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# Lightning Revolution. The luminous enzyme "luciferase" could replace electric light bulbs

**A light bulb. A simple device converting electricity into light. Thomas Edison's revolutionary invention has made our daily lives easier for over 140 years. But can the light bulb be replaced? Yes, it can. Scientists Martin Marek, Martin Toul, and Andrea Schenkmayerová from the Loschmidt Laboratories, RECETOX, Faculty of Science, MUNI have described an innovative and sustainable way to produce light. They have clarified the mysterious illumination mechanism of the sea cnidarians' luciferase,** *Renilla reinformis***, which could light up our streets in the future.**

In the 19th century, Thomas Edison was not afraid to experiment, and his scientific research led him to invent the light bulb, which caused a technical revolution. However, the current energy crisis is forcing people to find other sustainable and environmentally friendly light sources. Scientists have been inspired by organisms living on the seabed and ocean floor with the ability to produce and emit "cold" light, known as bioluminescence. Brno scientists **Martin Marek Martin Toul and Andrea Schenkmayerová from the Loschmidt Laboratories** have described the luminescence process of enzymes called luciferases and explained its mechanism in detail. Scientists from all over the world have been trying to explain this process for the last forty years. However, Martin Marek and Martin Toul used a model organism, the sea coral *Renilla reniformis*, which enabled them to reveal its molecular basis.

Biologist **Martin Marek** says: *"The planet's resources are not endless. We constantly use fossil fuels that are not renewable, and their massive use negatively impacts the global ecosystem and human health. Luminescent enzymes could be used in our everyday lives and not just in laboratories where they are commonly used. And just by mapping the bioluminescence process in detail at the molecular level, we are a few steps closer to doing just that. Heat is released when a light bulb shines, whereas luciferases do not release heat and can convert energy into light very efficiently. Our discovery represents a luminous revolution."*

Scientists from the Loschmidt laboratories were able to capture the glowing enzyme in action with the use of X-ray crystallography. Martin Marek, Martin Toul and Andrea Schenkmayerová monitored the structure of the enzyme when a luciferin was being bound, whose subsequent chemical transformation generated light. It allowed them to describe in detail the reaction in the enzyme. They also reconstructed the ancestor of today's enzyme luciferase, *Renilla reniformis*, with the protein engineering methods and revealed the secret of its evolution from the original non-luminous enzyme. *"It was clockwork. We developed several possible ancestors from the enzyme and then compared them. Thanks to it, we have a more precise understanding of how they evolved from each other and in which aspects they gradually improved to form today's high-intensity light-emitting enzyme. It will now allow us to push the new luciferases further and make their light even more efficient,"* **Martin Toul** explains the search process.

However, scientists are currently facing another research question: how long the enzyme can shine without interruption? So far, under laboratory conditions, luciferase has lit up a test tube for 48 hours. *"We still do not know how living organisms synthesize the energy-rich luciferin. Just as a nuclear reactor needs fuel in the form of enriched uranium, so luciferases need fuel for their operation, and that is luciferin. We have mastered methods to synthesize luciferins chemically in the laboratory, but this process is economically inefficient for practical use. We need to unravel the biosynthetic pathways leading to the formation of luciferins and their recycling in cells to able to construct a genetically encoded and energy-independent light source,"* outlines **Martin Marek** the future research pathways who currently looks for investors to support the development of these technologies.

Scientists worldwide are already looking at how to use bioluminescent organisms for lighting. The findings of Brno scientists in collaboration with French colleagues will make it possible to bring this idea to everyday life.

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**Martin Toul** works as a researcher in the Protein Engineering team at Loschmidt Laboratories, RECETOX, Faculty of Science, MUNI, under the supervision of prof. Zbyněk Prokop and prof. Jiří Damborský. In 2020 he was awarded a Fulbright Postdoctoral Fellowship for Ph.D. students, thanks to which he spent a semester at the University of Texas at Austin in the group of prof. Kenneth A. Johnson.

**Martin Marek** leads the Structural Biology research group in Loschmidt Laboratories, RECETOX, Faculty of Science, MUNI. For his project "Decoding the molecular principles of enzyme evolution," he received financial support from the Grant Agency of Masaryk University (GAMU) in the category for venture projects that have a real potential to push the boundaries of his field.

**Andrea Schenkmayerová** works in structural biology and protein engineering. In 2019, she participated in a prestigious scientific workshop organized by the University of Cape Town, South Africa. The international committee awarded her poster, "Structural analysis of a haloalkane dehalogenase from subfamily HLD-III" as the best one in its category.

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