Every mouth is an ecosystem, with millions of interactions between the human body and the bacteria, fungi, and other organisms that call it home. Dr. Hyun (Michel) Koo, Professor of Orthodontics and Divisions of Pediatric Dentistry and Community Oral Health at Penn Dental Medicine, wants to find out how to alter these interactions to prevent oral disease.

“The major mission in our group is to look for ways to prevent disease that are more efficacious, and preferably cheaper,” says Dr. Koo. “We are trying to tap into every single possibility across Penn’s rich research environment. We are looking at chemicals in food waste products, to nanotechnology in collaboration with engineers and with chemists, and to biotechnology and other fields of research that can provide us with out-of-the-box thinking.”

A STICKY SITUATION

Dr. Koo focuses on microbes such as the bacterium Streptococcus mutans, which causes dental caries, also known as tooth decay or cavities. These microbes feed off sugar, producing acids that cause teeth to erode—and they are very hard to get rid of.

That’s partly because the bacteria form a “biofilm” on the teeth—commonly known as dental plaque—which consists of a sticky mix of microbes and glue-like polymers that attach themselves to one another and to the tooth. Plaque helps bacteria stay in place to promote increased acidity on the tooth surface, which contributes to tooth decay.

“If you’re only killing the bacteria, you’re just doing half of the job,” he notes. “You have to actually break down the polymers to remove the plaque.”

DELIVERING DISRUPTION—PRECISIONLY

A therapy that disrupts the biofilm might make S. mutans less able to cause decay. Dr. Koo has searched for such a compound in unlikely places—from cranberries to food waste to beehives—and uncovered substances that seem to inhibit plaque formation. Now he is looking for new ways to deliver these anti-plaque agents along with existing therapies like fluoride. Always ready to think outside of traditional boundaries, Dr. Koo has teamed up with Penn Dental Medicine’s Dr. Henry Daniell to explore the possibility of delivering antimicrobial and anti-plaque compounds through bioengineered lettuce that is powdered and freeze-dried.

“Penn is a unique environment where you can collaborate with top scientists with diverse expertise,” says Dr. Koo, who is working with Dr. Daniell to bring a workable, low-cost treatment to market, with support from Johnson & Johnson.
Dr. Koo is also collaborating with colleagues at Penn Engineering on new delivery methods that incorporate nanotechnology—for instance, using nanoparticles that disrupt biofilms and tiny carrier molecules that will release cavity-fighting substances when they come into contact with the acidic biofilm environment.

**INTERRUPTING A CROSS-KINGDOM THREAT**

In 2014, Dr. Koo and colleagues discovered that *Streptococcus* bacteria have help from an unusual partner in building biofilm. They found that the fungus *Candida albicans* can help *S. mutans* produce large amounts of gluey polymers when exposed to sugars. This “cross-kingdom” interaction (bacteria and fungi are in different “kingdoms” of organisms) puts biofilm production into overdrive, boosting the colonizing ability of both microorganisms on the surface of the teeth.

The *S. mutans-C. albicans* partnership may be the culprit behind extreme tooth decay commonly found in underprivileged children. “We think one of the reasons for these really severe cavities is that bacteria are working together with fungi,” Dr. Koo says. “Hopefully by better understanding the mechanisms we can find superior therapies.” His lab is also working to identify which children are more likely to get the severe form of early childhood caries, looking at the microbes involved to indicate the aggressiveness of the infection.

**STRONGER, BETTER, CHEAPER**

Dr. Koo has long been concerned with helping the people who suffer the most from caries and yet are least able to afford dental care. Finding therapies that are both cheaper and more effective than fluoride toothpaste takes patience—and an inquisitiveness that has taken Dr. Koo from the Amazon rainforest to the slums of São Paolo to Penn, where interdisciplinary connections and a growing dental research enterprise put him in an influential position.

“We have all the minds, all the experts in different fields,” Dr. Koo says. “With help from donors, Penn Dental Medicine can be a real leader in finding new therapies that target underprivileged populations both locally and globally.”

**MORE INFORMATION**

For more information on how to support the research of Dr. Koo, contact Elizabeth Ketterlinus, Senior Associate Dean for Development & Alumni Relations, ekett@upenn.edu, 215-898-3328.

**FIGHTING A LIFELONG MENACE**

Early childhood tooth decay is a public health menace because it affects so many children and is extremely aggressive and difficult to treat. The lesions can easily reach the nerve of the tooth and spread to other tissues.

“We’ve had times where children had to be hospitalized because of spread of the infection,” says Dr. Betty Harokopakis-Hajishengallis, Chief of Penn Dental Medicine’s Division of Pediatric Dentistry.

Children with early childhood caries also tend to stay at risk for developing caries later, but Dr. Koo’s work may be able to help.

“A treatment that disrupts the biofilm and the *S. mutans-C. albicans* partnership could be a helpful addition to existing fluoride treatments, especially if it can be given in a way that lasts over time,” he notes. “New therapies need to be affordable, as the disease affects mostly children and families of low socioeconomic status.”