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Okayama University research: Numerical modelling to assist the development of a retinal prosthesis

(Okayama, 15 July) **Researchers at Okayama University report in the *Journal of Neural Engineering* how numerical modelling provides insights into the functioning of a candidate retinal prosthesis for restoring vision in blind people. The model shows that the prosthesis is likely capable of triggering the right electrical responses needed for generating vision in ambient conditions.**

Retinal prostheses are a promising approach for restoring vision in patients suffering from diseases causing blindness. In retinitis pigmentosa, blindness is caused by dying photoreceptor cells, which form one of several cell layers in the mammalian retina. At Okayama University, a retinal prosthesis called Okayama University-type retinal prosthesis (OUReP) has been developed for treating retinitis pigmentosa and similar diseases. It has been successfully implanted in rat and monkey eyes. The key component of OUReP are organic molecules that can convert light into electric potentials. While it has been demonstrated that this conversion process indeed happens in an implant, the precise mechanism of how it stimulates a degenerated retina is not known. Now, Associate professor UCHIDA Tetsuya and Professor MATSUO Toshihiko (M.D.) from Okayama University and colleagues have modelled the visual response of OUReP. The results show that the prosthesis has the potential to replace a defect photoreceptor layer.

The scientists modelled the eye, implanted with OUReP, as a cylindrically symmetric layered system. Each layer has a particular thickness and conductivity; OUReP replaces the photoreceptor layer. Particular attention was given to the bipolar cells of the retina, which transmit electrical signals from the photoreceptors/OUReP further down the eye. The researchers took the role of ion channels into account; these consist of membrane proteins leaving pores for ions to pass through, regulating the membrane's electric potential. A total of 10 such channels was incorporated into the model.

The eye-with-implant model of Associate professor Uchida and colleagues can be seen as a big, complicated electric circuit with many components. Its physical behavior can be described by a set of equations that describe the underlying electrical process — the evolution of electric currents and voltages throughout the whole system. The equations are solved by the so-called finite element method, which divides the full system into many small units for which physical parameters can be more easily computed.

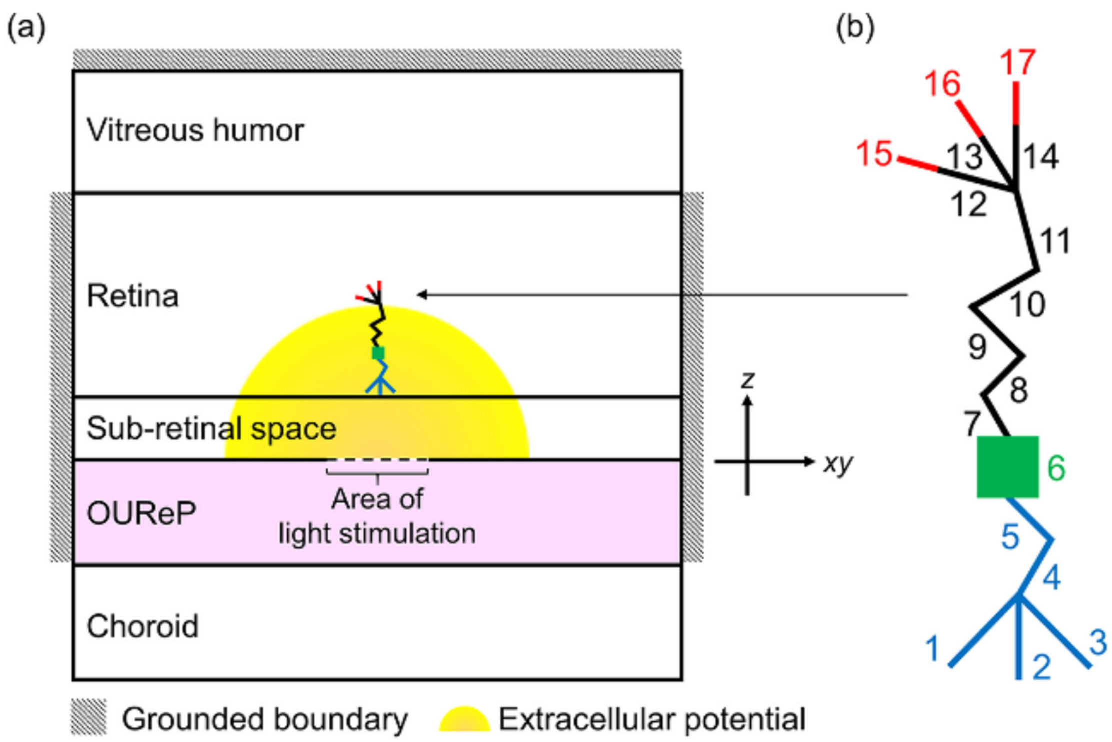
Numerically solving the model enabled the scientists to obtain insights into the photoresponsitivity of OUReP — that is, how well the prosthesis responds to light — and the spatial distribution of the electric potential generated at the OUReP surface. Other aspects that could be studied include how the size of the modelled bipolar cells or the precise position of the OUReP influence performance.

The main conclusion of Associate professor Uchida and colleagues is that stimulation of OUReP with bright environmental light results in an electrical potential large enough to trigger a response in the retinal bipolar cell layer that is typical for mammalian eyes. Another important finding is that this response is larger when the gap between the implant and the cells is smaller. The researchers conclude that “the results of this study can give further insights into improving the efficacy of sub-retinal implants of similar design as OUReP”.

Background

OUReP: Okayama University-type retinal prosthesis (OUReP) consists of a material that mimics the function of photoreceptor cells present in mammalian eyes: phototransduction, the conversion of light into neuron signals triggering biological processes. The main component of OUReP are so-called 2-[2-[4-(dibutylamino)phenyl]ethenyl]-3-carboxymethylbenzothiazolium bromide molecules, which are photoelectric dye molecules that can convert light into electric potentials. These molecules are attached to the surface of a thin polyethylene film; the resulting OUReP film can be used as an implant replacing non-functioning photoreceptor cells. OUReP is a particularly promising prosthesis material for situations where other retinal neuron cells (converting electric potentials into neuron signals) are still active. This is the case for the disease retinitis pigmentosa.
Associate professor UCHIDA Tetsuya and Professor MATSUO Toshihiko from Okayama University and colleagues have now modelled the physical processes happening in OUReP when implanted as a replacement of photoreceptors in a mammalian eye.

Retinitis pigmentosa: Retinitis pigmentosa is a disease, usually inherited, causing loss of vision. The pathology’s underlying mechanism is the progressive loss of photoreceptor cells in the eye — first rod cells die, then cone cells. It becomes manifest in diagnosis as dark pigment spots in the retina. Symptoms of the disease include difficulty in seeing at night and decreased side vision, which may lead to ‘tunnel vision’. The symptoms usually develop already in childhood.
There is at present no cure for retinitis pigmentosa, but the use of retinal implants such as OUReP, developed at Okayama University, holds promise.



Caption

(a) Layered model of the mammalian eye with OUReP replacing the photoreceptor layer. (b) Structure of a bipolar cell as used in the model.

Reference

Koichiro Yamashita, Prathima Sundaram, Tetsuya Uchida, Toshihiko Matsuo & Willy Wong. Modelling the visual response to an OUReP retinal prosthesis with photoelectric dye coupled to polyethylene film. *J. Neural Eng*. 18, 045006 (2021).
DOI: 10.1088/1741-2552/abf892
https://iopscience.iop.org/article/10.1088/1741-2552/abf892

Reference (Okayama Univ. e-Bulletin): Dr. MATSUO & Dr.UCHIDA's team

e-Bulletin Vol.8 : Photoelectric dye-coupled thin film as a novel type of retinal prosthesis
OU-MRU Vol.8 : Light-responsive dye stimulates sight in genetically blind patients
OU-MRU Vol.39 : Successful test of retinal prosthesis implanted in rats
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Okayama University Medical Research Updates （**OU-MRU**）

The whole volume : OU-MRU (1-)

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http://www.okayama-u.ac.jp/eng/access_maps/Tsushima_Campus.html

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◆**About Okayama University**

Okayama University is one of the largest comprehensive universities in Japan with roots going back to the Medical Training Place sponsored by the Lord of Okayama and established in 1870. Now with 1,300 faculty and 13,000 students, the University offers courses in specialties ranging from medicine and pharmacy to humanities and physical sciences.

Okayama University is located in the heart of Japan approximately 3 hours west of Tokyo by Shinkansen.

Website: http://www.okayama-u.ac.jp/index_e.html

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Hirofumi Makino, M.D., Ph.D.
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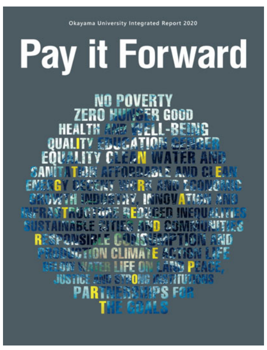

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