Proteins are a diverse group of complex biomolecules that play many important roles in the living organisms. To perform its specific functions proteins have to adopt the unique native structure in the process of protein folding. However, under particular pathological conditions, proteins can misfold and form **insoluble highly organized fibrillar aggregates, known as the amyloid fibrils**. Amyloid fibrils are mostly associated with neurodegenerative diseases such as Alzheimer's, or Parkinson's disease. However, lately the strictly pathological view on amyloid aggregates has taken a turn, as functional amyloids were found in bacteria, as well as in the human body, where they show diverse functions ranging from storage and protection to signaling and memory. This discovery in combination with properties like stability, mechanical strength and ease of formation and functionalization, resulted in growing interest in using amyloid fibrils as nanomaterials for a broad range of applications. Very interesting aspect of amyloid fibrils is also their **chirality**, which is exhibited on the different levels of their supramolecular architecture, starting from amino acids up to the mesoscopic organization. **Studying the chirality of amyloid fibrils is key not only for understanding these complex protein aggregates, but also for design of chiral materials.** One of the most attractive fields where such materials have a great promise is optoelectronics, where especially interesting is the design of devices exhibiting **circularly polarized luminescence (CPL)**, for use in light-emitting diodes, encryption or as detectors.

Unfortunately, precise and efficient control over the handedness of CPL still remains a great challenge and limits the use of CPL-active materials. A promising approach that could resolve this problem is using amyloid fibrils as a basis for systems with CPL activity, as the chirality of amyloid fibrils, and thus of the CPL signal, can be regulated via various external factors (such as temperature, pH, agitation).

The main goal of this project is to obtain supramolecular hydrogels with controllable chirality based on amyloid fibrils that will show intense CPL signal (Fig.1). By co-assembling light-emitting molecules with chiral amyloid fibrils, it will be possible to induce in them chiroptical properties and produce hydrogels with tunable handedness. The idea is to use amyloid fibrils from different building blocks (protein or short peptide), as well as different kinds of luminescent entities, in order to find the optimal conditions for the preparation of hydrogels with well understood characteristics. To achieve this goal various modern methods will be used, including **chiroptical spectroscopies**, which are sensitive to chirality via differential interactions of an optically active molecule with left- and right-circularly polarized light. Use of these techniques, alongside microscopy, will ensure **detailed characterization of the structure of obtained hydrogels on different levels of their organization, as well as assessment of their homogeneity, chirality and optical properties.** By changing the preparation conditions, composition and functionalization method (co-assembly or post assembly) the most successful way for the preparation of tunable chiral CPL-active hydrogels will be selected.

The key activities of the project are:

- preparation of chiral hydrogels based on amyloid fibrils from proteins and short peptides;
- functionalization of obtained chiral hydrogels with different luminescent entities (e.g. dyes, carbon dots, gold nanoparticles);
- measurements of CPL;
- characterization of luminescent hydrogels with spectroscopic and microscopic methods;
- and assessment of their structure, homogeneity, chiroptical properties, etc.

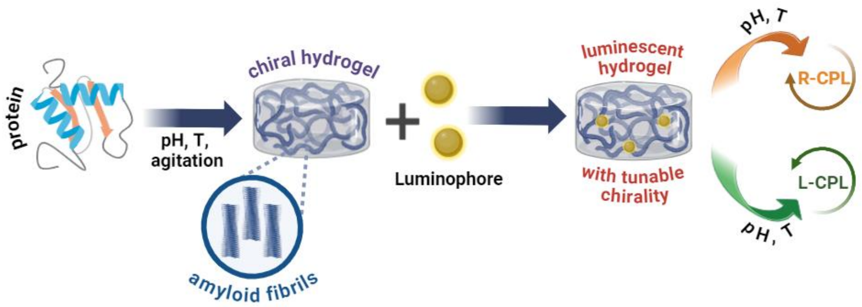

Fig. 1. Schematic representation of the research project concept.
(created in Biorender.com)

Presented research addresses up-to-date challenges in the field of chiral supramolecular systems and CPL materials and aims to present a comprehensive approach for studies of amyloid-based systems with use of a variety of modern techniques, especially chiroptical spectroscopies. **Results of this project will have a great impact on the development of chiroptical techniques and amyloid-based materials, and will be the basis for future design of advanced CPL-active materials for applications in optoelectronics or medicine.**