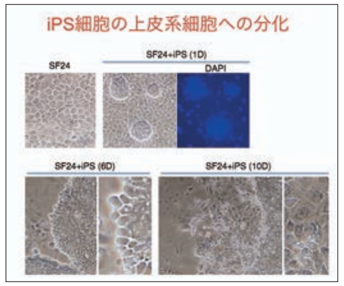
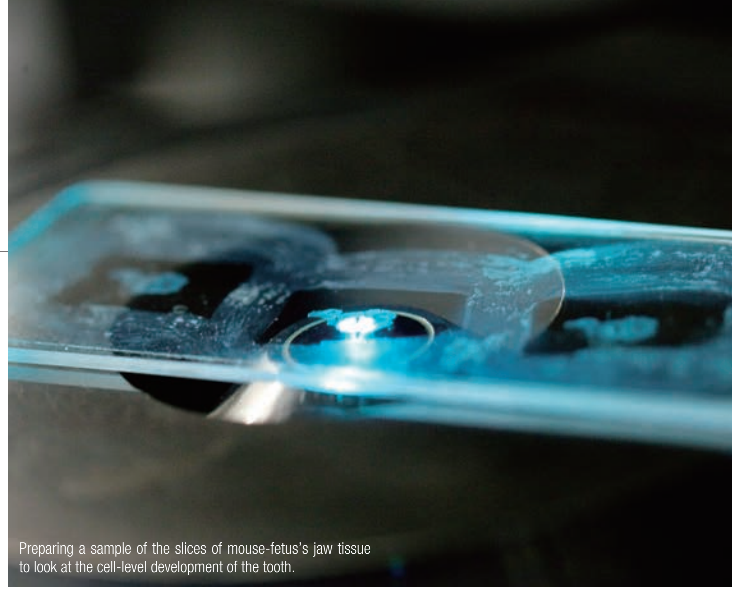
Regeneration of Teeth

Successfully Induced Enamel Forming Ameloblasts from iPS Cells



After the adult teeth have been formed, the cells that play a role in producing enamel in a human's body disappear, and consequently new teeth are never formed again.



Preparing a sample of the slices of mouse-fetus's jaw tissue to look at the cell-level development of the tooth.

In humans, primary teeth are replaced by permanent teeth. Once permanent teeth are lost, they do not regenerate. Using mouse iPS cells, Professor Fukumoto succeeded, for the first time in the world, in producing the cells involved in the formation of enamel, which is the hardest substance of the tooth. This achievement may reveal the possibility for the regeneration of teeth that do not develop again once they have been lost.

Dental enamel is the hardest tissue in a human's body. Ameloblasts differentiated from dental epithelial cells that exist in the oral mucosa secrete enamel on the surface of the dentin of a developing tooth and enamel-covered teeth are formed. In humans, once the adult teeth have been formed, the ameloblasts disappear and teeth cannot be formed any more.

Professor Fukumoto pondered the discovery that human teratomas originally contain quantities of tissues of hair, bone and teeth, and he began to conduct regeneration research of teeth. "In 2006, Professor Yamanaka's research group at Kyoto University succeeded in producing iPS cells. Immediately, we were provided with their iPS cells and tried to culture them in the cell line of dental epithelium. We found that ameloblastin was expressed in the cultured iPS cells. The ameloblastin is one of the enamel matrix protein secreted by ameloblast. Our research had progressed to this stage by 2008, however, we lost every sample when the Great East Japan Earthquake occurred in 2011. We had to start from the beginning again," says Professor Fukumoto.

Professor Fukumoto is at present promoting gene-level research on how the kind and size of teeth are determined, which is an important point in regenerating human teeth. When this mechanism has been revealed, it will give great impetus to the research of regenerating lost teeth.

Besides actively doing research, Professor Fukumoto frequently holds visiting lectures for dentists, public health nurses, school teachers and elementary school students. "There is a long way to go before regeneration technology of human teeth is established. That's why we should take good care of our teeth," appeals Professor Fukumoto. Such words from a top researcher in the field of state-of-the-art technology are very persuasive.

Teeth formed in the human jaw (x-ray photograph).

The mechanism for regenerating teeth has been revealed, however, there are still many challenges to be overcome for regenerating human teeth.

Students gathering in this laboratory are those who have an interest in regeneration medicine.

Division of Pediatric Dentistry,
Department of Oral Health and Development Sciences,
Graduate School of Dentistry

Professor

Satoshi Fukumoto

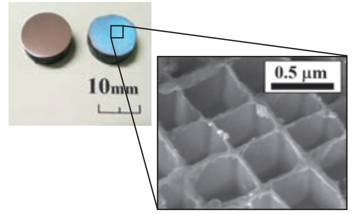
Born in 1969 in Okayama Prefecture. He graduated from the Nagasaki University Graduate School of Dentistry. He has worked at Nagasaki University, Nagoya University and National Institute of Health (NIH). After serving as associate professor at Kyushu University, Professor Fukumoto has served in his current post since 2007.

http://www.dent.tohoku.ac.jp/field/health/02/

Improving the Efficiency of Energy Utilization

Optimized Spectral Control of Thermal Radiation to Attain High Efficiency Energy Utilization

Experimental electricity generating equipment of a thermo-photovoltaic system using concentrated sunlight. The photo on the lower right corner shows the sunlight irradiation.



Research on energy conversion with high efficiency by spectral control of thermal radiation is at the stage of application for practical use.

Professor Yugami's laboratory is working on research involved with efficient utilization of renewable energy such as solar energy and hydrogen. One of their main research topics is the spectral control of thermal radiation, which relates to a technology to allow specific wavelength of light to be absorbed or reflected on microstructures fabricated on the surface of the material.

In conventional technology, only a 1 x 1 cm square or so square area of the microstructure could be fabricated on the surface of materials. For practical application, a much larger area of surface-microstructure is required, and the materials used for the product need to be tolerant of temperature above 600 degrees Centigrade. By optimally controlling the metal microstructure, Professor Yugami has successfully developed a technology to fabricate surface-microstructures over large area.

Today, solar thermo-photovoltaic power generation as well as photovoltaic power generation has become popular throughout the world, and the application of research achievements are expected in these fields. In addition, research on thermo-photovoltaic power generation is progressing. In photovoltaic power generation, electrical power is generated by solar radiation acting on solar cells. The conversion efficiency of the widely-used silicon solar cell panels is only about 15-16%. This low efficiency is due to poor matching between the silicon and the wavelength of the solar radiation. On the other hand, a thermo-photovoltaic system has an emitter that receives thermal energy and emits thermal radiation, which is converted into electricity with photovoltaic cells. Because of selective emission of radiation-wavelengths, spectral control of thermal radiation is possible, and this leads to the possibility of achieving a high generating efficiency. In addition to solar energy, thermo-photovoltaic systems are capable of using a variety of heat sources, including industrial waste heat. The current generating efficiency is about 15% at the maximum, but Professor Yugami predicts this can be greatly improved.

In 2012, Tohoku University launched a five-year Program for Leading Graduate Schools, which combines Master's Course and Doctoral Course. The Inter-Graduate School Doctoral Degree Program on Science for Global Safety is the first program that has been implemented in the Leading Program. The program is implemented in the collaboration between researchers in science and technology and researchers in human and social sciences, and covers a multidisciplinary field of safety and security. Global safety and security has become a prime issue after the 2011 Great East Japan Earthquake. Based on the three perspectives of "knowing safety and security," "creating safety and security" and "living in safety and security," Professor Yugami, serving as program coordinator, is devoted to fostering students to become excellent global leaders capable of playing noticeable roles involved in the science for global safety and security in the world.

In Professor Yugami's Laboratory, young researchers, who look ahead from an engineering viewpoint to future environmental issues.

Professor Yugami, who leads the Program for Leading Graduate Schools, is devoted to fostering the next generation of researchers.

Steady data accumulation leads to cues for new technological development.

Born in 1960 in Fukui Prefecture. Awarded his doctoral degree in Engineering from Osaka University in 1987. After serving as assistant professor at the Research Institute for Scientific Measurements, Tohoku University, and as associate professor in the School of Engineering at the same university, Professor Yugami has been at his present post since 2001. Since 2012, he has been a program coordinator for the "Inter-Graduate School Doctoral Degree Program on Science for Global Safety," which is part of MEXT's Program for Leading Graduate Schools.

Energy System Engineering,
Department of Mechanical Systems and Design,
Graduate School of Engineering

Professor

Hiroo Yugami

http://www.energy.mech.tohoku.ac.jp/