Each living cell in the human body consists of the outer and inner membranes. These biological membranes are primarily composed of a lipid bilayer, along with proteins and carbohydrates, which confer specific properties and functions together. Biological membranes are dynamic and complex structures essential for maintaining the integrity and functionality of cells. They are involved in many critical processes, from protecting the cell and facilitating communication to transporting substances and generating energy. The equilibrium and structure of these membranes influence cellular function and fate. In this project, we will investigate intracellular membranes in terms of their nanostructure based on stimuli of lipid nanoparticles (LNPs).

LNPs are nanometer-scale, spherical particles composed of lipids that deliver therapeutic agents, such as drugs, vaccines, and genetic material, to specific cells or tissues in the body. Additionally, they serve as a primary tool for gene delivery and editing in life sciences research. Since the COVID-19 pandemic, they have gained even more attention for their role in delivering the first mRNA vaccines. Lipid nanoparticles are recognized as a powerful and versatile tool in modern science and medicine, enabling the delivery of a wide range of therapeutic agents with improved precision and efficacy.

While LNPs are generally considered low in toxicity over standard experimental timeframes, our recent observations have shown that LNPs can cause significant changes to cell structures and hinder movement within cells within a few hours after being introduced. This unexpected effect raises questions about potential impacts on cell health and treatment effectiveness and motivates us for further investigation. The cell's inner environment and how substances move within it can significantly influence how well treatments work and how cells respond to them. Using Fluorescence Correlation Spectroscopy (FCS), we have found that LNPs disrupt this internal movement more than other stress factors like osmotic shock or starvation. This discovery suggests that the LNPs interact with the cell's membrane in a way that could have profound implications, potentially affecting the health of the cell's organelles and overall cell function.

This project aims to thoroughly understand the physical and chemical effects of LNPs on cells, focusing on how they might alter cell membrane structures and movement within cells. By combining physical measurements with biological tests, it's hoped that we can better grasp the implications of using LNPs, ensuring they're safe and effective for future applications in medicine and research. Even though some adverse effects might not be entirely avoidable, being informed about them can help develop strategies to minimize or manage these impacts.

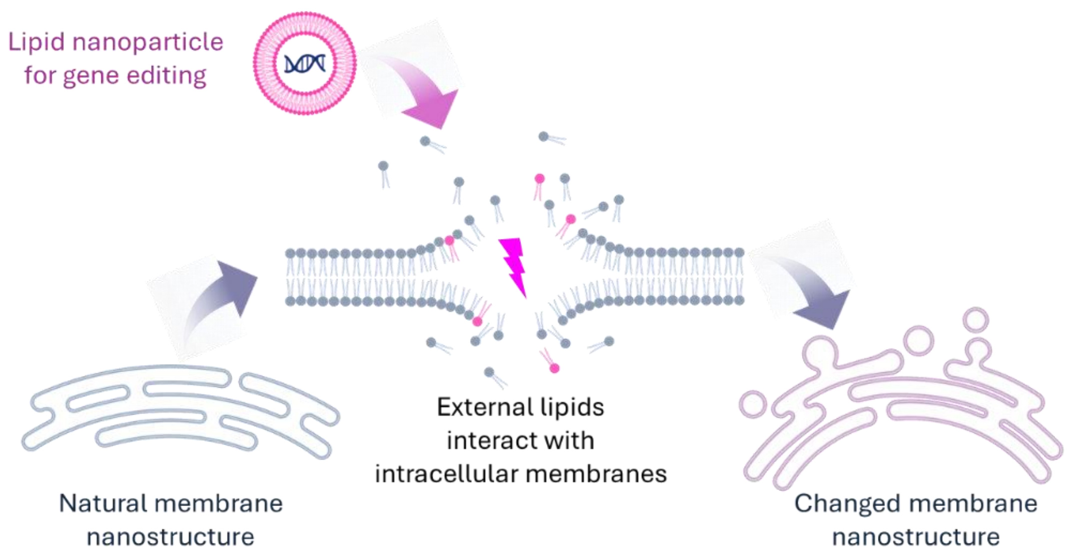

Figure 1. The scheme of the phenomenon that will be investigated during the project. We will quantify changes in membrane nanostructure and connect them with biological outcomes.