Boehringer Ingelheim Stiftung

Spot on for brain research: controlling nerve cells with light – 100,000-euro Heinrich Wieland Prize goes to Gero Miesenböck

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Mainz, Germany, November 3, 2015: Gero Miesenböck was the first to insert a light-controlled on/off switch into brain cells. His pioneering method allows scientists to switch nerve cells on and off selectively and observe how the behaviour of, for example, fruit flies or mice changes as a result. In this way, researchers can learn in a step-by-step process what behaviour the studied brain circuits control and what goes awry in disease. For his method, hailed as a "breakthrough of the decade," Professor Gero Miesenböck of the University of Oxford will receive the 100,000-euro Heinrich Wieland Prize of the Boehringer Ingelheim Foundation in Munich on November 6, 2015.

Optogenetics – derived from optics (the study of light) and genetics (the study of heredity) – has put seven-league boots onto the feet of brain research. It has shown which nerve cells wake us up and has helped to clarify how cocaine and other drugs re-program the reward system of the brain. Researchers have used it to restore lost memories, demonstrating that in some cases the memory itself is still intact and only its retrieval impaired. Optogenetics has revealed that the neuronal basis for "typical male" behaviour also slumbers within the female mouse brain. And in mice with Parkinson's disease it has turned the typical shuffling gait into sure steps once again. This year, researchers will use optogenetics for the first time to attempt to restore vision in blind people.

In order to deal with the challenges of life, different types of nerve cells in the brains of animals – and humans – are wired together into circuits. These circuits compare incoming signals, measure time, store memories, etc. When several of these circuits work together, they can master complex tasks, such as choosing between buying the red pullover and saving for that beach holiday.

Thanks to Miesenböck's optogenetic method, we can study such circuits much more precisely than before – and in the living brain. The approach provides something akin to a "magic wand" for controlling different nerve cell types within intact circuits, at the speed of thought.

He remembers the moment well: Late in the afternoon of June 12, 1999, Miesenböck had the inspiration that led to the birth of optogenetics. He modified nerve cells genetically so they produced proteins whose activity could be controlled with light. Thanks to these protein switches, the nerve cells responded to illumination with electrical impulses. However, Miesenböck needed to make sure that only the cells he wanted to study contained the switches. He did so by coupling the genes for the switches with gene sequences that are only active in the targeted cell types. Thus only the cell types of interest became responsive to light. "Miesenböck's great achievement was to insert light-regulated proteins into specific cell types and thus pave the way to turn nerve cells on and off quickly, simply, and reliably. This is why we have selected him as the recipient of the Heinrich Wieland Prize 2015," says Professor Wolfgang Baumeister, chair of the scientific selection committee of the Heinrich Wieland Prize.

“From the moment we conducted our first successful experiments, I knew this method would give us new kinds of insight into the brain. But the speed at which it has spread and been improved upon by other researchers still surprises me,” says Miesenböck. “Today, every other research group in neurobiology uses optogenetics to answer questions such as how our brain makes decisions, why we feel down, and what determines our appetite.”

Before optogenetics, researchers were able to control either a single cell or all cells and cell types within a given brain region by implanting electrodes. Now they can target one or several cell types even if they are spread out over the entire brain. A further advantage of optogenetics is that light signals can be turned on and off at the same speed at which nerve cells operate. Unlike other methods, it allows researchers to influence the brain circuits directly and thus also the behaviour of animals, as Miesenböck showed for the first time in 2005. Since its first use in cell culture in 2002, Miesenböck and other researchers have developed and improved upon the original idea. Nowadays researchers use switches tuned to different wavelengths to study several cell types and their interplay at the same time. (To read more about the method, see the information box on optogenetics.)

On the occasion of the presentation ceremony on November 6, 2015, the Boehringer Ingelheim Foundation will hold a scientific symposium on optogenetics at Nymphenburg Palace in Munich, Germany. In addition to a talk by the recipient of the Heinrich Wieland Prize 2015, there will be lectures by Professor Christian Lüscher, Professor Botond Roska, and Professor Arthur Konnerth dealing with their work on optogenetics, addiction, Alzheimer’s disease, and cures for blindness. All three speakers are internationally acclaimed scientists in their respective fields. The laudation will be given by Nobel Prize Laureate Professor Bert Sakmann. The programme of the English-language symposium is attached.

Journalists are welcome to attend and should contact Kirsten Achenbach at +49 6131-2750816 or write an e-mail to hwp@bistiftung.de. We will be happy to arrange interviews with the awardee or the speakers.

Gero Miesenböck – the laureate

Gero Miesenböck studied medicine at the University of Innsbruck, Austria, and conducted postdoctoral research at the Memorial Sloan-Kettering Cancer Center, New York, USA. He was a member of the faculty at Cornell University and Yale University, USA, before joining the University of Oxford, UK, in 2007, where he is now Waynflete Professor of Physiology and founding director of the Centre for Neural Circuits and Behaviour.

Optogenetics – the method

To switch specific nerve cells on and off using light, Gero Miesenböck initially transferred three different fruit fly genes into the brains of mice. As revolutionary as the concept was, its first application was cumbersome and the cells’ reaction was delayed by several seconds. However, within a few years’ time, Miesenböck and other researchers found ways to control the activity of nerve cells in millisecond intervals by transferring a single gene.

Today, researchers use a class of proteins called channelrhodopsins as switches. These proteins stem from single-celled organisms, fungi, and algae. Despite their primitive origin, even mammalian cells can easily incorporate them into their membranes. As the name implies, these proteins form channels within the cell membrane that open in response to light. Upon being activated by light, ions flow into or out of the cell, depending on the channel type. These ion flows cause the nerve cell to start or cease firing. Through this mechanism, researchers can switch the altered nerve cells on or off through an external light impulse.

Heinrich Wieland Prize – the award

This international award honours outstanding research on biologically active molecules and systems in the fields of chemistry, biochemistry and physiology as well as their clinical importance. The 100,000-euro prize is named after the Nobel Laureate Heinrich Otto Wieland (1877–1957) and has been awarded annually since 1964. Among the awardees – selected by a scientific Board of Trustees – are four later Nobel Laureates. Since 2011, the prize has been endowed by the Boehringer Ingelheim Foundation. www.heinrich-wieland-prize.de

Boehringer Ingelheim Foundation – the donor

The Boehringer Ingelheim Foundation is a charitable foundation. It was established in 1977 by Hubertus Liebrecht (1931 – 1991), a member of the shareholder family of the company Boehringer Ingelheim. The foundation aims to support excellent scientific work in medicine, biology, chemistry, and pharmacy. With its PLUS 3 Perspectives Programme and the Exploration Grants, the foundation supports junior group leaders. It also provides funds of 100 million euros over ten years to support the scientific running of the Institute of Molecular Biology (IMB) and 50 million euros for the development of the life sciences at the University of Mainz. The foundation also endows the internationally renowned Heinrich Wieland Prize and the Boehringer Ingelheim Prize for outstanding research in clinical and theoretical medicine at the University of Mainz. www.bistiftung.de

High resolution images are available:

Image Miesenböck:

Caption: Gero Miesenböck, Professor at the University of Oxford, UK, receives the 100,000 euro Heinrich Wieland Prize of the Boehringer Ingelheim Foundation for his concept of optogenetics.

Image fruit fly brain:

Caption: Optogenetics allows to control nerve cells with a light signal and thus analyse the workings of the brain. The image shows the brain of a fruit fly. The nerve cells shown in magenta are altered in such a way as to respond to the light signal (shown in the same colour).

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