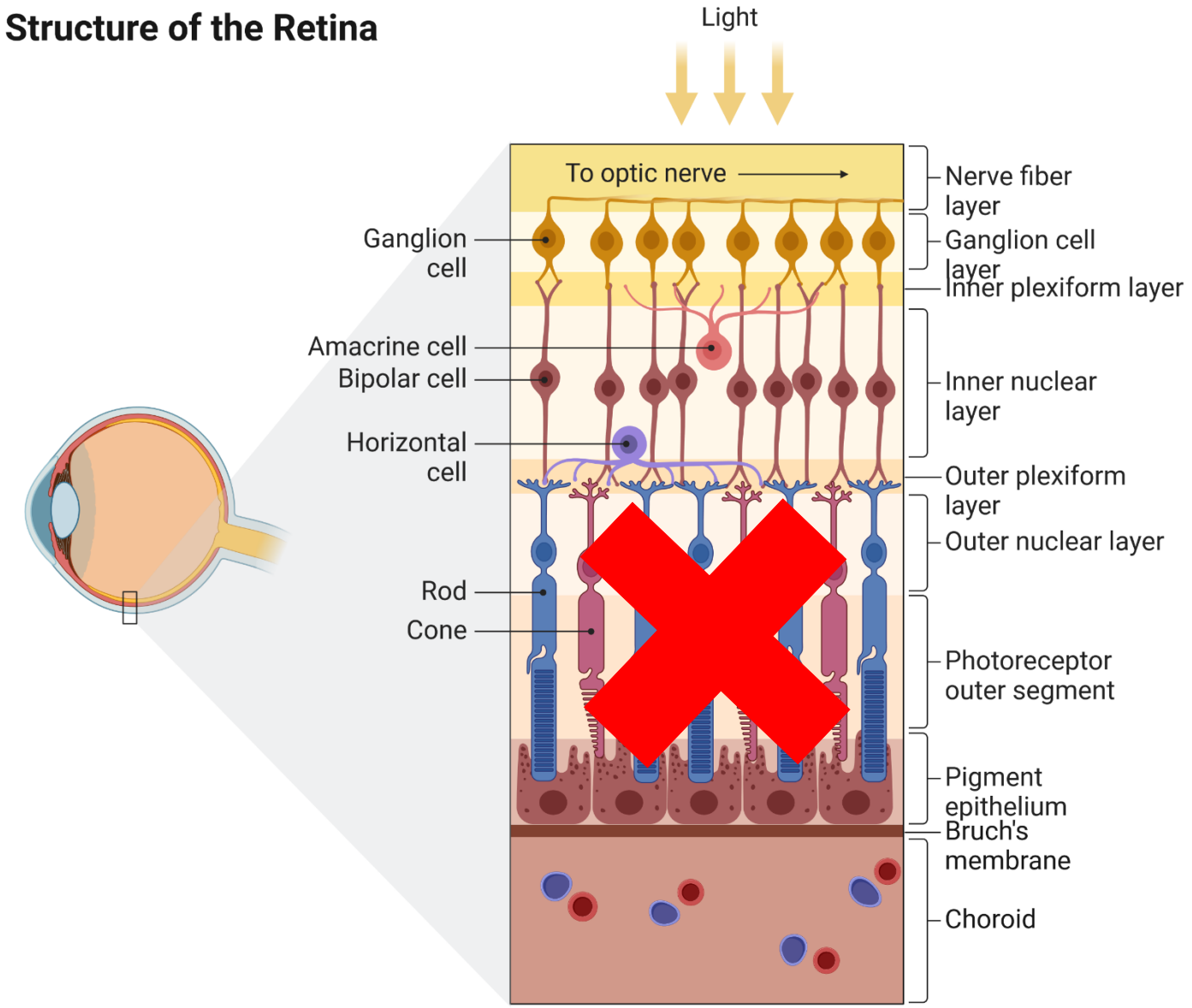
HYBRID PHOTOVOLTAIC AND OPTOGENETICS STIMULATION OF THE NEURORETINA TO RESTORE VISUAL FUNCTION IN BLIND PATIENTS

Research Day at ECE

13 OCTOBER 2023

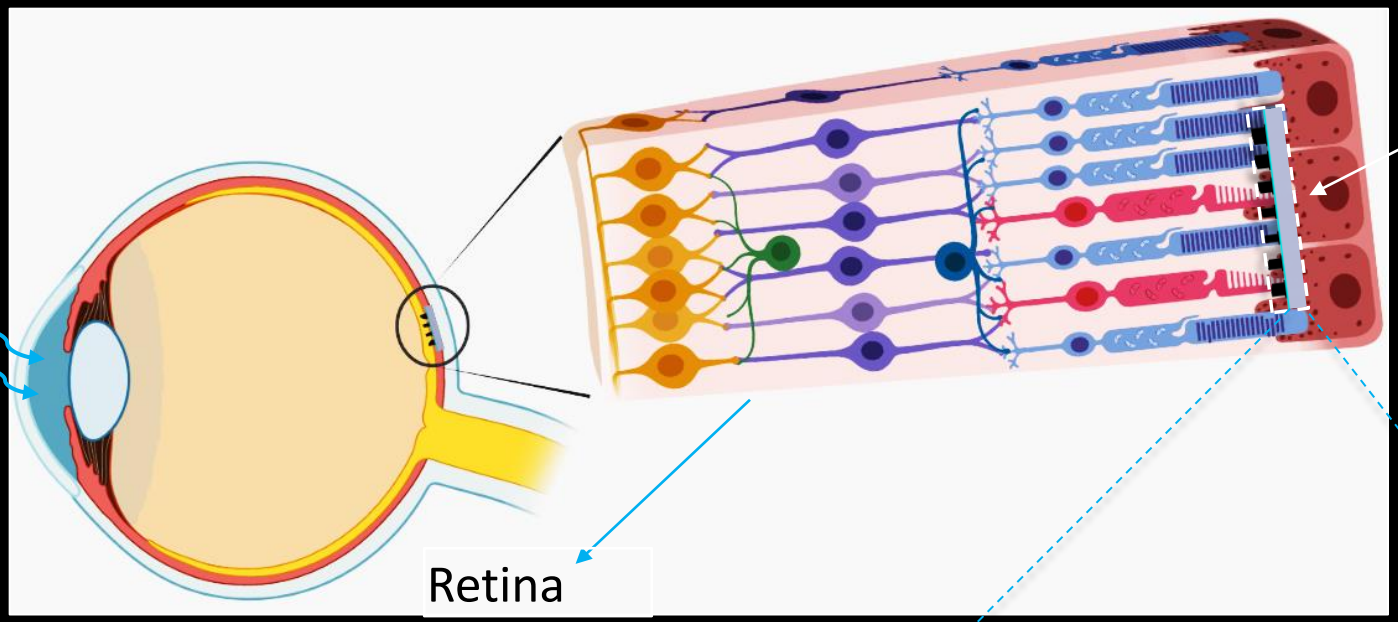
ASBJØRN CORTNUM JØRGENSEN
PHD STUDENT

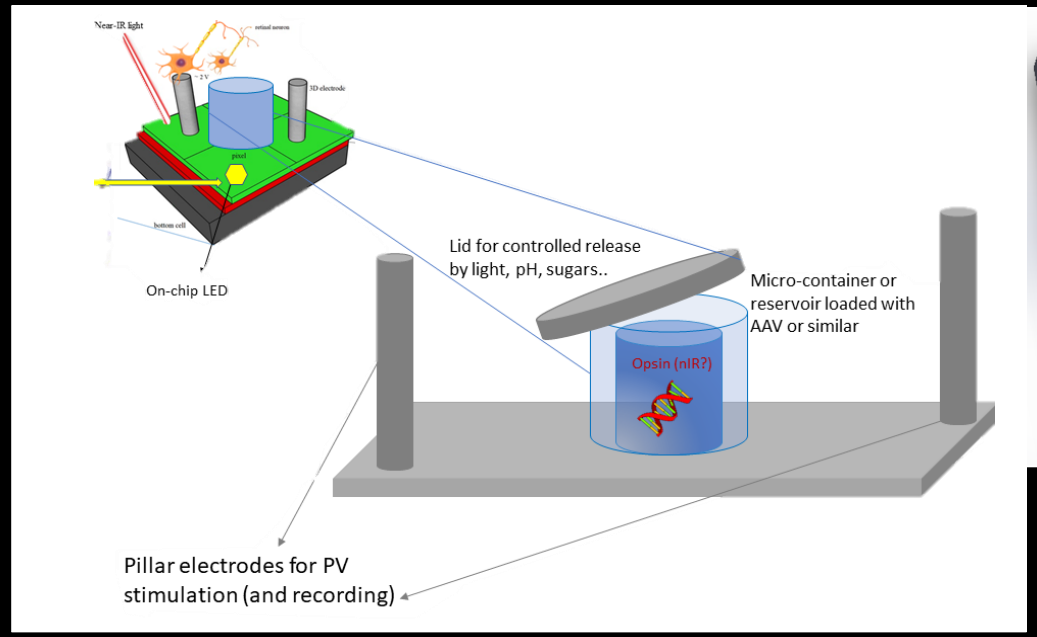


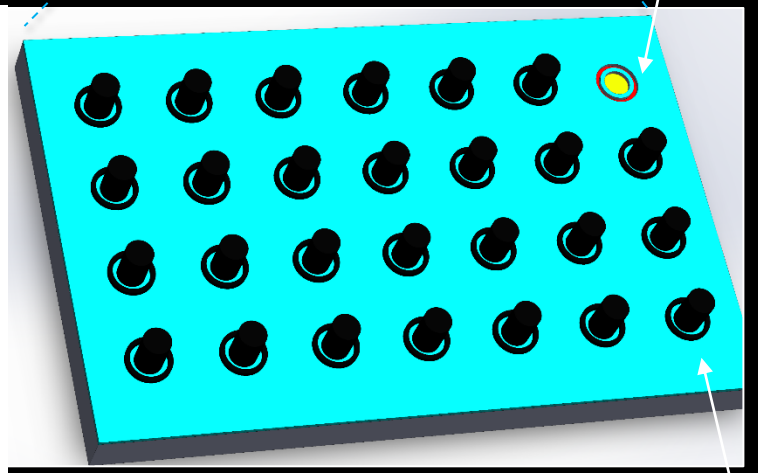
- The neuroretina converts light into a nerve impulse
- The photoreceptors have light-sensitive proteins in their membrane and are the first cells in the signalling cascade
- Eye diseases such as retinitis pigmentosa cause photoreceptors to degenerate

PHOTOVOLTAIC RETINAL IMPLANTS

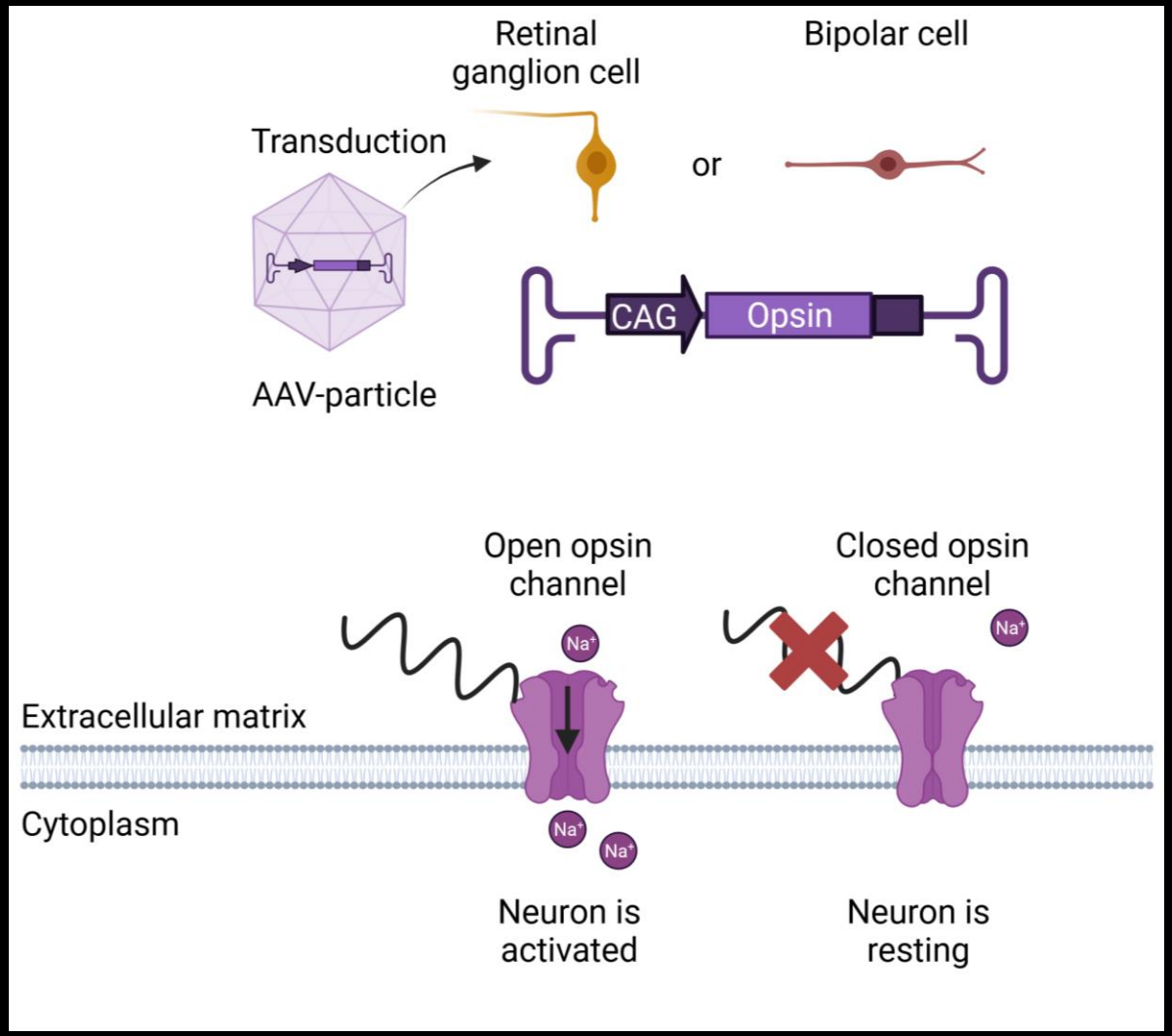
- Mimic the function of photoreceptors
- Transfer electrical impulses to downstream neurons
- Possibly utilized for on-chip drug delivery







OPTOGENETICS



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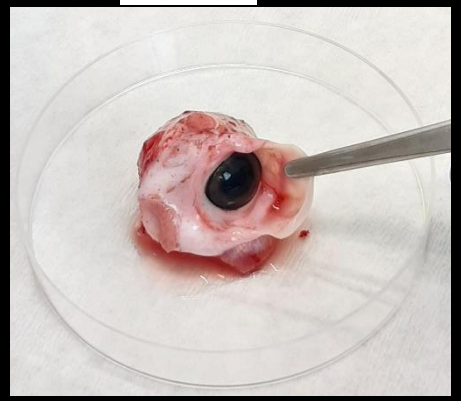
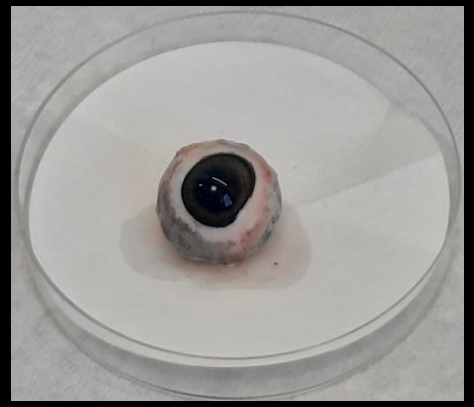
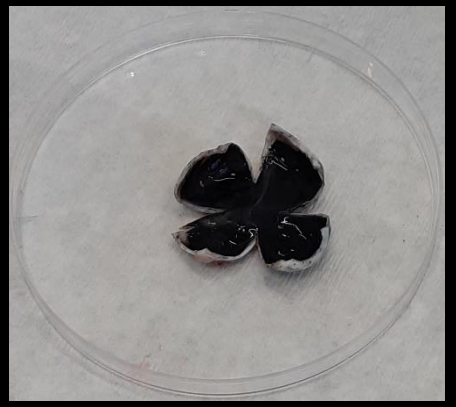
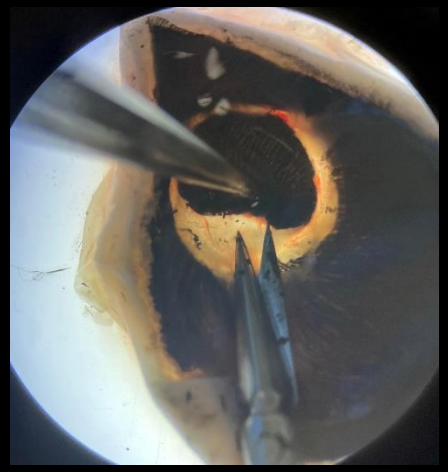
- An opsin gene is delivered to the neurons of the retina and opsin protein is produced
- The opsin protein is inserted into the cell membrane
- When illuminated by fitting wavelenghts the opsin protein opens its channel

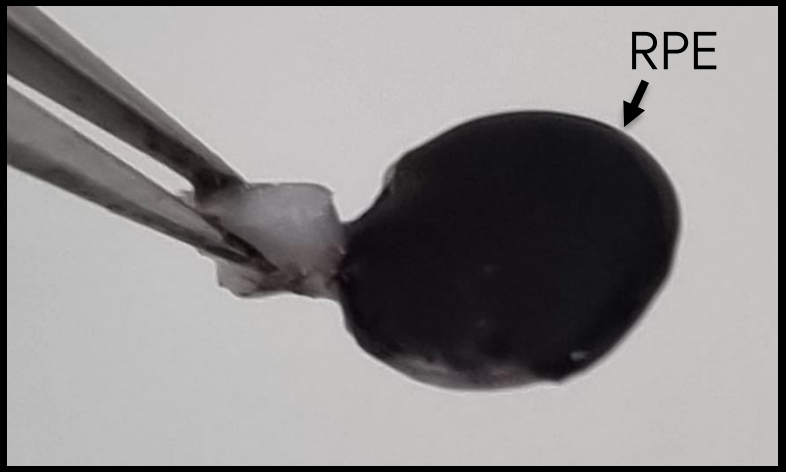
PORCINE NEURORETINA CULTURING







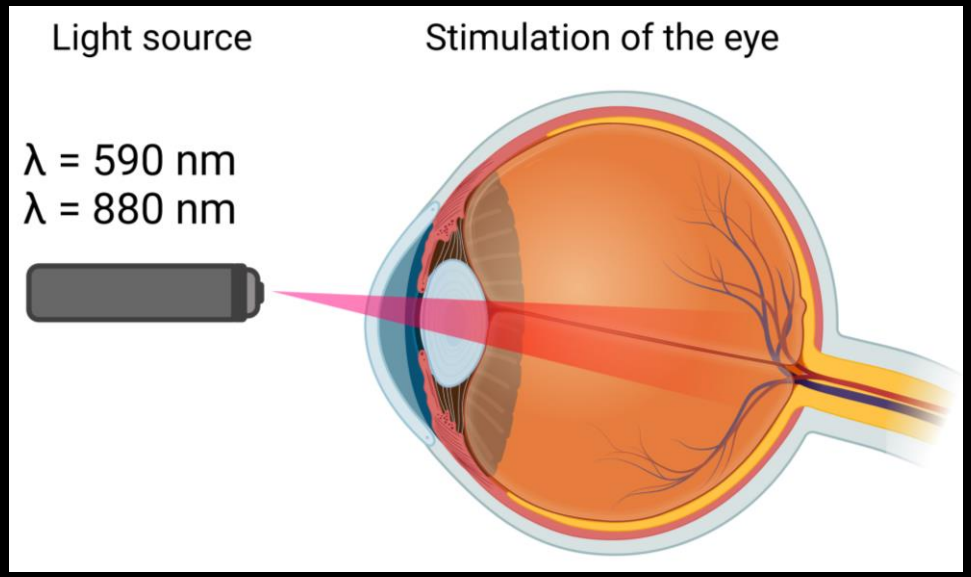


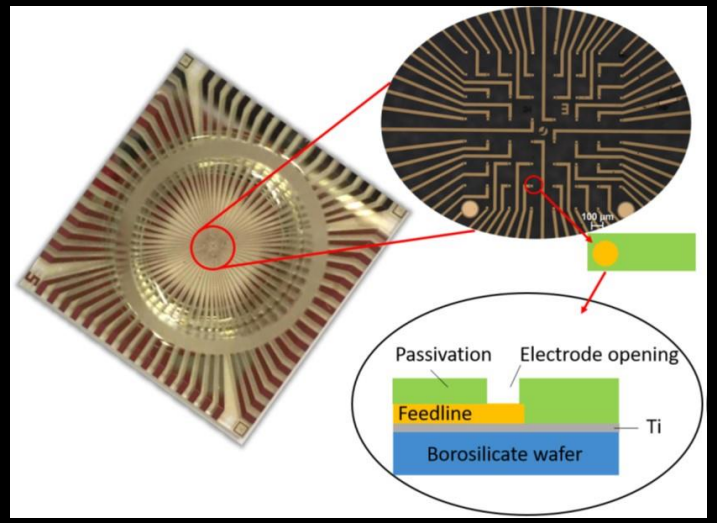


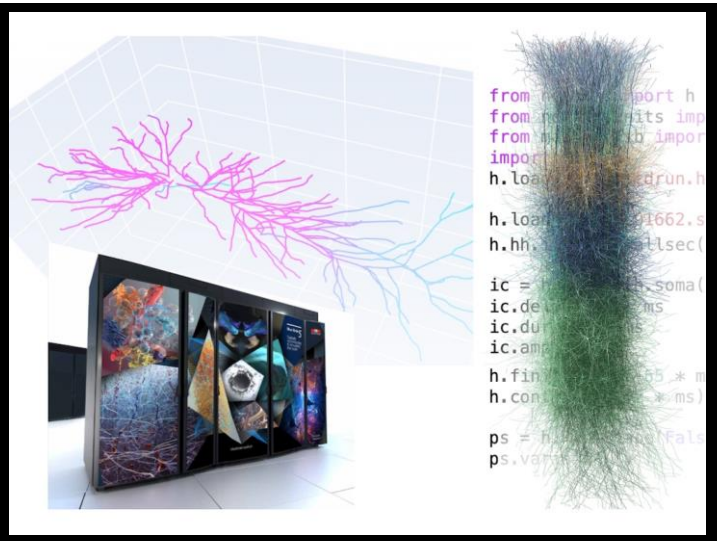
Images courtesy of PhD student Anna Bøgh Lindholm

PROJECT OPPORTUNITIES

- Focused pulsing of stimulating light
- Computersimulation of the neurons and the impact of implant
- Optimizing MEA measurements







CONTACT

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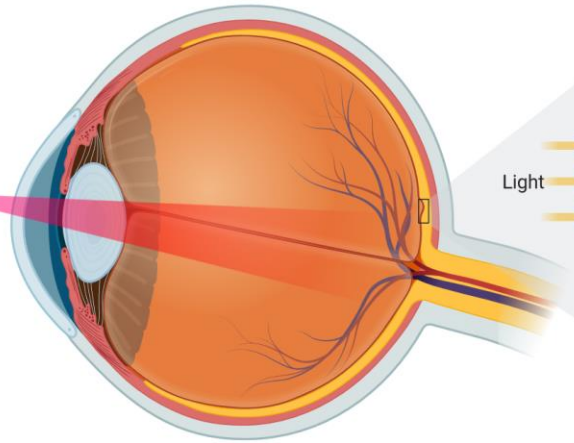
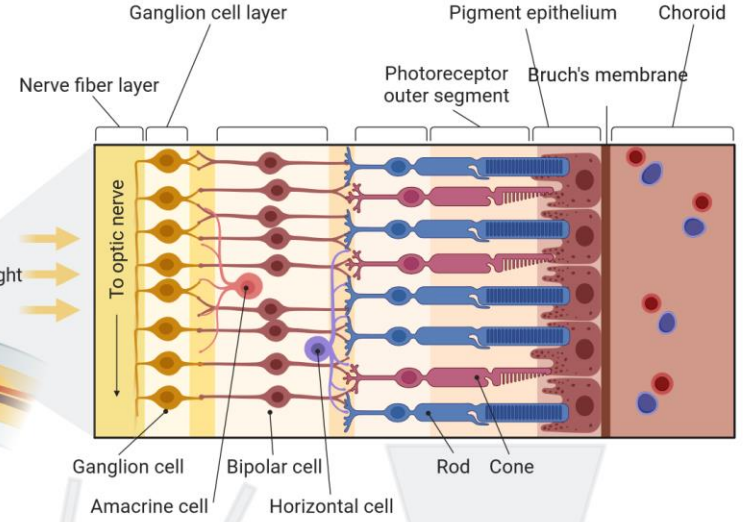
Hybrid Photovoltaic and Optogenetic Stimulation of the Neuroretina for Restoring Visual Function

Light source

λ = 590 nm
λ = 880 nm

Anatomy of the eye

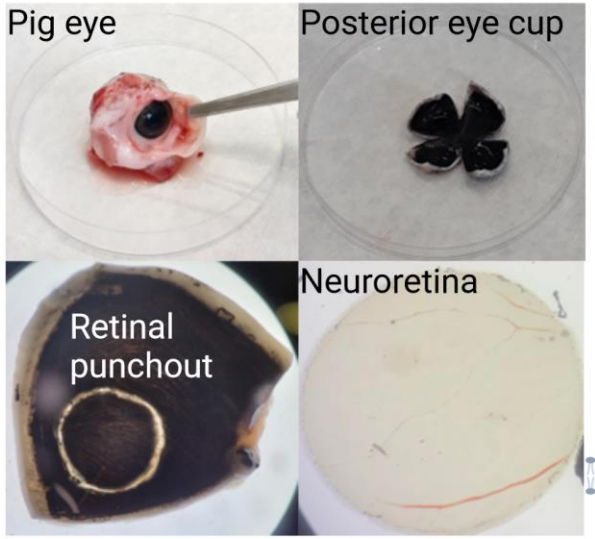




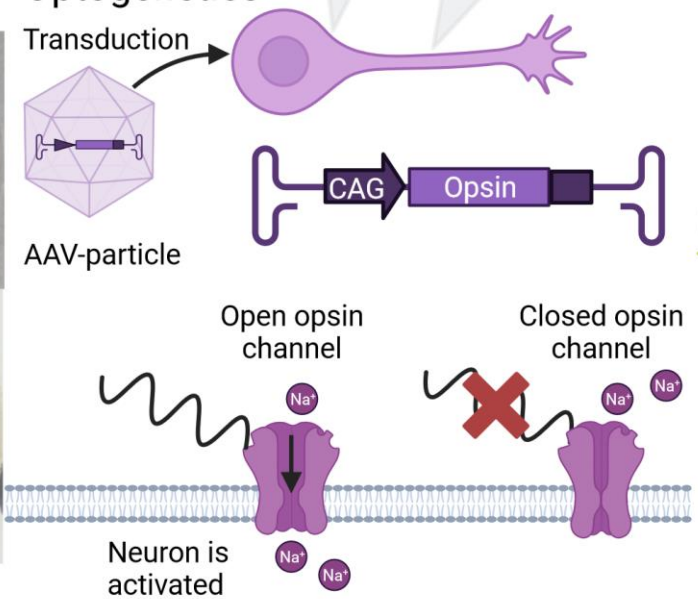
Possible student projects:

- Focused pulsing of stimulating light
- Computer simulation of neurons
- Optimizing MEA measurements

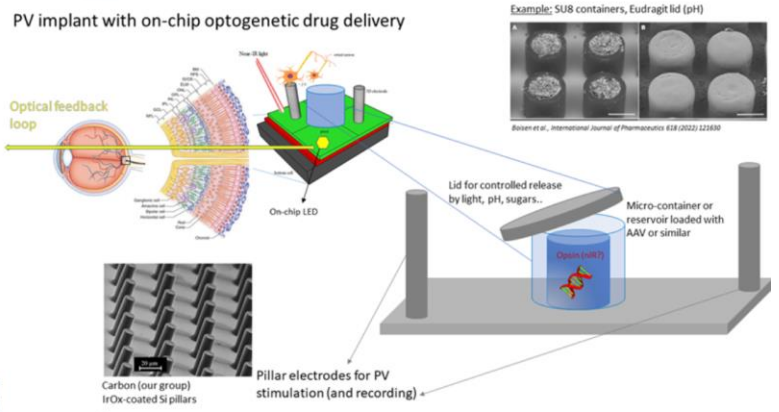
Porcine neuroretina culturing



Optogenetics



Photovoltaic implant



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SOURCES

https://app.biorender.com/

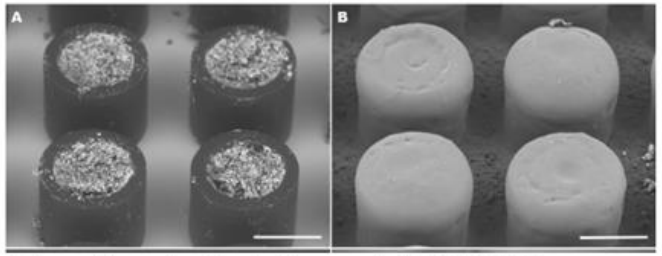
https://www.fz-juelich.de/de/ibi/ibi-3/forschung/microelectrode-arrays

https://nrn.readthedocs.io/en/8.2.3/

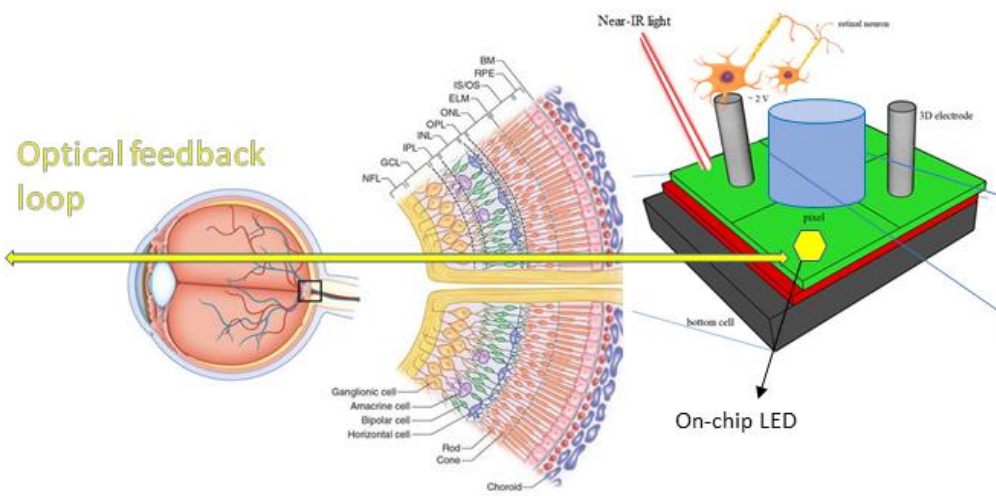
PHOTOVOLTAIC IMPLANT

PV implant with on-chip optogenetic drug delivery

Example: SU8 containers, Eudragit lid (pH)



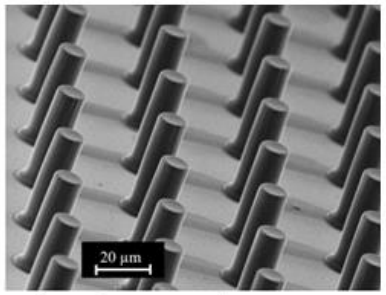
Boisen et al., International Journal of Pharmaceutics 618 (2022) 121630



Lid for controlled release by light, pH, sugars..

Micro-container or reservoir loaded with AAV or similar

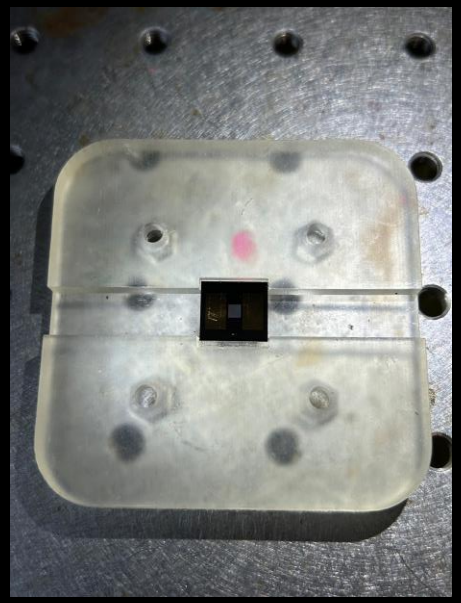
Opsin (nIR?)

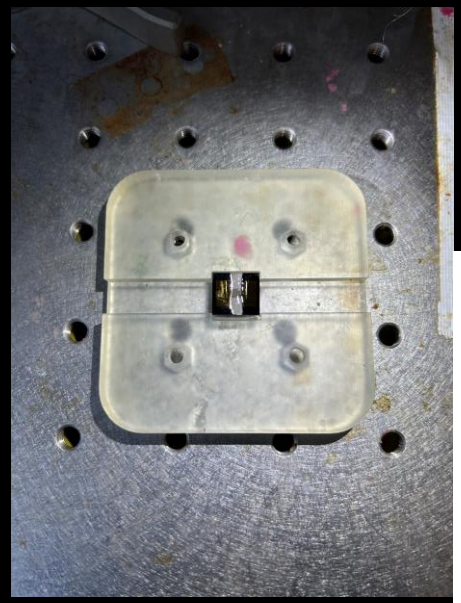


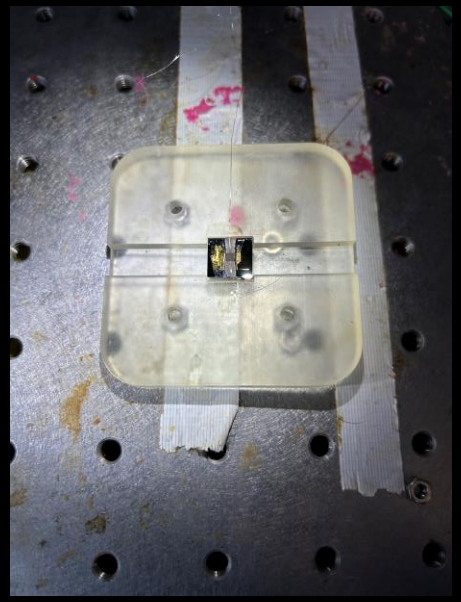
Carbon (our group)
IrOx-coated Si pillars
...

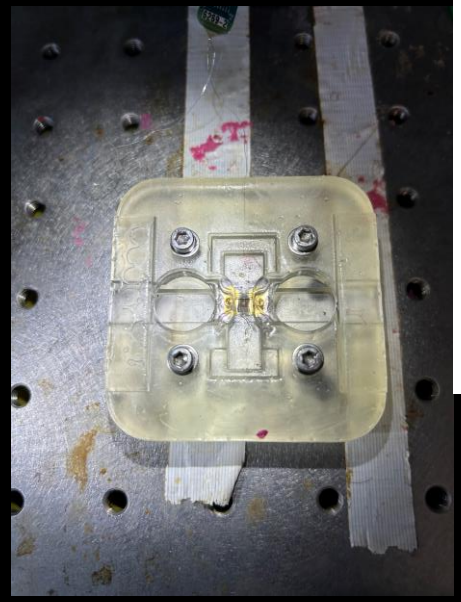
Pillar electrodes for PV stimulation (and recording)

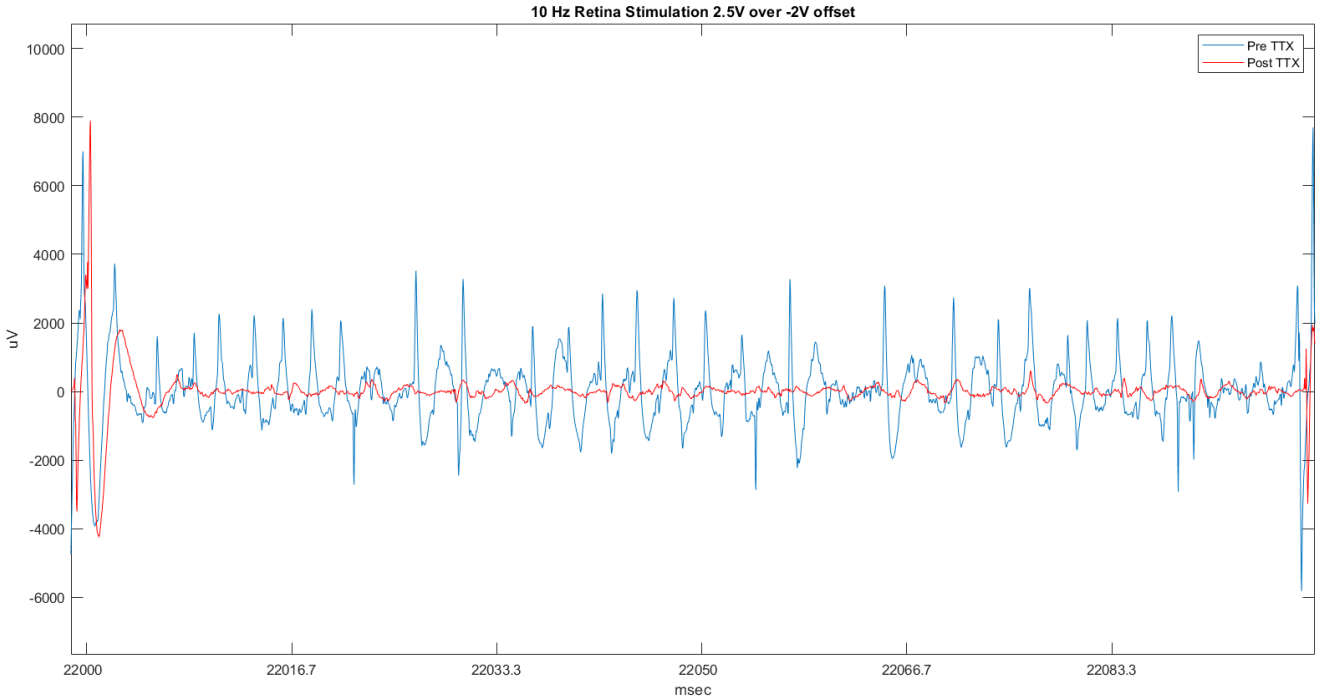
MEA MEASUREMENTS

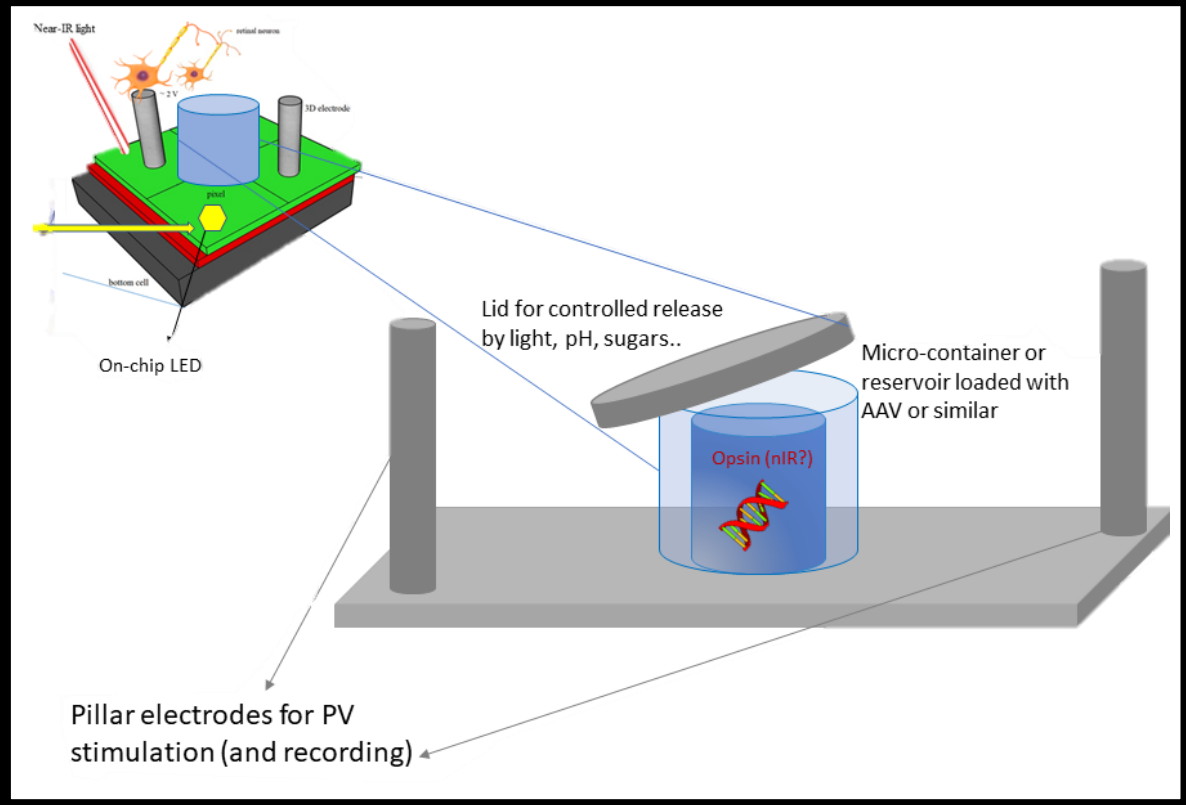











Near-IR light
retinal neuron
~ 2 V
3D electrode
pixel
bottom cell
On-chip LED
Lid for controlled release
by light, pH, sugars..
Micro-container or
reservoir loaded with
AAV or similar
Opsin (nIR?)
Pillar electrodes for PV
stimulation (and recording)

AARHUS
UNIVERSITY