Impact of Technology on Biology and Physiology

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Risks and Benefits of Technological Development:

Technological development is a double-edged sword; the development of new technologies provides considerable benefits to society, yet present a significant and unprecedented risks. Without proper regulation, new or uncontrolled uses of technology can lead to highly destructive technologies, even technological weaponization. A briefing on unprecedented technological risks indicate technologies not normally considered dangerous can be more concerning than technologies such as nuclear weapons, the logic being "nuclear weapons require the rare and controllable resources of uranium-235 or plutonium-239" (Unprecedented Technological Risks, n.d.). Although technological risks arise from a variety of technological fields, they can all be analyzed by their ability to achieve their expected result and their ability to influence. Conducting such evaluations would improve our knowledge on technological impact, thus leading to improved regulation and engineering practices.

An example of a technology that has the potential to damage is artificial intelligence (AI). AI can be advantageous areas such as communication speed, goal coordination, rationality, and computational resources. The risks of AI lie in its developmental stages and in the user. Primitive AIs can behave in unpredictable ways, and AIs that reach an above-human-level could take disastrous actions. Furthermore, actors that control powerful AI could gain a significant advantage over all other actors (Unprecedented Technological Risks, n.d.). In this thesis, the means by which different technologies have been weaponized in the past and technology that canoe weaponized in the future evaluated to understand its societal implications. With the weaponization of technology as one of the less recognized ramifications of technology and innovation, it is

important to analyze the gravity of this effect and address the issue. No one is fully protected from disease and technological advances, which is why the potential of technology against the common well-being as well as the future of technological weaponization concerns everyone.

Overview of Bioterrorism:

The current definition of biological terrorism, or bioterrorism, concerns the use of biological weapons potentially in the form of living organisms to cause illness or death (Danciu, 2011) (Jansen et al., 2014). An example of bioterrorism which perfectly fits the current definition is the Anthrax letters attack on America, also known as Amerithrax, following the September 11 attacks. Anthrax is an acute illness caused by *Bacillus anthracis*, a spore-forming bacterium which in extreme cases can lead to death (Anthrax—Symptoms and causes, n.d.). Through modern science, pathogens such as Anthrax are now easily produced as desired and in large quantities. The accessibility of Anthrax replication by terrorists resulted in a direct attack on high profile American officials and news media organizations as well as indirect attack on the associated population. Over 10,000 people were deemed at risk for Anthrax exposure, with 43 people having tested positive for Anthrax exposure and 22 people being diagnosed with Anthrax (A History of Anthrax | Anthrax | CDC, 2019). There were ultimately 5 casualties and a loss of $320 million dollars to Anthrax decontamination expenses (A History of Anthrax | Anthrax | CDC, 2019) (Schmitt & Zacchia, 2012).

The Amerithrax case thoroughly matches the definition of bioterrorism: the bacterium *Bacillus anthracis* was leveraged as a fatal weapon to cause fear and panic. This definition, however, does not take into account other forms of maliciousness; there are several instances of bioterrorism that do not follow this strict definition. Other technologies that are not biology-

based are capable of having an impact on living organisms. The atomic bombing of Hiroshima and Nagasaki resulted in between 90,000-120,000 and 50,000-80,000 casualties respectively, and the attack continue to impact survivors by increased potential for disease and genetic damage \ (Hiroshima and Nagasaki Death Toll, n.d.) (Genetic Effects of Radiation in the Offspring of Atomic-Bomb Survivors – Radiation Effects Research Foundation (RERF), n.d.). The impacts of nuclear bombs and a few other similar cases will be further analyzed for its biological/physiological, and social significance using science, technology and society (STS) frameworks.

Frameworks:

Technological fix is a term which defines the use of technology to solve social problems that are traditionally addressed through other social processes (Newberry, n.d.). One of the critiques of technological fixes is that while it a technology might be effective for solving one problem, it tends to have many unintended costs and consequences. This framework will be used to understand how effective a technology is at addressing the issue it was initially intended to solve, and the unintended consequences of the technology.

The politics behind a technology will also be considered in the analysis of a technology. The political significance of a technology can be identified relatively quickly, but the way in which such technology came to be and has evolved can be somewhat unclear. The political technology framework proposes that a technology can be politically influential by being either inherently political or deterministically political (Winner, 1980). One of the criticisms of this framework is that it is can be difficult to determine which of the two categories a technology falls under. Research suggest that bioweapons and weapons in general are developed as a political ad-

vantage (Guillemin, 2006). The technology reviewed in this research will be evaluated for how it was politically impactful and effective a political technology is as a technological fix.

Research Question and Methods:

The subject investigated is how the impact of technologies outside the realm of biotechnology influence biology or physiology. Background information on technology is gathered from news sources and reputable journals based on pre-identified cases. Extensive background research on a technology is presented along with its applications and implications for society are evaluated using the technological fix and political technology frameworks.

Results and Discussion:

Three different technologies and their histories are defined and analyzed for the effectiveness as a technological fix and political influence. Each technological example demonstrates how a technology originally non-biological in nature has a significant impact on biology or physiology, thus fitting the definition of bioterrorism. Each technology ultimately fulfills its intended purpose, but at the cost of the health and lives of countless people. Technologies used by powerful organizations, such as the government, also demonstrate a potential for political influence.

9/11 Attacks and Asbestos:

On September 11th, 2001, the World Trade Center in New York was attacked by an Islamic extremist group known as Al Qaeda. While the health effects of the September 11 terrorist attacks, commonly referred to as 9/11, are evident, the long-term health effects are equally significant, yet less recognized. Upon the collapse of the World Trade Center, a dust cloud lifted asbestos among other debris such, powdered concrete, gypsum, glass fibers, and various metals which polluted the air (Perlman et al., 2011). Three months after the attack, the average forced

expiratory volume of New York City Fire Department responders decreased by 372 mL, which is comparable the lung volume of an individual after 12 years of aging (Perlman et al., 2011). Four years post-9/11, 40% of affected firefighters reported experiencing rhinosinusitis, a swelling of them mucous membrane, and rates of dyspnoea and wheezing were still inflated (Perlman et al., 2011). Of the over 10,000 firefighters evaluated, 54% reported symptoms of gastro-esophageal reflux both one and four years post-9/11 (Perlman et al., 2011). Abestos is one of the primary sources responsible for the health complications observed from 9/11 that is analyzed. While asbestos has been found to be harmful, it continues to be used in certain products, most notably in construction materials.

Asbestos is a naturally occurring mineral utilized by mankind since 2400 BC (The History of Asbestos, n.d.). As a highly durable, fire-resistant mineral which could be found in abundance, asbestos began to be used commercially in the construction industry among other industries in the late 1850's (What is Asbestos?, n.d.; "20+ Products that May Contain Asbestos," n.d.). Asbestos proved to be an effective technological fix across multiple industries, saving energy by insulating boilers, and saving lives as a material used in car break pads (Harremoës et al., n.d.). Studies indicate that had theaters in the 1870s and 1880s been built with asbestos, 95% of death restyling from theatre fires could have been prevented (Harremoës et al., n.d.). Furthermore, asbestos brought about an increase in employment and is an affordable resource (Harremoës et al., n.d.). While asbestos is effective in constructing, manufacturing, and other industries, there are considerable unintended consequences that come from asbestos use. In 1930, Dr. Merewether discovered Asbestosis, a disease caused by asbestos exposure, and in 1934 a link between asbestos exposure and cancer was discovered. Asbestos warnings were ignored by many

industries until the Clean Air Act was passed, allowing for asbestos regulation. As a resource, asbestos fulfills the purpose it is intended for, but at the cost of wellbeing of the people heavily exposed to the substance.

Asbestos is a political technology because of its extensive history being used as a construction material. The use of Asbestos, specifically in the United States, continues to be permitted primarily due to political interests. In fact, many companies were aware of the connection found between asbestos and cancer as early as the 1930s but still let their employees unknowingly risk their health and altered the results of studies, concealing such information from the public (The History of Asbestos, n.d.). Companies ultimately relied on the ignorance of its employees and the public to stay in business and continue to profit. In 1964, academic and government scientists participated in a conference to formally discuss the health effects of asbestos, but the conference was influenced by a political and economic agenda. Scientist W.C Hueper, criticized the hidden agenda, stating "some commercially interested parties and their medical guardians and protectors still prefer for their own reasons and motives, to deny the existence of these dangerous and usually fatal sequelae of a respiratory contact with asbestos dust" (Murray, 1986). In 1989, the United States' Environmental Protection Agency (EPA) moved to phase out asbestos in nearly all products in the United States, but by 1991 the United States Court System overturned the EPA's ban (The History of Asbestos, n.d.). The history of asbestos regulation and the struggle to phase out a material linked to health complications demonstrate how asbestos is a politically influential technology.

Atomic Bomb and Radiation

The atomic bomb, a nuclear technology which uses fission on small molecules to release large amounts of energy, functions technological fix and inherently political technology. “As long as it exists at all, its lethal properties demand that it be controlled by a centralized, rigidly hierarchical, chain of command closed to all influences that might make its workings unpredictable” (Winner, 1980). The atomic bomb was developed as part of the Manhattan Project led by the United States and was first used during World War II (WWII) (Atomic Timeline, n.d.). One of the primary goals of the United States and its allies was to bring an end to the war, which required the complete surrender of Japan. By detonating atomic bombs on Hiroshima, Japan and Nagasaki Japan on August 6th, 1945 and August 9th, 1945 respectively, the Japanese finally surrendered to the Allies.

With the use of atomic bombs in WWII leading to the surrender of Japan, the atomic bomb proved to be a suitable technological fix for the allied powers. However, the use of atomic bombs came at the cost of unimaginable amounts of innocent lives and the tragic destruction of Japanese cities. By December 1945, the death count was up to 120,000 deaths from the attack on Nagasaki and up to 80,000 deaths from the attack on Hiroshima (Hiroshima and Nagasaki Death Toll, n.d.). Not only were there immediate consequences, but the bomb also had medium and long-term health and biology implications. Three to four months post bomb impact, surviving victims might have seen improvements in burn and radiation, but soon after secondary injuries such as disfiguration, scar formation, blood abnormalities, and sterility became apparent (AtomicBombMuseum.org—Destructive Effects, n.d.). In 1955 as an effort to capture the long-term effects of the atomic bomb on biology and health, a life span study was commissioned by the Atomic Bomb Casualty Commission. The life span study found Leukemia to be one of the first

radiation-associated long-term health effects detected in subjects (Douple et al., 2011). Soon after solid-cancer and non-cancer disease became observed radiation-associated causes of death in the mid-1960s (Douple et al., 2011). Other aftereffects are still prevalent over 50 years later, which include but are not limited to, birth defects, including intellectual disabilities, and disfiguring keloid scars (AtomicBombMuseum.org—Destructive Effects, n.d.). While the atomic bomb was adequate in its intended purpose, the cost of mass murder, the well-being of thousands or survivors, and the future mankind. The atomic bomb as also found function beyond its main objective as a politically influential technology in that is "similar to legislative acts or political founding that establish a framework for public order that will endure for many generations" (Winner, 1980).

The atomic bomb had become a political technology from the moment it was announced that the capability existed. The development of the atomic bomb provided a military advantage, bringing United States significant political power as "the ultimate source of coercive power in international politics" (Paul, 1995). The atomic bomb provided superpower nations with the technology safety in diplomatic negotiations, the access to other nations' valuables or services, and an efficient form of security thus allowing for resource reallocation (Paul, 1995). The use of the atomic bomb as a political tool continued on through the Cold War era, with 21 nuclear threats made by the United States and the Soviet Union in attempts to "influence bargaining outcomes in crises" (Paul, 1995). Other countries such as France have since attempted developing their nuclear capabilities to increase their influence, but their attempts were hindered by other factors such as economic power (Paul, 1995). Since the early 2000s North Korea has been working on expanding its nuclear capabilities in hopes of achieving its foreign policy objectives (Why

Does North Korea Want Nukes?, n.d.). The atomic bomb can be leveraged in diplomacy and applied for military purposes, making it a compelling technological fix and influential political technology.

Havana Syndrome and Sonic Technology:

Havana Syndrome refers medical symptoms experienced by United States and Canadian embassy personnel and their families in Havana, Cuba. The symptoms, which include headaches, vertigo, nausea, blurred vision, hearing phantom, and hearing loss have been speculated to be the result of sonic attacks (Carey, 2019; At Least 16 U.S. Embassy Staff In Cuba Treated After "Health Attacks," n.d.; Étude du Centre de traitement des lésions cérébrales de l'Université de Dalhousie | Hearing Loss | Major Depressive Disorder, n.d.; Cuba "sonic attacks," 2018). The origins of the symptoms remain unclear; there are several theories explaining the possible source, each argument having some validity. Kevin Fu of the University of Michigan reverse-engineered the purported sonic attacks and demonstrated how sounds heard by the diplomats could have been "a byproduct of a poorly engineered ultrasonic transmitter… that was supposed to inaudibly stream information or eavesdrop on conversation" (Cuba "sonic attacks," 2018). Studies at the University of California, San Diego report that the illness plaguing American and Canadian diplomats fit the known effects of pulsed radio frequency/microwave electromagnetic radiation (Researcher Links Diplomats' Mystery Illness to Radiofrequency/Microwave Radiation, n.d.). Other sources concluded the brain injuries experienced by diplomats was a result of repeated exposure to neurotoxins, and that no evidence of a virus or chemical agent could have caused the complications (Pesticides likely caused "Havana syndrome" that affected Cuba-based diplomats, n.d.; Hurley, 2018). Despite the cause of symptoms, a clinical study maintains "the clinical pre-

sentation, cognitive impairment in the spatial memory domain, positive auditory-vestibular results, degradation of fiber tracts in the fornix on DTI, leaky brain vessels on DCE-MRI and abnormal brain slowing on MEG all support the diagnosis of acquired brain injuring in the Canada diplomats and their families in Cuba" (Étude du Centre de traitement des lésions cérébrales de l'Université de Dalhousie | Hearing Loss | Major Depressive Disorder, n.d.).

Although the American government said it did not believe the Cuban Government was responsible for the attacks, at least two members of Cuba's U.N. mission were dismissed for attempting to "influence operations" and evicted 15 Cuban diplomats for "failure to protect staff at the U.S. embassy in Havana" (Chronology of U.S.-Cuba Relations | Cuban Research Institute, n.d.; Trump administration expels two Cuban diplomats, n.d.). In September 2017 the United States State Department ordered over half of its embassy staff, nonessential diplomats and families to leave Cuba in response to the alleged sonic attacks (CNN, n.d.). Whether or not Cuba was involved in the attacks and whether or not there was in fact a sonic attack, the presence of the a potential influenced the relationship and actions of the U.S. and Cuban governments, making the sonic weapon a political technology. The given circumstances led the United States to remove public officials from the embassy, hindering the functionality of the embassy.

Limitations:

Limitations of this study include but are not limited to the time allotted to conduct and complete the research, and the scope of the research. Information in preparation for this analysis has been gathered for less than one year. The information gathered along with the investigation performed focuses specifically biological and physiological ramifications and does not address psychological effects. This research is also limited in the amount of technology evaluated, only

deeply analyzing three different kinds. In the future, more technologies could be similarly examined for a more certain assessment by experts in the of science, technology, and society field. Since the technologies evaluated within this paper fall under the construction, nuclear, and sonic fields, the evaluation of technologies in other fields would be useful.

Conclusion:

Biotechnology is not the only type of technology that has a biological and physical impact; it is a possible outcome for any field of technology. When used by a powerful entity, such technologies may have large-scale health effects as well as political repercussions. When in the process inventing or innovating, engineers should consider if and how often the benefits of a technology will outweigh the costs, and the societal implications that might come with it. End users and consumers should be aware of the potency of the technology they possess, carefully consider the effects of their choice in technology, and be prepared to deal with unforeseen consequences.

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