A biophysical approach of cell volume

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The question of cell volume is a central question in biology. This is true for mitotic cells, in association with cancer, to decipher the mechanisms ruling cell proliferation. The issue of cell volume homeostasis is although pertinent for non-mitotic cells like neurons, as the early stage of degeneration is frequently accompanied by a volume swelling. The aim of our project is to study how neurons regulate their volume using a Digital Holographic Microscope.

Description

Neurons exhibit a large variety of sizes and shapes. How developing neurons control their morphologies, and how morphology guides function remains unclear. In this aim, we used adhesive micropatterns to constrain cell shapes, i.e. the number or the width of neuronal branches. We have shown in particular that an increase of the width of neuronal branches decreases their total length at the cell level without however a conservation of the total surface of adhesion (an increase by a factor two of the neurite width results in a decrease of the total length by only a factor 1.3). If the surface of adhesion is not conserved during in vitro neuron development, what about the volume?

The project aims at exploring the regulation of neuron’s volume using a Digital Holographic Microscope (DHM). We will build on our mastering of in-plane neuronal shape through micropatterning. This study implies also a thorough knowledge/mastering of the refractive index of both the cell compartments and the culture medium.


Surprisingly, larger neurites are also thicker. Moreover, neurons forced to elongate on stripes of variable widths (i.e. an alternance of 2 and 6µm wide stumps) adjust locally their volume.

The next step is to go deeper into the understanding of neuron volume regulation in physiological and pathological conditions.

Phase image of a neuron grown on an adhesive pattern offering only two branches for neurite elongation (pattern geometry and sizes in the inset). Converting phase to thickness using different procedures indicates that wider neurites are also thicker than thinner ones (Courtesy of C. Braïni, PhD)