# All-optical Neuron-Computer Interface:

## a tool to manipulate synaptic connections in neural network

**Your role**

We are looking for a student with programming skill in **C++**. If you are experienced in programming and interested in **neuroscience research**, this is a perfect opportunity for you! You will be involved in a development of a **cutting-edge system** for neuroscience research. The experimental setting is located in a laboratory at UMC but you can mainly work on the program at home.

The internship project can be either for **bachelor** student for simpler tasks or for **master** thesis for more comprehensive works.

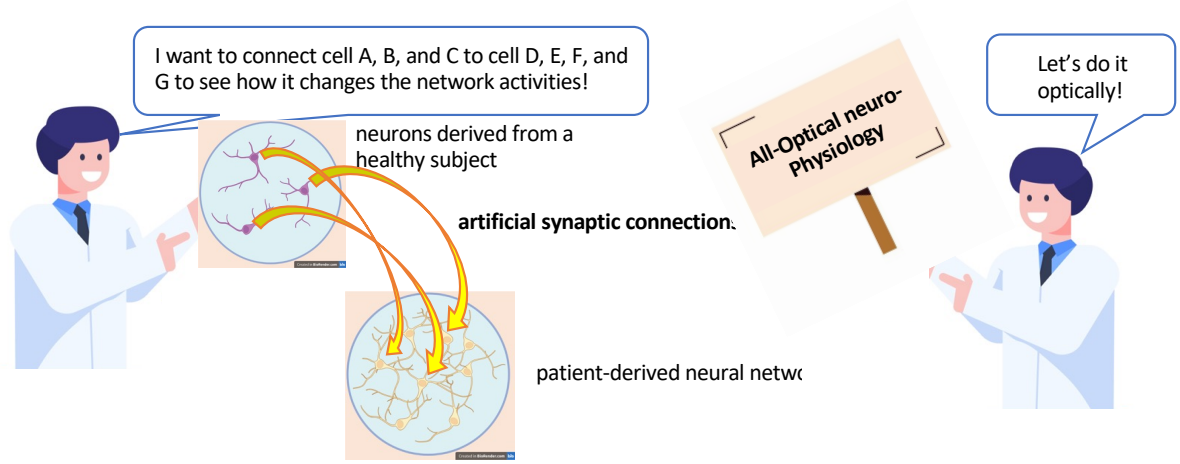


***Fig.1.*** *Ultimate goal: experimenters can select any neurons and make artificial synaptic connections between them.*

**Project Summary**

The intricate workings of the brain emerge from communication between neurons via large-scale synaptic connections. The study of synaptic communication holds the key to comprehending the root causes of many neurological disorders. By **incorporating computer-simulated artificial synapses** and a neuron-computer interface system called "dynamic clamp", we establish a comprehensive tool that **makes real-life neurons and artificial neurons interact**. Our goal is to establish "all-optical" dynamic clamp.

**Project Description**

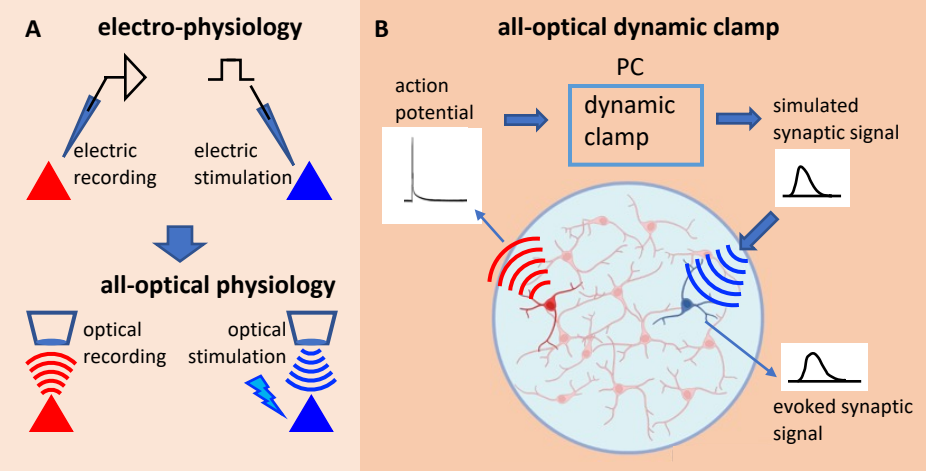


***Fig.2. A**: In AOP, electric recording and stimulation are replaced by optical recording and stimulation. **B**: An action potential of a neuron carrying voltage indicators (red) triggers a dynamic clamp system to simulate a synaptic signal that is given to a target neuron carrying actuators (blue).*

In an "all-optical physiology" (AOP)[1,2] approach, electrical recording/stimulation is replaced by optical recording/stimulation (Fig. 2A). By loading molecules to neurons that either emit light reflecting neural activities (called "voltage indicator") or activate neurons in response to an illumination of light (called "actuator"), it is possible to record and stimulate specific neurons optically. We ***advance the current AOP approach to the next level*** by introducing a function to add artificial synapses in order to manipulate interactions between neurons (Fig. 2B).

**Tasks and Skills**

- C++ programming skill
- Write C++ code for the dynamic clamp system we use (called StdpC, developed by our colleague, T. Nowotny[3])
- Graphic interface of StdpC needs to be modified to accommodate optical neural signals that are passed to artificial neurons and synapses within StdpC (Fig. 3)
- You must be interested in neuroscience research

**See preliminary results on YouTube**
https://youtu.be/NvZzZa_F73Q
https://youtu.be/qvmZcihdalc

**Supervisors**
Naoki Kogo, PhD (Naoki.kogo@donders.ru.nl)
Prof. Richard van Wezel Donders Institute for Brain, Cognition, and Behaviour (DCN)

**Literature references**
1. Emiliani, V., Cohen, A. E., Deisseroth, K. & Häusser, M. All-Optical Interrogation of Neural Circuits. *J. Neurosci.* **35**, 13917–13926 (2015).
2. Knöpfel, T. & Song, C. Optical voltage imaging in neurons: moving from technology development to practical tool. *Nature Reviews Neuroscience* **20**, 719–727 (2019).
3. Kemenes, I. *et al.* Dynamic clamp with StdpC software. *Nat Protoc* **6**, 405–417 (2011).