Chirality is a concept linked to symmetry, the object is called chiral if it cannot be superposed onto its mirror image. Chirality is widely present in nature, both at the molecular level (most biologically active molecules are chiral) and at the macroscopic level (e.g. helically coiled shells). Mirror symmetry breaking have intrigued researchers since the famous experiment by L. Pasteur, in which he demonstrated that during crystallization of racemic mixture containing two types of tartaric acid molecules that are mirror images of each other (enantiomers), two types of enentiomorphic crystals were formed, each built of only one enantiomer. Pasteur was also the first who noticed, what today is considered a well-documented fact, that the interactions between biologically active molecules are highly selective for their chirality. The molecules of the same and opposite chirality interact with different energies, which in combination with the directionality of molecular interactions in the crystals may lead to spontaneous breaking of mirror symmetry, observed by L. Pasteur. In liquids, due to the lack of translational and orientational order of molecules, the effect of chiral discrimination was believed to be negligibly small. Therefore, observation of spontaneous mirror symmetry breaking in liquid crystals and in liquids, composed of achiral molecules, was very surprising to scientific community. This discovery showed that molecular chirality is not a prerequisite for the formation of chiral soft matter phases.

The main objective of the project is to understand the mechanisms responsible for the formation of the chiral phases/structures in soft matter (liquids, liquid crystals) built of achiral molecules, due to weak, non-covalent interactions. The subject is particularly important, since most biological processes occur in the liquids, not in crystalline state. Two basic hypothesis will be considered, according to which the formation of chiral structures from achiral objects is a result of (*i*) spatial segregation and stabilization of instantaneously chiral conformers of achiral molecules; or (*ii*) building of local, structurally chiral nanoaggregates (e.g. fragments of molecular layers or columns of low symmetry). The chiral structures constructed with achiral molecules will be used as components of molecular chirality sensors (sensitive for traces of chiral compounds, including biological molecules) and electro-optical/optoelectronic devices (organic diodes, transistors, etc.). Within the project also chirality transfer processes will be studied, from the molecular level, through the phase structure level, to the chiral morphology of macroscopic objects, as well as mechanisms of chirogenesis – induction of homochiral states.