Biomineralization is the process in which a living organism forms a mineral skeleton or other mineralized structures which play important vital functions. These structures are produced in a complex, genetically-controlled process where the key role is played by organic molecules, such as proteins. Because of its biogenic origin and unique physicochemical properties these minerals are called biominerals.

A fascinating example of biomineral structures are otoliths which are inorganic elements of gravity receptors in fish that are responsible for maintaining orientation in space and receiving sound waves. The otoliths morphologically resemble inorganic crystals of calcium carbonate, but their shape, size and crystalline form (i.e., polymorphic form) are affected by a specific type of regulatory proteins, called intrinsically disordered proteins (IDPs). Although several proteins involved in the formation of otoliths have been identified in today's bony fish so far, their molecular characteristics and mechanism of action are yet to be determined. The spatial distribution of IDPs in the otoliths is unknown. However, this information is a prerequisite for the understanding of their interaction with calcium and carbonate ions in the real biomineralization environment.

Fish otoliths are found in a fossil record at least since the Devonian (approx. 380 million years ago), which demonstrates deep evolutionary roots of this kind of biomineralization. However, no studies have been performed so far to elucidate the effect of IDPs on the formation of these biominerals (biomineralization proteins have been also found in fossil mollusks and corals). In the proposed project, we are going to confirm the hypothesis that the properties of the biomineralization proteins reveal a considerable effect on mineralogy, crystallography and several geochemical features of fish otoliths at all levels of structural organization.

The current project will be carried out by two cooperating research groups: a team from the Department of Biogeology of the PAS Institute of Paleobiology (which will coordinate the studies on the mineral phase of the otoliths) and a team from the of Department of Chemistry, Technical University of Wrocław (investigations of the biomineralization proteins).

In the studies of the mineral phase of otoliths, a special attention will be devoted to nanometer-sized structures (1 nanometer is a millionth of a meter). At this scale level, we expect to get the most valuable information on the interactions of proteins with mineral phase and their influence on the crystallographic and geochemical properties of the biominerals. This will be possible thanks to the latest experimental facilities that are planned to be used, which includes atomic force microscopy, NanoSIMS ion microprobe and several biotechnological methods (e.g., production of antibodies). These methods will be employed to detect certain types IDPs in the otoliths. We also plan to detect IDPs in fossil otoliths - the specimens will be selected based on their preservation state. Excellent preservation state of fossil otoliths form our collection should allow to detect protein residues in the samples.

A number of otoliths will come from the Mesozoic era - the era of dinosaurs. The detection of complex organic compounds in the fossil otoliths and deciphering their function by analogy with the well-known feature of these compounds in modern fish will allow to better identify and revive biomineralization phenomena of the geological past.