Thesis Project Portfolio

Device for automated selection and placement of cell clusters within biofabricated tissue constructs

(Technical Report)

Body Commodification and Kidney Xenotransplantation

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Critique

This thesis consists of a technical project and an STS project which allowed for a better understanding of the sociotechnical relationships within this engineering discipline. The technical and STS projects are connected in that they are both potential solutions to a crucial shortage of transplantable organs and tissues. Focusing on the technical aspects of tissue engineering aids in the solutions of many diseases; furthermore, increased focus and scholarship on the social aspects of novel biotechnologies aims to increase the amount of those who benefit from such societal advancements. I will summarize the technical project and its connection to the STS project and remark on the importance of conducting both simultaneously.

Bioprinting is the application of 3D printing principles to the construction of organic material (Mandrycky et al., 2016). Cell seeding plays an essential role in forming functional tissues. The process, however, has yet to reach the level of automation that would allow it to be successfully incorporated into the bioprinting process. Dr. Highley and our team aimed to resolve this issue by constructing a micromanipulator controllable within a computational framework similar to devices previously described in the literature (Xu et al., 2021).

The aims of our project were threefold. First, we designed and constructed a manual micromanipulator capable of aspirating polymer microspheres based on an open-source model. We then developed a computational framework that can communicate with stepper motors to coordinate the movement of the device and the aspiration mechanism. Finally, we developed software solutions to successfully aspirate and move cell clusters to a target location intact.

We believe that meeting the above objectives will be sufficient to produce a functional automatic micromanipulator capable of being used in a lab setting. This device will enable more consistent and rapid development of engineered tissues in vitro by reducing the need for human inputs. In addition, this project lays the foundation for future designs that incorporate computer vision to automatically identify, select, and move target cell clusters. Overall this work aids the development of higher fidelity biofabricated tissues for experimental and therapeutic uses.

The Technical and STS projects of this thesis are connected because they both have similar final therapeutic goals of finding a solution to the organ shortage crisis. The technical project aims to advance the field of tissue engineering specifically by improving and furthering the biofabrication of tissue and organs. Another biotechnology aimed at solving the organ shortage problem and extending human capabilities is xenotransplantation which is the focus of the STS project.

Specifically, the focus is directed towards kidney xenotransplantation as it is likely to be the first organ to be used as a xenotransplant in a clinical setting. Background of the inequalities and injustices that have historically and currently persist within the practice of kidney transplantation is provided to understand better how xenotransplantation interfaces with the systemic injustices of the kidney transplantation system. The STS Project employs Nancy Scheper-Hughes and Margaret Lock's notion of "the body politic" from the 1987 work "The Mindful Body" to examine unjust practices within kidney transplantation and

xenotransplantation to connect and elucidate the manner in which transplantation practices commodify the body.

Additionally, I implement ideas from Donna Haraway's 1989 "The Biopolitics of Postmodern Bodies: Constitutions of Self in Immune System Discourse". In this chapter of her book, Haraway identifies immunology as a tool used within western biopolitics to differentiate self from others. Haraway notes that immunology and the immune system define the body as a coded text which is organized into a cybernetic information system. Haraway contemplates the implications of defining similarity and difference through science and technology, which I then apply to the practice of clinical kidney xenotransplantation. I also utilize Haraway's "A Cyborg Manifesto" to infer how historically inequitable practices within kidney transplantation may be continued, subverted, or be redefined through the practice of clinical kidney xenotransplantation. In doing so, I argue that kidney xenotransplantation as a clinical practice has the potential to do harm to previously marginalized groups and ethnicities within the US and globally.

This year, working on a technical project has allowed me to gain engineering and design experiences that will influence my career. In contrast, the STS project granted me opportunities to think critically about my position and responsibilities within a nation and global society that places great value on innovation within science and technology. Additionally, the STS project invoked respect for those burdened due to scientific and technological innovation and, in turn, a duty to consider diverse bodies when conducting science or developing technologies.