Thesis Portfolio

Evaluating and Quantifying Viability of 3D-Printed Cells with Mathematical Modeling Across Different Bioprinting Methods
(Technical Report)

How Past Biomedical Interventions Inform the Emerging Ethical Concerns Surrounding Artificial Organs
(STS Research Paper)

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Sociotechnical Synthesis

The technical portion of this project this project consisted of a quantitative analysis of cell viability using different extrusion-based bioprinting methods – pneumatic and piston – and varying nozzle diameters, culminating in mathematical modeling to relate shear stress, nozzle diameter, and cell viability. This project is done in the context of biomanufacturing of tissue engineered muscle repair (TEMR) constructs for treating volumetric muscle loss. Bioprinting has shown potential to enhance the manufacturing process for these constructs by reducing time and cost. However, in order to ensure successful integration of bioprinting in the field of tissue engineering as a biomanufacturing tool, it is necessary to fully understand the printing process and its effects on the printed cells. In particular, there is a large degree of variability in cell viability between printing parameters and across printing methods. The successful clinical translation of these bioprinted constructs relies not only on maintaining high cell viability but also a high degree of control, understanding, and reproducibility over the entire biomanufacturing process. Thus, this project seeks to investigate the effects of the printing process on induced shear stress and cell viability using mathematical modeling as a tool to quantify and predict these effects as well.

The relatively recent emergence of bioprinting technology which continues to improve has heavily contributed to advancements in the field of tissue engineering. This technology has enabled the creation of highly organized, heterogenous synthetic tissue constructs that more closely model native human tissues and diseased states. The emergence and fast-paced development of this technology is a crucial step towards the production of fully functional artificial organs for human implantation. Though we are far from being able to print such functional, biocompatible, and vascularized organs, the current research trends in the field of tissue engineering suggest that this is an impending reality. As such, it is important to begin a larger conversation among the experts involved in the development of this technology as to what ethical questions and concerns may arise from this technology. In doing so, it is

useful to look to the past and draw comparisons to similar biomedical inventions. Thus, the second portion of this work is focused on evaluating the ethical concerns that were present in the development and widespread adoption of past biomedical technologies – specifically, cardiac pace makers, insulin pumps, and artificial joints – and how these concerns can reasonably be expected to arise in the future. The justification for these predictions and comparisons comes from the key features and contexts of use that all of these past inventions share with future artificial technology. These features, along with the ethical concerns that arise from them, are explored in detail through the perspective of bioethicists and researchers involved in this area of tissue engineering in order to identify the most pressing concerns.