Thesis Project Portfolio

Conversion of *Escherichia coli* to Oxidize Methane for Reduction of Bovine Methane Pollution in Agriculture

(Technical Report)

Battle of the Bovines: Cattle, Colonialism, and the Conquest of the Bison

(STS Research Thesis)

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Executive Summary

Technical Project

Conversion of *Escherichia coli* to Oxidize Methane for Reduction of Bovine Pollution in Agriculture

Livestock production accounts for 14.2% of global anthropogenic, or human-caused, greenhouse gas (GHG) emissions. Bovines, specifically meat cattle and dairy cows, in particular, produce 2% and 4% of US greenhouse gas emissions, respectively. A few agricultural methods within livestock production are responsible for these GHG emissions, including land clearing for grazing, feed production, manure management, and rumination in bovine species. Rumination is defined as the process that certain species of animals, like cattle or sheep, digest their feedstuff. During rumination, microbial species known as methanogens in the rumen break down feedstuff by fermentation and produce methane (CH_4) as a byproduct. The produced methane is expelled from the ruminant's digestive system by the mouth and waste products. There are current mitigation measures aimed at reducing rumination methane emissions that include feed additives, formulations, or anti-methanogenic vaccines. However, targeting rumen methanogenic microorganisms with drug treatments is ineffective due to the resistance to change in the rumen methanogens. While altering the feed of ruminating species has shown to be more effective, developing technologies in genetic manipulation are more accessible to enact systemic changes across multiple ruminating species.

To this end, the technical project proposes an experimental approach to genetically manipulate *Escherichia coli* (*E. coli*), a common and harmless bacteria found in the bovine digestive system, to consume methane produced by the rumen methanogenic species. We attempt to incorporate the three gene encoding for the methane-oxidizing protein, particulate methane

monooxygenase (pMMO), from a bacteria species, *Methylococcus capsulatus*. We utilize genetic engineering techniques such as encapsulation of target genes in plasmid vectors, bacterial transformation, and validation tests of SDS-Page, which measures protein weight and aids in ensuring that the pMMO protein is expressed in the modified *E. coli,* and gas chromatography, which measures the changing methane concentration from *E. coli* uptake in a closed environment. Results show normal growth kinetics of modified *E. coli*. Further results show no decrease in methane concentration from *E. coli* uptake in methane-rich conditions. While we are unable to implement the successfully modified *E. coli* in bovine populations, future projects could implement the modified bacteria and ensure that the inclusion of the modified *E. coli* does not negatively impact the health of the bovine population.

Keywords: Greenhouse gas emissions (GHG), *Escherichia coli* (*E. coli*), particulate methane monooxygenase (pMMO), SDS-Page, gas chromatography

STS Paper

Battle of the Bovines: Cattle, Colonialism, and the Conquest of the Bison

In further discussions on the adverse effects of bovine production, I examine the historical and present consequences of colonization of North America, henceforth defined as Turtle Island with respect to one of many Indigenous terms to describe the continent, in a Science, Technology, and Society (STS) paper. In particular, I examine the introduction of European cattle to the Turtle Island bison populations. I argue that European colonization utilized cattle and bison as technologies against the Indigenous Nations, as I chose to define technology as the use of resources for anthropogenic change in the context of the paper. The introduction of

European cattle in colonization led to a decline of natural resources that sustained Indigenous populations for thousands of years. Cattle consumed and destroyed Indigenous landscapes and agriculture, and served as capital for European colonizers to sustain the invasion. Additionally, prior to European colonization, many Indigenous populations depended on bison for their way of life. The capital generated by bison husbandry gave bison-dependent Indigenous populations living standards higher than the average European household. Frustrated by the bison-dependent Nations refusal to move to reservations, the American government enacted policies that led to a rapid decline in bison populations in the late 1800s. After examining the historical context of European colonization with a lens on bison and cattle dynamics, I illustrate the historical and present consequences of colonization, bison population decline, and cattle population increase. I utilize the Social Construction of Technology (SCOT) framework to analyze how European colonizers advantaged both cattle and bison to induce societal changes from an Indigenous landscape to present-day American society. Further, I discuss present and future implications for Indigenous sovereignty with respect to bison conservation.

Keywords: Turtle Island (North America), Science Technology and Society (STS), European cattle, bison, Social Construction of Technology (SCOT)