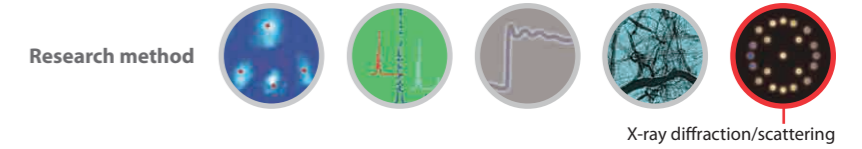


# Development of Anti-carries Chewing Gum

Crystallographic visualization of the process of restoration after early-stage caries



Beamline used at SPring-8: High Flux (BL40XU)

Award for this research: The 8<sup>th</sup> Hyogo SPring-8 Award (2010)

## Achievements

- First observation of crystal-structure changes involving **demineralization** and remineralization associated with **early-stage caries\*** (tooth decay)
- Restoring lost crystals by supplying **phosphoryl oligosaccharides of calcium\*\*** in cases of early-stage caries
- Development and commercialization of anti-carries chewing gum† containing phosphoryl oligosaccharides of calcium

R&D facility: Ezaki Glico Co., Ltd.

† This anti-carries chewing gum is approved as a Food for Specified Health Use (September 30, 2010)

**\*Early-stage caries:** Oral bacteria produce acids from carbohydrates contained in food, and these acids decay tooth crystals composed of phosphorus and calcium (**demineralization**). This mineral loss is termed early-stage caries. **Remineralization**, which refers to the process of restoring minerals lost in demineralization, allows recovery from early-stage caries.

**\*\*Phosphoryl oligosaccharides of calcium:** Phosphoryl oligosaccharides of calcium is a mineral that can be produced from potato starch. The compound is highly soluble in saliva. Caries-causing bacteria cannot use this compound to produce acids that cause caries.

## Role of SPring-8

### Background

When early-stage caries advances, the tooth surface is eroded and tooth cavities (cariou pits) develop. Tooth drilling is required to treat these cavities; therefore, preventive care such as regular tooth brushing has been recommended to remove caries-causing plaque.

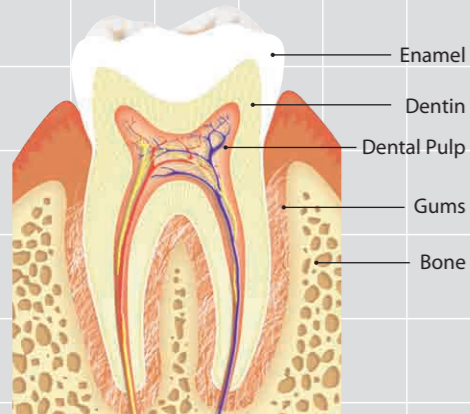
Recently, research on regenerating minerals eroded during demineralization, remineralization, has been conducted. These studies revealed that phosphoryl oligosaccharides of calcium, a relatively recently synthesized compound, can facilitate remineralization on the tooth. However, conventional experimental techniques can only evaluate changes in quantitative factors such as mineral content and hardness of the tooth; they cannot measure detailed changes in crystallization that determines the strength of the tooth. For these latter purposes, we turned to X-ray crystallographic studies.

### Results

Tooth crystals are eroded on scales of ~0.1 mm in early-stage caries; therefore, measurement at the micrometer (μm) level is required in order to examine **changes in the crystals**. Such fine measurements can only be achieved using X-ray microbeams at SPring-8. To this end, early-stage caries were experimentally generated on enamel samples extracted from bovine teeth; these samples were then subjected to remineralization for a certain period of time in human oral cavities. Remineralization was achieved through the chewing of gum that contained phosphoryl oligosaccharides of calcium. Healthy, demineralized, and remineralized areas were then analyzed using X-ray microbeams. This experiment revealed that demineralization occurs at the crystal level but not at the atomic level, the amount of crystals as well as mineral content in the remineralized area increases, and the crystals are oriented in the same manner found in a healthy tooth.

### Tooth structure and early-stage caries

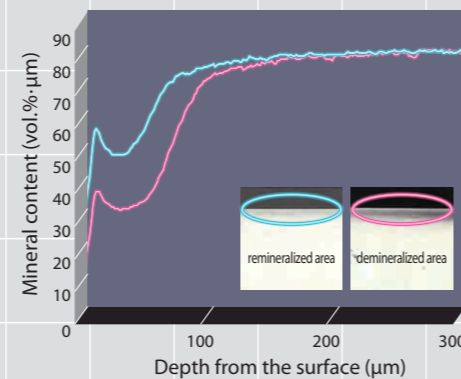
In the early-stage caries, minerals inside the enamel are eroded (demineralization) and the demineralized area becomes cloudy compared to the surrounding healthy area. At this stage, if phosphate and calcium ions in saliva are supplied to the demineralized area, remineralization can be induced.



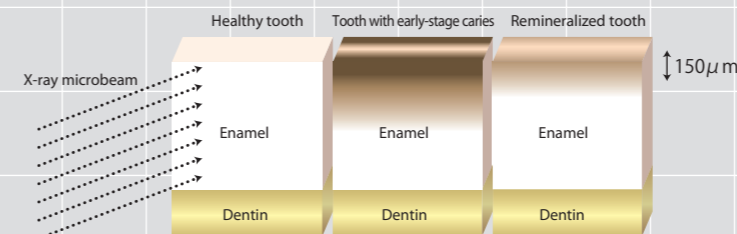
### Demonstration of recrystallization induced by phosphoryl oligosaccharides of calcium

#### Changes in mineral content Measured using conventional transversal microradiography

Mineral content decreases in the demineralized area (red), while it is restored in the remineralized area (blue).

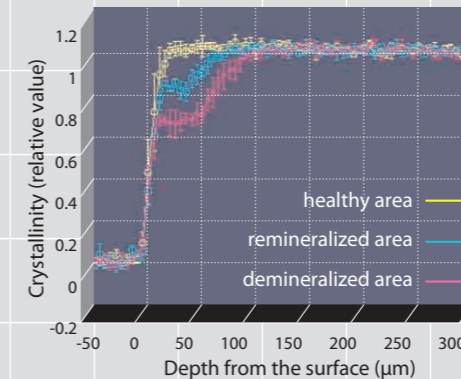


Publication: N. Yagi et al.; Journal of Synchrotron Radiation **16** (3), 398-404 (2009)  
T. Tanaka et al.; Caries Research **44** (3), 253-259 (2010)

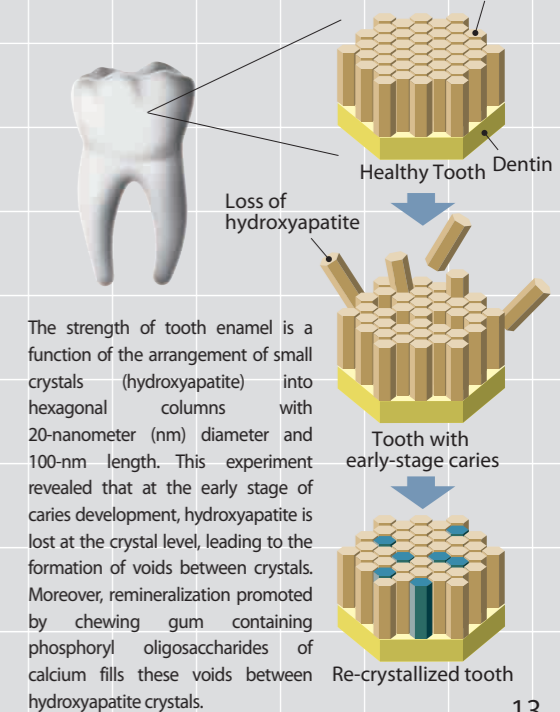


#### Changes in crystallinity Measured using X-ray microbeams at SPring-8

Crystallinity of the demineralized area (red) is degraded compared to the healthy area (yellow), while crystallinity in the remineralized area (blue) is restored.



### Phosphoryl oligosaccharides of calcium can facilitate recovery from early-stage caries



The strength of tooth enamel is a function of the arrangement of small crystals (hydroxyapatite) into hexagonal columns with 20-nanometer (nm) diameter and 100-nm length. This experiment revealed that at the early stage of caries development, hydroxyapatite is lost at the crystal level, leading to the formation of voids between crystals. Moreover, remineralization promoted by chewing gum containing phosphoryl oligosaccharides of calcium fills these voids between hydroxyapatite crystals.