Thesis Project Portfolio

Developing an Intranasal HIV-1 mRNA Vaccine Using Carbon Nanotubes (CNTs) as a Delivery System
(Technical Report)

Sociotechnical Imaginaries Developed by Biotechnology Companies Through CNT-based and Lipid-Nanoparticle-Based mRNA Vaccines
(STS Research Paper)

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Bachelor of Science, School of Engineering

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Table of Contents:

1. Sociotechnical Synthesis
2. Developing an Intranasal HIV-1 mRNA Vaccine Using Carbon Nanotubes (CNTs) as a Delivery System
3. Sociotechnical Imaginaries Developed by Biotechnology Companies Through CNT-based and Lipid-Nanoparticle-Based mRNA Vaccines
4. Prospectus

Sociotechnical Synthesis

Introduction:

The technical and STS research papers both focus on the development of CNT-based vaccines. The technical research paper focuses on engineering a CNT-based HIV-1 vaccine. In contrast, the STS research paper focuses on the world that biotechnology companies desire to create through CNT-based and lipid-nanoparticle-based vaccines. Through my experience working with Luna Labs to develop the HIV vaccine in my technical project, I learned that there was no current HIV-1 vaccine due to inadequacies with conventional vaccine development methods. A new method of vaccine development is needed to address supply chain issues, multiple dosages, and potential infection of the disease in patients. These issues are made a priority for biotechnology companies to address larger social issues. Therefore, in my STS research paper, I explored the social issues that are emphasized by biotechnology companies that explain their research in new vaccine methods. I did this through sociotechnical imaginaries because this framework allowed me to understand the motivations of the biotechnology companies.

Technical Project:

Human immunodeficiency virus 1 (HIV-1) is a virus that attacks the immune system by destroying immune cells, which affects their ability to protect the body from foreign objects (Chen, 2019). Currently, there is no vaccine for this virus. My technical project seeks to develop an intranasal CNT-based mRNA HIV vaccine. In particular, we optimized the ratio of mRNA to CNTs based on toxicity, cellular uptake, and production of target protein in the cells. mRNA vaccines function by entering cells and then producing key proteins that are detected and remembered by the immune system. However, mRNA is not stable in the body and therefore

needs a delivery system. Carbon nanotubes allow us to mimic the HIV virus structure while delivering the mRNA to target cells. We had two specific aims for this project: 1) prepare the CNTS to the proper size and in various CNT to mRNA ratios and 2) test these ratios in cellular uptake and mRNA translation studies. These experiments helped us narrow down a range of CNT-mRNA ratios for this vaccine. In future work, this ratio will be tested in animal models for toxicity and efficacy. It will also be optimized for manufacturing and the shelf life of the formulation will be tested.

STS Project:

My STS project seeks to understand the sociotechnical imaginaries created by biotechnology companies with their CNT-based and lipid-nanoparticle-based vaccines. In particular, I investigated the imaginaries of Luna Labs and Pfizer who are developing the CNT-based HIV vaccine and lipid-nanoparticle-based COVID-19 vaccine, respectively. Both companies have released information on their websites and research papers that address their social motivations for developing these vaccines. I argue that biotechnology companies view these vaccine delivery methods as avenues for social equality, public trust in public health systems, and global economic development. I also argue that these companies use co-production to create these sociotechnical imaginaries by addressing concerns voiced by patients and healthcare personnel. I analyze the language and content of the websites of these companies to make conclusions about the proposed sociotechnical imaginaries. It is important to understand these motivations for technology to understand how the technology is anticipated to affect the world. The sociotechnical imaginary framework helps me understand the necessity for the technology and reflect on how these companies incorporate feedback from other social groups in their design.

Conclusion:

Working on both these projects at the same time helped me see behind the curtain of how research projects are chosen and designed. Before my projects, I knew that engineering projects were created to solve a problem in the world most of the time. However, I realized, after the projects, that often, the methods used to solve a problem are motivated by social factors. CNTs were chosen for the technical project because they addressed social issues such as vaccine accessibility and vaccine hesitancy. The technical project taught me about the biomedical techniques used in engineering a vaccine. It also taught me about the FDA approval process and the tests needed for safety and efficacy. This information helped me identify the sociotechnical imaginaries in my STS paper and speak to the way that the biotechnology companies expressed these imaginaries through their technology. The STS paper, in return, made me aware of the importance of understanding the social motivations behind technology and how they can be incorporated in technical systems. It helps me reflect on the technical project and make a conscious effort to create a vaccine that not only reacts to existing social issues surrounding vaccines but also anticipate possible issues and address these as well.

References:

Chen, B. (2019). Molecular Mechanism of HIV-1 Entry. *Trends in Microbiology*, *27*(10), 878–891. https://doi.org/10.1016/j.tim.2019.06.002