

Energy is the driving force of physical and biological objects, in particular the brain. Without a sufficient amount of metabolic energy, neural cells (neurons) would not function properly, and more importantly, would not be able to process information incoming to the brain from the outside world. This information is encoded in long-terms in neural connections, which are called synapses. Information coding is possible due to a certain property of synapses, namely, their plasticity, i.e. the ability to modify the biophysical and biochemical structure. The processes of synaptic modification are fundamental for learning and memory in living organisms, but they are still weakly understood either on molecular or systems levels, despite many years of experimental research. Experiments demonstrate that synaptic plasticity is strongly dependent on electrical activity of neurons in the network and on neuronal correlations. Moreover, there are at least several types of synaptic plasticity. Generally, the larger neural activity the more metabolic energy they use. Taking all these into account, the question arises about the relationship between the degree of synaptic modifications, the amount of information the synapses can store, and the amount of the available metabolic energy.

The aim of this project is to study such relationships between energy, information, and synaptic plasticity. In particular to ask, how energy can restrict the types of plasticity and the amount of coded information. These topics will be investigated, based on empirical data, using the methods of theoretical physics, applied mathematics, and information theory, which allow us to build mathematical models of neurobiological processes and their exact quantitative analysis. The theoretical results will be also compared with the existing experimental data.