Epigenetic traces of anhydrobiosis: a study of DNA and protein modifications through tardigrade generations

The project aims to investigate the effect of different duration and numbers of anhydrobiosis episodes on epigenetic changes in tardigrades. Moreover, we would like to verify whether such changes are inherited by the offspring of parents subjected to anhydrobiosis and whether it has an impact on the survival abilities of subsequent generations of tardigrades.

Tardigrada is a group of small aquatic and/or terrestrial invertebrates found in almost all terrestrial ecosystems. They have typical and well-developed internal organs, but their bodies lack circulatory and respiratory systems. Tardigrades are distinguished from the majority of invertebrate groups with the ability to fall into cryptobiosis at any time of their lives. It is thanks to this ability that tardigrades can survive in extremely unfavorable habitat conditions. Consequently, tardigrades are a model organism not only in zoology but also in astrobiology or even medicine.

Cryptobiosis is a phenomenon in which there is an extreme but reversible cessation of metabolism in cells. Some invertebrates (including tardigrades) enter this state under unfavorable environmental conditions. One of the most common forms of cryptobiosis is anhydrobiosis, which is the ability of organisms to survive with almost complete loss of water. This is a special ability because organisms need water to carry out all life processes. Dehydrated tardigrades can survive in extreme conditions, such as low and high temperatures, high radiation doses, extremely high and low pressures, and even vacuum conditions. Despite numerous studies on anhydrobiosis in tardigrades, the molecular basis of this process has still not been determined. Additionally, the very anhydrobiotic abilities of individual tardigrade species are poorly known and understood.

Epigenetics is a branch of molecular biology that focuses, inter alia, on the study of the impact of non-mutational DNA changes and modification of histone proteins on the production of proteins in living organisms. Epigenetic changes can "turn on" or "turn off" certain genes, affecting the both molecular and macroscopic characteristics of the organism. Interestingly, the epigenetic changes that could arise from anhydrobiosis have not yet been studied in tardigrades. For this reason, it needs to be investigated how the duration and number of anhydrobiosis episodes influence such changes as DNA methylation, modification of histone proteins, and overall protein production. Additionally, such changes may be inherited and thus affect the anhydrobiosis ability of the offspring.

Two terrestrial species of tardigrades with high anhydrobiosis capacity will be used in the research. First, their genomes will be sequenced. Tardigrades will be bred in Petri dishes, on a specially prepared nutrient medium, and in special breeding chambers. Then the parent generation will be divided into groups that will undergo different variants of anhydrobiosis. After returning to the active state, offspring will be obtained, which will also be subjected to anhydrobiosis of the same course. DNA and proteins will be isolated from the appropriate groups of parents and offspring. Then, mass spectrometric analyzes will be performed. Thanks to this method, it will be possible to know the level of DNA methylation, types of histone modifications, and protein profiles of each test group. Such complex research will make it possible to identify epigenetic changes and compare them between the generations of parents and offspring, as well as between groups of tardigrades subjected to various variants of anhydrobiosis. This will allow us to broaden our understanding of this phenomenon in tardigrades and to learn about new molecular mechanisms that influence the ability to survive in anhydrobiosis. In addition, the ability of tardigrades to inherit epigenetic changes will be discovered.

Summarizing, the proposed project will provide a better understanding of anhydrobiosis in tardigrades and its molecular basis. Additionally, it will be possible to discover such epigenetic changes that may affect the survival abilities of both the parent generation and subsequent generations of tardigrades' offspring.