# Laridae

## SALISBURY UNIVERSITY

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Salisbury University
Office of Undergraduate Research and Creative Activity (OURCA)

Make Tomorrow Yours

## EMBRACING THE RICH CULTURE OF SRI LANKA

Piumy Rajapaksha

(Featured on the cover and above)


### ABSTRACT

My work is inspired by Sri Lanka, "The Pearl of the Indian Ocean." I incorporate the essence of my home country in most of my designs. The vivid colors of my artwork symbolize our diverse heritage and traditions. It brings me great pleasure to share my culture with others and use my art to represent who I am.

Illustrated in Photoshop, "Ceylon Blue Magpie" (on the cover) represents one of the most colorful endemic birds of Sri Lanka. The bird is a treat for the eye, with bright colors of blue and red inhabiting the hills' forests in Sri Lanka's wet zones. The idea behind the artwork is to celebrate the natural beauty of this species.

"Glorifying Sri Lankan Wooden Art" depicts one of the most notable aspects of Sri Lankan culture, wooden masks. The masks are inspired by the island and its ancient Buddhist culture. Historically, these masks are used in traditional dance performances, rituals, and ceremonies to ward off evils. Illustrated in Photoshop, my artwork portrays the colorful "Mayura Raksha" demon mask symbolic of prosperity, harmony, and peace

In both of my digital artworks, the selection of the subject and the colors were picked carefully, complimenting, and celebrating the rich culture of Sri Lanka.



### ACKNOWLEDGMENTS

Thank you to Professor Edgar Reyes, the graphic design lecturer, for providing effective feedback and guidance in encouraging the development of creative works sensitive to Sri Lankan cultural aesthetics. His helpful assistance and the input given by peers made the pieces a success. This work was created at The Universities at Shady Grove satellite campus, with the opportunity given by Salisbury University.

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# Letter from the Editor-in-Chief

*Laridae* began as an opportunity for Salisbury University students to showcase their academic work, and we have continued to curate a robust set of articles and creative works that demonstrate some of the best of what SU students have to offer. The journal hosts works from across disciplines within our larger categories of sciences, arts and humanities, social sciences, and interdisciplinary. We received 31 original submissions and accepted 13 articles and four creative works for our fourth edition.

The success of *Laridae* depends upon the contribution of so many individuals who work through the summer to create the journal you see before you. The support of the Office of Undergraduate Research and Creative Activity (OURCA) Director Dr. Rhyannon Bemis, our faculty reviewers, student editorial staff, and, of course, our authors are essential for the creation of this journal. Beyond that, the broader support of the SU community and our readers allows us to continue our work and bring you new editions each year.

In each edition, *Laridae* has continued to grow and accomplish its mission in new ways. For the first time, this edition begins with our science section highlighting the incredible research in topics like mRNA vaccines and genetic mutations that contribute to hearing loss. In addition to our sciences, we have articles and creative works on topics ranging from policies on biodiversity, to money laundering, and to the 1990s sitcom *Full House*. I invite you to get lost in reading the works of our talented authors, to explore a discipline or topic you have never considered before, and, above all, to keep learning.

I look forward to seeing how *Laridae* continues to evolve in its fifth edition under the helm of our next editor-in-chief Elizabeth Wash.

**Haley Taylor**
Editor-in-Chief

# Letter from the Future Editor-in-Chief

The growth of *Laridae* is unmatched, and I am overjoyed to be a part of this journey. I began as an editor of the Science Sections, moved to Managing Editor, and will be the Future Editor-in-Chief, and I am forever grateful for this experience.

*Laridae* is remarkable, providing a chance for undergraduate students to publish their academic work. As an undergraduate researcher, I understand the importance of a publication like this and how it changes one from being a student to becoming a true academic, an opportunity unique to the Salisbury University community.

It is because of the hard work and dedication of the diligent students, dedicated faculty, and brilliant editors that this journal has become what it is today. With that, I invite you to explore the fourth edition of *Laridae*, featuring 13 articles and four creative works in disciplines ranging from biochemistry to an analysis of *Full House*.

*Laridae* continues to represent our undergraduate student's desire for knowledge and exploration, and I hope to continue this legacy of providing a platform to share their research and contribute to SU as the next editor-in-chief.

Please enjoy our fourth edition and challenge yourself to learn something new, challenge preconceived thoughts, and dare to inquire.

**Elizabeth Wash**
Future Editor-In-Chief

# The COVID Era of mRNA Vaccines

*Drew Wagner and Aerin Rost-Nasshan*

**ABSTRACT**

Public awareness of mRNA, messenger RNA, vaccines has increased significantly since the beginning of the COVID-19 pandemic. However, the history and science behind them has been less discussed. This review addresses the evolution from inoculating oneself to smallpox scabs to sophisticated manipulation of genetic material. Moreover, it discusses the history of vaccination, especially mRNA vaccines along with how the vaccines interact with the human body. It also discusses the components of the SARS-COV-2 vaccine and how recent scientific breakthroughs have made the new mRNA vaccines possible. Additionally, the paper includes information about the vaccine delivery system used and specifics about the SARS-COV-2 vaccine.

## HISTORY OF VACCINATION AND THE MRNA VACCINE

Primitive forms of immunization date as far back as 17th century China where Buddhist monks used small doses of snake venom to become immune to the toxicity.[1] This idea, known as attenuation, fueled early attempts at disease prevention. The notable practice of variolation arose to provide protection against certain deadly diseases, such as smallpox. Variolation, which is the artificial infection with dried scabs from milder cases of smallpox, conferred less severe symptoms for the patient than a natural infection.[2] Then, in 1798, Edward Jenner, considered the father of vaccinology, inoculated his son with cowpox virus to confer smallpox immunity, resulting not only in the boy's full recovery, but also immunity to smallpox.[3] This attempt reinforced the idea that attenuated, or weakened, virus strains could be used to protect humans from disease. Early inoculations, like Edward Jenner's, used powdered smallpox scabs, while later injections of viral materials into the bloodstream were more common.[4] Fast forward a century and scientists started using mRNA vaccines, and therefore genetic material, to introduce vaccines directly into the cells.[5]

In 1991, researchers developed the first mRNA-based vaccine and found it to prevent influenza in mice.[5] Live attenuated vaccines (LAV) were, at the time, still favored and utilized a weakened form of a virus, which is inoculated into the body, with the hope of the body being able to later recognize the invader and mount an immune response.[4,6] However, LAVs are prone to viral mutations, causing disease in people with underlying health conditions.[7] To prevent this, in 1993, Katalin Kariko suggested the use of mRNA to help fight against viruses.[8] Since mRNA in vaccines functions in the cytoplasm of the cell, it never interacts with the nucleus[9,10] and therefore cannot impact genetics, unlike LAVs.

mRNA vaccines themselves have undergone several clinical trials, providing evidence for the safety and efficacy of the technology. Vaccines that use the mRNA delivery system are typically more effective than vaccines with other delivery methods, such as conventional LAV or vector-based delivery systems, which put genetic information for the antigen of interest into a harmless virus for delivery. mRNA vaccines also have a decreased likelihood of causing anti-vector immunity and genetic transformation.[11] One of the most notable trials of the mRNA vaccines occurred in 2013, for the H10N8 and H7N9 (bird) flu viruses. The purpose of this trial was to show the effectiveness of preventing severe illness from influenza. According to the study, 89% of participants who received a treatment dose elicited an active antibody response to the virus.[12]

The main issue for mRNA-based vaccines is that mRNA is highly susceptible to degradation, creating transportation and storage challenges. Such challenges prevented mRNA vaccines from becoming more widely used, at least prior to the COVID-19 pandemic. LAVs are still the primary form of vaccine as the technology is more widely understood and they are easier to store. Lipid nanoparticles (LNPs) have been developed to address these limitations. LNPs encapsulate the mRNA in a ball of lipid molecules, protecting it from environmental degradation and from nucleases, which are ubiquitous enzymes able to break the bonds in nucleic acids including DNA and RNA, and destroy them in unprotected environments. Furthermore, LNPs can be altered to target specific tissues or parts of the cell, which in turn allows them to be more versatile for vaccine use.[1]

The SARS-COV-2 mRNA vaccines were developed quickly and efficiently. Before 2020, vaccine development took typically 10-15 years with the mumps vaccine being the quickest on record with a five-year development time.[13] Many countries and labs had collaborations that allowed the SARS-COV-2 vaccine to be produced at record speeds. Previous RNA vaccine work laid the perfect foundation for responding to the pandemic. As of August 2020, over 200 different anti-COVID vaccine candidates were in various stages of development, including over 30 that were already in clinical trials.[13] Once the vaccines had made their way through clinical trials and were approved by various health agencies, including the FDA, the next step was determining a way to mass produce and transport the vaccine.

## THE INNATE AND ADAPTIVE IMMUNE SYSTEM

To begin understanding how vaccines work, one must first understand how the human immune system works, particularly when fighting off disease. The immune system is a series of many responses amongst immune cells that target foreign substances in the human body.[14] A critical aspect of the immune system is the body's ability to distinguish self from non-self.[15] This recognition is achieved by characteristic receptors present on the surface of immune cells that are shaped for various pathogen-associated molecular patterns (PAMPs). PAMPs, in the simplest terms, are markers to help the cell differentiate "good" cells from "bad" cells. Binding of the PAMP and receptor alerts the immune system to target and destroy the invader.[16]

The immune system can be divided into two categories, innate and adaptive systems. The innate immune system provides general protection for the body. In addition, the innate immune system is responsible for inflammation and heat caused by cells traveling to the site of initial infection and beginning to destroy the foreign biomolecules. The adaptive immune system provides more specific protection by identifying and targeting foreign material. It is composed of T cells and B cells which lead to the specific response and immune system memory.[14,15] The memory system is the basis for vaccine efficacy.[14]

T cells are both the basis of cellular immunity and the initiator of the humoral immunity response. The helper T cell stimulates the memory aspect of acquired immunity, which are B cells. These B cells are important in humoral immunity because they initiate the production of antibodies which are crucial for identifying and recruiting other immune cells that will eliminate the pathogen.[17] Moreover, nearby lymph nodes that are at the site of injection can contribute to the production of antibodies and

leukocytes.[18] Some common side effects of the vaccine are injection site pain, redness swelling, fever, malaise, and headache. These side effects are reflective of the immune system activity, which is necessary for appropriate and successful vaccine-induced protection.[14]

## TECHNICAL ASPECTS OF MRNA IN VACCINES

Many of the technical aspects of mRNA in these vaccines mimic natural mRNA functions within the body. In eukaryotes such as humans, DNA remains in the nucleus of the cell and contains the instructions for making all proteins and other gene products, as well as information regulating their production. The central dogma of molecular biology explains that for a protein to be synthesized, the DNA is first transcribed into messenger RNA (mRNA). This process is analogous to rewriting a sentence in the same language but phrased differently. The mRNA leaves the nucleus and enters the cytoplasm, where molecules of tRNA and ribosomes follow the code to build a protein, in a process called translation.[19] Using the example from above, translation is synonymous to rewriting a sentence in a different language.

Viral particles are typically composed of only proteins and either DNA or RNA to direct the synthesis and assembly of additional viral particles. After entering a human cell, RNA-based retroviruses, such as SARS-CoV-2, use enzymes for reverse transcription to copy their mRNA into the human genome[20]. Following the analogy used previously, this would be like the virus rephrasing a sentence into a format that the human cell will understand, tricking the cell into thinking that the viral code is meant to be there. The human cell then transcribes what had been viral RNA into mRNA, which the cell translates into viral proteins, producing the infection.

mRNA vaccines deliver mRNA sequences for parts of specific viral proteins to the cytoplasm of human cells. The cytoplasmic ribosomes translate the mRNA into protein fragments, which trains the immune system in recognizing the protein, and therefore the virus. There is no danger of infection, as the entire virus is never produced within the body. Furthermore, despite the human genome possessing the possibility of integrating foreign retroviral RNAs through the LINE1 gene, the 3′ terminal of the vaccine differs from the 3′ UTR present on natural retroviral genomes. This means that while the LINE1 gene can integrate foreign DNA into the human genome, the part of the virus that the LINE1 gene would recognize is not on the vaccine. Therefore, genetic integration is extremely unlikely due to the disconnect between the host's and the vaccine's genetic codes.[20]

In summary, messenger RNA is a single stranded molecule that transports genetic information from the nucleus to the ribosome in the cytoplasm to make proteins.[19] By manipulating the structural variables of mRNA and simultaneously applying natural laws of protein synthesis, the production of an immune targeted mRNA vaccine is plausible. In contrast to DNA vaccines, mRNA vaccines are generally much safer and elicit a predictable immune response.[21] However, many factors contribute to the instability of mRNA, such as the presence of ribose sugar, which is susceptible to hydrolysis and to degradation by RNases in the body.[22] All current mRNA vaccines contain one or more structural modifications of mRNA to improve stability and/or translation efficiency (Figure 1).[23]

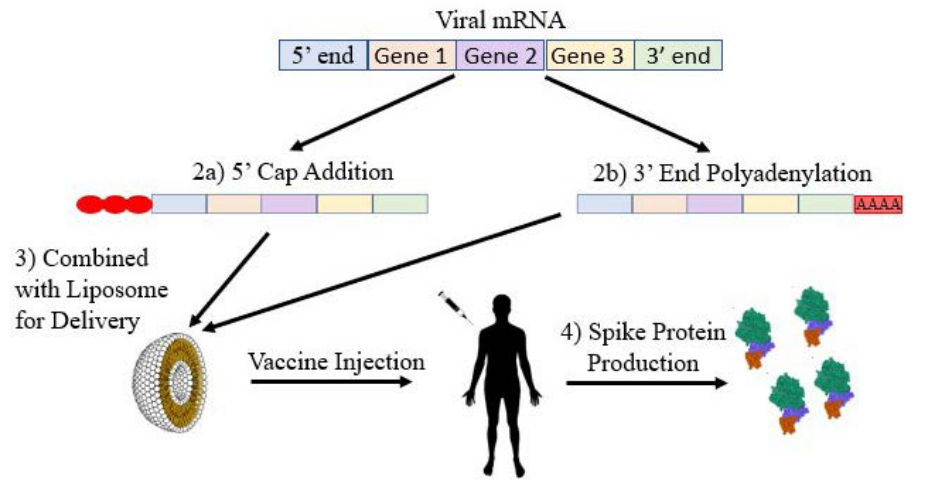


Figure 1: Structural modification and translation of mRNA vaccines. The transcription of mRNA for the vaccines occurs in vitro using a cDNA template and gets stabilized through either adding a 5′ cap (2a) or polyadenylation (2b). This processed and stabilized RNA is transferred into the host cell via a liposome (3) where the functional mRNA is translated into antigenic spike proteins (4).

Companies producing mRNA vaccines have many quality-control checkpoints to ensure the highest standard of mRNA and vaccines possible.[24] The vaccine is made with mRNA that encodes the spike protein, which is only one of the 29 proteins that make up the SARS-COV-2 viral particles. The spike protein is what allows the viral particles to bind and fuse with human cells.[25] Spike protein DNA is isolated and placed in a plasmid followed by the insertion into *Escherichia coli*.[26] The ***E. coli*** is used to produce many copies of the DNA, which can then be extracted, converted to mRNA, and used for vaccine manufacturing.[24]

A few useful modifications for vaccine manufacturing include 5′ cap and 3′ tail alterations. The 5′ cap is a highly regulated feature of eukaryotic mRNA and has a variety of functions. Cap modifications identify the mRNA as "self" rather than foreign and modulate both stability and translation.[22] This is especially important for mRNA vaccines derived from a foreign genome, like a virus. Without a recognizable 5′ cap, RNases readily degrade mRNA and prevent the desired translation of the viral antigen. The poly-A tail is another innate structure that protects mRNA from degradation.[23] Given the immense susceptibility on many fronts, the half-life of unprotected and unmodified mRNA ranges from minutes to hours.[27]

Polyadenylation is the process by which additional adenine bases are added to the 3′ end of the mRNA, and a longer poly-A tail corresponds to an increase in stability and higher levels of protein expression. The poly-A tail assists in the conservation of the nucleotide sequence, maintaining identical mRNA molecules.[28] The structural modifications of mRNA included in vaccines employ the body's own defenses to mount a strong protection against viral infection.

mRNA degrades more rapidly than DNA, meaning that the shelf-life, transportation, and the storage of the vaccines becomes a greater concern. The liposomes degrade, meaning that storage capability then also becomes a competitive aspect between manufacturers. The temperature at which the vaccines need to be frozen, as well as how long the vaccines can sit at refrigerator and at room temperature can determine where and how they can be handled. As of December 2020, Moderna could be stored at -20°C (a common industrial freezer temperature) for up to six months, whereas Pfizer-BioNTech must be stored between -60 and -80°C. Consequently, there are more places, both within the United States and internationally, that have the ability to store the Moderna vaccines. Additionally, Moderna can be stored at refrigerator and room temperature longer than Pfizer-BioNTech. Pfizer-BioNTech, however, has a smaller dosage requirement and therefore one bottle can serve more people.[21]

## SPECIFICS ABOUT MRNA IN SARS-COV-2 VACCINES

In addition to mRNA and lipids, other ingredients are included in the vaccine to assist with its stability. Pfizer –BioNTech vaccine for ages 12 and older contains salts that all help balance the acidity in the human body while sugar helps the molecules in the vaccine maintain their shape while freezing.[29]

The Pfizer-BioNTech vaccine for those ages 5- 11 contains sucrose, tromethamine, and tromethamine hydrochloride.[29] The tromethamine and tromethamine hydrochloride are acid stabilizers commonly used as a buffer in medication.[30] The Moderna vaccine contains all three of those ingredients as well as sodium acetate and acetic acid.[31] The acetic acid is commonly found in vinegar whereas sodium acetate is a salt,[31] and both are used to stabilize the vaccine while it is being stored at a pH between 6.9 and 7.9.[32]

The ultimate goal for these companies and their suppliers is to provide a method that mass produces the antigen needed for a bodily reaction, while ensuring the most affordable yet safe vaccine for the public. For mRNA vaccines, the DNA sequence of interest must be amplified or linearized for proper in vitro transcription. For the SARS-COV-2 vaccine, this DNA sequence is derived from the spike protein that is conserved through many variants. Additional ingredients for the conversion to mRNA include RNA polymerase, cofactors, pH buffers, and nucleotide triphosphates that act as building blocks for the preliminary mRNA strand. After the desired product is constructed, it must be purified to exhibit the safest and most effective form of the antigen to reside in the vaccine. The removal of excess DNA from the desired mixture includes DNase digestion paired with lithium chloride precipitation. Furthermore, truncated, or dysfunctional, mRNA products are effectively removed via reverse phase HLPC and other chromatography techniques. For global and national delivery, new bulk processes are being explored to cut costs and increase production efficiency to support another pandemic if it were to arise. One technique involves preserving the mRNA product while impurities are filtered out which then acts to resolubilize the mRNA. Continuous manufacturing is another technique that is already common to help reduce operational times. Despite the plethora of techniques, many issues arise in the techniques' ability to consistently remove all unnecessary products, instead of just effectively eliminating specific impurities.[33]

## THE MRNA VACCINE IN THE BODY

The Moderna vaccine uses mRNA which encodes the S-2P antigen,[34] which is the major surface protein of the virus, and it allows the viral particles to enter cells by binding to the angiotensin-converting enzyme 2, or ACE2 receptor. This area of infiltration is crucial due to the prevalence of ACE2 receptors in the lungs, contributing to the upper respiratory symptoms present during ID-19 infection. The S-2P antigen is immunogenic, or able to elicit an immune response in the body, which indicates to the immune system that the antigen must be neutralized.[35]

## THE LIPOSOME DELIVERY SYSTEM

Liposomes are composed of phospholipid bilayers, which closely resemble the complex structure of cell membranes. Because of the ability of liposomes to encapsulate hydrophilic molecules, they are being studied as drug delivery systems. Liposomes provide protection and transportation due to their stability in the blood since their membranes consist of long chain phospholipids. The liposome, which encapsulates mRNA, is a cationic lipid nanoparticle with its cationic side interacting with the mRNA (Figure 2).[36] The nucleic acid's negative charge removes its ability to pass through the cellular lipid bilayer; however, the cationic charge of the nanoparticles helps neutralize the charge interactions and allows the vaccine to travel into the cell. These lipid nanoparticles are amphiphilic and are composed of polyethylene glycol-lipid conjugates (PEG), which has been proven to improve circulation times for encapsulated drugs by decreasing phagocytosis through the renal filtration system.[36] With the COVID vaccine, the mRNA molecule is required to be absorbed by the cells, then escape through the endosome so that the proteins that it encodes can be expressed and the protection the lipids provide allow this process to occur.[11]

Despite the variety of systems, all mechanisms involve a degree of uniformity in the protection of the target drug within the membrane while also providing non-toxic, stable long-term circulation in the blood.[37] For the COVID-19 vaccine specifically, protection and integration of the S protein within the liposome are key variables that are controlled through encapsulation and the liposome's ability to target immune cells. Antigen presenting cells readily process its contents and allow for recognition of antigens via immune cells, leading to a proliferation of memory cells that can quickly produce antibodies in response to infection.[38]

This type of vaccine faced many challenges, including finding a way to prevent RNA degradation.[8] Strands of mRNA are highly susceptible to degradation, especially in the presence of human enzymes. This made mRNA difficult to work with and produce for large scale vaccine distribution. Another struggle with mRNA vaccines was determining a delivery mechanism that would allow the vaccine to be effective before being degraded in the body. This problem was addressed using synthetic delivery vessels, such as liposomes.[8]

## EFFECTIVENESS OF VACCINES

The vaccine process allows it to closely mimic a natural infection by artificially provoking the B cells in the adaptive immune system.[25] A clinical study from the NIH, where vaccine effectiveness was quantified, revealed that seven days following injection of the second dose, the Pfizer mRNA vaccine is 86.1% effective and the Moderna mRNA vaccine is 93.3% effective in preventing onset infection.[39] In another study, 110 recipients who received either version of the mRNA vaccine produced three orders of magnitude increase in anti-SARS-CoV-2 receptor binding domain (RBD) IgG. The number of RBD IgGs increased even further after receiving a second dose, showing that both vaccines are effective against SARS-COV-2.[40]

While research is still being conducted, there is already enough evidence confirming that mRNA vaccines such as Pfizer and Moderna provide some protection against viral variants, mostly in preventing the occurrence of severe cases. Each variant is identified by the mutations found in the DNA encoding the spike protein and how that affects the protein's function.[41] For example, the Pfizer/BioNTech vaccine provided 93.7% protection from the alpha variant and 88% protection from the delta variant following a standard two dose vaccine protocol.[42] Furthermore, receiving a booster shot was 93% effective in preventing hospital admissions, 92% effective against severe COVID cases and 81% effective in preventing overall death.[43] Despite this initial protection against variants with close familial ties to the original virus, future variants might prove to evade outdated vaccinations as mutations continue to occur. Laboratory data indicates that variants with

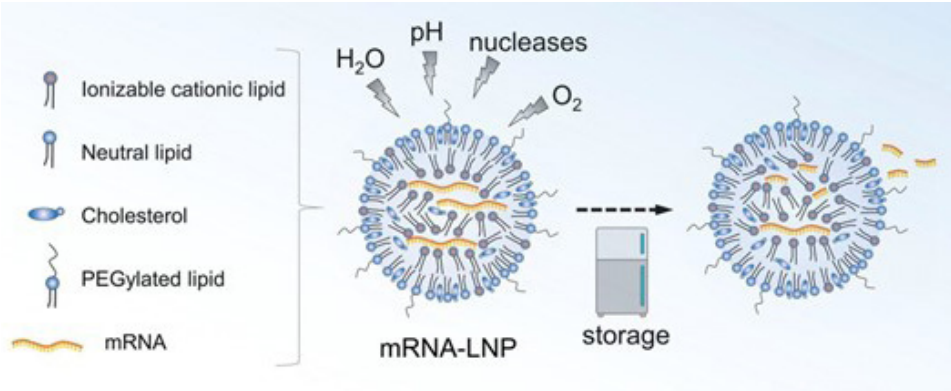


Figure 2. Liposome nanoparticles (LNPs) injected with mRNA. LNPs are composed of various lipids, often including phospholipids, cholesterol, ionic lipids, and polyethylene glycol-conjugated lipids, which form an aqueous center in which the charged mRNA molecules are located. Figure taken from (21).

mutations can lead to a reduced antibody response for those with the original vaccines; however, this can be corrected with an updated booster dose.[41]

A main concern facing the SARS-COV-2 vaccine was the notion that it negatively affects fertility and the health of a fetus. Despite this claim, studies have shown that there is no plausible evidence for the disruption of pregnancy or the ability to become pregnant. One research study showed that the COVID-19 vaccine did not cause any effect on the fertility rate among female mice. Fertility rate was 43/44 for the non-vaccinated group, while the fertility rate for the vaccinated group was 42/44. The pups' overall health was excellent in both groups, with no difference in physical observations and body weights. Thus, it is possible to conclude that COVID 19 mRNA vaccine is safe for pregnant women and does not affect the overall health of the fetus.[44] Sperm count reductions related to both the vaccine and the virus have been observed; however, the vaccine-related reduction has been observed to be temporary and is in line with known immune responses while the virus-related reduction is still being investigated.[45]

## CONCLUSION

mRNA vaccines train the body on how a new virus appears and behaves, without allowing any significant portion of the virus to enter. However, recent advancements have made it possible to use non-amplifying mRNA for vaccines against cancer, allergies, and gene therapy.[8] The cost to produce mRNA vaccines is low and they are fast to make. Another benefit is that mRNA can be moderated and is degraded by cellular processes already present or active in the body.[16] As with any foreign substance being introduced into the body, it has been discovered that rare allergic reactions leading to anaphylaxis may come from the LNPs-based mRNA vaccine for COVID-19. It is suspected by researchers that the very few anaphylactic responses to the vaccine may be due to the polyethylene glycol (PEG) component of the LNPs.[46] Despite the potential reaction, there are many benefits, including that manufacturing a booster for new SARS-COV-2 variants is a process that will take weeks to months, far faster than traditional vaccines technology.

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# Identifying the Genetic Mutation in a Female Presenting with Mild-to-Moderate Hearing Loss

*Margaret Giggey*

**ABSTRACT**

Genetic hearing loss and deafness can be caused by mutations in at least 152 different genes. These hearing-related genes can be categorized based on patterns of inheritance, syndromic or non-syndromic deafness, degree of severity, onset of hearing loss, and progression of loss. OtoSCOPE® genetic testing identified deletions on chromosome 15 within the *STRC* and/or *CATSPER2* genes in a female presenting with a congenital autosomal recessive mild-to-moderate sensorineural hearing loss. We aim to characterize the precise location and length of the DNA deletion, using Polymerase Chain Reaction (PCR) amplification, gel electrophoresis, and DNA sequencing. PCR primers were designed to exclude amplification of the nearby *STRC* and *CATSPER2* pseudogenes that contain nearly identical DNA sequences but do not encode functional proteins. Results indicate a deletion extending at least 85,000 base pairs at the *STRC* and *CATSPER2* loci. Results were compared against a human DNA control and reference sequences in the National Center for Biotechnology Information (NCBI) database.

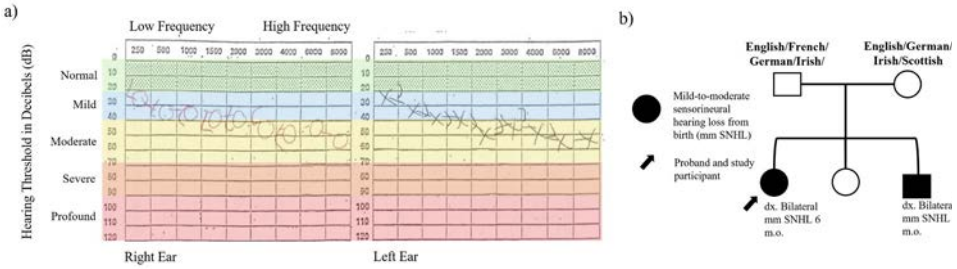
## INTRODUCTION

Genetic hearing loss can be caused by at least 152 genes each displaying different hearing losses, clinical presentations, and inheritance patterns (Molecular Otolaryngology and Renal Research Laboratories, 2020; U.S. National Library of Medicine, 2020). Fifty to sixty percent of hearing loss is genetic and 75-80% of this loss is attributed to an autosomal recessive pattern of inheritance (Vona et al., 2015) where two parents must each carry and pass on one copy of the defective gene for a child to inherit it. Presented in this experiment is a female 22 years of age with a pre-lingual autosomal recessive mild-to-moderate sensorineural hearing loss that is stable and down sloping as seen in Figure 1. A deletion mutation has been identified within the *STRC-CATSPER2* gene regions by OtoSCOPE® genetic testing which is a panel that screens for 224 different hearing genes and loci (U.S. National Library of Medicine, 2020; Molecular Otolaryngology and Renal Research Laboratories, 2020). **We aim to characterize the precise location and length of the DNA deletion, using Polymerase Chain Reaction (PCR) amplification, gel electrophoresis, and DNA sequencing.**

*STRC* deletions are the second most common cause of autosomal recessive non-syndromic hearing loss (NSHL), occurring as a homozygous deletion in 1.7% of the total hearing loss population and 4.3% among those with mild-to-moderate hearing loss (Yokota et al., 2019). The gene itself is located on the long arm (q) of chromosome 15 at the fifteenth band – 15q15.3 – and is commonly referred to as the DFNB16 locus, or deafness (DFN) autosomal recessive (B) locus (Moteki et al., 2016). The *STRC* gene codes for stereocilin – a structural protein in the inner ear–and is responsible for keeping adjacent hair cells bundled together and moving in tandem to transduce mechanical movement into an electrical signal for sound in the brain (Avan et al., 2019). Variations in the gene include whole gene deletions, partial deletions/ multi-exon deletions, nonsense mutations, and single nucleotide variations that render the coding region non-functional and the protein absent from the inner ear (Mandelker et al., 2014). Without intact hair cells, sound does not reach the brain and leads to difficulty hearing at certain frequencies. Amplification of the sound is needed in order for it to be perceived as loud enough.

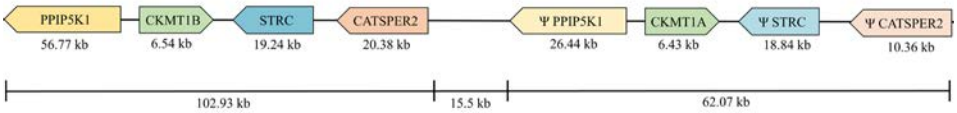
Deletions in *STRC* often include a second nearby gene, *CATSPER2*–which is the case in our female participant. This represents a contiguous, or two gene, partial or complete deletion (Avidan et al., 2003; Morgan et al., 2020; Zhang et al., 2006). *CATSPER2* is located on chromosome 15 upstream from *STRC* at the same 15q15.3 location and codes for a subunit in voltage-gated calcium channels responsible for sperm motility (Avidan et al., 2003). Females with a complete *STRC-CATSPER2* deletion have hearing loss at the DFNB16 locus, while males are diagnosed with hearing loss and

**Figure 1:** *Characteristics of the Participant*




Note. a) O and X represents the right and left ear respectively. The threshold of hearing is indicated by the connected X's and O's and lies within the mild (blue) to moderate (yellow) range at 20-55 decibels. The threshold is down sloping with a greater hearing loss at higher frequencies. Noises above the threshold line are difficult to hear. b) Autosomal recessive pattern of inheritance. Original pedigree was modified because no other family members had hearing loss. Squares represent males and circles represent females. The participant is the first in the family to have hearing loss.

**Figure 2:** *The Location of Interest is Near Pseudogenes*



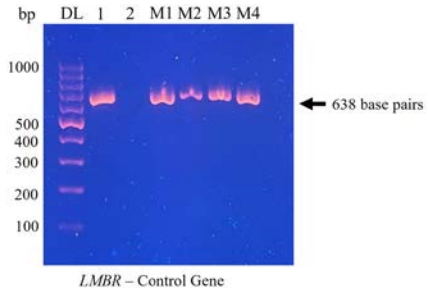

Note. Ψ indicates the pseudogene. A duplication exists about 100 kilo bases upstream from *PPIP5K1*, includes our location of interest, and makes DNA amplification difficult due to the similarities of the sequences. *STRC* alone is about 98.6% homologous to Ψ *STRC*.

infertility which is known as Deafness Infertility Syndrome (DIS) (Hildebrand et al., 2009). Females do not express the sperm channels because there is no need for them. Males with DIS cannot fertilize the egg and have a child unless it is through intracytoplasmic sperm injection (ICSI), which is another form of in vitro fertilization (IVF) where the sperm gets manually inserted into the egg.

Chromosome 15 has a segmental duplication that includes 5 functional genes – *PPIP5K1, CKMT1B, STRC, CATSPER2,* and *CKMT1A* – and three pseudogenes – Ψ *PPIP5K1,* Ψ *STRC,* and Ψ *CATSPER2* (Nishio et al., 2022; Zhang et al., 2007). Pseudogenes are defunct DNA sequences with similarity to coding genes that can cause misalignment of sequence reads and lead to false positive or false negative variant calls (Mandelker et al., 2014). The human genome is full of these repeated sequences from many different genes. The presence of the pseudogenes and the *CKMT1* paralog, *CKMT1A,* located upstream of the *STRC-CATSPER2* locus as seen in Figure 2 makes isolating these genes difficult, but not impossible. The *STRC* gene and pseudogene are almost 99% identical in the first half of the sequences and only differ by 56 nucleotides in the second half (Zhang et al., 2006; Shi et al., 2019); *CKMT1B* and *CKMT1A* are nearly identical with only two significant mismatches in the coding sequence (Zhang et al., 2007); and *PPIP5K1* and its pseudogene are highly conserved but differ significantly in sequence length with a 54% alignment in the first half of the sequences (NCBI BLAST). Ψ *CATSPER2* has a similar pattern to *PPIP5K1* with a 95% similarity and an alignment of 50% to *CATSPER2* (NCBI BLAST). This phenomenon is likely due to subsequent mutations, error, selection, and evolution over millions of years.

To combat the possibility of amplifying the pseudogenes, we created primers to exclude the defunct copies and only target the genes of interest–*STRC* and *CATSPER2*–and the locations around them. One primer pair in *STRC* from Vona et al. (2015) and one created based off of one from the Iowa MORL laboratories have proven successful for differentiation between the gene and pseudogene and will be used in the experiment. Furthermore, the absence of a band in the gel for a primer pair between *STRC* and *CATSPER2* can be used to confirm a deletion within the *STRC-CATSPER2* region (Avidan et al., 2003; Zhang et al., 2006).

**Figure 3:** *LMBR Control*




Note. DL is the DNA ladder, 1 is the human DNA control, and 2 is the negative control. M1-4 are DNA extraction methods for the participant: (M1) InstaGene™ Matrix, (M2) NucleoSpin® Blood QuickPure Mini Kit, (M3) prepIT®·L2P, and (M4) prepIT®·L2P + proteinase K. The amplicon is 638 base pairs.

## METHODS

### *Human subject approval*

Protocol #24 as approved by the Salisbury Institutional Review Board on Human Subjects Research (IRB) for the Fall 2021 to Spring 2022 semester. The sample size included a single female participant, age 21, chosen based on an audiogram showing mild-to-moderate hearing loss and a pedigree indicating the pattern of inheritance and genetic origin (Figure 1). Participation was voluntary and an Informed Consent was signed.

### *OtoSCOPE® genetic testing*

The participant had already signed an Informed Consent and sent her sample to the University of Iowa's Molecular Otolaryngology and Renal Research Laboratories (MORL) for OtoSCOPE® genetic testing for gene identification. The saliva sample was sent using Oragene·Discover (OGR-500) Saliva Collection (DNAgenotek) following the 1-5 step visual instructions. The same saliva collection tube method was used in the experiment.

### *Saliva Collection and DNA extraction*

An Oragene·Discover (OGR-500) Saliva Collection kit from DNAgenotek was used to obtain a sample from the participant in a sterile environment following the detailed visual instructions. An alternative method of saliva collection with PBS 1x (phosphate-buffered saline; 137 mM NaCl, 2.7 mM KCL, 10 mM $Na_2HPO_4$, 1.8 mM $KH_2PO_4$) was also used. DNA was then extracted using three different methods and protocols: InstaGene™ Matrix (adapted for saliva use), NucleoSpin® Blood QuickPure Mini Kit (adapted for saliva use), and prepIT®·L2P.

InstaGene™ matrix (BioRad) DNA Preparation from Whole Blood and Protocol 5 – Protocol of DNA extraction from whole saliva with InstaGene™ Matrix was adapted for saliva use (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5393535). Instead of using whole blood, 1.5 mL of saliva sample was used, and the sample was placed in a 4°C ice bath before each centrifuge. The tube was centrifuged at 10,000 g for 5 minutes and the supernatant was discarded. Physiological saline was added, and the tube was vortexed until the pellet dissolved. These steps were repeated two more times with physiological saline to increase yield of DNA and decrease impurities. InstaGene™ Matrix 200 µL was added to the pellet, vortexed, incubated at 56°C for 30 minutes, and then boiled at 100°C for 10 minutes. A final vortex and 13,000 g centrifuge for 5 minutes was completed. The supernatant containing the DNA was transferred for use in PCR.

**Table 1:** *Primer Pairs Used for PCR*

| Number | | Sequence (5'-3') | Product Size | Location |
|---|---|---|---|---|
| C | CF | AGGGTAGATAGAACTCCCAGAGAT | 638 | *LMBR* |
| | CR | CCGAGCCCGCATTTTAGAGA | | |
| 1 | 1F | CAACTTTGCATAGAAATGGCTTCAG | 904 | Downstream within *PPIP5K1* Intron 30 |
| | 1R | AGTAAGCAGGGTGTTAGTGGTAA | | |
| 2 | 2F | ACTTTTGTGTCTTTGTGGATTGCCT | 257 | Downstream within *PPIP5K1* Exon 30 |
| | 2R | ACAGGGTTTGAAGGGTGTTCC | | |
| 3 | 3F | CGTGGCTTTTGGAGTGTTGG | 501 | Downstream within *PPIP5K1* Intron 29 |
| | 3R | TCCCATCCCCATCCTGTTCA | | |
| 4 | 4F | ACAATGAAGCACACCACGGA | 1362 | Downstream within *CKMT1B* Exon 4/5/6 |
| | 4R | TTTGCACTCTCTGTCAACAGCC | | |
| 5 | 5F | CGTTACTCTTCCCAGGACCAC | 618 | Downstream within *CKMT1B* Intron 5 |
| | 5R | TCATTTATTCCTTCTTTGCACTCTC | | |
| 6 | 6F | CCTACATGGATTGGGTCTCCG | 431 | Downstream within *CKMT1B* Intron 7 |
| | 6R | ATAGTTCAGAAGGAACCATGCCATA | | |
| 7* | 7F | TATTTAAACACCCTCAGGCCCC* | 422 | Within *STRC* Exon 26 |
| | 7R | TGCTGAGGTAAAGGTGGACTTAC* | | |
| 8* | 8F | TCTGTGGGATGGGTGTTTGG* | 268 | Within *STRC* Exon 24 |
| | 8R | ACCCAGCAGTATGACTCCCA* | | |
| ** | 9F | CCTCTGATTTCGGGTAAAAGG** | 267 (gene) 264 (pseudo) | Within *STRC* Intron 18 |
| | 9R | GAAATTCGAGACCACCCTGA** | | |
| 10 | 10F | CCTTGAACAGTTACCCAACCAGT | 217 | Between *STRC* and *CATSPER2* |
| | 10R | AAACTTCTTGGGGTCACCAGAC | | |
| 11 | 11F | GCAAGAGCCTACCTTGTCCT | 212 | Within *CATSPER2* Intron 12 |
| | 11R | TGCCTACAACTAAAATAGGCAGAA | | |
| 12 | 12F | TAAACCAGCAACTAAACCTCCCC | 248 | Within *CATSPER2* Exon 2 |
| | 12R | GACATGGCCGCTTACCAACA | | |
| 13 | 12F | TAAACCAGCAACTAAACCTCCCC | 102 | Within *CATSPER2* Exon 2 Amplicon 12 |
| | 13R | GGTCAGCAGCCTATTTCTTCAC | | |
| 14 | 14F | ACTCCAACACTCCTTCGGG | 113 | Within *CATSPER2* Exon 1 |
| | 14R | GAGGCGGAAGCGTGAAATA | | |
| 15 | 15F | TGGATTTACCCTGAGGTACTGTTAG | 473 | Upstream *CATSPER2* |
| | 15R | AGGCTAAGAAGCGAAGACCTG | | |
| 16 | 16F | ATCCCAGTAGAGTAAGCACCAA | 249 | Upstream *CATSPER2* |
| | 16R | CCCTCCAGTTTGCGTCCG | | |
| 17 | 17F | TAGAAAGGCAAGGGCTACCG | 744 | Upstream within Ψ*PPIP5K1* |
| | 17R | GACATAGTGGTCTGCGCTGG | | |
| 18 | 18F | GTCAGAACTGGCCGAAGCAT | 884 | Upstream within *CKMT1A* Exon 5 |
| | 18R | TTTGCATTACCTGCCTTCTTCACTT | | |
| 19 | 19F | GTGAAGAAGGCAGGTAATGCAAAGA | 714 | Upstream within *CKMT1A* Intron 7 |
| | 19R | GGGGGAAACTCTTCCATCCAG | | |
| 20 | 20F | CTAACCTGGGCACTGGACTT | 881 | Upstream within *CKMT1A* Exon 9 |
| | 20R | GAAGGACACTAATCTTTGATCTCTG | | |

Primer pair inspired by Iowa MORL *STRC* detection protocol
*Primer pair from Vona et al. 2015

A NanoDrop™ spectrophotometer was used to determine purity.

NucleoSpin® Blood QuickPure Mini Kit DNA Purification from Whole Blood was adapted for saliva use. A cell pellet was created from the saliva sample and resuspended in PBS 1x (phosphate-buffered saline; 137 mM NaCl, 2.7 mM KCL, 10 mM $Na_2HPO_4$, 1.8 mM $KH_2PO_4$). Proteinase K and lysis buffer (guanidine hydrochloride 50-66%) were added to break cells open and digest proteins, and ethanol 96-100% was added after incubating for 10-15 minutes at 70°C to enhance binding of nucleic acids. The lysate was transferred to the polypropylene loading column and centrifuged at 11,000 g for 1 minute. The flow through was discarded. The sample was washed with Wash Buffer (chaotropic salts and ethanol), centrifuged again at 11,00 g for 3 minutes, and flow through was discarded. The Wash Buffer step was repeated a second time. The final purified DNA sample was

collected into a tube after the Elution Buffer was preheated, poured through the silica column, and centrifuged. A NanoDrop™ spectrophotometer was used to determine purity.

A trial sample of prepIT®·L2P (DNAgenotek) that can be used with DNA Genotek products such as Oragene·Discover saliva collection kits was utilized as the third DNA extraction method. After the sample was incubated in a 50°C water bath for one hour, PT-L2P (prepIT®·L2P reagent) was added and mixed by vortexing. To remove impurities the sample was placed in an ice bath and again centrifuged for 5 minutes at 13,000 g. Supernatant was transferred to a clean microcentrifuge tube, the pellet was discarded, and 95-100% ethanol was mixed by inversion. After about 10 minutes the tube was centrifuged again, and the supernatant was removed. 70% ethanol was then added, centrifuged, and the supernatant was discarded. The last step was to add TE buffer (1 mM Tris-HCl, 1 mM EDTA, pH 8.0) followed by an incubation step at 50 degrees for 1 hour. A NanoDrop™ spectrophotometer was used to determine purity.

A fourth DNA extraction method was simply adding proteinase K to one of the prepIT tubes.

### *Primer creation*

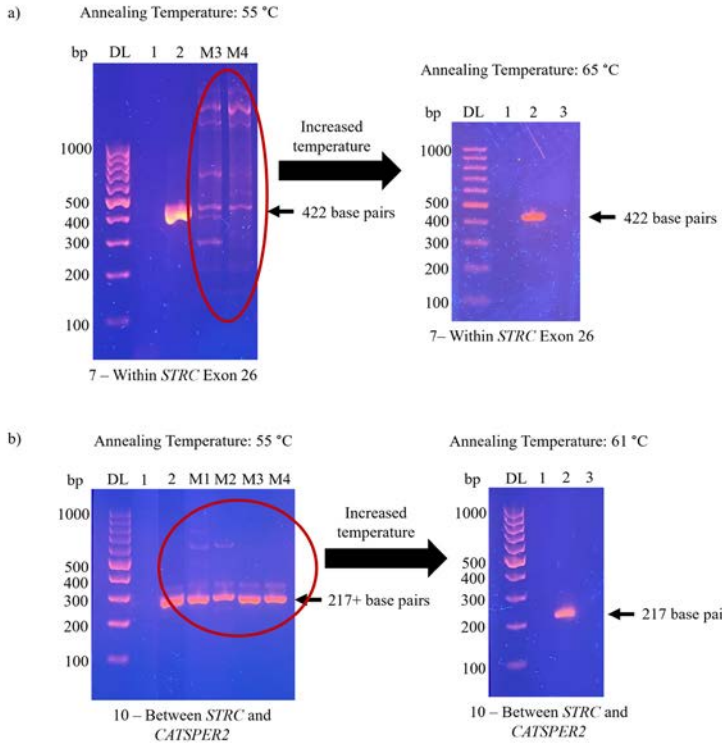
Primer pairs specific to the *STRC-CATSPER2* locus and surrounding genes/pseudogenes *(PPIP5K1, CKMT1B, CKMT1A, Ψ PPIP5K1)* were created through the NCBI primer-BLAST database (Table 1) or were found in existing literature (Molecular Otolaryngology and Renal Research Laboratories, 2020; Vona et al., 2015; Shi et al., 2019). Special care was taken to exclude the pseudogenes when targeting *STRC* and *CATSPER2*.

A total of 21 primer pairs were created: 1 control primer pair in the *LMBR* gene (638 bp), 3 in *STRC*, 4 in *CATSPER2*, 1 in between *STRC* and *CATSPER2*, 6 upstream of *CATSPER2* in *Ψ PIPP5K1* and *CKMT1A*, and 6 downstream *STRC* in *CKMT1B* and *PPIP5K1*. Three primer pairs were specifically created to amplify both the gene and the pseudogene and required sequencing to differentiate. All primer pairs were between 100-1,350 base pairs, were resuspended in 1x TE buffer and diluted to 10 µM using deionized water.

### *Polymerase chain reaction and gel electrophoresis*

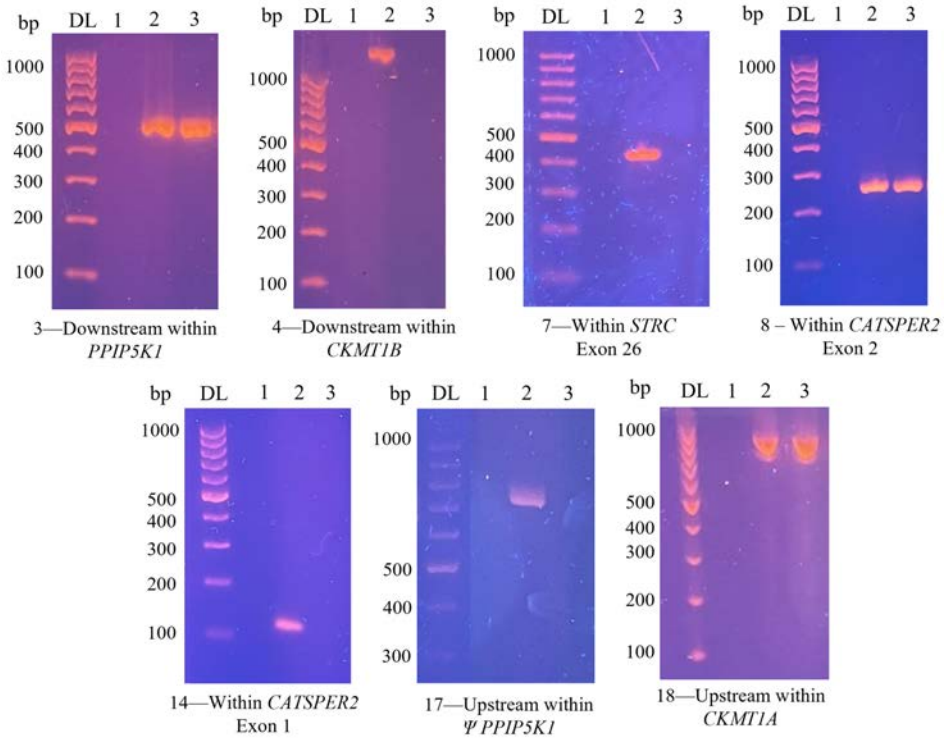
PCR was performed using GoTaq® Green Master Mix 2x (Promega Inc.). All four of the DNA extraction methods were diluted to a concentration at or below 8 ng/µL from their NanoDrop™ concentrations. These tubes remained the participant DNA stock throughout the experiment. TaqMan™ Control Genomic DNA (human male) at 10 ng/µL was used as a control for both PCR and gel electrophoresis. PCR thermocycler conditions were the following: 94°C initial denaturation for 3 minutes, 94°C denaturation for 30 seconds, the annealing temperature (Tm) for 30 seconds, 72°C extension for 30 seconds, for 39 cycles. The last cycle was a

**Figure 4:** *Low Annealing Temperatures Lead to Off-Target Priming and False Positives*




Note. DL is the DNA ladder, 1 is the negative control, 2 is the human DNA control, and 3 is the participant. DNA. M1-4 are DNA extraction methods for the participant: (M1) InstaGene™ Matrix, (M2) NucleoSpin® Blood QuickPure Mini Kit, (M3) prepIT®·L2P, and (M4) prepIT®·L2P + proteinase K. a) Annealing temperatures were increased from 55 °C to 65 °C. The red circle shows off-target priming. b) Annealing temperatures were increased from 55 °C to 61 °C. The red circle shows a false positive with an amplicon of 217+ base pairs.

**Figure 5:** *Sample of Gel Electrophoresis Results*




Note. DL is the DNA ladder, 1 is the negative control, 2 is the human DNA control, and 3 is the extracted DNA from the participant. A pink band confirms the presence of the amplified sequence, and no band indicates an absence or deletion of the sequence.

final extension at 72°C for 10 minutes with a hold at 4°C. Annealing temperatures were determined based on each primer pair and extension time was calculated as 1 minute per 1kb.

Gel electrophoresis was run at 125 V, with a 1.5% (w/v) gel in speed buffer (20x; 8 g NaOH, 30 g boric acid, deionized $H_2O$ to 1 L) diluted to 1x with the addition of ethidium bromide (0.3 µg/mL). A 100 bp DNA ladder (100-1000 bp) was used. For bigger amplicons, Thermo Scientific Phusion High-Fidelity PCR Master Mix, a 0.5% (w/v) gel, and a 1kb DNA ladder was used.

### *PCR purification and DNA sequencing*

GeneJet™ PCR purification kit and protocol were used for rapid and efficient purification after PCR. Samples requiring sequencing were then diluted to obtain a concentration between 0.2-0.6 ng/µL (100-200 bp) or 0.6-1 ng/µL (200-500 bps) according to the ACGT guidelines. FinchTV was utilized for participant sequence analysis and comparison against NCBI reference sequences for the gene and pseudogene.

## RESULTS

### *OtoSCOPE® genetic testing identified an STRC-CATSPER2 deletion of unknown length*

OtoSCOPE® v9 Gene Panel (224 genes): Comprehensive Next-Generation Sequencing (NGS) panel and copy number analysis identified a homozygous pathogenic deletion extending from *STRC* into an adjacent gene, *CATSPER2*. Genetic variants were also found in *COL11A1, COL4A4, COL4A5, GJB2, LARS2, MYO7A, TRIOBP, TRRAP,* and *USH1C*. The variants were associated with Non-Finnish European (five variants) and Ashkenazi Jewish (one variant) populations but were variants of uncertain significance, likely benign, or benign. Exact location and length of the deletion was not reported.

### *All DNA extraction methods resulted in viable DNA from the participant*

The four methods of DNA extraction – (1) InstaGene™ Matrix, (2) NucleoSpin® Blood QuickPure Mini Kit, (3) prepIT®·L2P, and (4) prepIT®·L2P + proteinase K – were successful. Purity was assessed by NanoDrop™ and all readings were blanked with the last buffer used in each method. A ratio of ~1.8 for the 260/280 (DNA/protein) marker was accepted. Concentration and 260/280 ratio for each of the four methods using the participant DNA were: (1) 120.9 ng/µL and 1.32, (2) 8.7 ng/µL and 1.28, (3) 396.5 ng/µL and 1.72, and (4) 62.1 ng/µL and 1.55. The 260/230 (DNA/salt) ratio for all methods was well below the accepted ~2.0 value; however, it did not interfere with PCR, gel electrophoresis, or sequencing, and additional washes and elutions did not improve the outcome. The commercialized human male control had a 260/280 of 2.50 and little to no salt contamination.

### *PCR and gel electrophoresis identified deletions*

The resulting amplicon for the *LMBR* gene primer pair control seen in Figure 3 was 638 bp in both the human control and the 4 participant samples and confirmed successful DNA extraction. Initially, annealing temperatures for primers 1, 7, 8, 9, 10, 12, and 15 were set too low at 55°C and were repeated closer to their annealing temperatures. Primer pairs 7 and 10 showed off-priming and false positives. When the annealing temperatures were increased for both pairs, the controls amplified, but the participant had no bands (Figure 4).

The prepIT®·L2P methods (3) and (4) with the highest DNA purity for the participant were used for the remaining gels (Figure 5). The other primer pairs were all run between 60°C and 65°C according to their annealing temperatures. Ten out of twenty primer pairs did not amplify sequences in the participant's DNA. A total of 6 pairs – 3 upstream and 2 downstream of the location of interest – were present. The controls amplified successfully in all the primer pairs. The remaining 4 pairs amplified within the *STRC* and *CATSPER2* genes in the participant and were sent for sequencing.

PCR amplification using Phusion High Fidelity (HF) polymerases for the farthest downstream forward primer (3F) and the farthest upstream reverse primer (18R) (Table 1) that amplified within the participant's DNA failed to produce a band on the gel.

### *Four primer pairs amplified pseudogenes and confirmed an 85,000 bp deletion*

The four primer pairs – 8, 9, 12, and 13 – that amplified within either *STRC* or *CATSPER2* were purified using the PCR clean up kit and were sent for sanger sequencing to AGCT inc. One sample of the participant's DNA for each of the 4 pairs and 1 sample of human DNA control for primer pair 12 were sent. A clean sequencing file was obtained for the five samples we sent. Primer pair 8 targeted a sequence within exon 24 of *STRC*, 9 targeted intron 18 of *STRC* (Vona et al., 2015), 12 targeted exon 2 of *CATSPER2*, and 13 targeted the first 102 bp of the amplified sequence from primer pair 12. Due to possible pseudogene contamination, the sequences were compared against both the gene and the pseudogene FASTA sequences from the NCBI database by nucleotide BLAST.

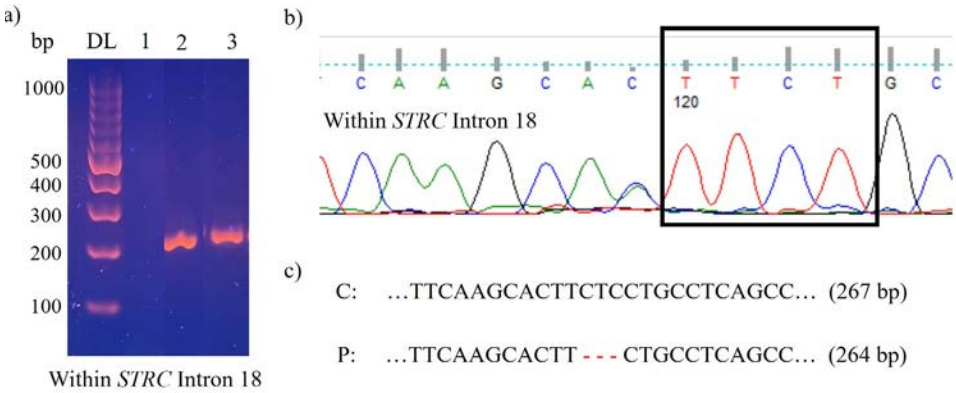
Primer pair 8 was 96% similar to the gene and 100% similar to the pseudogene. Primer pair 9 was created to amplify 264 bp in the pseudogene and 267 bp in the gene. The resulting amplicon on the gel was slightly smaller than the control and ended up being 97% similar to the gene and 99% similar to the pseudogene when sequenced. In Figure 6, sequencing showed 3 consecutive bases missing when compared to intron 18 of *STRC* which confirmed the presence of the pseudogene and the absence of *STRC*. Both the human control and the participant samples for primer pair 12 were analyzed. When compared against each other, they were 97% similar. The human control was 100% similar to the gene and the participant's DNA was 98% similar to the gene, but 100% similar to the pseudogene. Results of primer pair 13 were inconclusive as the gene and pseudogene comparison was 100%; however, primer 12 confirms amplification of the pseudogene.

All of the primer pairs sent for sequencing amplified the pseudogenes (Ψ *STRC* and Ψ *CATSPER2*) located about 100 kb upstream from *STRC* and *CATSPER2*. In total fourteen primer pairs did not amplify in the participant's DNA and six primer pairs upstream and downstream of *STRC* and *CATSPER2* did amplify. A summary of the results in Figure 7 indicates a deletion that is at least 85,000 base pairs with a complete absence of the *STRC* and *CATSPER2* genes.

## DISCUSSION

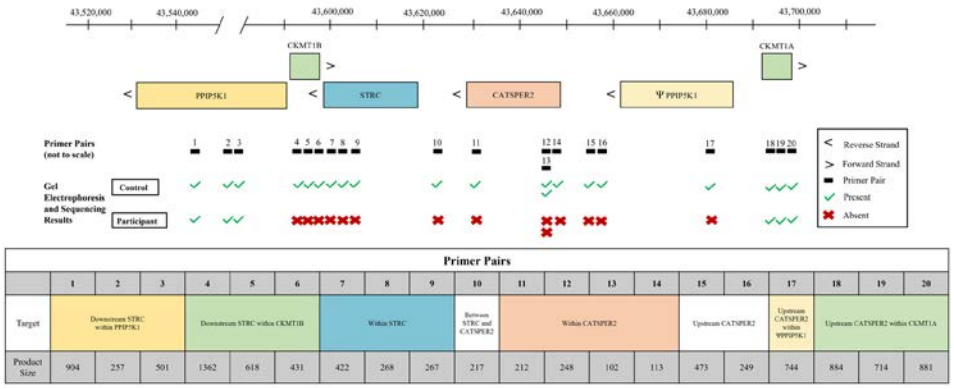
OtoSCOPE® genetic testing did not pinpoint the genomic coordinates or length of the deletion. Common deletions in the literature could be

**Figure 6:** *Sequencing Results of Primer 9*




Note. a) DL stands for DNA ladder, 1 is the negative control, 2 is the human DNA control, and 3 is the extracted DNA from the participant. b) Sequencing results. Black box indicates a location of difference. c) The control sequence (C) is compared to the participant sequence (P). The actual gene would have an amplified sequence of 267 base pairs and the pseudogene would be 264 base pairs.

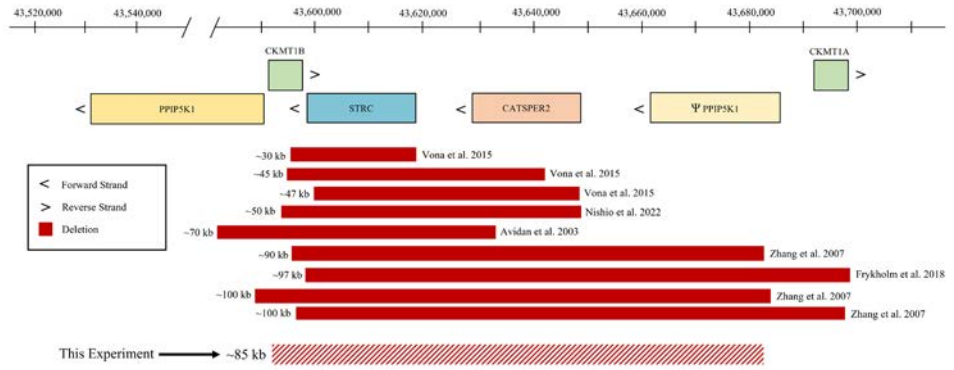
**Figure 7:** *Summary of the Results*




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Target | Downstream STRC within PPIP5K1 | | | Downstream STRC within CKMT1B | | | Within STRC | | | Between STRC and CATSPER2 | Within CATSPER2 | | | | Upstream CATSPER2 | | Upstream CATSPER2 within ΨPPIP5K1 | Upstream CATSPER2 within CKMT1A | | |
| Product Size | 904 | 257 | 501 | 1362 | 618 | 431 | 422 | 268 | 267 | 217 | 212 | 248 | 102 | 113 | 473 | 249 | 744 | 884 | 714 | 881 |

Note. Primer pairs are not to scale. Each show approximately what part of the genes are being amplified. The control is human male DNA. Primer pairs 8, 9, 12, and 13 required sequencing due to possible pseudogene contamination.

**Figure 8:** *Prediction of the Deletion Size in the Participant Against Common Deletions in the Literature*




Note. The red bars represent common deletions found in the literature. The striped bar represents the predication for the participant.

anywhere between 30,000 and 100,000 base pairs and encompass 1 to 3 genes. Due to the large variation in mutation, we designed a protocol from the existing literature to detect the length of deletion. Our experiment successfully confirmed a complete *STRC-CATSPER2* deletion and identified a region of deletion spanning at least 85,000 base pairs (Figure 8).

Four different methods of DNA extraction were used to determine which was more efficient and yielded the highest amount of DNA. Each method varied in concentration and purity, but there was no significant difference between methods in the amplification on the gels with the *LMBR* gene control; however, the prepIT®·L2P methods (3) and (4) with Oragene saliva collection had the highest DNA yield with the best purity and were used for most of the experiment.

Primer specificity and annealing temperature is determined by the number of bases, GC content, and affinity to the target sequence. The annealing temperature is the optimal temperature at which the primer binds to the complementary sequence on the DNA. Off-target priming suggests incorrect binding to a similar sequence in the DNA or, in the absence of a complementary sequence, an attempt to bind to completely different sequences throughout the DNA (Figure 4a). Initial difficulty with low annealing temperatures caused this phenomenon in our results. The likely culprits were the pseudogenes. When sequences are incredibly similar and only differ by a base or two, primers may loop out to accommodate or misalign and lead to a band on the gel and a false positive. Once temperatures were increased, at least two primer pairs did not amplify anything in the DNA indicating a deletion at that target location (Figure 4).

Three of the four primer pairs that amplified within *STRC* and *CATSPER2* all targeted the pseudogenes according to the nucleotide alignment and 100% identity to the FASTA pseudogene sequences. Primer pair 9 from Vona et al. (2015) targeted a divergence within the Ψ *STRC* sequence. The adjacent three base difference in intron 18 between the gene/pseudogene verifies that the deletion does not extend into Ψ *STRC*. Results for the fourth primer sequenced (13) were initially inconclusive due to 100% identity between the gene and pseudogene reference sequences, but primer pair 12 confirmed the presence of the pseudogene due to the nested PCR design.

Overall, fourteen locations from the last half of *CKMT1B* to Ψ *PPIP5K1* were not present in the DNA. The farthest deletion downstream of *STRC* at 43,595,434 and the farthest deletion upstream of *CATSPER2* at 43,680,830 makes the site of deletion about 85,396 base pairs as seen in Figure 5. Three locations downstream and three locations upstream of this site amplified, however they are each about 15,000 to 36,000 bp away from the site of deletion. The 100% similarity in sequence between *PPIP5K1* and *CKMT1B* and the upstream *CKMT1A* and Ψ *PPIP5K1* gene/pseudogene regions made it impossible to create primers closer to the deletion site.

Attempts to amplify the entire region of deletion with the forward primer of 3 and reverse primer of 18 did not work due to the 51,000 bases that still could be present in the participant DNA. Additionally, the Phusion HF polymerase has an extension limit of 10,000 base pairs. Long-range PCR techniques like that used in Vona et al. (2015) and Mandelker et al. (2014) are required.

The participant has a complete deletion of *STRC* and *CATSPER2*, and a suspected complete deletion of *CKMT1B*, because the last location of deletion extends from exon 4 of the longest transcript to the end of the gene. The loss of *CKMT1B* does not appear to be associated with any syndromes or physiological changes. This is likely due to the ubiquitous nature of the creatine kinase and recovery of protein function from the nearly identical *CKMT1A* gene product, or from other kinases in the body (MIM 613416; MIM 123290; Zhang et al., 2007). The deletion of the *STRC-CATSPER2* regions leads to the mild-to-moderate hearing loss phenotype. By identifying the ***STRC*** deletion in the participant, this paper is contributing to the expanding research on hearing loss genetics.

## CONCLUSION

We predicted that the participant has a deletion of at least 85,000 bp extending from the exon 4 of *CKMT1B* to the end of Ψ *PPIP5K1* with the complete absence of the *STRC* and *CATSPER2* genes. The upstream Ψ *STRC* and Ψ *CATSPER2* pseudogenes are present. The two-allele deletion in *STRC* causes the participant's stable autosomal recessive non-syndromic down sloping mild-to-moderate hearing loss. The absence of *CATSPER2* does not affect the participant. However, there is a possibility that her male sibling could have DIS. Analysis of the sperm would be needed to

confirm this diagnosis. Due to the limitations from pseudogene contamination, further research is required to determine the precise beginning and end of the deletion.

## LIMITATIONS

The deletion is likely more than 85,000 bp; however, we cannot confirm this theory due to pseudogene interference at the locations flanking the site of deletion. The 100% similarity made it impossible to locate the breakpoints. A different method would be needed.

Assuming the parents are indeed unrelated, the autosomal recessive nature of inheritance likely means that each parent passed on a different size deletion. One of their alleles for *STRC-CATSPER2* was normal and their second allele contained the deletion. PCR and gel electrophoresis would only be able to show deletion overlaps (negative results) or presence of the sequence (positive results). The results would not be able to show the two different alleles unless there was successful amplification on either side of the breakpoints. Successful amplification would show two bands of different sizes; however, the high sequence similarity and 10,000 bp limit of Phusion HF polymerase meant we were unable to locate the exact genomic coordinates with confidence.

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# An Investigation into Idiopathic Thrombocytopenic Purpura (ITP)

*Elizabeth A. Wash*

**ABSTRACT**

Idiopathic Thrombocytopenic Purpura (ITP) is a medical mystery. A disease that affects various components of the immune system has vast treatment methods, and varying symptom presentation leaves all medical professionals without answers, and patients a lifetime of suffering. With limited research available, and the research present all focusing on different aspects of this disease, a synthesis of this knowledge is required to give the best chance at survival for patients. ITP attacks the blood platelets in unconventional ways, preventing the clotting of the blood, allowing for internal bleeding and limited immune system results. While the body is undergoing a strenuous attack from the inside, the symptom presentation varies between patient to patient, but significantly between child and adult, as children are subject to intracranial hemorrhaging, a potential lethal symptom. The forms and treatments of ITP are variable, as the ITP can be persistent and require more extraneous forms of treatment, while some treatment methods can cause the disease to come out of remission. The lifelong effects of this disease are still somewhat unknown, with there being complications in both one's physical and emotional state. Idiopathic Thrombocytopenic Purpura is a disorder requiring further research and synthesis to give patients and doctors alike the best chance to combat this disease.

**KEYWORDS**

Idiopathic Thrombocytopenic Purpura; Petechiae; Purpura; IVIG; Hematoma; Platelets; Megakaryocytes; Autoimmune Disorder; Apoptosis; Splenectomy

## INTRODUCTION

Idiopathic, or Immune, Thrombocytopenic Purpura (ITP), an autoimmune blood disorder, is a mystery. With a disorder affecting various components of the immune system, most attributes of this disorder must be actively observed in patients who are currently afflicted, but with a rare disease, that is not a simple feat. Several aspects of ITP leave physicians confounded on the best treatment options to restore the platelet levels within the blood, treatment of the side effects caused by the lowered platelet count, and how to manage the lifelong effects. There have been a variety of studies, but these studies continue to have numerous unanswered questions, proving that more research is needed to know the true pathophysiology of ITP, symptom presentation, forms and treatment, and the lifelong effects that often go unnoticed.

## PATHOPHYSIOLOGY OF ITP

The destruction caused by ITP on one's body is caused by a reduction in platelet production, or even a specific antibody targeting the platelets within one's body. The megakaryocytes have several functions within the body, the main one being the production of blood platelets (Cines et al., 2009). With a disorder that targets the survivability and presence of platelets within the body, it can be determined that a key feature of this disease is due to the megakaryocytes having features of apoptosis (Cines et al., 2009). Apoptosis is a distinct form of cell death, and with patients exhibiting ITP, the majority of megakaryocytes do not reach maturity. Most megakaryocytes show alterations that are comparable to being in the stages of apoptosis in ITP patients (Cines et al., 2009). The result of the main cell involved in blood platelet production being induced early in apoptosis in ITP patients is the main contributor to the symptom presentation and the treatment methods used.

Blood platelets are vital in the clotting of blood within the body, which is necessary when one experiences a cut, bruise, or any injury or infliction. When the platelets are experiencing cell death before maturity, this means that they will not be functional when needed, allowing for blood to roam throughout the body, resulting in substantial internal bleeding, and an overall lower blood volume (Zufferey et al., 2017). This internal bleeding if not appropriately clotted can lead to potentially deadly results, and symptoms that can lead to a lowered immune response, and ultimately damage joints, organs, or tissues (McKenzie et al., 2013). If one was to cut themselves when lacking megakaryocytes, this could lead to substantial blood loss and irreversible results. The diagnosis of ITP is rare, as often the presence of megakaryocytes that are characteristically lacking in ITP, can be the same in patients experiencing leukemia (Zufferey et al., 2017). There must be a further analysis of the morphological changes that are present within the disorder and all blood cells when ITP is suspected or diagnosed in a patient.

## SYMPTOM VARIATION

All individuals are susceptible to being diagnosed with ITP; however, the onset display of symptoms can vary. The presentation of symptoms can vary depending on the nature of diagnosis, whether an individual develops the disorder in adulthood or childhood. The age at which one develops the disorder varies with the severity of the disorder. The presentation of ITP in adults mainly demonstrates as internal bleeding, causing hematomas (McMillian et al., 2004). The signs of this internal bleeding are seen in petechiae, purpura, skin discoloration, and blood in urine or stool (NHLBI, 2022). Petechiae is classified as pinpoint spots that appear on the skin as a result of bleeding, often presenting as a rash, while purpura are purple covered patches that can appear on the skin or on mucus membranes (NHLBI, 2022). Both of these symptoms can indicate internal bleeding, as they demonstrate pooling of blood beneath the surface of the skin due to the inability for the blood to clot, a further indication of a blood clotting disorder, such as ITP. While these symptoms can be exhibited in adolescent patients, ITP in childhood can present in several other manners and have deadlier symptoms than the presentation in adulthood. The rarity that accompanies the development of ITP, leads physicians and patients alike left to treat symptoms as they appear.

Idiopathic Thrombocytopenic Purpura has varying symptom presentation in children compared to the symptom presentation in adults. One rare side effect of ITP, when diagnosed in childhood, is intracranial hemorrhage. This complication of ITP, while rare, is of extreme concern, as it has a 25% chance of being lethal, and a 25% chance of having permanent nerve damage, with only a 50% chance of survival with a full recovery (Psaila et al., 2009). This symptom which can accompany the diagnosis of ITP can impact

the ability of the children to survive and recover. Idiopathic Thrombocytopenic Purpura is commonly seen to present after the presence of an infection in children, especially between the ages of 1 to 10 years old, and there have been several differences noted between younger to older aged children in symptom presentation and ITP occurrence (Kuhne, 2003). Children developing ITP have differing symptom presentations than adults, contributing to the rarity and lack of knowledge known about this disease.

## FORMS AND TREATMENT OF ITP

There are two main forms of Idiopathic Thrombocytopenic Purpura, which can be acute or long-term. The acute version is classified by having occurred for less than six months, and the chronic version occurring longer than six months (Page et al., 2007). The more common version of ITP is the acute version, and this is present mainly in children, whereas the chronic version typically affects adults more frequently. There can also be the development of secondary forms of ITP as the result of a splenectomy, a common treatment of Idiopathic Thrombocytopenic Purpura, especially in adults (Rodeghiero, 2018). The form that is present within a patient determines the appropriate treatment methods and could be used to predict potential side effects caused by the disorder.

Idiopathic Thrombocytopenic Purpura's treatment varies depending on the age of the patient, severity of the disorder, and previous medical conditions/history. The basic goals of treatment for ITP are to reduce the risk of bleeding and to create a long-term "cure," which can be cultivated in different ways depending on both the severity and age of the patient. For infants, a common practice is hospitalization with IVIG transfusion, whereas corticosteroids are often given to older children (Kuhne et al., 2003). IVIG transfusions are a treatment method for specific antibody deficiencies, such as platelets, in which antibodies are directly given to the patient intravenously, to restore the integrity of the blood (Kuhne et al., 2003). The treatment of IVIG restores the number of platelets within a patient's blood, increasing the efficiency of the immune system and effectively reversing the effects of ITP (Kuhne et al., 2003). Corticosteroid treatment is used to block the immune system, allowing for megakaryocytes to reach maturity, without any internal attacks, and to establish the appropriate number of platelets within one's blood (Kuhne et al., 2003). Another common treatment method, especially for adults, is that of a splenectomy, as it causes the disorder to become milder, and allow for other treatment methods to work better.

The treatment method of a splenectomy has several potential complications that can be just as deadly as ITP itself, with potential post–surgery infections, sepsis, and blood clots (Rodeghiero, 2018). All treatments for ITP come with a higher risk of thrombosis, as this is a major symptom of Idiopathic Thrombocytopenic Purpura, and if the treatment method fails, it can result in these symptoms being heightened. Overall, the treatment option of splenectomy is typically only used if an individual already has chronic ITP. The spleen removes the damaged or apoptotic platelet cells, so the removal of the spleen will allow for the number of platelets to increase (Rodeghiero, 2018). This increase would be due to allowing more platelets to circulate within the body and restore the platelet levels within one's blood. Even in the circumstances of having a splenectomy, other treatment methods, such as the use of IVIG transfusions or corticosteroids are used in addition to giving the patient the best chance to overcome the disease.

## LIFELONG EFFECTS OF ITP

There is little information about patients whose treatment for ITP fails, or how this disorder, even in remission, can have unexpected lifelong complications. The current treatment methods are used in sequential order, with corticosteroid therapy and IVIG transfusions being given first, and then if a patient does not respond, one must undergo a splenectomy (Rodeghiero, 2018). The initial approach of either corticosteroid therapy or IVIG transfusion only results in creating a stable response in platelet counts in 60 – 70% of patients (McMillan et al., 2004). When one has a splenectomy they are at a higher risk of becoming sick or not recovering from illnesses. Once a patient has ITP, even if it has been in remission for a long period, they have a higher incidence of other autoimmune disorders than other individuals, and can suffer ITP relapses (McMillan et al., 2004). The first treatment for an individual with ITP to increase their platelet counts is just the beginning for most patients, as there will be several lifelong impacts from this disorder.

Idiopathic Thrombocytopenic Purpura has effects on an individual's entire being, with results that can last a lifetime, depending on relapses and severity of the disorder. Patients who remain in a chronic ITP can potentially lose an average of 20.4 years of their life expectancy (Mathias et al., 2008). Individuals with ITP or having treatment for ITP have prolonged symptoms of anxiety, depression, fear, exhaustion, and fatigue. Idiopathic Thrombocytopenic Purpura especially impacts women and their ability to reproduce, whether it is having severe and prolonged menstrual bleeding or difficulties getting pregnant, and once pregnant, close monitoring and treatment must be provided (Mathias et al., 2008). This disorder can also impact an individual's social and work life, forcing one to take a less physical job and to avoid social activities to avoid bruising and internal bleeding (Mathias et al., 2008). The lifelong effects of ITP are not just physical but include the social and emotional parts of an individual, and most effects are still unknown.

## CONCLUSION

Idiopathic Thrombocytopenic Purpura is a rare autoimmune blood disorder, often going misdiagnosed and treated inappropriately. The rarity of this disorder contributes to the lack of knowledge surrounding it, leaving patients stranded with untreatable symptoms, and doctors floundering for potential cures. There is still much to be studied about ITP, but the main conclusion that can be synthesized is that this is a disorder that directly affects megakaryocytes, a cell type that makes blood platelets within the body. This can cause a variety of symptoms and symptom presentations depending on the age and severity of the patient, leading to a few different treatment options. While the treatment options can be combined, no single treatment method is guaranteed to cure or place the patient in remission, resulting in increased uncertainty, especially as the disorder can relapse once an individual is diagnosed. The lifelong effect of ITP ranges to all aspects of one's life, not just limiting itself to the physical aspects of one's health. Idiopathic Thrombocytopenic Purpura still is surrounded by unanswered questions, needing more research to provide a better understanding to all, and better quality of care to all patients suffering.

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# Radium Girl

*Sarah Hancock*


## ABSTRACT

*Radium Girl* is a digital piece inspired by the 1900s turn of the century: an era of innovation and discovery. For a time, it was believed that every newly discovered element could be beneficial to the human experience. During this rise of advertising and capitalism, these elements were sold as products ... one of them being radium. See if you can look through the lens of the *fin de siècle** at this romanticization and commodification of the female form, and the element that would be the demise of dozens of young women.

Inspiration for any piece of mine is, as I like to call it, a scrapbook method. I combine multiple influences and thoughts and see what I get. For *Radium Girl,* inspiration came from my personal interest in toxicology – the effects chemicals have on the human body – and the art nouveau period – where advertising had a monopoly on the art scene. Thinking economically, making the design digitally saves me time and material, and provides a new way for me to circulate art faster. This is the same mindset artists such as Alphonse Mucha had to have to make a living.

Radium is a trickster. When it enters the body, especially through digestion, the bloodstream mistakes it for calcium because of the atomic similarities between the two elements. Once deposited in one's bones, radium makes the bones radioactive, causing osteoporosis and literal degradation of the skeleton while the body is still alive. The young women who were employed to paint watch faces with radium paint would have grueling joint pain and eventually die prematurely due to tumors, blood loss, and a weakened body (Rapley, *The Poisoner's Handbook,* 2014).

Before the consequences of using radium were circulated, the element was used in a multitude of ways, with applications in makeup, food, beverages, paint, and even as small doses in your pocket (as Marie Curie did). Consider, how many times in modern commercials has a product claimed it would reap benefits for your appearance? The irony here is that radium has a chemical property allowing it to glow on its own, hence, the slogan "You'll Glow like Never Before." Take note of Lucy (the woman depicted in the poster) raising her brush to her lips. You can take it as a seductive marketing ploy, or as a nod to an artist's tendency to bring a brush to their lips to sharpen the tip for better precision … if that paint was radium, however, it would turn into a deadly habit. The watch-face is a nod to the countless watches painted with radium paint for the Great War by young women in factories, but it is also a cruel irony representing Lucy's impending death. For anyone else who enjoys hidden details, the time on this watch face reads 2:07, the position of radium on the periodic table. It is tiny hidden details that makes creating art enjoyable for me. The inclusion of other disciplines has inspired numerous works, this one being one of many. Hopefully the idea of scrapbooking different ideas together can resonate with others who struggle with creativity but wish to be creators.

**fin de siecle: A French term relating to the end of the 19th century and beginning of the 20th.*


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# General and Epigenetic Effects of Selected Nutrients on Fetal and Early Childhood Cognitive Development

*Jada Jackson*

**ABSTRACT**

It is important for parents and medical practitioners to understand the mechanisms of nutrients on early cognitive development. Most of the existing literature on the subject focuses on breastmilk and the nutrients within. However, there is much less research on the epigenetic effects of nutrients on the developing brain. To promote healthy brain growth in fetuses and young children, parents and medical practitioners must know all the ways nutrients can impact cognition. To uncover the actions of different nutrients on brain development, it is necessary to collect the existing literature involving the role of nutrients in the first few years of life. This thesis serves as a comprehensive literature review of information connecting diet and epigenetic modifications, as well as other pathways of nutrient impact on brain growth. The information in this thesis will serve to direct future studies involving early dietary experience and help guide medical practitioners and parents foster healthy choices enhancing early cognitive development.

Every parent wants to ensure that their child develops properly, and cognitive development is often a focus for parents and pediatric medical practitioners alike. Parents need to know that cognitive development depends on both nutrition and stimulation (Murgatroyd & Spengler, 2011). Cognition is the sum of conscious and unconscious thought processes that lead to action (Cowley, 2015). The neurons that make up the brain and the connections between them are the basis of cognition. Cognition is a broad topic, and few nutrients or experiences are objectively "good" or "bad" for cognitive development. Instead, there are many factors that can benefit cognition in different ways depending on one's developmental stage. For the purposes of this thesis, the author will focus on nutrients that affect neuronal development and communication. A lack of a nutrient may prevent neurons from functioning efficiently or developing properly (Simeoni et al., 2014). Fetuses and young children must get certain nutrients to support brain growth, and medical practitioners need to be able to communicate the necessity of these nutrients to parents. Research on essential nutrients indicates many routes of impact; however, there are few connections to the role of epigenetic modifications.

Epigenetics is a relatively new field of science and is the study of heritable and nonheritable changes to DNA expression (Franzago, et al., 2019; Indrio et al., 2017). Heritable means that these changes can be passed down to future generations. DNA is the genetic material that helps to determine a person's external and internal appearance, traits, and behavior (Levine & Miller, 2019). DNA is found in the nucleus of each cell and determines cellular actions. The same DNA sequences are found in most of the body's cells. Though the sequence of DNA does not change, its expression, or utilization, is different in the various types of body cells. The variation in DNA activation or genetic activity is possible through epigenetics, which alters how DNA sequences are used throughout the body (Franzago et al., 2019). Genes are segments of DNA whose expression is different depending on the cell (Levine & Miller, 2019). Epigenetics does not change the genes themselves, but rather changes how accessible genes are to the enzymes involved in their expression (Franzago et al., 2019). A DNA sequence associated with a pathological trait may be silenced or activated via epigenetic modifications. These changes to DNA expression are especially important within the brain.

Brain development is a subject of the classic debate of nature versus nurture. Parents want to know what factors will impact their children's cognition. Most parents understand that one's diet is important, but epigenetic findings can help people appreciate the developmental role of nutrients within the brain. While the idea of epigenetics has existed for centuries, Lester et al. (2016) believe that scientists are only starting to apply epigenetics to psychology, and that there is still much more to be discovered. Thus, few sources have connected nutrition to epigenetics in a manner that can be used by families and scientists alike. This paper will provide greater clarity and detail to this connection. By adding to the scholarly conversation, this literature review makes it possible for future research on epigenetic impacts of nutrients to be pursued.

Epigenetics, breastfeeding, proteins, and micronutrients are important topics to include in the discussion connecting one's diet to early cognitive development.

## EPIGENETICS

Epigenetics connects one's environment and experiences to long term changes in DNA expression. Franzago et al. (2019) defines epigenetics as "the study of molecular mechanisms that establish and maintain mitotically stable patterns of gene expression yet do not alter DNA sequence" (p.1). Indrio et al. (2017) adds that these epigenetic changes can be inherited meiotically as well, indicating that epigenetics can be passed on to one's offspring. This makes the epigenetic mechanisms of nutrients even more important, since these changes to DNA expression can have potential long-term, multigenerational implications. The nutrients one consumes can cause epigenetic changes that are inherited by one's children. Epigenetics provides plasticity to DNA, meaning that one's genes are not rigid because their expression can be altered. Although one's genome does not change, how genes function does change due to experiences (Murgatroyd & Spengler, 2011). Most of that experience-influenced change occurs early in one's life.

Much of the epigenetic activity in one's cells occurs during the first 1000 days of life, indicating that conception through age two is a critical period for epigenetic influence (Indrio et al., 2017). The early environment and diet have major impacts on the expression of one's genetic inheritance and controlling these two factors in fetuses and young children is imperative. Changes in gene activity can occur because of molecules that surround DNA, which are often determined by the diet of the mother during pregnancy, or the child postnatally. The primary sources of epigenetic alterations to gene expression are DNA methylation and histone activity (Murgatroyd & Spengler, 2011). Murgatroyd and Spengler (2011) explain that changing the histones that compact DNA and adding methyl groups to the strand are some of the most highly understood epigenetic modifications. Cedar and Bergman (2009) note that these two alterations to

DNA expression can interact, and that, for example, the presence of certain histones can prevent DNA methylation. Though they address this interaction, the two main types of epigenetic alterations are generally discussed independently.

When methyl groups are added to DNA, this usually decreases its transcription and translation, effectively deactivating the genes at that location (Indrio et al., 2017). Methyl groups are added to a specific part of the cytosine molecule by covalent bonding (Murgatroyd & Spengler, 2011). As covalent bonds are the strongest chemical bonds, these alterations are more stable than other epigenetic changes. DNA methylation patterns would likely be the most difficult to undo once they have been established, so ensuring that one's early diet is conducive to the establishment of healthy methylation is essential. In animals, except at CpG islands, most CpG dinucleotides start out methylated (Cedar & Bergman, 2009). Around the time of implantation, methylation is undone and redone in a pattern specific to the animal, making the prenatal period an important time for alterations to gene expression. Thus, pregnant women must follow a diet that facilitates proper methylation. Simeoni et al. (2014) note that methyl groups needed for DNA methylation and the cofactors needed for the involved enzymes are obtained through the diet. Hence, one's diet has a major effect on the suppression or activation of certain genes. Some of the important nutrients for DNA methylation include folate, choline, amino acids, vitamin B6, vitamin B2, and vitamin B12 (Simeoni et al., 2014; Barra et al., 2018). The other major way DNA expression is changed is via histone modifications.

Histones are proteins that DNA wraps around, and the more tightly certain DNA sections are wrapped around histones, the less they are expressed (Indrio et al., 2017). The N-terminus of histones can be significantly altered via the addition or removal of various chemical groups, such as methyl, acetyl, and phosphorus groups (Murgatroyd & Spengler, 2011). These alterations determine how tightly DNA wraps around histones and thus control DNA expression. Loosely wrapped chromatin, which consists of the DNA wrapped around histones, is termed euchromatin, and is accessible by transcription machinery. Heterochromatin is tightly wrapped and inaccessible. The acetylation of histone proteins via various enzymes tends to open chromatin for expression, while histone methylation can activate or inhibit expression at that site. Since the bonds involved in histone modifications are not as strong as the covalent bonds present in DNA methylation, histone structure is less stable, but nevertheless important for regulating DNA expression. Histone structure must be carefully controlled so that the right genes in each cell are expressed. Though histone modification and DNA methylation are the main epigenetic pathways, there are other ways that DNA expression can be altered.

Less studied mechanisms of epigenetic change include noncoding RNAs and ATP dependent chromatin remodelers. The transcription of noncoding RNAs is influenced by DNA methylation and histone activity (Simeoni et al., 2014). These RNAs are needed to keep DNA and its associated proteins together to preserve the shape of the chromatin (Barra et al., 2018). ATP dependent remodelers use the energy from ATP to change the associations between DNA and histones. Since these two forms of epigenetic change to DNA expression affect the more common DNA methylation and histone modification, they have been studied less, and are generally not the focus of most epigenetic research. When DNA methylation and histone modification are better understood, noncoding RNA and ATP dependent chromatin remodelers will likely be investigated more.

All these various changes to DNA expression can then affect development, namely in the brain (Indrio et al., 2017). Murgatroyd and Spengler (2011) posit that since changes to gene expression allow different neurons to have different functions, epigenetics have a crucial role in brain development. Mutations in the genes encoding for epigenetic machinery can result in brain abnormalities or developmental delays because neurons cannot regulate gene expression in response to their environment. In addition, excess or lack of adequate methylation in the brain can cause mental health issues. Epigenetic changes impact the brain at many different points in one's life, but the brain grows fastest during the first 1000 days of one's life and is consequently most sensitive to nutrient availability at this time (Mattei & Pietrobelli, 2019). Also, most epigenetic activity occurs from conception to early postnatal life, since this is when cells are differentiating (Simeoni et al., 2014). It is important to ensure proper early nutrition because the molecules found in nutrients can induce of epigenetic modifications that can make lasting impacts on cognitive development.

## BREASTFEEDING

Breastfeeding has been shown to have significant benefits to brain development (Herba et al., 2013). Breastfeeding has both short- and long-term positive effects on infants, and a recent study showed a connection between breastfeeding and the amount of white matter in the brain of seven and eight-year-olds. Though this study was on children born prematurely, these trends can be seen in full term individuals as well. The increase in white matter can be explained by the fact that the fatty acids found in breast milk are needed for neuron myelination, and these myelinated neurons make up the white matter in the brain (Prado & Dewey, 2014). Specifically, docosahexaenoic and arachidonic acids are two long-chain polyunsaturated fatty acids found in breast milk that are important for brain development (Cusick & Georgieff, 2016; Herba et al., 2013). Because of the fatty acids and other nutrients within, breastfeeding should be the exclusive form of feeding until an infant is six months old, and is beneficial until age two (Sherwood et al., 2020). Breastfeeding can lead to benefits in cognitive performance in young children.

Breastfed children tend to perform higher on cognitive assessments at age five and six than their non-breastfed peers (Rothstein, 2013). Though the differences are not always significant, most parents would want to know that breastfeeding has the potential to improve their child's cognitive development. Most of the long-term effects of breastfeeding, and early nutrition in general, are via epigenetics. The duration of breastfeeding is linked to changes in DNA methylation in certain genes, but these changes do not seem to persist into adulthood (Sherwood et al., 2020). In a study by Sherwood et al. (2020), a region that had increased methylation with increased duration of breastfeeding housed the "farnesyl-diphosphate farnesyltransferase1" gene, whose knockdown is associated with central nervous system development (p. 8). Thus, one link between breastfeeding and cognitive development is via epigenetic changes to gene expression. This connection must be further researched for full conceptualization of the cognitive benefits of breastfeeding.

Though many studies indicate cognitive benefits for breastfed infants, a 2018 study by Liu et al. (2018) sought to uncover more of these benefits, beginning with an exploration of why breast milk is more cognitively beneficial than formula. They found that in healthy, well-fed mothers, breast milk has more lutein than formula. Lutein is a carotenoid that has been shown to support healthy early cognition. Breast milk also has a chemical called RRR-alpha-tocopherol, which may improve cognitive development, whereas the synthetic version found in formula has less biological action. Though breast milk and formula may have similar ingredients, synthetic nutrients are often not as accessible to the infant as the natural versions found in breast milk. Consequently, breastfed infants tend to be better nourished. This study found significant differences in the microscopic structural development of the cortical gray matter and white matter in breastfed versus formula-fed infants' brains, though no difference in overall brain size was observed. It is unclear why there are benefits in some areas and not others, but most researchers have reached the consensus that breast milk is better for the developing brain than formula. Further epigenetic research can help to confirm the superiority of breast milk. Analyzing the microbiome also points to breast milk's advantages, including its influences on early gut colonization.

## THE MICROBIOME

The microbiome is the population of bacteria that live on and inside humans (Kundu et al., 2017). The exact composition of bacteria present in an individual is determined by a variety of factors, such as gender and diet. The microbiome also

changes based on one's life stage and hormone levels, adapting with one's physical growth. Preclinical studies point to the importance of proper colonization of the gut for the development of the central and enteric nervous systems (Carabotti et al., 2015). While the central nervous system is more commonly discussed, the enteric nervous system is in the gastrointestinal tract and is important for brain development and chemical communication throughout the body. Thus, the infant gut must be optimally colonized to maximize health. Carabotti et al. (2015) explain the gut-brain axis as consisting of two-way communication between the nervous system housed in the brain and spinal cord and that found in the GI system. The bacteria within the GI tract affect the cells there and are thus a major part of the gut-brain axis. The gut microbiome can influence molecules used in chemical communication within the body, which can then affect the brain. The enteric nervous system serves as the link between the microbiome and brain development, and breast milk is the link between diet and the microbiome.

Breastfeeding can have a major impact on an infant's gut colonization. An infant has a new immune system and a GI tract that must be properly colonized to promote immunity and brain health. After some in utero contributions and potential vaginal bacteria, breastfeeding is the next way that one's microbiome can be inherited by the next generation (Gabbianelli et al., 2020). Breastfeeding exclusively for the first six months is advised, which helps to properly establish an infant's microbiome. *Bifidobacterium* are present in higher numbers in breastfed infants compared to those that are formula fed. These beneficial bacteria give breastfed infants both gastrointestinal and cognitive advantages compared to their formula-fed counterparts. Even after infants are no longer breastfed, one's diet interacts with the microbiota. For example, vitamin C has been demonstrated to increase beneficial species like *Lactobacillus* and *Bifidobacterium* and decrease harmful *Escherichia coli*. The importance of diet cannot be emphasized enough; if one does not have the correct amount and diversity of bacteria within the gut due to a Caesarean section or early antibiotic exposure, the microbiome can be corrected by diet, namely breast milk.

## PROTEIN

Proteins are a category of macronutrients that are essential for early cognitive development. Macronutrients are dietary substances required in higher amounts, and include proteins, carbohydrates, lipids, and nucleic acids (Savarino et al., 2021). Though a growing infant needs all four, protein deficiencies have been most researched, as they are related to overall calorie deficiencies (Tanner & Finn-Stevenson, 2002). Protein tends to be more difficult to obtain than the other macronutrients in low-income environments, causing widespread deficiency. Protein is inherently related to energy, because if the body does not have other energy sources, it uses proteins. Protein is subsequently not available for other bodily functions. One of these neglected functions is cognition, and prenatal protein deficiency can have major detrimental impacts on a child.

Maternal diets low in protein can suppress the promoters of brain-derived neurotrophic factor, which is essential for memory and learning (Wu et al., 2019). In one preclinical study, maternal protein deficiency led to a range of brain abnormalities, including sleep-wake cycle issues and memory problems, some of which were irreversible (Barra et al., 2018). This serves to highlight the importance of expectant mothers consuming enough protein for themselves and their babies. Supplements used to combat protein and calorie deficiencies have been shown to improve infant motor skills, which predict later cognition (Tanner & Finn-Stevenson, 2002). Such measures to include enough protein in one's diet must be taken to preserve optimal brain function.

When children are not getting enough energy from their food or are not consuming enough protein, their brains also suffer other consequences. Proteins are made up of amino acid monomers, and these amino acids are used to make and balance neurotransmitters, which neurons use to communicate with each other and their targets elsewhere in the body (Tanner & Finn-Stevenson, 2002). Amino acids also have a role in epigenetic changes as they are involved in DNA methylation (Barra et al., 2018). Certain amino acids, like serine and methionine, can serve as donors of methyl groups, and not having enough or having too many methyl donors can be detrimental to cell metabolism and overall health (Wu et al., 2019). The connection between a lack of protein in the diet and not having enough methyl donors is clear. However, not consuming enough protein or calories to provide the energy needed to link amino acids can also lead to an excess of methyl donors. This is because without the energy or right substances to connect amino acids, there are more free amino acids that can erroneously donate methyl groups to DNA, which can be detrimental. Obtaining enough of the essential amino acids is important for normal development in general, and especially within the brain.

One study found that protein deficiency in rats led to decreased expression of CREB1 and CREBBP genes that encode transcription factors in the postnatal hippocampus (Barra et al., 2018). These transcription factors are involved in the plasticity of the hippocampus, and the hypermethylation of the Sk2a1 gene caused by this protein deficiency causes brain issues, such as lack of plasticity. Neuroplasticity is the ability of neurons to respond to experience or damage by altering themselves, often by the formation or deletion of synapses. Plasticity within the brain is essential, especially in young children, because it allows the brain to adapt to one's environment. Neuroplasticity allows learning and memory to take place. While protein deficiency can cause various changes to DNA methylation patterns, Iqubal et al (2018) associate low protein and overall energy intake with high levels of nonspecific DNA methylation in young children. Global methylation can cause a wide range of deficits, as many necessary genes could be silenced. A lack of energy consumption would also inhibit the actions of ATP dependent chromatin remodelers, causing further epigenetic challenges. Protein is an important macronutrient and is highly associated with energy intake, both of which can have significant impacts on early cognitive development.

## MICRONUTRIENTS

Certain micronutrients are essential for fetal and early cognitive development, and include iron, iodine, zinc, and B vitamins (Savarino et al., 2021). Micronutrients are only needed in small amounts but are nevertheless essential for normal functioning of the body. Iron is a micronutrient needed to make red blood cells and components of brain tissue, including neurotransmitters (Tanner & Finn-Stevenson, 2002). Iron deficiencies can lead to delays in cognitive ability in young children and can cause permanent deficits to communication among neurons, which affects conduct and attention. Signs of iron deficiency in young children are sometimes hard to identify as symptoms can be attributed to normal preschool behavior, such as the inability to focus for long periods of time. Iron deficiency is the most prevalent micronutrient deficiency, and half of deficient individuals are young children or pregnant women (Mattei & Pietrobelli, 2019). These deficiencies must be corrected, and more education about the importance of iron and its sources may be needed to promote healthy brain development in children. Iron supplementation has only been demonstrated to be beneficial to the neurocognitive development of the children of deficient individuals early in gestation, indicating an early sensitive period. This may be because iron deficient women conserve iron for their own bodies. Even with supplementation, the iron may not be transferred to the fetus in adequate amounts.

Iron levels also affect epigenetic changes because the Jumonji group of histone demethylases is dependent on the presence of iron (Karuppagounder et al., 2015). A lack of iron could cause excess methylation and deactivation of important genes. Iron also helps to repair DNA that has been incorrectly altered epigenetically, as iron-dependent dioxygenases oxidatively remove inappropriately placed methyl groups from the DNA. This may represent an important mechanism of chromatin repair and can help to guard against damage to genetic material. More research on the specific epigenetic impacts of iron is needed, though its overall importance to cognitive development is well understood.

Iodine is another important micronutrient, primarily discussed in terms of the mother's levels, as it is involved in the synthesis of the thyroid hormones. A fetus's production of triiodothyronine,

one of the thyroid hormones, depends on the mother's thyroxine levels, which are in turn determined by the mother's iodine intake (Cusick & Georgieff, 2016). A baby's thyroid cannot make its own hormones until 18-20 weeks, and the thyroid hormones are needed in the weeks before that for the development of stem cells that become neurons. (Demeneix, 2019). Mattei and Pietrobelli (2019) posit that the thyroid hormones are essentially involved in all aspects of brain development. Consequently, it is imperative that pregnant women get enough iodine to make enough thyroid hormones for themselves and their babies.

Both neurons and glial cells have many receptors for thyroid hormones, indicating the broad functions of these hormones (Mattei & Pietrobelli, 2019). Maternal thyroid deficiency has been linked to a variety of deficits, including limited neuronal growth and abnormal neuron location and function. The fetus is most sensitive to the mother's iodine, and subsequent thyroxine, deficiency during the first trimester, and severe deficiency can cause cretinism. Cretinism is a disorder characterized by difficulty hearing, speaking, and walking, and a low IQ (Cusick & Georgieff, 2016). The World Health Organization identifies iodine deficiency as the main preventable cause of brain damage (Tanner & Finn-Stevenson, 2002). Both mild deficiencies and high levels of thyroid hormones can be detrimental (Demeneix, 2019).

Thyroid hormones also operate epigenetically and are considered transcription factors. Demeineix (2019) explains that thyroid hormones attach to receptors that then act on genes that control DNA methylation and histone modifications. The thyroid hormones are unique in that their only mode of action is via epigenetics, so iodine represents one of the more epigenetically understood nutrients. Hence, ensuring that expectant mothers consume enough iodine is essential to fetal neural development. Though iron and iodine have clear cognitive mechanisms, there is uncertainty concerning zinc.

Less research has been done on the effects of zinc on the brain. Cusick and Georgieff (2016) are confident that zinc is needed for the growth, development, and communication mechanisms of neurons. However, this is based on preclinical animal models, and there is a lack of clinical evidence of the cognitive effects of zinc. Tanner and Finn-Stevenson (2002) agree that zinc has been linked to neurophysiology but believe more research is needed. Mattei and Pietrobelli (2019), whose research is most recent, believe that is it clear that severe zinc deficiencies lead to major alterations in brain structure. Clinical trials are not currently feasible, because there is no way to directly measure zinc within the body (Tanner & Finn-Stevenson, 2002). The epigenetic influences of zinc are better understood, because there are zinc-dependent enzymes that are involved in histone modifications of DNA (Karuppagounder, 2015). Zinc deficiency can thus cause excess expression of certain genes. This is especially detrimental within the brain because neurons are highly differentiated, or specific. Turning on the wrong genes could inhibit a neuron from functioning properly, impacting cognition.

The B vitamins represent an important nutrient for early brain development, and their epigenetic actions are well understood. It is generally well known that folate, also known as vitamin B9, and vitamin B12, are important for central nervous system development (Geoffroy et al., 2016). The lack of enough of either of these vitamins can lead to various adverse cognitive conditions. Common disorders that result from this deficiency include neural tube abnormalities and general breakdown of brain tissues. Physicians work to educate pregnant women to ensure that they are obtaining the B vitamins they need to nurture the growth of a healthy baby.

Adequate folate intake during pregnancy helps to protect a fetus from neural tube disorders, and folic acid supplements are usually recommended to women during their first trimester (Geoffroy et al., 2016). However, Geoffroy et al. (2016) sought to uncover if late term folic acid supplementation could also be beneficial to fetuses. Using an animal model, central nervous system disorders were reduced with folic acid supplementation late in gestation. Late supplementation may thus be recommended to high-risk women in the future. Xu et al. (2021) note that after birth, there is a very small window for B vitamin supplementation, and early deficiency can cause permanent detriments to brain development. It is essential that fetuses and young children obtain adequate B vitamins to avoid major cognitive issues.

Vitamins B9 and B12 are well understood epigenetically because they are required for DNA methylation (Barra et al., 2018). Geoffroy et al. (2016) explains that they are needed for the creation of a chemical that can donate methyl groups to a variety of DNA sections. Disorders caused by a lack of adequate methyl donors are associated with increased expression of certain microRNAs, which help to control gene expression. The main miRNAs involved in methylation within the brain are let-7 and miR-34, and when there are not enough methyl donors, miRNAs increase, causing their targets to be downregulated, leading to cognitive problems. Though generally not the focus of epigenetic research, miRNAs serve a major purpose within the brain and often act epigenetically. MiR-34a is involved in maintaining normal neuron function. Let-7 impacts the prevalence of the Trim 71 protein, which helps to ensure that the neural tube closes properly and is involved in cell differentiation. High let-7, as is the case with a lack of methyl donors, lowers Trim 71, causing issues with neurons and their differentiation. In summary, folate or B12 deficiencies cause hypomethylation, leading to increased miRNA expression, resulting in downregulation in signaling pathways and subsequent damaging changes to brain development.

These changes can sometimes be reversed. Geoffroy et al (2016) found that not having enough methyl donors in the fetal brain decreased DNA methylation throughout the genome, but this was resolved with folic acid supplementation. The value of late term folic acid supplementation is also due to the normalized methylation and subsequent downregulation of let-7 and miR-34. Folic acid supplementation lowers the high let-7 and miR-34 levels caused by hypomethylation, allowing their targets to function normally. Other methods of reducing the expression of these miRNAs allows their associated pathways to commence, leading to better brain development. Folate and vitamin B12 have major impacts on early brain development due to their role as methyl donors and subsequent impact on miRNAs.

## CONCLUSION AND FUTURE RESEARCH

The major nutrients needed for proper brain development are categorized as those in breastmilk, as well as proteins and micronutrients. Their actions are best conceptualized by including epigenetic mechanisms in their discussion. Epigenetics is a relatively new field of science that confers plasticity to the brain. The same DNA can be expressed differently based on one's environment and diet. Iodine and B vitamins are two of the major nutrients that seem to be adequately researched, and their mechanisms are generally well understood (Cusick & Georgieff, 2016; Geoffroy et al., 2016). However, the other essential nutrients require further study.

Breast milk has long been hailed as healthy for infants, and while it is clearly linked to some aspects of DNA methylation, more research can help to explain exactly how the components of breast milk promote healthy methylation patterns within the brain. It is also unclear why breastfeeding has not been clearly linked to long-term gains in cognition when methylation patterns tend to be relatively stable throughout one's lifetime. While it is beyond the scope of this paper, the possible toxins and microplastics found in breast milk must be examined to understand any caveats for its usefulness. The epigenetic impact of proteins is well researched, but the impact of related energy deficiencies on ATP dependent chromatin remodelers within the brain is a potential avenue for further study.

More research can also be done on the epigenetic implications of iron and zinc deficiencies. Zinc studies are still in need of a better way to measure the body's zinc levels, so this research may have to wait until measurement tactics are developed (Tanner & Finn-Stevenson, 2002). Understanding the epigenetic effects of nutrients is important for medical practitioners to know so that they can best educate their patients. Physicians can explain that the expression of one's genes can be heavily impacted by nutrition, and a family history of

a certain trait does not guarantee its manifestation in an individual. Many families are more likely to give their child a supplement or include a certain food in their diet if they understand exactly why it is important and what the nutrient will do. The current literature does not explain the epigenetic value of nutrients in a way that is understandable and accessible to parents, so this thesis fills that gap in the literature. Pediatric brain health is essential for providing people with the best cognitive foundation possible to facilitate them living as healthy and independent adults.

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# Getting Ready to Learn: The Role of Agitation Level on Children's Recall of Learning Events

*Regan Benton*

**ABSTRACT**

The purpose of the current study is to extend the literature on children's ability to reflect on their learning by looking at the impact of learning via a recorded video (rather than live in-person) and the impact of agitation on learning. This is an important area to investigate in elementary-aged children, as all children were learning via recorded videos or online during COVID-19. The jumping jacks were used as a method of agitation to see how agitation impacts a child's learning. Thirty-three children (ages 4-9 years) were divided into two conditions, one that did ten jumping jacks before learning and one that did nothing before learning. Children then watched a pre-recorded event and answered open-ended along with dichotomous questions about their learning. Results indicated that older children could more accurately recall the facts they learned and how they learned them. There was no impact on the experimental condition looking at agitation levels.

You are getting ready to learn; is a single source teaching you or are you learning through an experience? When you are getting ready to learn how do you prepare? Do you take notes? Do you give credit to the one you are learning from? Where did you learn these habits? According to the Oxford dictionary, learning is defined as "the acquisition of knowledge or skills through experience, study, or by being taught (*Oxford Advanced Learner's Dictionary,* n.d.)." Previous research has looked at developmental and gender differences in children's understanding of how and when they learn. The purpose of the current study is to extend the literature on children's ability to reflect on their learning by looking at the impact of learning via a recorded video (rather than live in-person) and the impact of agitation on learning. Current research findings about the role of agitation on learning are inconsistent, so we did not have a prediction about the role of agitation on children's memory in our current study. We did expect that learning from a video in our current study would limit the children's ability to recall since distractions may arise in the Salisbury Zoo and previous research has shown outcomes from learning with online tools do not meet the levels of learning in person. Understanding how using pre-recorded videos in children's learning is beneficial to know, due to the ways of learning over the last couple of years. COVID-19 changed the structure of learning for children, yet they previously were not the subjects of understanding online tools for learning in research. Agitation is another new focus as discussion arises looking at whether children benefit from physical exercise or if it is a distraction.

## CHILDREN'S UNDERSTANDING OF LEARNING AND RECALL OF LEARNING EVENTS

Taylor, Esbensen, and Bennett (1994) conducted a seminal study on children's knowledge acquisition where they investigated a child's ability to report when they had learned novel facts in four experiments, of which the third and fourth experiments are most relevant to the present study. Children in experiment three were taught two new color words (chartreuse and taupe) through a learning event involving two bear puppets, Betsy and Barnaby. Specifically, children were taught and then asked to identify the novel colors because they were helping Betsy and Barnaby pick colors for their house and clothes. For comparison, children were also asked to identify familiar colors. When the child picked up the correct color, they were then asked three questions "Did you know the color yesterday? Did you know the color when you were three years old? Have you always known the color (Taylor et al., 1994)?" If the child said no to question one, then the questioning stopped and similarly, if the child said no to question two then the questioning stopped. The results show a 4-year-old could not differentiate between information they had known a long time (the color yellow) versus the information they just learned (taupe). On the other hand, 5-year-olds were able to report knowing the color "yesterday" when asked about familiar colors, and when asked about novel colors they recognized they had just learned them. Experiment four explored how to elicit more correct responses so there were modifications during the interview. This experiment contained an explicit condition where the bear specifically stated they were teaching the child a novel color. Even with this modification, the accuracy of answering questions correctly was not high, with only 2 out of 14 4-year-olds answering all six questions correctly.

Regarding children's understanding of learning, Sobel, and Letourneau (2015) investigated how children understand learning. They looked at how children defined learning and their examples of facts they had learned and how they had learned them. Children's definition of learning was coded as either being a process definition; learning as an active process or a strategy, or a non-process definition; learning as the content learned, or simply saying learning means "to learn." Results indicated while few 4-5-year-olds could offer a process definition of learning (41.86%), the majority of 6-7 year olds (66.67% ) and 8-10-year-olds (94.74%) responded with process-based responses. Furthermore, older children gave more examples of their learning. This study indicates that by the age of 8, children understand learning as a process and can reflect on ways they learned in the past which impacts their ability to reflect on the facts they had learned. Both Taylor et al. (1994) and Sobel and Letourneau (2015) found that 4-year-olds were near floor-level performance in their ability to report on their own learning and define learning. However, a series of studies by Bemis et al. (2011) found that 4-year-olds are capable of reporting on their own learning at a modest level.

The main purpose of the Bemis et al. (2011) study is to look at children's memories of a learning episode associated with their factual knowledge. In this study, the children (ages 4-9 years) were asked six factual knowledge questions that were age-appropriate (i.e., what goes oink and lives in a sty?) and if they remembered the moment, they learned the answer to these questions. For both age groups, the majority of children (including 4-year-olds) reported at least one episodic memory of when they acquired the factual information. In contrast to Taylor et al. (1994), 4-5-year-olds were able to identify episodic memories that were the sources of their knowledge. This study was the first to demonstrate that preschoolers can recall and describe past learning episodes.

Bemis and Leichtman (2013) extended this research to include staged learning events where

memory accuracy could be assessed. The method used was to present learning events that were stimulating and interactive to capture children's memory as if they were learning a lesson in a classroom environment. In this study, the children learned about the Aleutian Island and the visual system. The children would learn about one learning event, then 4 to 5 days later learn about the other staged learning event. Two or three days after learning about the second staged learning event, the children were interviewed and asked six staged event questions and four factual knowledge questions, which were randomly selected trivia questions from Brain Quest Games. The factual knowledge questions were included to replicate the findings of Bemis et al. (2011) and to avoid a response bias where the children would say they learned the answers during the staged learning event. Therefore, the children had to consider where they are learning the information from as the factual knowledge questions were not a part of the staged learning event. Both age groups, 4-year-olds and 5-year-olds, indicated that they recalled an episodic memory when they learned the answer to a factual knowledge question in over one-third of their responses (39.6%), which is consistent with Bemis et al's. (2011) findings. Further, 50% of 4-year-olds and 67% of 5-year-olds correctly identified the staged learning event in at least one of their memories. There was no statistically significant difference between the two age groups. Children's performance in Bemis et al. (2013) was surprisingly good which elicited the idea to improve performance by lessening the demands of the task.

## RECALL FACTORS

To investigate factors that could impact children's accurate recall, Bemis and Leichtman (2019) conducted two studies to look at the effects of imposing varying delay intervals on young children's ability to accurately recall learning episodes in connection with facts they learned. The first study used the same naturalistic task developed by Bemis et al. (2013) but reduced some of the demands of the task that had been shown to hinder children's recall. Specifically, for study one, the task was modified where children were interviewed about each event so the only source distinction was between material learned in that specific staged event and material not presented in the event, and children were interviewed immediately after each event occurred. The age groups were the same as in Bemis et al. (2013), 4 and 5-year-olds. With these modifications, it was hypothesized that children's performance would be maximized. Children's overall accuracy when being interviewed was considerably low for 4-year-olds (14% and 7% for the visual system and Aleutian Islands event), while 5-year-olds showed 55% accuracy, disclosing at least one memory where they accurately identified the staged event. These results were substantially below the level of accuracy seen in Bemis et al. (2013), even with reduced task demands. In study two, there were three main differences from study one. The children only completed the Aleutian Island event and were divided into two randomly assigned delay conditions. One group was interviewed immediately after, and one group was interviewed 2-3 days after the staged learning event. 5-year olds who were interviewed after a delay provided a significantly greater proportion of accurate memories while there was no effect of delay on 4-year-olds accurate memories. 4-year olds overall accuracy rate was 50%, but at least one accurate memory occurred 38% of the time in the immediate condition and 25% in the delay condition. These number are low in contrast to Bemis et al (2013). However, 5- year-olds were only below the accuracy rate from Bemis et al. (2013) in the immediate condition (29% accurate), but comparable in the delay condition at 63%. This research shows that older children may benefit from a small delay interval when reflecting on their own learning.

Another factor that can impact a child's recall is conversations with adult caregivers about past events. Leichtman et al. (2017) research shows how parent-child conversations help children recall learning events. Children were taught about light in their classroom and that night their parent was told "Today at school, children had a visit from a scientist who taught them about light. We would like you to talk with your child in whatever way is natural for you about this event (Leichtman et al., 2017)". In addition to parents talking to their children about the learning event, they were also told to ask their children about a non-related event. Six weeks later the children were interviewed about the learning event about light. The way parents talked to their children was investigated and compared to what the child remembered about the learning event. During the interview with the child, some parents mentioned more novel concepts, activities, and details using more elaborativeness and descriptive language. Parents who used elaborativeness and descriptive language correlated with the children's use of descriptives such as the number of novel objects, concepts, and other details the children mentioned during the conversation with their parents. Parents who used descriptive language then saw their children using them. Elaborativeness was significantly correlated with children's recall of novel details in the interviews. The memory of children whose parents used descriptive language was significant across age and gender variables.

Along with factors such as descriptive language, the types of details queried have also been shown to impact children's ability to recall learning events. Tang and Bartsch (2012) focused on whether young children were better at recognizing how versus when they learned something. The researchers presented the children with different colored drawers with different toys in the drawers. In the seeing condition, children were shown what was in the drawer, and in the telling condition, they were told what was inside. A week later an experimenter returned to the classroom and ran the experiment again but used different items and the drawers were different colors. Children were asked to recall the contents of these new drawers as well as the drawers they had seen the week before. They were asked, "What is in this drawer, how do you know there is a _____ in the drawer? Did you see it, or did I tell you? Did you learn that there's a toy _____ in this drawer today or before today (Tang and Bartsch, 2012)?" Results showed children reported knowing how knowledge was acquired (e.g., they say saw the toy in the drawer rather than hearing about it) more correctly rather than when knowledge was acquired (e.g., that they saw the toy in the drawer last week vs. Today). To follow up on children's ability to report on when they learned, Tang and Bartch (2012) ran a second experiment varying the wording of questions focused on "when" learning occurred. The procedure was the same as experiment one, but the questions were asked as the following "Did you know that there's (a toy) in this drawer yesterday? Which have you known about longer, the X toy or the Y toy (Tang and Bartsch, 2012)?" Experiment two showed that children answered questions about when knowledge was acquired better when asked in the temporal distance "Which have you known longer, the X [a toy] or the Y [another toy]?", rather than temporal location such as "did you know that there's X [a toy] in this drawer yesterday (Tang and Bartsch, 2012)?"

## ONLINE LEARNING

Over the years, online courses and learning has been on the rise. Even before COVID-19 in 2020, there was research on the impact of online learning (Picciano et al, 2010). Online learning is discussed throughout this paper and refers to learning with online tools such as videos and materials on a tablet or computer for the student to consume. Before COVID, most K-12 students who took online classes were in high school and took the courses because their school did not offer the course (e.g., an advance placement class). This is in contrast to higher education where students could complete entire majors exclusively in the online format. Thus, it seems as if a foundation was established in higher education that would allow for the transition from in-person to online to be smoother, which was especially useful during COVID. Using online learning with younger children was limited before COVID thus the research is limited, so most studies look exclusively at higher education.

The U.S Department of Education conducted a metanalysis of studies investigating online learning (mostly in higher education) and found that distance learning had fewer positive results when the instructor involvement was low (Means, 2009). Moreover, they found that synchronous distance education was better. When looking at

the meta-analysis studies it seems that blended learning, combining in-person instruction with an online component, gives students more resources, time to learn, and promotes interaction amongst peers. This led to confounding variables between studies because they included both blended and distance learning. There are positive outcomes of blended learning over distance learning, but the extra variables were not promoted in exclusively online distance learning.

When looking at whether online learning is effective, there are other factors in the student's situation that are highly impactful (Adedoyin and Soykan, 2020). To learn online the student must have the technology to log on and have a stable Wi-Fi connection. Students (and their caregivers) must also be able to use and maintain their devices. Finally, students need a distraction-limited environment to learn, which may not be possible in every home settings.

## AGITATION

Agitation is an unpleasant state of arousal. An agitated person may feel stirred up, excited, tense, confused, or irritable (Agitation: Medline Medical Encyclopedia, n.d.). Stress and excitement are two factors that can accelerate heart rate. The sympathetic nervous system releases hormones that accelerate heart rate when stress and excitement occur (UC Davis Health, Sports Medicine, and Sports Performance, n.d.). Research has indicated that a state of agitation can influence the ability to learn (de Greeff et al., 2017; Welsch et al., 2021).

De Greeff et al. (2017) conducted a meta-analysis looking at 31 studies focused on agitation and learning. They found positive effects of agitation on overall cognitive functions (executive functions, attention, and academic performance) for acute physical activity and longitudinal physical activity programs in pre-adolescent children. The positive effects of acute physical activity were only found for attention. They also found positive effects of longitudinal physical activity programs which were consistent for all domains. This would indicate that continuous regular physical activity over several weeks would positively impact core learning domains.

Welsch and colleagues (2021) looked at children with ADHD and how physical activity (PA) interventions affect executive function (EF). Through a meta-analysis, Welsch compared chronic PA interventions on domains of EF in children with ADHD compared to no treatment groups. Three studies included working memory and they showed there was evidence of a large beneficial effect of PA on working memory. Moreover, PA that is higher in cognitive demand, like table tennis, showed a lower effect on working memory and attention than low cognitively demanding PA, like swimming. A possible reason for this could be that PA led to a cognitive overload in children. Research on children with ADHD has indicated that low cognitively demanding physical exercise, when combined with other forms of treatment, can improve performance on measures of executive functioning.

The purpose of the current study is to extend the literature on children's ability to reflect on their learning by looking at the impact of learning via a recorded video (rather than learning live in-person) and discover the impact of agitation on learning. Given the inconsistent findings regarding agitation and learning, we had no a priori hypotheses about how agitation would impact learning in the present study. We did expect that learning from a video would limit the children's ability to recall since there are distractions and previous research has shown outcomes from online learning do not meet the levels of learning in person (Means, 2009).

## METHODS

Thirty-three children (23 4–6-year-olds, $M_{age} = 5$ years, 3 months; 10 7–9-year-olds, $M_{age} = 8$ years, 8 months) participated in a one-session study at the local zoo in Salisbury, Maryland as part of a Living Laboratory partnership. One member of the lab approached families passing by the portable lab set up at the zoo to inform them about the opportunity for their children to be a part of a study. When families were approached, they were told that the research was being done in collaboration with the psychology department and Honors College at Salisbury University. They were told that the purpose of this research study was to look at how energy affects how children learn and how children remember facts they learned. They were also informed about what children would do in the study and the time needed to complete it. If the legal guardians agreed to the study along with their child, then they would sign a consent form. Along with the consent form, there was a short questionnaire that asked the legal guardians to indicate their child's birth month and year, their child's ethnicity, both of the child's legal guardians' ethnicity, and the highest level of education both legal guardians had completed. Based on the reports received from the legal guardians, 81.8% of children were Caucasian, 6.1% were African American, and 12.1% were Biracial. The ethnicities reported for mother/legal guardian one was Caucasian 78.8%, African American 6.1%, Biracial 12.1%, and 3% preferred not to respond. The ethnicities reported for father/legal guardian two were Caucasian 54.5%, African American 6.1%, Hispanic 3%, Biracial 3%, and 33.3% preferred not to respond. Most children (78.8%) came from a household where the first identified mother/legal guardian had taken some college classes or had a higher degree, including college degrees and graduate degrees, and 39.4% of the first identified mother/legal guardian had a graduate degree. Most of the second-identified fathers/legal guardians also reported having taken some college classes or having a higher degree (84.8%).

## PROCEDURE

The study took about five minutes for the children to complete. All children were interviewed outdoors at the Salisbury Zoo. First, children were randomly assigned to either the control or experimental groups. In the experimental group, children began the study by doing ten jumping jacks while in the control condition, children sat down immediately to watch the video. All children watched the same video where they were taught about the Aleutian Islands by the author's thesis advisor (called Rhy in the video) for three minutes and fifty seconds. During the video, the instructor Rhy introduced herself in the beginning so the participants knew who is talking which could be an identifier for how they learn. Rhy used props to help teach the children about the Aleutian Islands. These props were kept in a treasure chest with a gold cover. From the treasure chest, Rhy pulled out a globe that has a red circle around where the Aleutian Islands are. This is where she pointed to the different seas and oceans around the islands. Next, Rhy put away the globe and pulled out the map of Alaska from the treasure chest. Here she pointed out the state and how the Aleutian Islands are at the bottom. She showed how far away they are from the middle of Alaska by moving her finger to and from the middle of Alaska and the Aleutian Islands. Now, Rhy put away the map and pulled out a mini drawing of Alaska and people figures. This is when they pretended to have the people go on a trip. Rhy, moved the people from the top of Alaska to the middle of Alaska, to the Bering Sea, to the Pacific Ocean, and at last to the island in the Aleutian chain. At each location, Rhy announced where they were. In the end, Rhy gave an overview of what they learned and then said "bye" to the children. The goal of the video and the learning event is for the participants to at minimum learn 1) That the Aleutian Islands are in Alaska 2) You have to take an air taxi to get to the Aleutian Islands 3) There are two bodies of water, 4) The Aleutian Islands are far away and, 5) The Aleutian Islands are in the United States.

After watching the video, all participants were asked both free response and dichotomous-choice questions. The first free-response question was "Can you think of something you learned about the Aleutian Islands?". If the child did not respond, the researcher restated the question. If the children provided a fact they had learned, they were asked "How did you learn that?". The second free-response question was "Can you think of something else that you learned about the Aleutian Islands?". Once the child responded, the researcher would ask "How did you learn that?". The last three questions were dichotomous-choice 1) "The Aleutian Islands are part of what state? Alaska or Hawaii? 2) What do you have to travel in to get to the Aleutian Islands? A boat or an air taxi? 3) Are the Aleutian Islands next to the Atlantic Ocean or the Pacific Ocean?". Regardless of the child's accurateness to these

questions, following each question the researcher asked, "How did you learn that?" The researcher recorded the participant's answers on a data sheet with the participant's assigned number that would match them to the participant log. The participant log contained the participant's number, initials, age, gender, and if they were in the control or experimental group.

## RESULTS

The t-test looking at the conditions, control versus experimental, showed there were no significant results for the free-response questions, dichotomous choice questions, and the how questions (*n.s.*). The t-test looking at the age groups was consistent with previous research. Overall, older children performed better than younger children on all the questions. Results for each question type are reported below.

## CORRECTNESS

Free response**:** All the answers children provided to the free-response question about facts recalled (i.e., can you tell me something you learned about the Aleutian Islands), were coded for the correct number of facts children reported. Specifically, the number of the five key facts children reported were tallied. The five key facts taught in the learning event were 1) being in Alaska 2) being far away 3) using an air taxi 4) having two bodies of water or 5) being a part of the United States. Results showed that children provided some correct responses when responding to the free-response questions about the staged learning event. Younger children, 4-6 years olds, provided fewer correct facts than older children, $M = 0.74$ vs. $M = 2.50$ respectively., $t(33)= 4.15$, $p< .001$). A large percentage of younger children (47.8%) did not report an accurate fact when answering a free response question, which was reflected in the mean.

Dichotomous choice: All of the answers children provided in response to the dichotomous-choice questions (e.g., Are the Aleutian Islands part of Alaska or Hawaii?) were coded as being either correct or incorrect. Instances, where children could not provide an answer, or could not choose between the two choices (i.e., said both were correct) were coded as incorrect. Results indicate that both the younger children and the older children were able to recognize the correct answer to the dichotomous question. However, older children (M = 2.80) answer more questions correctly than younger children (M =2.13), $t(33) = 2.19$, $p = 0.04$. Children were asked "How did you learn that?" after they responded to each of the three dichotomous choice questions. Younger children reported less accurate details than older children, $M = 1.17$ and $M = 2.50$ respectively, $t(33) = 2.82$, $p = .008$. However, the majority of the younger children (52.2%) accurately reported the learning event as the source of their knowledge to at least one question.

## ACCURACY

The participants were asked "How did you learn that?" after answering each free-response and dichotomous-choice question. These questions were coded as being accurate or not. A response was coded as accurate if it included any mention of any detail associated with the learning event such as props in the video (globe, map, treasure chest), a person (Rhy, the teacher in the video), the location where the event took place (on the computer, the video, the show), or specifics from the script such as "because the Aleutian Islands are a part of Alaska". Results showed that children also provided accurate details when responding to the free-response question "How did you learn that?". The younger children reported less accurate details, $M=.13$, during their responses than the older children ($M=.80$., $t(33) = 2.61$, $p = .014$).

## DISCUSSION

The present study was performed to extend the literature on children's ability to reflect on their learning and to investigate the impact of learning via a recorded video (rather than learning live in-person) and the impact of agitation on learning. The present study shows that children can learn information about the Aleutian Islands and accurately recall details on how and when they learn the information presented via a video. Consistent with past research (Bemis & Leichtman, 2019), children's accuracy improved with age. Those who are older, 7-9 years, reported more accurate details and gave more correct responses to the free-response question, dichotomous-choice questions, and questions about the source of their knowledge. Thus, the older group consistently reported more facts and more correct source responses.

These findings are consistent with previous research. For example, Bemis and Leichtman (2019) found that older children were able to recall episodic memories after a learning event better than younger children. Sobel (2015) also reported that 8-10-year-olds reported process-based answers more often than the 4-6-year-olds which suggests older children understand learning as a process, which makes it easier to reflect on. The present study furthers the research on how children learn and suggests that, over a generalized population, younger children are developing a process-based understanding of learning while older children understand learning, making it easier to recall events.

The current study shows consistent data with previous research regarding age. This is significant because the current study used a video to show the learning event rather than the learning event being done in person, which had been used in all past studies (Bemis et al. 2013; Bemis & Leichtman, 2019). Therefore, it can be suggested that since the age groups performed consistently across many studies, learning via a video did not make a significant difference. The learning event in this study was similar to what may be used in a blended learning environment where teachers supplement face-to-face content with online content (Means, 2009). While the research on blended classrooms has predominately been conducted with older students, the result of the present study suggests that young students can also benefit from online content. Although further research should investigate this specifically, this is particularly important as more lectures and learning have been done online during COVID-19 and are continued to be kept online.

The conditions, control and experimental, did not have any significant differences from one another. Agitation simply did not affect learning in this study. As previous research showed inconsistent results, these results are not surprising. Replicating agitation in children during learning events is hard to examine as previous research and the current research have demonstrated. This suggests the intervention was too small and did not create high enough levels of agitation through heartrate variability for the experimental group to show any differences. The lack of differences could be due to the small sample size consisting of only 33 in total, 17 in the control group, and 16 in the experimental group. Also, since the laboratory was a zoo and the researcher was a stranger, the children may have already been agitated even if they were not in that condition. Other studies investigated more prolonged physical activity (de Greeff et al., 2017; Welsch et al., 2021) and included physiological measures of arousal (Gillie et al., 2014).

Overall, the results of the present study demonstrate that children can learn novel information presented in a video and the age differences in the recall of this information is consistent with past research. This is important because children do not appear to be significantly affected when the video was pre-recorded versus if the lesson was done live in-person. The agitation condition was not significant so it may be possible that children are already experiencing agitation in their environments. Future research on how children learn, and the impacts of learning online may be helpful to replicate the current study and should include a face-to-face condition for direct comparison of performance. Regarding agitation, using different methods, particularly long-term physical activity, might prove important as the existing research is not consistent.

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# Students Failing School or Schools Failing Students: Critical Thinking Education Deficits in Public American Secondary Schools

*Jane Simoncic*

**ABSTRACT**

While there is considerable emphasis on the importance and role of critical thinking in higher education and the workforce, effective critical thinking education is not provided to students by the public American secondary education system. Due to the noted contradiction, secondary students in the public American education system are failing to meet Common CORE standards and develop critical thinking skills sufficient for success in future endeavors, including postsecondary education, the workforce, and their daily lives. To address the gap in student knowledge, scholars noted that considerable research was completed on effective critical thinking education at the postsecondary level, finding a number of common trends among effective critical thinking education programs (Pnevmatikos et al., 2019; Snyder et al., 2019). However, scholars also expressed the importance of effective critical thinking education exposure at the secondary level (Darling-Aduana, 2021; Davies & Meissel, 2016). Based on parallels between critical thinking research completed at the secondary and postsecondary levels, effective higher education critical thinking programs should be assessed, modified, and applied to the public American education system. While the current parallels should act as a starting point, future research is imperative to determine best practices, align the school system more closely to Common CORE standards, and better prepare students for their futures.

**KEYWORDS**

Critical thinking, higher order thinking, secondary education, higher education.

## INTRODUCTION

Critical thinking is a set of skills involved in higher-level thinking at the cornerstone of successful completion of tasks and problem-solving for both students in higher education, college, and members of the workforce. Despite this importance, an effective method of integrating critical thinking education in public American secondary schools, i.e., high schools, is not being implemented (Darling-Aduana, 2021; Davies & Meissel, 2016). Scholars noted that many higher education institutions are developing methods for teaching and assessing critical thinking of their current students, but these methods are not without flaws (Bandyopadhyay & Szostek, 2019; Pnevmatikos et al., 2019). The majority of the current research is focused on emphasizing critical thinking at the higher education level; however, other experts expressed that it is also important to ensure that all students are exposed to effective critical thinking education at the secondary level (Darling-Aduana, 2021; Davies & Meissel, 2016). In order to address this inconsistency in critical thinking education, research at the higher education level may be, in some cases, able to inform public American secondary critical thinking education. Future research, using current parallels between critical thinking education at the secondary and higher education levels, is necessary to optimally teach, incorporate, and assess critical thinking at the secondary level in the public American education system to develop a citizenry more able to make thoughtful, informed decisions and judgments.

## CRITICAL THINKING AND ITS IMPORTANCE

Before the current state of critical thinking education implementation can be assessed, it is crucial to define critical thinking. Scholars generally define critical thinking as a set of skills, associated with analytical, higher-order, and multi-perspective thinking (Bandyopadhyay & Szostek, 2019; Ghanizadeh, 2017). This definition has considerable implications for the role of critical thinking in education. Critical thinking is a vast discipline of higher-order thinking and is versatile in its application. Although critical thinking is often associated with real-world problem-solving scenarios, this is far from its only application in educational instruction. For example, critical thinking can be incorporated into education via exercises, such as analyzing literature, interpreting data on graphs, and synthesizing cause and effect from historical documents. Furthermore, critical thinking consists of a large set of skills, which will not all be used in any given task that necessitates the use of critical thinking. Therefore, different measures of critical thinking and its effectiveness must be used in different situations. This definition and its implications serve as a framework for understanding critical thinking and its role in education.

While critical thinking is often considered in isolation, the relationships between critical thinking and other orders of thinking give insight into how various thought processes can be optimally used together. Notably, experts displayed that critical thinking is interrelated with another order of higher-level thinking: reflective thinking, which entails the ability to reflect on and assess information, events, and one's response after they occur (Ghanizadeh, 2017; Pnevmatikos et al., 2019). Critical thinking is more effective when used alongside reflective thinking, meaning that these orders of thinking should be fostered and applied together. This distinction adds a level of complication to critical thinking and its application. Solely focusing on critical thinking and neglecting to consider other orders of thinking can lead to ineffective thought processes and limit the positive impacts of critical thinking skills. Without other orders of higher-level thinking, critical thinking is not as effective and vice-versa. Acknowledging the interrelatedness of critical thinking and other orders of higher-level thinking, including reflective thinking, is necessary in order to ensure that critical thinking is not only being used in an effective manner, but also being taught effectively.

Beyond being an order of higher thinking, critical thinking is important for the academic success of higher education students. Ghanizadeh (2017) found that critical thinking skills were a positive predictor of grade point average at the higher education level (p. 108). This indicates that students with a solid basis of critical thinking were better higher achieving in postsecondary education.

Critical thinking skills can be used in many situations, including a variety of tasks asked of students in higher education courses. With strong critical thinking skills, students are better able to both complete individual assignments as well as reflect and assess their habits, misunderstandings, and quality of work in order to make improvements in the future. Students with effective critical thinking skills, then, succeed because they are able to apply knowledge across topics, regulate their work, and gain a deeper understanding of the material. When postsecondary students can effectively use critical thinking skills, they are more likely to get better overall grades and succeed in higher education.

Alongside higher education, critical thinking skills are instrumental in workplace success. Bandyopadhyay and Szostek (2019) highlighted the importance of critical thinking for professionals in the business sphere, indicating that critical thinking skills are integral in effective decision-making (p. 260). Critical thinking allows decisions to be made in a multi-perspective fashion, allowing members of the workforce to consider all possible outcomes and effects. The importance of critical thinking skills in professions is not, however, limited to one area. Kanbay and Okanli (2017) expressed that critical thinking allows nurses to better treat patients (p. 314). Decision-making is important in the workplace regardless of profession and can be developed through the use of critical thinking. For instance, an information technology professional may be asked by a client to diagnose and solve an error on an operating system, which requires consideration of sources of error, their likelihoods, how to diagnose the cause, and how to solve the issue while maintaining a positive image of their company. Critical thinking streamlines the decision-making process. Even beyond the work environment, the role of critical thinking in effective decision-making highlights its benefits for members of society as a whole, emphasizing the importance of teaching these skills at the secondary level.

## CURRENT STATE OF CRITICAL THINKING EDUCATION IMPLEMENTATION

Although critical thinking is shown to be imperative, critical thinking education is often not a priority for instruction at the secondary level. Experts indicated that students in secondary schools were more often taught memorization and recall skills than higher-order thinking (Darling-Aduana, 2021; Bandyopadhyay & Szostek, 2019). While memorization may be helpful in a classroom setting, higher-order thinking, including critical thinking, is much more applicable to settings outside of the classroom. When critical thinking is not emphasized in instruction, students will not learn critical thinking skills nor benefit from the previously mentioned positive impacts of critical thinking in postsecondary education or the workforce. It is important to note that Behar-Horenstein and Niu (2011) indicated some increases in critical thinking are intrinsic to life experiences (p. 37). However, relying on critical thinking developed solely through life experiences is nonoptimal and does not account for all students. Implementation of critical thinking in secondary schools is needed for the majority of students to develop sufficient levels of critical thinking skills. The public American secondary education system does a disservice to students by providing insufficient and ineffective critical thinking education.

While the lack of critical thinking education in the public American education system is noted at the secondary level, the resounding effects of the instructional gap are often evident in higher education. Behar-Horenstein and Niu (2011) indicated that the field of research on critical thinking education in the context of higher education is a rather large field and has been since at least the late 1990s (p. 28). Other experts noted that the driving force behind research on critical thinking education at the postsecondary level stems from insufficient levels of critical thinking skills in students entering higher education (Bandyopadhyay & Szostek, 2019; Pnevmatikos et al., 2019). The apparent focus on teaching critical thinking skills displays a disparity between the expected and actual levels of critical thinking skills of students entering postsecondary education. Therefore, a large proportion of students are entering higher education without appropriate levels of critical thinking skills, further cementing the notion that public American secondary schools are lacking in effective critical thinking education. The critical thinking education that does exist in the public American secondary education system is insufficient in fostering critical thinking skills, indicating that students are not being properly prepared for their futures. This cycle of events leads to a focus on critical thinking at the higher education level as postsecondary institutions take it upon themselves to implement critical thinking education.

Although students are not entering postsecondary education with sufficient critical thinking skills, students in the public American secondary education system are still expected to apply critical thinking. The Common CORE Standards, which the majority of American states adopted for use at the secondary level, ask students to answer questions based in higher-order thinking, with a focus on critical thinking, in subject areas including language arts, science, and math (Common CORE State Standards Initiative, 2010a; Common CORE State Standards Initiative, 2010b). The growing concern surrounding teaching critical thinking at postsecondary institutions indicates that Common CORE standards are not being fully achieved by many students at the secondary level. This raises a fundamental contradiction in public American secondary education. Secondary students are failing to meet the standards set by the public American education system because the critical thinking education provided is insufficient and ineffective in many cases. Amendments to the current system of teaching critical thinking at the secondary level in the public American education system are necessary for students to achieve Common CORE standards and benefit from critical thinking.

More than this contradiction alone, the inadequate critical thinking education provided to students by the public American secondary education system can have considerable negative consequences. At the secondary level, Darling-Aduana (2021) determined that expecting students to succeed in critical thinking tasks without appropriate critical thinking education could disenfranchise students in low-income situations, who are less likely to receive formal critical thinking education at any level (p. 10). Asking students to exhibit critical thinking skills without being first taught these skills, which happens most often in low-income school areas, is often discouraging and alienating. This possibility goes against the intentions of critical thinking education in public American secondary schools. While not providing critical thinking education has negative consequences, implementing ineffective critical thinking education programs comes with its own negative impacts, making these potential affects an important focal point when developing critical thinking programs. Critical thinking cannot be expected of students before providing adequate critical thinking education. Application and assessment of critical thinking play an important role in education, but the teaching of critical thinking is crucial. If students are expected to complete critical thinking tasks, they deserve to be afforded opportunities to learn critical thinking through instruction that facilitates the learning process.

## POSTSECONDARY CRITICAL THINKING EDUCATION

Acknowledging the current state of critical thinking education in public American secondary schools, change is needed to better prepare students for their futures and align the school system more closely with Common CORE standards. However, some proponents may claim that critical thinking is not teachable. Behar-Horenstein and Niu (2011) indicated that some past research claimed that critical thinking cannot be taught and that many gains in critical thinking may be a result of outside factors and life experiences (pp. 26, 37). While some increases in critical thinking originate from outside factors, recent research has determined that critical thinking education programs can be effective at increasing critical thinking skills. For example, Kanbay and Okanli (2017) found that a critical thinking education program was effective in facilitating the growth of critical thinking and

problem-solving skills (p. 319). The results of this study indicate that critical thinking is largely teachable and progressive. Not every critical thinking program or implementation will yield significant student growth in critical thinking skills because several factors contribute to the success of these programs. Nonetheless, effective critical thinking programs do exist and can inform future critical thinking education.

Since critical thinking is shown to be teachable, higher education institutions incorporate critical thinking education, and in doing so, several methods have been researched for their effectiveness at teaching, activating, and assessing critical thinking skills at the postsecondary level. Overall, scholars found that effective higher education critical thinking programs involve the use of explicit teaching methods, as well as long-term critical thinking instruction (Behar-Horenstein & Niu, 2011; Snyder et al., 2019). While implicit critical thinking education can act as a supplement, explicit instruction, in which students are taught about specific critical thinking processes and how to apply them, tends to be more effective. In addition, explicit instruction is less likely to cause negative effects by ensuring that more students are able to learn critical thinking skills. This is particularly true when critical thinking strategies and skills are being introduced to students who may not have sufficient experience with critical thinking education. On the other hand, long-term instruction of critical thinking leads to larger increases in critical thinking skills and encourages students to apply these skills in more contexts. Effective critical thinking programs at the postsecondary level are developed around the cornerstone of explicit, long-term instruction in order to increase positive student outcomes.

Beyond the overarching traits of effective critical thinking education programs at the postsecondary level, some aspects of programs specifically enhance the activation and teaching of critical thinking skills. Pnevmatikos et al. (2019) indicated that creating a stepwise approach and incorporating reflective aspects may be tied to effective activation and teaching of critical thinking (pp. 896, 900). It is essential to note that both aspects stem from the importance of explicit instruction. Stepwise approaches allow students to break critical thinking processes into more manageable parts and relate those parts to each other. Students working through steps prompting them to complete tasks, such as perspective identification, can use the framework provided to gain an understanding of where to start, what steps are required, and what order to complete them in. The same concept is true of incorporating reflective aspects; students will be better able to make connections and develop other orders of higher-level thinking if reflective thinking is explicitly synthesized with instruction. Ensuring that students understand how critical thinking works and what thought processes are involved augments the effectiveness of critical thinking education in activating and teaching critical thinking skills.

Alongside teaching and activating critical thinking, effective critical thinking programs must assess critical thinking skills and growth, which can present its challenges. Experts determined that effective assessment of critical thinking relies on using a variety of measures to assess different types of critical thinking and focusing on qualitative responses (Bandyopadhyay & Szostek, 2019; Pnevmatikos et al., 2019). Different critical thinking skills require the use of different thought processes. In the same way that it would be unreasonable to assess a student's understanding of history by giving them a mathematics test, there is no universal test for specific critical thinking skills, necessitating the use of different tests or measures in different scenarios. Additionally, critical thinking education focuses on the development of thought processes, meaning that how a student decides on an answer is as important as the answer itself. Therefore, qualitative, open-ended responses are more suitable for representing and assessing critical thinking. Effective assessment of critical thinking skills using these factors allows student growth and understanding to be communicated to both the instructor and the student such that future teaching can be informed.

While there is some consensus about the effective aspects of critical thinking education, there is less consensus surrounding postsecondary teacher training. Experts agreed that the training given to instructors was an integral facet of critical thinking programs; however, little elaboration was provided on what constitutes effective training (Pnevmatikos et al., 2019; Snyder et al., 2019). Critical thinking education requires that students develop an in-depth understanding of higher-level thought processes. If instructors lack sufficient understanding of how to explain and foster critical thinking skills themselves, effective critical thinking education is not possible. The Foundation for Critical Thinking (2019) provided resources for training higher education instructors how to teach critical thinking but noted that these resources alone are short-term and not optimal (para. 2). As established, critical thinking is progressive and benefits from long-term instruction. In the same way, optimal critical thinking education requires long-term training for educators. Without a defined teacher training method, educational institutions, at both the secondary and higher education levels, are limited in their ability to apply peer-reviewed critical thinking research in order to improve critical thinking among students.

Acknowledging the importance of teacher training in effective critical thinking education, some factors are suggested as guidelines for preparing instructors to foster, integrate, and assess critical thinking of postsecondary students. Edwards et al. (2016) indicated that effective training in one model included continuous, long-term training for teaching specific critical thinking skills and periodic feedback (pp. 8-9). While long-term critical thinking education training requires more time and monetary investment, the benefits of effective teacher training justify the use of these additional resources. The model emphasized teacher growth, meaning that instructional methods did not stay stagnant. Rather, through additional training and specific, detailed feedback, instructors are able to identify strengths and weaknesses and continue to improve in their critical thinking education approaches. Short-term educator training can provide context and information on critical thinking, but long-term training is needed for genuine improvement of critical thinking education.

## APPLICATION OF POSTSECONDARY CRITICAL THINKING RESEARCH AT THE SECONDARY LEVEL

Although there is not a large amount of research on critical thinking education at the secondary level, many of the same methods from research at the higher education level could possibly be adapted for use at the secondary level. Davies and Meissel (2016) reported that Quality Talk, one pedagogy for critical thinking education that encourages students to converse with critical dialogue, was an effective method of both teaching and activating higher-level thinking, including critical thinking, at the secondary level (p. 360). The results of this study indicate that effective critical thinking education is possible to implement at the secondary level. Furthermore, the specific traits of the Quality Talk program can serve as a foundation of understanding for what factors may contribute to the effectiveness of critical thinking education at teaching, incorporating, and assessing critical thinking in public American secondary schools. While this study is limited in scope and focuses on a small number of critical thinking skills, the overarching traits of effective critical thinking programs tend to remain constant across educational disciplines and specific critical thinking skills. Therefore, Quality Talk can be used as a baseline for effective secondary level critical thinking education in order to develop new solutions.

While Quality Talk is only one program, there are significant parallels between this method of critical thinking education and programs developed for use in higher education. Davies and Meissel (2016) noted that Quality Talk relies on qualitative responses, using multiple assessment measures, and giving instruction in steps in order to provide and support effective critical thinking education (pp. 347-349). These aspects share considerable similarities with foundational elements of effective critical thinking programs developed at the higher education level. The similarities indicate that some key aspects of critical thinking education programs may be conserved between the secondary and postsecondary levels. Furthermore, Davies and Meissel (2016) indicated that the Quality Talk

program uses explicit teaching methods and focuses on providing detailed teacher training (pp. 346-348). These factors are once again consistent with research completed at the higher education level. The numerous traits associated with critical thinking education at the secondary and higher education levels indicate a relationship and similarity between the two. This means that research on critical thinking education at the higher education level can serve as a starting point for reforming public American secondary critical thinking education.

Although there are notable parallels between critical thinking programs developed for use at the higher education and secondary levels, this does not indicate that all programs can be used interchangeably between the two. For instance, Darling-Aduana (2021) determined scaffolding of instruction to be of particular importance at the secondary level in order to prevent negative consequences resulting from improper critical thinking education implementation, including disenfranchisement (pp. 7-8). Scaffolding of instruction ensures that students learn each step of a critical thinking process, which means that students are less likely to be expected to exhibit critical thinking skills without first being directly taught them. While scaffolding of instruction is often not included in critical thinking programs developed at the higher education level, it can be incorporated with these programs to be applied to secondary education. Programs that implement a stepwise approach can be scaffolded easily by providing instruction and information on critical thinking processes at each step. In this way, a larger proportion of postsecondary critical thinking education programs can be implemented at the secondary level after the differences between the two levels are considered and accounted for.

Whereas it is clear which programs are effective at the postsecondary level and that some programs may need to be adapted before application at the secondary level, it is more difficult to determine which programs developed for higher education could be applied to the public American secondary education system. Snyder et al. (2019) proposed a series of traits that contribute to effective higher education critical thinking programs, which breaks down the aforementioned effective aspects, as well as some additional aspects, in order to provide a framework for designing and implementing critical thinking education (pp. 129-133). While not every effective critical thinking education program uses all these traits, programs that do are more likely to be effective at the postsecondary level. This indicates that the framework can predict the effectiveness of postsecondary critical thinking programs. The same parallels between Quality Talk and critical thinking programs developed for use at the postsecondary level exist between Quality Talk and the proposed framework, meaning the framework may apply to the secondary level in the same way it applies to the higher education level. The proposed framework can be used as a tool to initially determine which higher education critical thinking programs may be relevant to application in the public American secondary education system.

While it is acknowledged that most of the research on critical thinking education was completed at the postsecondary level and not every program will be useful for secondary education, this research can be reviewed, manipulated, and applied in a thoughtful, informed manner. Behar-Horenstein and Niu (2011) indicated that research on critical thinking education, in general, is limited by factors such as convenience samples and nonrandom group assignment (p. 33). While trends between critical thinking education at the secondary and postsecondary levels are evident, there is no way to guarantee that these trends are not impacted by confounding variables without more research on critical thinking education at the secondary level. The possibility of ineffective critical thinking education causing considerable negative consequences must be considered. Therefore, critical thinking education at the secondary level requires careful deliberation of numerous factors to adjust existing higher education critical thinking programs for implementation. Future research is needed to optimize critical thinking education and ascertain best practices, but current parallels between critical thinking education at the secondary and higher education level should serve as a basis to inform this future research.

## CONCLUSION

To begin the reform of critical thinking education in the public American secondary education system, some critical thinking research from the higher education level should be reviewed, altered, and applied to the secondary level. If nothing else, scholars agree that critical thinking education at the secondary level should be a priority (Bandyopadhyay & Szostek, 2019; Darling-Aduana, 2021; Davies & Meissel, 2016). The current critical thinking education provided by the public American secondary education system is insufficient in meeting Common CORE standards, fostering critical thinking, and preparing students for success. In order to ensure that critical thinking is being taught effectively, future research must be completed at the secondary level using current research and best practices from the postsecondary level as a starting point. Without sufficient critical thinking education at the secondary level, students will continue to enter higher education, the workforce, and their daily lives unprepared to examine the world around them and make thoughtful decisions, perpetuating the cycle that is enforced by the failings of the public American secondary education system in fostering critical thinking.

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# Beacon

*Joshua Killen*

**ABSTRACT**

*Beacon,* a sculpture made of cast iron resting on a spherical steel armature, was created in Laura West's Direct Metal Sculpture course. This work was sculpted using the ceramic shell method for iron casting. The original pattern was created in wax and then dipped into a ceramic-based slurry. After several dips and drying sessions, the slurry hardened into a shell, and the wax was melted out. Finally, molten iron was poured into the ceramic shell mold where it cooled and hardened into its final form. This piece was designed to resemble a spheroid of linking and converging skulls, representing the dead. Face bones appear fused together as if blending from one skull to the next. The unclear orientation of the skulls contributes to the sculpture's dizzying, otherworldly effect. The fragmented nature of the conjoining bones creates negative space within the spheroid. Once light illuminates this space from within, the sculpture can function as a beacon, ultimately summoning the spirits of the deceased. The visual aesthetic of this piece was inspired by the skeletal décor in the Sedlec Ossuary, a Roman Catholic chapel in the Czech Republic that is more famously called the Bone Church or Church of Bones. The 19th century Spiritualist Movement which took place in the United States influenced the title and intended function of this sculpture as spiritual mediums from the time were presumably able to communicate with spirits of the departed using similar devices.

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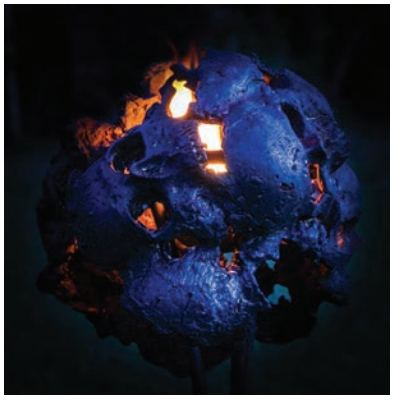

# The Adaptation of the "American Family": How Jeff Franklin's *Full House* Normalizes Unconventional Family Situations

*Georgia Foster*

**ABSTRACT**

This study examines the ABC network prime time situation comedy *Full House*. Although it aired from 1987 to 1995, examination of *Full House* is warranted as the program has maintained its popularity and continues to appeal to new generations of viewers. *Full House* portrays a widowed father who invites his best friend and his brother-in-law to move in and help him with the task of raising his three daughters. The three men do their best to tackle the responsibilities of parenthood while still growing up themselves, dating, and starting careers. Despite it all, this nontraditional family seems to find its way and viewers are left with a heart-warming life lesson as each episode draws to a close. The aspect of *Full House* that causes it to stand out from other programs, especially those during the time in which it aired, is that the program portrays three men successfully taking on duties conventionally associated with women. As a result, *Full House* viewers are encouraged to see nontraditional family situations as acceptable and as legitimate as traditional ones. Accordingly, this study seeks to demonstrate specifically how *Full House* operates rhetorically to shape audience attitudes about notions of family. Three episodes were deliberately selected that feature nontraditional family representations. A close reading of each episode produced three noteworthy examples which were then subjected to textual analysis.

## INTRODUCTION

***Full House*** was a popular sitcom that ran from 1987 to 1995. The series was created and produced by Jeff Franklin and could be watched on ABC during the channel's "TGIF" lineup on Friday nights. Although the show ended, it is still popular today and available to rent, buy or stream. *Full House* follows a fictional family that lives in San Francisco, California. The family is spearheaded by neat-freak, hug-wielding, widowed father, Danny Tanner (Bob Saget). Following the passing of Tanner's wife, Pam, in a car crash, he questions his ability to properly raise his three young daughters including D.J. (Candace Cameron Bure), Stephanie (Jodie Sweetin), and Michelle, (played by both Mary Kate and Ashley Olsen). Tanner decides to invite his brother-in-law Jesse (John Stamos), who is laid back and a bit egotistical, along with his struggling stand-up comedian best friend Joey (Dave Coulier), to move in with him. He does so in the hopes that they will help him navigate this new chapter of his life. Chaos ensues as the three girls grow up and face challenges when it comes to school, friends, boys, and more. Danny, Jesse, and Joey do their best to tackle the responsibilities of parenthood while still growing up themselves, dating, and starting careers. Despite it all, this nontraditional family seems to find its way and viewers are left with a heart-warming life lesson as each episode draws to a close.

The aspect of *Full House* that causes it to stand out from other programs, especially those during the time which it aired, is that the program portrays three men successfully taking on duties conventionally associated with women. As a result, *Full House* viewers are encouraged to see nontraditional family situations as acceptable and as legitimate as traditional ones. Accordingly, this study seeks to demonstrate specifically how ***Full House*** operates rhetorically to shape audience attitudes about notions of family.

## JUSTIFICATION OF THE STUDY

A variety of sources have addressed *Full House's* influence, as well as its popularity, thus establishing the program's worthiness for study. Douglas (2014) said *Full House*"... pave[d] the way for more non-traditional family structures that were eventually revealed in the realm of sitcom. .." Weiss and Wilson's (1998) study of 148 school-aged children ranging from kindergarten through the fifth grade yielded empirical evidence of *Full House's* influence on attitudes about family. They found that "children rated the depictions in *Full House* as very realistic ... [and] on average, children indicated that 'most' to 'all' real-life families are like the family in *Full House* ..." (p. 605). Loock (2017) described *Full House* as "a cornerstone of ABC's TGIF lineup consistently ranking among the top twenty prime-time shows" (p. 362). Moreover, "... the reruns have remained a ratings juggernaut ... long after [*Full House's*] initial broadcast and in a very different televisual landscape that has since embraced narratively complex dramas and edgy sitcoms" (p. 362). Villareal (2016) pointed out that *Full House's* popularity and exposure grew after its network run through constant syndication both domestically and internationally in nearly 200 countries. Finally, in covering the release of Netflix's 2016 *Full House* reboot fittingly named *Fuller House*, Dyball (2016) noted that photos of an episode's script posted on Instagram by John Stamos received "more than 125,000 likes. And the show's official teaser ... garnered 14 million-plus views ..." (p. 70).

## METHODOLOGY

For sampling purposes, episodes of *Full House* were viewed on the HBO Max streaming platform. Three episodes were deliberately selected that feature instances in which the Tanner family's nontraditional structure was reinforced. One episode was selected from season one, one from season three, and a third from season eight. Selecting multiple episodes for analysis demonstrated the persistence of the program's message about family throughout the series. A close reading of each episode was conducted, and three noteworthy examples of nontraditional family representations were identified. Each example was then subjected to a textual analysis as this critical approach "takes an in-depth interpretive approach to a program to understand what it might be saying about identity and how representations fit within broader cultural assumptions and contexts" (Mittel, 2010, p. 310).

## ANALYSIS AND DISCUSSION

The first example considered, which centers around

sibling rivalry, was selected from an episode from the first season titled "Sisterly Love" (Ripps & Chemel, 1988). Throughout the episode, Stephanie and D.J. are at odds with one another after Stephanie accidentally lands a cereal commercial role that Jesse had originally recommended for D.J. The conflict begins when Stephanie, who tags along with Jesse and D.J. to the studio, catches the director's eye while eating Oat Boats cereal, and he deems her adorable, offering her the role instead. Although unintentional, Stephanie is excited to get the part, evoking jealousy and anger from D.J. For example, at one point in the episode, as Stephanie rehearses at the kitchen table, D.J. laughs and gives her dirty looks. This causes Stephanie to become frustrated and say, "If I'm doing something wrong, will you help me?" D.J. replies with, "You didn't need any help stealing my part" further exhibiting her jealousy and anger regarding the situation.

Later, as the tension grows between D.J. and Stephanie, Jesse and Joey take D.J. aside and tell her that not even the best actors get every part. Jesse further sheds light on the situation saying, "D.J., you're right. Stephanie stole that part right out from under you. In fact, she planned this whole thing. She tricked us into bringing her along, pretending that she cares about you." With some new perspective, D.J. considers that she may have been too hard on Stephanie, and that she most likely didn't have evil intentions after all. D.J. then tells Jesse and Joey that she feels left out of the spotlight since her younger sisters came along. She adds that she is "so sick of sisters," and that "Everything was just fine when it was just [her]."

After D.J. calls it "disgusting" that people fawn over her younger sisters, Joey acknowledges that D.J. once received the same type of attention when she was Stephanie's age, and that Stephanie is not sinister just because she is young. He even turns the tables on her asking if it was "... so disgusting when … everyone thought [she was] so cute?" This allows D.J. to see the current circumstances in a different light and to consider that villainizing her little sister may be unfair. D.J.'s willingness to open up to Jesse and Joey, who are not her primary caregivers, demonstrates that she feels comfortable with their role in her family and their involvement in her personal life.

Jesse and Joey's insight leads to D.J. talking to Stephanie. D.J. says that she understands that Stephanie getting the part was not intentional, that "[she] didn't know what [she] was doing." Stephanie then replies that she never does – reminding D.J. that she is young and does not always consider how her actions affect those around her. D.J. recognizes that Stephanie didn't intend to steal the part or make her feel bad. D.J. goes on to help Stephanie practice her lines, despite her previous refusal to help her, as the episode closes. The girls' reconciliation evokes empathy from the audience, as well as contentment as everything worked out for the better. Underlying these feelings, viewers now know that the family was made stronger due to the presence of caregivers that a "normal," nuclear family lacks.

The next example considered was taken from an episode in the third season of the program and was titled "Aftershocks" (Ripps & Foster, 1989). It deals with children having feelings that they do not voice to their guardian that can, in turn, have a significant impact on their daily lives if gone unnoticed or ignored. The episode follows Stephanie's "problem" after an earthquake hits San Francisco causing Stephanie to cling to Danny more than she ever has. For example, in one scene, Stephanie latches onto Danny's leg as he tries to leave for a business dinner. She tells him, "No, Daddy! You can't go!" and despite reassurance from Jesse and Joey that they will stay with her, she continues to plead with her father not to leave. Danny then agrees to stay home and hugs her, giving the other two men a concerned look. Later, Jesse and Joey suggest to Danny that Stephanie may need professional help to overcome her obsessive clinginess. Danny, however, is adamant that nothing is wrong with Stephanie and insists, "It's not that serious!" Jesse then tells Danny that asking for outside help does not make him an inadequate father but that it shows "[he loves] Stephanie so much, [he] would do anything to help her."

Danny eventually concedes and decides it is necessary to seek professional help for Stephanie. He takes her to a therapist who tells Stephanie to draw what she is thinking and feeling out on paper. Stephanie draws each resident of the Tanner household inside the house with a crack through the wall due to the recent earthquake and Danny standing outside the house. This allows the therapist to see that Stephanie has separation anxiety due to her lack of knowledge regarding her father's whereabouts on the day the earthquake hit. To solve the problem, Danny promises to keep Stephanie in the loop the next time he leaves the house, especially if there are dangerous circumstances. The episode concludes with the newly confident Stephanie preparing for sleep in her own bed rather than Danny's since the earthquake. Surrounded by her family, Jesse, Joey, and D.J. tell Stephanie that they are always there when she needs them. As with "Sisterly Love," "Aftershocks" once again places men in the role of nurturers and redefines the notion of family. Danny, Jesse, and Joey are able to fulfill the role traditionally associated with a mother and a father, thus conveying that if this rendition of the family can work, other variations of the nontraditional family can work, too.

The final example analyzed was selected from *Full House's* seventh season and was titled "Wrong-Way Tanner" (Tatham, et al., 1993). The episode focuses on the youngest Tanner, Michelle, playing on Coach Joey's soccer team. Stephanie and D.J. excelled at soccer when they had played, but Danny notices that Michelle does not pick the skill up as naturally. To help, he pushes her to practice, unintentionally taking out all the fun. At one point, Jesse finds Danny and Michelle practicing in the back yard, and Danny refuses to let her eat dinner until she kicks a few more goals. Jesse explains that his father did the same thing when he'd played baseball as a kid, and it drove him to hate the sport. Danny insists that it's not the same and that he's a great soccer coach.

Later at a soccer game, Danny tells Michelle to be aggressive and score while Jesse assures her that it's just a game and winning isn't everything. In all the commotion and between the mixed messages, Michelle gets the ball and scores in the wrong goal, losing the game and upsetting her teammates. Back at the house, Danny and Jesse both try to take the blame, and Joey tells them it was both of their faults. Danny apologizes for being so tough on Michelle, but she is now too embarrassed to play and says "[she] wants to quit, just like [her] Uncle Jesse quit baseball." Jesse tells her that if she loves soccer she should continue to play, and Joey backs him up saying to get back out there because "Everybody gets embarrassed now and again."

At the end of the episode, Stephanie reveals video shot from a class project she'd been working on containing embarrassing clips of all the Tanner household's residents. One clip showed Jesse styling and talking to his hair. While the whole family laughs at the videos, Joey says, "See, Michelle, the best thing you can do when you get embarrassed is just laugh at yourself. It will get you through some really tough times." Jesse and Danny encourage her to get back out there and just laugh along with the other kids if she messes up and she agrees, saying "All I did was score in the wrong goal. It's not like I talked to my hair."

It is clear that Danny had particular beliefs about how his daughter should view soccer and as to how she should be taught. The episode reveals, however, that pushing her so hard was not necessarily the right thing to do. Because Jesse and Joey were close enough to Michelle to be involved, coaching and watching her play, they were able to see the possibility that Danny's method would have negative outcomes. In a traditional family, the mother most likely would have been the one to step in and suggest a different approach, but instead Jesse took on this role. Even after Stephanie's mistake, the men were able to compromise, realizing that they needed to help her get better but not so strenuously that it led to her disliking the sport altogether. When she wasn't ready to get back out there, it took their reassurance, advice, and their own experiences to convince her it was worth another try. The three men all care about Michelle and want what is best for her, and their ability to resolve the problem conveys that unconventional family environments can be as nurturing when it comes to learning and growing as traditional ones.

## CONCLUSION

The *Full House* episodes "Sisterly Love," "Aftershocks," and "Wrong-Way Tanner" exemplify

how the program positions its audience to see nontraditional families as normal and just as adequate as traditional ones. Such an approach has led the way for programs like *Two and a Half Men, Melissa and Joey,* and others like *Modern Family* and *Baby Daddy* that positively portray families lacking a traditional structure. As the concept of family evolves and changes, depictions like these have the potential to increase acceptance and understanding of various family modes. Not only do they help people understand why these nontraditional families are no less legitimate than historically nuclear families, they also serve to validate children and parents in nontraditional situations by giving them a model to which they might relate. They offer the possibility for them to achieve inclusion, happiness, and fulfillment despite the hardships they have been dealt or the lifestyle that they have chosen. Ultimately, *Full House* and its successors can be seen as going beyond mere entertainment and playing a significant cultural role due to their groundbreaking portrayals of nontraditional families.

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# What's the Point?: A Comparative Analysis of Prehistoric Projectile Points from Three Archaeological Sites in Maryland

*William "Max" Kichline*

**ABSTRACT**

Thousands of years ago, Native Americans in Maryland used projectile points for hunting in order to survive. Today, archaeologists find these remnants of their subsistence in relative abundance on archaeological sites across Maryland and North America as a whole. Based upon stratigraphy and radiocarbon dating, these points can be related to specific prehistoric periods, as certain point types were used at certain times in prehistory. For this reason, projectile points are an essential part of the prehistoric archaeological record. While intensive research has been done on prehistoric sites in Maryland, this research is primarily site-based or regionally focused, with little focus specifically on projectile points. In primary research for this paper, projectile points from three different sites in Maryland have been analyzed in an attempt to answer the question of site occupation by identifying and typing projectile points from these sites and placing specific point types in the prehistoric chronology. By understanding site occupation periods, these sites can be better understood within the larger chronology of prehistoric North America based upon point typology and associated point chronology. In addition, an understanding of site occupation can provide information about possible cultural and subsistence practices by people who lived at these sites during prehistoric periods.

## INTRODUCTION

Humans have resided in the Chesapeake Bay region for over ten thousand years, and during that time they have used projectile points to assist in their hunting practices. Due to the importance of hunting practices to the cultural lifestyle of prehistoric Native Americans, possibly the best indicator of human cultural change in the prehistoric Chesapeake region is the morphological change, or changes in point size and shape that is often related to different uses, of projectile point types over time. While changes in projectile point typology can indicate changes in manufacturing and subsistence practices, the identification of point types from specific sites can provide evidence for site occupation.

In this paper, projectile points uncovered at the Eliason site (18SO93) in Somerset County, the Nassawango site (18WO23) in Worcester County, and the Indian Creek site (18PR94) in Prince George's County will be analyzed. Each of these sites are located in Maryland (Fig. 1): the Indian Creek site is in western Maryland, while the Eliason and Nassawango sites are on the Eastern Shore. The point of this comparative analysis is to analyze point morphology and how these types relate to specific time periods. By relating identified types to specific periods, conclusions can be made as to periods of site use and occupation, and hypotheses can be postulated as to the cultural practices taking place at these sites during certain periods.

## PROJECTILE POINTS

Lithic tools are some of the most durable artifacts from prehistoric cultures and are valuable assets in understanding human behavior (LeeDecker and Koldehoff 1991:72). Projectile points are some of the most common intact lithic artifacts from prehistoric archaeological sites. A projectile point is a lithic tool with a trianguloid or ovoid blade and a stem by which the point is hafted, or attached, to a wooden shaft. Projectile points are produced in a way that is thin enough to penetrate the hide of an animal while large and heavy enough to cause significant damage to the target animal (Custer 2001:6).

Projectile points come in a variety of different forms, often differentiated by their function and by the way in which they are hafted to the shaft. For example, fluted points, like the Clovis point type, and eared points, like the Brewerton Eared Notched point type, are more conducive to notched hafting, which involves the point being placed in a notch at the distal end of the shaft and secured using an abrasive of some kind (Flenniken and Raymond 1986:605-606). Both triangular, like Madison, Potomac, and Levanna point types, and possibly pentagonal points, like the Jack's Reef Pentagonal point type, are indicative of the introduction of the bow and arrow to the eastern United States due to their small size (Lewis 1971:24-25).

The Paleoindian period, which refers to the time period between 13,000 BCE and 9,500 BCE, is defined by the fluted lanceolate point, also referred to as the fluted biface (Dent 1995:126; Custer 1994:331), while the beginning of the Archaic period is characterized by the transition from fluted type points to notched points, including the Palmer and Amos type points (Custer 1994:334). Fluted points are characterized by indentations in the center of either or both faces of the point. The bifurcate, or basal-notched, family of points, including Kanawha, MacCorkle, LeCroy, and St. Albans points, was introduced late in the Early Archaic, which refers to the time period between 9,500 BCE and 6,500 BCE, and into the Middle Archaic (Custer 1994:331; Ebright 1992:31). However, the Middle Archaic, which refers to the time period between 6,500 BCE and 3,000 BCE, was primarily dominated by the use of contracting and square stemmed points like the Morrow Mountain and Stanly types, while the late Middle Archaic included the introduction of the Guilford type (Anderson 1991:94-95; Custer 1994:331; Wesler 1983:22).

While Bare Island points are some of the most commonly found points in Maryland for the Late Archaic period, Piscataway and Vernon points are also quite common (Ebright 1992:35; Wesler 1983:24). The Late Archaic, which refers to the time period between 3,000 BCE and 1,000 BCE, is characterized by the introduction of the Broadspear tradition, which includes points like the Savannah River, Lehigh, and Snook Kill types, to the Middle Atlantic region, with Susquehanna and Perkiomen broadspears being produced slightly later (Custer 1994:331; Ebright 1992:35). The Early Woodland, which refers to the time period between 1,000 BCE and 0 (Custer 1994:331), is distinguished by the use of a variety of stemmed points, like the Calvert and Fishtail types (Wesler 1983:27), while the Middle Woodland, which refers to the time period between 0 and 1000 CE (Custer 1994:331), is demonstrated by the appearance of the Jack's Reef and Selby Bay types (Dent 1995:237). Increased

utilization of the bow and arrow occurred during the Late Woodland period, which refers to the time period between 1000 CE and approximately 1500 CE (Custer 1994:331), as demonstrated by small, triangular projectile points dating to this period (Dent 1995:245). The unique combination of these points in time and space in the Middle Atlantic region, specifically Maryland, is important in the study of prehistoric human history by allowing for the creation of hypotheses related to point types in an attempt to better explain the lifeways of these prehistoric peoples. As will be expounded upon further in the next section, the relationship between point types and prehistoric time periods is valuable in the establishment of periods of occupation for prehistoric sites.

## PROJECTILE POINT TYPOLOGY

Typology is extremely important in the analysis and identification of projectile points. Different types are characterized from a modern perspective in an attempt to demonstrate the changes in point morphology over time and space (Sørensen 2015:90). Since the design of projectile points are cultural traits, different types can provide information as to the cultural behaviors of indigenous individuals and groups (O'Brien et. al. 2016:692-693).

Variations in morphology make certain projectile points relatively easy to type, or classify. For example, Jack's Reef points are distinguished by their relatively unique pentagonal form and are associated with radiocarbon dates between 600 CE and 900 CE. However, certain projectile points can be difficult to type and date. Bare Island points are variable in morphology, given their overlapping characteristics with other types. In addition, radiocarbon dates for Bare Island points are highly variable, falling between 5000 BCE and 500 CE (Custer 2001:7-8).

Despite the importance of typology in the understanding of projectile points, many false types, such as those with overlapping characteristics with other point types or with too few specimens to confirm a unique type, have been identified as a result of not accounting for the rejuvenation of points, which refers to the process of resharpening or reshaping a point to make it reusable. In most cases, except in Late Woodland contexts, points that measure under 25 mm in length have been extensively resharpened and discarded (Hranicky 1994:9). Difficulties in point analysis often occur when a singular type has multiple names associated with that one type. Multiple names for a point with specific characteristics can lead to the establishment of false types and cause confusion when comparing points on a regional scale. For example, the Snook Kill point from the Middle Atlantic and Northeast regions is referred to as the Ledbetter point in the Southeast region. In addition, the Selby Bay point is alternatively referred to as the Fox Creek point in New York and Steubenville in the Ohio Valley (Hranicky 1994:10). In the analysis of these points, the terms Snook Kill and Selby Bay are used in order to remove any confusion as to the types referenced.

## PREHISTORIC CULTURAL PRACTICES OF THE MIDDLE ATLANTIC REGION

The Paleoindian period marks the beginning of human occupation in Maryland and on the Delmarva Peninsula around 10,000-12,000 years ago (Lewis 1971:5). Sites during this time were relatively small and primarily related to the seasonal rounds of resource procurement (Custer 1986:50). Custer (1994:333) believes these rounds for resource and lithic procurement were quite extensive, possibly up to 500 kilometers. The Paleoindian diet was primarily made up of large game like deer supplemented with gathered plant foods like nuts and seeds (Lewis 1971:6).

The Early Archaic is a period of cultural continuity from the Paleoindian period. The band-level hunter-gatherer lifestyle continued in this period, with small game like rabbit and deer being the primary sources of meat (Hranicky 1992:64; Jirikowic 1999:14). Unfortunately, due to the lack of sites in Maryland from the Middle Archaic, this period is quite poorly known. Because of this, it is primarily seen as a relatively uniform transitional period between the Early and Late Archaic in this area (Custer 1994:335).

The Late Archaic was a time of increased sedentism, social complexity, and overall population. This period saw increased intensification in the procurement of estuarine resources. The diet was increasingly enriched by shellfish in this period, and fish weirs, which are fish traps constructed of wooden stakes planted directly into the water, were probably used to keep up with the overall population increase (Dent 1995:204, 206). Semi-permanent settlements were mostly concentrated in estuarine and riverine areas which continued into the Early Woodland period, as evidenced by multi-house sites with large pit features (Custer 1994:339). However, the hunting and gathering of terrestrial food sources continued to comprise a major portion of the indigenous diet well into the Woodland period (Lewis 1971:7).

The Adena culture is a large part of Late Archaic and Early Woodland prehistory on the Delmarva Peninsula, including that of the Nassawango site. The Delmarva Adena cultures are part of a much larger complex that extends west into the Ohio River Valley and north into New England (Custer 1987:34). Sites with Adena occupation are often characterized by certain types of projectile points, like the Flint Ridge type and the aptly named Adena type, as well as copper artifacts, due to a trade network extending to the Great Lakes region, and Coulbourn ceramics (Custer 1987:35-36). The Adena complex is also well-known for its mortuary rituals, as evidenced by the Sandy Hill and Killens Pond sites (Custer 1994:340). Discoveries of *Amaranth* and *Chenopodium* seeds at the Wilgus site suggest that indigenous peoples of the Delmarva Adena complex may have practiced small-scale horticulture during periods of minimal food resources (Custer 1987:39)

The Early Woodland period is considered a perpetuation of cultural practices from the Late Archaic period, but with greater intensification due to increased population growth. This surge in population is demonstrated by the increase in size and number of sites. The appearance of storage pits as well as an increase in the house size during this period suggests increased sedentism (Custer 1994:340-341). However, seasonal rounds are still commonly applied during this period due to a continuity in the reliability of seasonally-available foods (Thomas et. al. 1992:13). The increased use and diversity of ceramics is related to increased food storage and may suggest increased sedentism during this period (Ebright 1992:37), although no evidence of horticulture corresponding to this period has been discovered on the Eastern Shore (Lewis 1971:9).

In terms of agricultural intensification and increased sedentism, the Middle Woodland is often seen as a transitional period. Beans and pumpkins were introduced to the Middle Atlantic at this time, but horticulture did not become a major source of subsistence until the Late Woodland period, since nuts like walnuts and acorns are still prevalent at sites from this period (Lewis 1971:10; Dent 1995:243). As horticulture became more heavily adopted, sedentism increased (Lewis 1971:10). Settlements were primarily found in riverine and estuarine environments, as shellfish were still exploited during this time, along with fish and crab. In addition, terrestrial animals like deer were still a major source of meat (Dent 1995:242-243).

The beginning of the Late Woodland is marked as an era of intense cultural and lifestyle changes. Cultigens became a major part of the indigenous diet during this period, most commonly corn, beans, and squash—possibly originating from the Southeastern culture area—as a result of migration. However, sites on the Delmarva Peninsula have not provided any concrete evidence that horticulture was utilized in any significant way. In areas like the Potomac River Valley where agricultural intensification is evident, there is also evidence for increased village and community size and increased sedentism (Custer 1994:344-345; Dent 1995:249). In fact, fortifications are commonly found at large village sites, suggesting an increase in societal and governmental complexity (Fogel et. al. 1994:14). In association with the increase in the intensification of agriculture, deer, as well as turkey, squirrel, and duck, remain the primary meat sources (Dent 1995:251).

## SITES OF INTEREST

The Eliason site is located along Dividing Creek in Somerset County. Due to a lack of intensive

excavations, very little recorded information describes the archaeological investigations conducted at the site. The lithics from the site were collected by the owner of the property, who farmed the land on which the site is located and collected the artifacts from the entirety of the farm (Elizabeth Ragan, personal communication, 2022). The artifacts from the collection are currently stored at both the archaeology lab at Salisbury University and at the Maryland Archaeological Conservation Laboratory (MAC Lab) in St. Leonard, MD.

The Indian Creek Site is located in Prince George's County concentrated within a 50-acre area near the Beltsville Agricultural Research Facility. During the primary investigations in 1989, approximately 945 total square meters were excavated (LeeDecker and Koldehoff 1991:4). From these 124 units, 568 bifaces–lithic artifacts flaked on two opposite faces–were uncovered, or an average of 0.60 bifaces per square meter, which included approximately 200 projectile points and over 100 unfinished bifaces (LeeDecker and Koldehoff 1991:82). Based on initial excavation, it was hypothesized that the site had been primarily used during the Early and Late Archaic with abandonment occurring during the Middle Archaic (LeeDecker and Koldehoff 1991:4). The artifacts from the collection are also currently stored at the MAC Lab.

The Nassawango site is situated along the Nassawango Creek in Somerset County, Maryland (Bastian 1975:1). During this period, 22 square-meter units were excavated, uncovering eleven prehistoric features, including four burial pits and one hearth (Wise 1973a:1). The earliest diagnostic artifacts, including a steatite bowl fragment and bannerstone fragment, were determined to be Terminal Archaic. Bannerstones are believed to have been used as atlatl weights, to counteract the downward trajectory of a lithic projectile point. Therefore, bannerstones and projectile points are highly correlated in their use in subsistence hunting. Occupation at the site continued into the Early to Middle Woodland, probably related to the Delmarva Adena complex, with copper grave goods and a banded slate pendant (Wise 1973b:1-2). Bannerstones, having first emerged in the Middle Archaic Period, are believed to have been used as atlatl weights. The artifacts from the collection are currently stored at the MAC Lab as well.

## METHODOLOGY

At the start of the research, the major question at hand was the comparative periods of site occupation between these three sites. This required a distinct separation of point types found at the three sites by prehistoric time period. Despite certain points that overlap in chronology between periods, points are separated based upon the radiocarbon dates with which they are most commonly associated. Due to the overall lack of provenience of points from these sites, relative dating between points is impossible. Nevertheless, the minimal number of points that are associated with more than one time period means that the separation of points by time period is still relatively accurate. In describing which points are characteristic of which period, the point types from the three sites are combined together in order to be concise.

Only one point is characteristic of the Paleoindian period: the Clovis type point. Eight points are distinctive of the Early Archaic period: Palmer, LeCroy, MacCorkle, St. Albans, Kanawha, Kirk Stemmed, Kirk Serrated, and Kirk Corner-Notched type points. Seven points are distinctive of the Middle Archaic period: Guilford, Halifax, Lackawaxen, Morrow Mountain I, Morrow Mountain II, Otter Creek, and Stanly type points. Fourteen points are distinctive of the Late Archaic period: Brewerton Eared Notched, Brewerton Corner-Notched, Brewerton Eared Triangle, Brewerton Side-Notched, Snook Kill, Savannah River, Susquehanna, Poplar Island, Clagett, Lehigh, Normanskill, Perkiomen, Pequea, and Lamoka type. Eight points are characteristic of the Early Woodland period: Adena, Bare Island, Calvert, Fishtail, Holmes, Piscataway, Rossville, and Vernon type points. Only three points are characteristic of the Middle Woodland period: Jack's Reef Pentagonal, Jack's Reef Corner-Notched, and Selby Bay type points. Similarly, only three points are characteristic of the Late Woodland period: Levanna, Madison, and Potomac type points.

The first collection analyzed was from the Eliason site. Since the owner of the site collected all lithic artifacts from his property, the first step in the analysis of the projectile points required typing lithic tools by form, focusing only on projectile point forms. Once all projectile points were separated from the rest of the lithic artifacts, it came time to type and catalog the points. As far as analysis is concerned, three main sources were used: the Diagnostic Artifacts in Maryland website, a reputable source for historic and prehistoric artifact identification, in conjunction with Custer's 2001 publication *Classification Guide for Arrowheads and Spearpoints of Eastern Pennsylvania and the Central Middle Atlantic* along with Hranicky's 1994 publication *Middle Atlantic Projectile Point Typology and Nomenclature,* which were used to maximize accuracy to point types in the region. In the process of cataloging point types, each point was assigned a catalog number, measured using an electronic caliper, and the lithic material was identified, in order to provide as much detail for any future researchers. Due to the extensive size of the Eliason site collection, point identification required over 25 hours of research in January and February of 2022.

The study of the other two sites required a visit to the MAC Lab. Since the collections from both of the sites had been previously cataloged and stored with lithic material and measurement information, my only task was to confirm the type previously identified by the original curators. For detailed explanation of point types, lithic materials, and measurements of points from each of the three sites, please see the associated artifact catalog, since this research takes into consideration only numbers of points from each period.

## ANALYSIS

From these 459 total points identified from the Eliason site (Fig. 2b, Fig. 5), 32 unique types were identified. 52 of the points from the Eliason collection were unable to be typed (Fig. 6). 43 of these were only portions of the point that were unidentifiable, while nine were complete points whose characteristics overlapped with multiple different types that made it unidentifiable.

Although no points representative of the Paleoindian period were discovered at the Eliason site, a few points distinctive of the Early Archaic period were discovered (Fig. 2a). However, significantly more points characteristic of the Middle Archaic, Late Archaic, and Early Woodland were identified. A substantial decrease in number of points occurs from the Early Woodland to the Middle Woodland, with only a few points from each period having been discovered at the site.

From the 170 total points excavated at the Indian Creek site (Fig. 3b, Fig. 5), 30 unique types were identified. Sixteen of the points from the Indian Creek collection are unable to be typed (Fig. 6). Eight of these were only parts of the point that were unidentifiable, while eight were complete points whose characteristics overlapped with multiple different types.

While no points from the Paleoindian period were discovered at the Indian Creek site, several points characteristic of the Early Archaic period were discovered at the site (Fig. 3a). The number of points steadily increases in the Middle and Late Archaic periods before dropping slightly in the Early Woodland period. This number decreases significantly in the Middle and Late Woodland periods, since only one point from each period was discovered at the site.

From the 64 total points excavated from the Nassawango site (Fig. 4b, Fig. 5), 23 unique types were identified. Fourteen of the points from the Nassawango collection were unable to be typed (Fig. 6). Nine of these were only parts of the point that were unidentifiable, while five were complete points whose characteristics overlapped with multiple different types.

The Nassawango is the only site out of the three sites analyzed which had points from all seven prehistoric periods. While only a couple of points from each period were discovered that are characteristic of the Paleoindian and Early Archaic periods, the number of points identified from the site increases steadily in the Middle and Late Archaic periods (Fig. 4a). The number of points also tends to remain relatively constant through the final three prehistoric periods: Early, Middle, and Late Woodland.

## DISCUSSION

The association between point types and prehistoric time periods can provide valuable information about the periods of occupation for prehistoric archaeological sites. This means that this relationship can be readily applied to the study of the Nassawango site, the Indian Creek site, and the Eliason site. In fact, these different types may have been developed based upon the cultural practices relating to specific prehistoric periods. For example, the lack of point types and overall lack of points from the Paleoindian period in the region is related to the lack of cultural diversity in the area during the period. The Paleoindian period in this area marks the introduction of humans to the region, so the recency of human arrival would mean a lack of diversity. The diversity in point types generated as a result of social learning requires the input of multiple generations, which is not possible since the Paleoindian period marks the beginning of human occupation in Maryland.

Several factors may affect the production of projectile points during the Archaic period. An increased focus on small game (like rabbit) while continuing to hunt larger game (like deer) probably led to the variety of point sizes and point types seen throughout the Archaic period, starting mainly in the Middle Archaic. Since the Middle Archaic was also a period of increased trade, the increased variety of points from that period may be due to cultural transmission and diffusion. The Broadspear tradition, dating to the Late Archaic period, is possibly associated with the increase in marine resource procurement, since fish and shellfish became an important part of the prehistoric diet. The points from the Broadspear tradition have a comparatively broad base, which would have made it easier to catch the fish without losing it, had they been used for that purpose.

The increased standardization of point types in the Woodland period, specifically the Middle and Late Woodland periods, seem to contradict the earlier hypotheses about the increase in point types. However, this contradiction may be explained by the increase in population and intergroup violence. The points from the Middle and Late Woodland periods were generally standardized to be triangular and pentagonal. A standardization and simplification of point types makes the production of points accessible to a wider audience, necessary for both hunting for a larger sedentary population and an increase in weapons and man-power in intergroup conflict. An increased dependence on horticulture and harvested goods during this period may also account for the decrease in overall types.

The identification of points from sites is a great indicator of occupation periods at a particular site. For instance, the graph showing the number of points by time period found at the Indian Creek (Fig. 3a) site shows intensive occupation and use of the site starting in the Early Archaic and intense usage through the Early Woodland before dropping off before the Middle Woodland. A study of the same graph from the Eliason site (Fig. 2a) shows very little to no use of the site before the Middle Archaic and after the Early Woodland, with most intensive occupation occurring between these two periods. Intensive occupation refers to a subjective measure of site use based upon the number of points found at the site relating to that time period. Since significantly more points dating from the Early Archaic through the Early Woodland were found at the Indian Creek site than points dating from the Middle and Late Woodland, it can be concluded that the site was used more intensively from the Early Archaic to the Early Woodland periods. Although research into Middle Archaic occupation and settlement indicates a sharp decline in overall population, the statistical analyses of points from each of these three sites show relatively concentrated occupation. Most interestingly, the points found at the Nassawango site provide evidence for occupation through all seven known prehistoric periods. Despite the original report stating that occupation only occurred at the site between the Terminal Archaic and the Late Woodland periods, the associated graph (Fig. 4a) indicates that the most intensive occupation occurred during the Late Archaic period, with less intensive occupation during the three previous periods. Despite their overall small size, the discovery of Clovis points dating to the Paleoindian period suggest that the Nassawango site may be one of the oldest sites on the Lower Eastern Shore of Maryland. It is highly unlikely that these Clovis points were either traded to or used at the site for a significant period of time after their manufacture. Although it is difficult to study the use life of projectile points outside of modern experimental archaeology, it is improbable that an oft-used point would last more than a year to a few years.

Comparatively, all three sites experienced most intensive occupation during the three central periods: Middle Archaic, Late Archaic, and Early Woodland. Since there is no evidence of direct contact between the two sites based upon current analysis of the projectile points from the two sites, I would consider this to be coincidental. I would also consider the differences in the levels of occupation between the Nassawango site and the Eliason site to be coincidental, while the extent of occupation into the Middle and Late Woodland may also be an indicator of the resource richness of the Nassawango site due to its location near the Nassawango Creek. While an understanding of cultural practices is difficult to ascertain from current data, understanding periods of occupation is a great first step in comprehending the chronology of artifacts discovered alongside projectile points and the site as a whole.

Determining site-to-site interaction based upon projectile points types can be problematic. Just because two sites have points of the same type does not necessarily mean that the people from these two sites interacted with each other. However, the likelihood increases when points are distinctly characteristic of a cultural tradition. It is understood, based upon the cultural materials and features uncovered at the site, that the Nassawango site is part of the Adena culture. In addition, one point from the Eliason site was identified as being an Adena type point. Although one point is not enough to provide concrete evidence that the people from the Eliason site were part of the Adena culture, it is reasonable to assume that at least some of the individuals from the site engaged in practices similar to those found in that tradition, such as characteristic burial practices, or used exotic items, such as copper goods. For this reason, it is reasonable to assume that individuals from the Eliason site and Nassawango site probably interacted with each other.

Additional analysis of the points from each site are necessary in order to further understand the cultural lifeways of the peoples from each site. I would make a recommendation to do intensive lithic analysis on the points from these three sites, focusing on proper lithic identification with an associated lithic sourcing test. These would provide more information on the possible extent of trade networks held by the peoples from each of these three sites. An examination into the chemical and physical characteristics of the lithics used in projectile point production in connection with a similar study into common lithic sources may create a connection between the lithics used and the lithic source, showing the extent of trade networks developed by the peoples of the Middle Atlantic region during specific time periods. Nevertheless, this study has been vital to the increased understanding of the indigenous peoples who occupied these sites, especially in the study of the periods of occupation for these sites. However, with increased analysis of these points, we can further understand these sites in reference to the larger picture of human prehistory in North America.

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## FIGURES AND PICTURES

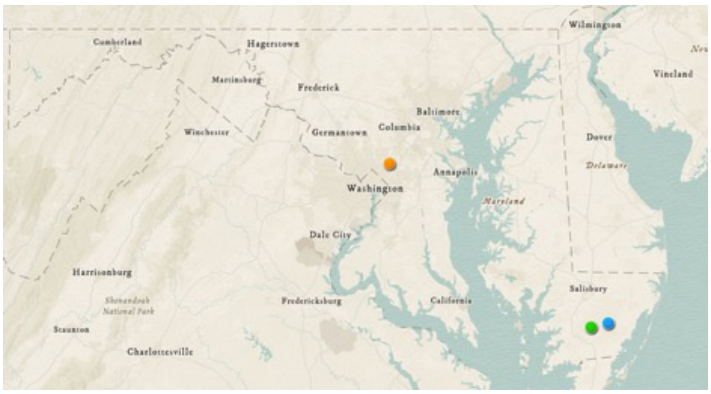


Figure 1: Approximate locations of sites in relation to each other; scale: 1 inch to 30 miles

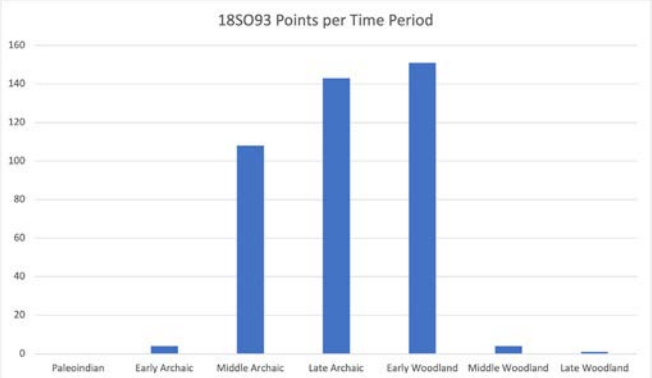


Figure 2a: Number of points per prehistoric period from the Eliason site in chronological order

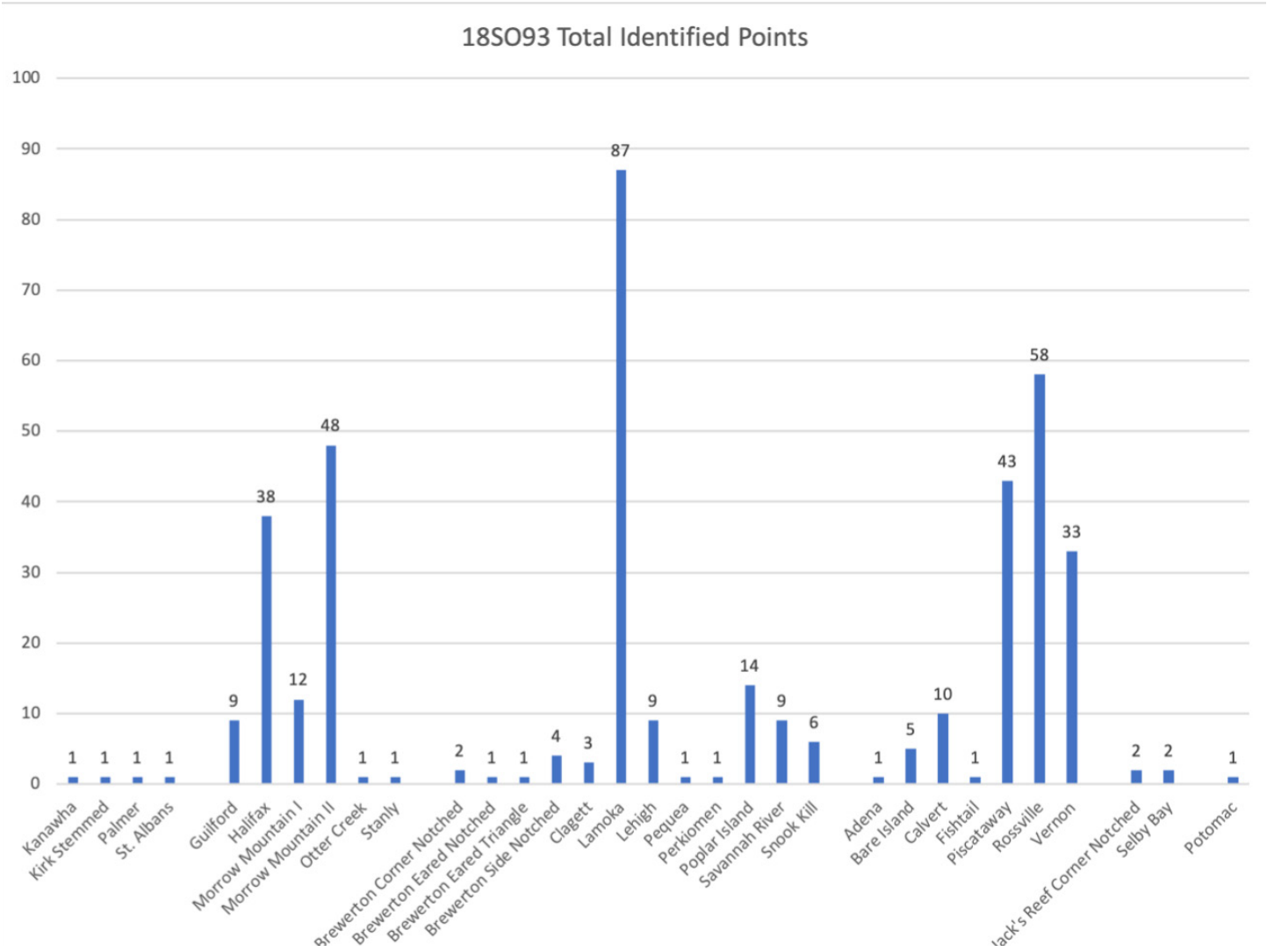


Figure 2b: Comparison of the total number of points from the Eliason site by type in chronological order

## FIGURES AND PICTURES

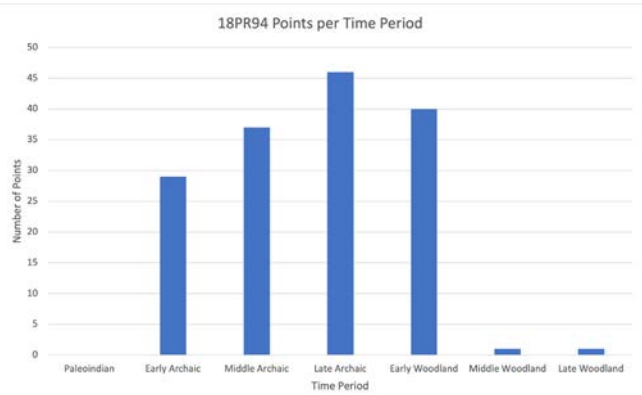


Figure 3a: Number of points per prehistoric period from the Indian Creek site in chronological order

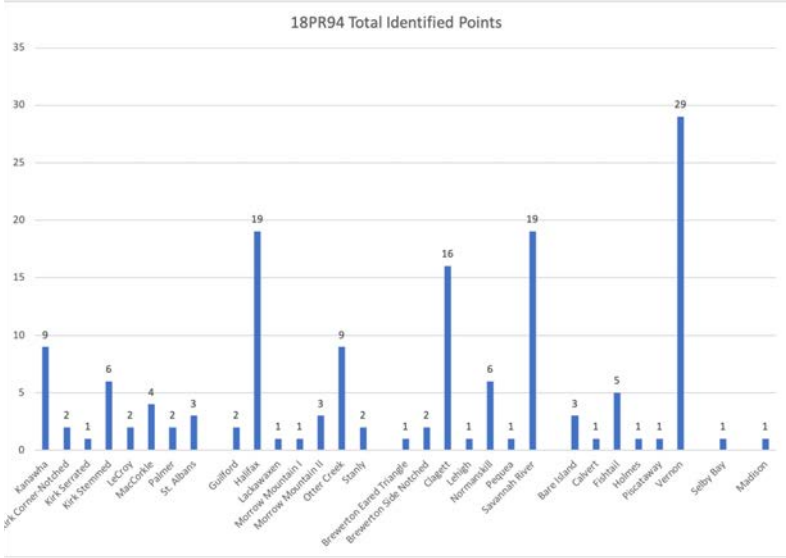


Figure 3b: Comparison of the total number of points from the Indian Creek site by type in chronological order

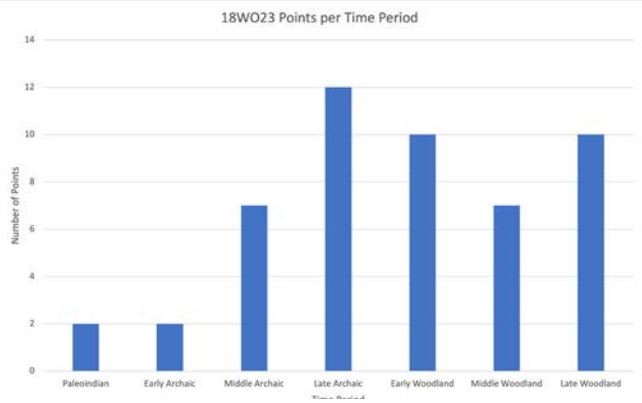


Figure 4a: Number of points per prehistoric period from the Nassawango site in chronological order

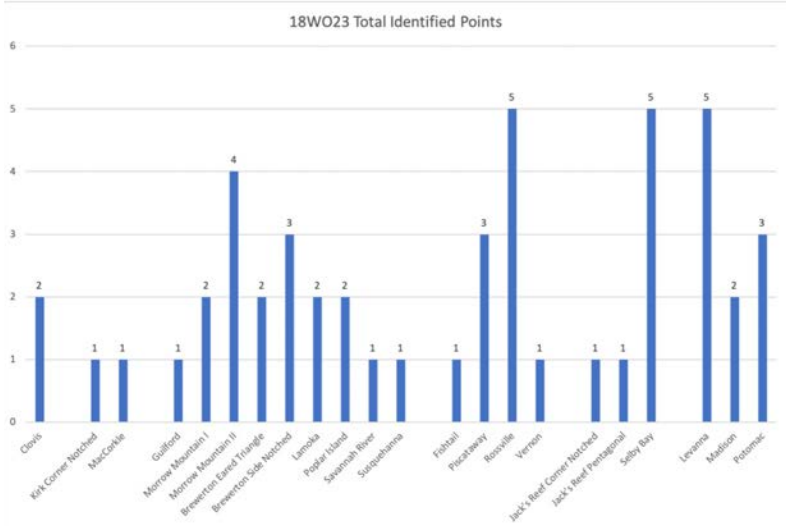


Figure 4b: Comparison of the total number of points from the Nassawango site by type in chronological order

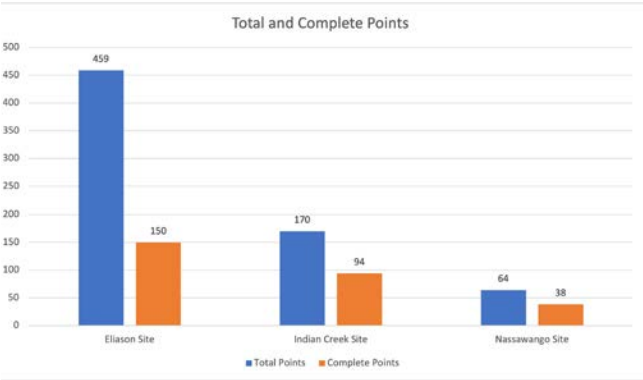


Figure 5: Comparison of total and complete points from each of the three sites

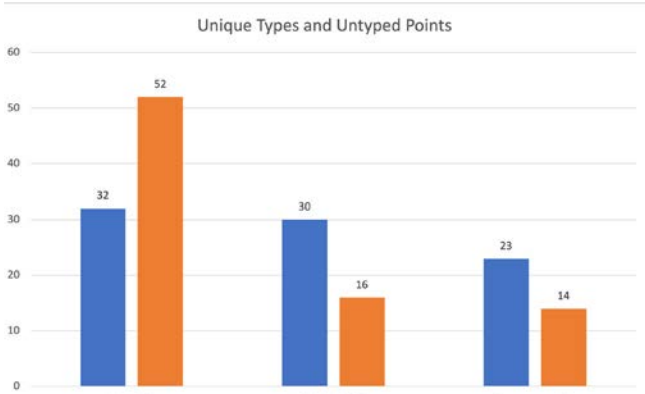


Figure 6: Comparison of unique types and untyped points from each of the three sites

## FIGURES AND PICTURES

| Catalog # | Count | Material | Color | Form | Intact | Measurements | Notes | Cataloger | Catalog Date |
|---|---|---|---|---|---|---|---|---|---|
| 18SO93: 1992-1 | 1 | The term "pe | Tan | Unknown | Yes | L: 35.56 mm W: 25.4 mm | Possibly a Perkiomen point | WK | 1/20/22 |
| 18SO93: 1992-2 | 1 | Argillite | Gray | Morrow Mountain II | No | L: 38.1 mm W: 20.32 mm | Missing distal end | WK | 1/20/22 |
| 18SO93: 1992-3 | 1 | Argillite | Gray | Morrow Mountain II | No | L: 38.1 mm W: 22.86 mm | Missing distal end | WK | 1/20/22 |
| 18SO93: 1992-4 | 1 | Argillite | Gray | Morrow Mountain II | No | L: 45.72 mm W: 22.86 mm | Missing part of body and distal end | WK | 1/20/22 |
| 18SO93: 1992-5 | 1 | Argillite | Gray | Savannah River | No | L: 55.88 mm W: 30.48 mm | Missing part of body and distal end | WK | 1/20/22 |
| 18SO93: 1992-6 | 1 | Quartz | Off-white | Morrow Mountain I | Yes | L: 35.56 mm W: 30.48 mm | | WK | 1/20/22 |
| 18SO93: 1992-7 | 1 | Quartzite | Tan | Morrow Mountain I | No | L: 43.18 mm W: 35.56 mm | Missing distal end | WK | 1/20/22 |

Figure 7: Spreadsheet Example from the Eliason Site Artifact Catalog

| Site | Lot | Provenience | Count | Material | Color | Form | Notes | Length | Width | Cataloger | Catalog Date |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18WO23 | 2 | Surface | 1 | Quartzite | Reddish Tan | Morrow Mountain II | | 48.26 mm | 27.94 mm | WK | 1/18/22 |
| 18WO23 | 2.001 | Surface | 1 | Basalt | Gray | Groundstone | | 67.31 mm | 26.67 mm | WK | 1/18/22 |
| 18WO23 | 4.005 | Surface | 1 | Argillite | Gray | Drill | | 35.56 mm | 20.32 mm | WK | 1/18/22 |
| 18WO23 | 4.015 | Surface | 1 | Rhyolite | Gray | Selby Bay | | 37.0 mm | 23.1 mm | WK | 1/18/22 |
| 18WO23 | 4 | Surface | 1 | Chert | Brown/Tan | Brewerton Side-Notched | Part of base missing | L: 35.56 mm W: 20.32 mm | | WK | 1/18/22 |
| 18WO23 | 4 | Surface | 1 | Chert | Gray | Fishtail Type | One stem longer than other side; Late Archaic to Early Woodland | 38.1 mm | 11.43 mm | WK | 1/18/22 |
| 18WO23 | 4 | Surface | 1 | Chert | Brown/Tan | Drill | Base of drill broken, most of drill bit intact | L: 27.94 mm | | WK | 1/18/22 |
| 18WO23 | 4 | Surface | 1 | Argillite | Gray | Poplar Island | | 50.8 mm | 15.24 mm | WK | 1/18/22 |

Figure 8: Spreadsheet Example from the Nassawango Site Artifact Catalog

| Site | Box | Provenience | Lot | Count | Material | Color | Form | Notes | Length | Width | Cataloger | Catalog Date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18PR94 | 03236-29 | TU 60 Lv2 | 1430 | 1 | Rhyolite | Gray/Tan | Vernon | | 45.72 mm | 20.32 mm | WK | 1/19/22 |
| 18PR94 | 03236-29 | TU 61 Lv1 | 1443 | 1 | Rhyolite | Gray/Tan | Otter Creek | | 44.45 mm | 20.32 mm | WK | 1/19/22 |
| 18PR94 | 03236-29 | TU 61 Lv2 | 1444.001 | 1 | Quartz | Off-white | Otter Creek | Missing distal end | L: 43.18 mm W: 26.67 mm | | WK | 1/19/22 |
| 18PR94 | 03236-29 | TU 64 Lv2 | 1514 | 1 | Rhyolite | Gray/Tan | Morrow Mountain II | Missing stem and distal end | L: 43.18 mm W: 20.32 mm | | WK | 1/19/22 |
| 18PR94 | 03236-29 | TU 63 Lv1 | 1498.001 | 1 | Quartzite | Dark Red | Savannah River | | 44.45 mm | 21.59 mm | WK | 1/19/22 |
| 18PR94 | 03236-29 | TU 64 Lv1 | 1512.002 | 1 | Quartzite | Dark Red | Savannah River | Missing much of body and distal end | L: 50.8 mm W: 38.1 mm | | WK | 1/19/22 |
| 18PR94 | 03236-29 | TU 66 Lv1 | 1531.001 | 1 | Rhyolite | Gray/Tan | Normanskill | Labeled as Lackawaxen | 50.8 mm | 15.24 mm | WK | 1/19/22 |
| 18PR94 | 03236-29 | TU 66 Lv2 | 1533 | 1 | Rhyolite | Gray/Tan | Morrow Mountain II | Missing part of stem and distal end | L: 38.1 mm W: 22.86 mm | | WK | 1/19/22 |

Figure 9: Spreadsheet Example from the Indian Creek Site Artifact Catalog

# New Zealand Biodiversity: How Policy Can Solve Biodiversity Loss and Restore Indigenous Cultural Practices

*Jamie Larson*

**ABSTRACT**

Biodiversity and indigenous cultures are declining, and policy typically lacks the proper resources to restore both. To recover biodiversity and indigenous culture/communities, policies must recognize the connectivity between biodiversity and people. A perfect study for implementing new policy that strives to restore biodiversity and indigenous culture is within New Zealand. New Zealand is a biodiverse hotspot home to flora and fauna found nowhere else on Earth. The relatively recent introduction of humans (both indigenous peoples and colonizers) to New Zealand has dramatically impacted the biodiversity, often resulting in decline. Without proper measures to restore the biodiversity, once these species are lost in New Zealand, they are gone forever. Along with unique biodiversity, New Zealand is also home to the indigenous Māori people who have cultivated and lived on the land long before European colonizers. Embedded within Māori culture is great environmental stewardship and responsibility that was neglected by colonizers and more modernly, the New Zealand government. The atrocities of colonization have negatively impacted indigenous communities alongside biodiversity, and new policies must reflect the urgency of restoring iconic biodiversity and uplifting indigenous communities. The proposed new five tenant policy within this paper seeks to: reevaluate the relationship between the Māori and New Zealand government, utilize traditional ecologic knowledge, increase joint decision-making authority, instill Māori cultural practices and worldviews, and gain consent from indigenous communities to use such knowledge.

**KEYWORDS**

Biodiversity, Māori

## INTRODUCTION

To maintain New Zealand's iconic landscapes and indigenous culture, the restoration of biodiversity is essential. This restoration cannot occur without the people who have existed on the land long before European colonization. Amplifying the voices of those who have existed on the land considerably longer than their colonizers can revolutionize biodiversity recovery across the globe (Smith, 2008). New Zealand's biodiversity and indigenous Māori cultural practices are declining at an alarming rate (Craig et al., 2000). However, existing policies address the decline of Māori culture and biodiversity as separate entities. By implementing new policy within the Conservation Act of 1987, New Zealand can act as an example to the rest of the world by recovering biodiversity and restoring indigenous cultural practices. This new five tenant policy will: reevaluate the relationship between the Māori and New Zealand government, utilize traditional ecologic knowledge, increase joint decision-making authority, instill Māori cultural practices and worldviews, and gain consent from indigenous communities to use such knowledge.

The New Zealand government and the Department of Conservation have policies to recover and restore biodiversity however, the policies are insufficient because they lack integration between Māori culture and biodiversity (Conservation General Policy, 2005). The Conservation Act of 1987 falls short in restoring and maintaining biodiversity, especially when considering the role of Māori in conservation. New Zealand Māori and endemic biodiversity requires new policy that provides better strategies for restoration. Section 6B of the Conservation Act (1987), which argues the function and role of the Conservation Act, has no mention of Māori principles, worldviews, or responding committees that aid in conservation and restoration. There is also no mention of a Māori authority that oversees New Zealand biodiversity. The first mention of the Crown's relationship with the Māori in the Conservation Act is embedded in the Public Service Act (2020) within the Conservation Act in Subpart 3- Crown's Relationship to Māori. Article 14.1 reiterated that the Crown and Māori relationship adheres to the 1840 Treaty of Waitangi. This assertion is problematic and inadequate because of historic misunderstandings since the Treaty of Waitangi's inception (Franklin, 1989). The foundation of this treaty is inadequate, as it was originally translated from written English to the spoken Māori language (Franklin, 1989). The imperfect translation resulted in different interpretations of the treaty (Attwood, 2013). The relationship between the Māori and the Crown (and hence, the New Zealand government) is based on a misconstrued and ignored treaty since its creation. This is problematic because the relationship between the government and Māori today is defined by the misunderstood treaty. Currently, New Zealand policy adheres to this treaty, setting up a poor foundation for trust between the government and Māori.

## TENANT #1

Due to the shortcomings of the Treaty of Waitangi and the Conservation Act of 1987, the first tenant of the new policy aims to rectify the wrongs of the Treaty of Waitangi and reestablish government and Māori relations. Today, the dynamic between the Māori and the government adheres to the Treaty of Waitangi, which failed to demonstrate the goals of the Crown and the Māori. It is not enough to understand that the foundation of government and Māori relations were tumultuous and that the Treaty of Waitangi was misleading, it is essential to address this in the new policy. To form a better relationship between the Māori and the government, the policy must reestablish the relationship beyond the distrust of the Treaty of Waitangi. The new policy requires a new treaty with genuine intent to work together in a non-exploitative way. This new policy will include an addition that requires genuine respect and appreciation for Māori culture with greater clarity. Although this does not make up for years of misinterpretations, it is a start in the right direction that holds policymakers to a higher standard. The new policy ensures a superior government-Māori relationship via a treaty with no translation errors. Since the treaty, the lack of trust challenged the capacity of the government and Māori to

work together (Taiepa et al., 1997). Restoration and redeclaration of a new treaty, or at least an addition to the Treaty of Waitangi, would reaffirm a willingness to work together through a treaty that is not plagued by misunderstanding. To make policy more efficient, it is essential to clearly define relationships between the government and the Māori. The first tenant of this new policy will reaffirm and build upon the Treaty of Waitangi, to finally create a more honest and trustworthy relationship between the government and the Māori.

**TENANT #2**

The second tenant of the new policy recommendation acknowledges the validity of traditional ecological knowledge (TEK). Not only is the foundation of the relationship between the Māori and the government flawed, but the inadequacies of the Conservation Act itself also fail to recognize the wisdom and authority that Māori culture provides. Cultural knowledge is an essential tool in biodiversity research and is lacking in policy regarding Māori and conservation (Ramstad et al., 2007). For much of the twentieth century, TEK of indigenous groups has been discarded because of its holistic view of nature (Berkes et al., 2000). Yet, TEK from Māori communities has been an integral part of the scientific community through its species identification efforts (Moller et al., 2010; Ramstad et al., 2007). For conservation policy to be effective in New Zealand, TEK needs to be a component. The new policy may create a committee that oversees the use of TEK in science and allows Māori communities to share their contributions. Many Māori groups who observe their historic cultural practices also participate in long-term TEK via species monitoring for hunting purposes (Moller et al., 2004). Through their monitoring, Māori groups collect data on population size and ensure the population is adequate before harvesting (Moller et al., 2004). Participating Māori communities have been conducting long-term surveys, making them the perfect addition to conventional scientific population studies. The knowledge gained from traditional long-term monitoring must be included and validated in the policy, as it offers data that cannot be replicated by standard science. Including a section that validates TEK is essential for the new policy because it provides integral information for conservation. The Conservation Act fails to mention that scientists who study New Zealand biodiversity have relied on Māori TEK to find nest locations, population size, extinct species, life-history traits of endemic species, and more (Moller et al., 2010; Ramstad et al., 2007; Watson et al., 2015). Science has used Māori TEK for years, but that knowledge is seldom represented in the pre-existing policy (Conservation General Policy, 2005).

Although TEK has an important role in New Zealand conservation, it is flawed. TEK uses empirical data but when specific data is required for monitoring, it falls short (Becker & Ghimire, 2003; Moller et al., 2010). TEK also relies on qualitative data over a lengthy period, which is not always accurate. When science or governments require extreme accuracy (dates, numbers, etc.), TEK is not a reliable source because it is not typically used for its complete accuracy (Madsen et al., 2020). The goal of TEK is often not scientific, so it does not undergo the important procedures that conventional science requires (Ludwig & Macnaghten, 2020). Even with its flaws, TEK is helpful over a long period that does not require complete precision. The TEK revival in science utilizes culturally based understandings of localized species through long-term monitoring that cannot be replicated by conventional science (Becker & Ghimire, 2003). Including TEK in the policy offers another avenue for long-term research essential for restoring isolated populations with minimal modern data. TEK is also one of the only forms of data collection that science has regarding extinct species (Ramstad et al., 2007). Utilizing TEK also strengthens the Māori communities who participate in it. TEK reaffirms indigenous contributions to science, and the inclusion in policy ensured that indigenous voices are included within important conservation topics.

**TENANT #3**

The third tenant of the new policy recommendation provides joint decision-making authority between Māori groups and the government. Māori communities require biodiversity conservation for their livelihoods and culture. New Zealand conservation is not just about restoring biodiversity because it is pretty or nice, it is essential for Māori communities (Lyer et al., 2014). The joint authority over protected lands is important because the indigenous people of New Zealand live on or closer to protected areas (as compared to other groups in New Zealand) (Lyer et al., 2014). Māori communities that live in protected areas have more first-hand experience on the land that has been absorbed by the New Zealand government (Lyer et al., 2014). The lack of power in Māori community is problematic because they lack the authority to make choices concerning their own homes. New policy must require equal power to make decisions because the Māori are the first to be impacted by the biodiversity loss in their communities. The desire for environmental protection and conservation extends beyond the goals of the government as more Māori live in protected lands than any other group of people in New Zealand (Lyer et al., 2014). Restoring equal decision-making power ensures that Māori communities have authority over their own homes, which is an important aspect of the new policy. Typically, biodiversity improves when indigenous communities have more decision-making power, so this must be prioritized in the policy (Taiepa et al., 1997). The policy needs to include a clause that provides equal decision-making authority between the government and Māori which requires equal representation in committees. This will ensure that no Māori voices are excluded from protecting their homes. The Department of Conservation must increase Māori representation to amend and enhance policy regarding conservation. Within the new policy, there must be more Māori voices and committees that have decision-making authority. In the past, Māori in government committees was often tokenized and lacked real power to make decisions regarding land use, conservation, and resource management (Lian, 1987; Taiepa et al., 1997). The conservation strategies proposed between the Māori and the New Zealand government were varied in their approach, and this resulted in the dismissal of Māori principles that could be effective in restoring biodiversity (Lian, 1987). In the new policy, Māori would have equal decision-making authority in government when considering conservation strategies. New policy must recognize Māori authority.

Although joint-making decision authority is essential to recovering biodiversity and Māori culture, it is not easy to instate in New Zealand due to longstanding representation lulls in government. Joint decision-making authority alone is not enough to restore biodiversity and joint authority only works if there is equal representation in government, which there is not. The communities with the power to make decisions are typically not those who are most affected by biodiversity loss so, it will not be easy to make decisions that empower Māori communities and the environment. When both groups (the government and Māori communities) have different goals and priorities, it is not likely that decisions made are quick enough to be effective. Relying on the government to provide equal authority promptly is not efficient for the precarious nature of biodiversity in New Zealand. Even though it is challenging to implement, joint decision-making authority is essential to the new policy because it accounts for the voices of those who are most impacted by biodiversity declines. The Māori population in New Zealand is the second-largest population demographic and with a substantial proportion of the population belonging to Māori lineage, there is room for increased representation in government (New Zealand Census, 2018). Increased representation ensures greater equality in decision-making regarding biodiversity and other aspects of Māori life that requires better representation and challenges current tokenization. Without including minority voices in policy, groups are often neglected, and needs are not met. Joint decision-making authority ensures that all people are included in conservation conversations that pertain to Māori livelihoods and New Zealand biodiversity.

**TENANT #4**

The fourth tenant of the policy recommendation

includes Māori worldviews in conservation to aid in biodiversity recovery. European colonization of New Zealand prompted an inferior view of Māori culture on the island (Rameka & Paul-Burke, 2015). Europeans established the belief that Māori society was less intelligent and more barbaric than European society (Rameka & Paul-Burke, 2015). This thinking sought the conversion of Māori into "Brown Britons" and the overthrow of Māori culture (Belich, 2001). The dynamic between the Māori and the Europeans established a tradition of oversimplifying Māori culture. European colonizers forced Māori into traditional English-style schooling to educate them on European society and erase their connection with Māori culture (Rameka & Paul-Burke, 2015). Many Māori worldviews, stemming from origin stories, instilled environmental responsibility. The implementation of these worldviews would uplift biodiversity and Māori communities. For example, the inclusion of the Māori concept of *Kaitiakitanga* in the new policy. *Kaitiakitanga,* as described by Māori author Merata Kawharu (2000), is the principle of guardianship that includes all elements – human and non-human, material and immaterial that need balance. *Kaitiakitanga* defines taking care of the environment, or acting as guardian of nature, within a cosmic setting (Kawharu, 2000). It is powerful in conservation policy because it enables practitioners to act as guardians and protectors over the land. The belief is all-encompassing, which means it can be applied to resource and environmental conservation (Kawharu, 2000). Māori community members who wish to be seen as guardians of the environment must be included in this new policy. Through policy, guardians of the land would receive official titles and authority. Through an official title, Māori communities would uphold greater authority over land use and inspire greater connectivity to ancestral roles. Implementing a role in policy for guardianship of the environment can reduce the unemployment rates that disproportionately affect Māori communities (Lyver, 2014). The inclusion of Māori principles into policy would help bridge the gap between Māori and the government and allow Māori communities greater decision-making authority to protect the ecosystems in New Zealand.

More recently, there have been efforts to reconnect with historic Māori culture, but years of colonization and forced education have impacted the presence of Māori culture in New Zealand today (Graham-McLay, 2018). Years of suppression have the perpetuated the underrepresentation of Māori culture in New Zealand and unfortunately, misunderstandings have allowed cultural practices to be disregarded. Although there is some rudimentary Māori education taught in New Zealand public schools, the wealth of cultural Māori knowledge is still underrepresented (May & Hill, 2018). In public schools, students are required to learn *"te reo Māori"* as a language subject, which is a great start in understanding the worldviews of Māori culture and how they can be applied in conservation (Ministry of Education, 2021).

## TENANT #5

The fifth tenant of the new policy includes a clause that Māori communities agree and wish to work within the policy. Although Māori principles in policy could be very beneficial, it is important to understand that Māori protection of land is more than spirituality and connectivity. The Māori relationship with land extends beyond religion and guardianship (although part of it was through spiritual practices), and the environment was essential to Māori economies and politics historically (Lian, 1987). To look at Māori through the "Noble Savage" trope is incorrect and unproductive. This policy will gain consent from Māori communities to use such knowledge and cultural practices because they benefit indigenous communities *and* biodiversity. Māori conservation is not solely spiritual, and conservation is essential for Māori lifestyles and historical cultural practices (Lian, 1987). Conservation of the landscape was important for Māori politics and economies, and it is important to understand and recognize this in policy (Lian, 1987). The new policy must benefit Māori communities as well as the environment. If done correctly, the new policy will uplift Māori communities and begin the recovery of biodiversity.

## CONCLUSION

The five new policy tenants are not enough to recover New Zealand's biodiversity and rectify the abuse of colonial suppression, but they are an effective start. There is no linear solution to recovering culture and biodiversity, and to assume one policy can do so is wrong. However, recovery must start somewhere. Abstaining from the new policy because it is not enough to "fix" the problem enables systemic inactivity surrounding environmental and cultural crises. All-encompassing solutions are nonexistent and waiting for one to solve all environmental issues creates complacency within a broken system. The precarious nature of New Zealand's biodiversity requires swift action, and this policy is an excellent start to recovery. There is no clear solution to restore biodiversity and no easy way to rectify the injustices from years of colonization. However, the proposed five tenant addendum to the Conservation Act of 1987 is a step toward biodiversity recovery and the restoration of Māori culture in New Zealand.

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# How Race and Mental Health Diagnoses Influence Treatment in American Correctional and Rehabilitative Institutions

*Lindsay Remetz*

**ABSTRACT**

This literature review identifies prejudice within the American Criminal Justice System, as well as associated stigmatized mental health diagnoses of different racial populations. These analyses provide credible evidence to show how these inequalities can directly influence treatment in legal and mental health institutions. This supports the argument that the growing prison population crisis in America today plays a major role in the institutional disenfranchisement of people of color at the expense of their mental health and the possibility of rehabilitation. Changing the narrative, by eliminating both the implicit bias and stereotyping in legal and mental health practice and treatment, is essential as our society moves forward.

## INTRODUCTION

The U.S. Department of Justice and the U.S. Department of Health and Human Services were each designed to maintain health and safety for all Americans. This statement, however, is contradicted by a plethora of racial disparities in the treatment and rehabilitation services provided, resulting from the historical background from the time these institutions were founded.

Considering the frequent reports of police violence and the intense sociopolitical racial tension in America today, this thesis is a timely and unique perspective on the treatment of people of color by comparing prejudice in both our legal and mental health institutions.

There should already be considerable awareness, especially with the emergence of the Black Lives Matter movement, that people of color are more likely to face prejudice and discrimination during any law enforcement procession from arrest to incarceration (Gramlich, 2020). Recent events in the criminal justice system have increased public awareness of these issues through mainstream media, heightening the possibility of greater racial polarization. American mental health institutions have had similar, yet less violent, contributions to the public awareness of racial inequities, as was emphasized in October 2021 when the American Psychological Association (APA Council of Representatives, 2021) recognized and apologized for its role in creating systemic racism by describing methods historically used by psychologists which have harmed and marginalized people of color. However, evidence of continuing racial disparities in diagnostic practices and treatment have been identified within the last decade (Binswanger et al., 2012).

This research identifying recent failures is significant because recognizing, addressing, and apologizing for discrimination alone does not constitute significant change. The APA organization, via this apology, advocates for racially conscious psychological practice, education, and criminal justice among other domains. This ideology can be used as a model in mitigating discriminatory biases and practices within the American legal system.

## RACE SIGNIFICANTLY AFFECTS CORRECTIONAL TREATMENT AND REHABILITATION

There is a long history of racial prejudice in the American legal system. After the Civil war ended and slavery was abolished, vagrancy and destitution became a problem especially in more urban areas on both sides of the Mason-Dixon line due to the new "surplus" of freedmen (Adamson, 1983). This led state legislatures to pass a series of vagrancy laws and Black Codes, termed Jim Crow laws, that explicitly applied only to Black people, to severely limit their economic rights and social mobility. Due to the increase of restrictive laws and over-policing in communities comprised primarily with residents of color, more Black people were incarcerated not just with the intent of punishment but, as many historians say, for cheap labor as well. Equal Justice Initiative (2019) states that slavery then "persisted in the form of convict leasing" (para.1) until the 1930s, which was the ability of state penal systems to lease labor contracts with different industries that forced inmates to work during their sentence.

Scholars today agree with this notion that slavery persists in or has slowly evolved into this form of mass incarceration and police violence, regardless of malicious intent, through unconscious biases (Garrett-Akinsanya, 2020; Hetey & Eberhardt, 2018; Fuentes & Ray, 2020). Clinical psychologist Dr. BraVada Garrett-Akinsanya wrote that "the dehumanization of people of color is encoded in the law and must be unlearned" (para. 7). Scholars (Garrett-Akinsanya, 2020; Hetey & Eberhardt, 2018) argue that there is a lack of true education in many influential U.S. systems, such as schools and police forces, due to misinformation and omittance of information, often termed "white washing" of United States history. They also argue that this ignorance or unconsciousness of the wrongdoings of slavery allows for the dehumanization of people of color and dissonance from our country's history, causing a continuum of these ideologies. Changing the narrative and educating our people about the true horrors of slavery and systematic oppression is an imminent step forward.

While the Civil Rights Movement achieved great strides towards equality, including the Civil Rights Act of 1964, which desegregated public institutions, and the Voter Rights Act of 1965, which outlawed voter discrimination, some argue that the movement's success is limited (Onion et al., 2009). Contemporary critics argue that residues of these founding ideologies remain in many United States institutions so much that there is still the "need to continue the Black liberation struggle for freedom" taking new form as the Black Lives Matter (BLM) movement (Clayton, 2018, p. 448). Among protesting ongoing police violence, BLM has brought attention to the racial disparities in the criminal justice system and other "systems in place that continue to devalue the lives of Black and brown people in different aspects," namely the "prison industrial complex, housing markets, food security, and voting rights" (Schmitt et al., 2017, p. 3).

Incarcerated populations in this manuscript are defined as the total number of incarcerated individuals in correctional facilities including federal and state prisons, local jails, and halfway houses. Statistics from the 2010 U.S. Census show the incarceration rates per 100,000 people in the United States show that primarily Black and Latinx populations are overrepresented in prisons in almost every state (Prison Policy Initiative, n.d.). This is alarming as the United States has the highest incarceration rate in the world (Gramlich, 2021),

and the number of incarcerated individuals is still rising.

According to the data collected by the United States Bureau of Justice Statistics there is a positive trend nationwide for incarcerated individuals beginning in 1925 to 2022 including State (85,239-1,182,166), Federal (6,430-142,028), and local prisons (99,249-549,100) respectively (Pew Research Center, 2020). These overwhelming numbers are not proportional to the United States racial populations, as statistically Black people amount to 33% of incarcerated individuals while being only 13.4% of the total United States population (Pew Research Center, 2020). Additionally, among all incarcerated populations in the United States, the incarceration rate is 6 times higher for Black males and 2.3 times higher for Hispanic males compared to White males (Gamache et al., 2021, p. 53). Black Americans are more likely to be placed on death row and executed by the death penalty (Gamache et al., 2021). They are also more likely to have a previous criminal record to be arrested for serious crimes (Kim & Kiesel, 2018). Black men who commit the same crimes as White men receive prison sentences that are, on average, nearly 20 percent longer, according to a new report on sentencing disparities from the United States Sentencing Commission (Schmitt et al., 2017). These disparities were observed "after controlling for a wide variety of sentencing factors," including age, education, citizenship, weapon possession and prior criminal history (p. 6).

Other disparities include those before sentencing, involving plea bargaining and judgments of criminal responsibility (Berdejó, 2018). White defendants with no prior convictions receive charge reductions in 63.91% of the cases which is 13.25% higher than the rate of change reductions for Black defendants with no prior convictions at 50.66% (p. 1221). Similarly for misdemeanor cases, 44.82% of cases involving White defendants were dropped or amended, while only 30.89% of Black defendant cases dropped/amended (p. 1216). Even in felony cases with the same severity, 49.83% of White people see charges dropped or amended while Black defendants stay at 39.87% (p. 1216).

Instead of taking the opportunity to reexamine the disparities in the criminal justice system some argue that current statistics may justify these disparities found within that system today. (Hetey & Eberhardt, 2018). However, it is important to understand how incarceration disparities are partially the result of the subjectivity involved in judicial discretion during sentencing and using a jury to decide the guilt of defendants which can introduce a plethora of complexities due to biases. According to a study of juror perception on defendant race, bias is evident as Black defendants were rated as more guilty than White defendants for the same crimes (Pfeifer & Ogloff, 1991). The rhetoric was similar in Gamache et al. (2021), suggesting that Black people were described as a "violence prone minority" as justification for the disparity. This also provides further justification for jurors to decide on the "future violence probability" of the defendant and to view "Black perpetrators as more violent and dangerous when the victim is White" (p. 54). In the instance that the victim is of any other race, Black people are viewed as less violent in comparison (Gamache et al., 2021). For example, when the victim race of the crime is White with a Black perpetrator, the perpetrator is more likely to receive a high penalty sentence, whereas if there was a Black victim, the White perpetrator is more likely to receive a lower penalty sentence Other studies suggest that in these instances, "substantial racial disparities" do exist "that cannot be explained by purely legally relevant factors" such as crime severity and criminal history (Crutchfield et al., 2010).

## RACE SIGNIFICANTLY AFFECTS DIAGNOSIS AND TREATMENT OF MENTAL ILLNESSES

Similar to the establishment of the criminal justice system in the United States, it is evident that mental health institutions contributed to the racist ideology that people of color were inferior. While many foundational psychological theories were eventually challenged as inherently prejudiced, and refuted by today's standards, residues of this ideology linger in mental health institutions today as evidenced by the American Psychological Association's apology in 2021. This apology (APA Council of Representatives, 2021) acknowledges that past and current diagnostic criteria are biased, Eurocentric, and discriminatory, strongly suggesting that current methods will not always accurately capture the cultural and lived experiences of people of color. This is significant because it could influence the accuracy of mental assessment and the quality of effective treatment for individuals with differing cultural perceptions and expectations.

In addition to concerns involving the diagnostic methods employed, significant differences exist in determining the administration of diagnostic testing and treatment among differing racial populations. For example, in researching disparities in mental health treatment in the Juvenile Justice System it's evident that, people of color are less likely to be diagnosed or treated for mental illness even when factors like substance abuse and financial need were statistically controlled (Development Services Group, 2017, p. 5).

Comparable evidence from different studies show that mental health and legal outcomes are associated with being diagnosed with a positively perceived versus stigmatized mental illnesses. For example, African Americans of all ages are more likely to be diagnosed with stigmatized disorders, like schizophrenia, and are less likely to be diagnosed with mood disorders, like depression and anxiety, even though relevant diagnostic characteristics and symptoms presented were consistent relative to any other racial population, including White people (Perry et al., 2013; Del Bello et al., 2001; Neighbors et al., 1999). Black people are 4 times more likely to be diagnosed with a psychotic spectrum disorder and Latinx people are 3 times more likely to be diagnosed, than White people (Schwartz & Blankenship, 2014, p. 133). Being diagnosed with a mood disorder, like depression, leads to better mental health outcomes because patients, of any race, with mood disorders are more likely to be placed in an environment that is more conducive to their treatment and are perceived to be less dangerous or isolating in comparison to other mental disorders (Perry et al., 2013; Baillargeon et al., 2010). Contrastingly, psychotic spectrum disorders have been shown to be associated with greater stigma, social isolation, and reduced life chances (Link et al., 1999; Phelan et al., 2000). These reduced life chances were loosely defined as low socio-economic status, unemployment, greater crime, and incarceration rates.

Being an individual who is both Black and diagnosed with schizophrenia will have specific ramifications within the legal system, partly because being more violent, paranoid, and unpredictable is associated with the disorder. This ideology emerged in the early 1960s, after the APA published the second edition of the Diagnostic and Statistical Manual, "in the midst of a political climate marked by the Civil Rights Movement's profound protest and social unrest," (Lane, 2010, para. 7). The DSM-II categorized paranoid schizophrenia as a disorder of masculinized belligerence as "the patient's attitude is frequently hostile and aggressive," terms that were used to disproportionally diagnose black men with the "dangerous disorder" of schizophrenia to perpetuate association between Black men and violence, and to justify the differential treatment and imprisonment of black men in the 1960s and 1970s (Lane, 2010, para. 6).

## COMPARING DISPARITY

The information above has made it evident that people of color receive unequal treatment in both mental healthcare and criminal justice institutions. However, researchers have noticed that little research has focused on the interaction between the two systems (Perry et al., 2013). Here, the intersectionality of race and diagnosis is important to examine within the context of the criminal justice system. Intersectionality is a term coined in 1989 by legal professor Kimberlé Crenshaw to describe how race, class, gender, and other individual characteristics "intersect" or overlap, creating unique life-experiences (Coaston, 2019). The focus here will be to specifically analyze how the race and mental health diagnosis of a defendant affects and influences treatment within the United States court systems.

There is evidence of an extremely subjective judicial process which has a dramatic impact on

sentencing and treatment, as a result of implicit biases from judicial professionals about people with mental illnesses. Such biases can include variations in how mental illness is interpreted culturally or unconscious stereotyping of behaviors of people with mental illness. Unconscious stereotypes or biases are defined as "the automatic assumptions or stereotypes we have about certain groups of people outside of our conscious awareness that influence our attitudes and behavior… which is pervasive and often does not align with our expressed or declared beliefs" (University of South Carolina Division of Human Resources, n.d.). Empirical studies in brain sciences and the law explain how our current legal system makes assumptions about mentally disabled people that often perpetuate fears and apprehensions about mental disorders (Perlin & Dorfman, 1993). This is most evident in criminal trials where the mental status of the defendant was examined resulting in "increased visibility in the media and public" where the mental illness of the defendant can be scrutinized and perceived in negative ways (p. 47).

Psychological forensic evaluation and testimony plays a crucial role in how the court views the prevalence of, and the degree to which, the mental health of the defendant affected the outcomes of the case. Forensic psychological science also helps determine who should be provided mental health care or rehabilitation versus who should be incarcerated without treatment. It is evident, especially due to the APA's apology for contributing to discrimination, that racial disparity exists within mental health care and treatment. This is due to the Euro-centralization of current diagnostic standards and biased evaluative methods in determining the administration of treatment, which often leads to the misdiagnosis of mental illnesses among people of color (APA Council of Representatives, 2021). Evidence of this leads to plausible conclusions that mental health disparity is also present within mental evaluations in court. As explained earlier, race is a determining factor among referrals, access to mental health and drug rehabilitation services, and the quality of treatment (Development Services Group, 2017). This is significant to revisit because these are deliberate decisions, based on Eurocentric diagnostic standards. A major concern is that these standards are being made by forensic psychologists who may lack the cultural perceptions of mental illness and treatment, leading to further racial disparity in the treatment of mental health disorders within the criminal justice system.

There have been considerable amendments to current laws and regulations partly due to ever-changing definitions and diagnostic criteria of mental disorders and competency. However, there is evidence that the legal system that the courts use scientific data on mental illnesses when it is in support of the intended resolution but disregards data when it questions the validity of the resolution (Perlin & Dorfman, 1993). Regardless of this fact, it is important to recognize the immense difficulty and red tape required to create laws that protect against all forms of subjectivity in differing court cases.

According to the National Alliance of Mental Illnesses (2022), data has shown that 1 in 4 people with a serious mental illness has been arrested at some point in their lifetime, booking approximately 2 million mentally ill offenders in the United States. It is also made evident from Stanford University's Three Strikes project in 2014 that mentally ill offenders receive disproportionately longer sentences than non-mentally ill offenders (Mencimer, 2014).

Evidence of extremely diminished effort to utilize mental health rehabilitation or therapy to combat the prison population crisis in the United States is a blatant example of how seriously mental health disorders are treated today. These are decisions that directly affect an individual on a life-altering scale, especially considering the previous discussion about how legal settings often neglect treatment for incarcerated individuals with mental illness or exhibit appropriate regard to possible mental health ramifications from the court process or sentence itself. Mental health rehabilitation is one of the most obvious methods of reducing criminal activity, and subsequently, the total incarcerated population. To explore this idea further, researchers must analyze the lack of mental health treatment and rehabilitation in disenfranchised racial populations, while also considering the immense racial disparity in the arrest, evaluation, sentencing, and correction processes. This brings to question the extent to which the lack of mental health treatment in correctional processes can be attributed to the racial disparity and overrepresentation of people of color in correctional facilities.

## INTERSECTIONALITY OF RACE AND MENTAL ILLNESS ON CRIMINAL SENTENCING AND INCARCERATION

Researchers claim that mental health diagnoses are indicative of the results of forensic psychological evaluation, but its interpretation relies on the judge and jury's attributions of criminal responsibility and mental illness. These attributions rely largely on their preconceived stereotypes of race and mental illness which can influence their perception of the legitimacy of the defendant's psychological evaluation and criminal responsibility (Thompson, 2010). This idea supports the overall argument of this manuscript, but still considers race and mental illness to be mutually exclusive. Relevant research combines these ideas stating that "determinations of mental state have important implications for the criminal justice system" as diagnosis and "mental health treatment tends to result in…more punitive criminalization for racial minorities" (Thompson, 2010, p. 100).

Although people of color are more likely to be identified as having psychotic mental health problems, they are still more likely to be incarcerated and extremely less likely to receive access to quality treatment, if any at all. In a study on disparities in mental health referral and diagnosis in the New York City Jail, results showed that both non-White and juvenile patients in the New York City jail system were less likely to receive mental health services and more likely to be placed in solitary confinement (Kaba et al., 2015). Other studies on Black people with behavioral health disorders show considerable evidence that racial stigma, and stigma due to mental illness or addiction, act as separate and "independent barriers" to mental healthcare (Yu et al., 2021). This is because there are different "cultural conceptions of mental illness" which "have dramatic consequences for help seeking, stereotyping, and the kinds of treatment structures [created] for people with mental illnesses" (Link et al., 1999, p. 1328). Statistics estimate that out of the 45% of all incarcerated individuals having mental illnesses that meet diagnostic criteria, 66% did not receive any mental health care while serving out their sentence. (Gill & Ring, 2017).

## IMPLICATIONS FOR BETTER FORENSIC MENTAL HEALTH OPPORTUNITIES

The effects of racially biased court processes in mental health evaluation and diagnosis allow for disparate mental and legal prognoses for different racial populations within the criminal justice system. This disparity is becoming increasingly problematic due to the rise of incarcerated mentally ill individuals, without much significant change in the systems geared towards psychological rehabilitation. It seems likely that there is a lack of mental health care in American legal institutions for all races, but particularly for people of color. Fortunately, scholars have identified unique solutions which may address these problems.

In analyzing such a complicated topic, it is difficult to find broad-scope solutions that can essentially remediate the problem of systematic racism and discrimination. However, changing practice and ideology in current institutions may help bring more progressive change overall. There are a few solutions that will be provided in this section, primarily geared towards the role psychologists and forensic evaluators play in determining mental health outcomes. Solutions include a call for more education on the historical treatment of people of color in this context, to spread cultural humility rather than cultural competence, and to encourage the use of bias free language and attitudes toward the intersectionality of one's identity.

## MORE EDUCATION AND HEALING

The common solution provided by Garrett-Akinsanya (2020), Hetey and Eberhardt (2018), and Fuentes and Ray (2020) is essentially the need for more education to actively unlearn ideologies of

racial inferiority. This involves deeper learning of the history of the United States involving the horrors of slavery, the deliberate racial differentiation and segregation, and how institutions, many of which are still in place today, exploited and discriminated against people of color. Social justice movements in the 21st century, like BLM, have made some progress towards racial equality by using social media to conjure the power of public awareness and constitute change (Clayton, 2018). In a time where American institutions, like the APA, are finally addressing their own contributions in creating and preserving systematic racism today, it's imperative to shift the focus from equality to equity, not just to nullify, but also to counteract the harmful effects of generations of disadvantages, misinformation, and exploitation.

Great examples of this solution are the education and reparation efforts in Germany after the Holocaust, or in South Africa after Apartheid. Both have had active community learning and healing, in which victims received reconciliation and reparations (Kahn, 2020). Germany began efforts in the 1980s named "Vergangenheitsaufarbeitung," which translates to "working off the past," as a moral imperative that "postwar generations insisted on owning up to its own deep shame" (para. 6). Acts of "cultural rehabilitation and renovation were taking place all across German cities and towns" including the destruction of Nazi structures and the disbursal of reparations to Holocaust victims, to essentially level the playing field for equal treatment moving forward (para. 6). Similarities are also found within South Africa and Rwanda in which peace advocates "demanded that perpetrators [of the Apartheid] appear in a public forum to detail for the record the full extent of their violence" (Konadu, 2021, para. 26) and "called for member countries to think beyond money to consider reparations measures aimed at healing trauma and establishing broad social justice" (para. 28).

Although it might be possible to say that institutional racism and prejudice have been less explicit in recent years, unfortunately, implicit bias and prejudice is alive and well. These are more obscure things that are less frequently addressed because of their implicit nature. An example of these are microaggressions, or "subtle words and behaviors, committed consciously or not, directed towards a member of a marginalized group, that has a demeaning effect" (Cuncic, 2021, para. 2). However, this "demeaning effect" is empirically shown to be a form racial trauma, as studies in substance abuse found that there is "significance of racial microaggression on health outcomes for Black young adults" and "can inform future research in the area of trauma exposure and substance use risk" (Zapolski et al., 2021, p. 2). We must also learn how these implicit biases, like microaggressions, can permeate American society and negatively affect equal opportunity and treatment, as well as hopefully, identifying ways to decrease their influence. However, it would be interesting in future research to investigate a possible association between racial trauma and substance use and how it could be related to the racial inequalities found within the American criminal justice system.

## USING CULTURAL HUMILITY INSTEAD OF CULTURAL COMPETENCE

Racial sensitivity and awareness are growing topics among many American institutions. It is critical to address implicit biases about race, especially due to evidence of psychologists' disinclination and incompetence in treating mentally ill people of color within current mental health institutions. There are ways in which the field of psychology can become more inclusive and racially sensitive by including the diverse lived experiences of all races. Psychologists must advocate for more inclusive evaluative processes for defendants of color and for additional mental health resources. Specifically, better mental health resources within the criminal justice system to prevent and treat possible mental repercussions from the psychological harm of arrest, court, and incarceration proceedings. To do this, there are actions and ideologies that psychologists can implement in practice to allow for a more equal and inclusive diagnosis and treatment. These possible actions include changing our cultural competence to cultural humility, diversifying the psychological workforce, and implementing inclusive and bias-free language and practice.

Multicultural competence, or "the ability to understand and constructively relate to the uniqueness of each client's diverse cultures and perspective" is often prescribed to fix cultural misunderstandings (Stuart, 2004, p. 3). However, it is arguably more effective to reflect on one's own race and culture to determine how it might influence the relationship, rather than being culturally competent in understanding all the perceptions and experiences of every other culture. This is termed as having cultural humility, or radical openness in psychological literature, referring to the receptivity of the mental health professional to "the unexpected in relation to oneself and in relation to the other" (Hart, 2017, para. 5). This will increase the ability of a mental health professional to understand and be comfortable with unmet expectations of their own preconceived assumptions of stereotypical behavior because "even well-intentioned providers who are motivated to be nonprejudiced may stereotype racial/ethnic minority members, particularly under conditions that diminish cognitive capacity" (Burgess et al., 2004, p. 1154).

Incongruences often exist between the racial identities in a therapeutic relationship, or any other mental health processes, for many people of color (Neighbors et al., 1999). Data published in 2020 showed that even though there is a positive trend in diversifying the psychology workforce, 84% of psychologists are White (American Psychological Association, 2020). However, studies on racial therapeutic relationship shows that Black "patients who were treated by Black providers had higher levels of satisfaction, perceived the providers to be more respectful, accessible, better listeners, and better at explaining their medical problems" (Burgess et al., 2004, p. 1157). This is the key to dismantling the racial disparity in mental health care and treatment so that mentally ill people of color feel heard and represented, while also allowing for more inclusive research and diagnosis so the field of psychological knowledge can be more universally and culturally accurate. The field of psychology needs a more diverse workforce so that new and more universal knowledge can be applied to current practice, evaluation, and treatment to be more inclusive and effective for people of color.

## CONCLUSION

The U.S. Department of Justice and Department of Health and Human Services have not inclusively maintained health and safety for all Americans. This statement is supported by a plethora of racial disparities in the treatment and rehabilitation services provided. These analyses include credible evidence to show how these inequalities directly influence treatment in current legal and mental health institutions.

Evidently, there is a need for more, and better, psychological evaluation during correctional processes to ensure that mentally ill defendants of color, compared to white defendants, receive the rehabilitation and access to the care that they need. Solutions call for more education on the historical treatment of people of color in this context, to spread cultural humility rather than cultural competence, and to encourage the use of bias free language and attitudes towards the intersectionality of one's identity. However, changing practice and ideology in current institutions may help bring more progressive change overall. Restoring mental health in marginalized populations could drastically reduce the racial disparity in the already overcrowded United States prisons.

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# Gemini Graveyard

*D'Shon Jae McCarthy*

**ABSTRACT**

Self-identity has been emphasized through art history as it influences the creative choices of the artist. In particular, the Surrealist movement has encouraged deeper exploration of one's subconscious in order to understand the influences on one's identity. Surrealist Frida Kahlo, in most of her portraiture, showcased her identity using symbolic, dream-like images to represent personal experiences. Death, post-Revolution Mexican culture, and personal relationships were common themes in Kahlo's artwork. The self-portrait *Gemini Graveyard* serves as a diary as it documents the artist's journey to discover the evolving nature of her identity within the confines of a 48" x 60" canvas. Surrealists like Kahlo inspired this artist to look within herself, determining how the loss of opportunities, how complicated relationships, and how losing a sense of control have affected her perception of her own identity. Central to the painting is the artist's figure, tearing from the chest up. Whatever the figure had previously identified with, whatever she had previously known herself to be, was ripping apart, splitting in different directions. Trees painted in painful, dark red and withered violet and a distant, decaying house colored in eerie grey represent a past she would like to be away from. A fear of moving forward causes the right side of the figure's body to stay behind, attached to the ominous house. To the left of the figure rests a large, purple amethyst crystal, representing the fearlessness that is required to let go and move forward. These opposing sides cause the figure to struggle, leading her to rip herself apart. Undergoing this figurative death ultimately helps her understand that once she let's go, she will discover other versions of herself she did not know before. By parting with the side of her body that wishes to stay behind, she is released and able to move forward. Now free to look deeper into herself, the figure uncovers vibrant blue chrysanthemums, a symbol of knowledge and optimism she did not know she carried. The flowers and amethyst serve as guides as the figure splits apart and moves towards the unknown: the future. The artist observes that without enduring the pain of tearing away from elements of her past, she would not have been able to recognize the hope that lies in her future and appreciate the flowers blooming before her.

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# Instagram Reels for Small Business: How to Hook, Bait, and Reel in Customers

*Daisy Holder*

**ABSTRACT**

Advertising has a significant impact on the success of a business, particularly for small businesses. In the age of social media, businesses have had to adjust to digital advertising. Specifically, the platform Instagram offers a cheap and wide-reaching option for small businesses. Their new, short video feature Instagram Reels allows creators to share videos up to sixty seconds long, a feature that many small businesses use to advertise. Numerous small businesses praise this feature and attribute the growth of their business to its use. As it is a new feature, however, there is no academic literature available on its usage. This paper explores how scholarly research on short video advertising can be applied to the Instagram algorithm to determine the most effective Instagram Reels advertising methods for small businesses. This paper also assesses recommendations from small business creators who currently utilize the feature. Findings suggest that businesses must consider product compatibility with short video advertising, messaging, appeals, and sourcing to create the most effective advertisements on Instagram Reels. The most effective short video advertisements will involve hedonic and low involvement goods, will be entertaining and emotionally provoking, and will encourage viewer participation with the video. All these elements are synonymous with the Instagram algorithm and should produce the most effective Instagram Reel advertisements for a small business.

## INSTAGRAM REELS: A GUIDE FOR SMALL BUSINESSES

Despite constituting a sizable portion of the U.S. economy, over half of all new small businesses fail within the first five years, with only 25.7% of small businesses surviving fifteen years (SBA, 2021). Many factors influence the survival of a small business; however, advertising is particularly impactful due to the recent shift away from traditional advertising and toward social media advertising. Specifically, in the younger generations, media consumption revolves around social media. This shift has meant that small businesses have had to adapt their advertising methods. Unfortunately, many small businesses are failing to utilize social media as a tool for advertising (Sullivan et al., 2021).

Social media offers a cheap alternative to traditional print advertising, making it an attractive option for small businesses lacking the means to employ outside resources or looking to enhance their existing social media presence. A particularly popular social media platform is Instagram, a photo-sharing app that was launched in 2010 and has gained popularity ever since. Instagram is perceived as one of the best social media apps to engage with small businesses (Abitbol & Rook, 2020). The app's popularity makes it imperative for small businesses to understand how best to use it, particularly the new feature Instagram Reels. Launched in August 2020, the short video technology enables users to create and post short videos up to sixty seconds long. Since its launch, small businesses have begun to implement Reels into their marketing strategies, making it worthy of academic attention. Due to Reels being a new feature, there are no scholarly sources on Instagram Reels; however, by applying research into short video advertisements to the Instagram algorithm, this lack of research can be remedied to determine the most effective Instagram Reels advertisement methods. Businesses must consider product compatibility with short video advertising, messaging, appeals, and sourcing to create the most effective advertisements on Instagram Reels.

## INSTAGRAM ALGORITHM AND SMALL BUSINESSES

Instagram is a particularly impactful platform for small business social media advertising. Instagram offers businesses a vast audience with over one billion monthly users in 2021 (Omnicore, 2021). For small businesses that are often geographically limited and have a smaller customer base, this expands the reach of their ads significantly. Instagram also gives businesses complete control over the content they produce, and visibility of the ad's success based on likes, comments, accounts reached, and other insights. Tracking these characteristics can guide small businesses in what ads to produce, which products are the most successful, and what content garners the most attention. These insights are helpful for small business owners who otherwise have limited measure of how successful their traditional advertising is. The platform also promotes smaller creators, particularly those with unique life experiences and perspectives (Instagram, 2021). The focus on smaller creators inherently benefits small businesses due to their limited following, making Instagram a good option for social media advertising. This focus may deter larger businesses from creating content, however, if they have an established following, their content will still be consumed and shared, just not pushed by the algorithm as much. In short, the algorithm works particularly well for small businesses trying to grow their accounts and expand their customer base.

Small businesses also gain additional benefits from the use of Reels. Instagram (2020) launched Reels with the primary intent of entertaining people; however, small businesses have since altered that objective to include advertising. Many small business owners on Instagram recommend using Reels to advertise and accredit the growth of their accounts and businesses to the consistent use of Reels (Fryer, 2021; Pearl, 2021a, 2021b, 2021c). Their support suggests that Reels is an effective advertising medium, though true success rates are yet to be measured, due to how new the feature is and the lack of academic literature. Creators also offer suggestions on how to create the most effective Reels. The validity of these suggestions is uncertain as they are unsupported by any academic literature.

Instagram uses an algorithm to determine which people see what post. The app uses a survey to evaluate the posts that are deemed entertaining to users and uses this classification to promote specific posts over others (Mosseri, 2021). Instagram also highlights posts that encourage creation, posts that use audio from the Instagram audio library, vertical reels, and those that show diverse and meaningful views. There is a more personalized approach to the algorithm, however. Instagram also assesses the likelihood of someone engaging with a Reel. Engagement involves liking the Reel, watching it in its entirety, sharing it, or using the audio. How likely a user is to engage with a post is determined based on previous actions the user has taken. All these elements impact which Reels are shown to what users; thus, it is necessary to understand the algorithm to ensure that posts reach the maximum audience possible. These considerations are combined with research into short video advertising to inform suggestions for Reels content, which are explained later in this paper.

## SHORT VIDEO ADVERTISING

Businesses must also understand how short video advertising works. A critical component of this is knowing whether the product being advertised

works with short video advertising. Research indicates a difference in the effectiveness of video advertisements for different types of products, namely, low involvement, high involvement, hedonic, and utilitarian (Stewart et al., 2019). These terms refer to goods of minimal risk, elevated risk, enjoyable goods, and practical goods, respectively. Hedonic products grant consumers immediate gratification when consumed, a process based solely on emotional reaction, whereas utilitarian goods provide functional value to the consumer (BizNews, 2021). While goods can have hedonic and utilitarian elements, common examples of hedonic goods are ice cream, luxury products, and vacations (BizNews, 2021). These goods induce an emotional reaction that provides satisfaction to the consumer. For utilitarian products, attention is drawn to the good's practical merits, resulting in more time spent researching the product and its alternatives. Simply put, hedonic products are easier to purchase than utilitarian products and require less of a time sacrifice.

In addition to this classification, products can also be high involvement and low involvement. High involvement products represent someone's status and are often expensive, have complex features, are differentiable from alternatives, and are higher risk for consumers if they fail (Chand, 2014). Contrary to this, low involvement products are less important, have a negligible effect on someone's sense of status, and result in brand hopping (Chand, 2014). These differences are crucial in understanding advertising. Overall, video advertising is more effective for hedonic, low involvement products than high involvement, utilitarian products, as high involvement products require more information processing, which is not conducive to the video format (Stewart et al., 2019). Low involvement, hedonic products require less thought and attention to purchase, making products easier to sell. Fewer details are needed to convince a consumer to buy the product, as there will be no detrimental effect on a personal sense of worth or significant loss of money and/or time. Small businesses on Instagram Reels cater to an audience unaware that they will view an advertisement. Low involvement and hedonic products are more likely to make an impact than high involvement, utilitarian products, as users can easily purchase the product without much thought, meaning businesses should utilize short video advertising if their goods are hedonic and low involvement.

Once a product has been deemed compatible with video advertising, small businesses need to consider the characteristics of short video advertising which can be generalized to the purpose of the ad, specifically, whether it aims to promote a specific message or general awareness of the brand. Research indicates that video ads work best at promoting awareness of a brand rather than specific messages. Hautz et al. (2014) found that richer modalities, such as video, shift focus away from messages and arguments and toward the characteristics of the source. Simply put, the rhetoric of the video becomes less important as the emphasis is placed on the creator of the video, the business. This focus also applies to six-second ads. Campbell and Pearson (2021) found that six-second ads work best for generating awareness rather than specific messages. This is particularly applicable to Reels, as creators on Reels often suggest keeping reels between 5-10 seconds long (Manski, 2021; Nichol, 2021). Thus, short video ads of approximately six seconds in length lend themselves to creating awareness of a brand rather than promoting specific messages.

## STORYTELLING AND ENTERTAINMENT IN ADVERTISING

In addition to messaging, businesses should also consider what appeals they include in their reels. Research indicates that businesses should opt for emotionally driven ads rather than straight-sell, informational ads (Coker et al., 2017). This manifests in entertaining ads which incorporate a narrative and storytelling (Coker et al., 2017). Tellis et al. (2019) found that ads incorporating aspects of drama, such as having a plot, including likable characters, and having elements of surprise helped create positive emotions and induced sharing. Storytelling increases the relatability of the advertisement by helping consumers visualize themselves using the product in their everyday lives. It also helps consumers form an emotional connection with the brand. This results in a feeling of accomplishment if they decide to support the business by purchasing a product (Coker et al., 2017). In other words, storytelling ads help consumers form an emotional attachment to a brand, resulting in higher engagement. Yang and Zhao (2020) expand on this stating that consumer's engagement with social media ads is primarily driven by "the affective route of information processing" (p. 538). This refers to the viewer's propensity to engage with affective or emotional information, meaning that social media ads are most conducive with emotional appeals. These scholars indicate the importance of making ads entertaining through storytelling and suggest that by doing so, consumers will be more likely to share the ad, feel positive emotions towards the business, and purchase the product.

Narratives can also apply to short video advertising, though they need to be altered. Campbell and Pearson (2021) suggest that narratives can be adapted to the six-second format. For this, advertisers must relinquish the classical narrative structure in favor of simplistic storylines and fractured narratives which omit the beginning, middle, or end, open narratives in which the narrative is constructed by the viewer, omitting unnecessary shots, alluding to things outside the frame, drawing on preexisting knowledge of consumers, and using sociocultural context (Campbell & Pearson, 2021). Wang et al. (2020) reinforce the effectiveness of short ads, stating that six second ads fostered more positive emotions than fifteen or thirty second ads. While there are issues in transferring messages through the ad due to its short length, alternative actions such as using text or titles can help make up for this (Wang et al., 2020). Creators could also use multiple six-second advertisements (whether sequentially ordered or not) to pique viewers' interest in the brand and present a wider narrative (Campbell & Pearson, 2021). In other words, six-second narratives rely on the viewer to infer events happening outside what is shown in the video; however, they are still able to transmit stories and meaningful messages. Businesses must be aware of the nuances of these other narrative styles to ensure that they can effectively create a narrative in such a brief period. Failing to understand how narratives apply to short video format may result in incomplete or ineffective advertisements that lack the necessary information and present incomplete narratives.

Whether emotional appeals provoke positive or negative emotions also plays a role in the effectiveness of the ad. Researchers agree that ads with emotional appeals are more engaging and help engender a favorable change in attitude towards a brand (Dafonte-Gomez, 2014; Yang & Zhao, 2020). This effect further increases when the emotions are positive. Ads evoking positive emotions such as amusement, surprise, and inspiration, are more likely to be shared and go viral than ads that generate negative emotions (Guadagno et al., 2013). This is not to say that emotional appeals must be positive, however. Ads inducing negative emotions are still more likely to be forwarded than ads with no emotional appeals (Guadagno et al., 2013). So, while businesses should prioritize producing ads that create positive emotional reactions, as they are most effective at inducing sharing, any emotional appeal is better than none.

Conversely, some ads use informational appeals, which provide factual details about the product and are persuasive. Despite being common in advertising, research suggests that informational appeals decrease sharing (Tellis et al., 2019; Yang & Zhao, 2020). Coker et al. (2017) theorize that informational appeals prompt analytical processing and counterargument in the consumer, resulting in decreased sharing. In other words, consumers naturally become defensive and search for potential flaws in the product. While logical reasoning can be beneficial for products that are high-risk, new, or expensive, this type of product is not compatible with short video advertising (Stewart et al., 2019). In general, businesses should avoid informational appeals in short video advertising, as it makes consumers more critical of the brand and hurts sharing.

There are drawbacks to producing solely entertaining ads, however. Teixeira et al. (2014) found that when advertisers maximize the entertainment value of an ad, they forfeit maximizing purchase intent. In other words, there is a tradeoff between entertainment in ads and creating purchase intent. In addition to this, Tucker (2015) found that ads with many views had lower rates of purchase intent, meaning that they encouraged less intent within the viewer to purchase the product. Simply put, though entertaining ads may garner more watch time and views, they are less likely to be persuasive. This is negated, however, by the fact that any entertainment increases the effectiveness of the ad, as viewers are more likely to watch the entire video. These findings suggest that entertaining ads work best for creating brand awareness and increasing reach, but not for being persuasive. This principle also applies to short video advertising in general. Thus, businesses must accept that when using short video advertising, they will sacrifice persuasiveness in favor of generating brand awareness.

## USER ENGAGEMENT

A critical aspect of short video advertising is user engagement. Ge et al. (2021) found that a higher

number of comments on a post increased sales; however, the degree to which sales are impacted depends on the source of the comments. When the comments come from buyers, the comments are more impactful, as they are not motivated by sales and are more genuine (Ge et al., 2021). Consumers value the unbiased opinion of others, thus having unsolicited (positive) reviews of a product in the comment section of a post will increase the efficacy of the ad. This suggests that getting users to engage with videos is crucial for increasing product sales. Similarly, Hautz et al. (2014) found that peer recommendations from user-generated videos (UGVs) are better than recommendations from agency-generated videos (AGVs) due to their increased credibility. As with the increased credibility of comments, UGVs are videos created by a user (rather than a business or agency), thus making them a form of unbiased review, and more credible. In this context, these videos would be unsolicited advertisements for a product. Hautz et al. (2014) recognize that although businesses cannot expect UGVs to perform better than AGVs, as there are other moderating factors, in general, UGVs are better, due to their increased credibility. These scholars all suggest that increasing user engagement with a business, whether that be commenting on videos or creating videos themselves, increases the effectiveness of the ad. Businesses should attempt to incorporate UGVs and peer recommendations into their marketing strategies by prompting users to create ads and engage in the comments.

## APPLICATION TO REELS

Once a business decides to use Reels, there are several important considerations. It is first important to maintain a consistent presence on social media. This not only displays dedication on behalf of the business, but also increases the chance of success based on quantity alone. Abitbol and Rook (2020) found that college students, a sizable portion of Instagram's userbase, value commitment and effort from businesses on social media. They also respond best to honest and optimistic language (Abitbol & Rook, 2020). Thus, businesses must post consistently on Instagram Reels to increase the likelihood of their success. Additionally, maintaining an open and honest relationship with consumers will benefit the business. This suggests that businesses must fully embrace Instagram as an advertising tool by posting consistently to appeal to users.

It is critically important to make Instagram Reels advertisements entertaining, as Instagram Reels promotes Reels that entertain. One method of making Reels entertaining is through a narrative: a method that has already been established as effective advertising. In terms of a business, this can be done by telling the story of the business. Businesses could create multiple reels about the development, values, visions, and goals of the business. This would help consumers develop an emotional attachment to the business, prompting purchases and a positive change in attitude towards a business. In addition, businesses producing Reels displaying behind-the-scenes activities like designing products, making products, and packaging orders will increase emotional connection and relatability. By using these suggestions, businesses will appeal to both the Instagram algorithm and consumers, as consumers will see themselves as involved in the story, prompting them to support the business.

Instagram also states its commitment to displaying reels that inspire creation (Instagram, 2021). This includes reels that incorporate trends, whether that be existing trends or creating new trends. Using trending audio increases the spread of the Reels more people will view the audio page and be exposed to the Reel. In addition, Instagram will promote it at a higher rate, as users may be inclined to participate in the trend themselves. Ge et al. (2021) also found that short videos with music and females increased product sales. So, by including music, particularly trending audio, businesses can increase the spread of their Reels and increase purchase intent. In addition to music, businesses can also increase user engagement through comments, likes, and inducement to visit their webpage. A "call to action" (CTA) prompts users to answer a question, respond, or share something in the comments of a video. Examples of CTA's include "follow for more updates," "like for part two in this series," "Relatable? Share this to your story," and "share this with your audience to…" (Osborne, 2021). These all encourage the user to engage with the content in some way, all of which will increase traffic to the post and generate more reach. Incorporating this into a Reel would increase the comments, leading to more product sales (Ge et al., 2021). Additionally, prompting users to create UGVs giving reviews of a product or service may also help the business. In general, businesses should try to encourage users to engage with their Reels to appeal to the algorithm and increase the overall effectiveness of the ad.

There are also technical considerations that will impact the effectiveness of the ad. The algorithm promotes vertically filmed Reels at a higher rate than horizontally filmed ones. In addition, vertical orientation makes the ad easier to process for younger people and increases ad interest (Mulier et al., 2021). Younger people can process vertical ads more fluently as young people find they require less effort to watch than horizontal ads, which require the screen to be turned (Mulier et al., 2021). Conversely, older people find horizontal ads easier to process, as they feel that vertical ads require more effort to watch (Mulier et al., 2021). In other words, the ad is more effective for younger users who are the primary user base of Instagram, when they are filmed vertically. Hashtags are another principal element to consider. When creators use hashtags on Instagram, the post is shared to that hashtag's page, which users can follow. This is particularly impactful for businesses, as this means that an existing audience could now become interested in the product. Thus, it is important to utilize this feature.

## LIMITATIONS AND CONCLUSION

Instagram offers small business owners with any experience level a platform to advertise their products to a large audience for little cost. With this, however, businesses must remain up to date on the most effective social media advertising methods in the digital age. Regarding Instagram Reels, this involves applying short video advertising methods to the Instagram algorithm. This takes the form of ensuring products are compatible with short video advertising, using video ads to generate awareness of a brand rather than specific messages, using emotional appeals, and encouraging user engagement with the ad. These characteristics work with the Instagram algorithm to promote effective ads that are most likely to be featured on Instagram. More research needs to be conducted into whether these suggestions garner the most reach and engagement on Instagram when utilized. Additionally, more research should be conducted into creating entertaining and informational ads to establish the perfect balance between the two. Understanding these factors will ensure that the lifespan of small businesses extends far beyond the typical five years.

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# Tactics to Prevent the Use of Blockchain Technology as a Facilitator for Laundering Money

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**ABSTRACT**

The nature of decentralized currencies has led to its use as a medium for laundering money by illicit businesses, perpetuating the detrimental effects of organized crime and terrorism. This not only endangers the safety of the general population but also disrupts the global economy. Scholars agree that there is an urgent need for the United States government to establish regulations that would apply anti-money laundering legislation to cryptocurrency. Scholars also agree that the nature of decentralized cryptocurrency makes it difficult to implement any preventive measures that would inhibit money laundering. This paper argues that the most viable method of regulating decentralized currency is through the framework proposed by the Financial Crimes Enforcement Network (FinCEN). This would include revising the Bank Secrecy Act (BSA) and implementing the FinCEN framework, allowing the federal government to enforce regulations over cryptocurrency exchange platforms and conduct direct investigations of transactions that occur over exchanges. These actions would deter criminal organizations from conducting laundering operations through cryptocurrencies to preserve the United States financial system and promote other nations to enact similar anti-money laundering (AML) legislation.

**KEYWORDS**

Decentralized currency, blockchain, laundering, illicit business, anti-money laundering, Financial Crime Enforcement Network, Bank Secrecy Act, exchange platforms. Word count: 198

Blockchain technology has made a profound impact on the way that businesses and individuals conduct transactions. Blockchain is an information storage system for transactions conducted using decentralized currency. The term decentralized refers to the fact that these currencies rely on a network of computers and nodes to operate rather than a single entity. Blockchains store information regarding the sender, receiver, and public key which acts as verification for the value of the asset being exchanged. Given the decentralized nature of cryptocurrencies that are prevalent today, illicit businesses have adopted cryptocurrencies such as Bitcoin to fulfill their money laundering needs, which presents government agencies specializing in anti-money laundering (AML) with a major challenge. Economists have emphasized the detrimental impact that money laundering has had on both national economies and the global economy. In 2009, an estimated $1.6 trillion was laundered, mostly in the US, which is approximately 2.7% of the global GDP at the time (Sanchez, 2017). This figure has continued to grow along with the tax gap that it creates, as hundreds of billions of dollars are not collected annually due to money laundering and tax evasion. It is now estimated that as much as two trillion dollars are laundered globally each year, which equates to 5% of the global GDP. In addition, money laundering over the years has subjected financial institutions to extensive damage by disrupting cash flows and encouraging corruption which has led to the growth of organized crime and terrorism (FATF, n.d.). Despite the clear dangers that money laundering poses and the rapid growth of cryptocurrency which exacerbates those dangers, national governments around the world have failed to respond with effective regulation. Although the nature of decentralized currencies has made anti-money laundering regulation a complex issue, there is a need for government regulation of exchange platforms through the revision of preexisting legislation to combat the growth of organized crime and terrorism.

## ECONOMIC ANALYSIS OF MONEY LAUNDERING

With hundreds of millions of dollars laundered in the U.S. annually, the financial capabilities of illicit businesses conducting these operations pose a major risk to government and financial intermediaries such as banks and pension funds. This risk assumes the form of corruption and the perpetual effect of crime which trickles through the U.S. economy (Kumar, 2012, p.114). Consequentially, this corruption leads to activities such as insider trading, bribery, and overall damage to the integrity of the U.S. government. Other components of money laundering lead to much more direct effects that endanger the social welfare of the nation. The underlying capital that illicit businesses launder acts as funding for criminal activities like sex trafficking, drug trafficking, arms sales, and bribery (Kumar, 2012, p.117). The growth of money laundering following the 9/11 terrorist attack has led to significant growth in terrorist and organized crime activities based primarily in the United States. Although United States government agencies such as FinCEN and private authorities such as Financial Industry Regulatory Authority (FINRA) have made attempts to mitigate these effects, jurisdictional issues limit the execution of optimal preventative measures.

Given the lack of traceability and the abundance of indirect impacts, the full extent of economic damage caused by money laundering is difficult to quantify. Even more so because the process of money laundering is conducted through numerous channels, such as the financial sector, business activities, and assets with no objective value (Kumar, 2012, p.117). These alternative methods of laundering money allow for much lower economic productivity, leading to both monetary damages and damage to the integrity of the nation's financial structure. Illicit funds that originate in the U.S. are often sent to offshore accounts meaning they never enter the U.S. financial system and as a result, contribute to the already detrimental loss of tax revenue. Contributing to this list of channels are decentralized currencies that offer unmatched anonymity and minimal loss of capital in the laundering process, making for a complicated issue from the perspective of AML agencies. Although money laundering is an international threat with a broad scope of repercussions, the association between crime and money laundering acts as an unseen benefit if effective preventative measures can be established.

## LAUNDERING WITH FIAT CURRENCY AND CRYPTOCURRENCY

It is important to have a basic understanding of traditional money laundering to understand the impact that cryptocurrency has made on the laundering process. Traditionally, money is laundered in three steps: placement, layering, and integration. The first step in the laundering process, placement, is characterized by mixing the "dirty money," money obtained from illicit businesses, and placing it into the financial system (Albrecht et al., 2019, p. 211). This can be done in several ways such as through traveler's checks, money orders, debit cards, etc. This step is by far the most difficult because once the money enters the financial system it can be tracked and potentially traced back to its source. The second step in the

process is layering which is intended to obscure the source of the funds by sending it through a variety of channels that make it difficult to trace. During the process of layering, the illicit funds can be passed through financial institutions and into shell companies or offshore accounts (Albrecht et al., 2019, p. 212). This practice is quite common because by moving the funds away from the geographic location where they were obtained, they are much more difficult to trace. The last step in the process is integration, which is when the laundered funds are placed back into the economy in the form of bonds, securities, or any other asset or investment.

Although these steps also apply to laundering through cryptocurrency, funds can remain as a cryptocurrency throughout the entire process, allowing many of the complex procedures to be bypassed, most notably those involving the banking system. Placement when using cryptocurrencies can be completed by simply converting illicit funds into cryptocurrency using a form of crypto wallet or an online exchange. The process of layering is when cryptocurrencies become especially effective. Cryptocurrency can be placed in special tools called tumblers and mixers which pool cryptocurrencies from a variety of sources and distribute the currencies back but through many transactions and into more than one wallet (Desmond et al., 2019, p. 483). The main difference between tumblers and mixers is that tumblers redistribute the cryptocurrency as the same kind of currency whereas mixers redistribute a different kind of cryptocurrency that amounts to the same value.

Another key component of the layering process when using cryptocurrency is, like traditional methods of laundering money, illicit funds are often sent to offshore accounts and shell companies to create a geographic barrier between the funds and their source. Unlike laundering through fiat currencies, such as the U.S. dollar, cryptocurrency is much easier to transfer and transact given the only requirement to send cryptocurrency from one country to another is WIFI (Albrecht et al., 2019, p. 213). Not only does this provide the geographic barrier but it also enables individuals to send cryptocurrency to countries with looser cryptocurrency regulation or countries without the capability to investigate cryptocurrency crime at all. Nations such as Switzerland and Puerto Rico are prime examples of cryptocurrency safe havens because of their loose financial regulations and tax policies.

## ISSUES WITH REGULATING CRYPTOCURRENCY

The decentralized nature of cryptocurrency makes it difficult for regulatory agencies to exercise any control over transactions. These issues are only present among decentralized currencies, which is proven by E-Gold, a centralized digital currency company that was forced to desist from its operations because unlike decentralized currencies like Bitcoin, Monero, and Ethereum, E-Gold was a business with an administrative body (Albrecht et al., 2019, p. 214). This means that the issue is more complex than regulating cryptocurrencies, rather it is understanding blockchain technology that supports decentralized currencies and finding ways to extract data and exercise some form of control over it.

The defining characteristic that distinguishes decentralized currencies from other currencies and digital currencies, is their peer-to-peer currency system, which allows an individual to make a purchase in exchange for a digital key, giving them access to the cryptocurrency that was used in the transaction (Akhigbe, 2018, p. 557; Albrecht et al., 2019, p. 210;; Gamble, 2017, p. 349; Reynolds & Irwin, 2017, p. 173; Sanchez, 2017, p.180). Decentralized currencies supported by blockchains follow the basic principles of cryptography, meaning that transactions are often anonymous and difficult to track. These basic characteristics have led to decentralized currencies being an optimal choice as a channel for laundering money. Traditional methods of AML have been rendered nearly useless as decentralized currencies exhibit very few similarities with any other present-day financial instrument.

These complex characteristics have been the root of global challenges that revolve around the use and regulation of cryptocurrency and have caused several nations to outlaw cryptocurrencies completely, but for the United States, cryptocurrency has gained too much popularity. Outlawing cryptocurrency in the U.S. would have a significant impact on the national and global economy. Akhigbe, (2018) stated that without proper regulation and efforts to reduce money laundering, illegal businesses are given financial freedom to operate and even grow their business (p. 567). Many national governments and agencies have expressed the need to implement regulation that targets cryptocurrencies; however, minimal action has been taken to directly regulate cryptocurrency, leaving regulation in the hands of exchange agencies and state governments within the United States.

Although national security is placed at risk with the growth of money laundering, incorporating cryptocurrency regulation within anti-terrorism legislation has been criticized as reaching beyond the scope of the legislation. Regardless, money laundering is an international problem and cannot be solved by legislation that addresses terrorism within a single nation. The ease with which cryptocurrency can be transferred from one country to another makes it a global problem that at some point will require significant cooperation between nations to eradicate.

## ROLE OF EXCHANGE PLATFORMS IN PREVENTING MONEY LAUNDERING

Although cryptocurrency can be easily transmitted across national borders, exchange agencies are the primary intermediary of cryptocurrency transactions, many of which operate within the jurisdiction of the US. This means that with appropriate regulation, cryptocurrency transactions can be investigated through de-anonymization. Reynolds & Irwin (2017) evaluated the extent to which Bitcoin exchanges follow "Know Your Customer" (KYC) guidelines and found that three out of four exchange services identified and did not verify fraudulent accounts. They also discovered that three out of the four exchange services prohibited the use of TOR software and other proxy software that would hide information relating to the user such as IP addresses and associated personal information that could be used for de-anonymizing the user. This study shows that despite the lack of formal regulation of exchange platforms, basic business protocols such as KYC are upheld to some degree. However, the U.S. federal government must implement its own security measures and conduct AML action through direct investigation to de-anonymize criminal users and ensure security within these platforms.

To identify and de-anonymize the user, tactics such as clustering, identifying public key addresses, and mapping IP addresses to geographic locations could be used. Clustering is portrayed as the most viable method by Reynold & Irwin (2017) as it does not require public key information but instead relies on mapping nodes of service that the individual used (p.179). This method supplies authorities with enough information to subpoena suspected individuals and prosecute them. Direct methods of de-anonymizing users have become a more feasible method for U.S. regulatory agencies to prevent crypto-facilitated money laundering as technology improves along with our understanding of blockchain technology.

Despite signs of optimism that may arise from the discovery of viable de-anonymization methods, there is no current federal legislation that regulates crypto-exchange platforms, making it difficult for government entities to enforce control over exchange agencies or conduct their own preventative measures. The U.S. financial regulation system was developed to rely on intermediary parties to uphold policies and regulations such as the KYC rules to prevent fraud and money laundering. In the case of cryptocurrency, exchange platforms are the only intermediary party that exists (Marian, 2015, p. 58). The issue with this current system is that although the U.S. Government could function as a second intermediary system, this has the potential to disrupt the cryptocurrency market and its overall value. When the volatility of the crypto market is being considered, the best method of obtaining the necessary information to monitor transactions on exchange platforms would be for FinCEN to view transaction records through the ledger as well as transactor information which would require KYC protocols to be followed. A prerequisite for FinCEN intervention will be legislation that delegates the federal government and relevant agencies the authority to regulate exchange platforms.

## BARRIERS POSED BY STATE LEGISLATURES

One of the key issues that exist when regulating exchange platforms is the concentration of authority within local and state governments rather than the federal government and federal agencies. Jurisdictions within the United States lack uniformity when it comes to regulating cryptocurrency and as a result, exchange platforms avoid certain operations depending on the jurisdiction and its policies (Olly, 2019, p. 2). The Gemini exchange platform, a high-performance crypto trading platform, although serving as a key example of a compliant exchange platform, also includes information on its website that demonstrates the disparities between state regulations. As stated by Cryptopedia (2021), certain states such as Colorado allow for political candidates to receive donations through cryptocurrency, while other states such as Minnesota prohibit such practices. This example serves two purposes, with the first being that it shows how different regulatory policies can be across states

when it comes to cryptocurrency. It also shows that the loose restrictions in Colorado have the potential to facilitate fraudulent activity and the potential for politicians to launder money through cryptocurrency donations. This is one policy within a single state that fails to acknowledge the issues that cryptocurrency poses in preventing fraudulent activities. Having the federal government regulate cryptocurrency would eliminate gaps, omissions, and inconsistencies in regulations between states and in doing so, facilitate the establishment of uniform regulation which would inhibit exchange platforms from avoiding operations in stricter jurisdictions.

The current direction of cryptocurrency regulation does not show any indication that states will abdicate their authority to regulate at their discretion. Currently, the states reserve the right to regulate money service businesses (MSB) and money transmitters (Hughes & Middlebrook, 2015, p. 523). In many cases, exchange platforms fall under the classification of a money service business which is the reason that state governments are authorized to regulate exchange platforms. The authority of the state legislatures to regulate money service businesses is one of the largest barriers inhibiting effective AML action. To resolve this issue, it is necessary to pass legislation that would delegate the authority to regulate cryptocurrency exchange platforms to the federal government, while still allowing state legislatures to maintain their authority to regulate money service businesses to keep states compliant and avoid conflict.

In addition, the current regulation of money service businesses only includes services that deal in fiat currency. By avoiding the exchange of cryptocurrency to fiat currency, many exchange platforms circumvent the process of developing AML protocols (Olly, 2019, p. 2). This is common among exchange platforms because exchanges that exhibit less regulation usually attract more customers because of a more simplistic transaction process. The positive aspect of this situation is that exchanges are starting to adapt their platform to allow customers to convert cryptocurrencies to fiat currency as cryptocurrencies become a more popular method of payment. Regardless, it would be in the best interest of the public and government regulatory agencies to implement regulations that would regulate exchanges uniformly, requiring all to develop AML programs. To pursue this strategy, the federal government should follow the framework proposed by FinCEN. The FinCEN organization is responsible for investigating financial crimes and specializes in preventing money laundering and fraud with most of its authority deriving from the Bank Secrecy Act.

## METHODS OF EFFECTIVELY REGULATING EXCHANGES

As of the year 2021, the most comprehensive form of anti-money laundering regulation is the Bank Secrecy Act. The Bank Secrecy Act was enacted as AML regulation that improves record-keeping in financial institutions and the banking system but recent suggestions by FinCEN have highlighted the need to target cybercrime, virtual currencies, and terrorist financing (FinCEN, 2021). The Bank Secrecy Act outlines five guidelines for money service businesses to follow which include registering the business with the federal government, developing an AML program, reporting cash transactions, reporting suspicious activities, and E-filing of Bank Secrecy Act documents. Although the Bank Secrecy Act has effectively limited criminals' abilities to launder money through traditional methods that involve fiat currency, further revision of the Bank Secrecy Act to encompass regulation over the cryptocurrency sector has been considered by FinCEN and economists to be one of the most viable methods for preventing the use of cryptocurrency to launder money. The application of the Bank Secrecy Act to digital currency has not yet been formally implemented but to some degree is in development. Currently, FinCEN is the primary authority that enforces the Bank Secrecy Act and could potentially promote a revised version that would incorporate cryptocurrency regulation into the act. The largest barrier that FinCEN would need to overcome is the authority of state governments to regulate cryptocurrency using the Bank Secrecy Act.

For the Bank Secrecy Act revision framework to be a potential solution, exchange platforms must continue to be viewed as a money service business while also imposing mandatory regulations on the states treatments of these entities to uphold the Bank Secrecy Act's proposed guidelines and meet the standards proposed by FinCEN as policies are established. This action would enable FinCEN to implement AML regulations and hold state Governments responsible for upholding these federally mandated guidelines. Given that this would grant FinCEN the authority to revise the Bank Secrecy Act to counter money laundering more effectively, it is important to consider the capabilities of FinCEN and the extent to which the Bank Secrecy Act can regulate cryptocurrencies. The proposed regulation would only be within the capabilities of FinCEN if the exchange agencies were classified as a money service business, which is currently under the discretion of state legislatures. As previously noted, the authority of state governments to regulate cryptocurrencies would pose a problem to FinCEN intervention which could potentially be counteracted by the states since states determine if exchange platforms are classified as a money service business. For FinCEN to effectively regulate cryptocurrency, it is critical to classify them as and uphold the classification of a money service business, while granting the authority of FinCEN to intervene with state-governed financial institutions without conflicting without interfering with state policy precedents.

By classifying cryptocurrency as a money service business, the Bank Secrecy Act would require associated financial institutions to develop an AML program that would prevent the money service business from being used as a method of laundering money or funding criminal organizations (FinCEN, 2016). Several complexities exist for exchange platforms attempting to develop AML programs when compared to other financial institutions that deal in fiat currency. For example, it may not be as simple for exchange platforms to report transactions across national borders and associate them with a specific individual, especially if identification information is not correct or not provided at all. For AML programs to be effective the exchange platforms themselves must ensure that KYC protocols are followed to account for the anonymity factor of blockchain.

In the case of cryptocurrencies, exchange platforms would be responsible for developing and supervising the AML program. More specifically, exchange platform administrations would be required to implement internal controls, train employees to ensure compliance, monitor transactions, and implement their own regulations (FinCEN, 2016). Compliance with the Bank Secrecy Act will be one of the most difficult aspects of enforcing AML protocols on exchange platforms but are critical to preventing criminals from continuing to use cryptocurrency for illegal purposes. It will be the responsibility of FinCEN to supervise the exchange agencies to ensure there are no security risks. Specifically, FinCEN must monitor the AML program that is put into place in addition to the agents within the exchange that enforce AML protocols and policies (FinCEN, 2016). Agents that are not found to fulfill their duties properly should in all cases be terminated and potentially investigated to ensure that first, the principle of separation of duties was properly followed, and second, the agent has no association with a criminal organization. The severity of these policies can be attributed to the threat that money laundering and organized crime pose to a nation's safety. By placing pressure upon exchange platforms to enforce internal controls and AML protocols, exchange platforms will be more thorough and stricter when carrying out the policies that are implemented.

## RECLASSIFICATION OF DECENTRALIZED CURRENCIES

The issue of regulatory agencies collaborating to prevent crypto-based money laundering has proven to be substantial in classifying cryptocurrencies, making it difficult to pass any comprehensive legislation. Most notably, competing views among the IRS (Internal Revenue Service), SEC (Securities Exchange Commission), and CFTC (Commodities and Futures Trading Commission) have been raised. For example, the IRS classifies cryptocurrency as "property" for taxation purposes rather than applying regulations (Hughes & Middlebrook, 2015, p. 532). The SEC views cryptocurrencies as securities and would like to apply existing security laws to digital assets for the purpose of reporting realized gains, like the IRS, whereas the CFTC intends the regulate cryptocurrencies as derivatives (Hyatt, 2021). These classifications were established to target the public and individual investors by applying taxation policies and laying a framework for selling cryptocurrencies on self-managed trading platforms. With this being considered it is unlikely that the SEC, CFTC, or IRS would enact proper AML regulation. Instead, these agencies would likely limit channels of access that individuals must obtain and trade cryptocurrency, while also placing regulations on transaction size and reporting requirements, something that the U.S. government has already considered implementing.

The views of the CFTC and SEC have been widely considered and debated by many scholars to be a potential method of regulating cryptocurrencies. Despite there being some agreeance among scholars and the agencies, Hughes & Middlebrook (2015) discussed, the competing perspectives from both the SEC and the CFTC in reference to regulating cryptocurrency and clarified that implementing regulation by labeling cryptocurrencies as a commodity or security would be ineffective in further regulating "third party payment participants", such as exchange platforms (p. 530). In other words, the SEC and CFTC would do little regarding preventing money laundering but would rather prioritize record-keeping for taxation purposes in compliance with the IRS. In comparison to the CFTC and the SEC, which regulate the trading of securities and commodities, FinCEN specializes in investigating financial crimes such as fraud and money laundering. Therefore, the goals and framework that FinCEN has provided more effectively address the issues that cryptocurrencies pose to the nation.

## CONCLUSION

The potential for devastating effects on national security and the economy has made it clear that there is an urgent need for action to prevent cryptocurrencies from being used for illicit purposes. The decentralized nature of today's cryptocurrencies which is characterized by their anonymity and ease of transaction facilitates their use as a method of laundering money. As a result, billions of dollars have been laundered in the United States alone, allowing criminal organizations to grow their operations, resulting in a need for cryptocurrency inclusion into the Bank Secrecy Act, which is subject to FinCEN oversight. To better understand the issue of blockchain-facilitated money laundering, further research is needed to evaluate the extent to which FinCEN is authorized to intervene with entities such as crypto wallets, crypto exchanges, state governments, and international financial institutions which may play a role in laundering illicit funds. This research would help the United States federal government to establish a case for the legality of such regulations and incentivize other nations to take similar action. By establishing more effective AML regulation that targets cryptocurrency, the welfare of the public and the economy can be protected as the growth of organized crime and terrorism is inhibited.

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# Capitalism: The Synthesis of Economic Growth and Climate Change

*Kyle Tranfaglia*

**ABSTRACT**

Climate change is evidently an anthropogenic phenomenon, but in the broad scope of human activity, the question becomes, whom do we blame? Progression toward a climate crisis arose during the Industrial Revolution, but the issue goes beyond industry. The problem rests within the system that expanded industry, constructed a culture of consumerism, and developed unsustainable infrastructure that exploits the environment to yield economic growth. This system is capitalism. The capitalist agenda to produce an indefinitely growing economy directly results in environmental exploitation and influences limited and underdeveloped environmental policy. This is due to the establishment of economically driven infrastructure and fundamental contradictions between capitalism and environmental sustainability. As production and distribution costs are transferred to the environment to maximize economic growth, the true price becomes hidden in the market. Further, large companies that benefit from this system have created a culture of consumerism, influencing people to invest in this unsustainable system. The companies then use their growing political-economic power to influence policymaking and continue with unregulated expansion. A shift towards environmental sustainability must be a shift away from capitalism or an immense infrastructural and systematic change to the capitalist economy. The possibility of green capitalism is unlikely, but if it does exist, we are far from it.

**KEYWORDS**

climate change, industry, consumerism, infrastructure, capitalism

The Earth's climate is a constantly changing ecosystem that has gone through multiple ice ages and warm periods that have reshaped the planet and its creatures. However, what is known as the climate crisis does not match the patterns of Earth's evolution. This global environmental crisis has been proceeding at unprecedented rates since the mid-20th century (NASA, 2022). Even though there is concrete evidence that humans have influenced climate change since the Industrial Revolution, denial remains. However, it is unequivocally anthropogenic, as it is undeniable that post-industrial human activities have warmed the atmosphere, ocean, and land (NASA, 2022). Knowing this is anthropogenic, a more significant issue is identifying the root of the problem and formulating a solution.

Although it may seem easy to blame the rise of industrial manufacturing and combustion machines, the problem is much bigger and more systematic. The problem rests within the system that not only expanded industry but constructed a culture of consumerism and developed unsustainable infrastructure that exploits the environment to yield economic growth. This system is capitalism. Capitalism is a system powered by greed and dominated by a select few that control the economy and manipulate the environment to fit their needs. As a result, the environment pays the price of capitalist expansion. The companies benefitting from the system withhold immense political-economic power and use it to construct a system that continues to benefit them, no matter the environmental costs. Thus, the capitalist agenda to produce an indefinitely growing economy directly results in environmental exploitation and influences limited and underdeveloped environmental policy. This is due to the establishment of economically driven infrastructure and fundamental contradictions between capitalism and environmental sustainability. Further, there must be a detachment from modern capitalism to prevent an ecological collapse.

Whether or not climate change is anthropogenic is not debatable, nor is it appropriate to ignore the seriousness of such a swiftly growing global issue. Since the Industrial Revolution, atmospheric carbon and other greenhouse gasses such as methane, nitrous oxide, and water vapor have steadily increased, alongside the ocean and atmospheric temperatures (NASA, 2022). The heat-trapping nature of carbon dioxide and other greenhouse gasses was demonstrated in the mid-19th century, proving that this simultaneous increase is not coincidental (NASA, 2022). Human activity has disrupted the natural cycle of Earth's processes, and the results are becoming evident at a very alarming rate. Carbon dioxide is increasing more than 250 times faster than after the last ice age, and paleoclimate evidence reveals that the current warming pattern is ten times faster than the average rate of previous ice-age recoveries (NASA, 2022). In fact, since the late 19th century, the average surface temperature has risen about 1 degree Celsius, and the top 100 meters of the ocean have warmed over 0.33 degrees Celsius (NASA, 2022). With the temperature rise, glaciers have retreated near the poles. Greenland lost an average of 279 billion tons of ice annually between 1993 and 2019, and Antarctica lost about 148 billion tons (NASA, 2022). However, the temperature is not the only victim of unregulated human development. Melting glaciers have caused global sea levels to rise about 20 centimeters in the last century, doubling the rates of previous centuries (NASA, 2022). Additionally, pollution, deforestation, biodiversity loss, and the destruction of ecosystems are now overwhelming and widespread. These are just a fraction of the ecological changes, as humans continuously alter nature to fit their demands, exploiting Earth's resources and using nature as a pit for waste.

Capitalism, by its nature, is very conflicting with environmental sustainability, especially in its current state. Although many blame those with unsustainable lifestyles, mass industrialization, or the government, the problem more evidently stems from the expansion of modern capitalism. The existing infrastructure and lifestyles of the common person are not structured to be sustainable, as large corporations, through the power of marketing, have created a culture of consumerism and materialism to solve the issue of supply outstripping demand (Adams, 2020). After World War II, this cultural engineering occurred as economists combined interest with the wealthy, maximizing the production of goods until it surpassed a point of excess, a problem to be solved with the notion of hyper-consumption (Adams, 2020). Consumerism has dominated American culture and spread to other developed nations. Household consumption is now responsible for 60-80% of adverse environmental effects due to the demands of lifestyles corrupted by consumerism (Adams, 2020). As consumers continue to become puppets of a capitalist economy, ecological suffering expands.

To put the unsustainability of consumerism in perspective, consider the demands for clothing presented by fast fashion, a section of consumerism created by clothing industries to influence a frequent change in popular fashion, ultimately characterizing clothing as a disposable commodity with an expiration date. Manufacturing one T-shirt takes about 256 gallons of water, and the textile industry accounts for nearly 10% of the carbon emissions (Adams, 2020; The World Bank, 2019). The problem of consumerism runs the most rampant in the United States; the average American spends almost $18,000 a year on nonessentials, a rate of overconsumption so massive that if globalized, nearly five Earths would be needed to fit this demand

(Adams, 2020). It is no surprise that countries with the highest consumption rates have up to 5.5 times the global average environmental impact, with nations such as the United States producing a cumulative 397 gigatons of carbon dioxide since 1750 (Adams, 2020). Nature simply cannot sustain the resource demands of consumerism nor the waste produced by it.

The capitalist agenda is simple: grow the economy no matter the costs. Capitalism is a system that succeeds through continued investment and constant expansion. It is a quest to increase supply, demand, and investment simultaneously. It strives for economic growth, freedom, security, and efficiency through an unregulated market governed by competition and fueled by greed. In a capitalist system, the environment becomes no more than a means of capital, exploiting natural materials and using nature as a pit for unwanted by-products (Hamilton, 2012). It commodifies every aspect of nature, aiming to turn Earth's resources into monetary profit to overcome the limits of economic expansion (Storm, 2017). Capitalism is a regime driven by an incessant need for growth, and despite the exhaustion of natural resources to meet its desires, it is never satisfied (Adams, 2020). Without strong government influence, competition and the invisible hand do not protect the environment from exploitation, and it becomes the landfill of an efficient market. Capitalism seeks exponential growth, meaning production and distribution costs require minimization. However, the notion of exponential growth embedded in capitalism is mathematically impossible as finite perceptions constrain it (Schweickart, 2019). Even if possible, the commodification and exploitation of nature cannot happen indefinitely. Still, capitalism continues to find ways to push the economic threshold, serving only to prolong inevitable failure and accelerate the destruction of nature.

One may consider that technological industrialism is a major contributor to climate change over capitalism (Hamilton, 2012). Technological industrialism may have led to climate change outside of capitalism. It prompted immense unsustainability amidst developed nations in advancing human life, which all economic systems strive to achieve. Similarly, environmental damage under socialism has been just as destructive as capitalism; Soviet industrialization was infamous for its environmental destructiveness (Hamilton, 2012). The shared destructiveness is because capitalist and Marxist ideologies share similar foundations: the objective of progress should be to advance material well-being, derived from nature and only restricted by the limits of self-interest (Hamilton, 2012). Economists claim that, over time, capitalism could be a solution to the climate crisis and its related issues, as the current problem may be that there is too little faith in the power of capitalist ingenuity (Pierrehumbert, 2016). Faith in capitalism comes with more confidence in the invisible hand to adjust the natural thermostat (Storm, 2017). This technocentric perspective adopts the idea of Adam Smith that egoism is altruism: an individual's self-interest will eventually benefit the whole. The idea is that letting the economy grow with minor regulation will generate the funds necessary to combat the issue and that strict policy with immediate environmental goals will only serve to unnecessarily hurt the economy. However, these ideas are incomplete, manipulative, and deceptive. Each claim is a vague argument that ignores the overarching culprit.

Capitalism is the progressor and fuel to technological industrialism, as it was guided with tremendous economic influence into overwhelming expansion. Technological industrialism was not inherently harmful but became destructive under a world economy controlled by capitalist nations using technology to advance their economic power (Adams, 2020). Also, socialism is not inherently destructive like capitalism and can reform without an economic collapse as socialism does not feed off of endless exploitation. Socialism is much more fixed and uniform in the production and marketing sectors, differing from a free capitalist market that enables greed and relentless iniquity (Pierrehumbert, 2016). Capitalism is fundamentally a zero-sum game and a system of decadence. Although socialism shares similar goals, it does not share the incessant need to exploit people and nature to support economic advancement. Additionally, the term "necessary funds" used by economists is ambiguous and irrational, as funds will never be willingly sacrificed to combat climate issues. With the goal of continuous growth comes the value of profit over all else, meaning an ongoing prioritization of investment and reinvestment in the economy over monetary sacrifices for non-economic causes (Pierrehumbert, 2016). Ultimately, the capitalist cycle fosters the growth of greed, which becomes impossible to satisfy.

Despite other contributors to climate change, fundamental contradictions between capitalism and environmental well-being comprise it as the primary contributor. Capitalism fundamentally uses and alters nature to enable its functionality, and with the quest for exponential growth, this contradiction expands. The problem with capitalism is that it relies on continuous investment and expansion to remain successful. With strict policies impacting production, distribution, and consumption, money and resources will redirect, and the economy will undoubtedly take damage. The capitalist need for compound economic growth rates and the capacity of the planetary ecosystem as a source of material inputs and a sink for unavoidable wastes cannot uphold (Hudson, 2021). Capitalist production unavoidably involves material transformations, extracting natural resources and transforming them into commodities as a form of capital, which intrinsically affects the environment (Hudson, 2021). Capitalism is a system of endless greed, never to be satisfied. The need for perpetual economic growth is an environmental contradiction, especially since technological solutions have not reached their promised performance and market-based schemes to mitigate harm have failed (Beer, 2022). Considerable economic growth requires neoliberal policy and a way to transfer the costs of capital accumulation, and, besides people, the environment is the most accessible system. For this reason, capitalism is inherently destructive to the planet, and regardless of its energy supply, unregulated capitalism will consume Earth's resources until exhausted (Beer, 2022). The conflict between capitalism's drive for growth and ecological sustainability does not present a clear solution, but it is clear that this conflict will only result in a radical and abrupt change with either a collapse of the economy or the climate (Storm, 2017). Capitalism is the ruthless dictator of the future, and it must fail before the environment crumbles.

A major obstacle to the sustainability of human development is infrastructure, something that capitalism has driven with such economic and industrial force that it has created an ecological nightmare. Human lifestyles cannot change unless an infrastructural change happens first. Climate change is a public infrastructure challenge, not a private market failure (Nordhaus, 2019). A prime example of economically driven infrastructure is within consumerism: a market of cheap and heavily advertised products designed to be used and discarded. The current infrastructure in the United States results from post-World War II industrialization, a system designed to maximize production and increase consumer goods, which has not undergone reconstruction to be more ecologically considerate (Adams, 2020). Infrastructure in developed nations remains in the industrial phase, excessively extracting resources and dumping waste back to the source.

The capitalist market does not cater well to people that care about their environmental impact. Poor communities experience the worst industrial violence, and poor and rural communities have the smallest opportunity to change their lifestyles (Gonzalez, 2021). For instance, electric vehicles are unsuitable in rural areas due to a lack of charging stations and limited accessibility and affordability of home electrical modifications. They are also expensive for the average person, and the electricity to power the vehicle would likely be produced in a coal power plant. Additionally, eating local, non-processed, or low-impact foods may be difficult due to competition from large industrial companies, and these diets tend to be more costly. The largest issue is that the market is overwhelmed with unsustainable products, and individuals are encouraged to be unsustainable because of its mere accessibility (Adams, 2020). Capitalism has constructed an efficient infrastructural system for economic growth but not ecological sustainability, thus synthesizing economic growth and climate change.

After four years of economic focus and no acknowledgment of the increasing dilemma of the climate crisis in the United States, newly elected President Joe Biden was quick to issue programs to begin shifting the American infrastructure, such as the Bipartisan Infrastructure Deal in January 2021. The $89.9 billion in funding will greatly invest in clean energy sources and improve the population's ability to incorporate more sustainable features into their lifestyles by targeting a major contributor to carbon emissions: transportation (The White House, 2021). The legislation will invest in low-carbon technologies in port, waterway, rail, and airport infrastructure (The White House, 2021). Additionally, half a million electric vehicle chargers will be constructed, accompanied by large investments in clean energy plants and transmission lines (The White House, 2021). In collaboration, in 2021, the Environment Protection Agency (EPA) issued amendments and proposals to many environmental acts. For example, there will be a phase down in the U.S. production and consumption of hydrofluorocarbons by 85% over the next 15 years, more strict gas emission standards for new vehicles, and a sharply reduced allowance of methane production (EPA, n.da). This recent headway is an excellent step toward sustainable development; however, it may not be nearly enough with the

immense prolonging of infrastructural investment and environmental policy.

A critical failure in addressing climate change has not been the national government's inability to handle the issue but rather the prolonging of necessary change. Until recently, the United States went over 30 years without notable environmental legislation (Meyer, 2017). Government bodies are the most substantial powers that can significantly act on climate change, so the issue continues to grow when this power is misused (Sobel, 2021). Systematic and infrastructural change can quickly happen if governments apply their legislative power appropriately. In 1970, after years of exponentially increasing carbon emissions in Sweden, there was an abrupt stop, which was a clear result of government response (Pierrehumbert, 2016). However, many developed nations have failed to follow in Sweden's footsteps. For example, the United States has a per capita emission of 4.5 tons, compared to Sweden's 1.25 tons (Pierrehumbert, 2016). Ultimately, existing policy attempts have been met with little success, and the failures to handle climate change threaten commodity production, the ecological system in which capital is embedded, and the survival of humans (Hudson, 2021). This failure derives from the government analysis of climate change. The Identity and Access Management tool used to estimate probability and risk has built-in unrealistic assumptions on economic growth, climate change, and climate risks (Storm, 2017). This tool provides misleading data favoring financial investment over climate change (Storm, 2017). The response to the unwanted effects of climate change have varied, but they share a common theme of limited efficacy, a failure driven by government ignorance (Hudson, 2021). Overall, the U.S. government values economic gain over ecological stability, feeding into the reckless oppression of capitalism.

The U.S. government has been unsuccessful in handling climate change as it has failed to create an updated and progressive policy. In 1987, the Montreal Protocol was finalized in order to protect the ozone layer; it was an overall successful agreement that greatly decreased the usage of major ozone-depleting substances such as chlorofluorocarbons (CFCs) and halons (U.S. Department of State, 2021). However, this agreement has seen minimal modifications since its creation. It was not until 2016 that it adopted the Kigali Amendment to phase down the production and consumption of hydrofluorocarbons, a widely-used and still destructive substance used as an alternative to CFCs (U.S. Department of State, 2021). Even with this, the agreement remains to ignore other harmful substances contributing to climate change. Similarly, the Clean Air Act of 1970 and the Clean Water Act of 1972 have had similar fates: initial success with no follow-up, as after over 30 years, they have yet to be amended (EPA, n.db; EPA, n.dc). Even more recent agreements with more longevity, such as the Paris Agreement, will not be sufficient in mitigating the damages of climate change as it is simply not enough (Gonzalez, 2021). Overall, government action fails to establish a robust and revised plan that appropriately assesses the current harms and future threats of climate change.

Perhaps the greatest government failure is the mindset that the current policies are timely and sufficient when the reality is that these initiatives are decades late and still not complex or robust enough to be successful. Short-term solutions are essential, but they cannot be the extent of policy; there must be rapid and elaborate solutions to mitigate immediate damage, which must overlap with long-term plans (Waldron et al., 2013). Mostly, short-term and long-term goals are uncommon. There seems to be a failure to understand that sustainability cannot be incentivized into existence (Sweeney, 2015). Similarly, correcting carbon prices is not enough to induce resource mobilization for a carbon-neutral economy, just as a carbon tax or an emission market will not produce the sustainable technology or infrastructure required for sustainability (Storm, 2017). Current government policy is underdeveloped and lacks a complex and long-term plan that will create an infrastructural system to support ecological recovery and resistance. There has been an overarching government failure for the last few decades, and one can blame the manipulative and controlling nature of large companies in a capitalist nation.

Large companies influence the policies passed and get around current policies by finding alternatives that still harm the environment. Fossil fuel companies have sponsored misinformation and denialism to prevent restriction and have used their economic and political power to maximize profit at humanity's expense (Sobel, 2021). Governments allow these large companies to transfer the costs of economic growth to the environment, as neoliberal acts boost efficiency and growth by exploiting people and the environment. To maintain a booming economy that will continue to be "indefinitely exponential," large companies push for unregulated industry, more of a true free-market economy, to continue strong economic growth. The government falls victim to the desire for economic prosperity. Climate change denialism emerged from U.S. think tanks funded by fossil fuel corporations and evolved into a political and cultural movement (Hamilton, 2012). Fossil fuel billionaires deny anthropogenic climate change to secure unimaginable sums of money (Schweickart, 2019). Capitalist nations such as the United States greatly benefit from doing little about climate change. The power of fossil fuel companies to influence this inaction is the product of a capitalist economy. The issue is that only governments can remake a system and produce sustainable infrastructure, but they partner with the victors of a capitalist economy to grow more prosperous, ignoring the future fate of a climate catastrophe (Sobel, 2021). These companies will not run out of resources anytime soon, meaning the only thing that can stop the continuous exploitation and destruction is government intervention (Sweeny, 2015). Few unions openly expressed concerns about capitalists' inability to handle climate change and the radical restructuring necessary to be sustainable (Sweeny, 2015). Capitalism will likely remain as long as governments stay a puppet of economic powerhouses.

The government is not blind to the manipulation that is occurring. The policymakers and elected officials know that the economy's foundation controls them. However, the problem is that they do not want to disrupt the profitable system. The government seems to listen to the economists who state that overly ambitious climate targets will unnecessarily hurt the economy and immediate action is too expensive (Storm, 2017). Economists claim it is efficient to allocate resources to higher-yielding investments and use the returns to finance future climate mitigation technologies (Storm, 2017). A ramp-up approach can happen when the economy is flourishing, as the economy and infrastructure will be better suited to support it (Storm, 2017). However, there is not enough time for this plan to happen, not to mention it is risky and enabled by greed, an aspect of capitalism that created this problem. All economists recognize that markets produce externalities, and most agree that the government plays a role in rectifying these defects, but they refuse to sacrifice any economic growth (Schweickart, 2019). The economists, or representatives of large companies, view efficient policy as making the economic pie as large as possible, leaving the disproportionate winners to compensate for the three billion poor who suffer the most from climate change (Storm, 2017). Adam Smith's idea that egoism is altruism has yet to prove promising. The economic reasoning of large companies has swayed the dynamic of environmental policy for decades, rendering most policies unsuccessful and limiting the overall enactment of policies and legislation.

The failure to address climate change on the governmental level goes beyond tackling the causes, as the consequences of climate change are handled with severe insufficiency. Targeting the core causes of climate change is unequivocally more critical, especially for enduring the long-term consequences. However, immediate action is necessary to combat the current effects of anthropogenic climate change. Instead of providing a home for the refugees forced to move due to climate displacement, the U.S., Europe, and Australia are increasingly criminalizing migration (Gonzalez, 2021). The increasing criminalization of migration introduces an ethical dilemma and social injustice, as developed nations contribute the most to climate change yet fail to compensate for the disproportionately harmed victims (Gonzalez, 2021). Capitalist greed not only prioritizes economic growth over ecological stability but over the well-being of others, further emphasizing the flaws of a capitalist economy. Oppression and exploitation are embedded in the functionality of modern capitalism, which is the reason for its contradiction to ecological flourishment and the need for reformation in the form of a political-economic rebirth.

The economy does not have to be inversely related to environmental sustainability. An economy can grow and provide a high standard of living while simultaneously decreasing its environmental impact (Pierrehumbert, 2016). Nations like the United States need to look for reassurance that decarbonization is not mutually exclusive with economic growth (Pierrehumbert, 2016). Sweden has shown that it requires adjustment as soon as possible with continued amendments and sustainable infrastructural development. However, the issue with capitalism, specifically in the U.S., is that the infrastructure is unsustainable. Sweden shifted away from the chaos of capitalism with some socialist policy before it devoured the nation. The culture of consumerism and overwhelming demand for investment make it impossible for change to happen anytime soon, and time is not sparing. The remaining options are to change every aspect of the economic system or watch climate change destroy the planet (Beer, 2022). The fundamental properties of creating capital in a capital-

ist system constitute green capitalism as an unrealistic theory. Further, a shift away from capitalism is necessary to enable the coexistence of the environment and the economy (Beer, 2022). Greed will constrain once a systematic change occurs, and economic growth can continue more sustainably, devoid of oppression.

In its current state, capitalism is destroying itself. It relies on extracting resources from nature for production yet exploits nature and pollutes it, ultimately destroying a fundamental property of capital. The political-economic structure of many developed capitalist countries prioritizes short-term profit with a deceptive claim of long-term growth. This system fails to acknowledge the monetary costs of anthropogenic climate change, both in damages to human development and depletion of material resources. For instance, if human development remains on its current track, by 2050, there will be $106 billion worth of coastal property below sea level (NOAA, 2022). Additionally, in the next 25 years, a food shortage will likely occur as crop yields will decrease 10-20% in some Midwestern and Southern countries (NOAA, 2022). Still, more immediate economic dangers will come from the $7.3 billion damage increase from hurricanes, bringing the annual costs for hurricanes and other coastal storms to $35 billion (NOAA, 2022). The economic predictions show that capitalism's synthesis of economic growth and climate change will soon be a synchronization of an economic and ecological collapse.

Since a fundamental property of capitalism is the extraction of material, and this process requires a beyond sustainable exploitation of nature and an inherent need to disregard unwanted by-products, green capitalism is unrealistic and contradictory within itself. Suppose capitalism's exploitative and oppressive drive is removed. If so, it will no longer function in a profitable manner, at least not nearly to the extent it does today. A capitalist economy requires a system to absorb the costs of production. If the environment absorbs less of these costs, the proletariat that suffers the most from capitalism and its consequences will only suffer more. Wages will decrease, consumers will have less money to spend on goods that will only increase in price, and the continual investment that capitalism needs will decline. For this reason, green capitalism is a pipe dream (Schweickart, 2019). Capitalism runs on an expand or collapse imperative, requiring constant economic growth to succeed, as a stagnant economy leads to a collapse of the system, and the crises identified by Marx and Engels will occur; workers will not have the money to buy enough of what they produce, leading to layoffs, decreasing demand, and leading to a recession (Schweickart, 2019). The future of capitalism will unlikely be green, as it will either be unrecognizably reformed or completely destroyed, hopefully before the irreversible destruction of the planet.

Although only governments have the power to enact the changes necessary to develop an infrastructure and push legislation that would enable a more ecologically friendly development of human civilization, individuals do play a role. Even if people willing to make sacrifices are challenged by the unwillingness of governments or large companies, individuals remain a valuable piece of systematic reform. Individual actions matter because they can change culture, and culture can change politics (Sobel, 2021). For instance, gay marriage seemed politically impossible until cultural change pushed a legislative change (Sobel, 2021). Individuals may not have much choice in changing their lifestyles, especially if they are limited geographically or in wealth, but they can fight against consumer culture. Consumerism is one of the most destructive aspects of a capitalist economy, and individuals have the power to shift culture collectively and, in the process, reform capitalism.

In most developed nations, capitalism partners with a form of democracy in which individuals have the power to delegate. The issue is that rich and poor people place personal freedoms, small government, low taxes, and national sovereignty above environmental stability and empower people with similar values (Hamilton, 2012). Only about 27% of Republicans in the United States believe climate change is a major threat, a horrifically low statistic considering the visible consequences of climate change and the concrete evidence of its exponentially growing dangers (Adams, 2020). Even if individuals cannot control the government's actions, they can control who holds power as a representative of the people. The reluctancy of individuals, most predominately ones greatly impacted by climate change, to vote for government officials that are committed to radical action consistent with the scientific warning is not a result of fossil fuel companies or the government's obsession with protecting the economy above all else, but the mindset of the public (Hamilton, 2012). Individuals must realize their role in rectifying a corrupt and troubled system that expands the catastrophic impacts of climate change; the role of voting for electives that understand climate change and endorse major systematic changes to the economy. Progression can be made even if they cannot vote their way out of capitalism, and progress is important as all change requires it.

Similarly, governments need to give individuals more power to make an environmental difference. An essential part of a green development plan is recognizing that people must be involved in the process (Kumar & Kumar, 2011). Whether on a local, national, or global scale, individual impact is very significant and collectively can empower large changes that make impactful differences. Governments should focus on providing more voice and power on the federal and communal levels, as the most outstanding successes tend to be at the local scale, whether it is local preventative policies, ecosystem restorations, or shifts in infrastructure (Hudson, 2021). Since the impacts are much more noticeable on a local scale, more people are encouraged to participate and feel like they are making a difference. The collective local impacts develop a strong international influence when done on a global scale. Furthermore, a crucial step in mitigating the damages of climate change and pushing towards a more sustainable future is shifting power so that individual actions are more noticeable and impactful.

Overall, the goal of human development moving forward is to prevent a planetary catastrophe. Fulfilling this goal means a shift away from capitalism. Government bodies must stop feeding into the capitalist system, allowing it to exploit and oppress freely. Government action tends to encourage change rather than enforce or invest in it, and these incentives must be removed (Schweickart, 2019). Encouraging acts such as carbon taxes work, but they are constrained; infrastructure must support emission reduction, especially if the goal is to be carbon-neutral (Pierrehumbert, 2016). In a capitalist economy, this infrastructure will not miraculously form without government intervention, as the invisible hand does not promote infrastructure that favors the environment's health (Pierrehumbert, 2016). A first step in developing a robust plan to combat climate change is creating strict regulation that takes a bottom-up approach (Kumar & Kumar, 2011). A method that ramps up and updates continually to progress sustainable development, rather than making a plan that will meet a goal and then become stagnant and no longer improve sustainably. With this, there must be very in-depth and complex proposals for rapidly implemented infrastructural development, as change cannot come without the means to shift the system, especially one woven into the culture (Nordhaus, 2019). Climate change must be viewed as an infrastructural challenge rather than a market failure, as infrastructure provides a change that regulation and pricing cannot offer alone (Nordhaus, 2019). Ultimately, the planet's fate falls in the hands of the governments of developed nations. To prevent a global ecological collapse, the removal of capitalism is necessary, as the foundations of modern capitalism are irreformable and incompatible with environmental sustainability.

Capitalism is indisputably a flawed system with its inherent contradictions to ecological stability and manipulative, oppressive, exploitative, and neglective characteristics. A capitalist economy is powered by greed and values economic growth over all else, producing destructive consequences. Despite other political-economic systems producing notable externalities, capitalism reigns supreme in its unjust and disproportional environmental damages, even with recent headway in developing more sustainable infrastructure. As the capitalist economy remains, it will continue to strive for exponential economic growth, exploiting natural resources, overwhelmingly disregarding its inevitable by-products, and manipulating the policymaking of a nation to satisfy its unsustainable but profitable processes. With the fundamental contradictions between indefinite economic growth and environmental sustainability, and infrastructure designed to be profitable over ecologically sustainable, capitalism is a system destined for long-term failure. Without the ridding of the system, it will collapse, bringing the environment down with it. Perhaps sustainable development does not truly exist, but if it does, it will certainly not occur under a modern capitalist economy. Recovering the biosphere will be challenging, yet the first step is transitioning away from capitalism, as the solution lies in adopting a system of wisdom and virtue rather than imprudently clamping to the origin of the global dilemma.

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