Thesis Project Portfolio

The Current State of 3D Bioprinting and Embedded 3D Bioprinting (EMB3D) as Novel Methodology for Tissue Engineering

(Technical Report)

Involuntary Manslaughter: The Danger of Healthcare as a Privilege in American Domestic Policy

(STS Research Paper)

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Noah Benjamin Stern

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Sociotechnical Synthesis

Over the past several decades, the evolution of modern healthcare has become an increasingly prevalent issue socially, politically, and culturally throughout the world. As infrastructure and medical science has improved to the point where people can live happier and healthier lives, discourse has shifted to asking how will care be funded, who will be eligible, and what future directions should be taken. Through the course of this work, I have attempted to add context to the discussion of these three questions. My STS research, which concerns the first two questions, was devoted to analyzing the United States healthcare system. The goal was to elucidate the systemic cultural understanding of healthcare in the country and how issues far more complex than funding have led to a widespread disparity in the quality of care between the wealthiest and poorest Americans. My technical portion, which focuses around the third question, concerns the development and implementation of a new methodology for tissue engineering called Embedded 3D Bioprinting (EMB3D). Beyond just demonstrating the viability of this technique, the aim was to place the advantages of EMB3D in the context of other developing methodologies in an effort to show its great potential. While these topics are not clearly related at first glance, they are in fact deeply intertwined. Cyclically, how Americans perceive healthcare is essential to how research is supported and funded, while the efficacy and results of medical research deeply informs how Americans perceive healthcare.

My STS research was centered around the troubling idea that amongst developed nations, the United States ranks first in metrics like healthcare spending per capita and quality of medical research, yet the nation ranks near the bottom when discussing overall health of its citizens in areas like prevalence of chronic illnesses, deaths from preventable diseases, and life expectancy at birth. When taking a deeper look at this issue, it becomes very obvious that citizens in worse

socioeconomic conditions typically receive lower quality care, have much higher difficulty accessing medical professionals, and are much less likely to seek out care due to factors beyond their control. This disparity is often referred to as the "healthcare gap" by leading public health experts. Currently the talking points for every political campaign are all about increasing funding and ensuring better allocation of resources, yet I have found that there are deeply held cultural values in the United States that are far greater roadblocks than funding. Through comparison with another world power that ranks well above the United States in many rankings, it can be seen that the prevalence of lobbying in government, a reactionary approach to governance, and a systemic mistreatment of immigrants and low-income workers are major hindrances to improved policy in the United States.

As tissue engineering has evolved into a fascinating and rapidly growing field in the domain of biomedical engineering, my technical research focuses around the development of a new technique that could revolutionize the field. Built upon recent advancements in conventional 3D-printing, EMB3D is a technique that will potentially allow researchers to reproducibly and reliably build 3D models and functioning tissues with living cells. EMB3D differs from other bioprinting techniques in that instead of printing cells *on top* of some kind of support structure, cells are printed *within* a specially designed gel matrix. The matrix provides sufficient strength to safely hold cells in the position they were printed, while also allowing for diffusion of necessary biomolecules and for the motion of the printing nozzle through its bulk. Through my work, I was able to show that EMB3D produces viable cell structures which can grow and proliferate despite harsh printing conditions. With further studies and experiments, EMB3D could be adopted as a crucial technique as the field struggles to overcome issues with cell viability, tissue formation, and reproducible results.

As the STS and technical research projects were completed in tandem, they offered crucial insights in to how each would progress. To an outside observer, the billions of dollars that are devoted to medical research every year must be baffling. My technical project has helped provide me with the context necessary to understand. On my project alone, I used dozens of different pieces of equipment, multiple lab spaces, and a wide array of different chemical and biological substances. To obtain accurate and potentially actionable results in the medical field, years of work must be completed and rechecked. I am just one unpaid undergraduate student and my project quickly became incredibly complex, yet this complexity pales in comparison to the wider network of medical research funding and values that I uncovered through both my STS and technical portions. Also like many other engineers, I was initially focused on simply how to make my project work. I wanted it be to functional and work well every single time. However, as I dove deeper into my STS research, I realized things like making sure the technology was accessible and simple enough to be implemented, and the necessity in keeping the technique affordable were just as essential. There is so much more to being a great engineer than building impressive devices, as each engineer must be responsible for how their work will be implemented, scrutinized, and built upon going forward. I have learned that everything I do as an engineer must be informed by the many actors and networks it will be a part of if I am to be successful.