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# Biologically fit: using biotechnology to create a better soldier

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# NAVAL POSTGRADUATE SCHOOL

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# THESIS

**BIOLOGICALLY FIT: USING BIOTECHNOLOGY TO CREATE A BETTER SOLDIER**

by

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Biotechnology plays a critical role in treating war injuries, preventing and diagnosing disease, and protecting the force against exposure to harmful agents. While effective in its ability to provide medical intervention, biotechnology's non-medical side reveals opportunity to create a "super human" soldier who is more effective in combat and equipped to survive the rigors of war. Scientists in the field have proposed ideas on how to neurologically and physically enhance soldiers at the genetic level. These developments may help build soldier resistance to battle fatigue, increase endurance, and enhance intelligence making soldiers more decisive on the battlefield. Creating soldier that are stronger, faster and able to counter unpredictable enemy tactics will increase the military's ability to adapt to changing battlefield conditions and conduct major operations using a smaller force. This thesis examines performance and cognitive enhancement of the soldier via genetic engineering and its potential ability to arm the military with the capabilities to maintain rapid deployment cycles despite the reduction in force and fight wars using sophisticated techniques in order to reduce casualty rates. Understanding the ends and means of soldier enhancement and the novel ethical issues associated with genetic modification is critical to its future in military application.


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# BIOLOGICALLY FIT: USING BIOTECHNOLOGY TO CREATE A BETTER SOLDIER

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requirements for the degree of

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# ABSTRACT

Biotechnology plays a critical role in treating war injuries, preventing and diagnosing disease, and protecting the force against exposure to harmful agents. While effective in its ability to provide medical intervention, biotechnology's non-medical side reveals opportunity to create a "super human" soldier who is more effective in combat and equipped to survive the rigors of war. Scientists in the field have proposed ideas on how to neurologically and physically enhance soldiers at the genetic level. These developments may help build soldier resistance to battle fatigue, increase endurance, and enhance intelligence making soldiers more decisive on the battlefield. Creating soldier that are stronger, faster and able to counter unpredictable enemy tactics will increase the military's ability to adapt to changing battlefield conditions and conduct major operations using a smaller force. This thesis examines performance and cognitive enhancement of the soldier via genetic engineering and its potential ability to arm the military with the capabilities to maintain rapid deployment cycles despite the reduction in force and fight wars using sophisticated techniques in order to reduce casualty rates. Understanding the ends and means of soldier enhancement and the novel ethical issues associated with genetic modification is critical to its future in military application.

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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AFSOC | Air Force Special Operations Command |
| DARPA | Defense Advanced Research Projects Agency |
| DNA | deoxyribonucleic acid |
| DoD | Department of Defense |
| EFP | explosively formed penetrators |
| HAC | human artificial chromosome |
| HGP | Human Genome Project |
| HMB | hydroxy-methylbutyrate |
| HPM | Human Performance Modification |
| IED | improvised explosive devices |
| IOM | Institute of Medicine |
| NBIC | nanotechnology, biotechnology, information technology, and cognitive science |
| PTSD | post-traumatic stress disorder |
| rDNA | recombinant deoxyribonucleic acid |
| UAV | unmanned aerial vehicle |

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# I. INTRODUCTION

## A. MAJOR RESEARCH QUESTION

When deploying into combat, the primary mission of the United States military is to achieve battlefield superiority and a decisive defeat of its enemy. In compliance with the Clauzewitzian principle of "compelling our opponent to fulfill our will," the U.S. does not engage in conflict it cannot win and relies heavily upon its technical and industrial capabilities to design weapons systems that outmatch the capabilities of its potential adversaries.[1] While evolutionary technologies continue to change the conduct of war, the human factor remains constant. By means of its military tactics, the human soldier has always been the most essential and decisive weapon on the battlefield, but unlike M1A2 tank and the MQ-9 Reaper, the natural limitations of the human genome confines a soldier's war fighting capabilities. This factor makes the soldier highly susceptible to the hardships of warfare. Biotechnological enhancement of the soldier, however, could increase physical and cognitive abilities and increase their overall survivability of soldiers.

The inevitable controversies that encompass America's involvement in conflict abroad is not enough to gain public acceptance of, or ease societal concerns about modifying the human genome for military effectiveness. The idea of genetically altering a human being poses difficult questions for normative beliefs on the conduct of life and the natural evolution of man. These concerns held by both the public and policy makers, have a direct impact on the development and application of future technology. The scientific concepts and ethical issues surrounding the use of biotechnology for human enhancement are numerous and this thesis does not aim to address or provide sound solutions for all of them. Instead, the goal is to enhance awareness, guide future thinking in applying enhancement technology to the solider, and assess the feasibility of

[1] Carl Von Clausewitz, *On War*, eds. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), 75.

performance enhancement via genetic modification of the soldier. Is there a legitimate need for this method of performance enhancement? Additionally, does the ethical debate amongst biopolitical parties consider the operational needs of the military?

## B. IMPORTANCE

One of the long-term goals of biotechnology is the ability to manipulate the human genome. This science promises unlimited capabilities that extend beyond the realm of medicine. Whether aimed to protect an individual from exposure to infectious disease or enhance the soldier by increasing mental acuity and physical abilities, human enhancements will increase the capabilities of the American soldier. While these modifications will potentially benefit the armed forces, the institution will face moral, legal, and political implications associated with research that intends to modify human beings. Human enhancement is a contentious subject. Within it lies an assortment of opinions on the capabilities it can provide and positions for or against its continued research. Irrespective of the ongoing debate, the Defense Advanced Research Projects Agency (DARPA) and other research organizations grow closer to ground breaking innovations that could have a major impact on the institutional practices of the DoD. Therefore, novel concerns in ethics and policy require considerable attention to fill the gap between the development of appropriate regulation and ongoing scientific advancement. Furthermore, military mission and requirements must bear weight in the discussion of ethics and policy. This will both prevent the development of restrictions that may stifle the procurement of valuable enhancement capabilities and ensure that military applications are subjected to rigorous oversight.

Biological sciences are unveiling a multitude of human enhancement opportunities that may affect the future conduct of war.[2] Improved knowledge of the factors that control the generation and operation of organisms has enabled innovation within the biosciences, unlocking pathways to more advanced research that aims to alter

[2] William D. Casabeer, "Ethics and the Biologized Battlefield: Moral Issues in the 21st-Century Conflict," *Bio-Inspired Innovation and National Security* (Washington DC: National Defense University Press, 2010), 294.

and control organisms at the genetic level. Biotechnology is an open market industry, available to those who wish to control and make use of all it has to offer, hence, it is spreading throughout the global community at an unprecedented pace. In addition to our allies, adversarial states such as Iran, China, Russia, and North Korea have commercial biotechnology facilities and possess the capabilities to conduct advanced research. Therefore, with U.S national security as the top priority, it is of the utmost importance to equip our institutions with the necessary tools to protect the homeland from emerging threats. Biotechnology plays a critical role in treating war injuries, preventing and diagnosing disease, and protecting the force against exposure to harmful agents, but it also reveals opportunities to create a "super" soldier. Scientists have proposed ideas for neurological and physical enhancements of soldiers at the genetic level to help build resistance to battle fatigue, enhance sensing and monitoring of the battlefield, aid faster recovery, and endure extreme conditions and extended operations.[3] Ideally, these enhancements would increase force ability to adapt and adjust to changing battlefield conditions and conduct major operations using a smaller force by creating a soldier who is stronger, faster, has more endurance, and is better protected against unpredictable enemy tactics.[4]

The most important aspect of this discussion is the livelihood of the soldier. While a last resort option, the military often becomes the default response to adversarial pressures, placing soldiers in harm's way to defend America's freedom and interests.[5] For the military, budget cuts will lead to a reduction of personnel but will not reduce the operational requirements to sustain enduring overseas missions. The need to reduce casualties has also become a limiting factor on military operations, because leaders are

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[3] Guo Ji-wei and Xue-sen Yang, "Ultramicro, Nonlethal, and Reversible: Looking Ahead to Military Biotechnology," *Military Review*, accessed June 4, 2013, http://www.army.mil/professionalWriting/volumes/volume3/october_2005/10_05_4_pf.html, 75.

[4] National Research Council, *Opportunities in Biotechnology for Future Army Applications* (Washington DC: National Academy Press, 2001), accessed June 4, 2013, http://www.nap.edu/catalog/10142.html, 1–4, 6.

[5] D. Robert Worley, *Orchestrating the Instruments of Power: A Critical Examination of the U.S. National Security System* (Raleigh: Lulu Press, 2012), accessed June 4, 2013, www.drworley.org/Pubs/Orchestrating/, 2.

increasingly risk averse due to public response to soldier deaths. Additionally, the humane treatment of the enemy has captured public attention reinforcing international prohibitions against the use of weapons of mass destruction that would cause mass casualties. This increases the need for small unit tactics vs. large weapons attacks to defeat an enemy. Some strategists believe a more humane war would reduce American post-reconstruction efforts and reduce long-term political ramifications.[6] Yet, as seen in the conflicts in Iraq and Afghanistan, reconstruction and humanitarian missions, though nonlethal, are not necessarily peaceful and can last for many years. Therefore, enhancement of the Soldier via biotechnological methods may arm the military with the capabilities to maintain rapid deployment cycles despite the reduction in force, fight wars using sophisticated techniques in order to reduce casualty rates, and may potentially increase humanness in the conduct of war by potentially delivering more targeted and reversible damage to the enemy.

Unlike the soldiers in WWII, today's soldier faces an enemy that employs asymmetric tactics to weaken its opponent. When a traditional fight against two armies becomes a fight between an army and sect of unlawful combatants, the law of armed conflict is greatly altered. Evidence presented from the conflicts in Iraq and Afghanistan show that overwhelming military superiority alone is not effective in countering asymmetric threat. Lessons learned in both theaters show that the tactics of the individual soldier and small units is the most important weapon when fighting against a complex enemy. Unlike our most lethal weapons systems, soldiers have limits and are vulnerable to the rigors of war. Protracted wars take a toll on the human domain (i.e., battle fatigue, combat stress, increased vulnerability to surprise attacks, and prolonged exposure to foreign climates, and terrain). Therefore, there is an increasing need to enhance the physiological and mental capabilities of the warfighter. Equipping a soldier with enhanced cognitive functioning and superior physical abilities will allow them to survive the rigors of war and allows the U.S. to maintain a superior military advantage. While these modifications may potentially benefit the armed forces, there are several moral,

[6]Ji-wei and Yang, "Ultramicro, Nonlethal, and Reversible," 75.

legal, and political implications associated with its research and application to humans. Some potential questions include: How does genetic enhancement effect the organization structure of military units, are the enhancements reversible to prevent spillover into society when soldiers are discharged from the army, and most importantly once achievable how will the military employ these soldiers in combat. For the sake of space, this thesis will not address these aforementioned questions but they all require further research before the technologies reach fruition and soldiers undergo enhancement.

Biotechnology not only promises to enhance the soldier, it also proposes more aggressive capabilities to control and incapacitate enemy force by creating weapons designed to manipulate the genes of the enemy. These weapons would deliver a stronger and more civilized blow to the enemy versus the catastrophic results produced by conventional weapons systems. In adherence to treaties against the use of biological weapons, biotechnological weapons would replace traditional biological agents via lab manipulation and genetic engineering creating a more controllable and reversible weapons system. Creating more controllable weapons may increase public and international support of its use in future conflicts.[7] Though compelling this thesis will not discuss this in further detail but the implications demand further analysis.

This thesis examines the promised performance enhancement capabilities that biotechnology has to offer and their benefits to the individual soldier and DoD war fighting capabilities. Whether restructured to fight states or prolonged insurgencies, biotechnology may increase soldier capabilities in individual command and control, mobility, lethality, sustainability and survivability, while decreasing their vulnerability on the battlefield. This would allow the U.S. to maintain military superiority and therefore facilitate Washington's national security objectives.

## C. PROBLEMS AND HYPOTHESIS

Performance enhancement via biotechnological means will open the door to a multitude of military capabilities by improving the overall war fighting abilities of the

[7] Ibid., 78.

U.S. soldier, however, ethical barriers will limit its application and potential use in combat. Genetic modification is a potentially game changing concept, but existing information mostly focuses on futuristic and unproven ideas. The uncertainty surrounding the science and the ends and means by which biotechnology could enhance humans sparks a great deal of public concern. To draw an appropriate hypothesis on the potential benefits of genetic modification and the implications of applying these scientific enhancements to the force several questions need clarification. This thesis will assess the following questions:

- What does it mean to "enhance" a human?
- What is the feasibility of creating and controlling the means to genetically alter a soldier?
- How much of the ethical debate is based on actual science vs. drawn hypothetical conclusions based on the philosophical roots of each biopolitical party?

First, biotechnology promises an outcome for scientific intervention, "enhancement." Current discussions center on the term without a clear working definition that generates a line of distinction between ethical and immoral uses of biotechnology. Enhancement in of itself is a simple term that means "to exceed the current state of being." Human enhancement denotes changes made to the mind and body to increase capacities, abilities, and characteristics beyond its natural limits. In the later use of the term, it becomes more complex and raises novel ethical questions about the effects on human dignity, and society. It forces question of how radical changes will affect the present-day meaning of life. The greatest ethical concerns stem from the uncertainty of the science and an unclear understanding of the ends, means, and motivation for its use. Because of the link between biotechnology and medical innovation, the word "enhancement" in this thesis implies using biotechnology to increase natural human abilities beyond the limits of "normal" health.

Second, significant data suggests the improved capabilities that biotechnology promises, but little empirical data exists on whether these capabilities are truly achievable. While enthralling, the concepts of biotechnology appear futuristic and lack real and definite planning for future testing and implementation. This realm of science

promises to enhance future combat capabilities but the basis of its research is an unproven science. Genetic research is associated with several complexities and uncertainty that make it difficult to achieve targeted goals. Research starts with an assumption based on historical data but is ultimately subject to evolutionary changes associated with living organisms. For example, research in human performance modification (HPM) has uncovered computational issues in cognitive modification and biological issues in tissue engineering. In order to enhance cognitive function, researchers apply computers to the human body that interconnect with their natural neurological process. This computer to neuron interface intended to advance sensory, communication, and overall cognition. However, current computational devices are incompatible with the complex cognitive processes of the human brain.[8] Like cognitive modification, tissue engineering intends to improve human performance by increasing recovery and improving the quality of regenerated tissues. While this field of study has successfully accomplished these tasks, tissue engineering methods remain unable to enhance the normal cellular performance of healthy tissue. Because this study requires direct contact with human subjects, scientists remain unable to overcome challenges in obtaining an adequate number of sustainable cells to conduct advanced research.[9] Scientists can expect to face unknowns that are hard to predict in the preliminary stages of research. Current information regarding biotechnology suggest that research is not too far off from uncovering the keys that will make these concepts reality but none are clear on just how close. This thesis will attempt to determine the feasibility of the proposed studies in genetic modification of human physiology and cognition and it potential use to advance the force.[10]

Lastly, ethical dilemmas present the most profound barriers within the field of human enhancement research. There is no way to predict what the enemy or conflict will look like in the next 30 years but the assumption is the soldier will remain the center of

[8] National Research Council, *Human Performance Modification: Review of Worldwide Research with a View to the Future* (Washington, DC: National Academies Press 2012), 2.

[9] Ibid., 4.

[10] Ji-wei and Yang, "Ultramicro, Nonlethal, and Reversible," 78.

gravity for future combat operations. Information alludes to an ever-present social sensitivity to the use of biological agents and the manipulation of human genes. The uncertainty and unpredictability associated with biotechnology and the ends and means by which is aims to enhance human's sparked debate among ethicist and political elites. Each party struggles to define the proper use and limits of the science to protect or better society. The argument focuses on the need for enhancement within the general populace of civilians and little emphasis on those that defend the freedom of the nations. Service member responsibilities are vastly different and more complex than of the general populace. What remains unanswered is whether the ethical debate will lead to the development of policy that strikes a balance between the needs of society and the military. This thesis will address these issues as they pertain to the study of human enhancement via genetic engineering, and its future military application.

## D. METHODS AND SOURCES

This thesis will use existing research and data on genetic engineering to provide an explanation of present biotechnology and the human enhancement capabilities it could potentially provide to the military. Due to the lack of empirical data on how human enhancements will affect DoD policy, this project will use historical data on the effects of the use of force enhancement methods on military operations and policy to draw a hypothesis. An essential aspect of this study is an analysis of the ethics that govern scientific research and the biopolitical debate that affect research involving human subjects. Therefore, this thesis will examine and compare the schools of ethics, their philosophical basis that drives their understanding of human enhancement, and the push for legislative control over the life sciences that will potentially stifle human enhancement research and application methods. This analysis will potentially lead to a proposed policy recommendations that enable flexible research and effectively govern the practice of performance enhancement via biotechnology. The next chapter is a review of the literature that addresses human enhancement and public concerns of genetic modification.

The next chapter will identify and compare the biopolitical parties to include differences and similarities in their philosophical roots. This analysis will help with understanding the concerns addressed within the debate, assess how hypothetical assessments are based on scientific fact, and whether ethical exceptions are possible based on the operational needs of the military.

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# II. LITERATURE REVIEW

This section will provide an overview of the existing schools of thought on the potential capabilities of human enhancement, discuss bioethical theory and institutional issues that effects human enhancement research. The study of human enhancement is uncharted territory with limited data addressing actual case studies of successful application. Most of the works are speculative in nature, hypothesizing future capabilities by using data from existing deoxyribonucleic acid (DNA) studies and micro-level research. While there is an array of literature that provides a general overview on ethics, few discuss bioethical implications associated with military use. A few articles provide a brief overview of the laws that prohibit misuse of biotechnological material and the institutional issues that affect continued research within the field of study. The scope of this literature review is limited to the concepts and findings presented in journal articles, scholarly works, academic reports, and open source data from government and other informational websites that discuss genetic engineering to enhance human performance.

## A. BIOTECHNOLOGY: HOW IT PROMISES TO ENHANCE NATURAL HUMAN ABILITIES

Throughout history, humans have tried to find new ways to advance the species beyond its natural biological abilities. Some examples are the creation of contraceptives to control the reproductive cycle, the invention of plastic surgery to enhance physical appearance, and the production of prosthetics designed to replace lost sensory and improve the natural abilities of a missing limb. A London exhibit called "Super Human" that opened in July of 2012 highlighted historical examples of various cultural attempts to modify the human body. The exhibit displayed a range of artifacts from ancient Egyptian prosthetics to modern day science fiction images that depict the futurist ideas of the physical enhancements that nano- and biotechnology promise. Emily Sargent, Curator of the "Superhuman" exhibit, describes human enhancement as *"one of the most exciting and feared areas of modern science"* and the artifacts prove that the ideas are *"not an*

*exclusive preserve of the contemporary technologist, as our desire to enhance ourselves and our ingenuity to do so is in evidence throughout our history* [emphasis added]."[11] Therefore, it is not surprising that modern day scientists would leverage the advancements in biotechnology while studying new and innovative methods to enhance the human species.

Before discussing capabilities, there must be a clear understanding of what the term "human enhancement" means. Definitions expressed throughout the literature commonly describe human enhancement as actions designed to restore or improve human performance, hence enabling a person to overcome imposed or natural limitations.[12] Memory, hearing, sight, strength, and mobility are examples of the human functions this research intends to improve. Due to the complex nature of the human genome, the collaboration of various disciplines including biotechnology, engineering, neuroscience, and computing is necessary to conduct research and create functional systems.[13] A joint board study lead by the National Academy of Science (NAS) took their research a step further by assessing the effects of human enhancement in the workplace. Their hypothesis is that the use of enhancements may influence a person's ability to learn and conceptualize key tasks within a profession, motivate the pursuit of a profession, enable an individual to work in more extreme conditions for longer periods, reduce work related illness, and facilitate faster recovery times to reduce time away from work.

Although these capabilities are compelling, preexisting social and ethical beliefs make the marketing of these ideas difficult. Therefore, more education is necessary to reduce public fear of biotechnological enhancements. The board agreed that the implications of human enhancements on the workplace and the long-term health effects

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[11] Tim Morley, ed., "Wellcome Collection Press Release," July 2012, accessed June 11, 2013, www.wellcomecollection.org/press/press-releases/superhuman.aspx.

[12] Academy of Medical Sciences, the British Academy, the Royal Academy of Engineering, and the Royal Society, "Human Enhancement and the Future of Work," accessed on June 11, 2013, http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/projects/human-enhancement/2012-11-06-Human-enhancement.pdf, 7.

[13] Ibid., 9.

on the individual are areas of the study that require further examination.[14] A biotechnology review conducted by the Boards of Army Science and Technology (AST) and the Royal Society reveals similar theories. In the military workplace, a soldier is required to perform basic human functions while detecting and protecting themselves from danger, differentiating friendly from enemy forces, and surviving unforeseen changes on the battlefield.[15] In the combat zone, genetic enhancements provide increased strength, endurance, and marksmanship abilities while reducing battle fatigue, combat stress, and increased regenerative abilities to reduce force reduction.[16] Researchers predict the application of biotechnological enhancements to the individual soldier will increase combat capability and effectiveness within the organization. In an institution where physical characteristics and performance are the key criteria's used to subdivide and select soldiers for specific duties or units, advanced studies of the human genome could allow for better pairing of an individual with their appropriate job. Both research boards agree that the ethics of enhancement and guidelines of use must be resolved in order to increase public support and continue research to further advancements.[17] Equipping the force for the future combat environment is an ever-present theme that appears throughout the literature but what is the future combat environment and what does that mean for the military?

Scientists Guo Ji-wei and Xue-sen Yang describe the future battlefield as one that relies heavily on cyber technology, communications, and micro-information to stay abreast of enemy activity and sense changes on the battlefield.[18] They believe the need for information dominance in the modern era drives the study of human genetics and the enhancement of soldier capabilities. Aligned with previous assessments, these scientists

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[14] Ibid., 53.

[15] Rod Flower et al., "Brain Waves Module 3: Neuroscience, Conflict, and Security," *Excellence in Science* 6, no 11 (2012), accessed July 11, 2013, http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/projects/brain-waves/2012-02-06-BW3.pdf, 5.

[16] National Research Council, *Opportunities in Biotechnology*, 63.

[17] Ibid.

[18] Ji-wei and Yang, "Ultramicro, Nonlethal, and Reversible," 75.

believe that the laws, rules, and essential qualities of genetic modification remain unclear. Therefore, to reduce the fear and uncertainty associated with this type of research, applied enhancements must be ultra-micro, nonlethal, and its effects reversible. Their position is if America wants to take and maintain control of the battlefield, it must pursue biotechnological enhancement of the force to stay abreast of the evolutionary changes to global conflict and secure national and strategic objectives.[19]

While genetic modification of the human genome is somewhat hypothetical, the research presented within this subsection declares it an important and testable concept. Future advancements within this field of study require public support and a clear understanding of its potential benefits, and the potential effects on an individual, organization, and social institutions.

## B. THE EMERGENCE OF BIOPOLITICS: THE BIOCONSERVATIVES, BIOPROGRESSIVES AND TRANSHUMANISTS

The literature poses significant questions on whether the ideas of human enhancement will pass the bioethical test or whether moral and social norms ultimately hinder continued research and future application. Research indicates an increasing overlap between biology and politics in the ever-present fight between bioethical parties over control of the life sciences.[20] While the prospect of human enhancement advertises great benefits, it sparks great debate between the bioconservatives, bioprogressives and the small, but rising group the transhumanists on the question of safety, efficacy, and morality of its use. Ethicist Jonathan Moreno states that each of the camps possess different understandings of the effects that science has on humanity, with human adaptability to moral challenges at the heart of the philosophical debate.[21] The bioconservatives believe enhancement by either medical or technological methods are inhumane. Their goal is to greatly restrict or ban research and future application because

[19] Ibid., 77.

[20] Jonathan D. Moreno, *The Body Politic: The Battle Over Science in America (New York:* Bellevue Literary Press, 2011), Kindle edition, loc. 209.

[21] Ibid., loc. 318–19.

it violates social and moral values. The primary fears that drive the bioconservative argument is the belief that enhancing humans will degrade or cause more harm to society and that "posthumans" may pose a threat to normal citizens.[22] Contrarily, the bioprogressives are in favor of private enterprise and innovation and promote the use of biotechnology to increase the capabilities of mankind. Within this camp is a dividing line between right wing activists that believe in liberty and free enterprise as the greatest sources of innovation and the left wing activists that believe in regulation of biotechnology and equality of use for the greater good of society. Like the bioprogressive party, the transhumanists are in favor of using biotechnology to enhance humans but they adopt the position that technology will promote the factors of human life that the bioconservatives fight to protect (i.e. human dignity and the natural essence of human life).[23]

The book, *Radical Evolution*, by Joel Garreau, draws a literary illustration of the debate between the ethical camps. Garreau begins by describing human enhancement as a melding of genes, robotic information, and nano-technologies to create unrecognizable change in society.[24] While he holds no distinct position within the debate, Garreau creates three scenarios known as the heaven, hell, and prevail scenarios, each of which describe the hypothetical future of humanity and the potential effects of accelerating evolution by technological means. The Heaven Scenario describes a world of post humans within the next 20 years whereas the Hell Scenario describes the end of humanity due to rapid and unprecedented technological advancement. Lastly, the Prevail Scenario describes humanity coming to grips with evolutionary changes and taking control of their destinies. People that embrace the Prevail Scenario will entrust their futures in the laws of

[22] Nick Bostrom, "In Defense of Posthuman Dignity," *Bioethics* 19, no. 3 (2005): 204.

[23] Moreno, *The Body Politic*, loc. 318–19.

[24] *Joel Garreau, Radical Evolution: The Promise and Peril of Enhancing Our Minds, Our Bodies, and What It Means to Be Human* (New York: Doubleday, 2005), accessed on June 12, 2013, http://www.garreau.com/main.cfm?action=chapters&id=52.

natural evolution and human decision. While Garreau believes, the actual future may be a combination of the three scenarios, the fight for theoretical dominance continues between the parties that embrace each scenario.[25]

In support of the heaven scenario, bioprogressive Nick Bostrom is in favor of using technology to advance human abilities, and believes the results are socially desirable.[26] Like others within his camp, Bostrom is an advocate of embracing the advancements of biotechnology while establishing strong policies to defend human rights and taking action against concrete threats such as biotechnological use by terrorist organizations.[27] Bostrom believes the bioconservative view is one based on religion or secular grounds and considers them a camp that lacks clearly defined rationale to support their arguments. Prominent bioconservative Leon Kass, who holds a vastly different opinion, states:

> …the use of biotechnical powers to pursue 'perfection,' both of body and of mind—is perhaps the most neglected topic in public and professional bioethics. Yet it is, I believe, the deepest source of public anxiety about biotechnology, represented in the concern about 'man playing God,' or about the Brave New World, or a 'posthuman future.'[28]

Kass views innovation in biotechnology as a potential risk to the dignity and essence of humanity, one that society may not overcome. Bioconservative Francis Fukuyama takes the argument a step further deeming transhumanism as *"the world's most dangerous idea"* and believes society is at risk of abolishing equal rights by partaking in biotechnological enhancement.[29] He questions whether enhanced humans will claim additional rights to set them apart from the ordinary class, which will ultimately draw a wedge between groups and lead to a future political fight over human

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[25] Ibid.

[26] Nick Bostrom, "In Defense of Posthuman Dignity," 203.

[27] Ibid.

[28] Leon Kass, Beyond Therapy: Biotechnology and the Pursuit of Happiness (Washington, DC: President's Council on Bioethics, 2003), 7.

[29] Francis Fukuyama, "Transhumanism," *Foreign Policy*, September 1, 2004, http://foreignpolicy.com/articles/2004/09/01/transhumanism.

rights.[30] Transhumanist Ray Kurzweil strongly opposes the bioconservative view and embraces the idea of technology progressing humans beyond their normal capabilities. Kurzweil defines this concept as "singularity" an era that will alter the concept of man and give new meaning to the conduct of human life and the natural life cycle of man.[31] Ideally, singularity is the result of the merger between biology and technology that allows humans to surpass their biological roots. According to Kurzweil, the final epoch of human evolution is an era where human form is no longer strictly biological. Technological advancements in modern science will allow humans the ability to overcome physical and mental limitations, enable the control of one's fate and mortality by ridding disease and other ailments, and allow the power of the mind to exceed unassisted human intelligence.[32] This marks the beginning of the merger of man and machine where machine ultimately dominates. Kurzweil considers this an inevitable implication of the "law of accelerating returns"- exponential growth in technology will surpass the natural evolutionary process.[33] As a futurist, he believes that 2045 marks the beginning of human immortality, and radical life expansion. He shuns the idea that two-dimensional views of the genome limits scientific research and believes, in a matter of time, that computational advancements will allow scientists to visualize and model structures that are more complex.[34]

Another issue highlighted in the literature is that the debate amongst ethical groups has reached a stalemate without achieving a clear consensus on the future of human enhancement and its possible application to society.[35] While the groups believe that individual choice is the key component to human dignity, each group accuses the other of using coercive measures to influence the creation of policy that may violate an

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[30] Ibid.

[31] Ray Kurzweil, *The Singularity is Near: When Humans Transcend Biology* (New York: Penguin Group, 2005), 7.

[32] Ibid., 9.

[33] Ibid., 35.

[34] Ibid., 482.

[35] Rebecca Roache and Steve Clarke, "Bioconservatism, Bioliberalism, and the Wisdom of Reflecting on Repugnance," *Monash Bioethics Review* 28, no. 1, Art. 4(2009): 2.

individual's freedom of choice.[36] Professors of Philosophy Steve Clarke and Rebecca Roache state, "whilst moral intuitions can be useful tools in moral deliberation, intuitions alone are an unreliable final arbiter of what is right and wrong, and they are highly likely to be influenced by social factors…[and]…also susceptible to external manipulation."[37] With neither group willing to concede to the will of the other, the debate continues. Philosophers Patrick Lin and Fritz Allhoff believe the debate is far from resolution and that proposed laws on restriction would likely be imperfect or ineffectual where no law at all would allow uninhibited enhancements.[38] Currently there are no regulations or laws that restrict or ban human enhancement research. Instead, existing law intends to restrict the creation of novel and increasingly lethal biological or biotechnological agents for weapons. Because the "post human" concepts are so futuristic and risk remains hypothetical, Roach and Clark believe that without clearly defined risks or posed health concerns, the government is less likely to implement legislative restrictions or bans. Therefore, in a Western liberal society where no clear policy exists, the liberal view will overcome the view of the conservative party.[39]

## C. THE MILITARY PERSPECTIVE

Research on the ethical, legal or policy implication within the DoD with reference to the use of biotechnology is limited. Yet a few sources address the need for soldier enhancement capabilities and the need for policy consideration. For greater perspective, discussion begins with an article entitled "The Human Dimension in the Close Fight," by Retired U.S. Army Major General Robert H. Scales. In his article, Scales draws his reader's imagination into combat as member of a tactical squad. As a soldier within this team, you are highly competent and equipped with the ability to think linearly and

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[36] Jess Hasken, "Coercion in Bioethics," *Macalester Journal of Philosophy* 16, no. 1, Art. 3 (2007): 15–16.

[37] Rebecca Roache and Steve Clarke, "Introducing Transformative Technologies into Democratic Societies," *Philosophy & Technology* 25, no. 1 (2012): 43.

[38] Patrick Lin and Fritz Allhoff, "Untangling the Debate: The Ethics of Human Enhancement." *NanoEthics* 2, no. 3 (2008): 262.

[39] Roache and Clarke, "Bioconservatism, Bioliberalism, and the Wisdom of Reflecting on Repugnance," 16.

because of your heightened senses, you are extremely aware of enemy movement and tactics. All members of your team are resilient, low stress, have minimal fear of death or of killing the enemy. Most importantly, your team has complete confidence in your leaders and supporting units to make superior decisions for the sake of the mission and survival of your team. His perspective provides a better understanding of the necessary components that drive the success and effectiveness of military missions at the small unit level. Training can only go so far to prepare a solider for combat. As a proponent of enhancement technologies, MG Scales concludes his article by stating "the best investment [is to] use the human sciences to improve the fighting power of close-combat, to focus as much on what goes in the soldier and what goes on the soldier."[40] Scales' request is not farfetched because seeking improvement to overcome innate human limitations is natural part of the human psyche.

A recent article written by Dr. Edmund G. Howe addresses the effects of human enhancement on military medical ethics. He believes the military mission dictates how and whether biological advancements are legitimate for military application and employment in combat.[41] Gathered from Howe's comment is the requirement for the DOD to reevaluate its traditional institutional practices in order to strike a balance between ethics and national security. Human enhancement will not only change the face of military medicine, it will also change military operations and soldier conduct in war. Therefore, further examination of these practices is necessary to create new policy that will regulate the application and use of human enhancement technologies within the military. A report conducted by Mehlman et al., states that there is a significant lag time between the development of enhancement technologies and the necessary discussion to guide its appropriate use. The group holds a firm opinion that before soldiers undergo any form of technological enhancement the government must adequately consider the implications of enhancement technologies to include the risks on the soldier, the impact

[40]Robert H. Scales, "The Human Dimension in the Close Fight," *Army Magazine*, May 2012, accessed October 24, 2013, www.ausa.org/publications/armymagazine/archive/2012/05/Documents/Scales_0512.pdf.

[41]Edmund G. Howe, "New Biological Advances and Military Medical Ethics," *Bio-Inspired Innovation and National Security* (Washington DC: National Defense University Press, 2010), 9.

on society when enhanced soldiers return to civilian life, and the possible mishandling of biotechnology for malicious use.[42] As DARPAs and other institutions research gains significant momentum towards breakthroughs in biotechnology, it is of increasing importance that DoD leadership examines the moral considerations of military enhancement.

## D. CONCLUSION

Research shows that biotechnology promises new methods to enhance the human species beyond its natural limits. Whether biotechnology is used to increase speed, sensory, or rapid recovery, it could provide the military with potential capabilities to fill operational gaps when conducting future operations. Such capabilities are associated with large costs that may affect how the military will act to achieve victory. Overcoming ethical hurdles are one of the largest costs that the military must bear to obtain enhanced performance of its soldiers. The uncertainty of biotechnological enhancement sparks great debate between bioconservatives, who take a religious perspective aimed at protecting human dignity and the laws of evolution, and bioprogressives and transhumanists, who see this advancement as a natural part of human evolution and its proposed benefits as highly desirable. The debate has not reached a consensus on whether to ban, restrict, or embrace human enhancement. There is minimal research that applies these concepts to the military. Further research is necessary to understand the potential effects that enhancement capabilities may have on the individual soldier and on the military as an institution. This thesis will analyze the available information on human enhancement to provide a basic picture of its potential benefits to the military. The literature on the bioethical debate will allow for an adequate comparison of ethical camps, and an assessment of how their arguments align with the operational requirement of the military.

[42] Patrick Lin, Maxwell J. Mehlman, and Keith Abney, "Enhanced Warfights: Risks, Ethics, and Policy," Case Research Paper Series in Legal Studies, January 2013, last modified on September 15, 2013, http://ssrn.com/abstract=2202982.

The next chapter is on force enhancement, what it means, and its importance. The discussion will examine military need, historical and current methods to enhance soldiers, and the biotechnological breakthroughs in genetic engineering that may provide a permanent fix to natural limitations. The next chapter will provide an overview of concept of soldier performance enhancement. It will help to understand what enhancement means, how the military has used science to sustain and increase performance, and the potential force enhancement capabilities that genetic engineering may offer.

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# III. ENHANCING THE FORCE: WHAT DOES IT MEAN AND WHY IS IT IMPORTANT

## A. INTRODUCTION

In 1940, Steven Rogers, a tall gaunt man from New York City attempts to enlist into the United States Army only to be rejected due to his physical limitations. His perseverance to join the fight against the rising power of Nazi Germany captures the attention of scientists Abraham Erskine, the lead scientist for "Project Rebirth." Project Rebirth was a secret military project that sought to create the perfect soldier by enhancing humans to optimal levels of physical perfection. Injected with a special serum and exposed to high levels of atomic energies to activate and stabilize the exogenous chemicals, Rogers is reborn from an inherently frail state to one of total human perfection. The serum not only enhanced his musculature and brain activity, it also increased cellular regeneration ultimately slowing degeneration. Scientific research of this caliber did not end with Steven Rogers. It improved with the introduction of novel technologies and the release of investigative findings. In the early twenty-first century, Private First Class Kenneth J. Kitsom, a solider recruited into the Army despite of his sub-average IQ and cognitive disability. Soon after his training, he was spuriously declared dead as a result of a roadside bomb during the Iraq War. Kitsom's contrived death masked his recruitment into "Operation Outcome," a clandestine special operations program designed to create the ideal field operative by altering the chromosomes that controlled physical and mental abilities. Scientists used manufactured viruses to achieve their proposed effects and a series of medications called "chems" to control and maintain the genomic changes. Like Rogers, Kitsom also experienced increased muscle efficiency, strength, and intelligence, but new genetic advancements allowed Kitsom to suppress extreme pain and execute a level of mental improvisation and linear problem solving unrealized by the typical special operator.

These two fictional depictions may sound familiar. That is because they are describing the popular comic book character Captain America, and Bourne Legacy film character Aaron Cross. Advancements in biotechnology allowed scientists to genetically

modify these soldiers and create specially designed biopharmaceuticals to stabilize and solidify the changes made to their genomes. Project Rebirth and Operation Outcome are fictional scientific programs, but the idea of using biotechnology to enhance physical and mental abilities that each portray is not. Scientific research has already begun within the halls of DARPA, uncovering new ways to leverage advancements in biotechnology in an attempt to create soldiers who are more biologically fit to deal with the rigors of complex warfare. A common question in the ethical debate is whether there is a need to alter a soldiers DNA to increase their performance in combat, how will these scientific enhancements increase force effectiveness, and what are the long-term effects of these modifications. Science is not there yet, but as research continues these forward thinking questions will be easier to answer. For now, the public requires knowledge and awareness to help guide legislature and policy. This chapter will discuss what it means to enhance a soldier, why this is of importance to the military, how the military has attempted to biologically alter soldier using the scientific means of their time, and where biotechnology promises to advance the force in preparation for future conflict.

## B. WHAT DOES ENHANCEMENT MEAN?

Before embarking into further discussion of performance enhancement via biotechnological methods there must first be a clear definition of what it means to "enhance" the human form. To be precise, the word enhancement is the act of increasing or improving something's magnitude, quality, or value. Thus, the phrase "human enhancement" means the process of increasing well-being by improving the human mind, physical function, and natural abilities. Therefore, exercising, studying, and maintaining healthy diets are, by technicality, acts of enhancement.[43] In general, enhancement is an uncomplicated term, and the aforementioned techniques are straightforward with little public debate of whether they are suitable to enhance human survivability or well-being. For this reason, those examples hold little value in further discussion of human enhancement throughout this thesis. Nevertheless, the term enhancement, when used in

[43] Fritz Allhoff, Patrick Lin, James Moor, and John Weckert, "Ethics of Human Enhancement: 25 Questions and Answers," *Studies in Ethics, Law, and Technology* 4, no. 1, art. 4 (2010): 3.

context of applying biotechnology to alter innate human function to achieve the same objectives becomes controversial and increasingly difficult to define. Discussion of current and future technologies to increase physical performance, though compelling, sparks a great deal of ethical debate over how far one should go to obtain perfection beyond the typical human dimension.[44] There is major public concern of just how far scientific research will go to make the actual application of enhancement technologies a reality. Literature centers on the term "enhancement," yet its definition is ambiguous and subjectively defined by the theoretical paradigm of the author.[45] Additionally, each of the theoretical approaches draw different hypothetical conclusions on the potential implication to society that human enhancement poses. Ethicist Robert Veatch states that the theory of bioethics is a:

> …comprehensive, systematic account of a general approach to addressing an ethical question in the medical or biological sphere. It may be from religious tradition or a secular worldview; it may be articulated by health professionals or by medical lay people. It may be limited to the medical sphere or, more plausibly embedded in a more general ethical theory.[46]

This layer of complexity makes reaching agreements on should we, how to, and when to genetically optimize the human form a difficult task. Therefore, resolution and future application of enhancement technologies to the U.S. military relies heavily upon clearly defining the term "enhancement" and establishing a mutual understanding of the end goal that it hopes to achieve.

There are several methods used to define the term enhancement.[47] The leading and most influential approach is to explain enhancement as a non-medical treatment as defined by traditional medical practice. The enhancement vs. therapy approach is

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[44] Norman Daniels, "Normal Functioning and the Treatment-Enhancement Distinction," *Cambridge Quarterly of Healthcare Ethics* 9, no. 3 (2000): 309–311.

[45] Roache and Clarke, "Bioconservatism, Bioliberalism, and the Wisdom of Reflecting on Repugnance," 1–3.

[46] Robert M. Veatch, "Theories of Bioethics," *Eubios Journal of Asian and International Bioethics* 9, no. 2 (1999): 35.

[47] Julian Savulescu, Ruudter Muelen, and Guy Kahane, eds., "Defining Enhancement," *Enhancing Human Capabilities* (New York: Wiley-Blackwell, 2011).

commonly employed during talks of performance enhancement via biotechnology because of the sector's linkage to the modern medical process of finding the root cause of disease, methods for diagnosing illness and the development of drugs that can target specific molecular problems.[48] To clarify the distinction between enhancement and therapy, bioethicist Eric T. Juengst states that enhancement is the "characterization of the intervention designed to improve human form beyond what is necessary to restore, and sustain good health."[49] By common definition, "therapy" means to treat disability, disease, or impairment by means of medical intervention in order to return a person to a normal state of health.[50] Conversely, enhancement transcends therapy because it goes beyond common medical treatment. Enhancement via biotechnology does not denote the use of biology or medicine to fight a disease or repair degeneration. Rather, these methods are employed through direct intervention with a healthy human body to improve its normal state of physiological or cognitive functioning.[51]

Under this guideline, some examples of enhancement are an athlete resorting to blood doping to achieve maximum aerobic capacity to increase physical endurance, a student without cognitive impairment using Adderall to heighten their ability to learn, a pilot that uses stimulants like Dexedrine or Modafanil for extended operations where sleep is limited. This meaning carries over into future yet speculative concepts of human enhancement where soldiers receive engineered viruses to alter metabolic function allowing them to survive weather extremes, run faster, sleep less, and traverse rugged terrains like a form of life indigenous to a specific region. Then there are the intelligence-enhancing genes introduced into a soldiers brain cells via somatic gene transfer to alter neural plasticity – the brains ability to undergo physical, chemical, and structural changes

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[48] Brüggemeier, Mathias. "Biotechnology-New Directions in Medicine," trans. David Playfair (Switzerland: LaRoche Ltd, 2006), accessed October 19, 2013, www.roche.com/biotechnology_new_ways_in_medicine.pdf, 5.

[49] Eric Juengst, "The Meaning of Enhancement," *Enhancing Human Traits: Ethical and Social Implications*, ed. Erik Parens (Washington, DC: Georgetown University Press, 1998), 29.

[50] Leon Kass, *Beyond Therapy: Biotechnology and the Pursuit of Happiness* (Washington DC: The President's Council on Bioethics, 2003), 13.

[51] Daniels, "Normal Functioning and the Treatment-Enhancement Distinction," 309.

in response to stimuli from the external environment and learning experiences.[52] This will increase intelligence, rapid problem solving and may potentially increase a soldier's ability to process information at the speed of a home computer.

On the surface, the distinction between enhancement and therapy is useful when discerning between which biotechnological interventions are for treatment and that cross into the realm of enhancement. The implantation of a pace maker to normalize irregular cardiac function is a treatment while the use of anabolic steroids to increase an athlete's performance is enhancement. A deeper analysis reveals that this approach is not without complexity because the definitions of medicine and therapy are not always agreed upon.[53] Most scientists and medical professionals will agree that medicine is an evolutionary concept and is not an exact science. What one considers "normal" or "ideal" are very subjective terms with different connotations from culture to culture. Thus, when using this method, researchers must remain aware of the ever-present grey area in terminology that often places a fine line between intervention for treatment and intervention for enhancement. These nuances make it difficult to adopt collective definitions of medicine and therapy, or establish exact parameters for its application. A prominent figure in the bioethics community, Erik Parens states:

> …there is no one universally accepted conception of the goals of medicine. The lack of such a consensus has much to do with the fact that there is no one universally accepted conception of what health is. And thus neither is there a universally accepted definition of what "going beyond health to enhancement means.[54]

Consequently, the distinction between the two terms is highly sensitive to context and ultimately becomes a game of semantics.

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[52]"Medical Gene Transfer-Somatic Gene Transfer," Center for Genetics and Society, last modified October 19, 2013, www.geneticsandsocietyorg/article.php?id=290.

[53] Savulescu, Muelen and Kahane, Enhancing Human Capabilities, 3.

[54] Erik Parens, "Is Better Always Good? The Enhancement Project," *The Hastings Center Report* 28, no. 1 (1998), accessed October 10, 2013, http://www.biomedsearch.com/article/better-always-good-enhancement-project/20459123.html.

For instance, if the average male who runs 100 meters between 13–14 seconds is given a performance enhancing drug that allows him to run as fast as Usain Bolt, and Bolt whose runs a time of 9:58 seconds exceeds the normal range, this intervention is considered enhancement. However, if Usain Bolt suffers an injury that impairs his ability to run receives the same drug to restore his natural abilities, even though his abilities are outside of the normal range for human speed this intervention becomes therapy. A different example uses the 20/20 vision standard as the normal range for visual acuity even though only 35 percent of the population has 20/20 vision without glasses, corrective lenses, or surgery.[55] So if the remaining 65 percent of the population underwent corrective surgery to achieve 20/20 vision, would this count as therapy, or is it enhancement? Some literature also points out the difficulties in determining whether immunizations are a form of therapy for prevention or falls into the spectrum of enhancement.[56] Some scholars believe that immunizations can be a form of enhancement because they bolster the immune system prior to exposure. In this case, the body is not ill and there is no restoration of health to an original level. However, according to Juensgt's definition, immunizations would work to sustain health and can be a form of prevention. Now there is question of whether the definition of intervention is not only sensitive to syntax but also to time.[57]

Despite its perplexing nature, the distinction between enhancement and therapy is suitable to identify potential problems that may arise when discussing the use of biotechnology to enhance the physical and cognitive performance of U.S. soldiers. In a debate as controversial as human enhancement, having clear definitions of its central

[55]Tim Johnson, "What is 20/20 Vision?," University of Iowa Hospital and Clinics, last modified October 10, 2013, http://www.uihealthcare.org/2column.aspx?id=225702; Lin, Mehlman and Abney, "Enhanced Warfighters: Risk, Ethics, and Policy," 14.

[56]See, for example, Patrick Lin, Maxwell J. Mehlman, and Keith Abney, "Enhanced Warfighters: Risks, Ethics, and Policy," Case Research Paper Series in Legal Studies, January 1, 2013, last modified September 15, 2013, http://ethics.calpoly.edu/Greenwall_report.pdf; Nick Bostrom and Rebecca Roache, "Ethical Issues in Human Enhancement," *New Waves in Applied Ethics*, eds. Jesper Ryberg, Thomas Petersen and Clark Wolf (New York: Pelgrave Macmillan, 2008): 120–152; and Fritz Allhoff, Patrick Lin, James Moor, and John Weckert, "Ethics of Human Enhancement: 25 Questions and Answers," *Studies in Ethics, Law, and Technology* 4, no. 1, art. 4 (2010).

[57]Lin, Mehlman, and Abney, "Enhanced Warfighters: Risk, Ethics, and Policy," 15.

terms and a universal understanding of their meanings is imperative. Unfortunately, this is not the case and disparities only complicate the task of determining under what conditions it is morally correct to proceed with research or apply these enhancements to the human soldier.[58] Reaching an ethical agreement on the rights and wrongs of human enhancement seems as futuristic as the scientific concepts in review. Therefore, it is paramount for the DoD to justify the need for biotech enhancement and develop strict guidelines for its use if it ever hopes to see its visions realized.

## C. CHANGING CONDITIONS DETERMINE THE NEED FOR ENHANCED CAPABILITIES

One of the principles of evolutionary psychology states that adaptation is the act of making up for past shortfalls. Therefore, it is only natural for military leaders to pursue new capabilities that will ensure their troops are more fit and prepared to respond to changes in national security strategy, and to operate in complex combat environments. Rapid advancements in technology have changed the conduct of war. Like the introduction of the spear and shield in ancient societies, the invention of the tank, aircraft and combat ships have shaped the warfare tactics of modern societies.[59] Defense officials have witnessed the effects of growing innovations in technology and the enemy's application of its use on the battlefield. Improvised explosive devices (IEDs) and explosively formed penetrators (EFPs) activated by long range cellular transmitters came as a surprise to forces entering Iraq and Afghanistan. As a result, the military has changed its strategy, tactics, and technology to stay abreast of the changing operating picture and the nuances of asymmetric conflict. Diminishing conservative strategies along with the continued development of more sophisticated enemy operations had triggered a phase of transformation within the DoD to create a more dynamic force to maintain battlefield superiority and information dominance. An example is the employment of autonomous weapon systems like the MQ-9 Reaper UAV that can gather intelligence through

[58]Ibid., 18.

[59] Martin van Creveld, "War and Technology," *Newsletter of the Foreign Policy Research Institute's Wachman Center* 12, no. 25, last accessed October 14, 2013, https://www.fpri.org/footnotes/1225.200710.vancrevald.wartechnology.html.

surveillance technologies, independently select and discriminate targets, and render lethal effects with minimal collateral damage. Though technology continues to evolve and increase the lethality of today's battlefield, it is unimaginable to think that these technologies will ever replace the human factor of warfare. The diverse nature of current combat operations has heightened awareness of the continued importance of the individual soldier. The soldier and his team have always been the most critical integrated combat system and like the UAV, these assets require optimization to increase performance and promote their effectiveness and lethality of the battlefield.

The military found that the best way to defeat this asymmetric threat it to employ small groups of elite soldiers who are physically and mentally fit to withstand the rigors of war. The surge during the Bush administration called for over 92,000 troops to conduct counterinsurgency operations in Iraq. To achieve the mandated quota, standards for recruitment were lowered, resulting in a force that was very clearly substandard with regard to IQ and physical prowess.[60] Statistics released by the National Priorities Project provide a closer look at some very disheartening data on the quality of U.S. military recruits. The report shows that in 2007 only 70 percent of the population of military recruits had a high school diploma, which is significantly lower than the traditional accession goal of 96.8 percent and a decline not seen since WWII and Vietnam. In the same year, based on Armed Forces Qualification Test (AFQT) scores only 44.9 percent of recruits were categorized as high quality, which was an 11 percent decrease from 2005. Another grim detail highlighted in the report shows that the military increased their minimum percentage recruitment standard for personnel falling within the "Category IV" aptitude range to .4 percent. Soldiers that fall within this category are considered below average trainability and past DoD policy restricted Category IV enlistment to no more than .2 percent. On a good note, despite not yet meeting prescribed objectives, the quality of soldiers within the armed forces is steadily progressing.[61] An article by journalist Fred

[60] Noah Shachtman, "Be More Than You Can Be: Heat-resistant, Cold-proof, Tireless. Tomorrow's Soldiers are Just Like Today's—Only Better. Inside the Pentagon's Human Enhancement Project," *Wired*, March 2007, last accessed on October 18, 2013, http://www.wired.com/wired/archive/15.03/bemore.html.

[61] National Priorities Project, Military Recruitment 2010, last modified October 21, 2013. http://nationalpriorities.org/en/analysis/2011/military-recruitment-2010/notes-and-sources/.

Kaplan states that "a dumber army is a weaker army" and in the era of persistent asymmetric conflict soldier are required to be stronger and more intelligent to overcome the obstacle imposed by this type of warfare.[62] This data does not intend to label the military as an institution of idiots rather it shows that in times of increased operational need the organization may not get the caliber of personnel it requires.

In a technical report released in 2003 by Strategic Analysis, Inc., officials from the DARPA state that the Peak Soldier Performance (PSP) program was:

> …designed with the vision of enhancing warfighters' physiological abilities and providing them the stamina, strength, and endurance needed to complete grueling extended military operations. The mission of the warfighter is limited by his/her ability to sustain physical and cognitive performance over extended periods of time and in extreme environments. At present, the warfighter does not possess the physiological and psychological capabilities to keep up with the advances in technology.[63]

The *2010 Defense Quadrennial Review Report*, the Department of Defense (DoD) also asserted its need to focus on evolving and enhancing the force in order to protect and advance U.S. interests in the near and long term future while remaining capable of conducting full spectrum operations unilaterally or in partnership with allied forces.[64] In order to create a more dynamic force to remain superior over its adversaries, the DoD has expanded its interests in the study of biotechnological enhancement to include continued DNA research, studies in genetic engineering, and continued research of the human metabolic process to develop better performance enhancing supplements for increased energy and endurance. While the programs are still in their infancy, ongoing research continues to unlock genetic codes, moving researchers closer to their desired goal of creating the "super soldier." The conceptual super soldier is one who is more decisive,

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[62]Fred Kaplan, "Dumb and Dumber: The U.S. Army Lowers Recruitment Standards … Again," Slate, January 24, 2008, accessed on October 21, 2013, http://www.slate.com/articles/news_and_politics/war_stories/2008/01/dumb_and_dumber.html.

[63] Holloway, Clay and Kerrie Gruber, "Peak Soldier Performance," *Perspective, Science and Technology at Strategic Analysis, Incorporated*, 4th Quarter, 2003, accessed October 15, 2013, http://www.sainc.com/TechnicalReports/download/4QTR03.pdf, 1.

[64] U.S. Department of Defense, *Quadrennial Defense Review Report*, February 12, 2010, accessed November 15, 2013, http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf.

protected, and equipped to survive the battlefield. Their bodies will quickly adjust to extreme temperatures, while increased tissue regeneration will promote the rapid wound healing and recovery. Soldiers will be able to detect adverse situations and quickly traverse complex targets via their optimized ability to solve problems. Heightened endurance and lessened fatigue will ensure unit success during extended combat operations. The idea is simple: whether a threat is conventional or complex, the soldier that possesses more superior physiological and mental capabilities than his enemy will prevail.[65] Therefore, we must explore the possible benefits of genetic engineering because it could potentially lessen the innate limitations of the American soldier bringing them to parity with other decisive large platform weapon systems.

## D. FORCE ENHANCEMENT: A HISTORICAL AND MODERN DAY PERSPECTIVE

A warfighter's effectiveness lies within his or her ability to perform five critical functions: command and control, lethality, mobility, survivability, and sustainability.[66] These capabilities are interdependent and their importance and impact vary based on the specific combat mission or operational environment. In 1989, the DoD became increasingly cognizant of the soldier's growing importance as an integrative combat system. They created the Soldier Enhancement Program (SEP) and the Marine Enhancement Programs (MEP). These programs acquire and field enhanced tactical equipment to increase survivability, force protection, and lethality of the soldier.[67] While the DoD has made vast improvements in the individual protective equipment, communication and intelligence collection capabilities, soldiers are still highly susceptible to the innate limitations of their individual genomes. Soldiers remain at risk for disease, vulnerable to extreme weather conditions and they pay a physical toll when

[65] See, for example, JASON, *Human Performance*, report no. JSR-07-625, March, 2008, accessed October 2, 2013, http://www.fas.org/irp/agency/dod/jason/human.pdf, 7–11.

[66] Harry J. Kirejczyk, Dianne St Jean, and the United States Army Natick Research, Development And Engineering Center, "Analysis of Current Light Infantry Soldier System Costs" (Natick, MAs: Fort Belvoir Defense Technical Information Center, 1993), accessed October 16, 2013, http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA265173.

[67] Soldier Enhancement Programs, last modified November 15, 2013, https://peosoldier.army.mil/sep/.

negotiating through tough terrain with or without the weight of a combat load. Increased pressure on the force, post-traumatic stress disorder (PTSD), and chronic musculoskeletal issues are amongst the list of common trends associated with protracted war. A critical factor to mention is the effect of stress and fatigue on the decision-making abilities of the individual soldier. All of the aforementioned factors contribute to reduced troop performance, which is detrimental to combat operations. Most importantly, a 25 cent bullet is still very effective at draining the life from the military's ~$1 million dollar investment. Therefore, continued research in human performance enhancement via biotechnology enables a closer look inside of the human genome and the ability to modify the human body in ways that will remove natural limitations. Ultimately, this method may have a positive effect on the military's ability to fight future conflict.

The means by which the military is able to enhance a soldier's performance is evolving, but the concept itself is as old as the Revolutionary war. While this thesis does not discuss or categorize vaccinations as a form of human performance enhancement, it is remiss not to mention that one of the first documented cases of soldier enhancement dates back to the American Revolution in 1775–82 when General Washington ordered the inoculation of his troops to protect them against small pox.[68] The moderately contagious virus *Variola major* caused smallpox, which for England had long been an epidemic. This increased the likelihood that British soldier were already immune to the disease where American soldiers were not. Taking heed to the detrimental effects of the smallpox outbreaks witnessed during the siege of Boston and Quebec, and the mobilization of Lord Dunmore's Ethiopia regiment, General Washington knew that any exposure would greatly reduce the operational effectiveness of the Continental Army and would lead to its decisive defeat by the British Army. Therefore, he implemented measures to enhance his force making them more resistant to what he suspected was a British biological warfare tactic. Similar to today's ethical debates, inoculation was a highly controversial topic amongst the American colonials because outbreak of the disease was rare

[68] Lin, Mehlman and Abney, "Enhanced Warfighters: Risk, Ethics, and Policy," 5; Elizabeth A. Fenn, "The Great Smallpox Epidemic," *History Today* 53, no.8 (2003), accessed October 1, 2013, http://www.historytoday.com/elizabeth-fenn/great-smallpox-epidemic.

throughout the colonies. Though he lost one percent of his overall force to the adverse effects of inoculation, Washington's risky decision saved the lives of his remaining force proving that the need for the enhancement measures outweighed the risk of exposure. The program's success led to its continued implementation in preparation for future operations.[69]

An equally relevant and more contemporary example of soldier enhancement is the use of amphetamines to increase alertness and reduce combat fatigue during extended operations. Performance degradation and increased risk for catastrophic accidents such as fratricide is the eventual effects of the fatigue seen universally in all soldiers conducting sustained operations. Once limited by daylight, the preparation and execution of combat operations has become a 24-hour affair. Tactical aviators and some ground forces are subject to continuous operations that extend beyond a 24-hour period. Additionally, sleep loss and the disruption of natural circadian rhythms are experienced when crossing time zones. These factors, combined with preparative work for deployment can produce a great deal of operational fatigue and reduce soldier performance.[70] When operational demands limit a unit's ability to implement routine rest periods or delay operations until soldiers adjust to new environments, leaders have resorted to the use of medications to sustain and enhance the performance of their operators.

Dating back to the 1940s, amphetamines became the drug of choice to maintain alertness and reduce fatigue during American military operations. This synthetic drug shares a similar chemical structure to the neurotransmitters adrenalin and noradrenalin and whether inhaled, ingested, or injected stimulates the release of these natural transmitters resulting in a profound effect on brain and muscular activity. During this period, amphetamines were widely used in Europe and Japan and by June 1940, the

[69]Elizabeth A. Fenn, "The Great Smallpox Epidemic;" Mary C. Gillet, "Chapter 3: From Seige to Retreat, 1775 to May 1777," *The Army Medical Department, 1775–1818* (Washington, DC: U.S. GPO: 1981), accessed October 1, 2013, http://history.amedd.army.mil/booksdocs/rev/gillet1/ch3.html.

[70]Department of the Navy, Naval Strike Air Warfare Center (NSAWC)/Naval Operation Medical Institute (NOMI)/Naval Aeromedical Research Labs (NAMRL), Joint document: NAVMED P-6410 Performance Maintenance During Continuous Flight Operations: A Guide for Flight Surgeons, January 2000, accessed October 16, 2013, http://www.med.navy.mil/directives/pub/6410.pdf, 2.

German Army consumed a staggering 35 million tablets of the methamphetamine Pervitin. Some scholars believe that the use of this drug drove German success during the early stages of the Blitzkrieg.[71] During this era, the common hypothesis shared by psychiatrists and neurologists was that amphetamines adjusted hormone levels within the central nervous system and provided ample stimulation to the brain enhancing alertness and muscle control. Therefore, the drug became popular for treating depression, narcolepsy, and Parkinson's disease.[72] Considered safe and beneficial for a myriad of physical and mental disorders, healthcare providers noticed that continued use decreased its effectiveness for appetite suppression. Increasing the dose to maintain the same weight loss effect resulted in negative shifts in mood to include irritability, paranoia, insomnia, psychosis, and euphoria.[73] Another disadvantage was its highly addictive property that provides a high potential for abuse.[74] These adverse side effects led to the development of the protocols used today to govern its distribution and use. Despite the disadvantages, these stimulants produced remarkable results when combating fatigue and boredom. Studies conducted in the 1940s and 50s showed that when amphetamines were given to healthy, non-fatigued individuals their mental acuity increased by five percent and there was significant improvement in reaction time and hand eye coordination. Studies also showed that in subjects suffering from fatigue with depreciated mental function, using amphetamines returned them to normal cognitive levels.[75] The results of these studies increased the attractiveness of amphetamine because it possessed great utility to prevent physical and mental degradation, and helped maintain tactician performance during combat operations.

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[71]Nicolas Rasmussen, *On Speed: The Many Lives of Amphetamine* (New York: University Press, 2008, 54.

[72]Ibid.

[73]Ibid.

[74]Nicolas Rasmussen, "America's First Amphetamine Epidemic 1929–1971: A Quantitative and Qualitative Retrospective With Implications for the Present," *American Journal of Public Health* 98, no. 6 (2008): 975.

[75]Rhonda Cornum, John Caldwell, and Kory Cornum, "Stimulant Use in Extended Flight Operations." *Airpower* 11 (1997), accessed on October 17, 2013,http://www.airpower.maxwell.af.mil/airchronicles/apj/apj97/spr97/cornum.pdf, 54.

During WWII, the American military dispensed the drug Benzedrine in a 5mg dose as part of a soldier's standard issue as well as units medical and emergency response kits.[76] The use of amphetamines to reduce combat fatigue would extend beyond the Great Wars. Because of its ability to maintain alertness for up to 30 hours, dextroamphetamine (Dexadrine), known as the "go pill" became a popular drug amongst America's aviation community.[77] By 1960, the U.S. Air Force Strategic Air Command (SAC) sanctioned the use of Dexedrine, later followed by the U.S. Air Force Tactical Air Command in 1962. By Operation Desert Storm, increased medical and administrative oversight resulted in a vast improvement of drug effectiveness and pilot acuity. Providers introduced the sedative Temazepam (Restoril) also called the "no-go pill" to readjust the circadian rhythm to reduce operational fatigue.[78] A report from Desert Shield/Dessert Storm states that 65 percent of pilots within the TAC used dextroamphetamine to sustain flight operations while deployed, which most deemed necessary for mission success.[79] Recent history has also seen use of dextroamphetamine as a force enhancer for extended flight operations. A report by Kenagy et al. shows the rigorous demands of flight operations and the use of Dexedrine during Operations Iraqi Freedom and Enduring Freedom. B2 bomber missions to Afghanistan were in upwards of 44 hours in length and considered the longest combat missions in aviation history.[80] During these conflicts, aviators executed combat and mission support flights that extended beyond a 16-hour period. Though amphetamines were common among the tactical aviation community during periods of conflict, use of the drug was also found amongst helicopter, tanker, and E-2 pilots during low stimulus support missions to combat boredom. In the aforementioned cases, success may not have been possible without some form of anti-fatigue medication.

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[76] Rasmussen, "America's First Amphetamine Epidemic 1929–1971," 975.

[77] NAVMED P-6410, "USAF Experience in Desert Storm: An In-Depth Look at One Successful Squadron," January 2000, 10–18.

[78] Ibid.

[79] D. L. Emonson and R. D. Vanderbeek, "The Use of Amphetamines in U.S. Air Force Tactical Operations during Desert Shield and Storm," *Aviation Space Environmental Medicine* 66, no. 3 (1995): 260.

[80] David N. Kenagy et al., "Dextroamphetamine Used During B-2 Combat Missions," *Aviation, Space, and Environmental Medicine* 75, no. 5 (2004): 381.

Recent studies have gone steps further to not only prove the beneficial effects of amphetamines on cognition and physical performance, they also investigate how certain genetic factors will affect the metabolism of the drug and the potential side effects associated with each variant.[81] The evidence provided by these reports aids further study in the development of newer performance enhancing drugs with less potential side effects. The DoD is currently investigating alternative drugs like modafinil, which is reported to keep a person awake for 64 to 90 hours without the side effects commonly associated with dextroamphetamines.[82] In 2012 the Air Force Special Operations Command (AFSOC) authorized aviator use of modafinil and extended it operational use to its ground forces.[83] The drug Ampakine (CX717) is also in test phase but there is little data on its effects on human brain function. Though findings are limited, preliminary research shows that CX717 has potential for fatigue prevention and performance maintenance.[84]

The 2002 Tarnak Farms friendly fire incident in Afghanistan forced policy makers to take a closer look at the USAF sleep policy and the use of amphetamines during combat operations.[85] During this event, two American pilots, while under the influence of Dexedrine, accidentally killed four Canadian soldiers and injured eight others. During the trial, the defense attorneys stated that dextroamphetamine consumed by the pilots might have impaired their judgment. This claim led to a public investigation

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[81]Beata Y. Silber et al., "The Acute Effects of D–Amphetamine and Methamphetamine on Attention and Psychomotor Performance," *Psychopharmacology* 187(2006):154–169; Venkata S. Mattay et al., "Effects of Dextroamphetamine on Cognitive Performance and Cortical Activation," *NeuroImage* 12 (2000): 268–275; Venkata S. Mattay et al., "Catechol O-Methyltranferase Val158–Met Genotype and Individual Variation in the Brain Response to Amphetamine," *PNAS USA* vol 100 no. 10 (2003):6186–6191.

[82] Jonathan Moreno, "Juicing the Brain: Research to Limit Mental Fatigue Among Soldiers May Foster Controversial Ways to Enhance Any Person's Brain," *Scientific American Mind* 17, no. 6 (2006): 66–68.

[83]*Air Force Special Operations Command Instruction 48-101*, November 30, 2012, 8.

[84] N. J. Wesenten, R. M. Reichardt, and T. J. Balkin, "Ampakine (CX717) Effects on Performance and Alertness During Simulated Night Shift Work," *Aviation Space Environmental Medicine* 78, no. 10 (2007): 937–43; J. Boyle et al., "Acute Sleep Deprivation: The Effects of AMPAKINE Compound CX717 on Human Cognitive Performance, Alertness and Recovery Sleep," *The Journal of Psychopharmacology* 26, no. 8 (2012): 1047–57.

[85] Jonathan Moreno, "Juicing the Brain," 66.

of the effects of amphetamine on personal judgment. While some studies propose that amphetamines impair judgment, other studies disprove or report no such finding leaving the question of whether amphetamines impair judgment unanswered.[86]

Today, all three military services use dextroamphetamine to sustain performance within its combat aviation community under circumstances of prolonged operations where fatigue is likely.[87] Incidents like Tarnak Farms lead to public debate of whether it is ethically correct to use amphetamines during military operations. However, critics of the current policy sometimes fail to consider the unpredictable and harsh nature of war that may require the employment of necessary aids for success.[88] Additionally, military operators must think beyond their immediate actions, consider the possible implications of a failed mission and the effects on the livelihood, and mission success of other service members in combat. Therefore, the ethical use of stimulants in combat must be assessed within this context and opponents of the policy should consider the higher benefit versus risk ratio in this scenario.

On a smaller scale, but worth mentioning is the military's interest in nutritional supplements to enhance the physical and mental performance of its military personnel.[89] In 2008, the Institute of Medicine (IOM), as a subcommittee under the Committee on Military Nutrition Research, began a long-range study to analyze the dietary supplements most commonly used among service members and assessed their potential benefits and risks to health and physical and cognitive performance. The board's report states that the heightened emphasis on fitness and operational readiness has increased military interest to seek dietary supplements to enhance performance beyond what is achievable through a

[86]Venkata S. Mattay et al., "Effects of Dextroamphetamine on Cognitive Performance and Cortical Activation," 274; Andrew B. Meadows, "Fatigue in Continuous and Sustained Airpower Operations: Review of Pharmacologic Countermeasures and Policy Recommendations" (Maxwell Air Force Base, AL: Air Command and Staff College Air University, 2005).

[87] John A. Caldwell, "Go Pills in Combat: Prejudice, Propriety, and Practicality," *Journal of Special Operations Medicine* 8, no. 4(2008): 98–99.

[88]Ibid.

[89] Institute of Medicine (US) Committee on Dietary Supplement Use by Military Personnel, *Use of Dietary Supplements by Military Personnel*, eds. MRC Greenwood and Maria Oria (Washington, DC: National Academies Press, 2008), accessed October 17, 2013, http://www.ncbi.nlm.nih.gov/books/NBK3977/pdf/TOC.pdf.

balanced nutritional diet. Therefore, any products that increase physical or mental capacity are of special military interest.[90] Of the list of supplements examined, those that presented the greatest potential for performance enhancement are caffeine (alertness), tyrosine (anti-stress), melatonin (sedation), the amino acid hydroxy-methylbutyrate (HMB) (lean muscle production for increased strength), creatine (increased physical performance with a reduction of injury), and chromium (increased metabolism, strength, and weight management).[91] The study's findings show that military use of dietary supplements is twice that of the general U.S. populace with 60 percent of U.S. military personnel reportedly using dietary supplements as a part of their daily nutritional routines. Of this military populace, 85 percent were in the Special Operations community.[92] The use of dietary supplements may be morally uninteresting because its better aligns with societal practices for living a holistic healthy lifestyle. However, the findings of this study indicates that subpopulations within the military, like the Special Operations or infantry community that undergoes increased levels of physical and mental exertion during training and combat express a greater need for performance optimizing supplements.

The examples discussed in this section show the adaptive nature of the military and the need to optimize force performance to adjust to changing battlefield conditions. Smallpox inoculation and the use of amphetamines were the chosen methods of enhancement determined by operational need and scientific advancement of each era. Knowledge of the risk and benefits of each of the methods was marginal at best. However, leader decisions to apply these enhancement measures allowed for further analysis of it potential benefits, which in each scenario became critical factors to overall mission success. Therefore, in an era where technological advancement increases the lethality of combat and surpasses the natural evolution of man, biotechnology may be the method of choice to increase force performance and adaptability in future conflicts. The

[90]Ibid., 28.

[91]Ibid., 87–155.

[92]Ibid., 44–45.

perceived risks and benefits associated with genetic enhancement are hypothetical and the uncertainty causes great concern, but concern should not prevent further investigation, because without it the actual benefits will go unknown.

## E. BIOTECHNOLOGY: THE BREAKTHROUGHS AND DOWNSIDE OF GENETIC ENGINEERING

Human enhancement requires the convergence of four field of science—nanotechnology, biotechnology, information technology, and cognitive science (NBIC).[93] While each play a significant role in enhancing performance, biotechnology opens the gateway to the human genome and allows an in-depth look at the basic building blocks of life—DNA. Understanding how the body functions at the molecular level presents opportunities to biologically modify human physiology and cognition to maximize overall effectiveness.[94] Where scientists were once limited to temporary solutions to maintain and maximize performance, biotechnology may provide a permanent fix to the natural limitations one seeks to eliminate (i.e., pain, fatigue, and stress).

The biological revolution of the 1970s began an era of scientific innovation that led to the discovery of new methods and products that would reshape medical practices and discoveries to enhance human performance. While most of the breakthroughs and application of biotechnology occurred within the last 30 years, the scientific practice began over a hundred years ago with the discovery of DNA.[95] Biotechnology applies the practice of engineering to the life sciences in order to enhance the human condition, and protect the force in time of conflict. Some would also argue that biotechnological advancements will make the conduct of war more humane and will reduce American

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[93]Mark S. Frankel and Christina J. Kapustij, "Enhancing Humans," *From Birth to Death and Bench to Clinic: The Hastings Center Bioethics Briefing Book for Journalists, Policymakers, and Campaigns*, ed. Mary Crowley (Garrison, NY: The Hastings Center, 2008), 56.

[94] Stefan Reschke et al., "Neural and Biological Soldier Enhancement: From SciFi to Deployment," Proceedings of NATO RTO Symposium Human Performance Enhancement for NATO Military Operations (Science, Technology, and Ethics), Sofia, Bulgaria, 2009, 1.

[95] Frederick B. Rudolph and Larry V. McIntire, eds. *Biotechnology: Science, Engineering, and Ethical Challenges for the Twenty-First Century* (Washington, DC: Joseph Henry Press, 1996), 1.

post-reconstruction efforts and long-term political ramifications.[96] Biotechnology has exhibited endless potential within the realm of medicine. To date, the growing industry is primarily responsible for over 50 percent of medical innovation.[97]

A beneficiary of the Human Genome Project (HGP), biotechnology embarks on new methods to redesign organisms at the genetic and molecular levels. The HGP provides a basic understanding of the genetic structure of an organism in relations to its function and health. The genomic roadmap provided by its research has moved science from an era of DNA sequencing to an era of DNA synthesis. Findings of the HGP revolutionized the biotechnology industry and triggered innovations within a broad range of biotechnologies to include genetic engineering, bioinformatics, proteomics, and transgenic technology. Genetic engineering is the direct modification of an organism's genes through techniques that remove innate material or replace it with exogenous DNA that is directly inserted into a host or a cell. The end goal is to fuse or hybridize new DNA with a host to alter its form and or function. Bioinformatics studies the gene and protein molecules, which are the crux of organism development. Continued research within this realm provides scientist with an in depth review on how to manipulate DNA, the conductor of genetic development and functioning. Proteomics takes scientific investigation a step further by examining the function of key proteins that control human physiology, and the multitude of physiological functions a single protein can possess. Current findings in proteomic research has identified proteins role in neurotransmission, cell reproduction, tissue growth, blood production, and immune response to disease.[98] Last, studies in transgenic technology provide some concept of gene control and reconstitution. While research in this realm of study is limited, transgenic studies continue to open new gateways to advanced genetic manipulation.[99] Ultimately,

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96 Ji-wei and Yang. "Ultramicro, Nonlethal, and Reversible," 77.

97 Ibid.

98 American Medical Association, "Proteomics," accessed October 2, 2013, http://www.ama-assn.org/ama/pub/physician-resources/medical-science/genetics-molecular-medicine/current-topics/proteomics.page.

99 Ji-wei and Yang. "Ultramicro, Nonlethal, and Reversible," 77.

successful biotechnologies will change a living organism's ability to perform new functions. For the military, this means a deeper understanding of how to control or change a soldier's battlefield effectiveness.

In 2010, a study conducted by the JASON Group, a scientific advisory group to the U.S. government, identified the U.S. military as the top consumer of medical services because they possess unique medical needs that surpass those of the general population. For this reason, the military will greatly benefit from innovations in genomic research because it will enhance the medical capabilities of the military and facilitate greater treatment outcomes.[100] JASON's research shows that continued genomic research may greatly impact offensive and defensive operations because the application of genomic technologies may enhance soldier fitness, performance, and operational readiness.[101] Through its medical data systems, the DoD is more than equipped to receive and store, analyze and secure the genotypic and phenotypic information of its service members. This data will allow researchers to better understand individual responses to battle-fatigue, susceptibility to PTSD, prolongued exposure to extreme weather conditions, and rate of recovery of injury.[102] Their research, access to a large population of personnel, medical data storage, and their ability to leverage support from civilian biotech agencies will allow the DoD to greatly contribute to realm of biotechnology and realize its concepts for force enhancement.

DARPA is underway in their attempts to develop tools to enable genetic engineering that may one day enable the DoD's ability to create a biological fit soldier. Through their "Living Foundries," program DARPA's hopes to "enhance methods for genome transplantation that will enable the engineering of complex functionality into human cell lines than are currently possible."[103] Within the program, there are several

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[100] JASON, *The $100 Genome: Implications for the DoD* report no. JSR-10-100, December 15, 2010, accessed October 2, 2013, http://www.fas.org/irp/agency/dod/jason/hundred.pdf, 1.

[101] Ibid.

[102] Ibid., 43.

[103] Daniel Wattendorf, "Advanced Tools for Mammalian Genome Engineering," Small Business Innovation Research, last modified October 22, 2013, www.sbirsource.com/grantiq#/topics/88854.

areas of interest, to include developing tools for rapid gene construction and editing and manipulating genetic designs. By soliciting the help of private biotech corporations, DARPA aims to improve their methods to implant human artificial chromosomes (HACs) into mammalian cells as highlighted in a document on the DoD's Small Business Innovation and Research page. The idea of genetic enhancement seems like it is rooted in science fiction, but the following examples of ongoing research gathered from open source information will provide sufficient evidence of its reality.

### 1. Anti-Fatigue

Sleep and the reduction of mental fatigue are the most heavily researched areas in human performance. Currently, stimulants like caffeine and modafinil provide a temporary solution to counter fatigue. However, findings from recent fatigue studies indicate a genetic component associated with fatigue and has found that some humans are naturally resistant to mental exhaustion.[104] Scientists are uncovering genes that control specific aspects of sleep, creating a genetic map that can one day become the key to sleep regulation and reducing fatigue in humans.[105]

### 2. Enhancing Mental and Cognitive Function

In a study conducted by Tang et al., researchers successfully enhanced the learning and memory in laboratory mice by genetically modifying the synaptic response of neurons ultimately altering brain plasticity and memory formation. The findings of this study lead researchers to believe that genetic enhance of mental and cognitive abilities in mammals is possible.[106]

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[104]D. Aeschbach et al., "A Longer Biological Night in Long Sleepers Than in Short Sleepers, *Journal of Clinical Endocrinology and Metabolism* 88, no. 1 (2003): 26–30; Scott A. Rivkees, "Time to Wake-Up to The Individual Variation In Sleep Needs," *The Journal of Clinical Endocrinology & Metabolism* 88, no. 1 (2003): 24–25.

[105]Chiara Cirelli, "The Genetic and Molecular Regulation of Sleep: From Fruit Flies to Humans" *National Review in Neuroscience*10, no.8 (2009): 549–560; K. V Allebrandt, N. Amin, B. Müller-Myhsok, T. Esko et al., "A K-ATP Channel Gene Effect on Sleep Duration: From Genome-Wide Association Studies to Function in Drosophila," *Molecular Psychiatry* 18 (2013): 122–132.

[106] Y.P. Tang et al., "Genetic Enhancement of Learning and Memory in Mice," *Nature* 401, no. 6748 (1999): 63.

### 3. Physical Enhancement

In an attempt to study muscle disease and reverse a loss in muscle mass associated with aging, McPherron et al. genetically engineered laboratory mice to have increased muscle growth and strength. Scientists discovered that the blocking of specific growth factor genes through gene targeting increased skeletal muscle mass in laboratory specimens.[107] Researchers continue to study the Myostatin gene and its effect on elite athletic performance.[108]

### 4. Immunity

The 2008, scientist joined forces to launch the Immunological Genome Project to develop a "road map" of the genes that control various immune cells. Increased knowledge of the immune system may allow scientists to genetically modify cellular function to help treat or prevent exposure to infectious disease.[109]

### 5. Pain Management

Pain reduction is of major interest to researchers. Increasing pain thresholds and decreasing the inflammatory response associated with injury may reduce mental and physical stress that can degrade performance.[110] One of the leading biotech companies, the Rinat Neuroscience Corporation created the RN624 pain inhibitor vaccine that blocks pain within 10 seconds with results that last for 30 days. While the serum does not

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[107] Alexandra C. McPherron, Ann M. Lawler and Se-Jin Lee, "Regulation of Skeletal Muscle Mass in Mice by a New TGF-Beta Superfamily Member," *Nature* 387 (1997): 83.

[108] D.S. Mosher et al. "A Mutation in the Myostatin Gene Increases Muscle Mass and Enhances Racing Performance in Heterozygote Dogs. *PLoS Genetics* 3, no. 5(2007): e79, accessed October 21, 2013, http://www.plosgenetics.org/article/fetchObject.action?uri=info%3Adoi%2F10.1371%2Fjournal.pgen.0030079&representation=PDF.

[109] Tracy S. P. Heng, Michio W. Painter, and The Immunological Genome Project Consortium, "The Immunological Genome Project: Networks of Gene Expression in Immune Cells" *Nature Immunology* 9, no. 10 (2008): 1091–94.

[110] Mohammed A. Nassar et al., "Nociceptor-Specific Gene Deletion Reveals a Major Role for Nav1.7 (Pn1) in Acute and Inflammatory Pain," *PNAS* 101, no. 34 (2004): 12706–12711.

remove the initial sensory response of an injury, it significantly reduces the inflammation and swelling that are responsible for pain.[111]

### 6. Anti-aging

Research conducted by a team of UCLA scientist uncovered a "biological clock" embedded within the genome that promotes the aging of tissue. By chemically altering human DNA, scientists were able to create an internal clock that accurately determined the age of various organs, cells, and tissues while identifying parts of the body that aged faster than others did. Geneticist Steve Horvath states:

> "the process of transforming a person's cells into pluripotent stem cells resets the cells' clock to zero. The big question is whether the biological clock controls a process that leads to aging. If so, the clock will become an important biomarker for studying new therapeutic approaches to keeping us young."[112]

### 7. Human Regenerative Healing

Scientific studies are uncovering ways to manipulate the genes to make humans regenerate like a newt, flatworms, and the hydra. The study led by Ellen Heber-Katz, a professor at the Wistar Institue in Philadelphia, found that by deleting the p21 gene in laboratory mice reactivated the ability for cells to renew surgically removed tissues without signs of scarring or previous damage. The study was successful in finding the genetic link to tissue regeneration yet further research is necessary to control implications caused by the removal of the gene. A thorough understanding the implication of their finding will allow researchers to one day be able to accelerate healing in humans.[113]

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[111] Joel Garreau, *Radical Evolution: The Promise and Peril of Enhancing.*

[112] University of California, Los Angeles (UCLA), Health Sciences "Scientist Uncovers Internal Clock Able to Measure Age of Most Human Tissues; Women's Breast Tissue Ages Faster Than Rest of Body," *Science Daily*, October 20, 2013, last accessed October 21, 2013, http://www.sciencedaily.com-/releases/2013/10/131020203006.htm; Steve Horvath, "*DNA Methylation Age of Human Tissues and Cell Types," Genome Biology* 14 no.10 (2013): R115.

[113] Khamilia Bedelbaeva et al., "Lack of P21 Expression Links Cell Cycle Control and Appendage Regeneration in Mice," PNAS 107, no. 13 (2010): 5845–5850, accessed October 22, 2013, www.pnas.org/cgi/doi/10.1073/pnas.1000830107.

## F. FEAR OF THE UNKNOWN

While this field of science shows great benefit towards the future protection and enhancement of the human condition, genetic engineering also possesses a downside. Its unpredictable nature generates questions of its safety and the potential side effects of modifying genetic pathways. Additionally, some of the methods used to introduce new genes into the human body can threaten health and potentially lead to death. The human genome is a complex system of cells that are responsible for a multitude of functions, biological signals, and pathways. Alteration requires a level of mastery that scientists have not yet obtained. For instance, disrupting one gene to treat a defect may cause other problems. Scientists found that blocking the gene to increase intelligence in mice also leads to an increase in sensitivity to pain.[114] A study performed by Heber-Katz et al. (2009) revealed similar findings. Their research found that prohibiting the functionality of the p21 gene promoted increased tissue regeneration but also removes the body's natural ability to regulate production of the p53 gene can lead to its uncontrollable proliferation, which, if not controlled, can lead to the overproduction of cells that can lead to some cancers or aptosis - increased cellular death.[115]

Gene therapy using recombinant DNA (rDNA) is the oldest and most common technique for moving exogenous genes into a host. This method uses live biological vectors like plasmids or viruses to deliver rDNA into an individual's genome to repair genetic mutations. The vector must surpass the immune system and properly target its specified cell. Any error can lead to increased complications. As witnessed in a small number of gene therapy cases complications could lead to subject death. In the reported circumstances, death was due to severe immune reactions to the vectors and transgenes, or the inappropriate insertion of a viral vector and transgene that led to viral propagation

[114]Feng Wei et al., "Genetic Enhancement of Inflammation Pain by Forebrain NR2B Overexpression," *Nature and Neuroscience* 4 (2001): 164–169

[115] Bedelbaeva et al., "Lack of p21 Expression," 5845.

or cancer causing mutations.[116] Additionally, any mishap when engineering rDNA transfer vectors could lead to the creation of a stronger and more resistant virus or bacteria. If released, these germs could theoretically cause a major epidemic.

The aforementioned issues address some of the known negative or potentially negative side effects of genetic engineering. However, the most frightening aspect is not knowing the answers to the unknown questions associated with this field of science. There is no clear understanding of the long-term effects or the implications of altering DNA. The unknowns naturally lead to reluctance, controversy and pointed arguments over its potential effects and the parameters of research. The science remains unperfected, unpredictable, and uncontrollable. Despite this, continued scientific research leads to discovery of these issues and allows for the development of effective solutions to make genetic engineering a stable practice.

## G. CONCLUSION

This chapter analyzed the concept of enhancement, the military's operational need for it, and how breakthroughs in genetic engineering could soon create more biologically fit soldiers. Despite the wars in Iraq and Afghanistan drawing to a close, it is only a matter of time before conflict abroad calls for America's attention. As history shows, the conduct of war evolves over time and with radical advancements in technology, the battlefield will become more lethal and complex. Modern advancements in biotechnology, though radical, may someday help the military fill capability gaps by creating a force more physiologically and intellectually fit to survive the rigors of future conflict. Technological capability for such an endeavor is years from existing. Nevertheless, further research to assess the risks and benefits associated with genetically modifying soldiers should undoubtedly continue. It is up to DoD to decide the pros and cons of genetic engineering and establish policy to determine which methods should be

[116] Mae-Wan Ho, "Gene Therapy Woes: Research Continues to Turn up New Obstacles and Dangers, and Tough Questions are Raised over the Ethics Involved," Institute of Science and Technology Report, accessed October 27, 2013, www.i-sis.org.uk/GTW.php:; S. Hacein-Bey-Abina et al., "LMO2-Associated Clonal T Cell Proliferation in Two Patients after Gene Therapy for SCID-X1." *Science* 302, no. 5644 (2003): 415–419.

used or prohibited. In the meantime, increasing awareness and quelling public concerns surrounding genetic modification is essential to prevent the disruption of further research and future military application of genetic enhancements. The next chapter will conclude this thesis and provide recommendation for future research.

# IV. CONCLUSION

In the post 9/11 era, America's policy makers are challenged by changing world politics and how to best implement its military to maintain order throughout the international community and secure U.S. national security and interest. Robert Mueller, former Director of the Federal Bureau of Investigation, best describes the erratic changes in global politics and rising threats by stating, "*Surveying today's threats is somewhat like peering into a kaleidoscope, where even the slightest rotation creates new patterns of color and light. Just when it seems you understand a threat, the world turns, and the threat has changed* [emphasis added]."[117] Staying ahead of the threat means increasing the operational demands on the military. Military leaders are responsible for balancing operational requirements while ensuring the greatest level of force health protection, which is a challenging task. To meet the demands of persistent and complex warfare, military leaders must investigate new technologies that will enable the optimization of force performance and effectiveness when operating in current and future battlefield conditions. As discussed in previous chapters, the military places great emphasis on the development of advanced weapon systems to outmatch its enemy, however, in an era of prolonged dual-front warfare, leaders are realizing more the importance of the soldier as an integral weapon system and the most critical element of mission success. Though the soldier is identified as being an eminent asset in the military's arsenal of weapon systems, the soldier is the weakest link due to its natural genetic limitations. Unlike inanimate advanced large platform weapon systems used to produce lethal effects on the battlefield, the human soldier is vulnerable to his or her own biological constraints as well as environmental and occupational factors that can adversely affect health and performance.[118] While it may be slightly absurd to think that fighting wars could ever be

[117] Robert S. Mueller, "Changing Threats in a Changing World: Staying Ahead of Terrorists, Spies, and Hackers," Federal Bureau of Investigation, November 17, 2011, accessed on June 4, 2013, http://www.fbi.gov/news/speeches/changing-threats-in-a-changing-world-staying-ahead-of-terrorists-spies-and-hackers/.

[118] Lester Martinez-Lopez, "Biotechnology Enablers for the Soldier System of Systems," The Bridge 34, no. 3 (2004): 17.

an easy process, biotechnology may one day enhance soldiers beyond their inherent genetic shortfalls making it easier and safer for them to operate on the battlefield and withstand the rigors of war.[119]

Human enhancement techniques have a long lineage throughout military history and continue to evolve over time. Of the DoD's list of paradigm-shifting technologies, biotechnology has become a front runner in scientific and technological innovation that may facilitate the successful transformation of the U.S. military into a fast acting, highly networked joint force capable of rapid deployment, increased decision making while maintaining its ability to achieve battlefield superiority.[120] DARPA scientists are moving their research beyond the development of advanced external body armor to the investigation of methods to enhance strength and endurance, metabolic response, fatigue resistance, rapid healing and cognition. They have begun to divert their attention to improving the internal workings of the human being to enhance soldier fitness from the inside out. Scientist are leveraging emerging biotechnologies that promise great technological advancement that may provide the military with unprecedented capabilities by shaping the future of human performance and creating a soldier who is more decisive and effective in combat. Scientific and technological advancements are occurring at an unprecedented pace, shifting the concept of genetic engineering of the human genome from science fiction to reality. Concepts once portrayed in movies and comic books may become the realized future of the military. Ongoing research in genetic engineering continues to unlock genetic codes that may one day enable the successful and stable enhancement of a soldier's physical and cognitive condition. By removing what some scientists consider "genetic imperfections," soldiers may be able to endure the extremes of weather and terrain, heal and recover faster, move quicker, survive longer without nutritional sustenance, and think in ways that transcend normal human abilities.

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[119]Lin, Mehlman and Abney, "Enhanced Warfighters: Risk, Ethics, and Policy," 8, 86.

[120]John A. Parmentola, "Army Transformation: Paradigm-Shifting Capabilities through Biotechnology," *The Bridge* 34, no. 3 (2004):33.

As highlighted in Chapter II, there is an expected level of social angst when discussing or dealing with futuristic ideas where the possible outcomes are unpredictable and have the potential of producing uncontrollable effects that may alter human life. Research shows that the uncertainties surrounding the new technologies are highly speculative and farfetched. At this point, no one really knows the real outcomes of biotechnological research and how its byproducts may affect human life in the future or specifically, the life of a soldier and his or her conduct in future wars. There is little debate over innovations in science and technology that have led to great medical breakthroughs such as the creation of new pharmaceuticals, cures for diseases, bodily dysfunction, and the replacement of organic limbs and organs. However, when the use of science and technology extends beyond the restoration of health and becomes a tool to alter the human form from its normal state some scholars believe that it challenges the essence of what it means to be human and threatens societal values. At the core of this argument is the belief that genetically modifying the human genome makes humans look like artificial life forms that can be manipulated either for their own personal desire or for the needs of society. Most of the presented literature discusses the effects of biotechnology on the general American populace and how far people may go to increase their well-being and lifestyles via genetic modification. There is little analysis of its application to the military to enhance a population of soldiers that sacrifice their lives for the security of the nation and how these same technologies will reduce risk and increase personal sustainment during complex operations. Therefore, the ethical use of biotechnology to genetically enhance an individual based on duty, responsibility and level of risk associated with their occupation demands further analysis.

Regardless of which side of the ethical debate one may be on, none can deny the importance of human performance and the need for the military to maintain its performance advantage to achieve victory in war. Examples discussed in chapter three are the military's use of neuro-pharmaceuticals (dextroamphetamine, modafanil, and ampakine "CX717") to support extended flight operations and the use of performance enhancing supplements by over 85 percent of the military's most elite forces. These medications and holistic supplements greatly enhanced athletic performance, cognition,

concentration, and alertness during high stress combat operations where mission success depended greatly upon the ability to combat sleep deprivation and battle-fatigue. The high percentages of use of the anti-fatigue medications and dietary supplements further support the notion that performance is a critical part of military culture. Nevertheless, ethical considerations will limit research activities and the application of genetic enhancements to the force. Furthermore, unclear definitions of human enhancements, poorly established limits in medicine, and theological beliefs on the limits of science will continue to complicate reaching an agreement of whether the military should or should not genetically enhance soldiers.

## A. POLICY IMPLICATIONS

While the debate continues, advances in science and technology are outpacing the development of policy that may inhibit or facilitate the life sciences that may one day allow the military to create its "super soldier." Due to complex and novel set of ethical, legal, and social issues associated with the use of genetic enhancements, it is of the utmost importance that the DoD increases public awareness of their need for human enhancement technologies. Gaining public support for the military to apply this type of enhancement method to its force is dependent upon the DoD's ability to clearly establish guidelines for and limits of its use. Critical questions that remain unanswered is will genetic enhancement technologies be applied to the entire force or targeted sectors depending upon the complexity of its military mission and whether these enhancements are reversible once a soldier has completed their tour of duty or military obligation? Obtaining the answers to these questions may not be possible for some time because the future of warfare is a hypothetical concept and research in genetic modification is still in its infancy with findings that are inconclusive. Therefore, future success in ensuring the development of policy that will facilitate the application of biotech enhancements lay in the scientific community's ability to communicate the importance of genetic enhancement research and its role in ensuring force health protection.

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