Assignment: Sensing mechanical changes in firing neurons

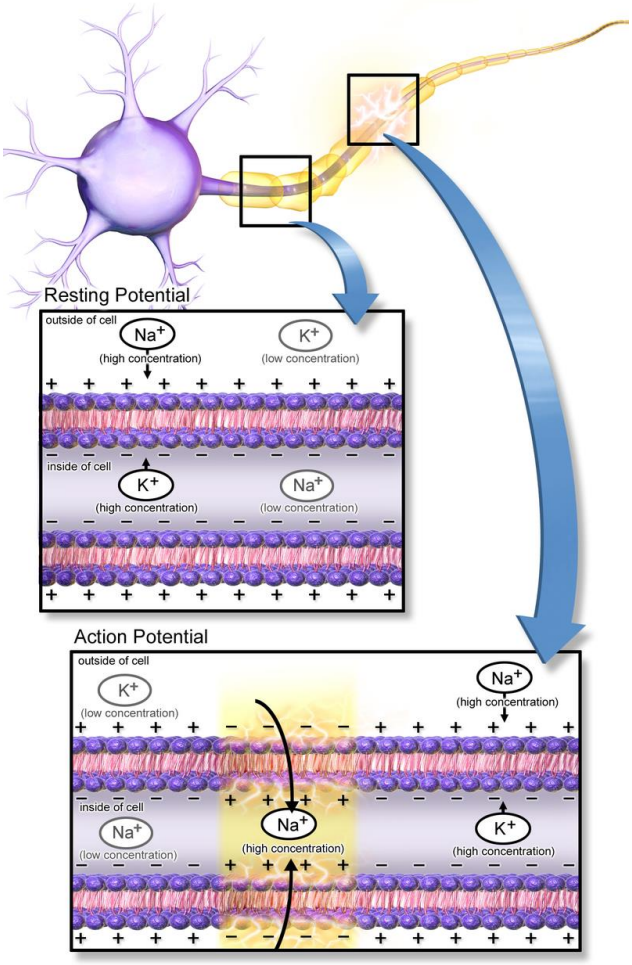
(Master only)

Goal: Grow an axon inside a microchannel and measure changes in its mechanical deformation using impedance spectroscopy

Background: This is a challenging assignment, part of a collaboration between the Clinical Neurophysiology and BIOS Lab-on-a-Chip groups. In this multidisciplinary project you will focus on (neuro)biology, microfabrication and electrochemistry (impedance spectroscopy).

Description: Due to different ion concentrations inside and outside a neuron, a difference in membrane potential of around -65mV for neurons is present in the resting state. The cell membrane is only a few nanometers thick, causing an electrical field strength over the cell membrane in the order of $20 \cdot 10^6$ Volts/meter. When an action potential travels down the axon, deviations from this resting potential in the order of 100 milliVolts occur, causing a strong change in electrical field strength over this membrane.

It is our hypothesis that this change in electrical field causes small mechanical deformations in the cell membrane. The cell membrane can be regarded as a capacitor, composed of two conductors separated by an insulating layer (the bilayer lipid membrane). Any changes in the spacing of these two conductors should have an effect on its capacitance. We hope to be able to measure these changes using two external electrodes placed inside a microfluidic channel containing the axon.



Source: Blausen.com staff. "Blausen gallery 2014". Wikiversity Journal of Medicine. DOI:10.15347/wjm/2014.010. ISSN 20018762.

Tasks:

- Fabricate a microfluidic chip to culture neurons and extend axons into a (narrow) microfluidic channel with integrated electrodes.
- Culture the neurons, visualize the cell culture using fluorescent staining.
- Measure the changes in impedance (membrane capacitance) of the axon inside the channel, during an action potential.

Contact information:

Dr. Mathieu Odijk
BIOS Lab-on-Chip Group
Carre 2413
053 - 489 4620

Dr. Loes Segerink
BIOS Lab-on-Chip Group
Carre 2415
053 - 489 4541

Prof. Michel van Putten
Clinical Neurophysiology
Carre 3615
053 489 4599

Recommended reading [1–4]:

1. T. Heimburg and A. D. Jackson, *Proc. Natl. Acad. Sci. U. S. A.*, 2005, **102**, 9790–9795.
2. I. Tasaki and P. M. Byrne, *Biophys. J.*, 1990, **57**, 633–635.
3. I. Tasaki, K. Kusano, and P. M. Byrne, *Biophys. J.*, 1989, **55**, 1033–1040.
4. J. V. Howarth, R. D. Keynes, J. M. Ritchie, and A. von Muralt, *J. Physiol.*, 1975, **249**, 349–368.