

**Thesis Project Portfolio**

**Electromechanical Bioreactor for Volumetric Muscle Loss Treatment**  
(Technical Report)

**Corporate Social Responsibility in The Hair Care, Beauty, And Medical Industries: A  
Deontological and Virtue Ethics Analysis of Hair Care Companies**  
(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

**Aparna Kola**  
Spring, 2022  
Department of Biomedical Engineering

## **Table of Contents**

Sociotechnical Synthesis

Electromechanical Bioreactor for Volumetric Muscle Loss Treatment

Corporate Social Responsibility in The Hair Care, Beauty, And Medical Industries: A  
Deontological and Virtue Ethics Analysis of Hair Care Companies

Prospectus

## Sociotechnical Synthesis

Volumetric muscle loss (VML) is the loss of skeletal muscle as a result of trauma or surgery, and can result in significant functional impairment. It affects veterans disproportionately in comparison to civilians, as 92% of warfighters with muscle deformities have VML (Corona et al., 2015). In order for a tissue engineering construct, conditioned using this capstone bioreactor, to be effective in the target clinical population, the social sensitivities surrounding the VML population must be well-researched and considered. This technical capstone partially concerns how medical conditions hurt some populations more than others and considers that treatments must be equitable in medicine. As VML injuries affect some populations disproportionately in comparison to others, the broader question follows—are some groups affected by certain phenomena more than others? This curiosity is explored in the case of a recent class-action lawsuit titled *Whipple v Johnson & Johnson Consumer Inc.* in which the Johnson & Johnson's OGX Shampoo and Conditioner line is contested to have harmful levels of a carcinogenic compound with a lack of appropriate contingency measures taken by the company (Whipple, 2021). With the recent rise of the natural hair movement, most prominent in the curly hair demographic, companies are responding by catering new products and marketing to natural, curly hair. This phenomenon begs the question whether certain minority groups have been affected by this harmful compound (Simeon, 2021). The relationship between hair care companies and their users, including the sociotechnical aspects of hair beauty and medicine, must be examined to better understand what responsibility these companies have as large influencers in the hair care space. The final sociotechnical deliverable is a virtue ethics analysis of the evolving relationship between hair care companies and hair care consumers, how minority

populations are affected in this relationship, and what responsibility companies hold in this equation.

Volumetric Muscle Loss (VML) injuries are debilitating and affect veterans disproportionately in comparison to civilians as 92% of warfighters with muscle deformities have VML (Corona et al., 2015). These injuries result in permanent loss of muscle tissue and function and in extreme cases, the consequent loss of whole-body function. Current research in the regenerative medicine space targeted towards VML injury repair fails to reconstruct the cellular environment of the neuromuscular junction (NMJ), and there is a need for a technology that holistically mimics the chemical, electrical, and mechanical forces of the NMJ. In efforts to address this need, the Caliri Lab at the University of Virginia Department of Chemical Engineering is building a collagen-glycosaminoglycan-polypyrrole (CG-PPy) scaffolds to better mimic the three-dimensional, anisotropically aligned, and electrically conductive NMJ and research neural and muscle cell growth on this novel tissue engineering construct (Basurto et al., 2021). A component of this five-year research proposal includes electrical and mechanical conditioning of the cell-seeded-scaffold to align the particles for optimal cell growth which is achieved by the final technical deliverable of the capstone research team. The capstone team has been tasked with designing and fabricating an electromechanical bioreactor capable of electrically and mechanically stimulating the cell-seeded-scaffold in a cell-incubator environment. The final technical deliverable is a working prototype of the bioreactor with an interface to adjust the electrical and mechanical stimulation along with preliminary testing data.

Shampoo is the most frequent type of cosmetic hair treatment, used by 307.84 million Americans (Statista Research Department, 2020). This research explores the patterns of hair care and beauty in the 21<sup>st</sup> century, namely the natural hair movement, and questions the

responsibility of companies in the exchange between hair care consumers and producers from a deontological ethics perspective. More specifically, it asks—How has the feedback loop between hair care companies and hair care product consumers evolved through history and how have minority populations been affected by the stated phenomena? This natural hair care movement will be evaluated from a paradigm shift perspective, while the ethical considerations for all parties involved in hair-care consumerism will be evaluated from a deontological and virtue ethics perspective. This research is important to evaluate the safety measures in place to protect both the consumer who uses the ingredients in commercially manufactured hair care products and manufacturing companies who may be accused of poor formulation or manufacturing. Ultimately, the research addresses the regulation of hair care products through policy, but also through consumer-manufacturer dynamics to evaluate where ethical responsibility should be placed. Results will inform consumers with potential solutions such as increased transparency and data availability between the consumer and manufacturer parties to create a more collective ethical responsibility and ensure the safety of both the consumer and manufacturer in the United States consumer society.

Developing these projects together has allowed for an understanding of how disparities affect various populations across the board—from the medical industry to the cosmetic industry, the way that manufacturers consider diversity of the market in research and development affects the safety and effectiveness of the product on the end user. This can often be biased toward the majority makeup of the target population, but can disproportionately affect minorities. Ultimately, this research allows for a broader understanding of equity, and how equitable practices can be improved by manufacturers in all industries.

## References

- Basurto, I. M., Mora, M. T., Gardner, G. M., Christ, G. J., & Caliarì, S. R. (2021). Aligned and electrically conductive 3D collagen scaffolds for skeletal muscle tissue engineering. *Biomaterials Science*, 9(11), 4040–4053. <https://doi.org/10.1039/d1bm00147g>
- Corona, Benjamin T., Jessica C. Rivera, Johnny G. Owens, Joseph C. Wenke, and Christopher R. Rathbone. “Volumetric Muscle Loss Leads to Permanent Disability Following Extremity Trauma.” *Journal of Rehabilitation Research and Development* 52, no. 7 (2015): 785–92. <https://doi.org/10.1682/JRRD.2014.07.0165>.
- Simeon, Aimee. (2021). How Natural Hair Has Influenced A Generation. <https://www.refinery29.com/en-us/natural-hair-industry-history-evolution>.
- Statista Research Department, & 2, J. (2021, July 2). U.S.: Usage of shampoo 2020. Statista. Retrieved December 9, 2021, from <https://www.statista.com/statistics/276924/us-households-usage-of-shampoo/>.
- Whipple, Larissa. IN THE UNITED STATES DISTRICT COURT NORTHERN DISTRICT OF ILLINOIS. n.d., 48.