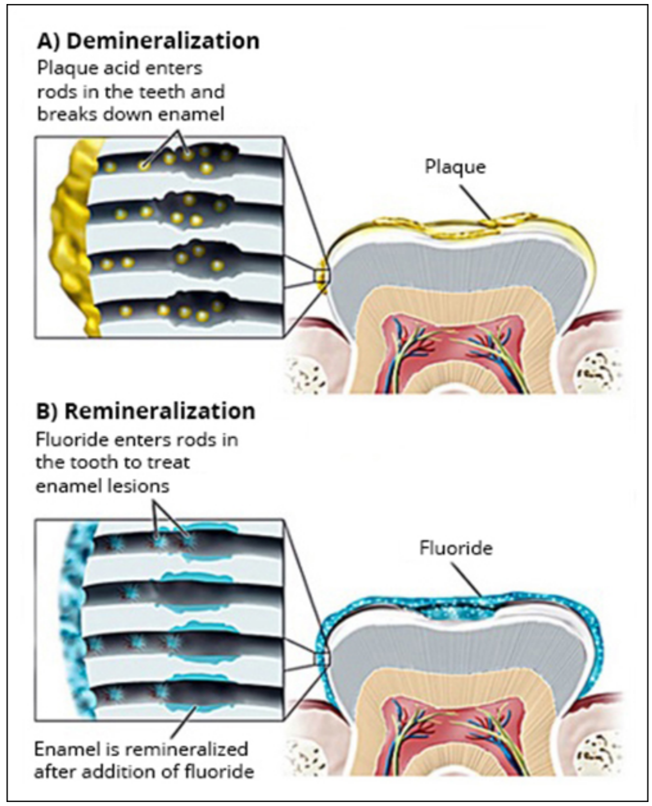
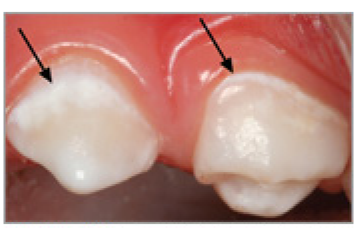


The breakdown of the hydroxyapatite can lead to the irreversible destruction commonly referred to as a cavity. Cavities, if untreated, can lead to pain, infection and even tooth loss (in baby teeth and in permanent teeth). Hydroxyapatite is a crystalline structure that makes up the majority, by mineral content, of the Enamel and Dentin. Hydroxyapatite is a mineral composed of calcium and phosphate ions (Calcium Phosphate), and its dense, compact arrangement in the enamel is what gives this outer layer of tooth its strength to withstand biting forces and resist bacterial attack.

Under normal oral conditions, there is a natural supply of hydroxyapatite in both the tooth structures and in the saliva. In a process known as demineralization (the breakdown of the tooth), calcium and phosphate ions are lost from the tooth structure. Remineralization is the opposite process, one that adds calcium and phosphate ions from the saliva back to the enamel.



Dental cavity formation, in its earliest stages (enamel white spot lesion formation, see image to the left) occurs as the demineralization of the tooth structure is happening at a greater rate than remineralization is possible. If untreated, these white spot lesions (item A in image below), can progress to active caries lesions (cavities) (items B and C in image below).

Hydroxyapatite toothpastes were originally developed pre-1970 by NASA for their astronauts who, in the absence of gravity, were losing mineral content in the bones and teeth. 1970 marks the year the first commercially available hydroxyapatite toothpaste was marketed, based on the rights they purchased from NASA.

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Toothpastes containing hydroxyapatite particles provide the saliva with increased calcium and phosphate ion concentration, either in the micro- or nanoycrystalline form. These particles have been found to bind to the damaged/demineralized areas of the enamel (white spot lesions) and help to fill (remineralize) these irregularities.

This occurs in much the same way that fluoride remineralizes the enamel crystalline structure, however fluoride combines with calcium and phosphate ions to form a structure called fluorapatite. Fluorapatite is less soluble than hydroxyapatite, and so in acidic conditions (when bacteria are most active/during cavity formation), fluorapatite tends to be more resistant to demineralization.

In children who are at elevated risk for fluorosis (too much combined fluoride in water or food), hydroxyapatite toothpastes are gaining traction as fluoride-free alternatives to traditional fluoridated toothpastes. Though there now exist a few peer-reviewed studies supportive of hydroxyapatite toothpastes as an alternative to fluoride toothpastes (sourced below), for now fluoride toothpastes continue to be the cornerstone in the remineralization process of the dentin and enamel, and ultimately in the prevention of dental cavities.

Amaechi, BT, et al. 2019. Comparative efficacy of a hydroxyapatite and fluoride toothpaste for prevention and remineralization of dental caries in children.

O'Hagan-Wong, K, et al. Nov 2022. The use of hydroxyapatite toothpaste to prevent dental caries.

Pajor, K, et al. Aug 2022. Hydroxyapatite and Fluorapatite in conservative dentistry and oral implantology–A Review.