The irresponsible use of antibiotic therapy means that each year brings new types of antibiotic-resistant microorganisms. There are only a few alternative treatments for similar infections, one of which is antibacterial photodynamic therapy. It uses photosensitizing substances that, under the influence of excitation with the appropriate wavelength of light, generate reactive oxygen species that lead to a bactericidal effect. However, what may seem surprising is that the exact mechanism of interaction of the generated oxygen with microorganisms remains partially unknown. Popular hypotheses assume that some photosensitizers interact with the bacterial cell envelope, causing mechanical damage to the cell membrane and lysis of the microorganism. Other theories describe the mechanism by which the photosensitizer enters the cell interior and damages the genetic material or processes necessary for life internally. Moreover, both of these mechanisms are said to be preferential for different groups of photosensitizers and microbes. However, this does not explain why different groups of microorganisms respond to photodynamic therapy with different groups of substances more or less effectively.

For this reason, as preliminary research for the project, observations of the methylene blue interaction process on *Staphylococcus aureus* bacteria were performed using a significantly modified transmission electron microscope. The methodology of observation proposed in this way allowed for a unique look inside the photodynamic therapy process, determining that the dominant mechanism of cell damage is the oxidation and delamination of the external peptidoglycan shell of the microorganism.

This project aims to continue research using the new method and correlate it with high-resolution light and fluorescence microscopy as an independent confirmation of the observed phenomena. The project also involves research on the interaction of light and electron beams directly with matter and microorganisms. Imaging of various groups of photosensitizers, including hybrid ones - enriched with plasmonic, biocompatible nanomaterials, is planned, as well as parallel testing of Gram-positive and Gram-negative microorganisms. This will be the first attempt in history to explain why such materials allow for even greater therapeutic success. And all thanks to a new setup of transmission electron microscope that allows us to interact with the specimen with light directly during performing observation.