**Thesis Project Portfolio**

# Design of a Pembrolizumab Manufacturing Plant Utilizing a Perfusion Bioreactor and Precipitation Chromatography

(Technical Report)

# The Success of Pfizer and Moderna and the Failure of Merck and Co. in Developing a COVID-19 Vaccine

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring, 2023

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**Sociotechnical Synthesis**

My technical work and my STS research project are related through the idea of improvements in the pharmaceutical industry. The pharmaceutical industry and more specifically the successful commercialization of a biologic, is complex and multifaceted with many areas for a new drug to fail along the way in R&D, clinical trials, manufacturing at scale, etc. The two works focus on different aspects of this development, manufacturing and the social aspects of drug design. My team's technical project describes the design of an improved manufacturing facility for Keytruda, Merck's biggest oncology drug while my STS research paper explores the social reasons Merck's COVID-19 vaccine candidates failed in development and design. So, while the focus of the projects may differ, both are thematically related through making improvements in the pharmaceutical industry.

The purpose of this technical project was to design a manufacturing facility with semi-continuous stages of production and the use of single-use equipment for Keytruda, active ingredient pembrolizumab, a monoclonal antibody (mAb) that is used to treat bladder, stomach, colon, and cervical cancers. Merck is the current producer of this drug however its patent is expiring in 2028 hence the need for more efficient manufacturing design to reduce costs and increase accessibility. Additionally, users of Keytruda are set to double by 2024 so increased capacity is required as well. This new facility makes use of single-use equipment to reduce the needs for caustic chemicals required for cleaning. Additionally, precipitation chromatography will be used in place of protein A chromatography, traditionally used in mAb production to reduce costs. With these new measures in place our facility is designed to produce 1400 kg/year enough for 7 million doses, accounting for 20% of the 2024 projected demand.

In my STS research I argue an additional explanation for the failure of Merck and Co.'s two COVID-19 vaccine candidates. In recent literature the failure is attributed to the poor immunogenicity displayed in clinical trials for the candidates however, it fails to also describe Merck and Co.'s design choices for these vaccines that contributed as well. I explore some of the social aspects of their design such as lack of strategic partnerships and differing perspective of relevant social groups that contributed to the company ceasing its development. I use the social construction of technology (SCOT) to describe these factors as technological success does not occur in isolation and the best designs do not always win so the other relevant social factors must be explored.

In researching both projects, I realized that pharmaceutical design is often based upon traditional practices and large companies like Merck believe in tried-and-true techniques. In making technical design decisions it seems easy on paper to implement, but in researching such a regulated business in practice the changes we have employed may require FDA validation and stringent testing to ensure an identical product is produced from the previous manufacturing platform. Similarly in researching Merck's vaccines I realized how these same ideals were held in its desire for safety of its product by focusing R&D on their established technologies rather than novel ones which actually won the vaccine race. Working on these assignments in tandem provided me a new perspective on how to make design choices and what social factors may need to be considered in each aspect of pharmaceuticals. In isolation manufacturing and research may seem far apart but together I learned how linked each process is.