Thesis Project Portfolio

Polymeric Synthetic Oxygen Carriers for Transfusion at the Location of Injury
(Technical Report)

An Analysis of the Ethical and Sociotechnical Context of Biotechnology in the Military-Industrial Complex
(STS Research Paper)

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Sociotechnical Synthesis

Given the fact that the technical project was quite firmly a part of the military-industrial complex, an exploration of the wider context of biotechnology in the military-industrial complex seemed appropriate. A major point of discussion in the research paper is dual-use technologies, which are technologies with both military and civilian potential uses. The synthetic oxygen carriers are a perfect example of a dual-use technology. The project is funded by the Department of Defense and its intended use is to aid wounded soldiers on the battlefield; however, the exact same technology can be used just as effectively by civilian EMTs responding to car crashes, gunshot wounds, or other scenarios in which injury or death due to severe hemorrhage is an immediate threat.

Another major point of discussion of the research paper is the relevance of the political, economic, and social factors surrounding any given technology to the creation and use of that technology. Much of the proposed military-industrial medical ethics framework focused on the clinical development of a biotechnology and beyond, which is a step or two beyond the current state of the synthetic oxygen carriers. However, as the project marches on, it will be increasingly important to think about the technology relative to the framework, and how we can be proactive in preparing the technology to be created and used in a bioethical manner.

Polymeric Synthetic Oxygen Carriers for Transfusion at the Location of Injury

During excessive blood loss, hemorrhagic shock can occur if tissues do not receive adequate amounts of oxygen. As a result, intracellular lactic acid and oxygen radical concentrations increase, leading to widespread inflammation and eventually cell death across the body. The leading cause of death in Americans aged 46 and under is hemorrhage due to physical trauma; as such, research into methods of rapidly controlling hemorrhagic shock is particularly important, especially for military healthcare. Blood transfusion can be an effective hemorrhage treatment, but blood has a relatively short shelf-life of 35 days and supply can often fall below demand due to sourcing difficulties. Perfluorocarbons are small molecules with high oxygen dissolving capabilities, but are not stable during lyophilization and while inert, may have some adverse effects in vivo. Thus, polymer-based nanoparticles or emulsions will be employed to encapsulate the perfluorocarbons and create synthetic oxygen carriers. The synthetic oxygen carriers can be transfused during severe hemorrhage to restore the oxygen-carrying capability of the blood. These synthetic oxygen carriers have a high dissolved oxygen capacity, while being stable either before and after lyophilization or over two weeks. Additionally, we demonstrate techniques to reduce the size of the synthetic oxygen carriers, which will be important for *in vivo* use. Murine hemorrhagic shock models show an increase in the partial pressure of oxygen in the blood after transfusion of the emulsion-based synthetic oxygen carriers.

An Analysis of the Ethical and Sociotechnical Context of Biotechnology in the Military Industrial Complex

In his 1961 farewell address, Eisenhower famously warned of the dangers of the military-industrial complex in the United States. In the decades since, the military-industrial complex has evolved into a vast industry driven by a national security state mindset and controlled by various economic, political, and military interests. At the same time, the biotechnology industry has also experienced significant growth in the last few decades, leading to biotechnology becoming an important sector within the military-industrial complex. Bioethics and military ethics both receive much scholarly attention, yet the heightened pace of development of biotechnologies hinders the creation of relevant ethical frameworks, especially when the confounding sociotechnical factors of the military-industrial complex are considered. Here, I analyze the social, ethical, political, and economic factors that have shaped the use of biotechnology in the military, with a focus on dual-use technologies in military issues of the 21st century. By understanding these factors, I then develop a new framework synthesizing biotechnology, bioethics, and the military to understand and predict ethical concerns of the future of biotechnology in the military. Using existing bioethical principles as a foundation, I will additionally outline the principles by which the military, legislators, and the biotechnology industry must act to strive for a more bioethical future.