Tissue engineering, utilizing bioprinting, has significantly advanced in recent years. The bioprinting of artificial skin has become possible, and numerous commercial bioinks have appeared on the market, often based on popular systems such as alginates or methacrylated derivatives of collagen and gelatin. Crosslinking methods, such as the use of calcium chloride or UV radiation, have become standard; however, scaffolds produced from these bioinks are mainly used as universal solutions for basic cell viability studies. While bioprinting has found application in skin reconstruction, efforts to improve this method are ongoing. The reconstruction of other organs, such as the bladder, is currently limited. The necessity of finding an alternative method for bladder wall and entire bladder reconstruction is of great importance due to the imperfections of currently used methods, which do not always effectively restore bladder functionality and patient quality of life. Currently used reconstructive materials include intestinal segments, skin, and oral mucous membranes, but they are associated with many complications, emphasizing the need for further development of more specialized and effective methods in tissue engineering. The primary challenge is the slow implementation of tissue engineering techniques into clinical applications. Difficulties in this technology primarily include problems in developing biomaterials that adequately mimic the mechanical and elastic properties of the natural bladder wall and ensure the integration and activity of implanted cells. Another important aspect is the proper regulation of the degradative properties of these materials to avoid premature damage to the implant structure during the regeneration process. The main challenges include ensuring the long-term biocompatibility and effectiveness of the biomaterials used, as well as managing the chronic inflammatory response, which can result in fibrosis and degeneration of the regenerated tissue. Therefore, it is necessary to further improve the production methods and properties of biomaterials used in bioprinting bladder tissue. One of the challenges is the regeneration of the epithelial layer of the urinary tract, such as the urethra, bladder, or ureter, which is crucial for recreating the protective barrier against urine. Considering cell scaffolds, where cells will proliferate and differentiate, emphasis continues to be placed on the importance of the extracellular matrix, particularly on hydrogels and polymers such as collagen and elastin. Focus should be directed on several aspects, such as the environment conducive to cell migration, proliferation, and differentiation, the crosslinking method, and factors that will support the integration of the scaffold with natural tissue. Therefore, an approach based on the use of chitosan, agarose, matrix components such as collagen or elastin, as well as bioactive peptides, is fully justified. The use of the chitosan-agarose system has been proposed in the studies by Banach-Kopeć et al., 2024 DOI: 10.1016/j.carbpol.2024.122120, as a printable, biocompatible composition that meets basic biological requirements. However, as with other systems, this base needs to be enhanced with additional components, such as collagen or elastin, to increase the mimicry of the natural extracellular matrix, and peptides that will stimulate the process of angiogenesis and cell differentiation.

The main goal of the project is to develop a bladder model based on biodegradable and biocompatible medical meshes. These meshes will serve as scaffolds on which successive hydrogel layers conducive to cell growth will be applied. In light of the limitations of typical bioprinters, which print layers one after the other, spherical printing technology utilizing 6-axis robotic arms will be employed. This will allow for the creation of oval constructs, such as the bladder, without the need for creating complex supports that are difficult to remove from the model. Our aim is to create a bladder or bladder wall model where cells will differentiate, forming tissue structures. In this context, we plan to use the peptide QHREDGS in free form or covalently bound to chitosan, using maleimide glycine as an efficient and mild crosslinking agent. The project will be carried out in an inter-university collaboration, combining the efforts of three universities: Gdańsk University of Technology, which will be responsible for creating a bladder wall prototype that meets all required mechanical, rheological, and basic biological safety aspects; the University of Gdańsk, which will handle the synthesis of bioactive pro-regenerative peptides; and Nicolaus Copernicus University, which will explore the possibilities of cell differentiation and the suitability of the solution as a potential research model and a new pathway for organoid creation.