

Mitochondria are the main intracellular organelles and have a crucial position in the functioning of the cell, tissue and organism. They are a source of cellular energy - adenosine triphosphate (known as ATP) - which they generate by oxidative phosphorylation. Without this form of energy, our body would have died in a few seconds. Mitochondria are also involved in ensuring the calcium balance in the body. That energy centres create very efficient communication networks between themselves. Morphological disorders (appearance, shape) of these organelles indicate damage to the functioning. It is especially visible during ageing and in conditions of extreme stress when mitochondria are fragmented in our nerve cells (neurons), which impair their functioning. In this way, neurodegenerative diseases such as Alzheimer's or Parkinson's disease manifest themselves at the cellular level.

The motivation for this research is the exploration of new, effective diagnostic methods both in the diagnosis and treatment of neurodegenerative diseases, as well as in the development of a new methodology for the study of drugs with selective activity against Parkinson's and Alzheimer's disorders. In our research, we will use microfluidic technology, which we will combine with biosensors based on the detection of mitochondrial specific biological reactions. It will enable us to learn the fundamental processes of neurodegenerative diseases at the molecular level. To understand why mitochondrial dysfunction is central in Parkinson's disease is an integral part of the fight against this debilitating disease. Therefore, it is a significant challenge in the development of effective neurological treatment. Effective development of therapeutic strategies can stop or slow down the progression of the disease, rather than just treating its symptoms. Therefore, in order to fully understand the mechanisms underlying neurodegenerative diseases, it is necessary to study a wide range of cellular processes and their links to the mitochondrial network.

Within this project, we propose to develop a new type of microfluidic sensors to monitor and control mitochondrial dysfunction and to detect microRNA and mitochondrial proteins associated with neurodegenerative diseases. MicroRNAs and proteins will serve as non-invasive human disease biomarkers and will be used to modulate mitochondrial dysfunction. For this purpose, we will construct a special microfluidic chamber coupled with gravimetric biosensors and fluorescent markers. The chamber will allow for a fast and effective change of the chemical environment that will be interacting with the cells and organelles. Transparency of the chamber will also make it possible to measure fluorescence and Raman spectra analysis of mitochondria reactions. At the same time, signals from gravimetric biosensors (based on piezoelectric detectors), placed in the chamber, will be collected.

Progress in research on non-coding RNA (microRNA) in the brain affected by neurological disorders and healthy brain will lead to better understanding, diagnosis and treatment of neurodegenerative diseases. Designing innovative bio-sensitive microfluidic devices and sensory matrices for mitochondria, protein markers and microRNA, will allow conducting experiments leading to the selection of new classes of candidates for drugs and improve the therapeutic outcomes of Parkinson's disorders treatment: (i) accelerate the early detection of this neurodegenerative disease and (ii) increase the effectiveness of Parkinson's treatment with new drugs. The results of the project will broaden our knowledge base and further enhance our capabilities in screening, diagnosis and treatment of neurological diseases.