ELAIA 2019

Stephen Case
Olivet Nazarene University, scase@olivet.edu

ELAIA

Volume 2   2019

The Honors Journal of Olivet Nazarene University

The name Olivet comes from Mount Olivet, or the Mount of Olives, a hill outside Jerusalem known in ancient times for its olive groves and which featured prominently in Christ's life and ministry. Olives have been cultivated for thousands of years and hold rich theological symbolism (the olive branch as a symbol of peace, for instance, or anointing with olive oil). In selecting a name for this journal, we wanted a title that drew upon the symbolism and history in Olivet's name itself.

ELAIA (el'AYE'ah) is the phonetic spelling of the Greek word for olive. The symbolism is apt in more ways than one: olive trees take years to mature and bear fruit, and the research contained in this journal is likewise the fruit of these students' years of labor. Like the olive tree, we pray these students continue to grow, cultivate deep roots, and bear the fruits of peace and holiness in all their scholarly endeavors.

ELAIA

The Honors Journal of Olivet Nazarene University

VOLUME 2   2019

OLIVET
NAZARENE UNIVERSITY

DIRECTOR'S NOTE

Each fall, the Honors Program at Olivet Nazarene University admits a small number of academically gifted students into its freshman class. From the moment they set foot on our campus, these women and men join a community of scholars, and together they read, reflect upon, and discuss the most important ideas of the past and present—all within a Christian fellowship. The first two years of the program involve a series of Honors courses, taught by a team of faculty and modeled on the historic "old-time college," where small class relationships, interdisciplinary discussion, and debate prevailed.

In the junior and senior years, the Honors Program shifts its focus away from the classroom to the laboratory or library. There, students work on a capstone scholarship project within their major that involves original research and writing. Honors students gain experience comparable to what happens at large research institutions as they work one-on-one with a faculty mentor and alongside their classmates in research seminars to conceive and complete their individual projects. For our graduates—many of whom go on to advanced study in medicine, law, or other fields—scholarship becomes a deeply personal, transformative, and spiritually meaningful act. Throughout their four years, Honors students ultimately learn how to love God with their minds, as well as their hearts.

Since its establishment in 2007, the program has continued to grow and flourish, and the depth of its research continues to increase. This second volume of *ELAIA* represents the fruits of that development, containing capstone research projects from the 2019 Honors Program senior class and their faculty mentors. The Table of Contents is diverse, and in that way it is a crystalline reflection of our program's community of scholars.

I, along with the members of the Honors Council, am gratified by the work of each student and faculty mentor printed within these pages.

- Stephen Lowe, *Honors Program Director*

CONTENTS

The Effects of Native and Domestic Grazers on the Health of Bumble Bee (*Bombus* spp.) Populations in a Historical Tallgrass Prairie Ecosystem

McKenna L. Conforti

Presented as Abstract only

ACKNOWLEDGEMENTS

ABSTRACT

Bumble bees (*Bombus* spp.) play an important role in the pollination of ecologically and economically significant plants worldwide. In recent years, bumble bee populations have suffered decline throughout North America, particularly in the Midwest. Many factors likely contribute to this decline, including the use of pesticides, disease, and habitat loss. Although cattle grazing space is a common use for Midwestern grassland, a comparison had not been made between the capacity of cattle pasture to support bumble bee communities with the capacity of tallgrass prairie, a habitat thought to be optimal for requisite floral resources. Additionally, the reintroduction of bison is becoming increasingly prevalent in the Midwest, both as a restoration tool and as a farmed meat, but it is not known if there is an effect of bison grazing on bumble bee communities. In this study, we sought to determine what effects grassland management for restored prairie, cattle pasture, and bison pasture have on the community composition of bumble bees at Midewin National Tallgrass Prairie in northeastern Illinois. Abundance, species richness, and diversity were recorded across transects in each habitat type using standard sweep net protocol. We found that restored prairie supports significantly higher abundance and species richness of bumble bees than either cattle or bison pasture. This study can be used to inform grassland managers of conservation implications when making land use decisions in the face of habitat loss and decline of bumble bees across the Midwest.

Keywords: bumble bee, conservation, prairie, grassland, pollinator, bison, cattle, grazing

Evaluating the Scalability of the Sonication Method of Graphene Oxide Synthesis

Evan J. Dexter

ABSTRACT

Graphene is a new material that was first isolated in 2004 and consists of one to a few atomic layers of carbon in a lattice sheet structure. Graphene has high tensile strength, high surface area, very low electrical resistance, and various other special properties that make it an excellent material for use in emerging technologies in the categories of electrical components, energy systems, and high strength applications. The production scale of graphene sheets and its variations is currently limited to laboratory use, with increasing research being conducted toward the development of manufacturing techniques of the material. We conducted experiments to analyze the scalability of graphene oxide synthesis through the sonication method and hypothesized that increasing sonication volume and time would increase yield of graphene oxide. The synthesis of graphene oxide was scaled over 100-500 mL while varying sonication from 60-180 minutes. The resulting product was analyzed for quantity by assessing the dry weight of each sonicated product. Product was to be assessed for definitive graphene oxide quality by Raman spectroscopy for both sheet size and purity of the product but was unable to be completed due to machine failure as of this writing. Our data demonstrated that the production rate of graphene oxide is constant with increasing sonication volume but decreases with increasing sonication time. The latter is typical of many chemical reactions and was expected of the synthesis, while the former indicates the feasibility of larger scale synthesis without trade-offs in production rate. Further research into the matter is needed at increasing volumes of sonication, and with greater repeatability of experiments.

INTRODUCTION

Graphene is a relatively new material, having been isolated for the first time in 2004 [1]. It consists of a few atomic layers of carbon atoms arranged in a hexagonal lattice, similar to the structure in the much more common graphite. Graphene with only one atomic layer is referred to as single layer graphene (SLG), and has superior characteristics to graphene with multiple layers, termed few layer graphene (FLG). Both categories of graphene possess many highly desirable traits that are uncommon in everyday materials.

Graphene's unique properties include high tensile strength, high proportional surface area, near zero electrical resistance, and high heat conductance [2]. These attributes make graphene a promising option for technologies currently in research and development. Possible areas of use for graphene include photovoltaic cells, display panels, supercapacitors, high strength composites, and various electrical devices [1], [2]. Due to its properties and broad applications, graphene promises to be an innovative force for technology in the foreseeable future, and consequently the demand for high volume graphene manufacture is anticipated. Currently, graphene is made in laboratory environments in relatively small volumes on the order of milligrams to grams [3]. The complexities of its manufacturing processes make synthesis a challenge at scales needed for commercial products. Transferring graphene from the laboratory to the production floor is a crucial step in its adoption as an emerging technology. The goal of this research is to evaluate the scalability of graphene sheet synthesis through the use of liquid-phase sonication exfoliation. In the course of research, graphene synthesis was conducted experimentally at various scales and the resulting products were analyzed for quantity.

Using the data from this research, the relationship between factors associated with the scaling of the synthesis process are evaluated to determine the efficacy of liquid-phase sonication exfoliation in large scale graphene synthesis.

REVIEW OF LITERATURE

Currently there exist various methods of graphene synthesis, including liquid-phase sonication exfoliation, physical exfoliation, chemical vapor deposition (CVD), and various hybrid methods that combine elements of each [4]. The synthesis method chosen for this research is liquid-phase sonication exfoliation because it is cost effective, produces high quality graphene, and shows promise of meaningful scalability [4]. While other methods will not be attempted in order to retain focus in the research, they are discussed to provide a wider understanding of synthesis techniques being developed.

Synthesis methods

Liquid-phase exfoliation methods remove graphene layers from larger particles of graphite while suspended in solution [2]. Prior to sonication, some methods include oxidizing graphite in order to expand the lattice structure and aid in the subsequent exfoliation [2], [5]. This produces a graphene oxide compound as opposed to a pure graphene material. After synthesis, graphene oxide may be reduced to graphene if it is desired; however, it may not be necessary, as graphene oxide shares many of graphene's unique properties [5]. Exfoliation is either achieved with the aid of an ultrasonic probe or with an ultrasonic bath. Both methods create ultrasonic waves but do so with differing equipment: the former uses a vibrating probe that is lowered into the solution, the latter vibrates the entire container of liquid. In both cases ultrasonic waves are sent throughout the solution, which cause cavitation bubbles to form, creating high shear stresses within the solution and causing graphene layers to shear off their parent graphite particles [6]. Present in the water solution is a surfactant which raises the surface energy of the solution to roughly that of the graphene sheets (~68 mJ/m^2) [3]. Various surfactants can be used so long as their concentration creates the appropriate overall surface energy for the solution. This prevents graphene sheets from coalescing and allows them to remain suspended in the solution. Others have used organic solvents such as NMP (N-methyl-2-pyrrolidone), which have equal surface energy in place of the water surfactant solution [3]. The drawbacks of an organic solvent include increased cost, difficulty in handling, and difficulty in evaporation compared to an aqueous solution [3]. During the sonication process, a portion of the ultrasonic energy is converted to heat, necessitating cooling of the solution over the course of the sonication [1]. Following sonication, both graphene sheets and remaining graphitic material are suspended in the solution. A centrifuge is used to settle the graphitic material to the bottom of the solution, leaving only graphene sheets in suspension as a result of their matching surface energy. The solution can then be decanted off and evaporated, leaving behind graphene product.

Physical exfoliation is a method similar in principle to liquid-phase sonication exfoliation, though regarded less in terms of production-level capability. This method uses physical motion, commonly in the form of a ball mill, to remove graphene layers from graphite [7]. This is a sophistication of one of the first methods of obtaining FLGs, which involves mechanically removing FLG layers with scotch tape from graphite. While incredibly

simple, this method produces very low quality and quantity graphene; drawbacks that extend to more sophisticated procedures of physical exfoliation [7]. The upside of this method is that it is inexpensive due to the simplistic tools involved and the use of few chemicals [7]. Despite this, the crystal structure of the graphene lattice struggles to stay intact during the mechanical exfoliation when compared to other methods [4].

CVD is a promising method that has been extensively researched but has a high cost in both setup and operation [8]. In CVD, a carbon containing gas is heated until it reaches a temperature of 300°C to 1000°C, depending on the specific method, and is then deposited onto the surface of a metal or metal alloy substrate [9], [8]. A positive aspect of this method is that it is capable of being a reel-to-reel process, which are commonly used in industry and have promising scalability potential. However, CVD requires specialized equipment involved in the superheating and channeling of gases, which greatly raises the initial costs of the method [2], [9]. While this method may become more developed and economical in the future, it is not feasible for this research to investigate it.

Gap in existing research

While much research has been done in the field of liquid-phase sonication exfoliation of graphene, a gap exists that this research will attempt to fill. From the available literature, no specific study has been done on the relationship between sonication time and volume in this specific method of graphene synthesis. These parameters of the synthesis are highly relevant to scalability, as they are likely to vary significantly between laboratory and production levels of synthesis. A significant portion of research previously done on this method of synthesis has focused on parameters not critical to scalability, such as graphite concentration [3], [6], surfactant concentration [3], thermal shocking effects [10], and vessel geometry [6]. Additionally, papers that investigate variable parameters of graphene synthesis typically do not include oxidation of graphite in their methods [1], [3], [10]. This research chooses to pursue an oxidative method, as it has been found to increase yield as the expanded crystal lattice of graphite oxide can more easily be exfoliated [3], [5].

This research aims to fill a gap in existing research done by other studies. Arao and Kubouchi investigated the effects of sonication volume and its relation with graphite concentration in the initial solution for sonication [3]. They found that the most effective way to increase the amount of FLG produced is to raise the initial concentration of graphite but not to exceed a critical concentration where efficiency decreases quickly [3]. The study found that this increase in graphite concentration was more critical to yield than an increase in sonication volume, which produced only a slight positive correlation with yield [3]. Another study by Gayathri et al. studied the effects of sonication time alone on the graphene product [1]. They concluded that yield increased linearly with sonication time but did not reach yields as high as Arao and Kubouchi's study [1]. However, neither of these studies used oxidative methods for synthesis, meaning that the combined effects of variable sonication time and volume with an oxidative synthesis method have not been determined. Direct comparison of key variables such as time and volume with respect to oxidative synthesis is critical to expanding our knowledge of graphene scalability.

METHODS

Experimental trial procedure

Graphene oxide was produced using 99.9% graphite powder, sold commercially as dry lubricant by Loudwolf Industrial & Scientific. The graphite was first oxidized by submersion in concentrated sulfuric acid for eight hours to produce graphite oxide. Graphite oxide was made in 20 g batches, each submerged in 100 mL concentrated sulfuric acid. The solution was vacuum filtered using a glass fiber filter, and the residue was dried in a crucible on a hot plate until visibly dry. The graphite oxide was then placed in a tall-form beaker as the sonication vessel. The concentration of graphite oxide used in sonication was 20 g/L. The planned total solution volumes used for sonication were 100, 200, 500, and 1000 mL. The tall-form beakers used were of volumes 200, 500, 1000, and 2000 mL for the different respective sonication volumes. Water was added to the graphite oxide up to the desired solution volume, and Triton X-100 surfactant was added at a concentration of 0.5 g/L. Aluminum foil was used around the rim of the beaker to keep solution from splashing out during sonication. Sonication of each solution was then performed with a VirTis VirSonic 475 sonication probe at full power for varying times of 60, 120, 180, and 240 minutes. With these four varying sonication times and the four levels of sonication volume, a total of sixteen trials were completed. The sonication probe was placed 1 cm into the solution, in the center of the beaker. An ice bath was used during sonication to keep the solution cool and the probe from overheating. The ice bath was refilled as needed during each sonication process. From the sonicated solution, 100 mL was pipetted into two 50 mL centrifuge tubes and centrifuged at 3220 RCF for 30 minutes. This centrifuge setting was picked as specific information could not be found in other studies, so the highest setting on the centrifuge was used. Preliminary testing indicated that this setting was sufficient to sediment the remaining graphitic material on the bottom of the tube. From each tube, the top 40 mL of solution was decanted off (for a total of 80 mL from each trial) and dried in an evaporating dish with a hot plate at 120°C until visibly dry. Initially each 80 mL sample had the appearance of clear liquid; however, brown to black powder residue resulted upon evaporation.

Analysis methods

Once the final graphene oxide was dried, the mass was weighed and recorded. Values of percent yield, yield per liter, and rate of production were calculated and compared for each run. It was assumed that the Triton X surfactant was evenly distributed in the sonicated solution, did not evaporate off, and therefore contributed to the final dried mass [3]. To confirm this assumption, three tests were done where a 100 mL solution of water, graphite oxide, and Triton X were centrifuged without performing sonication. The solutions were then dried as the sonicated trials were, and the residue weighed.

Samples from each experimental run were collected and sent to Dr. Gamini Sumanasekera at the University of Louisville for Raman spectroscopic analysis. From Raman spectroscopy results, conclusions about the graphene oxide's quality can be made. When graphene is analyzed with this type of spectroscopy, it produces distinctive bands named the 'D', 'G', and '2D' bands. The ratio of the intensities of

the 'D' and 'G' bands in the spectra can be calculated to find the relative quality of the graphene structure: a smaller ratio indicates fewer defects [3]. The '2D' band can also be analyzed for symmetry and peak intensity, both of which indicate fewer layers of graphene oxide with increasing value [3].

Process difficulties

During the experimental testing phase of this research, parameters outside of our control caused portions of the planned methods to remain incomplete. In order to sonicate the larger volumes of the 500 mL and 1000 mL solutions, a larger probe horn was purchased (Branson 620-001-156, Emerson Industrial Automation, used). Unfortunately, the new probe horn caused the sonication machine to overheat and was thereafter inoperable. This reduced the number of completed trials to six instead of the planned sixteen. Thus not all sonication times and volumes were tested. Table 1 shows the factor levels of the experimental trials that were completed. Once samples of each completed trial were sent to Dr. Sumanasekera for analysis, it was made known that the Raman spectroscopy machine at the University of Louisville was non-operational and in need of repairs. As of the writing of this thesis, the results of the Raman spectroscopy analysis have not been received back from Dr. Sumanasekera. Despite these setbacks, useful conclusions about the scalability of this method for the synthesis of graphene can be inferred from the data that were collected.

TABLE 1. COMPLETED EXPERIMENTAL TRIALS BY EXPERIMENTAL FACTOR LEVEL

Due to difficulties previously discussed, not all planned experimental trials could be completed. This table shows the trials that were successfully completed, identified by their specific combination of experimental factor levels.

Sonication Time Factor (minutes)	Sonication Volume Factor (mL)			
	100	200	500	1000
0 (Control)	Completed	N/A	N/A	N/A
60	Completed	Completed	-	-
120	Completed	Completed	Completed	-
180	Completed	-	-	-
240	-	-	-	-

RESULTS

In order to determine the scalability of graphene synthesis by liquid-phase sonication exfoliation, we utilized a direct comparison approach assessing both volume and time of oxidized graphite. Total product collected from varying sonication time and volume are shown in Table 2. The product collected is an adjusted value that reflects the removal of the remaining Triton X surfactant. As 0.5 g/L Triton X was used in each trial, 0.04 g would be present in each decanted 80 mL sample taken and was subtracted accordingly from the measured dry weight. This assumption was confirmed

by assessment of un-sonicated solutions. The three un-sonicated controls of 100 mL graphite oxide solution yielded residue masses of 0.033, 0.032, and 0.035 grams, attributed to the non-sedimenting and non-evaporating Triton X. Since the accurate collection of such small masses of residue was difficult, it seems that the true value of residue was in fact the calculated 0.04 g, making 0.04 g the appropriate amount to subtract from the sonicated residue to calculate graphene oxide mass.

The extrapolated product in Table 2 indicates the expected total yield had the entire solution (100, 200, or 500 mL) been processed as the product collected from the 80 mL portion. The percent yield reflects the percentage of graphene oxide obtained from the original graphite oxide. The rate of production shows the speed of the exfoliation process and is a key indicator of scalability of the synthesis. It should be noted that this is a calculated rate from the entire length of the sonication. The instantaneous rate of production likely varied with time during the sonication process, and will be discussed further below with the varying lengths of time, helping to determine the time variance of the rate of production.

TABLE 2. RESULTS OF EXPERIMENTAL TRIALS OF GRAPHENE OXIDE SYNTHESIS

In this table, the product collected is the raw dried weight measured from each trial, the extrapolated product is the calculated product if the entire volume of the trial was centrifuged and dried, the percent yield was calculated using the beginning weight of graphite oxide used, and the rate of production was calculated using the volume and time of each trial.

Sonication Volume (mL)	Sonication Time (minutes)	Product Collected (grams)	Extrapolated Product (grams)	Percent Yield (%)	Product Concentration (grams · L^{-1})	Rate of Production (grams · L^{-1} · min^{-1})
100	60	0.335	0.419	20.9	4.19	0.0698
100	120	0.422	0.528	26.4	5.28	0.0440
100	180	0.261	0.326	16.3	3.26	0.0181
200	60	0.234	0.585	14.6	2.93	0.0488
200	120	0.225	0.563	14.1	2.81	0.0234
500	120	0.370	2.313	23.1	4.63	0.0385

Due to extenuating circumstances, the Raman spectroscopy was unable to be completed for the synthesized samples. Consequently, the purity of the product created remains unknown. However, evidence suggesting the product primarily contained graphene oxide includes the results of the un-sonicated control samples, as well as the fact that prior to drying, the solution appeared clear without particles. Any significant graphitic material should have precipitated to the bottom of the centrifuge tubes, leaving only graphene oxide invisibly in suspension in the solution. Despite this, Arao and Kubouchi synthesized concentrations of FLGs up to 1.8 g/L in their probe sonication research, which is considerably less than the maximum concentration produced in this research [3]. This disparity in yield leads us to believe that some of the graphite oxide in our research may have been exfoliated into particles small enough to remain in suspension but too large to be considered an FLG, an explanation proposed by Dr. Sumanasekera

[5]. For the analysis of these results, it will be assumed that a significant portion of the dry products created are graphene oxide, and that the dry weight collected is proportional to the true amount of graphene oxide produced.

DISCUSSION

The objective of this research was to determine the scalability of graphene oxide synthesis. The calculated values were chosen to show how the parameters tested may affect the synthesis under differing conditions. The low number of trials completed is a weakness of this research and reduces the weight of subsequent conclusions. Ideally, and as a suggestion for future research, this research would have completed all sixteen combinations of factor levels as originally proposed and performed repeat trials under the same conditions for greater confidence. Additionally, greater volumes would also be a valuable addition to further research but would require additional lab equipment such as much larger beakers or vessels and larger sonication horns.

Upon initial review of the raw weights collected, any trends in data from sonication volume **(Figure 1)** and time **(Figure 2)** are difficult to assess due to low experimental number. The percent yield was also included in these graphs, as it corresponds directly to the dry weight collected. With a greater number of trials, a trend may have emerged, but with the data collected none are apparent. The concentrations achieved in this research was higher than those of other studies such as Arao and Kubouchi, and Gayathri et al. [1], [3]. In reference to Arao and Kubouchi's research (who achieved a concentration of 1.8 g/L compared to our maximum of 5.28 g/L), the discrepancy may be due to the use of oxidation and resulting graphene oxide product [3]. This cannot be definitively stated, however, since it is not known how much of the product is actually FLG. Comparing to Gayathri et al., their lower concentration of 6.6 mg/L can be explained by their lower power sonication probe: 100 W compared to our 475 W [1]. The probe used in Arao and Kubouchi's study was rated 600 W [3]. Additionally, Gayathri et al. cannot be compared to this research directly, as they used a differing method of sonication that included a substrate for the graphene film [1].

By taking the previous data and controlling for volume by dividing by the sonication
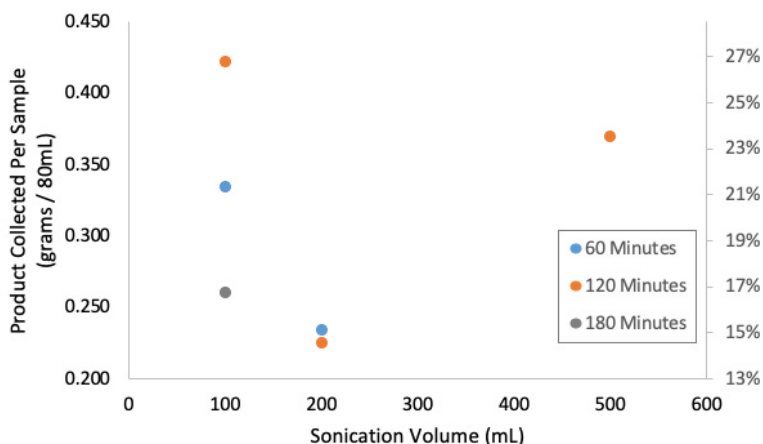
Figure 1: Product collected per sample and percent yield by sonication volume. The amount of product collected per sample is the raw measured dry weight. The percent yield was calculated using the beginning weight of graphite oxide used in each trial.
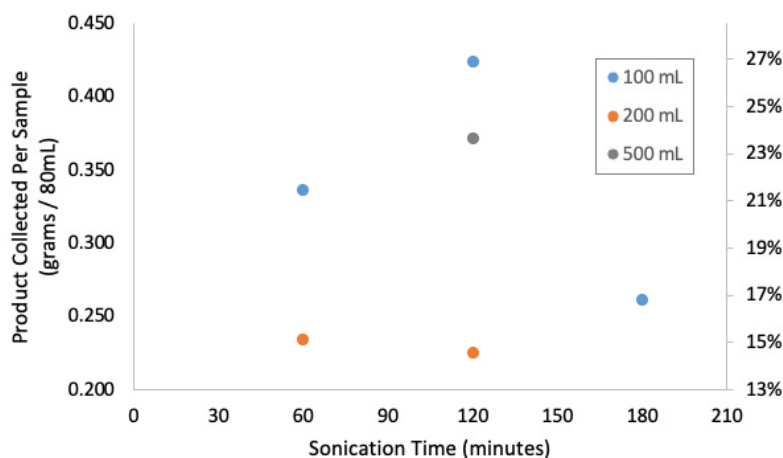
Figure 2. Product collected per sample and percent yield by sonication time. The same data are shown here as in Fig.1, but graphed by their time factor levels.

volume of each trial, the overall rate of production was found **(Figures 3 and 4)**. These results provide more useful data for conclusions to be made. Graphing the overall rate against sonication volume, shown in Figure 3, appears to indicate no trend. This is actually a positive result for the synthesis method, as one may have suspected the rate of production to drop as a result of increasing volume and subsequent increase on material needing to be exfoliated. The lack of a declining production rate indicates that the process may expandable to larger volumes without compromising the speed of the method. Again, a greater number of trials would be helpful to solidify this conclusion, particularly since there is a sizeable spread of rates within trials of the same volume amount.

When viewed as a function of sonication time, there is a negative relationship between
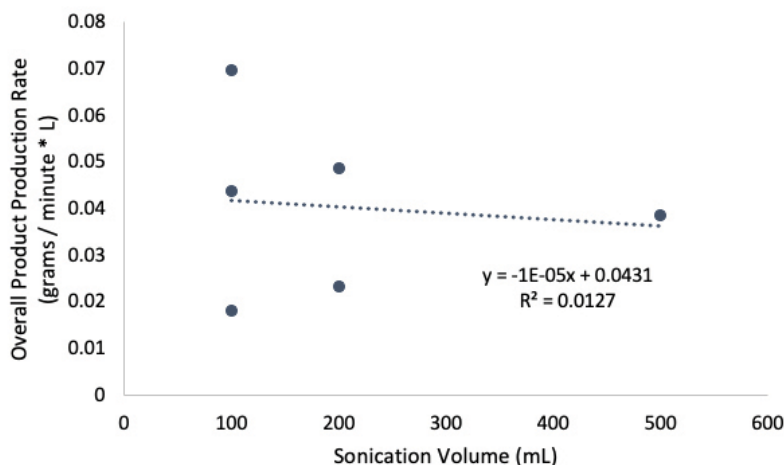
Figure 3. Overall product production rate by sonication volume. This graph shows the overall production rate of graphene oxide is not significantly influenced by sonication volume

production rate and sonication time (**Figure 4**). This suggests that there are diminishing returns to running the sonication for longer periods of time and that a majority of the work of exfoliating the graphene sheets may be done relatively early in the sonication process. It seems that the instantaneous rate of production would approach zero as sonication time increases. These results are typical of most chemical reactions, except in cases of thermally driven exothermic reactions. These results contradict the findings of Gayathri et al., which identified a positive linear relationship between time and yield [1]. We believe this is due to the lower power sonication probe used in their research (compared to ours and that used in Arao and Kubouchi [3]) meaning that their synthesis may not have reached a point of significant diminishing returns. Whether or not all of the graphite oxide would eventually be exfoliated to graphene oxide is uncertain. The application of this data would be that there is an ideal time that a sonication process should run to produce the most graphene oxide without needlessly lengthening the process. In an industrial setting, a recycle system might be implemented to capture the unexfoliated graphite oxide after the process and direct it back into the sonication process alongside fresh material.
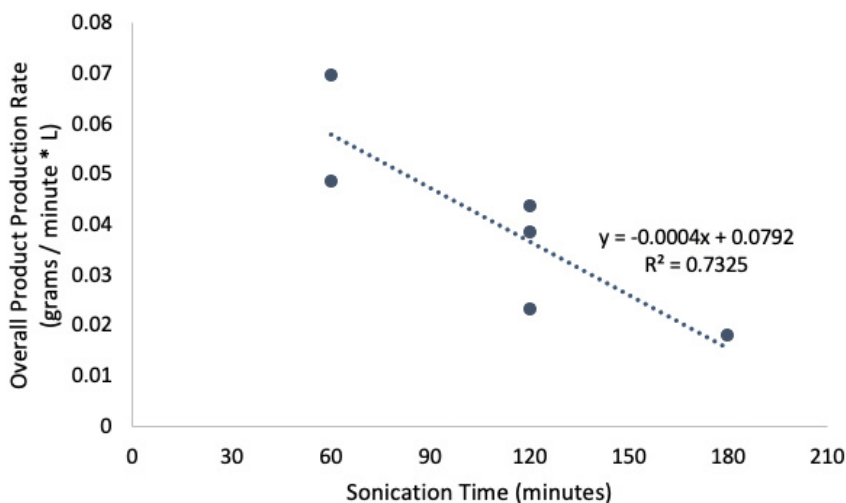
Figure 4. Overall product production rate by sonication time. This graph suggests a negative relationship between the overall production rate of graphene oxide and the sonication time.

The final mode of analyzing the data is shown in **Figure 5**, where the extrapolated product is compared to the sonication volume used. The results of this graph logically follow from the findings that production rate remains constant with increasing volume. Because the rate of production appears to remain constant despite increases in volume, an increased volume will directly lead to higher yields, as the concentration of graphite oxide was held constant. The combination of rate data and total extrapolated product data give evidence that larger volumes of sonication are feasible for synthesis processes. This makes liquid sonication an attractive method for graphene oxide production. In other methods, scaling up may require specialty or complex equipment to be obtained at larger sizes. However for liquid-phase sonication the major process component

appears to scale with the simple substitution of a larger vessel. More research is recommended to determine if these relationships continue to hold for increasing scales that approach production levels.
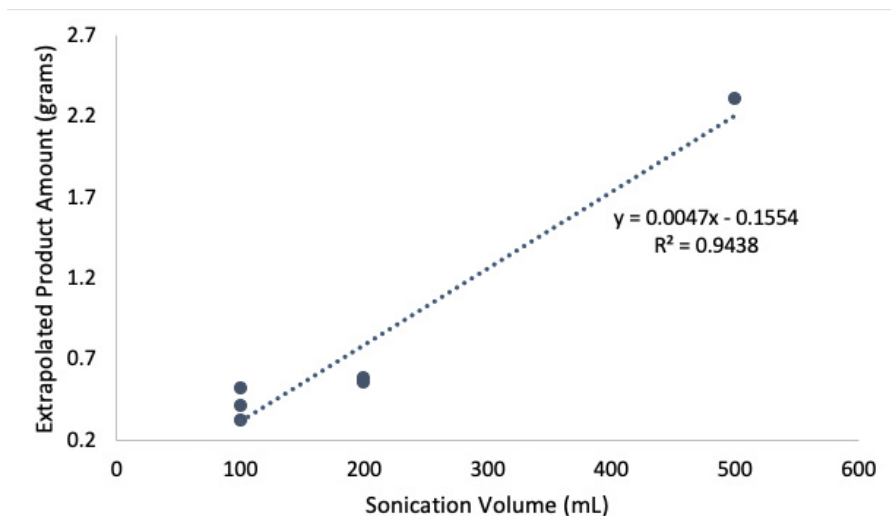
Figure 5. Extrapolated product amount by sonication volume. This graph shows the collected dry weight extrapolated out as though the entire sonication volume was centrifuged and dried. The approximately direct relationship between these values agrees with the previous conclusion that the overall production rate is unaffected by sonication volume.

REFERENCES

[1] S. Gayathri, P. Jayabal, M. Kottaisamy, and V. Ramakrishnan, "Synthesis of few layer graphene by direct exfoliation of graphite and a Raman spectroscopic study," *AIP Adv.*, vol. 4, no. 2, p. 27116, Feb. 2014.

[2] J. Phiri, P. Gane, and T. C. Maloney, "General overview of graphene: production, properties and application in polymer composites," *Mater. Sci. Eng. B*, vol. 215, pp. 9–28, Jan. 2017.

[3] Y. Arao and M. Kubouchi, "High-rate production of few-layer graphene by high-power probe sonication," *Carbon N. Y.*, vol. 95, pp. 802–808, Dec. 2015.

[4] W. J. Basirun, B. Nasiri-Tabrizi, and S. Baradaran, "Overview of hydroxyapatite–graphene nanoplatelets composite as bone graft substitute: mechanical nehavior and *in-vitro* biofunctionality," *Crit. Rev. Solid State Mater. Sci.*, vol. 43, no. 3, pp. 177–212, May 2018.

[5] G. Sumanasekera, "Personal Interview." 2018.

[6] M. Yi, Z. Shen, X. Zhang, and S. Ma, "Vessel diameter and liquid height dependent sonication-assisted production of few-layer graphene," *J. Mater. Sci.*, vol. 47, no. 23, pp. 8234–8244, Dec. 2012.

[7] S. Deng, X. Qi, Y. Zhu, H. Zhou, F. Chen, and Q. Fu, "A facile way to large-scale production of few-layered graphene via planetary ball mill," *Chinese J. Polym. Sci.*, vol. 34, no. 10, pp. 1270–1280, Oct. 2016.

[8] M. J. Madito et al., "A dilute Cu(Ni) alloy for synthesis of large-area Bernal stacked bilayer graphene using atmospheric pressure chemical vapour deposition," *J. Appl. Phys.*, vol. 119, no. 1, p. 15306, Jan. 2016.

[9] G. Pilatos et al., "Graphene by one-step chemical vapor deposition from ferrocene vapors: properties and electrochemical evaluation," *J. Appl. Phys.*, vol. 119, no. 6, p. 64303, Feb. 2016.

[10] K. Nawaz et al., "Effect of thermal treatment on production of graphene from graphite via exf...: EBSCOhost." [Online]. Available: http://web.a.ebscohost.com.proxy. olivet.edu/ehost/detail/detail?vid=1&sid=ab1bc88c-00a6-43e7-8b8a-c3d64b2b1b00%40 sessionmgr4010&hid=4002&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl# AN=120092655&db=a9h. [Accessed: 09-Apr-2017].

Thermal and Orbital Analysis of DarkNESS CubeSat

Anna Katherine Dickey

ACKNOWLEDGEMENTS

ABSTRACT

Fermi National Accelerator Laboratory is sending a 3U CubeSat into Low Earth Orbit (LEO) to search for a 3.5 keV photon corresponding to the decay of a theorized dark matter particle called the sterile neutrino. The CubeSat will encounter environmental variations while in orbit that can be computed through an orbital analysis using System's Tool Kit. In order to minimize thermal noise readout, improve optical resolution, and increase bandwidth, the sensors must be kept below 170 K while taking data. This temperature is difficult to achieve due to radiation from the Sun and the Earth's albedo radiation. Through the thermal analysis, the lowest temperature achieved by the CubeSat throughout its orbit was determined to be 190 K. In order to maintain the required sensor temperature, the CubeSat's cooling methods must be changed.

Using the information gained from the thermal analysis, the solar panel simulation results were analyzed. A six-panel approach resulted in maximum power of 11 watts. A nine-panel approach generated 22 watts at a sustained level, such that each orbit would yield a total of 39.6 kJ. With a power requirement of 20 watts, it was determined that the nine-panel approach would be ideal.

INTRODUCTION

The search for dark matter

Dark matter and dark energy are predicted to make up about 95% of all the matter in our universe. In order to explain the observed rotational curves of our galaxy, the theory of gravity predicts that dark matter must be dispersed evenly throughout our galaxy. The term dark matter was coined in the early 1930s by Swiss astronomer Fritz Zwicky [1]. Using redshift, Zwicky attempted to estimate the total mass and the velocities of visible matter in the Coma Cluster, one of the main clusters of galaxies in the Coma Supercluster. Through his calculations, he realized relative speeds of galaxies in the Coma cluster are too great to be held together by the gravity alone. He theorized that there must be additional unseen matter holding it together and named that unknown material 'Dunkle Materie' [1]. Dark Matter has become the subject of study for many physicists in order to better understand what makes up the universe. Each of the theorized dark matter candidates have yet to be supported by evidence. One candidate that is currently receiving a lot of attention in the scientific community is the sterile neutrino.

Neutrinos are leptons in the standard model of subatomic particles. Neutrinos interact solely via the weak interaction, which makes them particularly difficult to detect. As such, neutrinos have only been detected indirectly up to this point. The neutrinos that have been indirectly detected are nearly massless, which means they are able to achieve high speeds and energy. There are currently three flavors of neutrinos in the standard model that have been detected. Each corresponds with a charged partner: electron, muon, and tau [2]. A fourth neutrino flavor has been theorized and given the name sterile neutrino. This flavor of neutrino has not been detected and seems to interact independently of the fundamental forces that govern our universe, apart from gravity.

There are many different theories as to how a sterile neutrino could behave. One theory assumes the sterile neutrino is massive rather than close to massless. As the 7 keV mass sterile neutrino decays, its mass is converted into energy that occurs as a lighter state neutrino and a photon each with half of the converted energy [3]. Both lighter state neutrinos and photons are essentially massless, indicating the remainder of the mass is converted into kinetic energy.

The decay of sterile neutrinos may have been observed by large effective area telescopes such as Chandra, Suzaku and XMM-Newton. These telescopes have vast databases that have resulted in the detection of an unidentified emission line in far off galaxy clusters [4]. The 3.5 keV emission line detected is pictured in **Figures 1 and 2.** It corresponds with the theorized keV energy photon that is released from the decay of the sterile neutrino. If these X-Ray emission lines are indeed indirectly detecting sterile neutrino decay, a prime candidate for dark matter, then this same emission line should be present in our own galaxy.
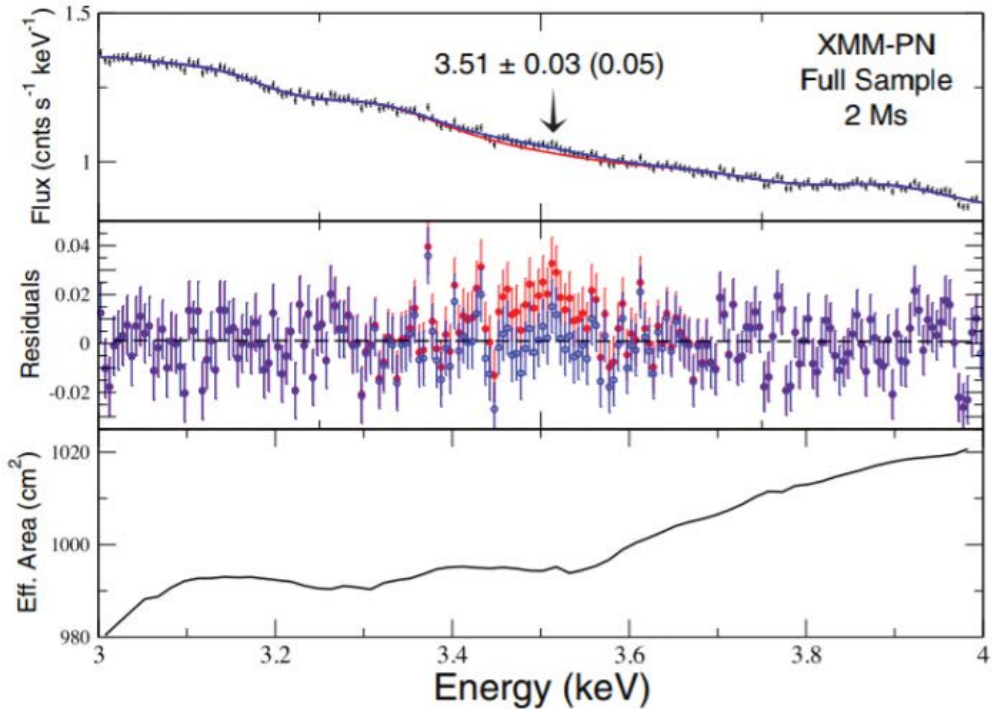
Figure 1: 3-4 keV band of stacked MOS spectra [4]
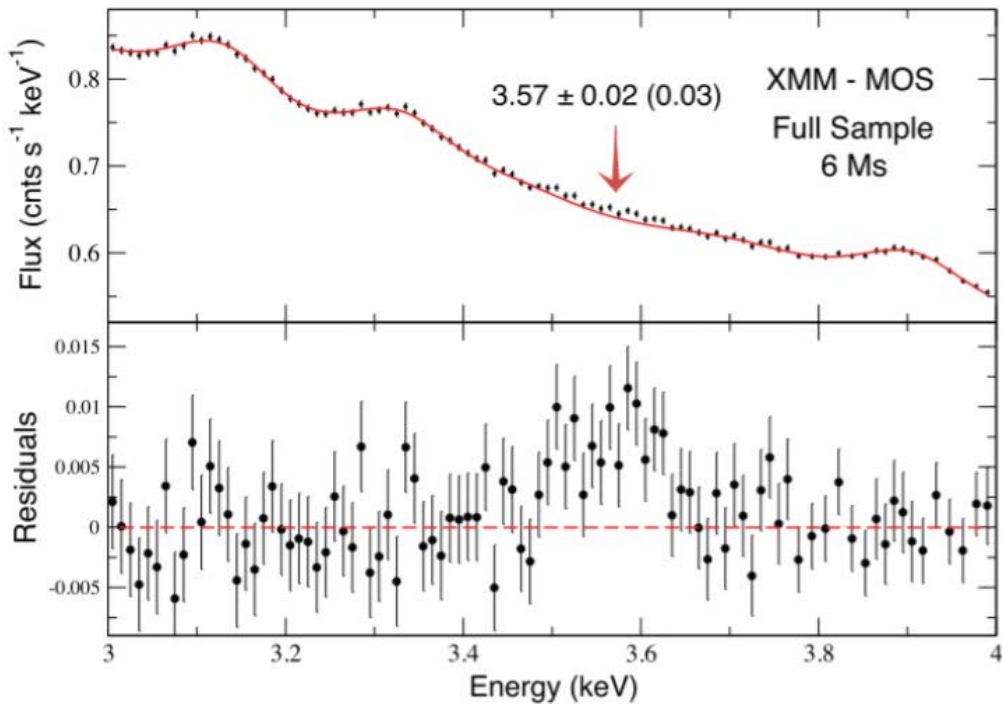
Figure 2: 3-4 keV band of stacked MOS spectrum rebinned to make the 3.57 keV more apparent [4]

Detecting this dark matter candidate by searching for the 3.5 keV X-ray emission line with current observatories has had challenges due to technical limitations. New sensors and equipment must be implemented to reach the sensitivity needed to demonstrate the source of the emission line. Potassium, calcium, or argon, whose radioactive isotopes generate X-ray emission lines that lie within that range, may be mistaken for the 3.5 keV emission line [5]. Current X-ray telescopes also have fairly small fields of view and lack the energy resolution to resolve the weak X-ray lines. Other physicists have performed observations using wide field of view X-ray microcalorimeters as payloads on sounding rockets [6]. Soundings rockets are small research rockets that allow measurement devices and sensors to take data in sub-orbital flight, far above the normal altitude of a weather balloon. Though sounding rockets' sensitivity can compete with the data seen in the large effective area telescopes, they have a short exposure time. Without longer exposure times, it remains challenging to differentiate between the X-ray lines. In order to meet these requirements, small satellites called CubeSats can be used. These satellites allow wide field of view devices to observe X-ray emissions lines for much longer exposure times ranging from several days to several years.

CubeSat specification and design
CubeSat is a specification of picosatellites developed at California Polytechnic State University in order to make experimentation in space more easily accessible to scientists and students. These small satellites are made up of either one, two, three, six, or sixteen units (U) and function completely autonomously **(Figure 3)**. Each unit

is a 10 cm cube that must weigh no more than 1.33 kg. The CubeSat standardization allows for transport as secondary payloads on launch vehicles. They have very strict regulations laid out in their specifications to protect the launch vehicles, payloads, and the CubeSats themselves [7]. Launchers are able to invest in a standard launching system called a P-POD (Poly Pico-satellite Orbital Deployer). This gives all launch companies the ability to launch CubeSats from any of their rockets, which leads to more affordable launches. Other regulations, such as restrictions on pressurization and materials, exist to protect the primary payload and the launch vehicle.
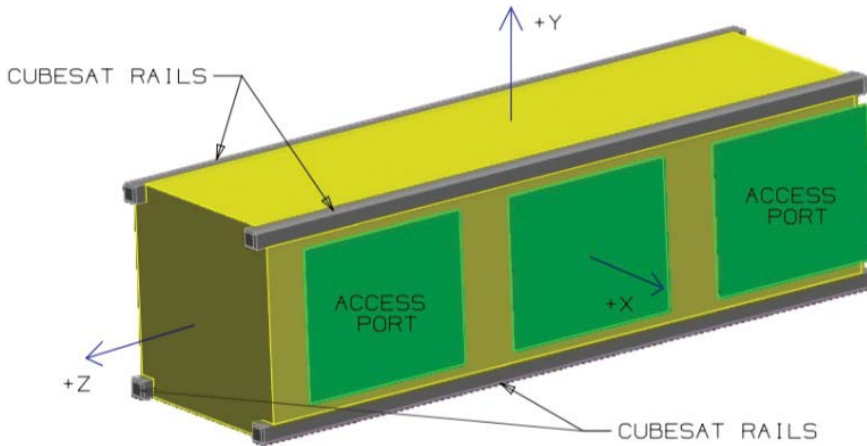
Figure 3: CubeSat drawing that lays out the general specifications for a 3U CubeSat to be launched in a P-Pod including CubeSat rails and general size.

Each CubeSat has its own power supplies, computing systems, attitude determination, attitude control, sensors, thermal management and communication antennas. The standardization allows the use of commercial products and keeps building costs fairly low. Most CubeSats today use PCI/104 standard electronic boards that have stackthrough connectors, allowing for quick easy assembly and electrical interfacing.

A CubeSat that has the capability of detecting the 3.5 keV emission line is being launched by Fermi National Accelerator Laboratory in the next few years. Dark matter as sterile neutrino search satellite (DarkNESS) will continue the search for dark matter as sterile neutrinos using wide field of view optics for long exposure times. The CubeSat's optics will consist of a charge-coupled device (CCD) detector with no optical lenses, allowing it to observe a large portion of the sky. The CCDs that will be used have been implemented in a previous experiment known as Dark Matter in CCDs (DAMIC), which is currently looking for Weakly Interacting Massive Particles (WIMPs) in underground mines. These WIMPs are another candidate for Dark Matter being searched for in the keV energy range. The detector is made of up eight 15 μm × 15 μm megapixels etched onto a 6 cm x 6 cm silicon wafer [8]. When a photon in the 3-4 keV range strikes a pixel on the CCD, it collects charges in potential wells **(Figure 4)**. Eventually these wells roll over and a sequence of voltages are sent back to the controller. There, the voltages are converted to an electrical signal to be read out digitally [9].

25

(a) A CCD pixel   (b) WIMP detection in a CCD
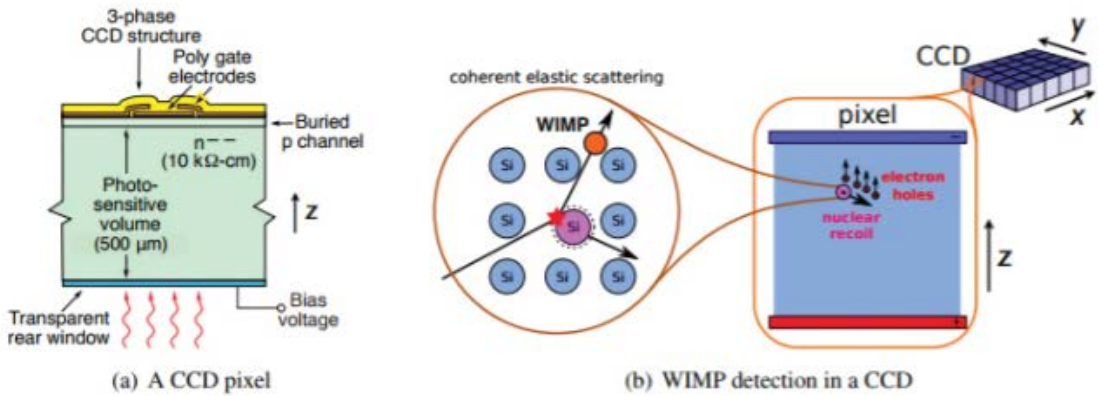
Figure 4: CCD configuration. Detailed explanation of how the pixels in a CCD take an image and how data from that image is transported [8].

In order to minimize thermal noise readout, improve optical resolution, and increase bandwidth, the CCDs must be kept below 170 K while taking data. Due to the close proximity to the Sun in addition to the Earth's albedo radiation, a floating body in the Earth's orbit can obtain high temperatures, making 170 K difficult to achieve. Considerable thermal analysis must take place to ensure the success of the DarkNESS CubeSat.

Orbital candidates

One contributing factor to the thermal analysis is the selection of the orbit. Due to their status of a secondary payload, CubeSat developers are not often able to decide when and where their orbits will take place and must instead plan for a range of possible orbits. The orbit that would allow for the longest experiment time is geostationary orbit. At an altitude of 35,786 km, this orbit allows satellites to remain constantly stationed over a single area of Earth [10]. It is the farthest orbit from the Earth's surface being considered, which allows for less debris and fewer unwanted particle interactions. This orbit is used primarily by weather satellites and global positioning satellites and has limited spaces. It would also be extremely expensive to obtain a spot, and the wait time for a launch would be far too long. In addition to this, CubeSats often cannot obtain the requirements needed for a larger satellite in this orbit. Propulsion, which CubeSats typically lack, is necessary to "knock" the satellite out of orbit when it has completed its mission in order to maintain a low level of debris in this orbit.

The range of orbits from the Earth's surface to 2,000 km is known as Low Earth Orbit (LEO). LEO includes orbits such as polar orbits and the orbit of the International Space Station. A polar orbit is any orbit that passes within 20 degrees of the poles. These orbits have a fairly consistent temperature, as the majority of their orbital time is in solar contact. The upside to this is that the solar panels will work to their maximum capacity. There are two large negatives to this orbit, however. The first is that the temperature will be much higher than desired. Additionally, the CCDs cannot take data directly into the Sun or the Earth. This orbit would drastically decrease the amount of data obtained, as the Sun or Earth would block data collection throughout the majority of the orbit.

The third choice for the DarkNESS CubeSat is the orbit of the International Space Station. The ISS orbit has an inclination of approximately 52 degrees with a perigee height of approximately 403 km and an apogee height of around 408 km. This orbit is approximately ninety minutes and allows for relatively consistent temperature and also a large amount of data collection. In addition to this, it is very easy and inexpensive for DarkNESS to be released from the ISS, as CubeSats can be transported easily with supplies and released from a hatch in the ISS. Due to the benefits of this orbit, it is the chosen orbit for the DarkNESS mission.

Thermal analysis

With the selection of the orbit, thermal analysis can be initiated. Thermal balance of a satellite can be computed using general heat transfer equations. One important characteristic to consider is that the CubeSat will be launched into an orbit that is at high vacuum with very little drag. A high vacuum means that convective interaction can be ignored, while no drag implies that there will be no significant aerodynamic heating. This significantly simplifies the equations used. These equations have been used to calculate the critical hot and cold extremes for the DarkNESS CubeSat. For the hot case, it is assumed that the CubeSat is in direct sunlight with a solar heat flux of 1414 W/m2, an Earth Albedo coefficient of .35, and an Earth heat flux of 260 W/m2 [10]. Using the simplified heat transfer equations for a black-body (emissivity and absorptivity equal to one) the hot case temperature would equate to:

$$T^4 = \frac{J_s + J_a + J_p}{4\sigma} = \frac{1414 + (0.35 \cdot 0.15 \cdot 1414) + 260}{4 \cdot 5.67x10^{-8}} = 23.16°C$$

The cold extreme temperature assumes the CubeSat is in the Earth's shadow and will receive no direct solar contact or heat flux. The Earth's albedo coefficient would be .25, and the Earth's heat flux would be 220 W/m2 [10]. Using the same equations, the cold case temperature would equate to:

$$T^4 = \frac{J_s + J_a + J_p}{4\sigma} = \frac{0 + (0.25 \cdot 0.15 \cdot 0) + 220}{4 \cdot 5.67x10^{-8}} = -90.94°C$$

These results show an expected range of approximately -91˚C to 24˚C. This result will not be entirely accurate, as the CubeSat does not behave as a blackbody. The selection of materials will change both the emissivity and absorptivity constants. Emissivity is the measure of how closely a surface approximates a blackbody; for the prior calculations this number is set to 1. A higher emissivity means a higher absorptivity due to Kirchhoff's law [11]. When the absorptivity of an object is higher, the rate at which it absorbs radiation is increased. This would cause higher temperatures overall.

METHODS

Software

Orbital analysis was assessed with the commercially available System's Tool Kit (STK) software (Analytical Graphics, Inc.), which allows engineers to design and analyze dynamic simulations on land, on sea, in air, and, for this project's purposes, in space. A free educational license of STK 11 with Space Environment and Effects Tool (SEET) was used to complete the orbital analysis. SEET evaluates the effects of the near-Earth space environment on the satellite including radiation, the geomagnetic field, particle impacts, and temperature. STK was selected because it is among the top software packages for orbital analysis at a very low cost. For the purposes of our analysis, the ISS orbit was simulated using STK for one year from July 1, 2018 to July 1, 2019.

Computing access

A full year's worth of data was taken and analyzed in STK to determine the most effective dates for the CubeSat's launch and operations. A 3U CubeSat model was created in NX, a CAD modeling software, and imported into STK. After assigning parameters for the orbit, sensors were also modeled. The sensors modeled had a conservative view of 20 degrees in the sky. The orbital constraints were assigned to the sensor to ensure the sensor was always facing the galactic center, specifically Sagittarius A*.

In order to take accurate data, excessive noise must be eliminated. The flux from the Sun and Earth can significantly lower the signal to noise ratio. To eliminate this flux, the CCDs must only take data while the sensors are out of view of both the Sun and the Earth. This constraint was assigned to the sensors. The access between the sensor and the galactic center was then computed from July 1, 2018 to July 1, 2019.

In order to determine the reliability of the data, the sensors must also take data looking out of the galactic plane. This process was then repeated with the CCD sensor pointing out of the galactic plane. This ensures that the signal shows correlation with the Milky Way, as expected from sterile neutrino emissions, which would not expect to be seen in the same quantity outside the galactic plane.

Solar panel simulations

In order to accomplish solar panel analysis, several CubeSat models were created in NX. These part files were converted to blender CAD files, and the materials were delegated to their locations on the satellite. This allowed STK to distinguish between the solar panels and the remainder of the satellite. After this was complete, the model was inserted into STK and an analysis of solar panel performance was completed to determine the amount of energy generated each orbit.

Three solar panel simulations were run with SEET using two different CubeSat models. The trials were run with the same orbital inputs for two orbits. The attitude constraints given to all three of the trials consisted of the CCDs pointing in the direction of the

galactic center with their field of view unobstructed by the Sun or Earth's surface. When the CCDs were not able to take data, the simulations varied in their constraints in order to focus on power generation by optimizing the contact area between the Sun and the solar panels. The first trial consisted of three sets of solar panels along the sides of the CubeSat nearest to the Sun, as pictured in **Figure 5**. When the CCDs are not able to take data, the CubeSat's side aligns with the Sun.
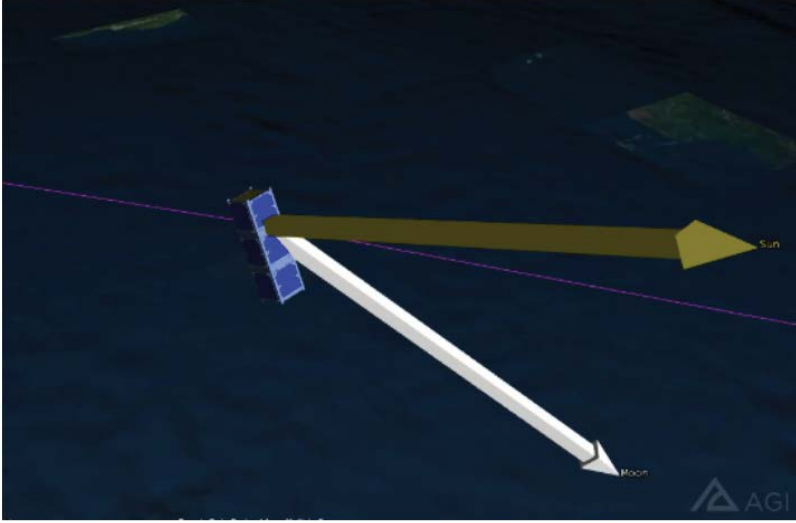
Figure 5: DarkNESS original three-panel approach in STK with one side of the CubeSat constrained with the Sun. The grey arrow shows the Sun constraint, while the white arrow shows the direction of the Moon relative to the satellite.

The second approach consists of the same CubeSat model with one side of the CubeSat at a 45 degree angle to the Sun when the CCDs are not able to take data, as seen in **Figure 6**. In other words, in this alignment the corner of the CubeSat was constrained toward the Sun, allowing two sides of panels to gather light.
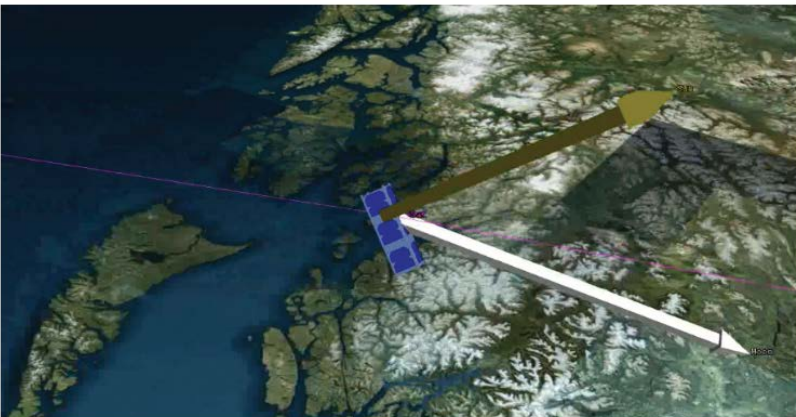
Figure 6: DarkNESS three panel approach in STK with the corner of the CubeSat constrained with the Sun. The grey arrow shows the Sun constraint, while the white arrow shows the direction of the Moon relative to the satellite.

29

Lastly, a new CubeSat model that implemented deployable solar panels was used. As shown in **Figure 7**, these three solar panels are constrained with the Sun at a 90 degree angle when the CCDs are not taking data.
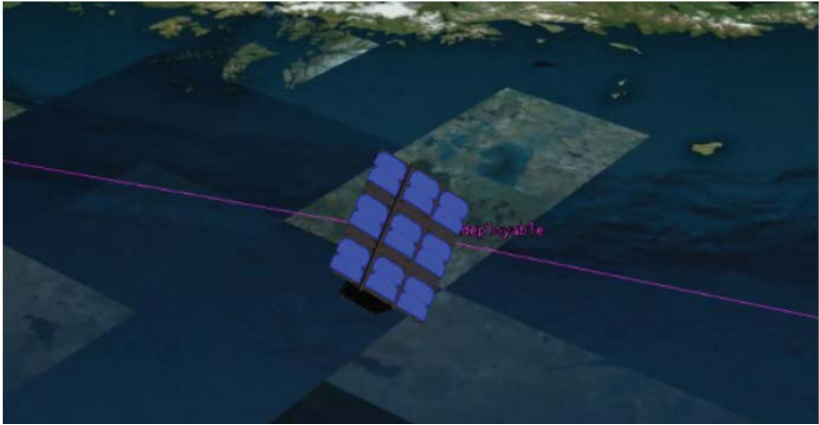
Figure 7: DarkNESS nine panel approach in STK with deployable solar panels with Sun constraint.

RESULTS

Thermal simulations

The range of temperatures the CubeSat will be subjected to was found using STK's SEET package. These results were then compared to the extreme heat transfer results to determine accuracy. Using SEET, STK can simulate the general temperature of the CubeSat as though it is a sphere with a cross sectional area of 0.01m2. The Earth's albedo, which can be thought of as the planet's reflectivity, is selected as 0.35 as a conservatively high estimate. The material selected has an emissivity of 0.81, whereas the absorptivity is 0.87. This is based on the most conservative numbers for aluminum 7075, 6061, 5005, or 5052, which are the only possibilities using the CubeSat standardization. Using these values, the simulation was run for the full year and demonstrated that temperatures oscillated from extremes of -90°C to 50°C, as shown in **Figure 8**.
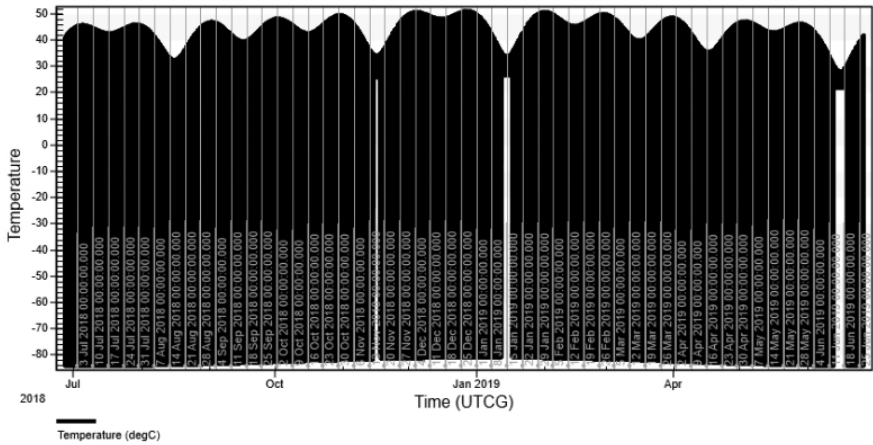
Figure 8: Temperature ranges in degrees C for the DarkNESS simulation throughout the course of one year using $\alpha = .87, \varepsilon = .81$ and Earth Albedo = .35. The CubeSat is modeled as a sphere with a cross sectional area of .01 m2.

Computing access

Times throughout the orbit when the sensors can be taking data were found using STK. For the first phase, access times occurred when CCDs were able to access the center of the galaxy without interference from the Earth and the Sun. A gap in data collection occurs from November 12th to January 14th, as seen in Figure 7. An additional gap exists between January 18th and January 30th.
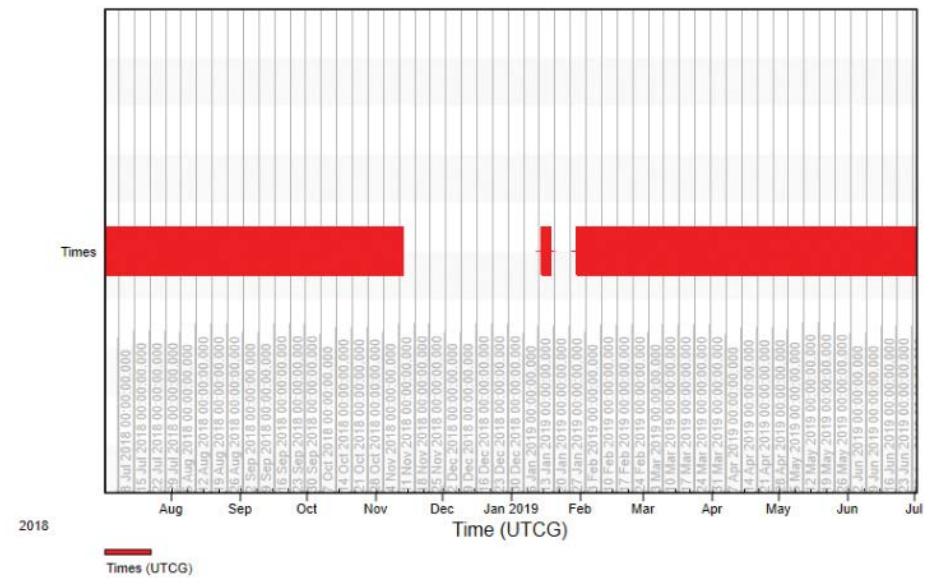
Figure 9: Access computed for CubeSat sensors pointing into the galactic center from July 1, 2018 to July 1, 2019. Grey represents time when access is maintained.

TABLE 1. ACCESS TIMES

Access times computed for CubeSat sensors pointing to the galactic center from July, 2018 to June, 2019.

Year	Month	Total Time (Seconds)	Total Time (Hours)	Rank
2018	July	1306758	362.9883	5
2018	August	1339861	372.1837	2
2018	September	1290931	358.5919	8
2018	October	1332531	370.1476	4
2018	November	506299.8	140.6388	10
2018	December	0	0	12
2019	January	109689.5	30.46929	11
2019	February	1213872	337.1867	9
2019	March	1342346	372.874	1
2019	April	1293115	359.1986	7
2019	May	1337226	371.4515	3
2019	June	1293412	359.2811	6

The tabulated data shows the total amount of time the satellite will be able to take data throughout the month. The longest amount of data collection occurs in March with 1,342,346 seconds, or approximately 373 hours, of data taking.

For phase two, data is collected pointing out of the galactic plane. Again, data collection is restricted to when there is no interference caused by the Sun and the Earth. These simulations show there are no gaps between times of data collection, as can be seen in **Figure 10.**
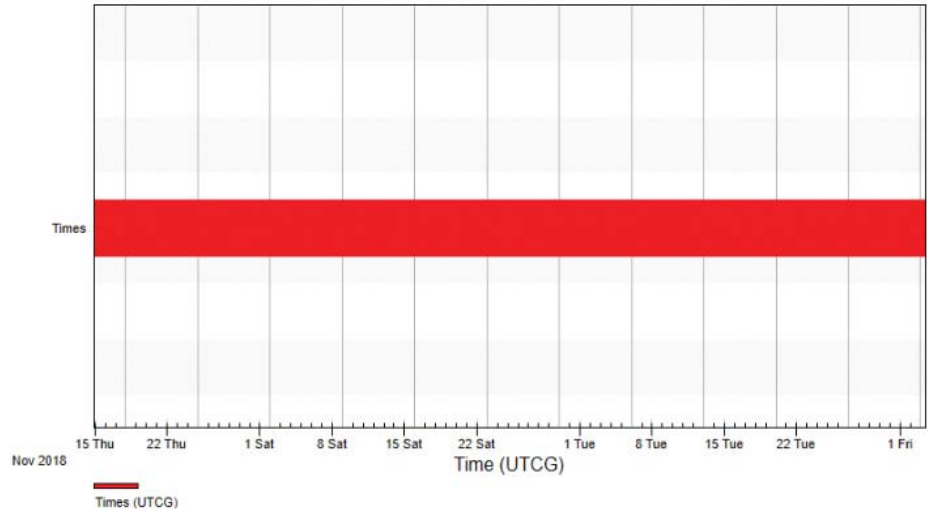
Figure 10: Access computed for CubeSat Sensors Pointing out of the galactic plane from July 1st, 2018 to July 1st, 2019. Grey represents time access is maintained.

Solar panel simulations

The solar panel configurations were then assessed. The first solar panel trial has three sets of solar panels along the sides of the CubeSat align with the Sun when the sensors cannot take data. The results of this approach are shown to have an average of 7.5 Watts when the solar panels are aligned to be taking power, as can be seen in **Figure 11.**
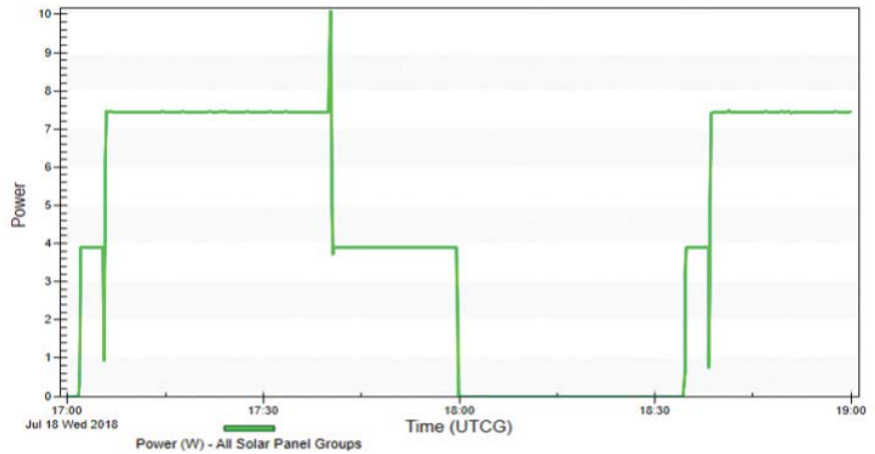
Figure 11: SEET results for three-panel approach in STK. DarkNESS original three panel approach in STK with one side of the CubeSat constrained with the Sun.

The results of the second three-panel approach show a maximum and average of 11 Watts of power when the solar panels are constrained with the Sun at a 45 degree angle, as can be seen in **Figure 12**. The results of third approach with deployable solar panels can be seen in **Figure 13** to have a maximum and average power collection rate of 22.2 Watts during power collection phase.
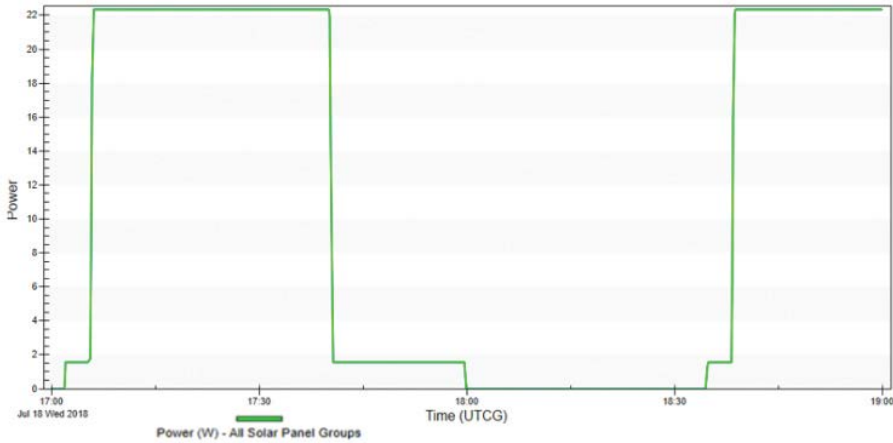
Figure 12: SEET results for second three-panel approach STK. DarkNESS original three panel approach in STK with corner of the CubeSat constrained with the Sun during power collection phase.
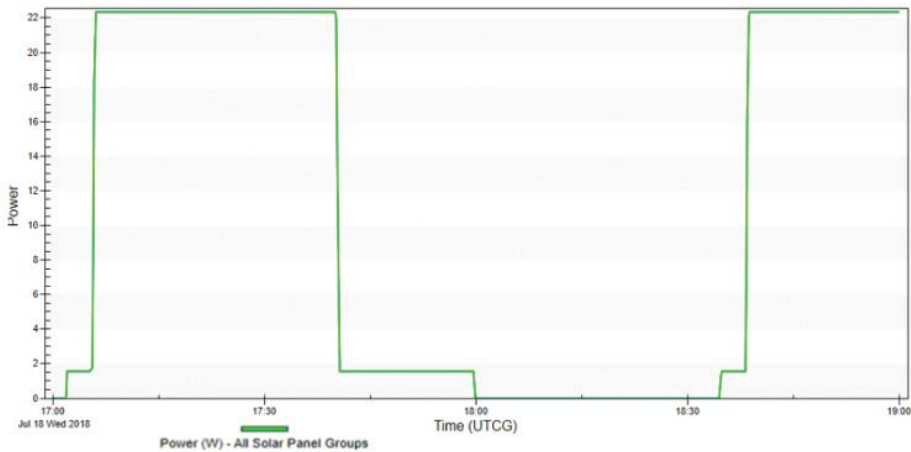
Figure 13: SEET results for deployable solar approach STK. DarkNESS deployable model in STK with solar panels constrained with the Sun during power collection phase.

DISCUSSION

Thermal analysis

Through the thermal analysis, we can see that the lowest temperature achieved by the CubeSat throughout its orbit is still 190 K. It becomes clear that the thermal requirements of remaining below 170 K will be unattainable without major changes to the CubeSat's cooling methods. Even with adjusting the orbit to avoid excessive solar

radiation, the CubeSat will remain above the acceptable temperature range. If data is taken above this temperature, the signal to noise ratio will be too small. Any data taken will be insignificant, as the data cannot be distinguished from noise. In order to reduce the temperature of the CCD sensors, various means of cooling must be taken into consideration.

Passive cooling

One cooling method to consider is passive thermal control, as it requires no input power, is low cost, low volume, low weight, and low risk. Thermal insulation such as Multi-Layer Insulation (MLI) acts as a thermal radiation barrier, lowering the amount of incoming solar flux in order to reduce excessive heat absorption. Unfortunately, the use of MLI will only function properly if extremely accurate attitude control is achieved. Without proper pointing, the MLI could be located on the incorrect side of the CubeSat, causing it to prevent heat dissipation. This would cause the CubeSat to heat rather than cool. Dunmore Aerospace Corporation is the first company to produce MLI for small spacecraft. However, their ranges for cooling are between -23°C to 40°C, well above the required temperatures for DarkNESS [12].

In order to dissipate more heat, thermal louvers may be implemented. These have a larger mass than most other passive cooling options; however, they are also more effective. They work by using bimetallic springs that expand when there is an increase in temperature, causing flaps to open to increase dissipation of radiative heat [13]. This technology, however, is very new and has not been used on a satellite as small as DarkNESS. A drastic decrease in active area may cause a decrease in efficiency.

Figure 14: Passive thermal louver on NASA 6U CubeSat [13].

Active cooling

Without major breakthroughs in passive cooling for nanosatellites, an active cooling element will be necessary. Active thermal methods rely on input power to operate but are much more effective [14]. Unfortunately, the number of active cooling elements that can be implemented in CubeSats are extremely limited. This is due to the satellite's small size, which requires miniaturization of current technologies before implementation.

The most efficient option for an active cooling element is a microcryocooler. These devices are extremely miniaturized coolers that can cool sensors to cryogenic temperatures. Many have been implemented in infrared sensors for military use. Due to their low size and weight, they are optimal for CubeSat missions with cryogenic requirements. Unfortunately, they typically have an extremely high power requirement and cost. The options for microcryocoolers are Stirling cycle, pulse tube, radiator, Peltier, Joule Thompson, cryogens and reverse Brayton coolers [15]. Stirling cycle and reverse Brayton coolers have not yet been miniaturized to the extent that they can be implemented in CubeSats. Radiator and Peltier coolers do not reach cold enough temperatures for the DarkNESS mission and also call for specific orbits that may not be guaranteed [12]. Joule Thompson coolers require an extremely complex design, and the Cryogen coolers have a short lifetime and low reliability. After eliminating unusable designs, only the pulse tube coolers remain as a viable option [15].

Pulse Tube coolers consist of a compressor and a fixed regenerator. Reliability is fairly high, as there are no moving parts at the cold end. They have also already been implemented in CubeSats. After comparing various companies' options for pulse tube microcrycoolers, a conservative estimate for power consumption at the required temperature would be approximately 10 Watts [13]. This would cause the required power input to rise to 20 Watts in order to run the CubeSat.

Access analysis

The time of year that the satellite should be launched is heavily dependent on the amount of time that the CCDs are able to collect data. In order to obtain sufficient data, there should be several months of data collection from the galactic center; Phase 1. This will be followed by Phase 2 with several months of data collection from outside of the galactic plane. Based on the collected data, launching in late summer would be ideal. August has the second longest data collection period at just over 372 hours. If the data collection begins on August 1st, the CubeSat would have approximately 1,242 hours of access time before November 12th. At this time, the satellite's attitude should shift to point outside of the galactic plane, beginning Phase 2 of its observations.

Assuming the access periods maintain consistent every year, late July or early August would be the ideal launch time. Before declaring a launch date, this process of analysis should be repeated for the prospective year in order to verify these results for the selected dates.

Solar panel analysis

Different solar panel configurations were tested in order to determine the optimal set up. Assuming an active cooling element is required, the microcryocooler would have a 10 Watt requirement for power. The CCD controller is estimated to have at most a 5 Watt requirement, whereas the remainder of the satellite should require approximately 5 Watts to run. The overall power budget the solar panels have to obtain in this case is 20 Watts in order to achieve our goal of data collection every orbit. This is very high compared to prior CubeSats, so the solar panels will need to have maximum performance.

The six-panel approach with the 95 degree constraint resulted in maximum power of 11 Watts. For a full ISS orbit, 11 Watts of energy would be collected for around 30 minutes. This would result in 19.8 kJ of energy. This energy could run the CubeSat for approximately 16.5 minutes per orbit if the microcryocooler is required. These minutes would need to be split up between collecting, computing, and transmitting the data. The nine-panel approach generated 20 watts at a sustained level, such that each orbit would yield a total of 39.6 kJ. This wattage would be able to power the CubeSat and microcryocooler for 33 minutes.

Based on the access computed, each orbit has on average 46 minutes of possible access periods. In order to maximize data collection, as much of those minutes should be accessed as possible. The nine-panel, deployable solar panel approach more closely meets the requirements for the success of the mission.

Deployable solar panels also have drawbacks. There is a high chance of failure when deployables are introduced to the design of a CubeSat. Due to the nature of these devices, there is very little that can be done to ensure the success of a deployable part. The advantage to this layout of solar panels is that if the panels fail to deploy, the satellite will be able to function as though the six-panel approach was selected.

CONCLUSION

This analysis has shown that the 170 K or lower temperature requirement to take data can be met using a microcryocooler. The additional power requirements created by the active cooling system are solved via the deployable solar panel approach. An August 1st launch date will allow for the maximum viable time to take data. A CubeSat with these elements is a possible option for identifying a prime candidate for dark matter and answering one of today's prime mysteries in astrophysics.

REFERENCES

[1] V. C. P. and V. N. Lukovic, "Dark matter in cosmology," *International Journal of Modern Physics A*, vol. 29, no. 19, 2014.

[2] D. H. Perkins, *Introduction to High Energy Physics*, New York, NY: Cambridge University Press, 1972.

[3] R. A. M. K. N. A. A. T. A. M. B. M. …. Z. K. Adhikari, "A white paper on keV sterile neutrino dark matter," 2017.

[4] E. Bulbul, M. Markevitch, A. Foster, R. Smith, M. Loewenstein and S. Randall, "Detection of an unidentified emission line in the stacked X-ray spectrum of galaxy clusters," *Astrophysical Journal*, vol. 789, no. 1, 2014.

[5] J. A. Bearden, "X-Ray wavelengths," *Reviews of Modern Physics*, pp. 86-99, 1967.

[6] E. Figueroa-Feliciano, A. J. Anderson, D. Castro, D. C. Goldfinger, J. Rutherford, M. E. Eckart, R. L. Kelley, C. A. Kilbourne, C. A. McCammon and K. Morgan, "Searching for keV sterile neutrino dark matter with X-ray microcalorimeter sounding rockets," *The Astrophysical Journal*, vol. 814, no. 1, 2015.

[7] California Polytechnic State University, "CubeSat design specification."

[8] A. Aquilar-Arevalo, D. Amidei, X. Bertou, M. Butner, G. Cancelo, A. Vazquez and J. Zhou, "Search for low-mass WIMPs in a 0.6 kg day exposure of the DAMIC experiment at SNOLAB," *Physical Review*, vol. 94, no. 8, 2016.

[9] A. Theuwissen, *Solid-State Imaging with Charge-Coupled Devices*, Kluwer Academic, 1995.

[10] P. Fortescue, J. Stark and G. Swinerd, *Spacecraft Systems Engineering,* John Wiley & Sons, 2003.

[11] Y. A. Cengel, J. M. Cimbala and R. H. Turner, *Fundamentals of Thermal-Fluid Sciences*, New York, NY: McGraw-Hill Education, 2017.

[12] Dunmore, "Dunmore Aerospace Satkit," [Online]. [Accessed 2018].

[13] B. Yost, "State of the Art of Small Spacecraft Technology," 2016.

[14] K. Hogstrom, *State-of-the-Art Thermal Analysis Methods and Validation for Small Spacecraft,* 2013.

[15] Oxford Cryogenic Engineering Group, "Cryocoolers for Space Applications," University of Oxford, 2015. [Online]. [Accessed 2017].

Stand Location Variance as an Indicator of Disturbance Regime in a Monotypic *Tsuga canadensis* Forest

Cole J. Doolittle

DEDICATION

To my Father, who first taught me to hear the Lord in the song of a Nuthatch, see the Lord in the complexity of an Orchid, and feel the Lord in the strength of an Oak.

ACKNOWLEDGMENTS

ABSTRACT

Disturbance regimes, which are critical components of forest ecosystems, influence forest morphology, biodiversity, and regeneration. The heterogeneity of disturbance regimes are not well understood on small scales. In this study I analyzed tree cores from five sites within a *Tsuga canadensis* (Eastern hemlock) forest in northern Wisconsin to investigate disturbance regimes through mean growth release criteria. This study investigated the following questions: 1) Are disturbance regimes in *T. canadensis* stand level or site specific? 2) If disturbances are site specific, is site location an indicator of disturbance regime? 3) Do site characteristics such as density and tree diameter at breast height (DBH) influence disturbance regime? I found that *T. canadensis* disturbance regimes are site specific and depend greatly on forest geomorphology and that density and tree diameter may be weak predictors of disturbance regime. Moreover, I observed a correlation between high intensity release, defined as large increases in ring growth, and low disturbance size, defined as a low proportion of trees with release record, suggesting that *T. canadensis* may have a differential evolutionary response to gap disturbances dependent on gap size. Though confined to one geographic location, this evidence suggests that *T. canadensis* disturbance regimes are complex, site specific, and predict growth strategies that ultimately influence forest morphology. The site specificity of *T. canadensis* disturbance regimes suggest that ecological and management studies, which often assume disturbance homogony, may miss important site differences.

Keywords: dendrochronology, windfall, northwoods, disturbance regime, eastern hemlock, monotypic forest, growth strategy, natural history, release

INTRODUCTION

Disturbance regimes

Disturbance processes are important drivers of vegetation dynamics across much of Eastern North American Forests (Attiwill 1994, Janowiak et. al 2014). Classically, a disturbance is defined as a "discrete event that disrupts the ecosystem, community, or population structure and changes the resources, substrate availability or physical environment" (White and Pickett 1985). In these Eastern forest systems, where water does not limit production, wind and fire disturbance regimes drive vegetation dynamics (Canham and Loucks 1984, Attiwill 1994). In this region 30% of late successional species compositions such as *Tsuga canadensis* (Eastern hemlock) may be replaced every twenty years as a result of windfall disturbance (Frelich and Lorimer 1991).

The Northwoods of UNDERC-East (University of Notre Dame Environmental Research Center) are a part of the Laurentian Mixed Forest System that covers the majority of the northern Great Lakes region (Cleland et al. 1997). This system is characterized by secondary temperate broadleaf and mixed boreal transition forests (McNab et. al 2007, Janowiak et. al 2014). *T. canadensis*, a late-successional evergreen tree species, is both shade-tolerant and well adapted to the cool temperate climate of the Northwoods. The cycle of disturbance-mediated gap creation and understory sapling recruitment in *T. canadensis* stands maintains a species-rich seedbank as well as habitat for gap-dependent forest species (Attiwill 1994). Due to the importance of

gap dynamics in T. canadensis stands, and the relatively long life of *T. canadensis*, they provide an excellent model for studying disturbance regimes in the Northwoods (Rooney 2008). At UNDERC, *T. canadensis* is found in remnant old growth forests **(Figure 1)**. Though a majority of forest stands at UNDERC have historically been repeatedly logged and do not predate the mid-1950s, the unlogged *T. canadensis* plot dates back to the 1790s. This old-growth plot provides a rare opportunity to study disturbance with little interference from anthropogenic land use.
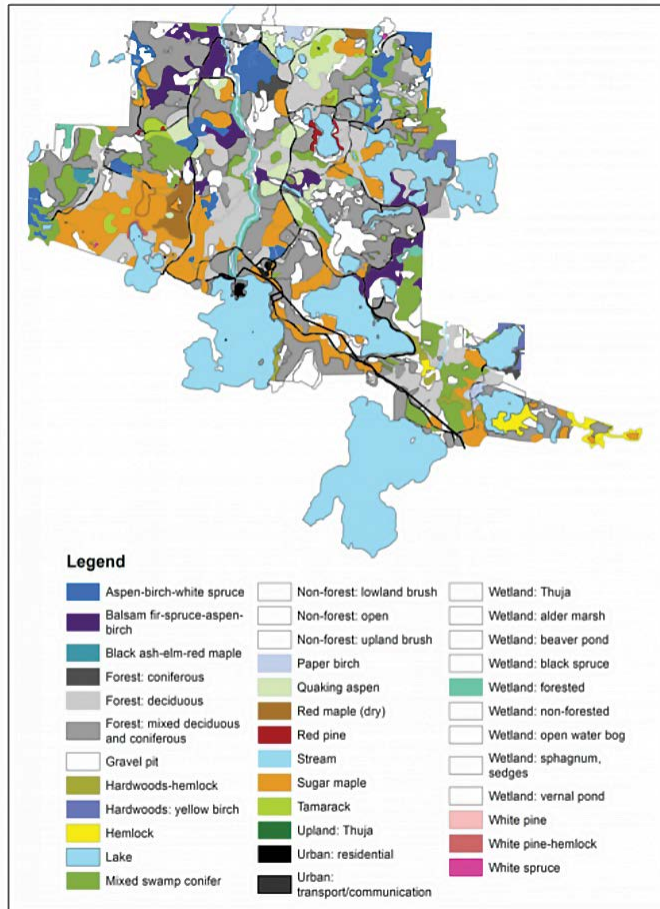
Figure 1: Forest composition at UNDERC-East in Land O'Lakes, Wisconsin. The Hemlock stand assessed in this study (light grey) is found by Crampton Lake in the southeast section of UNDERC-East. Map created by Bethany Blakely, University of Notre Dame.

Wind and fire are historically the most common forms of disturbance in the Northwoods (Frelich and Reich 1995a, Janowiak et. al 2014). Wind disturbance events are responsible for influencing the canopy structure and creating light gaps within a mature forest (Frelich and Reich 1995a, White and Host 2008). Fire, though once a common component of Northwoods disturbance regimes, has become effectively extirpated from the Northwoods. Since 1910 the frequency of regional fires has been dramatically reduced by anthropogenic intervention (Schulte and Mladenoff 2005, Heinselman 1973). Studies estimate that pre-European settlement natural and native inhabitant driven fire disturbance regimes

included stand-killing fires on a rotation of 50 to 100 years, whereas modern research estimates the rotation period between such fires is now 500 to 1000 years (Heinselman 1973). Unlike wind, fire does destroy understory seedlings and therefore can affect species composition (Davis 1996). After a fire disturbance event, the ability for a forest stand to retain the pre-fire species composition is referred to as compositional stability, or compositional "memory" (Frelich and Reich 1995). Hardwood-hemlock and White pine forests show relatively weak species compositional stability and therefore experience more compositional changes following fire disturbance (Frelich and Reich 1995a). The presence of a near-monotypic *T. canadensis* forest on UNDERC's property indicates a lack of stand-killing fire disturbance since establishment, which would encourage a polytypic canopy. Therefore, it is assumed that observing disturbance regimes through tree dating is analogous to observing non-stand replacing windfall events throughout the history of the *T. canadensis* forest. Wind gap-creating disturbance events, which remove old trees and promote understory tree growth, are important drivers of vegetation composition in forest ecosystems worldwide (Attiwill 1994, Janowiak et. al 2014).

The Northwoods and many other Eastern forest systems experience large scale fragmentation due to anthropogenic land use. Habitat fragmentation is one of the main contributors to native species loss and compromises many natural ecosystem processes including natural disturbance regimes (Wilcox and Murphy 1985). Small remnants of fragmented native forests are driven primarily by external (i.e. anthropogenic land use, pollution), not internal, factors (i.e. static disturbance regimes, decomposition; Saunders et al. 1991). These fragmented forested landscapes are more susceptible to external factors leading to increased ecological degradation and exotic invasion resulting in dynamic shifts in disturbance regime (Heilman et al. 2002, Rejmánek 1919). Disturbance regimes on a local site scale are not well understood, as a vast majority of research is done on forest or regional scales. However, understanding the localized disturbance regimes is critical for continued management of species diversity and old-growth characteristics within fragmented forest systems. At UNDERC, disturbance regime specificity within the *T. canadensis* forest may exist due to topography. Specifically, site specific disturbances may be determined by changes in elevation sheltering or exposure within *T. canadensis* plots to the predominant disturbance factor—wind. Fetch, a measure of the distance that wind has to pick up speed over water, was used in this study to test sites with potentially differential wind regimes. The presence of disturbance regime site specificity within UNDERC's *T. canadensis* forests would suggest that these monotypic forest systems have site specific responses to altered wind conditions prevalent in fragmented forests.

Climate change

Climate change also drives ecological shifts in forest ecosystems. As the climate warms, weather patterns become more unpredictable and violent, creating more windstorms with the potential to induce disturbance (Dale 2001). Extreme precipitation and temperature deviation from median values are known to predict understory disturbances, but the data are inconclusive on overstory disturbance dynamics (Elliot and Root 2006). Since disturbance regimes in the Northwoods are important drivers of forest composition and succession, any changes in disturbance frequency or intensity could have consequences for future forest composition. Therefore, understanding the forest disturbance structure and the impacts of climate change on disturbance in the Northwoods provides insight

into the health and resiliency of this important ecosystem. As our climate continues to rapidly change, a history of disturbance incidence will become crucial to understanding modern forest systems.

Dendrochronology

A chronological timeline of disturbance events can be recorded through analysis of tree rings (Frelich 1995a). Increment boring, a common dendrochronological tool, allows the collection of tree cores with minimal damage to the tree (Stokes and Smiley 1968). Analyzing growth patterns in tree rings reveals periods of stagnation followed by rapid growth, called releases, where a tree responded to a sudden increase in light and resource availability (Stokes and Smiley 1968). A release response is indictive of large increases in resource (light) availability, which in Eastern forests is typically created through windfall disturbance events.

This study constructed a timeline of release events throughout the history of an old growth *T. canadensis* forest on UNDERC property using tree cores from five sites, cross dating, and comparing stand density characteristics. Sites were selected for heterogeneity in microtopography. Once constructed, this timeline was used to assess the size and intensity of release events within each microtopographic area. Furthermore, local climate data (yearly precipitation and temperature) were compared with the resulting disturbance timeline. I addressed the following questions: 1) Are disturbance regimes in the *T. canadensis* forest of UNDERC forest level or site specific? 2) If disturbance regimes are site specific, is stand location a predictor of disturbance frequency? 3) Do site characteristics such as density and diameter at breast height (DBH) influence disturbance regimes? I hypothesized that disturbance regimes are site specific within the *T. canadensis* forest and that stand location influences disturbance frequency. Specifically, I expected lowland habitat within the *T. canadensis* forest topography to sustain both more frequent and larger disturbances compared to the interior and sheltered sites. I additionally hypothesized that sites with high tree density and large tree diameter experienced more frequent and more intense disturbance regime patterns.

METHODS

Experimental procedure

Field core collection

Five plots within the *T. canadensis* forest stand east of Crampton Lake were chosen on UNDERC-East property in Land O' Lakes, Wisconsin. The *T. canadensis* plots at UNDERC were located in the southeastern corner of the property and are not accessible by road **(Figure 2)**. Each plot met one of the following criteria: wind exposed forest-lake edge (LOW), wind protected forest-lake edge (EDS), forest interior (INT), forest-forest edge (FFE), or forest ridge (RID; Figure 3). All trees at each plot within a 10 m radius were measured for diameter at breast height (DBH) and distance to plot center. Additionally, all *T. canadensis* trees over 15 cm DBH within the 10 m radius were cored using a Haglof Increment Borer. Each *T. canadensis* cored was numbered and tagged using aluminum nails and tree tags. Cores were secured in straws and returned to the lab for analysis. GPS coordinates were recorded at each plot center. Site maps were created using ArcGIS (ESRI 2011).

Core preparation, mounting, and scanning
Once returned to the lab, cores were dried for forty-eight hours in a 50°C oven and mounted onto wood panels. Each core was hand sanded to a high polish in accordance with standard dendrochronological procedures using 100, 200, 320, 400, and 600 grit sandpaper (Black and Abrams 2003, Nagel et. al 2007, Stokes and Smiley 1968, Spletchna 2005). Each core was visually cross dated and scanned by an HP Scanjet G3110 into a .jpg file at 1200 dpi. Once scanned, the distances between rings in each core were transformed into a .pos file using CooRecorder and saved as a .rwl file using CDendro (Cybis Elektronik 2010). Digital cross dating using COFECHA was performed to recheck dating sequences as previously described (Grissino-Mayer 2001). Problems in core dating were solved using CooRecorder until correlation values for each site reached ecologically acceptable levels (>0.5; Cybis Elektronik 2010). Cores with persistent dating problems were omitted to ensure consistent dating across all analyzed cores.

Site descriptions and sample size
The 107 trees cored were split between the sites as follows: RID = 22, LOW = 29, EDS = 21, INT = 26, and FFE = 13 **(Figure 2)**. Of these trees, 31 were omitted due to COFECHA identified errors split between the sites as follow: RID = 9, LOW = 9, EDS = 8, INT = 4, and FFE = 2. Final sample size for data analysis was 76 trees. I had trouble hitting the pith in some trees due to natural pith decay. In some cases when approaching the pith, the core lost its rigidity and became unreadable due to this decay. Therefore, whereas some entire site records date to the late 1790s, the confidently cross-dated section of the records collected in this study only date back to the late 1800s or early 1900s.

Site analyses
Ridge (RID)
Ridge was selected due to its relatively high elevation. The RID site is situated on top of a small plateau met by steep declines to Crampton Lake on the West, North, and East edge and a steep decline to the forest interior on the Southern edge. Of the initial 22 ridge tree cores, nine were omitted due to persistent dating problems for a final sample size of 13 cores (series intercorrelation = 0.692). The 1,709 tree rings were cross dated back to 1820. The mean core age was 132.0 years.

Exposed Lowland Edge (LOW)
This low exposed edge was chosen due to its low elevation and western exposure to wind off Crampton Lake. Of the initial 29 low tree cores, nine were omitted due to persistent dating problems for a final sample size of 20 cores (series intercorrelation = 0.583). The 2,346 tree rings were cross dated back to 1850. The mean core age was 102.0 years.

Protected Forest Edge (EDS)
This protected edge was chosen due to its proximity to Crampton Lake to mirror LOW. Unlike LOW, EDS was protected from predominant winds due to a western elevation increase. Of the initial 21 protected forest edge tree cores, eight were omitted due to persistent dating problems for a final sample size of 13 cores (series intercorrelation = 0.572). The 1,529 tree rings were cross dated back to 1830. The mean core age was 109.0 years.
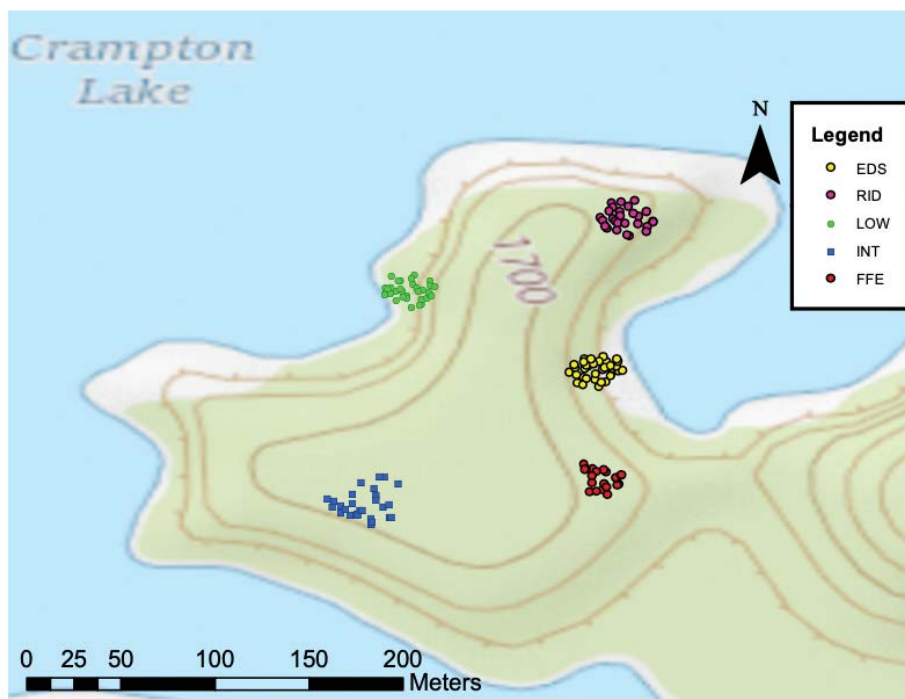
Figure 2: Distribution and classification of hemlock stand sites at UNDERC-East. Figure shows coring sites on topographic map. LOW site chosen for exposure to prevailing wind fetch. EDS site protected from prevailing winds by microtopography. INT site protected from prevailing winds by surrounding trees. RID site moderately protected by trees, but moderately exposed due to microtopography. FFE site selected at protected edge of hemlock stand. Map created in ArcGIS.

Interior (INT)

The interior site was chosen due to its distance from any edge. Of the initial 26 interior tree cores, four were omitted due to persistent dating problems for a final sample size of 22 cores (series intercorrelation = 0.635). The 1,060 tree rings were cross dated back to 1860. The mean core age was 61.0 years.

Forest-Forest Edge (FFE)

This forest-forest edge site was chosen due to its location on the transition boundary from monotypic Tsuga canadensis forest to a polytypic mixed hardwood forest. Of the initial 13 forest-forest edge tree cores, two were omitted due to persistent dating problems for a final sample size of 11 cores (series intercorrelation = 0.547). The 778 tree rings were cross dated back to 1900. The mean core age was 70.0 years.

Statistical analysis

Release events were identified from ring width data (.rwl outputs from CDendro) for each site using RStudio 1.1 and the TRADER package (RStudio Team 2015, Altman et al. 2014). Release events were based on growth averaging methods (Nowacki and Abrams 1997). Moderate and severe release events were defined as >50% growth increase and >90% growth increase; respectively. All release events must have met growth increase criteria for five consecutive years, and releases were limited to one per five-year span to limit false positive results.

Intensity of release per site was calculated from the means of percent growth increase from each disturbance of each site. These datasets failed the Shapiro-Wilk normality test (W=0.943, p=0.003) and were therefore analyzed using a Kruskal-Wallis rank sum test. Post-hoc analysis was completed using Dunn's Test, a non-parametric pairwise multiple comparison procedure based on rank sums.

Proportion of trees with release events per disturbance by site were calculated by dividing the number of trees releasing per disturbance by the total number of core records in that year. These datasets also failed the Shapiro-Wilk normality test (W=.80495, p=5.621e-09). However, parametric analysis was possible after log10 transformation (Shapiro-Wilk, W=.96775, p=0.0388). A one-way ANOVA allowed analysis of the transformed data, and post-hoc analysis was completed using Tukey's Honestly Significant Difference (HSD) analysis.

Diameter at breast height per site was analyzed using a one-way ANOVA, with post-hoc analysis completed using Tukey's HSD analysis. In all cases, $p < 0.05$ was considered statistically significant.

RESULTS

In analyzing the disturbance intensity, and therefore heterogeneity, I found clear variance. These data are nonparametric and analyzed via the Dunn post-hoc test for nonparametric data (Kruskal-Wallis, $\chi2$=33.4, df=4, p=9.89e-07). The intensity of release at individual sites was significantly higher at LOW than EDS; z=-3.743, p=0.0015; FFE; z=4.145, p=0.0003; and RID; z=3.987, p=0.0006; **(Figure 3)**.

T. canadensis disturbance proportion, another measure of heterogeneity, also showed clear variance. These data are parametric and were therefore analyzed using a one-way ANOVA; df=4, F=4.02, p=0.0519. The proportion of trees with detectable release events per disturbance was significantly lower at LOW than EDS; Tukey HSD p=0.0269; and FFE; Tukey HSD p=0.0264; **(Figure 4)**.

Diameter at breast height (DBH), measured for consistency across the five sites, showed variance between two sites. These data were parametric in nature, and therefore analyzed using a one-way ANOVA; df=4, F=675.9 p=0.0023. Diameter at breast height (DBH) was significantly lower at EDS than INT; Tukey HSD p=0.0009 **(Figure 5)**.

DISCUSSION

There are differences in disturbance intensity, frequency, and size across *T. canadensis* forest sites at Crampton Lake. The evidence supports the hypothesis that disturbance regimes in monotypic *T. canadensis* forests are site specific and vary over forest topography. Previous research suggests that information on disturbance regimes in individual forests is necessary for both scientific study and land management (Lorimer and Frelich 1989). However, data presented here suggest that scientific study and land management should account for disturbance intensity, frequency, and size fluctuation throughout a smaller ecological scale.
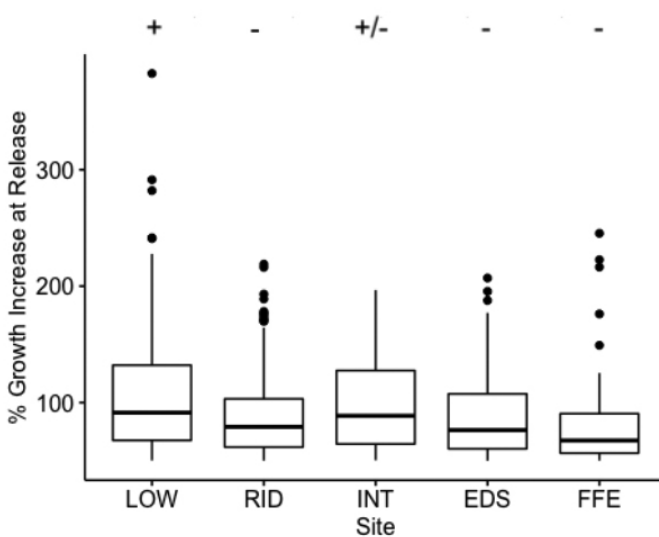
Figure 3: Differences in *T. canadensis* release intensity measured by percent growth increase. Results of Kruskal-Wallis nonparametric analysis reveal a significant difference between the intensity of release at LOW, EDS, FFE, and RID. Kruskal-Wallis: $\chi2$=33.4, df=4, p=9.89e-07; Dunn's Test, LOW-EDS p=0.0015, LOW-FFE p=0.0003, LOW-RID p=0.0006. Bars with different symbology (+, -) are statistically different.
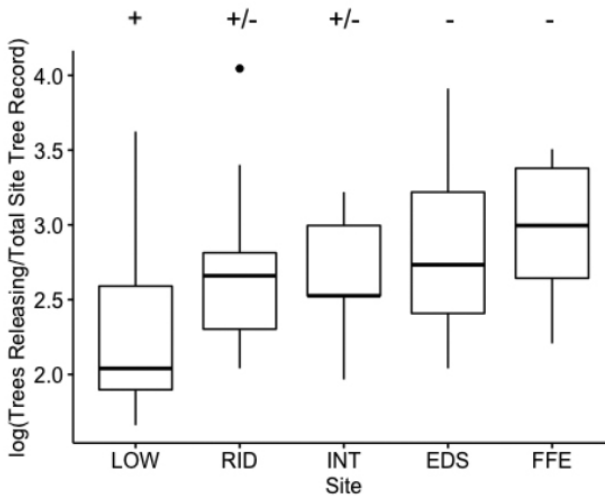
Figure 4: Differences in proportion of *T. canadensis* releasing at each site (log proportion). Log transformed results of one-way ANOVA reveal a significant difference between the proportion of trees that release at LOW, EDS, and FFE. 1-Way ANOVA, df=4, F=4.02, p=0.0519; Tukey HSD, LOW-EDS p=0.0269, LOW-FFE p=0.0264. Bars with different symbology (+, -) are statistically different.
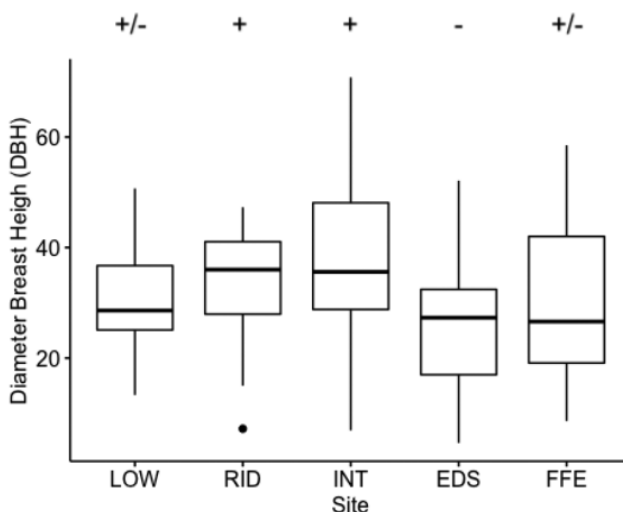
Figure 5: Differences in *T. canadensis* diameter at breast height at each site (diameter, cm). Results of one-way ANOVA reveal significant differences between DBH at INT and EDS; 1-Way ANOVA, df=4, F=675.9, p=0.0023; Tukey HSD, INT-EDS p=0.0009. Though significant, these results are not consistent with disturbance size and intensity data that suggests that DBH variance was not a significant factor in the disturbance study. Bars with different symbology (+, -) are statistically different.

The high intensity of release at LOW compared to EDS, FFE, and RID suggests that site location plays an important role in disturbance regimes (Figure 3). Stronger intensity release events may represent large gap sizes. Larger gaps allow more light to penetrate to understory branches of canopy trees and dramatically increase light availability to understory flora. Therefore, I would expect, due to the comparatively high intensity of releases at LOW, that disturbances on the exposed edge create relatively larger gaps. However, disturbance records appear in a proportionally lower number of cores at the exposed edge (LOW; mean: 11.2%) than the sheltered edge (EDS; mean: 18.4%) and forest-forest edge (FFE; mean: 21.3%) sites (Figure 4). The enigmatic suggestion from these data is that release events detected in tree growth at the exposed edges were large releases, but not very common across trees. It is possible that there is a response within *T. canadensis* that accounts for the mismatched disturbance size and release intensity results.

The disturbance size record suggests that there may be a differential response to light availability in *T. canadensis*. When presented with a moderate increase in light from a small gap, *T. canadensis* may respond by focusing growth in the apical meristem to reach higher where more light is available. Additionally, when presented with open canopy light availability *T. canadensis* may focus more energy into branch and needle development, allocation strategies which are both less visible in the core record than stem allocation. Previous research suggests that this life history strategy, first documented in Acer and Betula spp., may exist in *T. canadensis* saplings (Logan 1965, Vasiliauskas and Aarssen 2000). However, this is the first time it has been documented in mature *T. canadensis* within an unmanaged forest. Differential growth strategies in *T. canadensis* are not yet well understood. Further study into these strategies could document *T. canadensis* in gap environments and attempt to quantify the ideal light conditions for *T. canadensis* regeneration. Additionally, comparing direct observation on growth strategy to tree ring analysis would provide insight into the accuracy of post-gap determination of release intensity and disturbance size. This differential response, supported by my results, offers a plausible explanation as to why high intensity release events align with a proportionally smaller disturbance event.

Another possibility is that young, understory *T. canadensis* trees may simply not be successful under direct light conditions. Adapting to shade-tolerance may come with the trade-off of direct light productivity. The specific adaptation strategy of *T. canadensis* is unclear and understanding this complex physiological response will require more study. Furthermore, this study focused on one *T. canadensis* forest. Further study should include comparisons between *T. canadensis* forests across similar regions to determine if evidence presented here is indicative of all *T. canadensis* forests or unique to the UNDERC-East forest.

Diameter at breast height (DBH) also differs significantly across the sites (**Figure 5**). The interior sites, INT (mean: 27.8) and RID (mean: 33.4), have significantly larger trees than the sheltered edge (EDS; mean: 25.2) I expected DBH to inversely correlate with site density. Larger trees with a wider diameter leave less room for competition. RID

(26 trees/10 m rad.) and INT (27 trees/10 m rad.) are slightly less dense than EDS (36 trees/10 m rad.), which supported the hypothesis. However, it is important to note that only one plot for each of these categories was measured. A larger sample size is necessary to increase confidence in this relationship.

It must be noted that each site had cores removed due to persistent dating problems. In these cases, even after software analysis using CooRecorder and COFECHA there was a low confidence value that these cores aligned with the forest's historical record. There are three reasons why dating problems persisted in this study: resolution, false rings, and natural decay. Resolution, or the detail within the finalized core scans, was 400 dpi. This means that for years with particularly small rings it was difficult to define, or resolve, such a small ring growth. False rings, which are rings created by a tree in response to abrupt environmental shifts such as a cold spike or insect infestation, are identical to typical seasonal rings and could have skewed core interpretation if not properly identified. Finally, cores with natural decay were moist and often could not be sanded leading to assumptions of ring presence and width. These three complications could have contributed to a cascade of inaccurate dating potentially resulting in a cross dated core with a low confidence value. Since there was no pattern detected in the location or size of these problematic cores they were removed from the final record in accordance with established dendrochronological procedure (Black and Abrams 2003).

As forests become more fragmented, understanding disturbance on a localized, site level is critical. Rapid changes in forest morphology due to anthropogenic interactions likely have large effects on the disturbance regime and therefore forest structure. Additionally, growth strategies and disturbance regimes may differ across forests with various aging structures. Understanding the importance of age structure on disturbance regime could provide insight into the negative impacts of fragmentation and how to manage *T. canadensis* ecosystems.

Documenting disturbance regime is a daunting task. This research offered evidence that disturbance regimes are localized to specific geomorphic regions within a *T. canadensis* forest. These specific geomorphic regions interact with differential growth strategies of *T. canadensis* to shape the overall forest morphology. Documenting these site, disturbance, and tree interactions is critical for any ecologist or management officer looking to preserve old-growth characteristics of a *T. canadensis* forest. This study suggests that assuming a homogenous forest disturbance structure is an unrealistic management practice. Managing a forest based on the assumption of disturbance homogony may have adverse consequences for areas of the forest with unique disturbance regimes— decreasing productivity, biodiversity, and sustainability. As the Northwoods continues to be fragmented, it can be expected that disturbance regimes will change rapidly and unpredictably in conjunction with topography, climate, and anthropogenic land use. The destabilization of fragile, localized disturbance regimes will have numerous detrimental effects on ecosystem functions.

REFERENCES

Altman, J., Fibich, P., Dolezal, J., and Aakala, T. 2014. TRADER: A package for tree ring analysis of disturbance events in R. *Dendrochronologia*. 32(2), 107-112.

Attiwill, P. M. 1994. The disturbance of forest ecosystems: The ecological basis for conservative management. *Forest Ecology and Management*. 63: 47-300.

Black B.A. and Abrams M.D. 2003. Use of boundary-line growth patterns as a basis for dendroecological release criteria. *Ecological Applications*. 13: 1733–1749.

Briffa, K. R., Schweingruber, F. H., Jones, P. D., Osborn, T. J., Shiyatov, S. G., and Vaganow, E. A. 1998. Reduced sensitivity of recent tree-growth to temperature at high northern latitudes. *Nature* 391:678-682.

Canham, C.D. and Loucks, O.L. 1984. Catastrophic windthrow in the presettlement forests of Wisconsin. *Ecology*. 65(3): 803-809.

Cleland, D. T., Avers, P. E., McNab, H., Jensen, M. E., Bailey, R. G., King, T., and Russell, W. E. 1997. National Hierarchy of Ecological Units. Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources. 181-200

Cybis Elektronik, 2010. CDendro and CooRecorder., http://www.cybis.se/forfun/dendro/index.htm.

Dale, V.H., Joyce, L. A., McNulty, S., Neilson, R. P., Ayres, M. P., Flannigan, M. D., Hanson, P. J., Irland, L. C., Lugo, A. E., Peterson, C. J., Simberloff, D., Swanson, F. J., Stocks, B. J., and Wotton, M. 2001. Climate Change and Forest Disturbances: Climate change can affect forests by altering the frequency, intensity, duration, and timing of fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides, *BioScience*, 51(9):723–734.

Davis, M. B. 1996. Disturbance and Succession in Northern Hardwood-Hemlock Forest. *Eastern Old-Growth Forests: Prospects for Rediscovery and Recovery*. 148-150.

ESRI 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute.

Frelich, L. E., and Lorimer, C. G. 1991. Natural Disturbance Regimes in Hemlock-Hardwood Forests of the Upper Great Lakes Region. *Ecological Monographs*. 61(2): 145-164.

Frelich, L.E. and Reich, P.B. 1995a. Neighborhood effects, disturbance, and succession in forests of the western Great-Lakes Region. *Ecoscience*. 2(2): 148-158.

Grissino-Mayer, H.D. 2001. Evaluating crossdating accuracy: A manual and tutorial for the computer program COFECHA. *Tree-Ring Research*. 57(2):205-221.

Gustafson, E., and Sturtevant, B. 2013. Modeling Forest Mortality Caused by Drought Stress: Implications for Climate Change. *Ecosystems*. 16.

Hartshorn, G.S. 1980. Neotropical Forest Dynamics. *Biotropica*. 12(2): 23-30.

Heilman, G. E., Strittholt, J. R., Slosser, N. C., Dellasala, D. A. 2002. Forest fragmentation of the conterminous United States: Assessing forest intactness through road density and spatial characteristics. *BioScience*. 52(5):411-422

Heinselman, M. L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. *Quaternary Research*. 3: 329-382.

Janowiak, M. K., Iverson, L. R., Mladenoff, D. J., Peters, E., Wythers, K. R., Xi, W., Brandt, L. A., Butler, P. R., Handler, S. D., Shannon, P. D., Swanston, C., Parker, L. R., Amman, A. J., Bogaczyk, N., Handler, C., Lesch, E., Reich, P. B., Matthews, S., Peters, M., Prasad, A., Khanal, S., Liu, F., Bal, T., Bronson, D., Burton, A., Ferris, J., Fosgitt, J., Hagan, S., Johnston, E., Kane, E., Matula, C., O'Connor, R., Higgins, D., St. Pierre, M., Daley, J., Davenport, M., Emery, M. R., Fehringer, D., Hoving, C. L., Johnson, G., Neitzel, D., Notaro, M., Rissman, A., Rittenhouse, C., and Ziel, R. 2014. Forest ecosystem vulnerability assessment and synthesis for northern Wisconsin and western Upper Michigan: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-136. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 247.

Logan. K. T. 1965. Growth of tree seedlings as affected by light intensity. Department of Forestry Publication. 47-1121.

Lorimer, C.G., and Frelich, L. E. 1989. A methodology for estimating canopy disturbance frequency and intensity in dense temperate forests. *Canadian Journal of Forest Research*. 19: 651-663.

McNab, W.H., Cleland, D.T., Freeouf, J.A., Keys, J.E., Nowacki, G.J., and Carpenter, C.A. 2007. Description of ecological subregions: sections of the conterminous United States. Gen. Tech. Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80.

Nagel, T. A., Levanic, T., and Diaci, J. 2007. A dendroecological reconstruction of disturbance in an old-growth Fagus-Abies forest in Slovenia. *Annals of Forestry Science*. 64: 91-897.

Nowacki, G. J. and Abrams, M. D. 1997. Radial-growth averaging criteria for reconstructing disturbance histories from presettlement-origin oaks. *Ecological Monographs*. 67(2):225- 249.

Rejmánek, M. 1989. Invasibility of plant communities. Pages 369-388. In Drake J. A. et al. *Biological Invasions: A Global Perspective*. New York: John Wiley and Sons.

Rooney, T. P., and Waller, D. M. 2008. Plant Species Diversity in the Once and Future Northwoods. *The Vanishing Present: Wisconsin's Changing Lands, Waters and Wildlife*, 75-90.

RStudio Team 2015. RStudio: Integrated Development for R. RStudio, Inc. http://www.rstudio.com/.

Saunders, D. A., Hobbs R. J., and Margules, C. R. 1991. Biological consequences of ecosystem fragmentation: a review. *Conservation Biology*. 5:18-32.

Schulte, L. A., and Mladenoff, D. J. 2005. Severe wind and fire regimes in Northern Forests: Historical variability at the regional scale. *Ecology*. 86(2):431-445.

Splechtna, B. E. and Gratzer G. 2005. Natural disturbances in Central European forests: approaches and preliminary results from Rothwald, Austria. *Forest Snow and Landscape Research*. 79:57-67.

Stokes, M. A. and Smiley T.L. 1968. *An introduction to tree-ring dating*. University of Chicago Press.

Vasiliauska, S. A. and Aarssen, L. W. 2000. The effects of moose (Alces alces L.) on Hemlock (Tsuga canadensis (L.)Carr.) seedling establishment in Algonquin Provincial Park, Ontario, Canada. U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 148-153.

White, P.S. and Pickett, S. T. A. 1985. Natural disturbance and patch dynamics, an introduction. *Academic Press*. 3-13.

Wilcox, B. A., Murphy, D.D. 1985. *Conservation strategy: the effects of fragmentation on extinction*. *American Naturalist*. 125:879-887.

Yamamoto, SI. 1992. The Gap Theory in Forest Dynamics. *Botany Magazine*. 105:375-383.

The Relationship between Black Coffee Consumption and Weight Status

Amy Kaczor

ACKNOWLEDGEMENTS

ABSTRACT

Learning outcome
To understand the relationship between the amount of black coffee consumed and Body Mass Index (BMI) in individuals 18 years and older.

Background
Researchers have debated the relationship between weight status and coffee consumption with conflicting results. Lee, Kim, & Kim (2017) found a positive trend exists between the amount of coffee consumed and BMI. Conversely, Grosso et al. (2015) found an inverse trend between coffee consumption and BMI.

Methods
Quantitative design was used. A researcher constructed questionnaire was piloted through SNAP Survey at a small Midwestern university receiving 939 complete responses. Three questions were included on the pilot study questionnaire soliciting feedback regarding question wording, ordering, and comprehension. The questionnaire was revised for validity and clarity. The revised questionnaire for the main study was administered through Amazon Mechanical Turk. Fifty-seven complete questionnaires were received. Eighty-four participants from the pilot study who reported only black coffee consumption were included in the main study data analysis. The two samples were combined to increase statistical power (n=141). BMI (kg/m2) was calculated for each participant.

Results
An ANCOVA was performed to examine the relationship between BMI and black coffee consumption (oz.) per day (scale was 4 oz. to 40 oz.). The results showed no correlation between the two variables, $F(1, 138)= 0.65, p < 0.001$. Unlike the previous studies, this quantitative study controlled for additives (such as cream, sugar, and milk) as confounding factors so that the relationship between black coffee and weight status were studied solely.

Conclusions
Amount (ranging from ½ to 5 cups) of black coffee consumed per day was not correlated to BMI in this sample of adults.

Keywords: coffee, Body Mass Index, black coffee, weight status

INTRODUCTION

Coffee is one of the most consumed beverages worldwide. In an analysis of the responses from 22,513 adults from the National Health and Nutrition Examination Survey (NHANES) from 2003 to 2012, researchers found that 52.8% of participants consumed coffee (defined as caffeinated coffee, decaffeinated coffee, or coffee substitutes) (An, 2016).

Obesity is defined as having a Body Mass Index of 30 or higher, which puts an individual at greater risk for chronic disease states such as diabetes mellitus, cardiovascular

disease, and some cancers. Per the Centers for Disease Control and Prevention (2018), 39.8% of U.S. adults in 2015-2016 are obese. Therefore, about 93.3 million adults in the United States are considered obese and at risk for major health conditions.

Coffee and energy intake

An (2016) examined the correlation between coffee consumption and changes in energy intake. Based on the NHANES data from 2003 to 2012, coffee consumption was associated with an, on average, 108 kcal increase in total energy intake per day. More specifically, the consumption of coffee was related to a 60.7 kcal increase in daily energy intake of energy-dense, nutrient-poor foods. This number was highest among young and middle-aged adults (An). In other words, individuals who consumed coffee were more likely to also consume foods high in calories and low in nutrition.

Additionally, researchers have found a statistically significant difference between energy intake changes in normal-weight and overweight/obese individuals (Gavrieli et al., 2013). In normal-weight individuals, coffee consumption amount is not statistically significantly associated with a change in dietary intake or appetite (Gavrieli et al.). In overweight and obese individuals, moderate coffee consumption (1 cup) is associated with lower calorie consumption in the next meal as well as lower calorie consumption for the rest of the day (Gavrieli et al.). That is to say that biological mechanisms in coffee could be related to decreased appetite, possibly resulting in weight loss.

The amount of coffee consumed also has an impact on daily energy intake. In a study conducted by Grosso et al. (2015) that analyzed the results of the Polish arm of the Health, Alcohol and Psychosocial factors in Eastern Europe (HAPIEE), individuals who consumed three or more cups of coffee per day were more likely to have a higher total energy intake than those who consumed fewer than three cups of coffee per day. Future research is required to determine causality for this association. Furthermore, the consumption of three or more cups of coffee per day is associated with a lower exercise rates in Korean women (Lee, Kim, & Kim, 2017). With exercise quantity closely associated with weight status, this association would further indicate that the consumption of three or more cups of coffee per day could be related to higher weight status. In a study conducted on mice, coffee consumption was positively associated with food intake (Rustenbeck et al., 2014). When applied to a human population, this could suggest that with a larger amount of coffee consumed, the calories consumed increases as does weight status.

Coffee and clinical indicators

Many studies (Cai, Ma, Zhang, Liu, & Wang, 2012; Cowan et al., 2014) have examined the relationship between coffee consumption and variables such as blood lipid value and blood pressure. In a meta-analysis of twelve studies with a total of 1017 participants, coffee consumption was correlated with an increase in total cholesterol, low-density lipoprotein cholesterol, and triglyceride levels. This effect was more pronounced in those who drank higher amounts of coffee (Cai et al.). This relationship has been debated due to conflicting results. In a study performed on rats fed a high-fat diet, coffee had a protective effect against liver triglycerides (Cowan et al.). This provides an opposing conclusion than in the study performed by Cai et al.

Coffee and weight change

Current research shows that regular consumption of coffee has been associated with decreases in body weight (Pan et al., 2013). Caffeine increases metabolic rates in humans, which could be responsible for some of the weight loss, but similar effects on weight have been observed in those who drink decaffeinated coffee, showing that other constituents of coffee could be responsible as well (Bakuradze et al., 2014). Following an intervention of Special Blend coffee that consisted of high amounts of roast products such as N-methylpyridinium and a small amount of light roast that is high in green bean constituents, body weight of participants was statistically significantly decreased. Body fat was decreased after an intervention of the Special Blend as well as after the intervention of the Market Blend (consisting of five commercially sold coffees, to represent the typical blend of coffee). Components of coffee such as chlorogenic acids and green coffee bean extracts may be responsible for stimulating metabolic rate (especially in the catabolism of internal body fat) (Bakuradze et al., 2014). In support of this finding, in a synthesis of three cohort studies on coffee intake and weight within a four-year period, researchers found that for each additional serving of coffee consumed per day, 0.14 kg of weight was lost (Pan et al., 2013).

Researchers (Cowan et al., 2014; Moy & McNay, 2013; Rustenbeck et al., 2014) have studied mice and rat populations to examine the relationship between coffee and weight changes more closely. Cowan et al. fed a group of rats a high-fat diet with a water treatment and another group a high-fat diet with a coffee treatment. Rats who were fed a high-fat diet in conjunction with the coffee treatment had less weight gain and body fat gain than those fed a high fat diet with the water treatment. In a similar study that focused on caffeine in coffee, Moy and McNay (2013) found that the consumption of caffeine by rats fed a high-fat diet eliminated the weight that the non-caffeinated rats gained from the same diet. A similar result can be seen in mice. Rustenbeck et al. examined the effect of high coffee consumption on weight gain in mice. They found that coffee eliminated the weight gain in the normal-fed mice but just decreased it (not eliminated completely) in the high-fat fed mice. In other words, the presence of caffeine in the animal's diet when fed a high-fat diet decreases the amount of resultant weight gain. This concept is a potential mechanism of coffee in a human population. Though the current study is not examining the fat levels in participants' diets, further research should be conducted to determine if this effect exists in coffee.

Coffee and weight status

Researchers (Fathi, Ahari, Amani, & Nikneghad, 2016; Kim & Park, 2017; Lee et al., 2017) often disagree on coffee's relationship to weight status. In a meta-analysis performed by Fardet and Boirie (2014), they concluded that high levels of coffee consumption are associated with an increased risk of obesity (especially in women). More specifically, individuals who consume three or more cups of coffee per day are at an even higher risk of obesity. Additionally, coffee consumption of four or more cups per day is associated with an increase in all-cause mortality and adverse health effects (Kim & Park). In the study by Fathi et al. in which researchers surveyed physicians in Ardabil City, they found that coffee intake is a risk factor for overweight and obesity. Lee et al. studied Korean women and found that a positive trend exists between the

amount of coffee consumed and BMI. The consumption of three or more cups of coffee was positively associated with a BMI of 30 or higher (indicative of obesity).

On the other hand, many researchers (Grosso et al., 2015; Mogre, Nyaba, & Aleyira, 2014) have found the opposite to be true. In the analysis of the results from the Polish arm of the HAPIEE study, Grosso et al. found a statistically significant inverse trend between coffee consumption and BMI. Also, Mogre et al. found that in the adult students from a university in Ghana, the refraining from drinking coffee increased the risk of both general and abdominal obesity.

Current study

Studies by Lee et al. (2017) have investigated the relationship between coffee consumption and the risk for obesity in a population of Korean female adults and found a positive correlation between coffee consumption with additives (such as sugar, cream, milk, etc.) and the occurrence of obesity in the participants, but the mechanism responsible for this relationship is still unknown. In the current study, the coffee additives as a confounding factor are eliminated so that black coffee and weight status can be studied solely. Additionally, the current study measured the amount of black coffee consumed in participants who consume only black coffee daily to further examine whether a statistically significant relationship exists between black coffee consumption and weight status.

Research hypothesis/research question

The purpose of the current study was to explore the relationship between daily black coffee consumption on weight status (through Body Mass Index). The current study was directed by the following research hypothesis and research question.

Null hypothesis: There is no relationship between the amount of black coffee consumed daily and an individual's BMI.

Alternative hypothesis: There is a relationship between the amount of black coffee consumed daily and an individual's BMI.

Research question 1: What is the relationship between the amount of black coffee consumed daily and an individual's BMI?

METHODS

A quantitative study was conducted in which the researcher collected data that included the amount of black coffee each participant consumed on an average day and week. Data was also collected that included participant self-reported age, weight, and height in order for the researcher to calculate BMI.

Pilot study

A researcher constructed survey was piloted to 939 participants recruited from the undergraduate student body at a private Christian university in the Midwest (see Appendix A). An email was sent campus wide. The online survey was administered through SNAP technology. Participants provided feedback on question ordering, wording, and

comprehension through three additional questions at the end of the research survey (see Appendix B). Based on feedback received, the survey was revised to improve clarity (see Appendix C). All participants received a link to the informed consent document. Once completed, participants were directed with a link to the survey tool on SNAP. Directions advised participants to read each question carefully. They answered questions that covered coffee consumption, weight, height, age, exercise, and demographical information (year in school, race, gender). The survey was estimated to take approximately five to ten minutes to complete.

Main study

One hundred participants were obtained from Amazon Mechanical Turk to take the revised survey. The study participants included only those who solely drink black coffee. An attention-check question was included that asked the participants to select a certain response to ensure they were accurately completing the questionnaire. The question read, "Please select '24 oz (3 cups)' below." If they did not select the correct response, they were screened out and their responses were disqualified. Additionally, if, based on the responses, the participant did not fit the qualifications of the study (solely drinking black coffee), their responses were disqualified. After removing the responses that did not solely drink black coffee or did not correctly answer the attention-check question, 57 participants remained.

DATA ANALYSIS

From the data collected for each participant's height and weight, a BMI value was calculated by dividing weight (in kilograms) by height (in meters) squared. This data was then run in the data analysis along with average amount of coffee consumed per day. Of the 939 participants in the pilot study, 84 reported that they consume only black coffee and were included into the analysis with the main study participants ($n = 84$ for the pilot study and $n = 57$ for the main study for a total of $n = 141$).

An ANCOVA was run with ounces of black coffee and sample type (pilot study or main study) as predictors to examine the relationship between Body Mass Index (kg/m2) and ounces of black coffee consumption per day. For responses of "Less than 8 oz. (1 cup)" black coffee consumed per day, a value of four ounces was used in the calculation. For responses of "Greater than 32 oz. (4 cups)" black coffee consumed per day, a value of 40 ounces was used in the ANCOVA.

RESULTS

The results showed no correlation between the ounces of black coffee consumed per day and body mass index, $F(1, 138) = 0.65$, $p < 0.001$. A scatterplot summarizes these results (**Figure 1**). Overall, ounces of black coffee consumed per day is not a statistically significant predictor of BMI in adults.

Additionally, an effect of the sample type (pilot study or main study) was found, $F(1,138) = 17.05$, $p < 0.001$. In other words, the two samples had statistically significant differences between them. Specifically, the pilot sample had a lower average BMI ($M = 23.93$, $SE = 0.58$) compared to the main sample ($M = 27.68$, $SE = 0.702$).
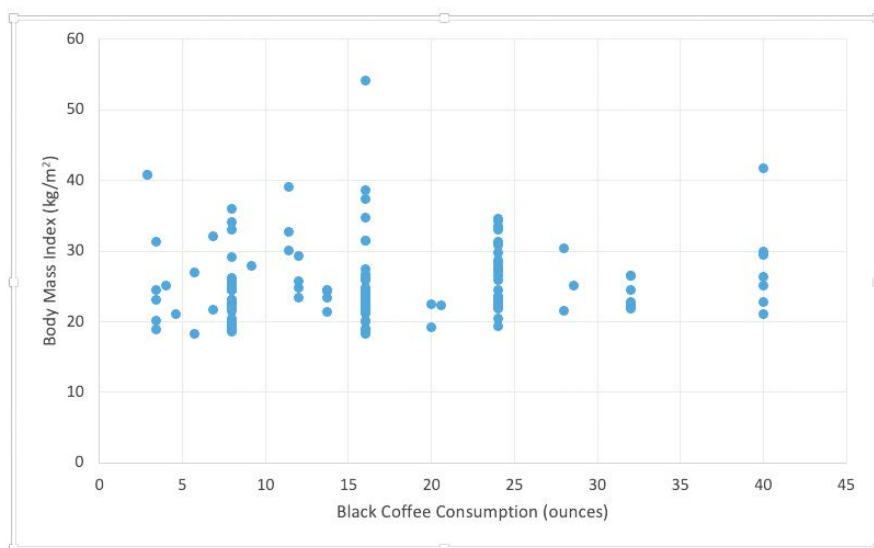
Figure 1: Scatterplot of black coffee consumption and Body Mass Index. There is no relationship between the amount of black coffee consumed and weight status (n=141). This figure includes results from the pilot study and the main study

DISCUSSION

The current study was directed by the following research hypothesis and research question:

Null hypothesis: There is no relationship between the amount of black coffee consumed daily and an individual's BMI.

Alternative hypothesis: There is a relationship between the amount of black coffee consumed daily and an individual's BMI.

Research question 1. What is the relationship between the amount of black coffee consumed daily and an individual's BMI?

The purpose of this study was to examine the relationship between black coffee consumption and weight status in an adult population. The main conclusion of this study is that there is no statistically significant relationship between the amount of black coffee consumed and weight status as measured by Body Mass Index. This is particularly interesting due to the strong correlations found in previous studies such as those by Fathi et al. (2016) and Lee et al. (2017). Though a meta-analysis performed Fardet and Boirie (2014) of all coffee consumption studies stated that high levels of coffee consumption are associated with increased risk of obesity, there are studies that show just the opposite, such as those by Grosso et al. (2015) and Mogre et al. (2014).

Data collection and analysis for the current study leads the researcher to fail to reject the null hypothesis. To answer the research question, there was no relationship found between the amount of black coffee consumed daily and an individuals' BMI.

A strength of the current study is the isolation of black coffee as a variable rather than combining black coffee drinkers with coffee drinkers who also consume coffee with additives (such as cream, sugar, or milk). Previous research does not specify the type of coffee that is consumed or whether additives are present. The current study eliminated coffee additives as a confounding variable to weight status to show that, while prior research suggests a relationship exists between coffee consumption and weight status, no statistically significant relationship exists between specifically black coffee consumption and weight status in the population studied. This further suggests that the coffee additives may play a large role in accounting for the relationship to weight status.

The current study was limited by the sample size. While the study began with one hundred participants through Amazon Mechanical Turk, twenty-one responses were eliminated because the participant reported to drink the black coffee less than seven days a week, one response was eliminated because the participant failed to correctly answer the attention-check question, and forty-two responses were eliminated because the participant reported to either sometimes or always drink coffee with additives (such as cream, sugar, etc.) or because the participant did not fully or correctly answer the questionnaire (i.e., putting height in feet and inches instead of inches like instructed). After all the invalid responses were eliminated, a sample size of fifty-seven remained. I recommend repeating this study with a larger sample size, enabling the results to be more adequately generalized.

Additionally, a limitation of the current study was the self-reported nature of the data collected. In the current study, all information, including height, weight, and coffee consumption, was collected through an online survey. Therefore, the data relies on the accuracy of the information self-provided by the participant. Specifically, the height and weight are variables that the participant could have estimated so I suggest repeating this study with a laboratory-measured height and weight to increase the accuracy of the data collected.

The current study adds to the body of knowledge that black coffee consumption may not be associated directly or inversely with weight status. Further research should be conducted to determine the extent to which coffee additives impact weight status in comparison to black coffee. Also, further research could be done to determine factors that influence coffee intake and the effect of daily coffee consumption versus coffee consumption less than seven days a week.

REFERENCES

An, R. (2016). "Beverage consumption in relation to discretionary food intake and diet quality among US adults, 2003 to 2012," *Journal of the Academy of Nutrition and Dietetics*, 116(1), 28-37. doi:10.1016/j.jand.2015.08.009

Bakuradze, T., Parra, G. A. M., Riedel, A., Somoza, V., Lang, R., Dieminger, N., . . . Richling, E. (2014). "Four-week coffee consumption affects energy intake, satiety regulation, body fat, and protects DNA integrity," *Food Research International*, 63, 420-427. doi:10.1016/j.foodres.2014.05.032

Cai, L., Ma, D., Zhang, Y., Liu, Z., & Wang, P. (2012). "The effect of coffee consumption on serum lipids: A meta-analysis of randomized controlled trials," *European Journal of Clinical Nutrition*, 66, 872-877. doi:10.1038/ejcn.2012.68

Centers for Disease Control and Prevention (2018). "Adult obesity facts." Retrieved from https://www.cdc.gov/obesity/data/adult.html

Cowan, T. E., Palmnäs, M. S. A., Yang, J., Bomhof, M. R., Ardell, K. L., Reimer, R. A., . . . Shearer, J. (2014). "Chronic coffee consumption in the diet-induced obese rat: impact on gut microbiota and serum metabolomics," *Journal of Nutritional Biochemistry*, 25, 489-495. doi:10.1016/j.jnutbio.2013.12.009

Fardet, A., & Boirie, Y. (2014). "Associations between food and beverage groups and major diet-related chronic diseases: an exhaustive review of pooled/meta-analyses and systematic reviews," *Nutrition Reviews*, 72(12), 741-762. doi:10.1111/nure.12153

Fathi, A., Ahari, S. S., Amani, F., & Nikneghad, M. R. (2016). "Study frequency of hypertension and obesity and their relationship with lifestyle factors (nutritional habits, physical activity, cigarette consumption) in Ardabil city physicians, 2012-2013," *Indian Journal of Community Medicine*, 41. 268-272. doi:10.4103/0970-0218.193332

Gavrieli, A., Karfopoulou, E., Kardatou, E., Spyreli, E., Fragopoulou, E., Mantzoros, C. S., & Yannakoulia, M. (2013). "Effect of different amounts of coffee on dietary intake and appetite of normal-weight and overweight/obese individuals," *Obesity*, 21(6), 1127-1132. doi:10.1002/oby.20190x

Grosso, G., Stepaniak, U., Micek, A., Topor-Mądry, R., Pikhart, H., Szafraniec, K., & Pająk, A. (2015). "Association of daily coffee and tea consumption and metabolic syndrome: Results from the Polish arm of the HAPIEE study," *European Journal of Nutrition*, 54, 1129-1137. doi:10.1007/s00394-014-0789-6

Kim, J., & Park, Y. S. (2017). "Light coffee consumption is protective against sarcopenia, but frequent coffee consumption is associated with obesity in Korean adults, *Nutrition Research*, 41, 97-102. doi:10.1016/j.nutres.2017.04.004

Lee, J., Kim, H. Y., & Kim, J. (2017). "Coffee consumption and the risk of obesity in Korean women," *Nutrients*, 9(1340), 1-12. doi:10.3390/nu9121340

Mogre, V., Nyaba, R., & Aleyira, S. (2014). "Lifestyle risk factors of general and abdominal obesity in students of the School of Medicine and Health Sciences of the University of Development Studies, Tamale, Ghana, *ISRN Obesity*, 2014, 1-10. doi:10.1155/2014/508382

Moy, G. A., & McNay, E. C. (2013). "Caffeine prevents weight gain and cognitive impairment caused by a high-fat diet while elevating hippocampal BDNF," *Physiology and Behavior,* 109, 69-74. doi:10.1016/j.physbeh.2012.11.008

Pan, A., Malik, V. S., Hao, T., Willett, W. C., Mozaffarian, D., & Hu, F. B. (2013).

"Changes in water and beverage intake and long-term weight changes: Results from three prospective cohort studies," *International Journal of Obesity (London)*, 37(10), 1378-1385. doi: 10.1038/ijo.2012.225

Rustenbeck, I., Lier-Glaubitz, V., Willenborg, M., Eggert, F., Engelhardt, U., & Jörns, A. (2014). "Effect of chronic coffee consumption on weight gain and glycaemia in a mouse model of obesity and type 2 diabetes," *Nutrition & Diabetes*, 4, 1-9. doi:10.1038/nutd.2014.19

APPENDIX A – PARTICIPANT SURVEY

1. What year are you in school? Freshman (1st year), Sophomore (2nd year), Junior (3rd year), Senior (4+ year)

2. What is your age?

3. What is your gender? Male, Female

4. What is your race? White or Caucasian, Black or African American, Hispanic or Latino, Asian or Asian American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, Another race

5. What is your height in inches?

6. What is your weight in pounds?

7. Do you: I drink all coffee black, I sometimes drink coffee black and I sometimes drink coffee with additives (cream, sugar, etc.), I drink all coffee with additives (cream, sugar, etc.), I do not drink coffee, Other

8. On average, how many cups (8 oz. = 1 cup) of black coffee (without sugar, cream, milk, or any other additive) do you consume per day? 0 cups, 1 cup, 2 cups, 3 cups, 4 cups, 5 cups or more

9. Of the number of cups stated in Question 1, how many are decaffeinated? 0 cups, 1 cup, 2 cups, 3 cups, 4 cups, 5 cups or more

10. How many minutes per WEEK (on average) do you exercise? 0 mins/wk, 1-30 mins/wk, 31-60 mins/wk, 61-90 mins/wk, 91-120 mins/wk, 121-150 mins/wk, Greater than 150 mins/wk

11. How many calories per DAY (on average) do you consume? 1200-1500 calories, 1501-1800 calories, 1801-2100 calories, Greater than 2100 calories

12. How long have you been drinking coffee? Less than 1 year, 1-5 years, 6-10 years , >10 years

APPENDIX B – PILOT STUDY QUESTIONS

Were there any questions in this survey that were hard to understand? If so, which one(s) and why?

Did the order of the questions in this survey make sense? If not, explain.

Do you have any other general comments about this survey?

APPENDIX C – REVISED PARTICIPANT SURVEY

1. What is your age?

2. What is your gender? Male, Female, Prefer not to say

3. What is your race? Select all that apply. White or Caucasian, Black or African American, Hispanic or Latino, Asian or Asian American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, Another Race

4. What is your height in INCHES? (1 foot=12 inches)

5. What is your weight in POUNDS?

6. Please select the option that most describes you. I drink all coffee black, I sometimes drink black coffee and I sometimes drink coffee with additives (cream, sugar, milk, non-dairy creamer, etc.), I drink all coffee with additives (cream, sugar, milk, non-dairy creamer, etc.), I do not drink coffee, Other

7. On average, how many days a week do you drink coffee? 0 days per week, 1 day per week, 2 days per week, 3 days per week, 4 days per week, 5 days per week, 6 days per week, 7 days per week

8. On average, how many ounces (8 oz. = 1 cup) of black coffee (without sugar, cream, milk, non-dairy creamer, or any other additive) do you consume per day? If do not drink coffee every day, answer the amount you would consume on a day you do drink coffee. 0 cups, Less than 8 oz (1 cup), 8 oz (1 cup), 12 oz (1.5 cups), 16 oz (2 cups). 20 oz (2.5 cups), 24 oz (3 cups), 28 oz (3.5 cups), 32 oz (4 cups), Greater than 32 oz (4 cups)

9. Of the number of ounces stated in the question above, how many are decaffeinated? 0 cups, Less than 8 oz (1 cup), 8 oz (1 cup), 12 oz (1.5 cups), 16 oz (2 cups). 20 oz (2.5 cups), 24 oz (3 cups), 28 oz (3.5 cups), 32 oz (4 cups), Greater than 32 oz (4 cups)

10. How long have you been drinking only BLACK coffee? Less than 1 year, 1-5 years, 6-10 years, >10 years

11. How many minutes per week (on average) do you exercise? 0 mins/wk, 1-30 mins/wk, 31-60 mins/wk, 61-90 mins/wk, 91-120 mins/wk, 121-150 mins/wk, Greater than 150 mins/wk

It's Not the End of the World: An Analysis of the Similarities in Dystopian Literature and Their Shared Reflection of the Innate Fears of Humanity

Marlena G. Kalafut

ACKNOWLEDGMENTS

ABSTRACT

This thesis analyzed common aspects of six major works of dystopian literature to assess their commonalities, as well as their authors' motivations in writing. Dystopian literature explores the major flaws of humanity, as well as the extent to which society could descend into chaos while simultaneously believing it is creating a better world. This thesis did not argue that within the studied works are all the same dystopian characteristics. Instead, it analyzed select dystopian qualities and made comparisons between the dystopian novels that share them, all of which were impacted by the utopian goals modeled in Plato's *The Republic*, Thomas More's Utopia, Sir Francis Bacon's New Atlantis, and H. G. Wells's A Modern Utopia. These shared characteristics demonstrate that humanity has been fearing the end of the world for several thousand years. As such, this thesis suggests that the prevalence of dystopian literature may not necessarily signal the result of the coming end times but instead may be the result of the natural human fears of chaos, abused power, and the end of the world.

Keywords: Dystopia, utopia, *Brave New World, Nineteen Eighty-Four, Fahrenheit 451, The Handmaid's Tale, The Giver, The Hunger Games, Catching Fire, Mockingjay*

INTRODUCTION

In its Greek etymology, "utopia" is derived from the prefix οὐ-, meaning "not," and the root τόπος, meaning "place." The construction of the word already implies the farfetched nature of the society it describes: one free of any political or social strife and where all members thrive, uninhibited. But, regardless of how desperately humanity may strive for a perfect society, the word itself demonstrates that a utopia is not possible. Universally, working towards a utopia is the goal of society—most communities dream of being one without political problems, social problems, economic problems, and any other issue which threatens the well-being of its people—but some authors use their writing to take a stance of skepticism regarding what could go wrong on the journey to a perfect world. These are known as anti-utopian novels or, more commonly, dystopian novels, a term which was "coined for its overtones of disease and malfunction, making it an accurate label for the genre's depictions of human foibles, weaknesses, and messiness that defeats attempts to create a perfect society" (Burnett and Rollin 77-78). Each work of dystopian literature addresses humanity's potential for reaching too far and tipping the balance in the wrong direction, away from the society of equality and perfection and towards one of abusive methods of societal control and neglect of its citizens. In *Utopia and Anti-Utopia in Modern Times*, Krishan Kumar describes the relationship between utopia and anti-utopia, saying, "As nightmare to its dream, like a malevolent and grimacing doppelganger, anti-utopia has stalked utopia from the very beginning" and anti-utopia is the "mirror-image of utopia—but a distorted image, seen in a cracked mirror" (99-100). Each dystopian novel conveys a distinct vision of fear for the future, warped from humanity's longing for a stable society.

Regardless of when the authors are writing or how they portray their concern—be it through children fighting to the death or the burning of books—patterns of bureaucratic structures, relational exploitation, and sociological adjustments can be detected in

aspects of all these visions. These are representative of the pattern of fear emulated in the fictional societies. This thesis will explore three common characteristics that often appear within dystopias and how these characteristics are shared in key pieces of literature in the dystopian genre. This is illustrated first by introducing four foundational utopian works and the major themes that will reappear within the dystopian novels, followed by summaries of Aldous Huxley's *Brave New World*, George Orwell's *Nineteen Eighty-Four*, Ray Bradbury's *Fahrenheit 451*, Lois Lowry's *The Giver*, and Suzanne Collin's *The Hunger Games*, which were chosen for their coverage throughout the twentieth and twenty-first centuries, therefore demonstrating the recurrent nature of these dystopian characteristics across time. These novels will be analyzed to assess the similarities they share with regards to the three characteristics. The first characteristic discussed is political structures, specifically the leaders of dystopian societies and the methods of control they employed. The second characteristic is interpersonal relationships and how sexual, familial, and friendly relationships are distorted in dystopian societies. The final characteristic is the way unity is achieved. Not all six dystopian novels will be discussed to the same extent in each section, as the three characteristics manifest themselves to different levels in the various texts. One text will be chosen as the best illustration of the dystopian characteristics and will, therefore, be more fully developed. It will be followed by several other textual examples that also illustrate the characteristics, but not to the same degree. After examining the characteristics in the texts, biographical and environmental factors in each author's life are explored to show to what extent these novels may act as representatives of innate human fears that are omnipresent rather than localized, regardless of the characteristics exhibited within the texts.

HISTORY OF UTOPIAN AND DYSTOPIAN LITERATURE

Foundations of utopian literature

Utopian literature and the concept of a utopia has deep roots in early religious stories and myths, which describe "an unrecovered earthly paradise or golden age of the past" (Sargent 8). Generally, the focus of such writings assesses perfect communities that do not come about through the effort of humans. Places such as the Garden of Eden and Paradise are known for their serenity and for being places of "abundance, unity, and ease" where there is "security, expressed negatively as an absence of conflict and positively in images of abundance" (8). In the following pieces of literature that explore how a utopic society could theoretically exist, the authors no longer consider the utopia as a place given to humans but instead as a place that requires communal collaboration and effort. The ideas explored in these utopian societies later contribute greatly to the dystopian genre, where abundance, unity, and ease are either abused or completely dismissed.

Plato's Republic

Plato's *Republic*, written in 380 BC, does not focus on the elements that would destroy a functioning society but instead develops the image of an ideal—a utopia. In his work, Plato outlines how social harmony can be created, beginning with a clear division of classes. The first and highest class is a philosopher-king, the second, auxiliaries who support and sustain, and the third are the producers who utilize their skills and follow

the ruler and auxiliaries. The goal of utopia is truly the creation of roles where everyone fits into a position to contribute what he or she has and is content with those roles. Plato writes of the value of unity for a city-state, saying, "Does not the worst evil for a state arise from anything that tends to rend it asunder and destroy its unity, while nothing does it more good than whatever tends to bind it together and make it one?" (163). The development of the society must focus on all members participating in the creation of the society by doing their share and feeling like each is a part of a whole. Plato explains this by saying, "The best ordered state will be the one in which the largest number of persons use [mine, not mine, another's, and not another's] in the same sense, and which accordingly most nearly resembles a single person" (163). In this way, all members should see themselves not just as members of the state, but as a part of a collective.

Thomas More's Utopia

Thomas More's *Utopia* was written in Latin in 1516, and through the work More explores the concept of a utopia not as an idea but as an existing place: the island Utopia. It is the island's values and structure that make it stand apart for More; he writes about the society's lack of social classes, its disinclination towards war, its communal property, and its collective productivity as just some of the qualities that make it a state that thrives. One vital point that allows the society to flourish is the following:

> The Utopians' opinion is that not only covenants and bargains made between private men ought to be well and faithfully fulfilled, observed, and kept; but also common laws, which either a good prince has justly published, or else the people, neither oppressed with tyranny nor deceived by fraud and guile, have by their common consent constituted and ratified, concerning the partition of the comfort of life, that is to say, the materials of pleasure. (112-13)

This belief is basic. The simplicity of all members accepting and upholding both informal covenants and common laws is dramatic in comparison to real life, where deals between individuals are not kept and laws are not upheld. This makes the belief much more radical than it would appear initially. Throughout *Utopia,* More also explores other radical and controversial topics that allow the society to function, such as euthanasia and slavery. It is unclear whether *Utopia* was written to encourage work towards achieving the peace like More's fictional island or, rather, to act as a warning against the socialist society to which More was opposed.

Francis Bacon's New Atlantis

Sir Francis Bacon's portrayal of a utopian future lay in an unfinished novel titled *New Atlantis*, published in 1627. Its plot, which focuses on the crew of a ship which discovers the island of Bensalem after being lost at sea, serves as a vehicle for Bacon to discuss the culture of its inhabitants and the state-sponsored institution for research called Solomon's House. The "generosity and enlightenment, the dignity and splendor, the piety and public spirit, of the inhabitants of Bensalem represent the ideal qualities" which Bacon explores as the desired state for a society (Bacon). Bensalem also acts as Bacon's "prophetic vision of the future of human knowledge" (Bacon). Within the society, science and religion coexist peacefully, and the goal is "finding out of the true nature of all things, (whereby God mought [sic] have the more glory in the workmanship of them, and insert the more

fruit in the use of them)" (Bacon). Within *New Atlantis*, Bacon demonstrated that a goal and acceptance of others can be a practical, as well as meaningful, way of creating unity within a utopia.

H. G. Wells's A Modern Utopia

H.G. Wells's *A Modern Utopia*, published in 1905, is told by a narrator known only as "The Owner of the Voice." The book is told as the Voice and his companion learn about the utopia chapter by chapter, discovering its topography, economy, and the presence of their utopian selves, which are exact replicas of themselves. Common to utopian societies, but only recognizable to an observer, "their common fault is to be comprehensively jejune. That which is the blood and warmth and reality of life is largely absent; there are no individualities, but only generalized people" (9). Wells's own description of *A Modern Utopia* is "a sort of shot-silk texture between philosophical discussion on the one hand and imaginative narrative on the other" (xxxii). As a result, Wells creates a literary bridge between the early utopian philosophers and the more fictionally-focused authors to come. Peter Fitting explains this when he writes, "The 'novelization' of utopia involves a significant transformation: from the positioning of the reader as the addressee in a philosophic dialogue… to the process of identification with a fiction character where the reader is implicated on an emotional and experimental level" (30). Such novelization implies less intent by the author to convince the reader and more to engage the reader by giving the reader a character with which to identify.

In their more general ideas, these four early utopian works have a great deal in common. They demonstrate that the basis for a perfect society lies in the unity created, the governments founded, and the thought processes of its members. By introducing these three structures into a community, each believed in a theoretical perfect society which replaced conflict with peace, scarcity with abundance, and hardship with ease. These authors create foundational literary works that continue to influence the genre because each began with a vision and an idea of something better than the world they knew.

Recent dystopian literature

The turn from utopia towards dystopia near the end of the nineteenth century took place because of two developments, according to Gregory Claeys: eugenics and socialism (111). Dystopian novels became "dominated by the promises of these two, often interwoven, ideals of social and individual improvement" (111). Dystopian novels are a means of exploring utopias under different lighting. Utopias follow "the social engineer's blueprints [which] are merely revised editions of the ancient text" and focus on the values within the works of Plato, More, Bacon, and Wells, encouraging its citizens to be happy, free, and fulfilled without oppression of their natural humanity or individuality (Koestler 16). However, dystopias take the same blueprints and emphasize the potential downsides and defects in such attempts in creating a perfect world.

Aldous Huxley and Brave New World

Aldous Huxley's *Brave New World*, published in 1932, contains most aspects of a dystopian society. The World State creates a genetically engineered society with an intelligence-based hierarchy within which every individual fits. Following the cataclysmic Nine Years' War and the Great Economic Collapse, a global government

is created known as the World State—the same name of the society in H.G. Wells's *A Modern Utopia*. Though several characters express their disdain for the World's culture, only one person—a "savage" named John—challenges the dystopic methods and meaninglessness of life.

When he wrote *Brave New World*, Aldous Huxley believed that the future would hold a revolution in five or six hundred years, though he later discussed this as being "excessive" in estimation and believed that George Orwell's writing—which was "made from a vantage point considerably further down the descending spiral of modern history than mine"—was closer in estimating when this revolution might take place (Huxley, "Variations on a Philosopher" 109). In his essays, Huxley frequently referenced the potential for revolutions, as well as the power of freedom. In an interview, Huxley discussed freedom and noted that it is not always a deliberate person who is trying to rob people of their freedom but instead that people are pushing in the direction of less and less freedom, imposing control on existing freedoms (Wallace). A witness to Hitler's rise, Huxley noted that Hitler was deliberately taking freedoms from people, using similar means as he discussed in his interview to rob people of freedom by doing so gradually and then with propaganda and brute force. In the same interview, Huxley also stated that Hitler "was using every modern device at that time … to the fullest extent and was able to impose his will on an immense mass of people" (Wallace). The use of propaganda, violence, and restricted freedoms are repeatedly visited within *Brave New World*.

George Orwell and Nineteen Eighty-Four

George Orwell's *Nineteen Eighty-Four*, written in 1949, also contains many of the qualities that can be seen in a dystopian world. The Party is led by the infamous Big Brother and threatens with violence and propaganda, creating a world where no one has privacy. The protagonist Winston Smith secretly opposes the Party and dreams of rebelling against them. This internal desire makes him a "thoughtcriminal," a crime which leads to his capture and torture. The Party does not care for the people it governs, only for power. This power holds everything in its wake, spying through two-way televisions and rewriting historical documents to fit new truths until there is no opportunity for dissention.

In a letter to Francis A. Henson, Orwell wrote, "Totalitarian ideas have taken root in the minds of intellectuals everywhere, and I have tried to draw these ideas out to their logical consequences" (quoted in Howe 287). Many of the significant ideas that he explores in his dystopian work—as well as fears that inspired it—were rooted in his experiences as a Talks Assistant for BBC. In *Nineteen Eighty-Four*, Room 101, where Winston acquires his complete understanding of Big Brother and the Party, was inspired by Orwell's work at BBC. Room 101 is different for every person, encompassing their deepest fear; for some, it may be a way of death, or for others, "it is some quite trivial thing, not even fatal" (*Nineteen Eighty-Four* 293). For Orwell, Room 101 included deathly boredom in meetings at BBC. As he worked with BBC during the war, he was always aware of propaganda and the diligent use of words. Orwell was an enthusiast for the artificial language of Basic English, which was an attempt at "a codified, error-proof version of English with an easily mastered, limited vocabulary," created by C.K. Ogden (Gordon 338-39). While Orwell endorsed Basic English, he understood that in order to use it in

translating, there were radically different ways of understanding what was being said. Newspeak in Nineteen Eighty-Four is a reflection of this communication method in the real world. Where there was the Ministry of Information in Britain, there was the Ministry of Truth in Oceania. Orwell's experiences during the war and his mastery of language allowed him to create a parallel world to address his fears: manipulation, totalitarianism, and war.

Ray Bradbury and Fahrenheit 451

Ray Bradbury's Fahrenheit 451 was written in 1953. Its main character is a fireman named Guy Montag, though his profession is the opposite of what it once had been: instead of obliterating flames, he creates them, lighting up books and the houses that conceal them, maintaining constant censorship of the works people are allowed to consume. After his wife's suicide attempt and his meeting of an intelligent, though "queer," young woman, he begins questioning his work and the words that hide between the covers of the books he ignites.

For $9.80, Ray Bradbury wrote in the library of UCLA, paying $0.10 per half hour to type. "What a place for a Fahrenheit 451 to be written," he had noted, "in a library, of all places, where it wasn't being burned!" ("A Conversation"). Censorship is largely the quality which defines *Fahrenheit 451*'s dystopic attributes, and Bradbury said that "we should learn from history about the destruction of books. When I was fifteen years old, Hitler burned books in the streets of Berlin, so I learned then how dangerous it all was" ("A Conversation"). His fears were rooted in the problems of World War II, as well as the tyrannical government of Germany. He first explored these fears in other stories, before *Fahrenheit 451*, such as "The Pedestrian," where he writes about unconventional people acting out of line with their society, just as Clarisse in *Fahrenheit 451* would. In the uncompleted novel *Where Ignorant Armies Clash by Night*, Bradbury writes of persuasion and conditioning, as an old man tells a child, "Everything is futile, all effort is in the end worthless… If you can't fight the meaningless with a religion, then slide along down the chute with it into oblivion. Make a religion of Meaninglessness. Make a sect of cruelty" (*Match to Flame*). Bradbury explored many topics in his writing. Eventually, common themes and early writings would converge at his writing of *Fahrenheit 451*, where he would explore fearful topics of censorship, conformity, meaninglessness, and dissatisfaction.

Margaret Atwood and The Handmaid's Tale

Margaret Atwood's *The Handmaid's Tale*, written in 1985, revolves around a woman called "Offred," referring to the man she serves, as she is "of fred." Offred is a handmaid, one of a few select women who are responsible for repopulating the earth following an ecological disaster. Brainwashed into acquiring many of the core beliefs of The Republic of Gilead—the government established after the disaster—but still unable to forget the husband, daughter, and life she left behind, she struggles to assimilate to her role.

The Handmaid's Tale's themes have roots in various fears and concerns for Margaret Atwood. Huxley's *Brave New World* made a deep impression on her. As a result, there are many similarities in the uses of power in both novels. The most potent reason for her writing, however, was her concerns regarding women's rights. In an interview, she

commented that "it does seem to be every totalitarian government on the planet has always taken a very great interest in women's reproductive rights," and the same can be said for novels with totalitarian leaders or dystopian themes (Oyler). When writing, she drew from current society the ways that women could be forced back into the home with no rights or opinions, noting, "You don't write those books because you hope those things will happen. You write those books because those things *might* happen" (Oyler).

When *The Handmaid's Tale* was published, there were critics who commented that it must have been written in response to particular societies in existence or to a specific country. In rebuttal, Atwood states, "It's about everybody. I took examples from all around the world and all you have to do is go back in our history maybe a hundred years and you're going to find very similar things" (quoted in Satalia). Atwood compiled these human experiences and fears into a novel that made people question: could it happen here?

Lois Lowry and The Giver

Lois Lowry's *The Giver,* written in 1993, chronicles the experiences of a young boy named Jonas as he begins training for the role of the Giver, an elder in the Community who carries the weight of history so that the society does not have to. Initially, Lowry stated she wanted readers to feel drawn into the community as a welcoming and safe place to live, only revealing later the sacrifices that were made ("Lois Lowry"). By depriving the community members of the sight of color, the memories of history, and the depth of feeling, the community is safer and at peace, but it is also devoid of meaning.

Lowry expresses that she never intended to create a work of science fiction but simply a book based in the future. The basis of *The Giver* arose when her father began losing his memory with age, and she noticed that he had forgotten the death of Lowry's older sister as well as the war he had fought in. Initially, Lowry commented, "Maybe that's a good thing if we could just obliterate the things that had ever been a source of pain to us, but then I began to think […] what else would we lose?" and "what would happen if we could manipulate human memory?" ("Lois Lowry on 'The Giver'"; "Lois Lowry: THE GIVER"). These questions were the seeds from which *The Giver* grew. For the plot of this book to occur as she imagined, she knew the book would have to be placed outside of the current world. Then she began removing the causes of problems in current society, beginning with poverty. Then she eradicated homelessness, traffic, crime, divorce, prejudice, pollution, and so on so that the world would "seem close to perfect" ("The Giver: A Conversation"). She admits that even she did not know where the story would go as she was writing, but she could feel the Community had been warped in some very dramatic ways, noting that "with the eradication of memory, feeling has been destroyed as well" and that "there's an emptiness there … that's kind of chilling" ("What if You Could Control Memory"; "Lois Lowry: THE GIVER"). As the book develops, she learned exactly what this would entail, writing a book that she knew would be different from any other book she had penned before. Her vision was not one of complete devastation for the world, as Huxley and Orwell might have envisioned, but one of a warning against a path to be avoided.

Suzanne Collins and The Hunger Games

Suzanne Collins's *The Hunger Games* trilogy, written from 2008 to 2010, follows a young woman named Katniss Everdeen through her life-altering struggle in her home of District 12 of Panem, a new nation formed from the post-apocalyptic remains of North America following a devastating world war. Named after the Latin phrase *Panem et Circenses*, translating to 'bread and circuses,' it is an early suggestion of the Capitol's use of entertainment to distract civilians from rallying politically. As a means of controlling its citizens following a rebellion, the Capitol introduces an annual event named the Hunger Games in which two children—one boy and one girl—are randomly selected to represent their home district in a fight-to-the-death. In a demonstration of rebellion, Katniss acts as an icon and encourages defiance against the Capitol.

Similar to Lowry, whose father went to war following the bombing of Pearl Harbor, Suzanne Collins was also impacted by her father and his time in battle while she was young. She cited an experience of looking at the television when she heard the word "Vietnam," where she knew her father was, and seeing the graphic images of war and feeling deep fear as influencing her writing ("Suzanne Collins on the Vietnam War").

From her early impression of television, the roots of *The Hunger Games* continued to take hold from the contemporary obsession with consumption of entertainment and television. Collins described the initial experience that ignited the idea, saying, "I was flipping [channels] and I was seeing footage from the Iraq war and these two things began to sort of fuse together in a very unsettling way and that is when I really, think was the moment where I got the idea for Katniss's story" ("Suzanne Collins Part 2"). The juxtaposition of consumable material on television—violence and entertainment—resonated deeply with her. Its impact can be seen in the required public viewing of many aspects of the Hunger Games: the choosing of tributes, the opening ceremony, the games themselves, and the victory tour. To the Capitol, the games are purely an entertainment spectacle. In one particular comment, Collins references the potentially indistinguishable aspect of entertainment when she says, "You see so many images that do they all begin to have a sameness to them? Are you really distinguishing between the different things that you see on different channels? Are you really distinguishing if you're flipping through quickly?" ("Suzanne Collins on the Vietnam War"). Capitol inhabitants exemplify this in their obsessions regarding the tributes, such as referencing the outfits of the tributes and asking questions about the relationship between Peeta and Katniss. Collins plays out her fears for society within *The Hunger Games*, accentuated by violence, distorted entertainment, and propaganda.

These six novels were chosen as representatives for the dystopian genre in this thesis because of their unique reiterations of anti-utopia, as well as the time span that they cover. Each book examines dystopia with a distinctive vision by applying a select variation of dystopian characteristics, therefore creating a dystopian world that exists entirely separately from any other. Though these books create new and unique worlds, considerable similarities exist in the ways political structures are used to acquire and keep power, interpersonal relationships are exploited and corrupted, and unity is formed to better assimilate inhabitants into the society.

The authors of these six dystopian novels share more in common than just the way they write their dystopian novels. Each author recognizes a concern he or she sees in the world and, hoping to warn the world around them or to demonstrate what could happen if humanity's course is not adjusted, they write. They write to express concerns about power struggles, gender inequality, war, mindless consumption of entertainment, and lack of knowledge of the happenings in the world. Often, their fears are shared, but that does not prove the validity of such fears. Instead, each dystopian work "makes its objections not in generalized reflections about human nature but by taking us on a journey through hell, in all its vivid particulars. It makes us live utopia, as an experience so painful and nightmarish that we lose all desire for it" (Kumar *Utopia and Anti-Utopia* 103). These fears are reflected throughout each novel and are warped distortions of the utopic models that came before them as a means of expressing human fears and, ultimately, their humanity. Utopian societies are "a timeless and unchanging constant, an ur-type or archetype of the human social imagination" (Kumar *Utopianism* 43). The dystopian worlds explored by these authors may simply be at opposing ends of this same timeless, unchanging spectrum of human imagination.

A SUMMARY OF THE CHARACTERISTICS OF DYSTOPIAN LITERATURE

The expression of a dystopian society can differ widely, depending on the point the author wishes to make, as well as the impression intended to be made on the reader. As such, the qualities of dystopian literature can vary widely, but it is the "oppositional and critical energy" that they share which binds them into the same genre (Booker 3). M. Keith Booker describes these qualities that lend a work to a dystopian nature when he writes that dystopian literature

> constitutes a critique of existing social conditions or political systems, either through the critical examination of the utopian premises upon which those conditions and systems are based or through the imaginative extension of those conditions and systems into different contexts that more clearly reveal their flaws and contradictions. (3)

It can be difficult to assert exactly what quality or characteristic makes a dystopian novel, because they show a utopia system take to the extreme. In this way, dystopian critiques can result from the implementation of any system that attempts to remove conflict, pacify citizens, or create universal contentment.

The dystopian characteristics which will be analyzed and compared within this thesis are the leaders of dystopian societies and their methods of control employed, specifically violence, drugs, censorship, and propaganda; the distorted sexual, familial, friendly relationships; and the ways that unity is achieved.

The rulers of dystopian societies can come in many different forms, as well as with different intentions in mind. While the Party and Big Brother in *Nineteen Eighty-Four* maintain power for the sake of power, the World Controllers of the World State in *Brave New World* truly believe in the world they are creating. Because of the power required to attain and maintain a peaceful and cohesive society, the rulers frequently are forced to turn to violence and aggressive methods.

Control is exercised in dystopian literature through a number of different channels. Without strong discipline to govern what is and what is not allowed in the dystopian society, the structure of the society would collapse. To prevent this from occurring, "discipline is utilized to control people's everyday lives in the form of a strictly regimented routine where people's actions are prescribed by the government-instituted schedule" (Gerhard 24). This control both works as a means of overseeing the functioning of the community and as a means of demanding conformity. This is because "dystopian citizens do not have a choice in what they can or cannot do, have lost the control over their own bodies and minds, and have become 'imprisoned' in the state's disciplinary system" (Gerhard 24). Every dystopian novel requires some method of control, though often several methods are utilized to maintain the dystopian populace.

Violence is a simple and absolute means of keeping the population in line. In dystopian novels like *The Hunger Games* or *Nineteen Eighty-Four,* the constant threat of violence is what keeps citizens in line, petrified of the harm that will come upon them for not following the society's norms.

Drug dystopias are defined as "near future societies where pharmacology produces or reinforces a dystopian social order" (Hickman 141). As a tool of control, using psychopharmacology is a particularly easy method. In dystopias as seen in *Brave New World*, the drug usage has so permeated the culture that citizens are hardly able to function without it. In other dystopias, such as Panem in *The Hunger Games*, drugs are simply a way to cope with the world.

Propaganda takes largely the same form in each dystopian novel, but the execution varies widely. The propaganda used by Gilead in *The Handmaid's Tale* is intended to degrade the value of former life and encourage handmaids to agree with their mission. Within Oceania in *Nineteen Eighty-Four*, propaganda changes with the purposes it is supposed to fulfill. The Party continues to change the truth according to how it needs to sway its citizens.

Censorship is a noninvasive means of control but one which is used deliberately to monitor what is and is not known by the general population. In "Fictional Futures vs. Historical Reflections: How Utopian Ideals Can Lead to Dystopian Results," Lauren Hayhurst explains the power of censorship in a dystopian society, writing, "Historical knowledge is fictionally portrayed both as a means to establish a ruling power and as a liberating force, suggesting that the key to control lies in the ability to inhibit historical truth; freedom of the masses depends on the access to or denial of such knowledge" (53). Without access to knowledge, as well as historical truth, as opposed to what the governing authority provides as history, the masses cannot be free.

Relationships may appear normatively in dystopian literature, but more commonly they are warped into poor facsimiles of what they once had been. In some societies, they are abolished altogether in favor of diverting citizen's energies to loyalty towards the rulers. Lynn Williams expands on this, writing, "Prejudice against emotional closeness is common … writers have often played down not only those personal relationships—mothers and fathers, brothers and sisters, husbands, wives, lovers —...but also those

institutions like marriage and the family which encourage possessiveness and the selfish pursuit of private happiness" (123). In dystopian societies, families and friendships are threats because of the society's intention to remove any sources of possessiveness and selfishness. Therefore, relationships that encourage such feelings are eliminated.

In any society, emphasizing a reason for unity and camaraderie can prove vital; without a reason to remain united to their fellow man, the society would crumble. This very issue is what threatens the viability of large utopian communities. However, dystopias can overcome this problem because of the tether between the individual and the community. Hayhurst explains,

> Large-scale utopia requires the use of dystopian methods… but utopia cannot be forced upon an external cultural reality...The only way around this enigma is to increase the boundaries of cultural reality. Dystopian fiction has the power to achieve this: by equating personal struggles to global disharmony, cultural barriers preventing such success can be transgressed (61).

In this manner, dystopian societies create indelible relationships between the world at large and the personal life of each individual. In order to create what the society hopes would be a utopia, however, the use of dystopian methods must be applied. This creates a kind of collectivism which unites all member of the society.

None of the six dystopian novels approach these characteristics from quite the same direction; however, they all "critically examine both existing conditions and the potential abuses that might result from the institution of supposedly utopian alternatives" (Booker 3). These examinations are in part the result of the authors' environment, but also may be the result of innate fears that rest in each person.

POLITICAL STRUCTURES

Within utopias, power exists and though it may be favorable to the rulers, the general public is neither ignored nor oppressed, as can be seen in Plato's *Republic*. Dystopian communities tend to evolve from their more hopeful and idealistic counterpart: the utopia. No community sets out to oppress its members, nor does a community intend to subject them to needless violence, fear, or destructive social structures. Instead, dystopias tend to evolve from utopian aspirations because "the desire to create a much-improved society in which human behavior [is] dramatically superior to the norm implies an intrinsic drift towards punitive methods of controlling behavior which inexorably results in some form of police state" (Claeys 108). Dystopias in literature never come about through the equal desire of the controllers and the controlled. Instead, there is a clear imbalance that harms those who are silenced or ignored. This chapter will explore political structures and how—by use of violence, drugs, propaganda, censorship, and the firm hand of a ruler—dystopian societies go to great lengths to keep their members in line.

Rulers
Dystopian societies are united and governed by someone; communities are told they would be unable to maintain the necessary levels of control and composure without

having a figurehead or a group of individuals in charge. Dystopian rulers typically rule with an iron fist, without mercy for the deviants and with dangerous consequences for insubordinate actions. For those who are not convinced of the society's ways, these rulers can strike fear into their hearts, but those who believe in the ruler and his or her mission are supporters that allow the society to keep running. Without someone to fear, nothing would be strong enough to keep members in their place for the community to continue.

The epitome of the dystopian rulers can be seen in Big Brother, the antagonist of George Orwell's *Nineteen Eighty-Four*. Following a third world war, the Party took over governing the newly formed superpower Oceania. The protagonist notes that he cannot quite remember when he first heard of the Party or of Big Brother, but "in the Party histories, of course, Big Brother figured as the leader and guardian of the Revolution since its very earliest days" (37). It is unclear whether Big Brother is a fictional fiend that was introduced by the Party to manipulate the population into compliance or is, in fact, an actual being who is running the world from behind the scenes. The descriptions of Big Brother capture his foreboding and omniscience: "The poster with the enormous face gazed from the wall. It was one of those pictures which are so contrived that the eyes follow you about when you move. BIG BROTHER IS WATCHING YOU, the caption beneath it ran" (Orwell, *Nineteen Eighty-Four* 1). Though the image is not innately frightening, it demonstrates the surveillance that governs the society. As such, the image does not need to frighten its civilians but only remind them that Big Brother sees all and knows all. According to Mark Miller, the image is a reminder that "in Oceania there is no possible escape from Oceania, but only continual rediscoveries of Oceania where one least expects it" (184). This is an irrelevant reminder for conformists, but for the outcasts, the thoughtcriminals, for those like Winston who are in violation, this is a constant looming threat.

One of the most unique characteristics of Big Brother is that the Party exhibits its strength through Big Brother. His presence is palpable for the citizens, gazing at them from posters, screens, and the like, and he is designed to exist everywhere, including in their minds. This lifts him into the realm of the supernatural, having grown from the status of a mortal to a god of the people. O'Brien, an inner Party member who abducted Winston for his thoughtcrimes, dismisses Winston's question, "Does Big Brother exist?" as both insignificant and nonsensical, answering "Of course he exists. The Party exists. Big Brother is the embodiment of the Party" (Orwell, *Nineteen Eighty-Four* 267). This response offers little to expand upon who Big Brother is beyond that of a Party-sponsored symbol. Yet, that is enough. When Winston asks if Big Brother will ever die, O'Brien responds curtly, saying, "Of course not. How could he die? Next question" (267). In this way, Big Brother is beyond the existence of a mere mortal; he is the essence of the Party, and as long as the Party exists, so does Big Brother.

For those unlike Winston, rulers such as Big Brother are figureheads of almost religious fervor. Those who are wholly assimilated in their culture do not struggle with the rulers of a dystopia because the control techniques have been adequate enough for them to internalize the governing power's message. In one instance, following the Two Minute Hate, one woman is shown to be the ideal follower for the Party because of her evident

love of Big Brother: "The little sandy-haired woman had flung herself forward over the back of the chair in front of her. With a tremulous murmur that sounded like 'My Saviour!' she extended her arms towards the screen. Then she buried her face in her hands. It was apparent that she was uttering a prayer" (Orwell, *Nineteen Eighty-Four* 16). These are the people that are easy for the Party to control because they are already intrinsically tied to the values of the Party and crave the beliefs that are held. Religion of any other kind is strictly banned, and "the Party actively works to appropriate the energies traditionally associated with religious belief and to use those energies for its own purposes, giving the Party itself a quasi-religious air" (Booker 209). This internal desire for societal fellowship is a vicious circle for those like this woman. As they already desire it, they are pulled in, exacerbating the desire, pulling them further into their passion for Big Brother. The passion for him continues to be demonstrated in actions such as the one that possessed the group after the Two Minute Hate: "It was a refrain that was often heard in moments of overwhelming emotion. Partly it was a sort of hymn to the wisdom and majesty of Big Brother, but still more it was an act of self-hypnosis, a deliberate drowning of consciousness by means of rhythmic noise" (Orwell, *Nineteen Eighty-Four* 17). It is the desire of these individuals to feel connected to Big Brother. They do not feel punished by the totalitarian government that watches their every move. Instead, they deny themselves in favor of praising Big Brother, choosing the route so delicately and deliberately designed for them by the Party.

The goal of the Party is for all members to feel connected and loving towards Big Brother. This is not to create a peaceful and idealistic society but instead because "the absolute power of this oppressive system is threatened by the presence of even a single dissident, someone who can laugh at its pretentiousness, energized by remembering when life was different and better, and by imagining future realities, future possible selves, with meaningful options and viable choices" (Zimbardo 127). Until the end of the book, Winston is this dissident and resists the pull and threats. By the end, however, "he had won the victory over himself. He loved Big Brother" (Orwell, *Nineteen Eighty-Four* 308). The framing of this quote illustrates that Winston had taken the least desirable route: he had not loved Big Brother. As a result of this, he was forced into battle with himself to learn the version of him that the Party wanted him to know. Because this ultimate battle is what forced him to be an outcast in his society, this greatly demonstrates that the Party wants a unified love in Big Brother to create and maintain order and control over the people. Furthermore, by demanding this kind of control over all its members, "people lose the ability to relate to each other as human beings and eventually lose their own identities," thereby creating a culture of complete loyalty (Griffin 58).

In Huxley's *Brave New World*, there are ten World Controllers for each of the ten zones of the World State. In Western Europe, "His Fordship" Mustapha Mond takes control as a result of actions that defied his society. Once a young and talented scientist, he performed illicit experiments that were eventually discovered, and he was given a choice: be exiled or trained to be a World Controller. His position is one of maintenance: to prevent any distancing from the world as it is, to continue it on its path, and to dismiss anyone who gets in the way. When it comes to social deviants, he reminds them that the world came to be this way for the sake of stability, saying, "The world's stable now. People are happy;

they get what they want, and they never want what they can't get... And if anything should go wrong, there's soma" (Huxley, *Brave New World* 220). The reason no revolution has come about is that every member wants to retain stability.

Though Mond did not create the society he resides in, he is still an active member in its function. Though intelligent enough to succeed in the World State and illegally perform experiments, he is still influenced enough by the dogma of the World State leadership to agree with their methods. He recognizes the value of separating the classes and assigning work to each group based on their function. He understands the destruction of emotion, the use of sexual activities, and maintenance via drugs. He continues to defend these means as the primary reason that the World State is able to function as it does, making him more than just a "yes-[man] for [his] sinister governments… it is the seeming reasonableness of [his] arguments that makes the slippery slope so dangerous" (McGiveron 125). He was forced to choose between powers of two kinds: powers to obliterate or power to create. With the conducting of science on an island, the scientific discoveries would be of no value: no one would be able to use the knowledge, nor would he be able to share them. Power to obliterate forces Mond to destroy the very thing he values and to "serve happiness" of other people (Huxley, Brave New World 229). Mond may have been given a position of value and respect, but he is forced into his role by the fear and conformity that permeates all citizens and manipulates their actions.

President Snow in *The Hunger Games* trilogy is another ruler with the power and control to create a society entirely as he envisions. He came to power by poisoning any person who threatened his rise, drinking from the same poisoned cup to draw away suspicion and taking an antidote to counter its effects. In *Catching Fire*, he arrives at Katniss's home to inform her that removing the people she loves from this earth would be easy for him and in order to secure their lives, she needs to convince not only the Districts, but also the President himself, that her act of rebellion with Peeta during the games had been the result of only hopeless, foolhardy love.

President Coin, however, came to power through other, but perhaps equally wicked, means. Hers is a gradual takeover which likely would have been successful if not for the violence she performs against her own people and blames on President Snow. By taking President Snow's methods and applying them in her own leadership, she becomes like those she wished to defeat. Katniss, still holding onto hope of the rebellion, struggles to accept the death of her sister, especially after her conversation with President Snow regarding Coin's role in the bombing that killed Primrose. President Snow, awaiting his execution, explains, saying:

> My failure… was being so slow to grasp Coin's plan. To let the Capitol and districts destroy one another, and then step in to take power with Thirteen barely scratched. Make no mistake, she was intending to take my place right from the beginning. I shouldn't be surprised. After all, it was Thirteen that started the rebellion that led to the Dark Days, and then abandoned the rest of the districts when the tide turned against it. But I wasn't watching Coin. I was watching you, Mockingjay. And you were watching me. I'm afraid we have both been played for fools. (Collins, *Mockingjay* 357)

Coin utilizes the tool of distraction to veil her real aims, fooling not only her enemies, but her allies as well. By keeping everyone's focus on the violence, the anger, and by directing it, Coin takes advantage of those she is supposed to lead. The betrayal of trust and her use of the fight against Snow's dictatorship for her own aims are the key factors that lead to her demise at Katniss's hands.

Rulers in dystopian societies keep everyone in line in the world of intense pressure for conformity. Maintaining stability is based on the rulers and their ability to govern with a strict hand of totalitarian nature. Dystopian rulers maintain stability with harshness, implementing a world where the unbalance between the ruler and the ruled remains in favor of those in charge.

Control techniques

Humans can be unpredictable, especially in the presence of other humans. When placed under oppressive rule in a dystopic environment, that unpredictability only continues to increase. Without having a stable society, rulers would be unable to prevent social deviants from uprooting the entire established order. On guard against such attacks, rulers use techniques—most commonly violence, drugs, propaganda, and censorship—that allow them to contain the masses and shape individuals to meet the society's criteria. The use of control techniques by the rulers is central to the part of humanity that wishes to exert order upon the chaos.

Violence

Violence is often the result of final efforts to eliminate individuality. When citizens have drifted too far from the norms or have, in more extreme cases, even acted rebelliously, violence allows for flexibility in how to rectify the unbalance. As a result, the violence can often be framed as a mistake made by the offending parties; if they had not diverged from social norms, then violence would not be necessary. Only offenders will be blamed for the violence bestowed upon them, and, for fear that they might incur such a punishment, individuals may keep their wavering from society's norms to a minimum or work even harder to assimilate as much as possible.

In *The Hunger Games*, violence is the annual reminder to the members of the twelve districts of Panem that they are wholly at the mercy of the powers that be. These games are a result of the "Dark Days," when the districts rose against the Capitol. After the Capitol defeated twelve of the districts and destroyed the thirteenth, they implemented the games, providing the clear and devastating message to all districts: "Look how we take your children and sacrifice them and there's nothing you can do. If you lift a finger, we will destroy every last one of you. Just as we did in District Thirteen" (Collins, *The Hunger Games* 19). Each year, Panem's people are reminded that they brought the Hunger Games upon themselves; if they had accepted the ruling hand, their children never would have been at stake.

While holding its members hostage is already a concrete enough punishment, the government encourages its members to make the impossible choice between starving and increasing their children's chances of fighting to the death in the Hunger Games. In exchange for food, a family may add a child's name an additional time. In fact, a child may carry the weight of his or her whole family, each year adding his or her name into

the lottery pool as many times as the number of members in the household. This issue particularly impacts the poor in Panem; for those who have enough money to purchase food, there is no motivation to increase one's likelihood for certain death. Katniss describes this dichotomy as "a way to plant hatred between the starving workers of the Seam and those who can generally count on supper and thereby ensure we will never trust one another" (Collins, *The Hunger Games* 14). Year after year, this hatred is continually sustained as some families must fear the reaping—and the violence that follows it—more than others.

Through the series, violence is constantly brewing. The friction between government and governed sparks riots and an increased need to stifle the flame Katniss had sparked. In *Catching Fire*, Gale is punished for his illegal hunting outside the boundaries of the district by a new Peacekeeper—a Capitol-sanctioned security keeper for the districts, especially those predisposed to rebellion. Though hunting was once a common and systematically ignored practice, Gale is beaten with a whip until "his back is a raw, bloody slab of meat" (Collins, *Catching Fire* 105). This monumental increase in punishment indicates that, though there had been a perceived understanding between the civilians and security officers, the officers always held the power; now, it is simply being used.

While the Capitol's physical abuses could be considered largely expected—as the governing rulers of a dystopia, using it as a method to keep others in line—the rebels are evidence that violence begets violence. President Alma Coin, who leads the rebellion out of the remains of District 13, is initially an ally to Katniss. Though she leads with a strong hand, it is one that opposes the Capitol and encourages District 13 to operate democratically, with fair trials, justice, and hope.

In *Mockingjay*, President Coin's true essence is revealed when she orders bombs be dropped on rebel medics and Capitol children under the guise that it was the work of President Snow, hoping to arouse the last ounce of rebellion against the Capitol. Her capacity for violence is realized after the capture of the Capitol when she proposes one final Hunger Games composed only of children of the Capitol. The path to power can be paved with violence, and that is even more so when dystopian power is, itself, corrupt and toxic. Coin craved power, and perhaps the exposure to decades of unrelenting violence warped her into the very ruler she wished to overthrow. Within a dystopian society, it is difficult to think of anything beyond the violence which they are constantly exposed to.

Violence is perhaps the most prevalent means of control in dystopian narratives, though it is not always as prevalent as it is in *The Hunger Games*. In *The Handmaid's Tale*, violence is uncommon, though the threat of violence and death always hangs over the heads of the handmaids, as well as anyone not following the rules of Gilead. For the handmaids, infractions that demonstrate noncompliance are met with swift and damaging punishment. After Moira attacked a Martha, the Angels began by injuring her feet until "they did not look like feet at all. They looked like drowned feet, swollen and boneless, except for the color. They looked like lungs" (Atwood 91). By using frayed steel cable, the Angels are free to injure the hands and feet of the handmaids because, as Aunt Lydia said curtly, "For our purposes your feet and your hands are

not essential" (91). Although it is rare for the handmaids to be permitted to dole out violence, violence is common at the Salvaging, where violators of Gilead's rules are executed for their crimes. A political rebel, under the guise of having raped one of them and killed her baby, is presented to the handmaids for their judgments. Offred describes the collective rage of the handmaids when they hear this, saying, "A sigh goes up from us; despite myself I feel my hands clench. It is too much, this violation. The baby too, after what we go through. It's true, there is a bloodlust; I want to tear, gouge, rend" (Atwood 279). They are allowed to kill him for his supposed actions against them. Through their violence, Gilead's rules are reinforced in the minds of the citizens: the handmaids only need their wombs, and any misalignment with Gilead's cause will be dealt with swiftly and with no mercy.

Similarly to *The Hunger Games*, violence is a frequent control technique in *Nineteen Eighty-Four*. It is used as a form of punishment and as a means of brainwashing. Winston cannot see as the Party demands that he see; when they hold up four fingers, he tells them there are only four fingers when he is supposed to see five. This is a violation for which he is punished. His inability to accept the Party and see things with their prescribed mindset places him face-to-face with O'Brien for re-education. His perceptions—like those of any other "flaw in the pattern"—must be forced into the Party line with violence, and only once he accepts them wholly as truth will they execute him (Orwell, *Nineteen Eighty-Four* 263). O'Brien explains, "We make him one of ourselves before we kill him. It is intolerable to us that an erroneous thought should exist anywhere in the world, however secret and powerless it may be. Even in the instant of death we cannot permit any deviation" (Orwell, *Nineteen Eighty-Four* 263). Endless torture and, ultimately death, awaits any member of Oceania who does not see what the Party wants them to see. Their conversion does not save them from the final act of murder by the Party. They have already committed the thoughtcrime and though they have been rectified of their insanity, they must pay.

Violence in all of its forms is also a kind of anxious fear for those who suffer its consequences. It is always a worthy option to control those who cannot be kept in their place by any other means. The threat of injury, death, and the harm of loved ones consistently keeps the socially deviant in line.

Psychopharmacology
In these dystopian novels, the use of chemicals to influence the mental state of citizens is not as common as some other means of control, but it still has considerable power. In some cases, drugs are an escape, strictly chosen by the individual, which simultaneously allows them to be more easily controlled. However, in most cases, drugs are used as a self-maintaining system, implemented by leadership, where citizens perform the control on themselves with the choice to take the pills. It is especially uncommon for people to choose against taking pills. The chemical maintenance creates predictability in ways that other control techniques cannot by creating a bridge between the physical and the mental.

Soma is the emotion-manipulating drug common in *Brave New World*. This is a tool that is especially valuable for the government in the World State, because its citizens— like all human beings—innately desire avoiding pain, embarrassment, and discomfort

in favor of bliss. This desire is warped to encourage people to distance themselves from their emotions and choose to take soma at the earliest sign of negative emotions. World Controller Mustapha Mond describes soma and its power, saying, "There's always soma to calm your anger, to reconcile you to your enemies, to make you patient and long-suffering. In the past you could only accomplish these things by making a great effort and after years of hard moral training" (Huxley, *Brave New World* 238). Soma carries with it all the properties required to function in the World State. Should civilians find themselves lacking, they need look no further than to consume the drugs provided to them. Encouraged to consume for any emotionally challenging moment, they are effectively addicted to the stability soma grants them.

This stability, though, comes at a cost. Jeanie Griffin addresses this, writing, "In theory, the society is supposed to bring happiness to individuals because they have no physical or emotional hardships; however, in reality, the totalitarian society has generated a civilization filled with spiritually comatose individuals obediently fulfilling their predestined role in society while living in a slave-like blissful state of ignorance" (54). John is the only civilian who can see through the guise of stability and recognize it for what it is: an inferior version of humanity. In a discussion regarding emotions in the World State and John's disagreement with the maintenance of emotion and the removal of many inconveniences presented in the New World, Mond comments that he is "claiming the right to be unhappy," to which John agrees, claiming that he is (Huxley, *Brave New World* 240). This is a right that the entire society has gladly sacrificed, but John has lived in a world of suffering and humanity. His world held humanity in all of its flaws of nature, and it held "the right to grow old and ugly and impotent; the right to have syphilis and cancer; the right to have too little to eat; the right to be lousy; the right to live in constant apprehension of what may happen tomorrow; the right to catch typhoid; the right to be tortured by unspeakable pains of every kind," to which John confirms, "I claim them all" (Huxley, *Brave New World* 240).

These rights that John confirms are inherently a part of being human which the World State has destroyed to better humanity. The World State's citizens' need to be free of these problems is best seen in Linda, who was once a member of the New World but who was left behind on the Reservation. Believing deeply in the values of her society, she was ashamed of becoming pregnant and did not try to return. Without the soma or resources of the New World, she became old and medicated with alcohol instead. Once she finally returns to the society she once knew, she attempts to escape on a soma-holiday and remains in a drug-induced stupor until she dies. The values that drugs induce are so deeply ingrained in the civilians, and the need to feel nothing so innate in the society, that removing this resource can be detrimental, creating a "dystopian picture of the use of psychoactive drugs. In it, soma stands for alienation, de-humanization and superficial mind-numbing pleasure" (Schermer 121).

The community within Lois Lowry's *The Giver* prioritizes the strict span of emotional developmental as well, but emotional maintenance is not what they correct with pills. Because families are artificially constructed in this society through careful consideration and without any physical requirements of those who raise the children, the elders choose to regulate the hormonal balances of every person who resides within

the society. This is done easily with pills, given to each individual once they begin experiencing "Stirrings," a veiled reference to puberty. In a society where sex is not mentioned, and Birthmothers are not held in high esteem, the regulation of physical desires is a necessary component to keep the society functioning properly.

While the use of drugs as control is less common in other dystopian works, it still can be seen, primarily as a means for individuals to numb themselves from their society. In *Fahrenheit 451*, Montag's wife Mildred overdoses but vehemently denies taking thirty sleeping pills in one sitting. This, however, is not a strange occurrence. Overdoses are so widespread—often nine or ten a night—that doctors are no longer sent to the houses to revive people. Instead, a machine was created to filter the blood, making it a more efficient option. Critic Kingsley Amis says the regularity of these incidents creates a dangerous demonstration to show "how far the devolution of individuality might go if the environment were to be modified in a direction favorable to this devolution" (111). If the society were to continue in this same direction, one could be easily assured that the rate of chemical dependency and subsequent overdose would escalate accordingly.

In *The Hunger Games*, drugs are uncommon but alcohol still exists as a means of escaping the downtrodden society. Haymitch Abernathy, one of only three victors of the games from District 12, is rarely sober. For the twenty-three years following his own victory, he mentors the tributes from district 12 and half-heartedly tries to keep them alive. His experiences in the arena, the killings of his mother, brother, and girlfriend by President Snow, and his failed mentorships lead him to erase the memories with alcohol, paranoid and alone. Though Haymitch chose to use alcohol to escape, it lessened his likelihood of rebellion and kept him under control of the Capitol.

The Capitol, though, is known for using a method of psychopharmacology against its rebels, known as "hijacking." By taking the venom of a tracker jacker—a species of wasp, genetically engineered by the Capitol for use in the Hunger Games—and using it to conduct fear conditioning, they are able to induce "terror. Fear. Nightmarish visions…mental confusion" and "a sense of being unable to judge what [is] true and what [is] false" (Collins, *Mockingjay* 180). By using this against Peeta, the Capitol was able to position him against his own allies, even attempting to kill Katniss when they are first reunited. By altering his memories to align with the Capitol's notions of society as well as to distrust those who he once fought for, Peeta is left in a state of unpredictability, wavering between ally for the alliance and weapon for the Capitol.

Either by their own choice or encouraged by the government that controls them, drugs are a means of keeping people docile, malleable, and controllable. After having been so deeply conditioned to lean on the drugs they are encouraged to take, it is impossible for civilians to function without them because they have never experienced the complexity or depth of emotion without the calm induced by drugs. It would be detrimental to the society for emotional maintenance to be required of each member, potentially even if they had never encountered these chemical compounds in the first place. Along with their controlling properties, drugs are the governments' insurance policies against the society truly recognizing what is happening around them and, sometimes, within themselves.

Propaganda

The use of propaganda in literary dystopian societies occurs by creating messages and projecting them to the masses with consistency; the masses are eventually conditioned to believe what they are told. This is especially the case when no other evidence exists to contradict the message. In each of these novels, protagonists are forced to consume propaganda.

Oceania in *Nineteen Eighty-Four* has an exceptional model for propaganda and conditioning use for controlling citizens. Propaganda is managed by the Ministry of Truth; contradictory to its name, the ministry concerns itself with the lies of the Party, while the Ministry of Love focuses on war, the Ministry of Peace on torture, and the Ministry of Plenty on starvation and rationing (Orwell, *Nineteen Eighty-Four* 222). In the novel, Orwell describes the depths of the Party's power over human memory and the way its propaganda corrupts a person's understanding of his or her own life: "Even the outline of your own life lost its sharpness. You remembered huge events which had quite probably not happened, you remembered the details of incidents without being able to recapture their atmosphere, and there were long blank periods to which you could assign nothing" (*Nineteen Eighty-Four* 33). No one can hold onto the truth with enough strength or authority to determine its truth. Simultaneously, the truth is what the Party wants it to be; for Winston, after enough pressure, torture, and propaganda, truth eventually has no meaning at all.

This ever-fluctuating truth, promoted by the Party's propaganda, occurs by "rectifying" records in an endless cycle of creating content, distributing it, and then editing it to align the content with a new truth of the Party (Orwell, *Nineteen Eighty-Four* 39). The citizens are left in such a state of confusion that rebellion would be utterly impossible. Winston works for the Ministry of Truth, altering messages to create continuity. He explains, in one instance, a prediction had been printed in a news article which has turned out to be incorrect. It is his job to rectify the prediction to match the correct value (Orwell, *Nineteen Eighty-Four* 40). With the truth in constant revision, the only consistent truth the citizens have to rely on is Big Brother. Both of these are results of Oceania's obsession with the present. Kathryn M. Grossman expands upon this when she writes, "The use of technology to discover people's thoughts, to rewrite the history of the state, and to torture and destroy its dissenting citizens is but a symptom of a greater disorder—the will never to change. Technology exists as a tool for Oceania's ceaseless striving towards its own form of static perfection" (53). Propaganda is a powerful tool for the seeking of constant perfection and acquiring power for the Party.

Propaganda is a prevalent weapon seen frequently in other works. The World State, as it is described in the pages of *Brave New World*, is saturated with propaganda, beginning with its very motto: "Community, Identity, Stability" (Huxley, *Brave New World* 3). As long as members identify with the community, they will be stable. The propaganda is often recognized by the characters who struggle to fit in with the society, but it has the most impact on John, the savage. Since he has experienced life where humanity still remains, he struggles to reconcile the World State and its "stability" with the humanistic values of the life he left behind on the Reservation. Andrew W. Hoffecker writes that "the Savage is reminded that the virtues such as self-denial,

nobility, heroism, and chastity are impossible because conditions of instability do not exist where they can be exercised" (51). These are only qualities that can exist or are valued where instability exists. Attempts to demonstrate any of these—self-denial, nobility, heroism—are met with discomfort from surrounding citizens who recognize the atypical behavior as resistance to the propaganda.

In *The Handmaid's Tale*, before graduating and becoming a handmaid, Offred and her fellow handmaids are subject to conditioning and propaganda at the Rachel and Leah Center, named for the Biblical women. Propaganda comes in many forms, often paired with violence and conditioning should the message not be as direct as necessary. Offred describes many of the films that the women are forced to watch to remind them how life had once been and how far they had come, a testament to the betterment of society because of Gilead's existence. Images of rape, violence, murder, and degradation are used to make the handmaids grateful for the state of their community. Other videos of the Unwomen protesting authority, marching as part of a crowd, are used to make them grateful for their role. These Unwomen, according to Aunt Lydia, were "wasting their time like that, when they should have been doing something useful" (Atwood 118). Where a lack of innate loyalty exists, the aunts cultivate it by reminding them what life could be like.

President Snow in *The Hunger Games* uses propaganda to frequently lie to citizens regarding the status of Panem. As Don Latham writes, "In Panem, as in all totalitarian societies, the government's survival depends not only on its ability to impose punishment and enforce discipline, but also on its ability to manipulate media and control the flow of information" (35). After drugging and torturing Peeta to make him complicit in the Capitol's goals, Snow uses him as a spokesperson against the rebellion and against the imminent battle for control over Panem. Over a televised interview, he offers a veiled threat to remind all viewers of the last time a rebellion occurred: "We can't fight one another…There won't be enough of us left to keep going. If everybody doesn't lay down their weapons—and I mean, as in very soon—it's all over, anyway" (Collins, *Mockingjay* 26). Katniss, along with the rebels of District 13, are distressed by the converting of such a loyal ally, and Peeta is labeled a traitor for his proclamation of a cease-fire.

President Coin and the rebel cause she leads use propaganda not to calm the citizens but to enrage them to join District 13. By manipulating Katniss's emotions, they use her image to create propaganda to incite districts to rebel. Though the uprising of District 13 has goals of setting Panem free of tyrannical leadership, Coin has ulterior motives of claiming control of the nation for herself and she encourages violence as the primary means of securing her victory. The rebellion analysis of the images they distribute demonstrate that they are not aiming only to encourage the districts from freeing themselves from the Capitol's rule but also to deliberately influence opinions and loyalties of the districts. While negotiating her terms for agreeing to act as the rebellion symbol, Katniss asks that Gale join her to which President Coin asks, matter-of-factly, "Do you want him presented as your new lover?" (Collins, *Mockingjay* 39). This is followed by another rebellion leader who comments, "I think we should continue the current romance. A quick defection from Peeta could cause the audience to lose sympathy for her ... Especially since they think she's pregnant with his child" (39). Rather than making choices that would encourage

and inspire viewers to believe in a better future of peace and equality, the rebel leaders plot and deceive to achieve their goals.

Coin's legacy of deceit continues through the fight for control over Panem. Though, initially, Katniss is a fitting and vital symbol for the rebellion, as time progresses, her value diminishes in Coin's eyes as the war draws to a close. Boggs, Coin's second-in-command, explains to Katniss, saying, "She doesn't need you as a rallying point now. As she said, your primary objective, to unite the districts, has succeeded … These current propos could be done without you. There's only one last thing you could do to add fire to the rebellion … Give us a martyr to fight for" (Collins, *Mockingjay* 266). This is proven correct; following the apparent death of Katniss, Coin uses it as a propaganda opportunity to proclaim to all districts: "Dead or alive, Katniss Everdeen will remain the face of this rebellion. If ever you waver in your resolve, think of the Mockingjay, and in her you will find the strength you need to rid Panem of its oppressors" (294). Katniss acts as a symbol for the rebellion, and in death, she becomes a martyr for the cause.

Conditioning and propaganda go hand-in-hand in their constant inundating of the masses with information until they have no choice but to believe it. The conditioning and propaganda can be especially difficult to consume for those who have witnessed life that no longer exists in their society. Resistance to the truths offered by authority can have dangerous consequences, as is the case with Winston, John, and Offred, all of whom are removed from society for their counter-truths.

Censorship
Where propaganda gives to the masses, censorship takes away. A society unable to educate themselves is unable to participate adequately in a civilized democracy or consider life outside of themselves. This is the ideal for a government that desires to easily mold their citizens and create predictability. Books, television, and forms of entertainment are often both censored and transformed into propaganda by taking the courageous thoughts that inspire and replacing them with unsubstantial, government-approved drivel.

In the society in *Fahrenheit 451*, like many other dystopian societies, reading and owning books is a criminal offense and instead of firefighters snuffing out fires, they set them. This is a formidable means of control because the firefighters are "burning not just books but ideas" (Day). Unlike most dystopias, this is a society that its members accepted for themselves. To avoid unhappiness, stress, and worry, information was gradually withdrawn. As Beatty told Montag, "If you don't want a man unhappy politically, don't give him two sides to a question to worry him; give him one. Better yet, give him none" (Bradbury, *Fahrenheit 451* 58). Simultaneously, the government and its people worked to create a world where people were "happy." Taking information from the masses makes them easier to control, while it also allows people to worry less about the happenings outside their lives.

Faber, a retired English professor in *Fahrenheit 451*, explains the culture of carefreeness and the way that it cannot simply be altered by one person picking up a book with determination, as Montag has done. He says, "So few want to be rebels any more. And out of those few, most, like myself, scare easily. Can you dance faster than the White Clown, shout louder than 'Mr. Gimmick' and the parlour 'families'? If you can, you'll

win your way, Montag. In any event, you're a fool. People are having fun" (Bradbury, *Fahrenheit 451* 83). No one is interested in rebelling against the establishment and, in fact, it would be impossible to pull them away. While books were no longer allowed, they had been replaced with suitable entertainment and constant fun to distract the masses, keeping them happy and free but also living a meaningless life. This freedom, however, is in opposition to the freedom spoken of by Plato in his vision of utopia. James Filler explains "Freedom, then, is for reason to rule over the soul. But this, by itself, is insufficient. Reason can be misguided or lack knowledge … For Plato, not only are knowledge and freedom not antagonistic, but also true freedom occurs only through knowledge" (3). If the public is unable to access knowledge, then freedom, as Plato saw it, is not possible. Within *Fahrenheit 451*, there is a belief that, because they do not have to carry the weight of the knowledge of wars, famines, or tragedy, they are able to be free, when, in fact, the exact opposite is true. It is by their ignorance that they are unable to possess any freedom at all. According to Sunjoo Lee, Montag is in opposition because of "reclaiming this nearly 'forgotten' body of him, of his [hands'] being shocked to life again, in the process of which he will take back his freedom to read and think" (144) Without realizing it, he is attempting to exercise true freedom through knowledge.

Montag's wife is a perfect example of consuming meaningless content while expecting it to provide her with meaning in her life. She is far more connected to the "family" she visits every night on the three television screens of her living room than she is to Montag. Her horror over his collection of books is related more to the fear that the firemen will burn and destroy her "family" rather than the act itself. This supports M. Keith Booker's statement that "the entire culture of this society seems designed precisely to numb the minds of the populace and to prevent them from experiencing any real thought or feeling" (88).

Censorship occurs frequently in other dystopian works because of its ability to make people ignorant. *The Handmaid's Tale* is similar to *Fahrenheit 451* in its societal ban on reading and censorship. The censorship in Gilead even goes so far as to remove the words on store signs, replacing them with images of what can be purchased there in order to forgo the slightest possibility of reading. Offred craves words and the exercise of her mind, regardless of the punishment it threatens. Once invited into the Commander's study, she discovers books and magazines, forms of entertainment only allowed in the hands of those "beyond reproach" (Atwood 158). Upon her visits, her hunger to use words is seen in the games of Scrabble she and the Commander play, as she uses words like "larynx," "valance," "quince." Later, this hunger evolves into devouring the illicit magazines he provides her and the books within his office. Offred describes the intensity of her reading, saying, "I read quickly, voraciously, almost skimming, trying to get as much into my head as possible before the next long starvation" (Atwood 184). Because Offred, in her former life, knew the joy of books and their knowledge, she craves them still.

Unlike *Fahrenheit 451* or *The Handmaid's Tale*, censorship comes in a different form in *The Giver*. There is no temptation to violate the laws governing books and their censoring because there has been no exposure to them in the first place.

Instead, knowledge of all kinds is censored; the knowledge outside the community is compressed and granted to only one individual. The memory of an entire society—the history, art, pain, suffering, and happiness of all civilization—rests in the mind of one person so that all others focus only on what is in front of them. They cannot ponder outside of their lives because they have no knowledge of anything greater than living within a community.

When Jonas ponders the absence of decision-making in the Community, he expresses feelings of both frustration and fear. Unable to see color consistently, he exclaims his annoyance, saying, "If everything's the same, then there aren't any choices! I want to wake up in the morning and decide things!" (Lowry 9). He retains these feelings in his conversation with the Giver, but he also recognizes the devastating impact that having choices could have on individuals or the community at large. Should a person decide on a mate or a job without the weighty consideration of the Committee of Elders, the likelihood of an incorrect choice increases. Though he desires choice, Jonas agrees that it would be dangerous to allow it freely. Choices always provide the potential for poor outcomes, for disastrous consequences. Because of this, life is safer in the Community than without it and Jonas, in fact, supports this.

Censorship is destruction, not just of ideas, but of every thought that could have consequently arisen. When dystopian governments are trying to prevent freedom, censorship is a frequent tool because of the ease it creates for the public. Destroying thoughts of pain, suffering, and confusion, as well as destroying the potential of poor choices, can be a method which goes unchallenged by the governed. When censorship goes unknown, as it does in *The Giver*, no one is the wiser and they are content for it. However, when censorship occurs after members have known another life, as in *The Handmaid's Tale*, the craving to break rules may be too tempting to deny.

The rulers and political structures, in whatever form they take for dystopian societies, make up the expectations for the citizens and the consequences that follow when norms are not met. Big Brother, Mustapha Mond, and President Snow use fear to keep all citizens in line. Without their aggressive forms of control, such as violence, propaganda, and drugs, it would be impossible to demand complete obedience from those they oversee. Control and how they wield it are the rulers' greatest tools for manipulation and driving fear into the hearts of each citizen, demanding conformity and therefore creating a dystopia based on how they treat their members.

INTERPERSONAL RELATIONSHIPS

Relationships exist in dystopian societies, though they hardly resemble those that appear in the real world. They are, instead, poor facsimiles of the most important relationships that bind human beings together. This chapter will explore how corrupted sexual relationships, falsified families, and superficial friendships force every person into the role the rulers want them to play, always with the goals of the society in mind. To challenge the relationship standards that have been set is to risk one's life, but for the rebels within the dystopian societies, sometimes pushing aside their fear is worth the benefits of having an illicit relationship.

Sexual relationships

The qualities surrounding sexual activity and relationships can differ widely between dystopian novels, yet the power sex holds is always relatively high. Sexual acts and relationships are not private affairs. Instead, they fall into two categories, according to Sargent and Sargisson, "sexual relations [that reproduce]" and "sexual relations [that are] gender-equal assertion of the right to act freely" (316). This variability occurs based on the influence of the government within the relationship. Since sex has no reproductive purpose in *Brave New World*, it is only used for entertainment. In comparison, in *The Handmaid's Tale*, the future of the human species relies on a select number of women who are still able to bear children.

In Margaret Atwood's *The Handmaid's Tale,* sexual relationships are warped into something entirely void of relationship. When repopulation becomes the sole objective for humanity, the balance of power is revisited, and women are ranked based on their ability to contribute to this goal. The threat of being sent to the Colonies—an area contaminated by pollution, chemicals, and the like—is a death sentence, and therefore keeps the women in line. Gilead's history of killing protestors and rebels continues to prevent statements of discontent. Ofglen is a vessel for the future of mankind, her only value being her womb. Without any escape from this truth, she accepts her status, stating, "We are containers, it's only the insides of our bodies that are important" (Atwood 96). The usefulness of women—and what separates them from the "unwomen"—is to conceive and provide children. There is nothing romantic about their purpose or role. Aunt Lydia describes this society best when, while wagging her finger at the handmaids, she says, "Love is not the point" (Atwood 220).

Sex becomes a means to an end for the chosen citizens of Gilead, and that is exactly what they are told—they have been chosen. Sex is regulated for both genders. Though women bear the weight and stress of furthering the species, sex is still a rarified commodity for the society. It is illegal to have sexual relationships not sanctioned by the state because "marriage is promoted as a social goal, though it is only available to those who have reached a certain social status in this strongly stratified society. Indeed, wives are literally 'issued' to successful males as rewards for loyal service in the community, demonstrating the thorough commodification of women in Gilead" (Booker 78). Gilead and its moral base do not wish for sexual relationships to be seen as they once were; instead, they are transactional. Since each household desires the honor and pride of having a child of their own, they experience the degrading and uncomfortable addition of a third party to the relationship: man, wife, and a Handmaid to consequently provide a child. Offred describes this:

> Above me, towards the head of the bed, Serena Joy is arranged, outspread. Her legs are apart, I lie between them, my head on her stomach, her pubic bone under the base of my skull, her thighs on either side of me. She too is fully clothed. My arms are raised; she holds my hands, each of mine in each of hers. This is supposed to signify that we are one flesh, one being. What it really means is that she is in control of the process and thus of the product. If any. (Atwood 93-94)

By introducing this third member to the relationship, Gilead's leaders have forced a discomfort that no individual can overcome. This is by design; the process is not meant to

be enjoyable, for, if it is enjoyable, it is sin. Sex is for one purpose: to have children, and, in doing so, to glorify God. No members of the society deny this, nor is sex an experience to be savored. Instead, Ofglen describes it, saying, "It has nothing to do with sexual desire … Arousal and orgasm are no longer thought necessary; they would be a symptom of frivolity … This is not recreation ... This is serious business. The Commander, too, is doing his duty" (Atwood 94-95). She notes that no one in this situation is pleased by it, yet they all participate because this is their job. This is how they contribute to the society.

To remind everyone why the world has evolved, there are constant references to what life had once been like, to the flaws of the oversexualized and immoral world that Gilead left behind. During training, Aunt Lydia judges the women of the former age, saying, "some women believed there would be no future, they thought the world would explode. That was the excuse they used, says Aunt Lydia. ... They were lazy women, she says. They were sluts" (Atwood 113). Here, Aunt Lydia creates a link between the words "lazy" and "slut" and their new meaning: sex for no purpose.

Sex without purpose, however, is exactly the goal within *Brave New World*. The World State has eliminated emotions, parenthood, and connections, all to eliminate exclusiveness and its "narrow channeling of impulse and energy" (Huxley, *Brave New World* 40). Sex has a stringent purpose: "Sex is for fun or religious devotions, procreation is via hatcheries, love and the family and motherhood are useless components of the package and have been discarded" (Walsh 142). As a result, sex carries with it no emotional attachments nor consideration of any consequences. As one of the World State leaders explains, "No civilization without social stability. No social stability without individual stability … Stability. The primal and the ultimate need. Stability. Hence all this" (Huxley, *Brave New World* 43). Everything the World State implements is to foster development of their motto: "Community, Identity, Stability" (3). From a very young age, the children of the World State are exposed to sexual activity and the accompanying belief that "every one belongs to every one else" as a kind of game (40). This normalization primes them for a life of mindless consumption of sex, devoid of any feelings or relationships.

In *The Giver,* the exact opposite is true. There is no place for sexual desires or activities. There are specified roles for reproduction and drugs are implemented to assuage sexual desires. Ultimately, this conforms all members to asexuality, where sexual interest and conduct are banned from human life. Conveniently, this is done by the Elders by drugs which makes all members of the Community disinterested in sexual activity as well.

Sexual relationships in *Nineteen Eighty-Four* most closely resemble those of the real world, still with its own dystopian distortions. Sex is still reserved for Party-approved marriages, but it is not used as an expression of love. Rather, it is used only for procreation. Winston and his wife live separately because the only real component of marriage in Oceania is conception and they are unable to do so. Winston's relationship with Julia would have been a form of rebellion even without sex, due to their deviant conversation and beliefs. But their unsanctioned and deliberately hidden sexual relationship violates the true goal of the Party in the elimination of sex outside of marriage. While important, this was not "merely to prevent men and women from forming loyalties which [the Party] might not be able to control. Its real, undeclared purpose was to remove all

pleasure from the sexual act. Not love so much as eroticism was the enemy" (Orwell, *Nineteen Eighty-Four* 67). While Winston and Julia feel loyal to one another, their erotic relationship and enjoyment is the true affront to the Party and is the reason that Winston's emotional attachment to Julia must be extinguished during his time in Room 101.

Sex, regardless of how it is used, is meant to be separated from meaningful relationships for the individuals of the society in dystopian novels. For protagonists who feel at odds with the values their community emphasizes, sexual relationships are perverted from a means of loving expression to a worthless form of entertainment, a purely reproductive exercise, or an activity that only lives in the past. Dystopian novels explore alternative ends for sexual relationships and the potentials for how those relationships may develop, but in every instance, the former meaning—a loving union between two people in a mutual relationship of their choosing—is excised and ultimately forgotten.

Family

It has been theorized that when family units became the norm for homo sapiens, they demonstrated the first instance of humanity. Jean-Jacques Rouseeau writes they were "united husbands and wives, parents and children, under one roof; the habit of living together gave birth to the sweetest sentiments the human species is acquainted with, conjugal and paternal love. Every family became a little society" (216). These are the very sentiments that make familial relations so dangerous within societies that demand absolute control over the masses. Family units in dystopian literature often take a particular kind of planning and predetermination, if they exist at all. The best means to safeguard the relationship between state and individual and to fracture any sentimental or biological bonds—as seen in families—would be to eliminate them altogether. If that is not possible, an alternative is to create an environment where the present is ever consuming to reduce sentimentality. In dystopian literature, if families still act as a prevalent way of raising children and preparing them for their community responsibilities, these relationships are rarely genetically authentic. More often, they are the result of strategic planning on the ruler's part, to ensure adequate transition or proper upraising.

In *The Giver*, like many other dystopian societies, families are completely dictated by the parties in control. Families begin with the initial pairing of spouses, which is given "such weighty consideration that sometimes an adult who applied to receive a spouse waited months or even years before a Match was approved and announced" (Lowry 48). Since the cohesiveness of the community depends largely on these spousal pairings and the family units, common qualities such as disposition, energy level, and intelligence are vital. Jonas noted his mother's higher intelligence and his father's calmer disposition as factors in their successful marriage (Lowry 48).

Giving children to the spouses to raise is given the same amount of weighty consideration, but, even in a society that values families and their development, it is women who work to bring children into the world and are still devalued. These women are known as Birthmothers for the three years that they spend having children. Then they are Laborers for the rest of their lives until they enter the House of the Old. The contrast between family units and the women who make it possible is yet another instance of the value that is placed on the nuclear family.

Within the Community, the nuclear family lasts only one generation. The past is constantly eliminated, similarly to the way that the past is forced to be carried by the Giver, so that any connections are destroyed. Families are an illusion, created artificially, and its members move from one nuclear family to the next. Jonas discovers this with surprise when he learns that he has grandparents, or parents-of-the-parents. Each child is raised in a family with a mother, a father, and a sibling of the opposite sex. Later, the children move on with their lives, hoping to acquire spouses and nuclear families of their own, thereby abandoning one family for the next, leaving behind their past in pursuit of their own futures. Once Jonas moves on to have a family, he realizes, his parents will no longer be a part of his life. When conversing with the Giver about the death of his parents, Jonas states, "I won't even know about it. By then I'll be so busy with my own life. And Lily will, too. So our children, if we have them, won't know who their parents-of-the-parents are, either" (Lowry 124-25). The cycle of constant movement from one nuclear family to the next emphasizes the Community's intolerance towards the past as well as emotional connection.

In *Nineteen Eighty-Four*, there is a family of a different kind. Near its end, Winston learns to see as the Party wants him to and he exclaims, "O cruel, needless misunderstanding! O stubborn, self-willed exile from the living breast!" (Orwell, *Nineteen Eighty-Four* 308). This creates a tone of maternal relationship with the Party, which Aaron S. Rosenfeld describes as a "perverse switch on the family romance, the subject's true home in the law. 1984 closes with Winston's successful return to the bosom of 'family'" (354). This connection between the people and Big Brother now seems obvious to Winston. His thoughtcrimes will have him executed at a time unbeknownst to him, and now he can see Big Brother as he always should have. This misunderstanding will separate him from this parental figure he now finds in Big Brother. Winston is like a lost son who finally returns home, which, according to Paul Robinson, "suggests the collapsing of all dichotomies—threatening patriarch and beckoning mother, self and non-self, history and timelessness-into oceanic oneness" (157).

Biological families are still in existence in *Nineteen Eighty-Four*, and they, too, emphasize the law as family. Winston is married, though he and his wife live apart because of her inability to conceive. There is a threat that accompanies parenting children in Oceania. Since children have no memory of life before the revolution, they are blank slates for the Party and for Big Brother to imprint upon. These children are especially radical in enforcing the Party's beliefs. Mr. Parson—a fellow worker at the Ministry of Truth—has a wife and two children: the Parsons are a nuclear family. Upon visiting the family, Winston is struck with fear when witnessing the children playing spies because the "family had become in effect an extension of the Thought Police. It was a device by means of which everyone could be surrounded night and day by informers who knew him intimately" (Orwell, *Nineteen Eighty-Four* 168). These children are so easily and completely impacted by the teachings of the Party that they consume it completely and make them informal spies for the Party. This results in the severing of "emotional bonds between family members, effectively demolishing the true family unit and creating citizens whose loyalty to the state is stronger than their loyalty to their parents or siblings" (Griffin 53-54). In fact, these same children turn in their father for speaking against the party in his sleep. Loyalty, for these children, does not rest with their parents; it rests with their family, the law.

In *The Handmaid's Tale*, the structure of family also takes a unique form. Because of the addition of a third member into the reproductive process, birthmothers are only vehicles for the birth of another woman's child. Offred comments that there have been problems with Handmaids unwillingness to give up their children, a choice entirely out of their control. The process of birth shares similarities with conception, as the wife sits on the Birthing Stool, behind the handmaid. When the child is born, the wife of the household is tucked into bed and the child placed into her arms, as though the handmaid had never been there.

The Everdeen family of *The Hunger Games* is an excellent example of the radical loyalty that can grow when ties have not been severed. Katniss, Primrose, and their mother have a relationship forged by dystopian struggle—one only to be broken by death. It is a relationship distinct from other families in her community: when Primrose is initially chosen as tribute for the Hunger Games, Katniss's first reaction is to demand taking her place, but when Peeta is chosen as tribute, neither of his brothers volunteer themselves. Katniss clarifies, saying, "This is standard. Family devotion only goes so far for most people on reaping day. What I did was the radical thing" (Collins, *The Hunger Games* 26). Her commitment is unique, and that makes it dangerous. Lindsey Issow Averill explains what separates Katniss from others, writing, "Undoubtedly, the emotions that motivate Katniss to act courageously are good ones: loyalty, love, devotion, compassion, and care … Katniss volunteers to go in Prim's place because her devotion to protecting her sister runs much deeper than anyone in District 12 believes is morally required, not because she's compelled by some abstract moral principle" (Averill 164). No one else has the degree of devotion Katniss feels for her family, which continuously drives her to do whatever it takes to protect them. If the Capitol had strained or severed the familial ties, Katniss would have stood by and watched—as Peeta's brothers did—while her sister was sent to her death, and the Capitol would likely have been left standing.

In dystopian novels, typically familial ties are strained in a manner to prevent any loyalty that would eclipse the loyalty that should be felt for the community at large. Relationships in which loyalty could lie somewhere other than within the community are effectively managed in other means of the dystopian society and, more likely than not, become impossible. Family relationships are subject to the same scrutiny as sexual relationships and friendships, ultimately requiring vows to the community, not to each other. Consequently, it is most common for nuclear families to be eliminated whenever possible.

Friendship

Friendships in dystopian literature are truly rare and could, in fact, be considered a kind of control technique implemented by the powers of the society. The rarity of friendship is typically the result of the awareness that everyone is distinctly and intentionally separated from each other. For fear that there may be an uprising, resulting from connections made, the society is often deliberately organized to prevent such relationships. The extreme social duress that people feel in these societies prevents them from seeing any real benefits to investing in relationships with others.

In *The Handmaid's Tale*, Gilead is pervaded with suspicions. No one is above doubt, and no one feels safe enough to trust another person. This, however, does not prevent attempts to bond with others. Offred comments on this bluntly, stating, "We aren't allowed to go there except in twos. This is supposed to be for our protection, though the notion is absurd: we are well protected already. The truth is that she is my spy, as I am hers" (Atwood 19). The society has demanded fear of others from all parties and uses these friendships as a means of spying, expecting those who see or hear things abnormal to report them. As Margaret J. Daniels and Heather E. Bowen describes it, "Friendships, then, are strictly forbidden, this mandate taken to the extent that the Handmaids can only speak to one another in dictated generalities and are not permitted to look at one another directly" (5). Breaking these generalities and customs, as a result, has become a thing of revolt. Even the simple act of saying "yes" when responding to a comment instead of the prescribed "Praise be" is considered taking a chance.

Though threats abound for the handmaids who attempt to bond, that does not stop them from occasional and brief interactions. During Birth Days, for instance, the handmaids are full of jubilation. When Offred climbs into the Birthmobile, she is greeted by handmaids she has never met but who are sharing in the same joy she feels. She describes another handmaid saying, "She's laughing, she throws her arms around me, I've never seen her before, she hugs me, she has large breasts, under the red habit, she wipes her sleeve across her face. On this day we can do anything we want" (Atwood 112). This has its limits, though; shared joy over a birth is not the same as friendship.

One instance of making a dangerous attempt at friendship occurs when Ofglen expresses the keyword "Mayday" to Offred, which notes her as a nonbeliever in Gilead's mission. Though she speaks casually enough, this is actually a deliberate and dangerous attempt at friendship. This, however, is a worthless effort because the word's meaning within the network is unknown to Offred. This expression is later mimicked by Offred to Ofglen's replacement. Instead of obliviousness as Offred had expressed to the first Ofglen, her new walking partner is not quite so ignorant of Mayday's meaning. She, however, is not one of them and the mistake haunts Offred.

After Offred's outing as a "violator of state secrets," Nick assures her that things will be all right immediately before she is to be taken by the black van, using the same keyword of alliance that she had heard before. He says, "It's all right. It's Mayday. Go with them" and goes so far as to call her by her real name (Atwood 293). This, however, does not convince Offred of anything. Even with the use of this keyword, Offred does not let her guard down, asking herself, "Why should this mean anything?" and wondering if he is perhaps an Eye, trying to make her go with them more easily (Atwood 293). Even after having an intimate, illicit relationship with him, Offred questions his intentions, who he is, and what he actually wants as she does with anyone else she has met since her world changed.

Though their once free and honest speech evolves into whispered words in bathrooms, Moira and Offred demonstrate best that to have alliances in their world is to be a threat. Their relationship contrasts with that between Offred and Ofglen because of the environment where they had been formed. Since Moira and Offred had no reason to

mistrust each other when their relationship began, this attitude continues through their lives and their unexpected meetings. They had the grounds to connect so deeply in the past and continue to adapt their friendship for the circumstances that face them.

When Offred is first united with Moira, they know any sign that they knew each other could be dangerous. Even before they are fully trained handmaids, they have no doubts about the peril imposed upon them. Offred describes the first time seeing her in the center, saying:

> We avoided each other during the mealtime lineups in the cafeteria and in the halls between classes. But on the fourth day she was beside me during the walk, two by two around the football field. We weren't given the white wings until we graduated, we had only the veils; so we could talk, as long as we did it quietly and didn't turn to look at one another. (Atwood 71)

They had little opportunity to communicate before Moira's final escape, but the same friendship that had bonded them before keeps them safe in each other's company.

It would be many years before they would be united again, and when they were, their initial reactions are anything but jubilant. Offred says, "We stare at one another, keeping our faces blank, apathetic. Then she makes a small motion of her head, a slight jerk to the right. […] Our old signal" (Atwood 239). Though Moira is not a handmaid and lives in a world much different from Offred, she is still not allowed friends, nor is she allowed to act in any way that would suggest that they have just reconnected for the first time in years. But instantaneously, their relationship resumes. The risk is irrelevant; they crave the connection too intensely.

Friendships—like any other relationships that differ from the society's norms—are regularly met with discomfort and even suspicion in other dystopian works. In *Brave New World*, it is considered distinctly abnormal for individuals of the opposite sex to spend any continuous amount of time together. It does not warrant a second glance if two women often speak with one another—for instance, Lenina and Fanny; however, it is considered strange to repeatedly associate with someone of the other gender. Even having sex with the same person several times is met with confusion. Though these do not demonstrate friendships in any sense, these are the means by which the World State discourages any relationship other than those that they wish to instill.

In *Fahrenheit 451*, Montag lives a meaningless life, but he finds joy in a strange young woman named Clarisse. She, like Montag, is unlike the people around her. She has no interest in destruction or killing like other children her age, and the peculiar questions that she asks Montag are the catalyst that forces him to reconsider his job and his life. Clarisse is presumably killed and disappears from Montag's life, but her influence resonates with Montag. The relationship between the two, however brief, is still one that leads to Montag's rebellion.

Friendships in dystopian societies carry fear of two kinds. First, there is the fear of being found out and for bonding over illicit topics. This is one which may be met with violence and even death. Second, and perhaps worse, is the fear of being betrayed.

Violence and death are certainly potential outcomes, but the loss of what a dystopian citizen believed to be a friend may be even worse. Because trust is such a rare and, often, falsified commodity, it is often easier to give into the fear than fight against it.

Dangerous or not, the craving for companionship and understanding, whether it be in sexual, familial, or friendly relations, overwhelms people, even in the circumstances of dystopian societies. Alone, one person can make very little difference, but united, limitless destruction can come to the dystopian societies that rulers and governments worked so hard to create and maintain. For rulers to prevent such uprisings, they encourage separation and forbid any interactions that are not strictly superficial, loyalties beyond that to the government can be avoided.

THE CREATION OF UNITY

In these dystopian worlds so strictly monitored and deliberately organized, there are still opportunities for connection between the people. Some of these are implemented by the government, aware that the human race is a social animal and that the society would be unable to thrive without some form of unification. In each dystopian novel, the individuality of each person is eradicated in favor of creating groups of people with shared characteristics. As such, no person is unique, but they are unified with members of the community similar to them and together, they are bonded with something that separates them from other groups. This chapter will explore the final common characteristics of dystopian literature and the various ways societies create unity within communities while devaluing individuality.

In *Brave New World*, unity is created by methodical and deliberate means. People are discouraged from bonding themselves specifically to individuals—for example, being a part of a monogamous relationship—but they are conditioned to identify only with members of their caste and to dismiss the other castes. This is done regardless of where members fall on the social ladder. Beginning in youth, children are conditioned to appreciate the work of the castes above them, listening in their sleep to a soft voice say, "Alpha children wear grey. They work much harder than we do, because they're so frightfully clever. I'm really awfully glad I'm a Beta, because I don't work so hard" (Huxley, *Brave New World* 27). They are conditioned to dislike those below them: "and Delta Children wear khaki. Oh no, I don't want to play with Delta children. And Epsilons are still worse. They're too stupid to be able to read or write. Besides they wear black, which is such a beastly colour. I'm so glad I'm a Beta" (Huxley, *Brave New World* 27). From the conditioning of their youth and the continued value of the caste system during their life, the "citizens of Huxley's bourgeois dystopia lack real individual identities … Instead, they exist principally as specimens of their class" (Booker 172).

The unity created in *Brave New World* has deep roots in the basis Plato described as the utopia, with Bokanovsky's Process acting as a counterpart for Plato's allegory describing the tiered roles for society. Instead of the three tiers described by Plato, Huxley expands this to cover a range from Alpha-plus to Epsilon-minus. The manner of assigning individuals to their position is also improved in *Brave New World*. As

W. Andrew Hoffecker writes, "The genetic engineering of *Brave New World* appears to have fulfilled such a view by guaranteeing through technology a perfectly ordered society. Not only are people's natures and skills determined at birth; they are actually created" (4). In the lesser members of society, their value is lessened even further, as Deltas, Gammas, and Epsilons may have as many as ninety-six identical siblings, all created from the same egg and sperm, which is the method of Bokanovsky's Process. Suljic and Öztürk write about this process, saying, "The methods of accomplishing such high social goals—such as genetic engineering for the sole purpose of providing human bodies for the state's requirements for mass production and consumption—are gruesome and Dystopian" (35). As gruesome and dystopian as it may be, it is a simple process of life not just in London but across the entire world. Unity is particularly easy to create within the lower classes considering many members are genetically identical.

Within *The Giver*, Lowry has depicted a harmonious community of form and communication. However, this communication is largely prescribed, as there are anticipated comments and responses that are generally followed by all members of the society. In one instance, Jonas's friend Asher is running late for his class—as is common—and he expressed "the standard apology phrase," saying, "I apologize for inconveniencing my learning community" (Lowry 4). Following this statement, it is expected that an explanation will follow, which Asher offers. There are many other instances of unity being created through expected call-and-response conversations in the community, most often in the form of apologies. The etiquette of speaking in the Community is quite strict, forbidding boasting or calling attention to differences in others. These rules keep the society organized in that no one asks questions for which another is not allowed to answer, as well as preventing behavior that would disturb the order.

One of the unique aspects of community and unification in *The Giver* is the December ceremony that takes place every year. Primarily, this is a celebration of the youth becoming twelve years old, as no one has individual birthdays. All other members are there to support the children as they mature. Upon their first December ceremony, children are incorporated into their new families and given names. Some years are marked by gifts or milestones, such as new jackets that button in the back to teach interdependence at four years of age, front-buttoning jackets at 7, and bicycles at age eight. The most important ceremony takes place at age twelve when children are given assignments within the community. Up until this point, they have been included in the society but have not been contributing as the adults do. Their twelfth December ceremony is the culmination of all their experiences and preparation to be integrated into the community. Similarly, children of the same age are grouped for their first twelve years, but upon receiving their assignments they are dispersed. No longer do they identify with their age group, but instead they identify themselves by the responsibilities they hold. In fact, age often becomes irrelevant after the ceremony of twelve. Jonas's father states, "After Twelve, age isn't important. Most of us even lose track of how old we are as time passes, though the information is in the Hall of Open Records, and we could go and look it up if we wanted to. What's important is the preparation for adult life, and the training you'll receive in your Assignment" (Lowry 17). This is yet another instance where the past is eliminated in favor of only keeping eyes on the present.

While the December ceremony is certainly an important one, it is not the only one which ties the community together. Though they experience far fewer incidental deaths or tragedies, they have their own ceremony to commemorate these losses, known simply as the Ceremony of Loss. In one instance, a young boy fell into a river and drowned. On that day, "the entire community had performed the Ceremony of Loss together, murmuring the name Caleb throughout an entire day, less and less frequently, softer in volume, as the long and somber day went on, so that the little Four seemed to fade away gradually from everyone's consciousness" (Lowry 44). Later, when his parents received a new child, he was given the same name—Caleb—and the ceremony was reversed, the crowd bringing the name back to life now in this new little boy. In this way, the whole community celebrates and mourns, waxing and waning as one.

In *The Hunger Games*, division is intentional for fear that the people should rise again to rebel against the rulers of Panem. This is done by pitting the children of each district against each other and by preventing movement or communication between districts. Because these communities are intentionally separated, kept apart and made to dislike each other to prevent another uprising, it is important that they are unified only within themselves.

When Katniss volunteers to take her sister's place, she witnesses a moment of bonding among her district. She says, "Instead of acknowledging applause, I stand there unmoving while they take part in the boldest form of dissent they can manage. Silence. Which says we do not agree. We do not condone. All of this is wrong" (Collins, The Hunger Games 24). Even if just for a moment, she unites her people in dissent and silent rebellion. They resist in their boldest form, even in their fear. Remarkably, this is a televised event, to be shown to all districts throughout Panem. Though they may never know the impact of their silence, they demonstrate an even stronger symbol of unity: "almost every member of the crowd touches the three middle fingers of their left hand to their lips and holds it out to me. It is an old and rarely used gesture of our district, occasionally seen at funerals. It means thanks, it means admiration, it means good-bye to someone you love" (Collins, *The Hunger Games* 24). Out of empathy and respect—rare qualities in dystopian societies—the district unifies in recognizing Katniss's pain, as well as love.

While the Hunger Games unify District 12 in fear, this is not the case in some other districts. For those districts "in which winning the reaping is such a great honor, people are eager to risk their lives" and they are instead unified by their intense vigor to represent their community (Collins, *The Hunger Games* 22). The fervor of the training and the increased likelihood of a victor coming from these districts continues a vicious cycle. Since "the Capitol will show the winning district gifts of grain and oil and even delicacies like sugar," a winning district is more capable of perpetuating its environment of active preparation for the Hunger Games, further increasing their likelihood of winning again, and so the cycle goes (Collins, *The Hunger Games* 19-20). Furthermore, the Capitol places special value on the inhabitants of these districts because of their consistent anticipation of the games. Simultaneously, though, members of these districts are placed at odds with each other for the desire to fight in the arena. The pride of representing their district, the considerable likelihood of their victory, and

the comfortability for the rest of their lives unifies the wealthier districts in support of the Hunger Games but still manages to create distance between members.

Loyalty is expected from the districts, but not within the districts. To create camaraderie within the individual social structures of the districts would be to invite danger and distance from the Capitol. By taking two members from each district to fight, tributes fend for themselves. The rewards for victory isolate others, either encouraging anticipation for the games in affluent districts or cultivating fear in unprepared districts. The Capitol has created a delicate balance of unity which was sustainable for seventy-four years until two tributes rebelled with a handful of berries.

Unity is perhaps the most valuable tool within dystopian novels. It can be used to guide the society, lean them in one direction or another, and even pose members against each other. It has the responsibility of solidifying the community. Regardless of values, attitudes, means of power, or means of manipulation, without creating some form of durable unity, the dystopian will fall.

FEAR OF HUMANITY

Each of the six dystopian novelists within this paper take unique approaches to demonstrating flawed versions of the utopias of Plato, More, Bacon, and Wells. These iterations of dystopia are undoubtedly influenced by the individual experiences of the authors and the troubles they saw within society. As Bradbury found censorship and the destruction of knowledge a terror to society and then wrote about it, so did Atwood explore reproductive rights and Collins address war and its relationship with entertainment. Each author took a fear they had within society and applied it to their fictional dystopian world.

Rulers and government structures lead the society in its supposed utopian direction; however, these rulers and the control techniques they utilize are the reasons that their societies take a turn towards dystopia. With rulers like Big Brother, Mustapha Mond, and President Snow, they hold the power to manipulate and inflict fear upon all members. They demonstrate the reckless nature of humans and the desire for control, no matter what measure it might require.

In most dystopian societies, relationships that encourage selfishness or loyalty to anyone other than the governmental power are eliminated. Loyalty in a relationship draws energy away from the loyalty that citizens should be feeling towards the government or ruler. Where friendships are eliminated in *The Handmaid's Tale* because they have no value to Gilead and are only seen as a threat, families still exist because they are a form of service to the community. This is similar to Nineteen Eighty-Four, where friendships demonstrate loyalty to someone other than Big Brother and family is monitored by the extremist, pro-Party children in the family. Violations of the relational rules of the dystopian societies are dealt with swiftly and violently. Rarely are citizens brave enough to face the fear of rulers and their methods of control. As a result, these rules are usually upheld.

Unity, in a world of fear, gives dystopia's citizens opportunities to connect and lean against one another. Though fear can be the very thing that unifies the community, as it is in *The Hunger Games* trilogy, this is less common. Instead, unity is used to encourage a sense of community to offset the decreased value of individuality. This is seen in *The Giver* and *Brave New World*, where there is a sense of oneness and collectiveness for all members.

The etymology of "dystopia" is not much different from that of utopia. The two words share a root, but dystopia introduces the prefix *dys-*, representing the Greek δυσ-, meaning "hard, back, unlucky." Dystopias and utopias are polarized opposites; where one seeks a society that is as great as can be imagined, the other is a place where nothing could be made worse. But the history of the words themselves demonstrates that society will not reach either polar opposite, regardless of how hard we try to reach a utopia or how close people fall to a dystopia. The fears embodied in the dystopian works of each writer are natural human fears, fed by eerie uncertainty towards the future. Though these feelings of fear continue to well up in the creative works of the human race, this has been happening for hundreds of years and will continue to happen well into the future. Dystopian works are fed by concerns rooted in humanity's nature; as such, humanity will continue feeling them and authors will continue writing about them. That, however, does not mean it is the end of the world.

REFERENCES

Amis, Kingsley. *New Maps of Hell: A Survey of Science Fiction*. *New* York, Arno Press, 1974.

Atwood, Margaret. *The Handmaid's Tale*. New York, Penguin Random House, 1986.

Averill, Lindsey Issow. "Sometimes the World is Hungry for People Who Care." *The Hunger Games and Philosophy: A Critique of Pure Treason*. Edited by George A. Dunn and Nicolas Michaud. Wiley, US, 2012.

Bacon, Francis. *The New Atlantis*. Generic NL Freebook Publisher.EBSCOhost. Accessed 27 Mar. 2019.

Booker, M. Keith. *Dystopian Literature: A Theory and Research Guide*. Greenwood Press, 1994.

Bradbury, Ray. *Fahrenheit 451*. New York, Simon & Schuster, 1951.

— *Match to Flame: The Fictional paths to Fahrenheit 451*. Gauntlet Publications, 2006.

Burnett, G.Wesley, and Lucy Rollin. "Anti-Leisure in Dystopian Fiction: The Literature of Leisure in the Worst of All Possible Worlds." *Leisure Studies*, vol. 19, no. 2, Apr. 2000, pp. 77–90. EBSCOhost, doi:10.1080/026143600374761.

Claeys, Gregory. "The origins of dystopia: Wells, Huxley and Orwell." *The Cambridge Companion to Utopian Literature*. Edited by Gregory Claeys, Cambridge UP, 2010, 107-131.

Collins, Suzanne. *Catching Fire*. New York, Scholastic Press, 2009.
—. *The Hunger Games*. New York, Scholastic Press, 2008.
—. *Mockingjay*. New York, Scholastic Press, 2010.

"A Conversation with Ray Bradbury." *The Big Read*. National Endowment for the Arts, 2008.

Daniels, Margaret J. and Heather E. Bowen. "Feminist Implications of Anti-Leisure in Dystopian Fiction." *Journal of Leisure Research*, vol. 35, no. 4, 2003, pp. 423-440.

Day, James. Interview with Ray Bradbury. *Day at Night*. CUNY TV, 1974.

Filler, James. "Ascending from the Ashes: Images of Plato in Bradbury's Fahrenheit 451." *Philosophy & Literature*, vol. 38, no. 2, Oct. 2014, pp. 528–548

Fitting, Peter. "Positioning and Closure: on the 'Reading-Effect' of Contemporary Utopian Fiction." *Utopian Studies 1*. Beauchamp, Gorman, et al., University Press of America, 1987, 23-36.

Gerhard, Julia. "Control and Resistance in the Dystopian Novel: A Comparative Analysis." 2012. California State University, Chico, Master's thesis.

"The Giver: A Conversation with Lois Lowry." YouTube, uploaded by HEC Media, 12 June 2014. www.youtube.com/watch?v=rQsTD2ImkSc&t=703s

Gordon, W. Terrence. "Undoing Babel: C.K. Ogden's Basic English." ETC.: *A Review of General Semantics*, vol. 45, no. 4, 1988, pp. 337–340.

Grossman, Kathryn. "'Through a Glass Darkly': Utopian Imagery in Nineteen Eighty-Four." *Utopian Studies 1*. Edited by Beauchamp, Gorman, et al., University Press of America, 1987, 52-60.

Griffin, Jeanie. *Family Dynamics in Dystopian Societies*, California State University, Dominguez Hills, Ann Arbor, 2007.

Hayhurst, Lauren. "Fictional Futures vs Historical Reflections: How Utopian Ideals Can Lead to Dystopian Results." *Foundation*, vol. 39, no. 109, 2010, pp. 53.

Hickman, John. "When Science Fiction Writers Used Fictional Drugs: Rise and Fall of the Twentieth-Century Drug Dystopia." *Utopian Studies*, vol. 20, no. 1, Mar. 2009, pp. 141–170.

Hoffecker, W. Andrew. "A Reading of Brave New World: Dystopianism in Historical Perspective." *Christianity and Literature*, vol. 29, no. 2, 1980, pp. 46-62.

Howe, Irving, ed. 1984: *Texts, Sources, Criticism*. New York: Harcourt, 1982.

Huxley, Aldous. *Brave New World*. New York, Harper Perennial, 1932.

—. "Variations on a Philosopher" *Complete Essays*. Edited by Robert S. Baker and James Sexton, vol. v, Ivan R. Dee, 2001.

Koestler, Arthur. *The God That Failed*. New York, Bantam Books, 1965.

Kumar, Krishan. *Utopia and Anti-Utopia in Modern Times*. Oxford, Basil Blackwell, 1987.

—. *Utopianism*. University of Minnesota Press, 1991.

Latham, Don, and Jonathan Hollister. "The Games People Play: Information and Media Literacies in the Hunger Games Trilogy." *Children's Literature in Education,* vol. 45, no. 1, Mar. 2014, pp. 33–46.

Lee, Sunjoo. "To Be Shocked to Life Again: Ray Bradbury's FAHRENHEIT 451." *Explicator,* vol. 72, no. 2, Apr. 2014, pp. 142–145.

Lois Lowry on 'The Giver,' 26 June – 1 July 2014, Las Vegas, *American Library Association*, 30 June 2014.

"Lois Lowry: THE GIVER" YouTube, uploaded by The Movie Times, 3 August 2014. https://www.youtube.com/watch?v=Ez2vF5XCJBc.

"Lois Lowry" YouTube, uploaded by AmericanGraduateDC, 1 May 2012, https://www.youtube.com/watch?v=tVDFDLKaOto

Lowry, Lois. *The Giver*. Dell Laurel-Leaf, 1993.

McGiveron, Rafeeq. "'They Got Me a Long Time Ago': The Sympathetic Villain in *Nineteen Eighty-Four, Brave New World, and Fahrenheit 451." Dystopia*. Edited by M. Keith Booker, Salem Press, 2013, 125-141.

Miller, Mark Crispin. "Big Brother is You, Watching." *Reflections on America*, *1984: An Orwell Symposium,* Edited by Robert Mulvihill, University of Georgia Press, 1986, 179-201.

More, Thomas. *Utopia*. Edited and translated by H. V. S. Ogden, Harlan Davidson,1949.

Orwell, George. *Nineteen Eighty-Four*. New York, Penguin Group, 2003.

Oyler, Lauren. Interview with Margaret Atwood. *Broadly Meets,* Broadly, 2016.

Plato. *The Republic*. Translated by H. D. P. Lee, Penguin Books, 1955.

Robinson, Paul. "For the Love of Big Brother: The Sexual Politics of *Nineteen Eighty-Four*." *On Nineteen Eighty-Four*. Peter Stansky, W. H. Freeman and Co., 1983, 157.

Rosenfeld, Aaron S. "The 'Scanty Plot': Orwell, Pynchon, and the Poetics of Paranoia." *Twentieth Century Literature: A Scholarly and Critical Journal*, vol. 50, no. 4, 2004, pp. 337–67.

Rousseau, Jean-Jacques. "Discourse on the Origin and the Foundations of Inequality among Mankind." *The Social Contract and Discourse on the Origin of Inequality,* edited by Lester Crocker, Oxford UP, 1953, 151-258.

Sargent, Lyman Tower. "Utopian Traditions: Themes and Variation" *Utopia: The Search for the Ideal Society in the Western World*. Edited by Roland Schaer, Gregory Claeys, and Lyman Tower Sargent, Oxford UP, 2000, 8-17.

Sargent, Lyman Tower, and Lucy Sargisson. "Sex in Utopia: Eutopian and Dystopian Sexual Relations." *Utopian Studies*, vol. 25, no. 2, June 2014, pp. 299–320.

Satalia, Patty. Interview with Margaret Atwood. *Conversations at Penn State*, WPSU, 2014.

Schermer, M. H. N. "Brave New World Versus Island—Utopian and Dystopian Views on Psychopharmacology." *Medicine, Health Care, and Philosophy*, vol. 10, no. 2, 2007, pp. 119.

Suljic, Vesna, and A. Serdar Öztürk. "Where Dystopia Becomes Reality and Utopia Never Comes." *Journal of History, Culture & Art Research / Tarih Kültür ve Sanat Arastirmalari Dergisi*, vol. 2, no. 2, June 2013, pp. 30–40.

"Suzanne Collins on the Vietnam War Stories Behind The Hunger Games and Year of the Jungle" YouTube, uploaded by Bibliostar.tv, 8 Oct. 2012, www.youtube.com/watch?v=6MiVBAPg6TU.

"Suzanne Collins Part 2 - Contemporary Inspiration" YouTube, uploaded by I read YA, 18 August 2009, https://www.youtube.com/watch?v=zUTPQCYVZEQ.

Wallace, Mike. Interview with Aldous Huxley. *The Mike Wallace Interview*, The American Broadcasting Company, 1958.

Walsh, Chad. *From Utopia to Nightmare*. New York, Harper & Row, 1962.

Wells, H.G. *A Modern Utopia*. Lincoln, University of Nebraska Press, 1905.

"What if You Could Control Memory: Writing The Giver" YouTube, uploaded by Facing History and Ourselves, 26 September 2011, https://www.youtube.com/watch?v=vGcdEX8QeF4&t=4s.

Williams, Lynn F. "Everyone Belongs to Everyone Else: Marriage and the Family in Recent American Utopias 1965-1985." *Utopian Studies 1*. Edited by Beauchamp, Gorman, et al., University Press of America, 1987, 123-133.

Zimbargo, Philip. "Mind Control in Orwell's Nineteen Eighty-Four: Fictional Concepts Become Operational Realities in Jim Jones's Jungle Experiment." *On Nineteen Eighty-Four: Orwell and Our Future*, edited by Abbott Gleason, et al., Princeton University Press, 2005.

Tolkien's Tribute to England and its Roots in *Beowulf*

Elisa Lee Klaasen

ACKNOWLEDGEMENTS

ABSTRACT

This thesis endeavors to explore the connections between J. R. R. Tolkien's *The Lord of the Rings* and its predecessor, the famous medieval text *Beowulf*. Though Tolkien seldom talked about his own use of *Beowulf*, his fascination with the text is obvious in his many writings and lectures. Thus, this thesis uses Tolkien's own writings as well as the scholarly writings of others to explore his integration of tropes and themes from *Beowulf*. A case is simultaneously made for the impact that the integration of Beowulf has on Tolkien's *The Lord of the Rings* trilogy. Arguably, Tolkien's utilization of medieval stories helps him to root his own fiction in the very foundations of English culture. This thesis attempts to reveal the ways in which Tolkien's *The Lord of the Rings*, through its use of *Beowulf*, developed into a tribute to the culture of the country of England.

INTRODUCTION

J. R. R. Tolkien—though now a rather misunderstood pop culture icon—was a tremendously talented man whose genius was made evident in his works of criticism and philology as well as his works of fiction. Tolkien's fascination with scholarly criticism is evidenced in his many lectures and essays about medieval literature, fairy stories, and linguistics. However, Tolkien himself did not often elaborate on the connections between his scholarly work and his fiction writing. Thus, over the decades since the publication of *The Lord of the Rings*, many writers and critics have attempted to understand the deep, underlying connections between Tolkien's love of ancient and medieval literature and his creation of an intricate imaginary world.

In writing *The Lord of the Rings*, author J. R. R. Tolkien hoped to create a mythology for England. According to Habermann and Kuhn, "Tolkien regretted the lack of a proper mythology for England along the lines of the Germanic or Finnish sagas which he studied and admired, and he set out to create such a mythology, which he could dedicate 'to England; to my country'" (263). Clearly, Tolkien wished to use a variety of different texts to create a body of stories and ideas that would serve as a mythology for English people. In one of his many letters, Tolkien expresses this wish:

> Once upon a time … I had a mind to make a body of more or less connected legend, ranging from the large and cosmogonic, to the level of romantic fairy-story—the larger founded on the lesser in contact with the earth, the lesser drawing splendor from the vast backcloths—which I could dedicate simply to: to England; to my country. It should possess the tone and quality that I desired, somewhat cool and clear, be redolent of our 'air' (the clime and soil of the North West, meaning Britain and the hither parts of Europe: not Italy or the Aegean, still less the East), and, while possessing (if I could achieve it) the fair elusive beauty that some call Celtic (though it is rarely found in genuine ancient Celtic things), it should be 'high', purged of the gross, and fit for the more adult mind of a land long now steeped in poetry. I would draw some of the great tales in fullness, and leave many only placed in the scheme, and sketched. The cycles should be linked to a majestic whole, and yet leave scope for other minds and hands, wielding paint and music and drama. (*Letters* 144-45)

In addition, Habermann and Kuhn write that "in [Tolkien's] 'invention about truth', he gradually turned from more fanciful notions, such as seeing the world as a great Viking ship, to conceiving of his world as a mythical pre-history of our world" (264). Thus, Tolkien's world of Middle-Earth bears great similarities to both the real world as well as many medieval texts and myths. Clearly, Tolkien admires his country and its culture; in writing *The Lord of the Rings*, he seeks to honor that culture through an imaginative and mythical medium.

In his famous trilogy *The Lord of the Rings*, Tolkien utilizes tropes, themes, and cultural characteristics from *Morte d'Arthur* and *Sir Gawain and the Green Knight*, as well as many other more obscure medieval texts. However, one particular story that arguably impacted his fiction the most is *Beowulf*, an Old English epic that exists at the roots of English language and literature. *Beowulf* is thought to be one of the oldest surviving Old English stories. According to *The Norton Anthology of English Literature, Beowulf* is "the oldest of the great long poems written in English" (23), and "it is possible that *Beowulf* may be the lone survivor of a genre of Old English long epics" (24). Often found in the first few pages of English Literature anthologies, *Beowulf* is clearly a foundational English text. In creating a mythology of England, it was only fitting for Tolkien to utilize texts that have been formative to England's culture.

Tolkien's fascination with *Beowulf* is evidenced in many of his writings. One of the most valuable texts on the subject is actually one of Tolkien's lectures, which is entitled "*Beowulf: The Monsters and the Critics*." This lecture is famous for having reintroduced *Beowulf* as a text that is not just a valuable historical document, but a powerful literary text as well. In his lecture, Tolkien writes, "It is as an historical document that [*Beowulf*] has mainly been examined and dissected" (The Monsters and the Critics 6). However, Tolkien argues that *Beowulf* is worthy of literary study: "So far from being a poem so poor that only its accidental historical interest can still recommend it, Beowulf is in fact so interesting as poetry, in places poetry so powerful, that this quite overshadows the historical content, and is largely independent even of the most important facts … that research has discovered" (7). In addition to his defense of *Beowulf's* merit, Tolkien also translated his own version of *Beowulf* (from Old English into modern English), and he wrote several other essays and lectures on the medieval story. His interest in *Beowulf* is further revealed in his fictional works themselves, which demonstrate a dedication to the utilization of *Beowulf's* themes and tropes.

This analysis aims to reveal the ways in which Tolkien succeeded in creating a modern mythology of England by focusing on his detailed utilization of *Beowulf* in particular. Pritha Kundu writes that Tolkien's *The Lord of the Rings* "critiques, reconstructs, and reappropriates several Anglo-Saxon themes and ideas" (2). Therefore, his work bears much resemblance to *Beowulf*, but it is still a modern reappraisal of the ancient text. Tolkien created an entire world in his fictional work *The Lord of the Rings*, and he created histories, genealogies, and languages to accompany it. Though the world of Middle-Earth is fictional, it is a reflection of the real world, just as *Beowulf* is a mythical reflection of real men and a real culture that once existed. This paper will argue two different points. Firstly, it will demonstrate that Tolkien indeed utilizes *Beowulf* and bases many of his themes, characters, and tropes in *The Lord of the Rings* on that famous Old English text.

Secondly, this argument will propose that Tolkien's creation of "a mythical pre-history of our world" was not only successful, but also that his use of *Beowulf* was beneficial to his efforts because of its connections to the very roots of English culture (Habermann and Kuhn 264). By rooting his stories in a foundational English text and glorifying traditionally English characteristics in his works, Tolkien creates a mythical tribute to his own culture.

Over the years since Tolkien's death, a great deal of scholarly research about his works has been published. Writers have analyzed his use of a wide variety of medieval texts such as *Beowulf*, *Sir Gawain and the Green Knight*, and *Morte d'Arthur*. Additionally, scholars have also explored his linguistical naming systems, his focus on monsters, his connections with religion, and his utilization of Arthurian legends. For instance, Edman's extensive research about Tolkien's allusions to King Arthur and his knights is published in his article "Power in Jeopardy: A Poststructuralist Reading of the Arthurian Legend from Malory's Le Morte d'Arthur and Tennyson's 'Idylls to the King' to Tolkien's *The Lord of the Rings*." Scholars have even studied the plants and climate of Tolkien's imaginary world, Middle Earth. For example, Graham A. Judd and Walter Steven Judd wrote a book entitled *Flora of Middle-Earth: Plants of J. R. R. Tolkien's Legendarium*. Clearly, the minute details of Tolkien's series have been studied extensively and thoroughly explored in writing and research. However, few sources focus solely on Tolkien's use of *Beowulf* itself, and Tolkien's own lack of mention about his utilization of the medieval story makes its connections to his works even more fascinating. For instance, in his most famous work related to Beowulf, the lecture entitled "*Beowulf:* The Monsters and the Critics," Tolkien examines *Beowulf* without ever mentioning his own use of the tale. In addition, Tolkien translated his own version of *Beowulf*, and he wrote a commentary to accompany it. His passion for the story is undeniable, but its actual connections to his own fictional work, *The Lord of the Rings*, are not as evident. Additionally, though some writers have analyzed the connections between the two texts, few have connected this analysis with Tolkien's focus on founding his story in English culture and creating a tribute to his own people. Thus, this particular analysis is a unique and valuable work of research because it reveals both Tolkien's use of *Beowulf* as well as the ways that that use affects the story and creates meaning for his readers.

Historical context

At the time that *The Lord of the Rings* was written, English people needed a sense of identity, hope, and unity. According to William Indinck, "In Jungian psychology, myths are collective dreams, the communal expression of a culture's goals, wishes, anxieties and fears" (1). Interestingly, *The Lord of the Rings* ultimately venerates English people because it places hobbits beside valorous warriors, praising their courage and strength. Tolkien uses *Beowulf*, with all of its cultural significance in England, to formulate a nationalistic mythology of England that honors the characteristics of modern English people. It is worth noting that the goals and fears of Englishmen at the time that *The Lord of the Rings* was written were akin to the goals and fears of the hobbits, who wished to maintain the peace and beauty of their home despite the threat of a growing shadow in the East. Written between 1937 and 1945, *The Lord of the Rings* echoes many of the core desires of English people who were finding their own courage in the face of Hitler's tyranny. Adolf Hitler, much like Tolkien's Sauron, was also a menacing threat that grew

in the East, causing English people to experience a sense of hopelessness and impending doom. Tolkien's fictional works are full of hope for hobbits and for other good and simple people who face the terrible threat of Sauron's evil. Therefore, Tolkien's attempt to create a mythology of England indeed expresses the underlying desires of English people, and it also reveals an appreciation for England's past, which is seen through a fictional lens. Amidst a culture of hopelessness and fear, Tolkien wrote fantasy stories with which English people could identify and from which they could ascertain a sense of hope. The connection between *The Lord of the Rings* and *Beowulf* is yet another way in which Tolkien utilizes the core of English history and culture to create an epic mythology to which the people of his beloved country could relate at that time.

Interestingly, Tolkien himself explains that his love of mythology and fairy-stories grew to maturity through his experience in World War I. In his lecture "On Fairy Stories," which he delivered in 1939, Tolkien explains that for him, "a real taste for fairy-stories was wakened by philology on the threshold of manhood, and quickened to full life by war" (*The Monsters and the Critics* 135). Evidently, Tolkien's experience of war influenced his writing. This connection with war, power, and hope for mankind became a central element of Tolkien's writings, and his mentions of orcs "digging, digging lines of deep trenches in a huge ring" and "great engines for the casting of missiles" are reminiscent of the trenches of World War I (*Return of the King* 804). Tolkien once spoke of his experience as an Englishman in the war, saying, "I've always been impressed … that we are here, surviving, because of the indomitable courage of quite small people against impossible odds" (Carpenter, *A Biography* 180). Similarly, in *The Fellowship of the Ring*—the first volume of *The Lord of the Rings*—Elrond says, "This quest may be attempted by the weak with as much hope as the strong. Yet such is oft the course of deeds that move the wheels of the world: small hands do them because they must, while the eyes of the great are elsewhere" (Tolkien, *The Fellowship* 262). Clearly, Tolkien's fictional works themselves are deeply connected to his own life experiences and the historical context of his life. Just like the small, seemingly insignificant people who fought in the war with J. R. R. Tolkien, the hobbits of the Shire are small and insignificant people as well. Their connection to humanity, and, in turn, to the men who fight in wars, is further demonstrated in one of Tolkien's many letters:

> The Hobbits are, of course, really meant to be a branch of the specifically *human* race (not Elves or Dwarves)—hence the two kinds can dwell together (as at Bree), and are called just the Big Folk and Little Folk. They are entirely without non-human powers but are represented as being more in touch with 'nature' (the soil and other living things, plants and animals), and abnormally, for humans, free from ambition or greed of wealth. They are made *small* (little more than half human stature, but dwindling as the years pass) partly to exhibit the pettiness of man, plain unimaginative parochial man—though not with either the smallness or the savageness of Swift, and mostly to show up, in creatures of very small physical power, the amazing and unexpected heroism of ordinary men 'at a pinch.' (Carpenter 158)

Clearly, the hobbits of Tolkien's mythology are meant to represent a kind of man—a small, insignificant man—who has a good heart and very little desire for power and dominion over others. Interestingly, this lack of greed for power is part of the reason

that the ring is less tempting for the hobbits in Tolkien's tales. In turn, this idea reflects Tolkien's aversion to power-seeking men like Hitler who sought dominion—much like Sauron—around the time that Tolkien wrote his famous trilogy.

Mythology

According to the *Oxford English Dictionary*, the meaning of the word "mythology" has changed a great deal over the decades. "Mythology" was once known to mean a "parable" or an "allegory," but it can now refer to "a body of myths … belonging to a particular religious or cultural tradition," "the collective or personal ideology or set of beliefs which underpins or informs a particular point of view," or "the study of myths" ("Mythology"). Mythology is clearly a multifaceted concept, and its meaning has changed over the years. Thus, what did Tolkien mean when he said that he set out to write a mythology of England, and was he successful?

Though mythology is typically understood to be a body of pagan stories and beliefs that are considered to be untrue but perhaps useful, a new definition of mythology is now emerging. James E. Beichler writes about his understanding of modern mythologies:

> Modern science fiction and fantasy fiction movies can be considered new forms of mythology because they play the same role in modern culture that older forms of mythology played in earlier cultures. In this respect, these new mythologies offer us a way to look deeper into our own personalities and consciousness as well as physical reality itself than we could normally explore by purely scientific and logical means. When we look more deeply into the mythical scenarios presented by science and fantasy fictions, we can find that they offer a way of exploring how we believe that our own human consciousness is evolving. (Beichler 127)

In other words, mythical fantasy stories contain many of the elements necessary in a mythology. They contain aspects of the stories and cultures from which they originate, and they provide readers with a better understanding of the very essence of humanity and human consciousness. This new definition of mythologies is applicable to Tolkien's *The Lord of the Rings*.

England lacks its own mythology. Tolkien writes explicitly about his country's demythologization:

> I was from early days grieved by the poverty of my own beloved country: it had no stories of its own (bound up with its tongue and soil), not of the quality that I sought, and found (as an ingredient) in legends of other lands. There was Greek, and Celtic, and Romance, Germanic, Scandinavian, and Finnish … but nothing English, save impoverished chap-book stuff. Of course there was and is all the Arthurian world, but powerful as it is, it is imperfectly naturalized, associated with the soil of Britain but not with English; and does not replace what I felt to be missing. (Tolkien, 144)

In agreement with Tolkien's sentiments, scholar Thomas Shippey writes, "England must be the most demythologized country in Europe, partly as a result of 1066 (which led to near-total suppression of native English belief) … [and] partly as a result of the early

Industrial Revolution, which led to the extinction of what remained rather before the era of scholarly interest and folk-tale collectors like the Grimms" (*The Road to Middle-Earth* 304). Throughout *The Lord of the Rings*, Tolkien utilizes characters, archetypes, cultural references, and language from *Beowulf* in order to formulate his modern mythology. In his writings, he seeks for "a cohesion, a consistency of linguistic style, and an illusion of historicity," which inevitably indicates the mythological quality of his works (Tolkien, *Letters* 143). His stories form a kind of shadow world that indirectly reflects the experiences of Englishmen through the use of legendary stories and mythical creatures, providing English people with tales that they can relate to and use as a source of wisdom, much like the mythical tales of other cultures.

MONSTERS

Many monsters throughout Tolkien's *The Lord of the Rings* bear similarities to the monsters found in *Beowulf*. Some of them have comparable physical forms while others are undeniably alike in personality and character traits. These connections between *Beowulf* and *The Lord of the Rings* ultimately help Tolkien to create a mythology of England and a tribute to his own culture amidst the struggle of World War II. J. R. R. Tolkien was intrigued by monsters and their presence in various literary texts. In his influential lecture, "*Beowulf:* The Monsters and Critics," he notably defends "the monster's central place in *Beowulf*" (Nelson 466). He argues, "The monsters are not an inexplicable blunder of taste; they are essential, fundamentally allied to the underlying ideas of [*Beowulf*], which give it its lofty tone and high seriousness" (Tolkien, *The Monsters and the Critics* 19). Thus, understandably, Tolkien chose to use similar monsters in his stories, ultimately contriving a mythical style in his fiction. According to Verlyn Flieger, "The function of the monster in medieval narrative is to oppose the hero, to body forth tangibly the evil to be overcome, to be the force against which the hero's strength and courage are tested" (142). Indeed, as in many medieval narratives, Tolkien utilizes monsters in his trilogy in order to embody the evil and corruption that his heroes must overcome. His use of monsters connects *The Lord of the Rings* to *Beowulf*, and it also allows him to display the bravery and strength of his characters, who are representatives of English culture and history.

Gollum and Grendel

One of the monsters in Tolkien's *The Lord of the Rings* who is most recognizably connected to the story of *Beowulf* is the creature named Smeagol, who is otherwise known as Gollum. Gollum's character is intertwined with the character of Grendel, one of the major enemies in *Beowulf*. According to Verlyn Flieger's "Frodo and Aragorn: The Concept of a Hero," Gollum's "parallel with Grendel, the man-eating monster of *Beowulf*, is unmistakable" (141). Gollum and Grendel's characters have several similarities. Namely, they are physically similar, both share an affinity for water, and both bear a connection to the same biblical story.

First of all, Gollum and Grendel bear a significant physical resemblance to each other. Neither of them are described as fully human or fully monster. Instead, their true physical forms remain mysteriously ambiguous. Throughout Tolkien's *The Hobbit* and *The Lord of the Rings*, Gollum is described as a slimy, slinking creature. Tolkien writes that his

eyes are "two small pale gleaming lights" (*The Two Towers* 598). Though he is small, he possesses a malicious, wiry strength. In *The Fellowship of the Ring*, Tolkien writes that "[Gollum's] malice gives him a strength hardly to be imagined" (143). In *The Two Towers*, Tolkien describes Gollum's "clinging grip" as "soft but horribly strong" (600). Just like the slinking Gollum, Grendel is described as "a prowler through the dark" (*Beowulf* 86). The Beowulf-poet writes that when Grendel comes to attack Heorot, he comes "greedily loping" (711) with a "loathsome tread, while a baleful light, flame more than light, flared from his eyes" (725-27). At the thought of killing the men of Heorot, Grendel's "glee was demonic" (730). Grendel also possesses an unimaginably powerful strength because of his malice and resentment towards humankind. Notably, just like the incredibly strong grip that Gollum uses when fighting Sam Gamgee in *The Two Towers*, Grendel's grip is also a mighty one. Though he is able to overcome most men with the power of his hands, his vigorous handgrip is conquered by *Beowulf*, whose "handgrip [is] harder than anything / [Grendel] had ever encountered in any man / on the face of the earth" (750-52). Therefore, because of the sly, prowling bodies and the terribly strong and malicious grips of both characters, it is evident that Gollum and Grendel bear many physical similarities.

In addition, both characters, Gollum and Grendel alike, have a strong affinity for water. Gollum's family "loved the River, and often swam in it, or made little boats of reeds" (*Fellowship* 51). Gollum, in particular, is known as a lover of water and as one who "dived into deep pools" (51). Indeed, one of the most important moments in Gollum's life has much to do with his connection to water. When he is fishing with his kinsman Deagol in a small pond, Deagol finds a beautiful ring at the bottom of the pool of water. Overcome by temptation and lust for the object, Gollum strangles Deagol and takes the ring for his own (52). This moment of wickedness, greed, and lust is closely associated with swimming and fishing in the pond. Here, in one of the most impactful moments of Gollum's life, his affinity for water is again revealed. Similarly, Grendel is known for "haunting the marches, marauding round the heath / and the desolate fens" (*Beowulf* 103-104). The two monsters' similar affinity for water demonstrates another connection that draws them together.

Another similarity between Gollum and Grendel has to do with their mutual connections with the biblical story of Cain. Grendel's connections to this story are obvious. The *Beowulf*-poet writes about Grendel's connection to the biblical story:

He had dwelt for a time
in misery among the banished monsters,
Cain's clan, whom the Creator had outlawed
and condemned as outcasts. For the killing of Abel
the Eternal Lord had exacted a price:
Cain got not good from committing that murder
because the Almighty made him anathema
and out of the curse of his exile there sprang
ogres and elves and evil phantoms
and the giants too who strove with God
time and again until He gave them their reward. (*Beowulf* 104-114)

Thus, Grendel's connection to Cain is clearly stated in *Beowulf*. Later in the poem, the *Beowulf*-poet writes, "And from Cain there sprang misbegotten sprits, among them Grendel, the banished and accursed" (1265-267). Throughout the story, he is described as "lonely" (164), and the *Beowulf*-poet writes that "he was the Lord's outcast" (169). He is also characterized as "spurned and joyless" later in the story (720). Gollum, on the other hand, bears a subtler connection to the story of Cain. His given name, Smeagol, rhymes with Deagol's name, which indicates kinship between them. Brent Nelson writes, "They are at least brothers in a figurative sense, and the results are the same as in the Genesis story: the profound guilt of the murderer, his exile, and a subsequent growth of wickedness" (467). Indeed, it is Smeagol's wicked action of murdering Deagol that leads him into a state of exile, and he remains isolated under the mountains for hundreds of years. Nelson argues that a Cain figure is "marked by the guilt of his associated violence…a wandering outcast living in everlasting exile from human society" (468). Because of his status as a murderer and an exile, Gollum is associated with the story of Cain. Obviously, both Gollum and Grendel are affiliated with Cain. As a whole, the two characters bear a striking resemblance to each other, which is evidence of Tolkien's utilization of *Beowulf*.

Grendel's mother

Grendel's mother bears important connections to two different creatures in Tolkien's *The Lord of the Rings*. First of all, her lair is notably similar to the watery home of the Watcher in the Water—a sea creature that attacks the fellowship when they are attempting to enter the mines of Moria. Secondly, her character is reminiscent of Shelob, the spider that resides in Cirith Ungol. These similarities make Tolkien's use of *Beowulf* apparent, and ultimately, his use of tropes from that medieval text help him to create a mythical tribute to his own country, its medieval past, and its heroic struggle against a modern evil in the east at the time the trilogy was written.

After cutting off Grendel's arm and effectively killing him, *Beowulf* decides to follow Grendel into his mother's lair beneath a lake. Hrothgar describes Grendel and his mother:

They are fatherless creatures,
and their whole ancestry is hidden in a past
of demons and ghosts. They dwell apart
among wolves on the hills, on windswept crags
and treacherous keshes, where cold streams
pour down the mountain and disappear
under mist and moorland. (*Beowulf* 1355-361)

Similarly, in Tolkien's *The Lord of the Rings*, Gandalf describes the balrog and creatures like it: "Far, far below the deepest delvings of the Dwarves, the world is gnawed by nameless things. Even Sauron knows them not. They are older than he" (*The Two Towers* 490). Other such demons of the deep world include the Watcher in the Water, who waits outside of the gates of Moria—deep in a murky pool. In *Beowulf*, the *Beowulf*-poet writes,

A few miles from here
a frost-stiffened wood waits and keeps watch
above a mere; the overhanging bank

is a maze of tree-roots mirrored in its surface.
At night there, something uncanny happens:
the water burns. And the mere bottom
has never been sounded by the sons of men.
On its bank, the heather-stepper halts:
the hart in flight from pursuing hounds
will turn to face them with firm-set horns
and die in the wood rather than dive
beneath its surface. That is no good place. (*Beowulf* 1361-372)

Clearly, no one wants to draw near to the ill-boding pool where Grendel's mother resides. Even the deer choose to face death instead of stepping into the water. Similarly, in *The Lord of the Rings*, the fellowship is deeply disturbed by the pool of water where the Watcher in the Water waits. Boromir says, "How I hate this foul pool!" (Tolkien, *The Fellowship* 299), and Frodo says, "I hate this place … and I am afraid. I don't know of what: not of wolves, or the dark behind the doors, but of something else. I am afraid of the pool. Don't disturb it!" (300). Clearly, in both stories, a detestable creature lives beneath a pool of water. In The Lord of the Rings, the monster has "horrible strength" and "groping tentacles" (301), while in *Beowulf*, Grendel's mother has a "brutal grip" (*Beowulf* 1502) and "savage talons" (1504). The Watcher in the Water and its watery abode are reminiscent of Grendel's mother and her home under the lake. Evidently, many of the tropes and characters in *The Lord of the Rings* have medieval precedents.

Grendel's mother also bears connections to Shelob, the horrific spider who lives in the dangerous passageway called Cirith Ungol. Both characters help contribute to an aspect of almost Gothic horror in their respective stories. In both *The Lord of the Rings* and *The Silmarillion*, some of the most horrifying enemies are females—Ungoliant and her daughter Shelob. Similarly, in *Beowulf*, Grendel's mother is particularly disgusting, mysterious, and disturbing. She is described as a "demon" (*Beowulf* 1378), a "wolfish swimmer" (1506), and a "swamp-thing from hell, / the tarn-hag in all her terrible strength" (1518-519). Just like the balrog, the Watcher in the Water, and Shelob herself, Grendel's mother is like a long-lived demon who hides in dark places. Additionally, both Shelob and Grendel's mother hungrily feed on their innocent prey. Tolkien writes about Shelob: "She served none but herself, drinking the blood of Elves and Men, bloated and grown fat with endless brooding on her feasts, weaving webs of shadow; for all living things were her food, and her vomit darkness" (*The Two Towers* 707). Later, he writes that she "herself [is] a glut of life, alone, swollen till the mountains could no longer hold her up and the darkness could not contain her" (707). As Frodo approaches her lair, Tolkien writes that Shelob had recently "lusted for sweeter meat" (708). Similarly, Grendel's mother lusts for flesh as well. The *Beowulf*-poet writes, "The one who haunted those waters … had scavenged and gone her gluttonous rounds" (*Beowulf* 1497-498). Evidently, both Shelob and Grendel's mother are ancient creatures who feed hungrily on innocent flesh. Lastly, both creatures are ultimately killed by the stab wound of a brave and victorious warrior—a quintessential English man. In Shelob's case, she is stabbed by Sam, whose "blade scored…a dreadful gash" (Tolkien, *Two Towers* 711), and in the case of Grendel's mother, it is brave Beowulf who "took a firm hold of the hilt and swung / the blade in an

arc, a resolute blow / that bit deep" (*Beowulf* 1564-566). Therefore, the gluttonous female enemies in both stories are cut down by a brave warrior's blade. Grendel's mother bears connections to both the Watcher in the Water and Shelob. Her evil deeds and cruelty are juxtaposed with Beowulf's high, elegant, courageous manner of life. In both *Beowulf* and *The Lord of the Rings*, such horrific female monsters only serve to demonstrate the evil of the world and the goodness and strength of quintessential English people. In the minds of most English readers, Samwise Gamgee's defeat of Shelob is reminiscent of Beowulf's battle with Grendel's mother. By associating a simple hobbit like Sam with the renowned warrior Beowulf, Tolkien honors simple, brave people like those who fought with him in World War I. Thus, not only does Tolkien use *Beowulf* to form the plots of his stories, but he also uses it to form his fiction into a modern tribute to his people.

Other monster forms

There are repeated references to sea-beasts, dragons, trolls, and the like throughout both *Beowulf* and the Tolkien legendarium. Just like the *Beowulf*-poet, Tolkien seems to find such monsters to be both valuable and interesting. By including these mythical creatures in his own works, Tolkien refers to the well-known mythical beasts of English legend. Again, he invites readers to view his stories as an ultimate tribute to England, its history, and its myths.

Sea-Beasts

Near the beginning of *Beowulf*, Beowulf proudly recounts his many victories and achievements before Hrothgar, and he refers to sea-creatures in doing so. He says, "In the night-sea / [I] slaughtered sea-brutes" (*Beowulf* 421-22). Later, when he is defending his own character before Unferth, Beowulf refers to the sea-creatures again:

The deep boiled up
And its wallowing sent the sea-beasts wild.
My armor helped me to hold out;
My hard-ringed chain-mail, hand-forged and linked,
A fine, close-fitting filigree of gold,
Kept me safe when some ocean creature
Pulled me to the bottom. Pinioned fast
And swathed in its grip, I was granted one
Final chance: my sword plunged
And the ordeal was over. Through my own hands,
The fury of battle had finished off the sea-beast.
Time and again, foul things attacked me,
Lurking and stalking, but I lashed out,
Gave as good as I got with my sword.
My flesh was not for feasting on,
There would be no monsters gnawing and gloating
Over their banquet at the bottom of the sea. (*Beowulf* 548-64)

This tale of sea-beasts reveals Beowulf's supernatural abilities and unprecedented courage in the face of terrifying creatures. Additionally, when Beowulf is later approaching Grendel's mother's lair, the *Beowulf*-poet writes about the contents of her watery den:

The water was infested
with all kinds of reptiles. There were writhing sea-dragons
and monsters slouching on slopes by the cliff,
serpents and wild thing such as those that often
surface at dawn to roam the sail-road
and doom the voyage. (*Beowulf* 1425-430)

Much like the *Beowulf*-poet, Tolkien includes a notable sea-beast in his trilogy as well. As previously mentioned, the Watcher in the Water is also a sea creature, and its serpent-like body also writhes and contorts, much like the sea creatures in *Beowulf*. The fellowship first sees the Watcher when they look at the lake and see "the waters … seething, as if a host of snakes were swimming up from the southern end. Out from the water a long sinuous tentacle had crawled; it was pale-green and luminous and wet" (Tolkien, *Fellowship* 300). As the shape of the creature grows, "twenty other arms came rippling out. The dark water boiled, and there was a hideous stench…[as] groping tentacles writhed across the narrow shore" (301). Just as the *Beowulf*-poet writes about boiling water, foul creatures, and the infestation of serpent-like beasts, Tolkien also uses these descriptors to conceptualize a terrifying enemy—the Watcher in the Water. The similarities between the descriptions of sea-beasts in the two books is striking; clearly, Tolkien's passion for the story of *Beowulf* deeply impacted his own writings.

Dragons

Additionally, both the Tolkien legendarium and *Beowulf* refer to dragons and their treasure hoards. In Tolkien's case, the dragon actually appears in his book *The Hobbit*, which is a prequel to *The Lord of the Rings*. Additionally, the balrog in *The Lord of the Rings* is a dragon-like creature that is described as "a great shadow, in the middle of which was a dark form, on man-shape maybe, yet greater; and a power and terror seemed to be in it and to go before it … Its streaming mane kindled, and blazed behind it. In its right hand was a blade like a stabbing tongue of fire; in its left it held a whip of many tongs" (Tolkien, *Fellowship* 321). The balrog, a kind of mix between a dragon and a demon, is extremely dangerous, just like Smaug and the dragon that is included in *Beowulf*. In particular, it is notable that Gandalf's last battle, which leads to his death, involves the balrog, just as Beowulf's last battle, which also leads to his death, involves a dragon.

In Beowulf's last battle, he fights with a dragon that has been plaguing his home and his people. The *Beowulf*-poet introduces the dragon near the end of the epic as "a dragon on the prowl / from the steep vaults of a stone-roofed barrow / where he guarded a hoard" (*Beowulf* 2211-213). Interestingly, the *Beowulf*-poet writes that someone has managed to sneak past the dragon and steal one goblet from his hoard:

There was a hidden passage,
unknown to men, but someone managed
to enter by it and interfere
with the heathen trove. He had handled and removed
a gem-studded goblet; it gained him nothing,
though with a thief's wiles he had outwitted
the sleeping dragon. That drove him into rage,
as the people of that country would soon discover. (*Beowulf* 2213-220)

Similarly, Bilbo Baggins acts as a sneaky thief who angers the dragon named Smaug in *The Hobbit*. Just like Smaug, the dragon in *Beowulf* destroys the surrounding towns and countryside and plagues the people nearby. "Far and near, the Geat nation / bore the brunt of his brutal assaults / and virulent hate. Then back to the hoard / he would dart before daybreak, to hide in his den. / He had singed the land, swathed it in flame, / in fire and burning" (2317-322). Beowulf bravely fights with the dragon in order to defend his people, much like Gandalf fights with the balrog to defend the fellowship and its quest. Both scenes are epic moments in the two stories.

As a whole, the monsters in Tolkien's stories are strikingly similar to the monsters that the *Beowulf*-poet depicts throughout his famous epic. Tolkien's uses these same monsters, which were written about long ago in Old English, and he recreates them for modern readers in *The Lord of the Rings*. By reinventing a new epic tale about victorious English people and horrific enemies, Tolkien both hearkens back to his country's past and looks to its future—effectively enlivening the hopes, dreams, and desires of modern Englishmen.

ARCHETYPES

Throughout both Tolkien's legendarium and *Beowulf*, there is a focus on ancient heirlooms with a mysterious past. Often, these heirlooms are connected with famed men who were made eminent in ancient battles of renown. These ancient treasures in both stories are considered to be fascinating, powerful, and even somewhat magical. Additionally, both tales include an emphasis on the importance of ancient swords. This similarity between Tolkien's *Lord of the Rings* and the ancient epic *Beowulf* indicates that Tolkien used elements of *Beowulf* to form his story into a modernized Anglo-Saxon epic. Ultimately, these similarities strengthen his tale's mythical qualities and help him to effectively create a tribute to England.

The importance of treasures

Throughout *The Lord of the Rings*, J. R. R. Tolkien emphasizes the deep value of ancient archetypal treasures. Various characters throughout the story display an awe and reverence for treasures that were famed in ancient battles, and the discovery of such treasures is an exciting and awe-inspiring experience. This is first seen in Tolkien's earlier work, *The Hobbit*, which involves a dragon's lair and an ancient hoard of treasure, much like the treasure that Beowulf finds in a dragon's lair near the end of *Beowulf*. This added emphasis and valuation of treasures, found in both *The Lord of the Rings* and *Beowulf*, is a common theme in medieval literature and Anglo-Saxon culture. Tolkien's utilization of this theme is a reference to early English culture and the values of the Germanic warriors who are recognized as the foundation of English people; by referencing Anglo-Saxon literature and emphasizing the importance of ancient treasures, Tolkien refers to his country and its culture.

Treasures are mentioned repeatedly throughout *Beowulf*. At the beginning of the story, the *Beowulf*-poet writes about Beowulf's attire, saying, "Far-fetched treasures / were piled upon him, and precious gear" (*Beowulf* 36-37). Treasures even have the power to influence the moods of those around them: "Then an old spearman will speak while they are drinking, / having glimpsed some heirloom that brings alive / memories of the

massacre; his mood will darken" (2041-2042). Such heirlooms seem to act as symbols of times past, and the people view them as much more than simple relics. Additionally, the dragon in *Beowulf* guards a hoard of precious treasures, which is described as a "stone-roofed barrow / where he guarded a hoard" (2212-213). This focus on treasures continues throughout the entirety of the epic, and it is seen in the dragon's hoard (2231-236), in Beowulf's speech to Wiglaf (2747-749), and in Beowulf's burial scene at the end of the story (3163-167). Evidently, the Anglo-Saxons place a great deal of value on the ancient treasures that once belonged to their ancestors.

Similarly, throughout *The Lord of the Rings*, Tolkien emphasizes the value and the mystical qualities of treasures and heirlooms. For one, the ring itself is a magical treasure with a mysterious past. Tolkien uses lofty speech to refer to the rings of power:

> In Eregion long ago many Elven-rings were made, magic rings as you call them, and they were, of course, of various kinds: some more potent and some less. The lesser rings were only essays in the craft before it was full-grown, and to the Elven-smiths they were but trifles—yet still to my mind dangerous for mortals. But the Great Rings, the Rings of Power, they were perilous. (*Fellowship* 45-46)

Indeed, Frodo's ring is deeply powerful and shrouded in mystery and intrigue. Instead of treating the One Ring as a beautiful relic, Tolkien treats the ring as a character from *Beowulf* might—as a powerful, magical object of far more worth than any simple hobbit could imagine.

Other treasures throughout *The Lord of the Rings* are treated in a similar manner. For instance, Tolkien seems to be in awe of the mithril coat that Bilbo gives to Frodo, the treasures that Sam sees when the hobbits are captured by a barrow-wight and brought down into the barrows beneath the earth, the treasures in the dragon's lair in *The Hobbit*, the treasures in the troll's cave, and the gifts that Galadriel presents to the fellowship in Lothlorien. He utilizes vivid imagery and powerful diction to captivate his readers and elevate the majestic qualities of the treasures and heirlooms in his stories. For instance, Tolkien employs rich descriptions to depict the beautiful barrow treasures and their connection with the past. When Tom Bombadil looks through the heap of treasures, "He chose for himself from the pile a brooch set with blue stones, many-shaded like flax-flowers or the wings of blue butterflies. He looked long at it, as if stirred by some memory" (Fellowship 142). Tom then recalls the ancient lady who once wore the brooch: "Fair was she who long ago wore this on her shoulder. Goldberry shall wear it now, and we will not forget her!" (142). Additionally, Tom presents the hobbits with daggers:

> For each of the hobbits he chose a dagger, long, leaf-shaped, and keen, of marvelous workmanship, damasked with serpent-forms in red and gold. They gleamed as he drew them from their black sheaths, wrought of some strange metal, light and strong, and set with many fiery stones. Whether by some virtue in these sheaths or because of the spell that lay on the mound, the blades seemed untouched by time, unrusted, sharp, glittering in the sun. (142)

As the hobbits observe these shiny daggers, they suddenly imagine ancient men who lived long ago. Tolkien writes, "They had a vision as it were of a great expanse of

years behind them, like a vast shadowy plain over which there strode shapes of Men, tall and grim with bright swords, and last came one with a star on his brow" (142-43). The magical quality of these ageless daggers and their mystical connection with great deeds of the past contribute to the mythological quality of Tolkien's trilogy. Just as its connections to *Beowulf* and *Beowulf's* treatment of treasures associate the story with the past, the treasures themselves remind hobbits of the history of their own country. This repeated emphasis on the significance of treasures and heirlooms reveals a connection between Tolkien's legendarium and *Beowulf*; this connection ultimately helps Tolkien in his creation of a "mythical pre-history" of England—his beloved country (Habermann and Kuhn 264). By honoring treasures as men like Beowulf did in ancient days, Tolkien hearkens back to England's past.

Beowulf's sword and Aragorn's sword

Tolkien very clearly uses his writings to emphasize the importance and power of swords, which are ancient heirlooms and treasures as well. For instance, Bilbo's blade Sting is an ancient artifact that is recovered from the troll-hoard in *The Hobbit*. The mysterious blade notably glows blue when orcs or goblins are drawing near, and it famously helps Sam to wound and disable the monstrous spider Shelob in the passes of Cirith Ungol. Other such swords are presented throughout the tales, such as the sword that Gandalf possesses—Glamdring. When Gandalf stands in defiance of the balrog on the Bridge of Khazad-Dum, "Glamdring gleamed, cold and white" (Tolkien, *Fellowship* 322). As the balrog attempts to destroy Gandalf, Tolkien writes, "From out of the shadow a red sword leaped flaming. Glamdring glittered white in answer" (322). Clearly, the swords in *The Lord of the Rings* are used for great good and great evil, and their magical qualities are reminiscent of *Beowulf*—the trilogy's predecessor.

Another important reference to swords, which is seen both in *Beowulf* and *The Lord of the Rings*, is the image of a melting blade. In *Beowulf*, after the fight with Grendel's mother, Beowulf's newfound sword seems to melt in his hands: "Meanwhile, the sword / began to wilt into gory icicles / to slather and thaw" (1605-607). Notably, in *The Lord of the Rings*, there is a similar circumstance. After Frodo is stabbed on top of Weathertop, Aragorn picks up the knife that had inflicted the injury:

> [He] stooped again and lifted up a long thin knife. There was a cold gleam in it. As Strider raised it they saw that near the end its edge was notched and the point was broken off. But even as he held it up in the growing light, they gazed in astonishment, for the blade seemed to melt, and vanished like a smoke in the air, leaving only the hilt in Strider's hand. (Tolkien, *Fellowship* 193)

Evidently, in both *Beowulf* and *The Lord of the Rings*, the authors include the motif of a melting blade. All of these different references to powerful daggers and swords are continued throughout the Tolkien legendarium; however, the most important sword in all of Tolkien's stories is the sword that belongs to the king of men. At first called Narsil, the sword is re-forged for Aragon, and at that time it is renamed Andúril. Both Aragorn and Beowulf, two Anglo-Saxon kinds of warriors who act as the chief protectors of their people, have ancient swords of immeasurable power.

Throughout the epic *Beowulf*, Beowulf possesses several different powerful swords. While his men also fight with "ancestral blades" (796), Beowulf's sword is "both precious object and token of honor" (1023). Later in the story, Unferth gives Beowulf an ancient sword and describes it in detail:

A hilted weapon,
a rare and ancient sword named Hrunting.
The iron blade with its ill-boding patterns
had been tempered in blood. It had never failed
the hand of anyone who hefted it in battle,
anyone who had fought and faced the worst
in the gap of danger. This was not the first time
it had been called to perform heroic feats. (1457-464)

Beowulf's sword is greatly esteemed and given a name, just like many of the swords in *The Lord of the Rings*. When Beowulf describes Hrunting, he calls it his "sharp-honed, wave-sheened wonder-blade" (1490), saying, "With Hrunting I shall gain glory or die" (1491). Clearly, Beowulf's blade is one of amazing power and mysterious associations with men of old. However, Hrunting ultimately fails Beowulf, leaving him in need of a new blade. When Beowulf is losing the battle against Grendel's mother, the *Beowulf*-poet writes about Hrunting:

The shining blade
refused to bite. It spared her and failed
the man in his need. It had gone through many
hand-to-hand fight, had hewed the armor
and helmets of the doomed, but here at last
the fabulous powers of that heirloom failed. (1423-428)

At that moment, when Hrunting fails Beowulf, he suddenly sees another blade in Grendel's mother's lair. The *Beowulf*-poet writes about this new blade:

Then he saw a blade that boded well,
a sword in her armory, an ancient heirloom
from the days of the giants, an ideal weapon,
one that any warrior would envy,
but so huge and heavy of itself
only Beowulf could wield it in a battle. (1557-562)

Here, a truly magical sword is discovered. Only Beowulf can wield this sword, almost as if it was specifically meant for him and him alone. This magical attachment between Beowulf and his sword—which almost seemed to reveal itself to him in the perfect moment—indicates that the swords in *Beowulf* are mystical and bear magical attachments to powerful warriors, as if they were made for their masters.

Just like Beowulf, Aragorn esteems swords that were made long ago. These two characters' mutual veneration for history matches Tolkien's own veneration for the history of his country. Just as Beowulf is the only one who is meant to wield the sword

that he finds in the lair beneath the lake, Aragorn is the rightful king who is meant to restore the kingdom of Gondor with the sword that was broken long ago. Tolkien writes about how the elven smiths re-forge the ancient blade, previously known as Narsil:

> The Sword of Elendil was forged anew by Elvish smiths, and on its blade was traced a device of seven stars set between the crescent Moon and the rayed Sun, and about them was written many runes; for Aragorn son of Arathorn was going to war upon the marches of Mordor. Very bright was that sword when it was made whole again; the light of the sun shone redly in it, and the light of the moon shone cold, and its edge was hard and keen. And Aragorn gave it a new name and called it Andúril, Flame of the West. (*Fellowship* 269)

Throughout the entirety of the trilogy, Aragorn's sword serves as a reminder of hope, goodness, and the fight against Mordor. Sauron, the chief antagonist of the tales, deeply fears the Blade that was Broken since it symbolizes his own pain and defeat. Notably, when Aragorn is handing his sword over to the door-warden in Rohan, he says, "I command you not to touch it, nor to permit any other to lay hand on it. In this elvish sheath dwells the Blade that was Broken and has been made again. Telchar first wrought it in the deeps of time. Death shall come to any man that draws Elendil's sword save Elendil's heir" (*Two Towers* 500). Thus, only Aragorn, the true heir of Elendil, is capable of drawing the sword and wielding it in battle. This magical quality is reminiscent of Beowulf's sword, which "only Beowulf could wield … in battle" (*Beowulf* 1562). Indeed, both Beowulf and Aragorn possess magical, ancient blades that are meant for them alone. Not only does this elevate the value of the blades themselves, but it allows the authors to honor and celebrate the power of the two characters—both Beowulf and Aragorn. Both men are powerful, kingly Anglo-Saxon warriors who fight for the good men who are left in the world. Tolkien uses Aragorn, his sword, and his similarities to Beowulf to show an esteem for the ancestors of English people and the English qualities of strength, courage, and goodness.

CULTURE

There are two notable cultural similarities between the culture of *Beowulf* and the culture of Tolkien's *The Lord of the Rings*. For one, both works bear the same connections to paganism and Christianity. Tolkien likely identified with the *Beowulf*-poet's religious identity and admiration for certain tenets of pagan culture. Additionally, both *Beowulf* and *The Lord of the Rings* depict many elements of Anglo-Saxon culture, including a heroic code of honor and a high respect for chief-figures. This section of the analysis will examine these cultural similarities. As a whole, because Tolkien uses the culture of the original inhabitants of his land in his fictional stories, he is able to create a story that ultimately magnifies and glorifies traditional English qualities and the history and culture of England.

Paganism

Interestingly, both Tolkien and the *Beowulf*-poet faced a strikingly similar cultural dilemma. Both writers maintained deep and meaningful Christian faiths, but neither one of them mentions Christ, salvation, or biblical theology in his fictional works. The *Beowulf*-poet simply shows some pity for the heathen men in his stories: "That was

their way, / their heathenish hope; deep in their hearts / they remembered hell" (*Beowulf* 178-180). Thomas Shippey writes that "the *Beowulf*-poet's dilemma was also Tolkien's. His whole professional life brought him into contact with the stories of pagan heroes, Englishmen or Norsemen or Goths; more than anyone he could appreciate their sterling qualities. At the same time he had no doubt that paganism itself was weak and cruel" (*The Road to Middle-Earth* 199). Tolkien attempted to "repeat the *Beowulf*-poet's masterpiece of compromise" and create "a story of virtuous pagans in the darkest of dark pasts, before all but the faintest premonitions of dawn and revelation" (199). Thus, Tolkien and the *Beowulf*-poet share a similar appreciation for certain elements of paganism, and this similarity is apparent in their fictional tales.

Both *Beowulf* and *The Lord of the Rings* hint at the idea of Christianity without providing any explicit references to the Christian faith. The *Beowulf*-poet was a Christian writer who looked back on history and wrote about pagan men. Though Tolkien's Christian faith was an extremely important part of his life, he did not explicitly reference it in his most important work, *The Lord of the Rings*. Instead, he subtly alluded to its themes and ideas throughout his stories. For instance, the prevalent theme of hope in the face of darkness is found at the core of both *The Lord of the Rings* and the Christian faith, and that theme is further explained in a later section of this thesis. Tolkien explains his dislike for explicit references to the Christian faith in one of his many letters. He writes about Arthurian legends and their inability to mythologize his beloved country, England:

> For one thing its 'faerie' is too lavish, and fantastical, incoherent and repetitive. For another and more important thing: it is involved in, and explicitly contains the Christian religion. For reasons which I will not elaborate, that seems to me fatal. Myth and fairy-story must, as all art, reflect and contain in solution elements of moral and religious truth (or error), but not explicit, not in the known form of the primary 'real' world. (Tolkien, *Letters* 144)

In this letter, Tolkien distinctly states his distaste for explicitly Christian stories, and he makes it clear that in writing his own mythology of England, he will not repeat the mistakes that he saw in the Arthurian legends.

Thus, Tolkien never explicitly references the faiths of his characters. However, his characters look back on their heathen ancestors with distaste, implying a newly-found faith, much like the Beowulf-poet, who looked back on his pagan ancestors disapprovingly. This is evidenced through the use of the word "heathen." Scholar Thomas Shippey writes about this interesting connection in his book, *Roots and Branches: Selected Papers on Tolkien:*

> It may be a coincidence, but probably is not, that both Beowulf and *The Lord of the Rings* use the word hæðen, or 'heathen' (of human beings), exactly twice. Using the word of course implies that the user is himself a Christian … The *Beowulf*-poet knew that his old-time characters had been heathens (so Tolkien thought), but did not want to appear to condemn them for it … It is odd that *The Lord of the Rings*, like *Beowulf*, normally abstains carefully from saying that its characters are heathens. (Shippey 12)

Interestingly, both stories involve Christian writers who avoid explicit references to religion in order to create more timeless, archetypal, mythical stories. Because they made this choice, both writers created stories that have lasted for generations and impacted peoples of all faiths. Not only does this connection to *Beowulf* root *The Lord of the Rings* even more deeply in the foundations of English culture, but it also reveals the way that Tolkien attempted to connect with all English people and create a mythology for his entire country, not just for those who shared his faith.

Anglo-Saxon war culture

The heroic culture of Anglo-Saxon people is depicted in both *The Lord of the Rings* and *Beowulf*. Pritha Kundu argues that "when the Angles, the Saxons, and the Jutes began to settle in South-East England during the 5th century, they brought with them a distinctly Germanic concept of the warrior and the culture of a warlike society" (2). Indeed, the bravery of the chief and the men that fight for him in an Anglo-Saxon battle is of utmost importance: "To have retreated from the field, from one's own chief, is lasting shame and infamy for all life. To defend him, to protect him, to ascribe one's own great deeds to his glory is their particular oath: the chiefs fight for victory, the warriors for the chief" (qtd. in Kundu 3). This heroic code is demonstrated repeatedly throughout both fictional tales.

The loyalty of Wiglaf and Sam Gamgee

The characters in *Beowulf* and *The Lord of the Rings* exemplify the Anglo-Saxon warrior-king relationship. Near the end of *Beowulf*, Wiglaf displays extraordinary loyalty to his king—exemplifying the characteristics of a perfect Anglo-Saxon thane. He reminds the other warriors that they must remain loyal to their lord:

I remember that time when mead was flowing,
how we pledged our loyalty to our lord in the hall,
promised our ring-giver we would be worth our price,
make good the gift of the war-gear,
those swords and helmets, as and when
his need required it. (*Beowulf* 2633-638)

Pleading with the other men to join Beowulf and defend their chief, Wiglaf reminds them of all the ways that Beowulf has protected them: "I well know / the things he has done for us deserve better" (2656-657). Wiglaf's fierce loyalty to his king is a demonstration of Anglo-Saxon war culture and its values. Wiglaf proceeds to defend his aged king, demonstrating fierce bravery, despite the danger that he faces. The *Beowulf*-poet writes that the dragon attacked Beowulf "in a rush of flame and clamped sharp fangs / into his neck. Beowulf's body ran wet with his life-blood: it came welling out" (2691-693). Wiglaf responds immediately, leaping forward. He is eager to fight for his king: "[Wiglaf] saw the king in danger at his side / and displayed his inborn bravery and strength" (2695-696). Together, Beowulf and Wiglaf kill the foul dragon, and the *Beowulf*-poet calls them a "pair of kinsmen, partners in nobility" (2707). Wiglaf's honor, courage, and dignity is highly praised in Anglo-Saxon war culture. He fulfills his ultimate duty by sacrificing his own safety and security in order to protect his chief. Later, Wiglaf reprimands the other men for failing to protect their master, Beowulf:

Every one of you
with freeholds of land, our whole nation,
will be dispossessed, once princes from beyond
get tidings of how you turned and fled
and disgraced yourselves. A warrior will sooner
die than live a life of shame. (2886-891)

Clearly, the warrior-king relationship in Anglo-Saxon culture is of chief importance. By risking his life for his chief, Wiglaf maintains his honor.

Tolkien utilizes his knowledge of Anglo-Saxon war culture as a model for several relationships throughout *The Lord of the Rings*. One such relationship is the friendship between Sam and Frodo. Throughout *The Lord of the Rings*, Sam and Frodo maintain a deep and powerful friendship that gives them inspiration and encouragement when all seems hopeless. Ultimately, it is Sam's loyalty to "Mr. Frodo," his "master," that is most notable about his character. Tolkien himself writes in one of his many published letters, "[Sam] did not think of himself as heroic or even brave, or in any way admirable—except in his service and loyalty to his master" (*Letters* 329). Here, just like in Anglo-Saxon war culture, Sam's only objective as a kind of servant or thane-figure is to be completely and wholeheartedly loyal to his master, Mr. Frodo.

At the end of Tolkien's second book in the series, *The Two Towers*, Frodo and Sam are attacked by a monstrous spider named Shelob in her den of webs. When Sam sees Shelob approaching unbeknownst to Frodo, his concern is solely for his master. He cries, "Look out behind … Look out, master!" (Tolkien, *Two Towers* 709). Tolkien writes about Sam's "desperation at the delay when his master was in deadly peril" (709). Though Sam Gamgee is a small, unfrightening hobbit, he displays strength and bravery beyond measure in this scene. Frodo's peril gives him "a sudden violence and strength that was far beyond anything that Gollum had expected from this slow stupid hobbit, as he thought him. Not Gollum himself could have twisted more quickly or more fiercely" (709-710). Sam, a simple-minded gardener, finds himself in a fight to the death with Gollum—the traitor who led Frodo and Sam into Shelob's lair. His bravery and his loyalty to his master is vividly described.

As the scene continues, Sam's spirit of daring becomes even more striking. While Sam was fighting with Gollum, Frodo is "bound in cords" (711), and Shelob begins to drag his body away. Again, Sam springs to his master's defense. Tolkien writes, "Sam did not wait to wonder what was to be done, or whether he was brave, or loyal, or filled with rage…Then he charged. No onslaught more fierce was ever seen in the savage world of beasts, where some desperate small creature armed with teeth, alone, will spring upon a tower of horn and hide that stands above its fallen mate" (711). With no fear for himself, Sam fights in defense of his master, Frodo. His loyalty to his master trumps all other desires and thoughts of his own safety. Sam's fierce anger is displayed in his speech to Shelob: "Now come, you filth … you've hurt my master, you brute, and you'll pay for it" (713). Again and again, Tolkien reiterates Sam's fierce loyalty to Frodo. Just like Wiglaf, Sam is a thane-figure who follows the rules of the Anglo-Saxon code. His indefatigable loyalty is deeply connected with the Anglo-Saxon warrior's sense of loyalty to his

chief. The connection between *Beowulf* and *The Lord of the Rings* is quite clear. Both important scenes involve a thane-figure who fights in the face of impending death in order to defend his master. Additionally, both masters, Beowulf and Frodo, seemingly die despite their servants' valiant efforts. While Beowulf dies an honorable death, Frodo only lies in a stupor that Sam mistakes for death when he says, "Not asleep, dead!" (714) in desperation. Clearly, Sam embodies the qualities of an Anglo-Saxon warrior, just like Wiglaf does.

It is important to note that unlike the warriors in Anglo-Saxon tales such as *Beowulf*, Samwise Gamgee is a small, inconspicuous fellow. His bravery and loyalty do not match his cheerful demeanor and his short stature. In this way, Tolkien both connects his story to *Beowulf's* Anglo-Saxon war culture while also elevating hobbits and their quintessential English qualities to the ranks of the Anglo-Saxon warriors of old. Tolkien writes that Sam's strength in stabbing Shelob is "greater than any warrior's hand" (712), and he writes, "Not the doughtiest soldier of old Gondor, nor the most savage Orc entrapped, had ever thus endured her, or set blade to her beloved flesh" (712). Sam has an "indomitable spirit" that allows him to defeat Shelob, even though she is a mighty enemy (713). By revealing an undeniably brave and loyal warrior-figure in the unassuming body of a small man who loves his home, his garden, and his ale, Tolkien reveals the inner strength and value of English people. As the *Beowulf*-poet writes, "In a man of worth / the claims of kinship cannot be denied" (2600-601), and in recognition of Wiglaf's bravery, he writes, "So every man should act, / be at hand when needed" (2708-709). Just like Wiglaf, Sam's claim to kinship and status as a brave warrior is undeniable. By protecting his chief, master Frodo, Sam defends his honor and acts as a loyal Anglo-Saxon thane. By honoring Samwise Gamgee and connecting him to brave-hearted Wiglaf, Tolkien achieves his goal of writing a tribute to England, the country he so dearly loved.

Beowulf and Aragorn as Anglo-Saxon chiefs
In both *Beowulf* and *The Lord of the Rings*, there exists a mighty kingly figure who epitomizes hope in a hopeless time. When Beowulf arrives at Heorot, the men are disheartened because their friends have been killed. The *Beowulf*-poet writes, "There was panic after dark, people endured / raids in the night, riven by the terror" (*Beowulf* 189-190). They need an inspiring figure to replenish their hope. When Beowulf arrives, Hrothgar states his hopes:

Now Holy God
Has, in His goodness, guided him here
To the West-Danes, to defend us from Grendel.
This is my hope: and for his heroism
I will recompense him with a rich treasure. (381-85)

Just like Beowulf, Aragorn is the king who rises out of the shadows and restores hope to good men. While instilling fear in his enemy, Aragorn also reinvigorates the men in Rohan and Gondor. When Aragorn looks into the palantír, he challenges Sauron, and "wrenched the Stone to [his] own will" (*Return of the King* 763). After communicating with Sauron and showing him the sword of Elendil—the sword that has been re-forged—Aragorn says, "He is not so mighty yet that he is above fear; nay, doubt ever gnaws him" (763).

129

By challenging Sauron, Aragorn instills fear and doubt in Sauron's heart. Additionally, Aragorn establishes himself as a heroic Anglo-Saxon figure by committing himself to protect his people and the fellowship of the ring. He notably tells Frodo, "If by my life or death I can save you, I will" (*Fellowship* 168). This commitment to protecting his subordinates is present throughout the entire trilogy. Pritha Kundu writes about Anglo-Saxon culture, saying it is one of "intense loyalty and kinship-ethics" (3). This kinship bond exists between Aragorn and his people, and it is reminiscent of Beowulf's character.

Much like Aragorn, Beowulf is also a heroic and mighty man. Throughout *Beowulf*, he is extolled for his "heroic nature and exploits" (3173). Men say they have never "seen a mightier man-at-arms on this earth" (247-48), and they claim that "he is truly noble" (250). Just like Aragorn, he is considered "higher born" (2199). Thus, the "greater right and sway were inherited" by him (2198-199). Beowulf's kingly qualities are mirrored in Aragorn; thus, Aragorn is a kind of idyllic Anglo-Saxon king. Kundu writes, "Beowulf's greatness as a hero and a dutiful king may be wonderful to the extent of super-humanity: yet the basic virtues that are exaggerated and elevated in the character were real and respectable in actuality, for the Anglo-Saxon race and its socio-cultural ideals" (5). Thus, not only are Aragorn and Beowulf respectable fictional kings, but they also represent sociocultural ideals. By creating a modernized Anglo-Saxon king, Tolkien invites English people to reminisce about their country's heroic past and the ideal qualities of their ancestors.

Riders of Rohan

The Riders of Rohan are semi-barbaric warriors that are reminiscent of Anglo-Saxon warriors. Tolkien's use of *Beowulf* is even evidenced through the names that he bestows upon Rohan's men. For instance, the name "Eomer" is found in *Beowulf* (1960) as well as *The Lord of the Rings*. Additionally, the words "hrethel cyning," which are translated to "Hrethel King," are reminiscent of the manner in which Theoden of Rohan is addressed in *The Lord of the Rings*. Just like medieval kings of old, Theoden is called "Theoden King" rather than "King Theoden." Even these small connections are clear evidence of Tolkien's utilization of *Beowulf*.

One particular chapter of Tolkien's *The Two Towers*—a chapter that is focused on Rohan—draws its outline directly from *Beowulf*. The chapter, "The King of the Golden Hall," is quite similar to lines 229-405 of *Beowulf*. Thomas Shippey explains this similarity:

> [Tolkien's] fictional involvement with [*Beowulf*] lasted for at least fifty years, and one chapter of *The Two Towers* derives in outline and in detail from it: the approach of Aragorn and his companions to Meduseld in 'The King of the Golden Hall' follows the etiquette of *Beowulf* lines 229-405 almost exactly: first challenge, leave taking by the first challenger, second challenge by the doorwarden, piling of arms outside the hall, reception standing in front of the throne. (*Roots and Branches* 10)

Indeed, the resemblance between these two passages is striking. The *Beowulf*-poet writes, "So he rode to the shore, this horseman of Hrothgar's, and challenged them in formal terms, flourishing his spear: 'What kind of men are you who arrive / rigged out for combat in your coats of mail, / sailing here over the sea-lanes / in your steep-hulled boat?"

(*Beowulf* 234-40). Tolkien's gatekeeper at Rohan has a strikingly similar response when Gandalf, Legolas, Aragorn, and Gimli approach the gates of Rohan: "Who are you that come heedless over the plain thus strangely clad, riding horses like to our own horses?" (*Two Towers* 497). Both men, the horseman and the gatekeeper, proudly guard their respective kingdoms from outside intruders. This description of soldierly conduct and the heroic code form a clear connection between *Beowulf* and *The Lord of the Rings*. Since the characters in *The Lord of the Rings* are connected to *Beowulf* and are representative of English people, Tolkien shows the honor, respect, and heroism in his culture.

THEMES

Hope

One of the most prominent themes in *The Lord of the Rings* is the theme of hope. Amidst the struggles of World War II, Tolkien formed a set of tales that would honor English people, venerate their ancestors, bring them hope, and inspire them to fight for ultimate glory.

Throughout *The Lord of the Rings*, many characters fall into ruin because of a lack of hope. For instance, Denethor, the steward of Gondor, begins to despair in the face of evil when the armies of Mordor are at his doorstep—when he should stand strong and fight. Instead of instilling hope in his men, he waits in his tower, saying, "[The end] is near. Follow whom you will, even the Grey Fool, though his hope has failed. Here I stay" (Tolkien, *Return of the King* 806). Ultimately, Denethor tries to kill both himself and his remaining son—Faramir—by lying on a pyre and setting fire to it. His lack of hope clearly leads to his ruin. Additionally, characters like Saruman choose to believe that there is no hope for the good and beautiful things of Middle Earth. Saruman says, "There is no hope left in Elves or dying Numenor … We may join with [Sauron]" (*Fellowship* 253). Because Saruman decides that his only chance is in joining with Sauron, he ultimately loses his power and glory, and the title of the White Wizard is passed on to Gandalf, who maintains hope and humility in the face of great evil.

Though many characters in Tolkien's trilogy experience despair and fear when they give up hope, a few characters choose to cling onto a remnant of hope, a hope which Gandalf says is only a fool's hope—but hope the same: "Just a fool's hope, as I have been told … And yet in truth I believe that the news that Faramir brings has some hope in it" (Tolkien, *Return of the King* 797). In addition, Samwise Gamgee, one of the most honorable, loyal, and hopeful characters in the story—a true Englishman—clings onto hope and beauty even when he faces the very gates of hell—the entrance into Mordor: "For like a shaft, clear and cold, the thought pierced him that in the end the Shadow was only a small and passing thing: There was light and high beauty forever beyond its reach" (901). Indeed, even in the land of Mordor, Sam's hope does not wane: "But even as hope died in Sam, or seemed to die, it was turned to a new strength. Sam's plain hobbit-face grew stern, almost grim, as the will hardened in him, and he felt through all his limbs a thrill, as if he was turning into some creature of stone and steel that neither despair nor weariness nor endless barren miles could subdue" (913). Since Sam is one of the most important and most admirable characters in *The Lord of the Rings*, his indomitable spirit and unquenchable hope is made admirable as well.

Though *Beowulf* is not known to be focused on hope like *The Lord of the Rings* is, Beowulf brings great hope to mankind when he comes in all his power and glory to save the Danes, Hrothgar's people. In addition, Grendel—the epitome of evil—is jealous of the hope and joy of mankind since he is an exile. In other words, his own hopelessness leads to his despair and his evil deeds. Though this theme is not as prevalent in *Beowulf*, Tolkien's very utilization of *Beowulf*, which has been demonstrated throughout this thesis, helps him to form his tales into a mythology full of hope and adulation for English people. By writing about majestic kings of old who are reminiscent of old English stories, simple, honorable people like hobbits, battles of great renown, and goodness triumphing over evil, Tolkien inspires hope for his country and his people.

Power

Another prevalent theme in Tolkien's *The Lord of the Rings* is the idea of power and its evil uses. Throughout the trilogy, various characters struggle for power, the evil ring itself is named the "Ring of Power," and the desire for power often leads the peoples of Middle Earth into ruin and corruption. Ultimately, Tolkien turns the *Beowulf* epic on its head by dethroning power and emphasizing the importance of the powerless. In *Beowulf,* power is simply glorified. Men like Beowulf use power for good purposes. The *Beowulf*-poet writes, "Behavior that's admired / is the path to power among people everywhere" (24-25). Additionally, when writing about Beowulf's character, he writes, "There was no one else like him alive. / In his day, he was the mightiest man on earth, / highborn and powerful" (196-98). Though Tolkien does not completely shy away from power, he does stray from the *Beowulf*-poet's method in three different ways. First of all, he makes his kingly Beowulf character—Aragorn—hesitant about claiming power. Where Beowulf would proudly stake his claim to power, Aragorn postpones his coronation as king. Secondly, Tolkien ultimately honors simple, unpretentious hobbits above all other characters. Instead of depicting Aragorn as the chief character of the trilogy, Tolkien shifts the medieval epic's traditional plotline and creates a different kind of hero. Lastly, Tolkien chooses to create power-hungry enemies, essentially making the search for power seem like a corrupt pursuit.

Throughout *The Lord of the Rings*, Aragorn is cautious about claiming the throne. He is content to live in secret, out in the wild with the other Rangers—his kin. Aragorn says, "Little do I resemble the figures of Elendil and Isildur as they stand carven in their majesty in the halls of Denethor" (Tolkien, *Fellowship* 241). Instead of seeking power, glory, and admiration from others, Aragorn spends years of his life wandering in the wilderness, scorned by common people. He says, "'Strider' I am to one fat man who lives within a day's march of foes that would freeze his heart, or lay his little town in ruin, if he were not guarded ceaselessly. Yet we would not have it otherwise. If simple folk are free from care and fear, simple they will be, and we must be secret to keep them so" (242). Aragorn does not seek the luxuries of kingship. Instead, he hesitantly waits in the wild. He does not lust after power. Additionally, Aragorn demonstrates his caution about power through his commitment to Frodo. Instead of seeking to take power from Frodo, he supports the adventurous hobbit, later saying, "I would have guided Frodo to Mordor and gone with him to the end" (Tolkien, *Two Towers* 409). Evidently, Aragorn is not greedy for power. He only claims his kingship when the time is right. Thus, Tolkien utilizes Beowulf's character in creating Aragorn, but he also indicates that the desire for power can be dangerous.

Though Tolkien obviously utilized Anglo-Saxon tropes and ideas throughout his trilogy, especially in his allusions to *Beowulf*, he ultimately chose not to honor the powerful Anglo-Saxon warriors alone. Instead, he chose to honor and uplift the small, unassuming hobbits who live in a land that is reminiscent of England—the Shire. Near the end of his trilogy, Tolkien writes about men who sing praises to the hobbits: "And as the Hobbits approached swords were unsheathed, and spears were shaken, and horns and trumpets sang, and men cried with many voices and in many tongues: 'Long live the Halflings! Praise them with great praise!'" (*Return of the King* 932). Indeed, even Aragorn, the king of all men, "bowed his knee before them" and "led them to the throne…setting them upon it" (933). Though Aragorn is the powerful warrior and king, the hobbits are ultimately placed on his throne and venerated even by him. By giving power to the powerless instead of the power-hungry, Tolkien emphasizes the importance of leading a good and simple life. Unlike traditional Anglo-Saxon warriors, modern mankind should choose to honor the powerless rather than seek dominion over all. Undoubtedly, Tolkien's experience of World War I and II encouraged him to make this shift from the *Beowulf*-poet's understanding of power to a more nuanced understanding, which is more applicable to his modern readers.

Additionally, Tolkien solidifies the theme of power (and its association with corruption) by emphasizing the fact that the cruel enemies in *The Lord of the Rings* are power-hungry. Though Saruman and even Boromir desire power, it is Sauron's desire for power that is most evident. Saruman is ensnared by Sauron's call to power. He says, "A new Power is rising. Against it the old allies and policies will not avail us at all" (Tolkien, *Fellowship* 253). Though Saruman thinks he can join in Sauron's power, and he lusts after it, he is wrong. Sauron does not share power. Gandalf says, "Only one hand at a time can wield the One" (253). Clearly, Saruman's desire for power caused his downfall. Elrond claims that the more powerful a person is, the more dangerous and evil the One Ring can make him become:

> Its strength…is too great for anyone to wield at will, save only those who have already a great power of their own. But for them it holds an even deadlier peril. The very desire of it corrupts the heart. Consider Saruman. If any of the Wise should with this Ring overthrow the Lord of Mordor, using his own arts, he would then set himself on Sauron's throne and yet another Dark Lord would appear. And that is another reason why the Ring should be destroyed: as long as it is in the world it will be a danger even to the Wise" (261).

In other words, the more powerful a person is, the more he or she will desire power, and the more corrupt and evil that desire will become. Thus, the only way for the ring to be destroyed is to leave it in the hands of those who do not care much for power. C. S. Lewis writes about the dethronement of power in *The Lord of the Rings*, saying, "On the one hand, the whole world is going to war; the story rings with galloping hoofs, trumpets, steel on steel. On the other, very far away, two tiny, miserable figures creep … through the twilight of Mordor. And all the time we know that the fate of the world depends far more on the small movement than on the great" (12). Clearly, the only way to destroy the ring is to give it to people who do not lust for power. Therefore, not only does Tolkien honor the hobbits, but he encourages readers to emulate them. Not only is the traditional

bravery, strength, and loyalty of *Beowulf* important, but the humility and simplicity of the hobbits is also valuable and necessary. In this way, Tolkien modernizes *Beowulf* and conforms its plot and themes to the troubles of the modern world, which has so often been plagued by power-hungry dictators who seek dominion over other human beings.

CONCLUSION

This thesis argues two main points. First of all, it demonstrates Tolkien's repeated use of *Beowulf* in his fictional trilogy *The Lord of the Rings*. Though Tolkien wrote about his passion for *Beowulf*, few scholars have attempted to examine its reflection in his fiction. Secondly, this thesis shows how Tolkien's use of themes, characters, symbols, and ideas from *Beowulf* helps him to create a kind of mythology for his own country—a story that stands as a tribute to English people. C. S. Lewis, friend of J. R. R. Tolkien and scholar in his own right, argues that "One of the main things [Tolkien] wants to say is that the real life of men is of that mythical and heroic quality. One can see the principle at work in his characterization … Man as a whole, man pitted against the universe, have we seen him at all till we see that he is like a hero in fairy tale?" (Lewis 14). In writing his heroic stories and including Beowulf in his works, Tolkien mythologizes the bravery and heroism of mankind, and especially of Englishmen. Amidst the struggles of World War II, he indicates that good and simple men can stand in the face of evil and maintain a semblance of hope, even if their fight is against all odds.

Interestingly, though writing a tribute to England seems rather nationalistic, Tolkien was careful to make sure that his stories held selflessness and simplicity in high regard. Rather than honoring power and dominion, as many nationalistic writers might do, Tolkien honors hope, glory, bravery, and goodness. He honors the natural beauty of his country, and the simple pleasures of his people. Tolkien saw his country face nationalistic leaders like Adolf Hitler, and he sought to honor his country's choice to avoid that kind of nationalism. Thus, his tribute to his country actually warns against the pitfalls of nationalism.

The similarities between *The Lord of the Rings* and *Beowulf* are striking. The monsters, archetypes, culture, and themes are all elements that are intimately connected with *Beowulf* and its medieval tradition. Tolkien's passion for medieval texts allowed him to modernize a famous epic poem. In this way, he continues the tradition of *Beowulf* and allows readers to continue to experience the magnificent power of human strength, heroism, and goodness in his trilogy, *The Lord of the Rings*.

REFERENCES

Beichler, James E. "Muggles, Matrix, and Silmaril: The Pride of Modern Mythology." *The Journal of Spirituality and Paranormal Studies*, vol. 30, no. 3, 2007, pp. 127-156.

"Beowulf." *The Norton Anthology of English Literature: The Major Authors*, 7th ed., vol. A, edited by M. H. Abrams, W. W. Norton & Company, 2001, pp. 27-94.

Birzer, Bradley J. *Sanctifying Myth: Understanding Middle-Earth*. Intercollegiate Studies Institute, 2003.

Carpenter, Humphrey, editor. *The Letters of J. R. R. Tolkien*. Houghton Mifflin Company, 2000.

Carpenter, Humphrey. *J. R. R. Tolkien: A Biography*. Houghton Mifflin Company, 2000.

Flieger, Verlyn. "Frodo and Aragorn: The Concept of the Hero." *Understanding the Lord of the Rings: The Best of Tolkien Criticism*, edited by Rose A. Zimbardo and Neil D. Isaacs, Houghton Mifflin Co., 2004.

Habermann, Ina, and Nikolaus Kuhn. "Sustainable Fictions: Geographical, Literary, and Cultural Intersections in J. R. R. Tolkien's *The Lord of the Rings*." *Cartographic Journal*, vol. 48, no. 4, 2011, pp. 263-273.

Indinck, William. "Classical Heroes in Modern Mythologies: Mythological Patterns of the Superhero." *Journal of Media Psychology*, vol. 9, no. 3, 2004, pp. 1-15.

Lewis, C. S. "The Dethronement of Power." *Understanding the Lord of the Rings: The Best of Tolkien Criticism*, edited by Rose A. Zimbardo and Neil D. Isaacs, Houghton Mifflin Co., 2004.

"Mythology." *Oxford English Dictionary*, http://www.oed.com/view/Entry/124702?redirectedFrom=mythology#eid. Accessed 1 Jan. 2019.

Nelson, Brent. "Cain-Leviathan Typology in Gollum and Grendel." *Extrapolation* (University of Texas at Brownsville), 2008, vol. 49, no. 3, pp. 466-485.

Risden, E. L. *Tolkien's Intellectual Landscape*. McFarland & Company, Inc., Publishers, 1957.

Shippey, Thomas. *Roots and Branches: Selected Papers on Tolkien*. Walking Trees Publishers, 2007.

Shippey, Thomas. *The Road to Middle-Earth: How J. R. R. Tolkien Created a New Mythology*. Houghton Mifflin Company, 2003.

Tolkien, J. R. R. Preface. *The Silmarillion*, by Tolkien, Random House Publishing Group, 1999, pp. xi-xxxi.

Tolkien, J. R. R. *The Fellowship of the Ring*. Houghton Mifflin Company, 1994.

Tolkien, J. R. R. *The Letters of J. R. R. Tolkien*. Edited by Humphrey Carpenter, Houghton Mifflin Company, 2000.

Tolkien, J. R. R. *The Monsters and the Critics*. Harper Collins Publishers, 2006.

Tolkien, J. R. R. *The Return of the King*. Houghton Mifflin Company, 1994.

Tolkien, J. R. R. *The Two Towers*. Houghton Mifflin Company, 1994.

The Effect of FLiNaK Molten Salt Corrosion on the Hardness of Hastelloy N

David J. Kok

To my brother Nate.
I will continue to keep you in my heart until we meet again.

ACKNOWLEDGEMENTS

ABSTRACT

The desire to reduce pollution caused by electricity production has led to a call for the replacement of conventional fossil fuel power plants. In order to fulfill this goal, a large amount of new nuclear reactors is required, and this provides the opportunity to put new and innovative reactor designs into production. The Molten Salt Reactor (MSR) is one of the most promising concepts, but a suitable combination of molten salt and container material needs to be found to reduce the potential for corrosion before the concept can be put into production. FLiNaK molten salt and the nickel-based alloy Hastelloy N have been identified as prime candidates for this function. The severity of FLiNaK corrosion in Hastelloy N requires study before this combination can be used in the operation of an MSR. In this work, Hastelloy N samples were submerged in FLiNaK molten salt for varying periods over a 55-hour interval and then hardness tested at twenty points on each sample in order to observe the progression of corrosion over time. Regression showed a statistically significant linear decrease in the hardness of the Hastelloy N samples over 55 hours submerged in the FLiNaK molten salt. When combined with previous studies, these findings indicate that Hastelloy N and FLiNaK are not a suitable pair to be used in the MSR.

INTRODUCTION

The world of energy production faces an uncertain future. It is projected that world energy consumption will increase by 34 percent in the period between 2013 and 2035 (British Petroleum, 2017). Fossil fuels have dominated the energy production market since its inception, with coal being the fuel of choice in the industrial revolution. This dominance continues in the modern world, with 81% of global energy coming from fossil fuel sources in 2011 (Khatib, 2012). The projected increase in energy consumption looks as if it will serve only to increase dependence on fossil fuels because they are the least costly means of generating the large amount of power required to meet this new demand (Shafiee & Topal, 2009). However, concerns about this dependence have arisen because of the pollution released into the atmosphere when fossil fuels are burned, and this has led to steps such as the Paris Agreement being taken to halt the climate change brought on largely by this pollution. The Paris Agreement arguably represents world opinion, and the only way to achieve those goals is to decrease dependence on fossil fuels (Nieto, Carpintero, & Miguel, 2018). However, in order to decrease dependence, an increase in the production of alternative sources of power is required.

Baseload power is a continuous supply of electricity necessary to maintain a steady, reliable power grid. It is currently produced by mainly fossil fuel plants, with nuclear contributing a small portion as well. As the world moves toward clean energy, a replacement will still be needed for the baseload power provided by fossil fuels (Reichenberg, Hedenus, Odenberger, & Johnsson, 2018). Though renewable energy sources such as wind and solar are very promising, they do not have the capacity to provide this baseload power. The inherent variability and unpredictability in the energy production from renewable sources prevent them from being able to function effectively as a baseload power source (Suman, 2018). This is illustrated by the capacity factors shown in Table 1. Capacity factors are calculated by dividing the actual production

by the maximum potential production. Solar and wind power generators will run whenever possible because the "fuel" for operation is essentially free, so capacity factors are a good measure of reliability for these power sources. This means that the low capacity factors for solar and wind power indicate that they cannot be trusted to provide baseload power because of their unreliability.

Table 1			
Capacity factors for different power plant types			
Nuclear	Coal	Solar	Wind
92.2%	53.70%	25.7%	34.6%
Note: These capacity factors are averages taken over the year 2017. Values provided by EIA (Tyra, Cassar, Liu, Wong, & Yildiz, 2019).			

Nuclear power is shown to be a very reliable source of power by its high capacity factor in **Table 1**. This makes it an ideal baseload power source, but despite this advantage the nuclear power industry has yet to increase its global energy production share to above 7.5% because of economic and safety concerns (British Petroleum, 2017). The hazardous nature of nuclear power was demonstrated by accidents at Three Mile Island (1979), Chernobyl (1986), and Fukushima (2011). These costly reactor meltdowns around the world decreased confidence in nuclear reactors, slowing the growth of nuclear power (Gu, 2018). The perceived danger of nuclear reactors also prompted more strict safety precautions, causing the cost of constructing a nuclear power plant to increase significantly to $5148/kW compared to coal's $3584/kW (Tyra, Cassar, Liu, Wong, & Yildiz, 2019). This prompted many corporations and governments to decide that nuclear power plants were not worth the risky investment (Lovering, Yip, & Nordhaus, 2016). However, reactor development has continued, and the recent call for carbon-free energy has reignited interest in nuclear energy.

In addition to the increased demand for energy, many currently operating reactors are outdated, with the average age of currently operating nuclear reactors at 29.9 years as of September 2018 (Schneider et al., 2018). The aging reactors will need to be replaced with new ones, and this opens the door for previously unemployed reactor concepts to be put into use. One of the most promising designs is the molten salt reactor (MSR) because of the advantages that it has over the reactor designs currently in use. It is both safer and more efficient than currently operational reactors, and its thorium fuel is more abundant than the uranium used in other nuclear reactor designs (Uhlíř, 2007). Though the older generation of nuclear reactors uses steam or another gas to transfer heat, the MSR has the advantage of using molten salts to transfer heat from the nuclear fuel. Molten salts can sustain temperatures as high as 1600°C without boiling, which is much higher than the 400°C maximum temperature of the pressurized water used in the common pressurized water reactor. The MSR also has a safer design than currently

operating reactors, which is very desirable in a world where safety is a primary concern for any new nuclear reactor that is built. One inherent safety feature is that the molten salt coolant is capable of operating at barely above atmospheric pressure and remains liquid at very high temperatures, which removes the threat of an explosion caused by high pressure (Humphrey & Khandaker, 2018). Another inherent safety feature is that the reaction at the core is self-regulating because the rate of nuclear fission decreases as the core temperature increases (Elsheikh, 2013).

The significant advantages of MSRs also come with disadvantages though, and one of the largest disadvantages of the MSR is the corrosive nature of the molten salt in contact with the metal pressure vessel material (Serp et al., 2014). This corrosion has been observed in numerous experiments where metal samples are exposed to a molten salt coolant. These experiments were performed with the purpose of limiting corrosion in an MSR, as this is very important to the safety and cost of running an MSR. Significant corrosion will increase the operation cost and decrease the efficiency of the reactor. For the MSR to be a viable design, the corrosion must be reduced enough that it can compete with other reactor designs. It is important to consider the composition of the salt and of the container material when seeking to reduce corrosion.

In an MSR design, there are two separate molten salt coolant loops used to transfer heat from the fuel. The primary loop takes heat directly from the fuel and then transfers it to the secondary coolant loop, which in turn transfers its heat to water. Evaluating coolant for both loops is necessary, but the focus of this research is on the secondary loop. Many salts have been tested for this role, but a LiF-NaF-KF (46.5-11.5-42 mol %) mixture (FLiNaK) has been distinguished as the leading candidate because of its very good heat transfer properties, low vapor pressure, and small moderating ratio (Williams, Toth, & Clarno, 2006). The small moderating ratio means that FLiNaK salt is not an effective moderator, making it a less than optimal choice for the primary coolant loop where it would be expected to moderate the neutrons in a nuclear reaction. However, the heat transfer properties and low vapor pressure make it an excellent secondary loop coolant (Guo, Zhang, Wu, & Zhou, 2018). It was also found to be less corrosive than other molten salts with similar properties (V. Ignatiev & Surenkov, 2016).

Many materials have also been considered for molten salt coolant loops. The ideal material needs to be strong without being brittle and must be able to withstand high temperatures as well as corrosion from the salt (Ren, Muralidharan, Wilson, & Holcomb, 2011). Studies such as those by Olson et al. and Ignatiev & Surenkov have been conducted to find the material that best satisfies these requirements. It has been demonstrated that a nickel-based alloy is the most suitable material for containing FLiNaK because of the combination of strength and corrosion resistance (Ignatiev & Surenkov, 2013), and Hastelloy N has been shown to be more corrosion-resistant at a high temperature than other nickel-based alloys (Olson, Ambrosek, Sridharan, Anderson, & Allen, 2009). These properties make it the most promising candidate for use in an MSR.

FLiNaK and Hastelloy N is a promising combination for the secondary coolant loop, and as such, it has been the subject of several studies. Ouyang et al. compare the mass loss of Hastelloy N with another nickel-based alloy in their 2014 study (Ouyang, Chang,

& Kai, 2014), whereas another study found the migration tendencies of chromium and molybdenum in a similar nickel-based alloy exposed to FLiNaK by using a nuclear microprobe (Lei et al., 2017). Another study by Ye et al. examines what the corrosion of Hastelloy N in FLiNaK looks like at the microscopic level using several techniques such as x-ray diffraction and scanning electron microscopy (Ye et al., 2016). Studies such as these show the nature of FLiNaK corrosion in Hastelloy N, but they fail to determine how this affects the properties of the material. A more macroscopic study would be useful to acquire data in this area.

One property that can be used to judge the extent of corrosion is the hardness of the material. Hardness in this context is a material's ability to resist plastic deformation. This property has been used previously in studies such as those by Li and Yavas et al. to observe the progression of corrosion on a metal surface (Li, 2017; Yavas et al., 2018). The results of these studies show that a reduction in hardness can be used as indicator of corrosion, and that the hardness can be tested to observe the effect of FLiNaK corrosion on Hastelloy N. In addition, this hardness reduction can be associated with a decrease in yield strength, which is an important mechanical property considered when testing the materials used in a nuclear reactor (Cahoon, Broughton, & Kutzak, 1971).

In the experiment outlined in this paper, Hastelloy N samples were submerged in FLiNaK for varying times over a 55-hour period prior to hardness testing in order to assess the effect of FLiNaK corrosion on the hardness of Hastelloy N.

METHODS

Materials

14.059" x .75" x 2.75" Hastelloy N samples were purchased from Haynes International, Inc. and were machined down using a milling machine according to specifications (**Figure 1**). Fifty-eight grams of LiF, twenty-four grams of NaF, and 118 grams of KF were combined to meet the weight percent requirements of FLiNaK salt (Olson et al., 2009). A crucible with a 52-cubic inch capacity was used to hold the FLiNaK mixture and Hastelloy N samples for heating.
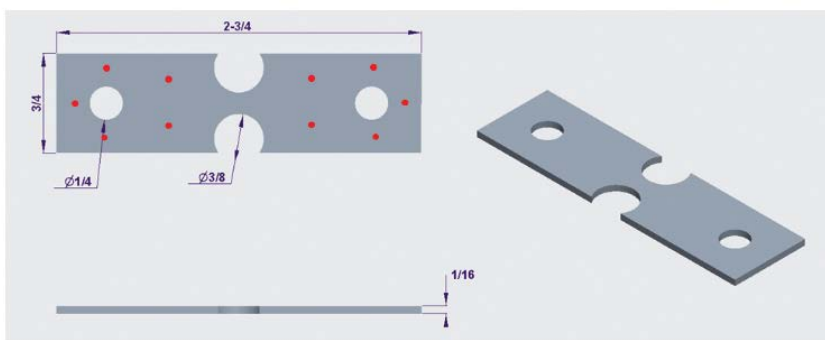
Figure 1: Dimensions (in inches) of machined Hastelloy N samples. These dimensions are based on measurements of an existing sample used for testing on the Rockwell Hardness Tester used in this study. The dots in the figure represent the approximate location that the hardness was tested (ten on both sides of the sample).

A custom stainless-steel lid was used to isolate the contents of the crucible from the outside environment, and a stainless-steel stir rod was used to mix the molten FLiNaK. Charcoal was used to provide heat for the experiment, and a custom-made apparatus was used to contain and concentrate this heat. This apparatus consisted of a hollow plaster cylinder with a small hole in the side for air flow, which was provided by a vacuum attached to this hole. A Rockwell Hardness Tester was used to find the hardness of the samples.

Procedure

The LiF, NaF, and KF were placed in the crucible together and heated to 993°C, which is the highest melting point of the three individual salts. The air flow to the charcoal was maximized to bring the contents of crucible to this high temperature. The stirring rod was then used to mix the molten salt and ensure that no solid salt remained in the crucible. Because FLiNaK is a eutectic mixture, meaning that the melting point is lower than that of its components, the melting point of the mixture dropped to its 454°C eutectic point after the initial melt. This allowed the air flow to the charcoal to be reduced in order to decrease the rate of charcoal burning.

This reduced air flow was maintained for the remaining duration of the experiment with charcoal being added every hour to ensure that the heat supplied to the crucible was constant. Eleven of the Hastelloy N samples were then submerged in the molten salt, and a single sample was taken out every five hours with the final sample being taken out after being submerged in the FLiNaK mixture for 55 hours. After the samples were removed from the molten salt, they were allowed to cool for one hour in the open air and then were cleaned in preparation for testing using an aluminum nitrate cleaning solution and subsequently water.

These eleven samples and three control samples with no exposure to the FLiNaK salt were then tested on a Rockwell hardness tester, which used a 1/16" indenting ball and a major load of about 981 N. This means that the machine measures hardness on the Rockwell B scale, which is a scale used to judge the hardness of metals. The hardness was tested on each sample at the same twenty locations shown in Figure 1, and the average of these tests was then taken as the hardness of the sample. A regression analysis was then performed on these average hardness values to determine the statistical significance of the data.

RESULTS

Hastelloy N samples were submerged in FLiNaK for varying times over a 55-hour period prior to hardness testing in order to assess the effect of FLiNaK corrosion on Hastelloy N. The average hardness calculated from twenty hardness readings on each sample is shown in Table 2 and Figure 2 for each exposure time. Whereas control samples maintained an average hardness of 80.89 ± 5.74 HRB, a progressive linear decrease in hardness was observed in the samples over the 55 hours exposure time (**Table 2 and Figure 2**). Furthermore, regression analysis revealed a statistically significant loss of 0.12% per hour in hardness ($p<0.05$).

Table 2

Hastelloy N hardness values decrease upon FLiNaK exposure

Exposure Time [hrs]	Hardness [HRB]	Standard Deviation
0	85.99	4.47
5	78.69	5.94
10	83.48	4.57
15	79.53	5.03
20	80.57	6.17
25	80.50	6.04
30	75.80	5.53
35	81.63	6.08
40	82.07	3.86
45	77.33	7.61
50	79.63	6.86
55	75.22	6.73

Note: The average hardness shown in this table is the average of the 20 hardness readings from each sample, and the standard deviation is for these 20 data points.

The HRB units represent the hardness measured on the Rockwell B Scale, which provides a meaningful comparison to other materials measured on this scale. For this study, they are simply used in comparison to the control sample.
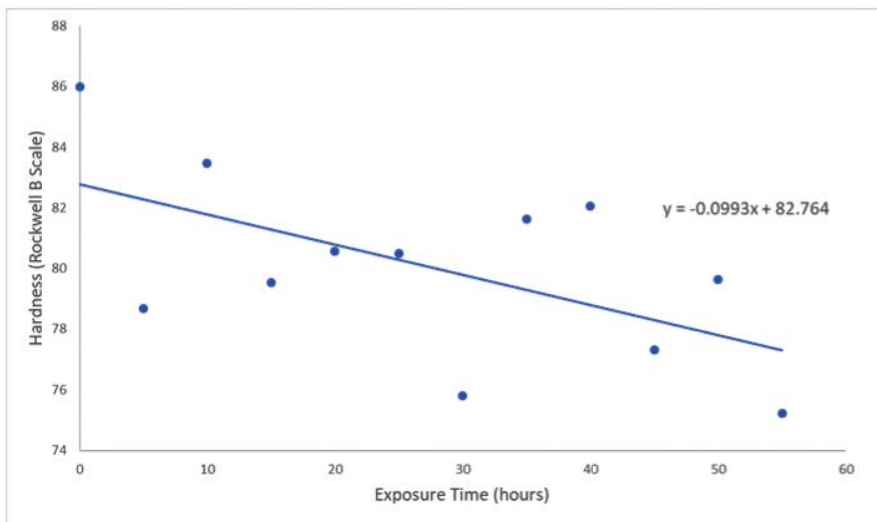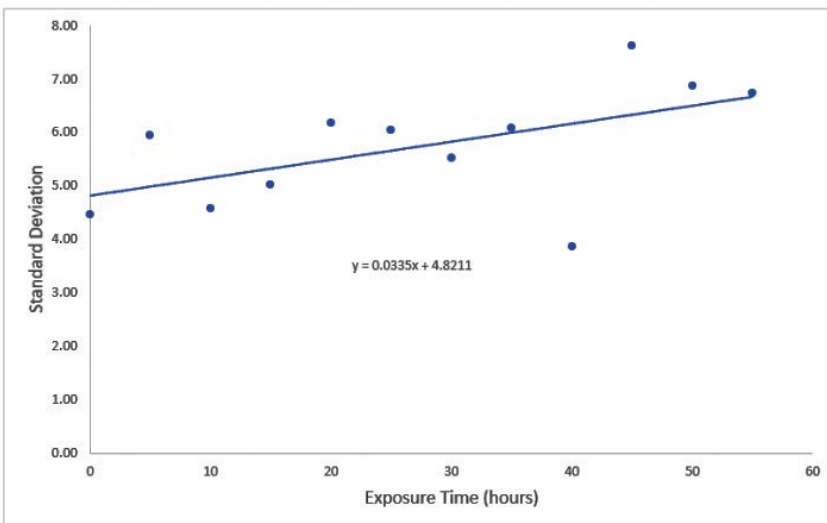

Figure 2: Hastelloy N samples hardness decrease upon increasing exposure to FLiNaK. The hardness values displayed on this plot are the average of twenty hardness readings from each of the fourteen Hastelloy N samples. A linear trend line fitted to this data is shown along with its representative equation.

143

As shown in Figure 2, the highest average hardness of 85.99 ± 4.47 HRB is observed in the control sample while the lowest average hardness of 75.22 ± 6.73 HRB is seen in the sample with the highest exposure time. Regression analysis revealed a negative trend representing a decrease in hardness as time exposed to FLiNaK increases, with an R square value (0.335) produced by this analysis demonstrating that approximately 33.5% of the variation in the data is accounted for by the linear model shown in Figure 2. The low p-value (0.0486) and high F-value (5.04) confirm the statistical significance based on a 90% confidence interval.

A residual plot was also produced to determine whether a linear model is the correct fit for the data (**Figure 3**). The equal distribution on either side of the x-axis of this plot indicates that the linear model shown in Figure 2 is correct.
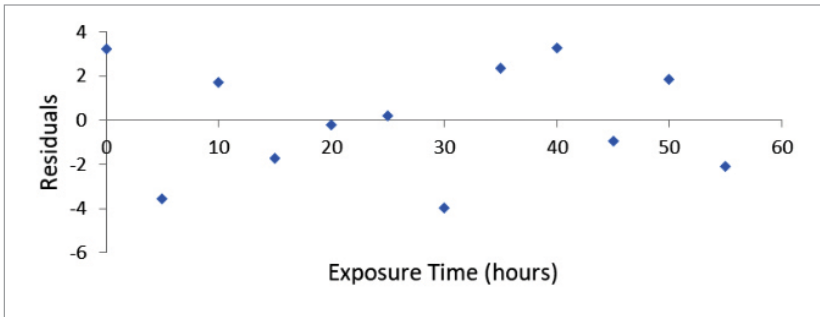
Figure 3: Plot of residuals vs the time submerged in FLiNaK molten salt. The residuals show the deviation of each average hardness value from the expected values calculated by the regression analysis, which means that ideal linear data would lie entirely on the x-axis. The exposure time is the duration that the Hastelloy N sample was submerged in the molten FLiNaK salt.

Figure 4: Standard deviation in hardness increases upon increasing exposure time. The standard deviation displayed on this plot are based on the twenty hardness readings from each of the fourteen Hastelloy N samples. The exposure time is the time that the sample corresponding to each standard deviation value was submerged in the FLiNaK molten salt. A linear trend line fitted to this data is shown along with its representative equation.

We also wanted to determine if variation of material hardness increased with exposure time. As shown in **Figure 4**, standard deviation in hardness did increase with exposure time, indicating that variation hardness in individual samples increased with increasing exposure time.

DISCUSSION

Next generation nuclear reactors, such as the molten salt reactor, are susceptible to corrosion, and thus research is needed to identify optimal materials that would allow this technology to be actualized. Here, we sought to determine if Hastelloy N samples would corrode in hardness when exposed to molten salt. Fourteen Hastelloy N samples were submerged in FLiNaK for varying amounts of time in order to determine the effect of corrosion on the hardness of the samples. This resulted in a linear decrease (-0.0993 HRB/hr) in the hardness of the samples over 55 hours of testing, including a high standard deviation in the hardness of the individual samples.

When combined, the regression analysis and residual plot demonstrate that the hardness of the Hastelloy N samples decreased in a linear fashion over the 55 hour time period. However, the standard deviation for the average hardness values is very high, with the average deviation being 5.74 HRB. This is troublesome when considering that the average hardness decrease is only 5.46 HRB over the 55 hours of the experiment. This calls into question the accuracy of the average hardness values, which, in turn, calls into question the validity of the findings from the regression analysis shown previously. In order to account for this variance, the results can be compared to those of previously conducted studies.

Having only one sample per time point prevents assessing the variation between individual samples, but the variation within samples shows an increase in standard deviation with an increase in the time submerged in molten salt (Figure 4). Hastelloy N, like all metals, is made up of grains, and the interface between the individual grains are called grain boundaries. It has been demonstrated that corrosion is most prevalent at the grain boundaries of Hastelloy N, and this is a possible explanation for the high standard deviation seen in the average hardness of the samples (Olson et al., 2009; Ouyang et al., 2014). This corrosion increases the prominence of the grain boundaries in the Hastelloy N, and it is possible that some of the locations where the hardness was evaluated were on the grain boundaries, resulting in a significantly lower value than would otherwise be observed. The measurements showing the decreased hardness at the grain boundary would increase the standard deviation in the average hardness by increasing the spread of data, and thus accounting for the greater deviation upon increased FLiNaK exposure.

Hastelloy N has chromium depletion 50 micrometers deep and a mass loss of about 2 milligrams per square centimeter of surface area after being submerged in FLiNaK molten salt for 500 hours, which indicates a progression of FLiNaK corrosion on the surface of the Hastelloy N sample over this span of time (Olson et al., 2009). The study conducted by Olson et al. indicates that the corrosion manifests primarily on the surface of the sample, making the surface weaker than the deeper material. A Rockwell hardness tester analyzes the surface of the material, so this corrosion at the surface

would be expected to cause a noticeable decrease in the measured hardness of the sample. The results of this study would agree with the findings of Olson et al. in that a decrease in hardness would be expected to accompany the surface corrosion previously demonstrated.

When analyzing the use of Hastelloy N and FLiNaK in an MSR, there is a subjective aspect of determining whether it suits the needs of those designing the reactor. However, the decrease in hardness shown in this study paired with the findings of mass loss and microscopic studies done previously indicates that the rate of corrosion could be cause for concern (Olson et al., 2009; Ouyang et al., 2014). On the other hand, studies of corrosion in other materials indicate that the rate of corrosion decreases over time (Gomes et al., 2019), so additional investigation should be done on the long term FLiNaK corrosion of Hastelloy N. Previous studies of long term corrosion have used ranges of 400 hours (Rhee, McNallan, & Rothman, 1986) and 3000 hours (Froitzheim et al., 2012; Gomes et al., 2019), so somewhere in this range would be acceptable. The samples should be removed at varying times, as in the current study, and then be tested for tensile strength and hardness in order to gain an understanding of how the mechanical properties of Hastelloy N change over time while submerged in FLiNaK molten salt.

It is nearly impossible to make a definite conclusion on the merits of Hastelloy N and FLiNaK for use in an MSR without considering the effect that the accompanying corrosion has on the yield strength of the material. A significant reduction in yield strength could be the cause of a failure in the reactor, so it is of paramount importance for testing. There are connections that have been drawn between hardness and yield strength, and these relations can potentially be used to find the decrease in yield strength resulting from corrosion (Yang et al., 2018). Examining this connection is not within the scope of this project, but it is an important factor that should be the subject of future studies.

CONCLUSION

The results of this study indicate that the hardness of Hastelloy decreases linearly at a rate of 0.12% per hour. This concurs with previous studies which found that FLiNaK molten salt corrosion occurs at the surface of the sample, with the corrosion being most pronounced at the grain boundaries of the material. It is possible that the lesser hardness at the corroded grain boundaries of the sample caused the high standard deviation seen in the average hardness of the samples, which is shown to be likely by the increase in standard deviation over time submerged in FLiNaK. This short-term study, when combined with previous findings, indicate that Hastelloy N and FLiNaK should not be used together in an MSR. However, further study of Hastelloy N in FLiNaK salt is required before a definitive recommendation can be made on its potential use in a Molten Salt Reactor. Specifically, an experiment that allows the study of long-term effects of FLiNaK corrosion on Hastelloy N rather than the short-term effects shown in this study is needed. Additionally, a study should be conducted to determine the decrease in yield strength that coincides with the reduction in hardness demonstrated in this study. This can be used to get a more accurate representation of the effectiveness of Hastelloy N in a nuclear reactor after exposure to FLiNaK corrosion.

REFERENCES

British Petroleum. (2017). BP Statistical Review of World Energy 2017. *British Petroleum*, (66), 1–52. https://doi.org/http://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf

Cahoon, J. R., Broughton, W. H., & Kutzak, A. R. (1971). The determination of yield strength from hardness measurements. *Metallurgical Transactions*. https://doi.org/10.1007/BF02913433

Elsheikh, B. M. (2013). Safety assessment of molten salt reactors in comparison with light water reactors. *Journal of Radiation Research and Applied Sciences*, 6(2), 63–70. https://doi.org/10.1016/j.jrras.2013.10.008

Froitzheim, J., Canovic, S., Nikumaa, M., Sachitanand, R., Johansson, L. G., & Svensson, J. E. (2012). Long term study of Cr evaporation and high temperature corrosion behaviour of Co coated ferritic steel for solid oxide fuel cell interconnects. *Journal of Power Sources*, 220, 217–227. https://doi.org/10.1016/j.jpowsour.2012.06.092

Gomes, A., Navas, M., Uranga, N., Paiva, T., Figueira, I., & Diamantino, T. C. (2019). High-temperature corrosion performance of austenitic stainless steels type AISI 316L and AISI 321H, in molten Solar Salt. *Solar Energy*, 177(November 2018), 408–419. https://doi.org/10.1016/j.solener.2018.11.019

Gu, Z. (2018). History review of nuclear reactor safety. *Annals of Nuclear Energy*, 120, 682–690. https://doi.org/10.1016/j.anucene.2018.06.023

Guo, S., Zhang, J., Wu, W., & Zhou, W. (2018). Corrosion in the molten fluoride and chloride salts and materials development for nuclear applications. *Progress in Materials Science*, 97(February), 448–487. https://doi.org/10.1016/j.pmatsci.2018.05.003

Humphrey, U. E., & Khandaker, M. U. (2018). Viability of thorium-based nuclear fuel cycle for the next generation nuclear reactor: Issues and prospects. *Renewable and Sustainable Energy Reviews*, 97(September), 259–275. https://doi.org/10.1016/j.rser.2018.08.019

Ignatiev, V., & Surenkov, A. (2013). Alloys compatibility in molten salt fluorides: Kurchatov Institute related experience. *Journal of Nuclear Materials*, 441(1–3), 592–603. https://doi.org/10.1016/j.jnucmat.2013.05.007

Ignatiev, V., & Surenkov, A. (2016). *Corrosion phenomena induced by molten salts in Generation IV nuclear reactors*. *Structural Materials for Generation IV Nuclear Reactors*. Elsevier Ltd. https://doi.org/10.1016/B978-0-08-100906-2.00005-7

Khatib, H. (2012). IEA World Energy Outlook 2011-A comment. *Energy Policy*, 48, 737–743. https://doi.org/10.1016/j.enpol.2012.06.007

Lei, Q., Liu, K., Gao, J., Li, X., Shen, H., & Li, Y. (2017). The elemental move characteristic of nickel-based alloy in molten salt corrosion by using nuclear microprobe. *Nuclear Instruments and Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms*, 404, 185–188. https://doi.org/10.1016/j.nimb.2017.01.070

Li, D. (2017). Corrosion effect on hardness of steel screws by nanoindentation. *PCI-Paint and Coatings Industry*.

Lovering, J. R., Yip, A., & Nordhaus, T. (2016). Historical construction costs of global nuclear power reactors. *Energy Policy*, 91, 371–382. https://doi.org/10.1016/j.enpol.2016.01.011

Nieto, J., Carpintero, Ó., & Miguel, L. J. (2018). Less than 2 °C? An Economic-Environmental Evaluation of the Paris Agreement. *Ecological Economics*, 146(November 2016), 69–84. https://doi.org/10.1016/j.ecolecon.2017.10.007

Olson, L. C., Ambrosek, J. W., Sridharan, K., Anderson, M. H., & Allen, T. R. (2009). Materials corrosion in molten LiF-NaF-KF salt. *Journal of Fluorine Chemistry*, 130(1), 67–73. https://doi.org/10.1016/j.jfluchem.2008.05.008

Ouyang, F. Y., Chang, C. H., & Kai, J. J. (2014). Long-term corrosion behaviors of Hastelloy-N and Hastelloy-B3 in moisture-containing molten FLiNaK salt environments. *Journal of Nuclear Materials*, 446(1–3), 81–89. https://doi.org/10.1016/j.jnucmat.2013.11.045

Reichenberg, L., Hedenus, F., Odenberger, M., & Johnsson, F. (2018). Tailoring large-scale electricity production from variable renewable energy sources to accommodate baseload generation in europe. *Renewable Energy*, 129, 334–346. https://doi.org/10.1016/j.renene.2018.05.014

Ren, W., Muralidharan, G., Wilson, D. F., & Holcomb, D. E. (2011). Considerations of Alloy N for Fluoride Salt-Cooled High-Temperature Reactor Applications. In *American Society of Mechanical Engineers, Pressure Vessels and Piping Division Conference* (Vol. 6, pp. 725–736). https://doi.org/10.1115/PVP2011-57029

Rhee, M. H., McNallan, M. J., & Rothman, M. F. (1986). Long term high temperature corrosion studies of high temperature alloys in chlorine contaminated environments. *Journal of Materials for Energy Systems*, 7(4), 294–301. https://doi.org/10.1007/BF02833568

Schneider, M., Froggatt, A., Hazemann, J., Katsuta, T., Stirling, A., Wealer, B., … Stienne, A. (2018). *The World Nuclear Industry Status Report 2018*. Paris, France. Retrieved from https://www.worldnuclearreport.org/IMG/pdf/20170912wnisr2017-en-lr.pdf

Serp, J., Allibert, M., Beneš, O., Delpech, S., Feynberg, O., Ghetta, V., … Zhimin, D. (2014). The molten salt reactor (MSR) in generation IV: *Overview and perspectives*. *Progress in Nuclear Energy*, 77, 308–319. https://doi.org/10.1016/j.pnucene.2014.02.014

Shafiee, S., & Topal, E. (2009). When will fossil fuel reserves be diminished? *Energy Policy*, 37(1), 181–189. https://doi.org/10.1016/j.enpol.2008.08.016

Suman, S. (2018). Hybrid nuclear-renewable energy systems: A review. *Journal of Cleaner Production*, 181, 166–177. https://doi.org/10.1016/j.jclepro.2018.01.262

Tyra, B., Cassar, C., Liu, J., Wong, P., & Yildiz, O. (2019). *Electric Power Monthly with data for November 2018*. Washington, DC.

Uhlíř, J. (2007). Chemistry and technology of Molten Salt Reactors - history and perspectives. *Journal of Nuclear Materials*, 360(1 SPEC. ISS.), 6–11. https://doi.org/10.1016/j.jnucmat.2006.08.008

Williams, D. F., Toth, L. M., & Clarno, K. T. (2006). *Assessment of Candidate Molten Salt Coolants for the Advanced High-Temperature Reactor (AHTR)*. Ornl/Tm-2006/69. https://doi.org/ORNL/TM-2006/69

Yang, H., Kano, S., Shen, J., McGrady, J., Zhao, Z., Duan, Z., & Abe, H. (2018). On the strength-hardness relationships in a Zr-Nb alloy plate with bimodal basal texture microstructure. *Materials Science and Engineering A*, 732(July), 333–340. https://doi.org/10.1016/j.msea.2018.07.028

Yavas, D., Mishra, P., Alshehri, A., Shrotriya, P., Hebert, K. R., & Bastawros, A. F. (2018). Nanoindentation study of corrosion-induced grain boundary degradation in a pipeline steel. *Electrochemistry Communications*, 88(December 2017), 88–92. https://doi.org/10.1016/j.elecom.2018.02.001

Ye, X. X., Ai, H., Guo, Z., Huang, H., Jiang, L., Wang, J., … Zhou, X. (2016). The high-temperature corrosion of Hastelloy N alloy (UNS N10003) in molten fluoride salts analysed by STXM, XAS, XRD, SEM, EPMA, TEM/EDS. *Corrosion Science*, 106, 249–259. https://doi.org/10.1016/j.corsci.2016.02.010

Exploring the Effects of Protein Kinase C Alpha Gene Knockout on the Proliferation of Human Embryonic Kidney Cells

Emma J. Kuntz

ACKNOWLEDGEMENTS

ABSTRACT

Signaling molecules have important roles in many cellular functions, but because these pathways are incredibly complex, the exact mechanisms often remain unknown. One signaling molecule, protein kinase C alpha (PKCα), is involved in cell proliferation and is expressed at high levels in many cancers. Interestingly, its activity as a tumor promoter or tumor suppressor varies depending on the cell type for reasons not yet fully understood. This study aimed to investigate the role of PKCα in cell proliferation in order to better understand its function as a signaling molecule. To assess this, a knockout line was generated using CRISPR-Cas9 and human embryonic kidney (HEK) cells. After confirmation of knockout, proliferation studies were conducted on untreated knockout and wild-type cells and upon addition of 0-0.5 µg/mL of PMA and 0-5 µg/mL of sphingosine-1-phosphate to induce proliferation. Our results indicate that compared with wild-type cells, untreated PKCα knockout cells exhibited reduced proliferation and had high percentages of cell death when treated with proliferative agents. This supports the hypothesis that PKCα knockout reduces proliferation in human embryonic kidney cells and suggests that PKCα has an important role in normal cell function in a tumor-promoting context.

Keywords: protein kinase C alpha (PKCα), proliferation, cancer, knockout, cell signaling

INTRODUCTION

Protein kinase C alpha (PKCα), a signaling molecule involved in many cellular processes, has an important role in cell growth and proliferation. The exact details of this pathway, however, are unknown, and further elucidation on the effects of PKCα on cell proliferation is needed. In this study, HEK cells were genetically modified using CRISPR-Cas9 to generate a cell line lacking PKCα. Together with a wild-type HEK cell line, these knockout cells were treated with varying levels of proliferative agents, and differences in the resulting growth rates were assessed. Developing a PKCα gene knockout cell line and assessing proliferation of these cells increases our understanding of the PKCα signaling pathway, helps to elucidate its involvement in cell growth and division, and contributes to hypotheses of the role it may play in the abnormal proliferation that is characteristic of cancer cells. In short, our findings contribute to the foundation for future applications of PKCα involvement in cell proliferation.

REVIEW OF LITERATURE

PKCα function

Cancer is the result of uncontrolled cell growth and is the second largest cause of death in the United States [5]. This abnormal cell growth is attributed to cancer-causing mutations that typically involve malfunction of tumor-suppressor genes and the activation of proteins involving cell proliferation. In fact, many cancers are known to involve a mutation in TP53, a tumor-suppressor gene [12]. Without the proper function of the protein produced by that gene, p53, cell growth and division are largely unregulated [12]. This results in abnormal growth, often initiated by cell signaling molecules that have a role in normal, non-cancerous cell proliferation. One of these

signaling molecules, an enzyme called protein kinase C alpha (PKCα), is activated in normal cells by diverse signaling pathways. Various stimuli, often involving interaction with a membrane, can lead to PKCα involvement in differentiation, apoptosis, cellular transformation, motility, cell growth, proliferation, and many other cellular functions [13]. Importantly, PKCα has been linked to proliferation, survival, differentiation and motility in tumor growth but can also act as a tumor suppressor depending on the context [4]. In fact, past research has shown that PKCα activation leads to the progression of many cancers (for example, bladder and breast cancer), while it may act as a growth-inhibitory kinase in others (such as colon cancer and non-small cell lung cancer) [1], [4], [10]. Its role in cell proliferation as an application of tumor promotion is, however, not well understood, but targeting PKCα as a potential therapy for many cancers has been suggested [4]. In order to understand more about how aberrant PKCα signaling may be contributing to the rapid growth and division of cancer cells, a better understanding of the functional diversity of its proliferative role in cells is needed.

Gene knockout and human embryonic kidney cells
There are two common methods used to understand protein function: genetically modifying a cell line to render the gene nonfunctional, and utilizing drug inhibition to block protein function. In the inhibition method, proteins are still present, so although function is impaired, it is still possible for the drug-inhibited protein to interact with binding partners. Drug inhibition often also has off-target effects [16], and thus an agent used to inhibit PKCα function may also interfere with molecules involved in other proliferation pathways. For example, UCN-01 is a PKCα inhibitor with anti-tumor applications, but because it does not work exclusively via the PKCα pathway it cannot be used to understand the specific role of PKCα in proliferation and tumor promotion [4]. In contrast, gene knockout prevents the production of the protein altogether and eliminates the problems associated with inhibition. Because it exclusively targets the gene that codes for a protein, gene knockout yields more specific results. Knocking out the gene for PKCα in human embryonic kidney (HEK) cells would generate a cell line that could serve as a comparison to wild-type HEK cells with a normal functioning PKCα gene.

HEK cells are commonly used in cell biology and cancer research for many reasons: they are easy to grow and transfect, relatively inexpensive, and tumorigenic [15]. These properties make HEK cells a practical and meaningful tool for use in a study involving gene-knockout and cell proliferation. Additionally, PKCα does not act as an anti-proliferative factor in HEK cells, so this cell line serves as an excellent model for better understanding the functional role of PKCα in proliferation and tumor promotion [13]. A common concern involving gene-knockout involves cell viability. Removing a gene can have drastic effects and is often too significant of an alteration for the cells to survive. In 2002, researches developed a method of targeting PKC isotypes in HEK-293 cells and demonstrated that subtype-specific differentiation was possible [6]. Specifically, they performed subtype-specific knockdown of PKC on HEK cells using short interfering RNA and grew them in normal conditions. Although this is not the same as gene knockout with CRISPR-Cas9, the survival of these HEK cells without active PKCα suggests that CRISPR-Cas9-generated PRKCA knockout HEK cells would be viable for use in proliferation studies.

CRISPR-Cas9

CRISPR-Cas9 is a relatively new technology that can be used for gene knockout. Since the first discovery of a CRISPR locus in 1993, CRISPR-Cas9 has been researched extensively [7]. In 2013, researchers used it to genetically modify the genes of mice and mark them with a fluorescent reporter. Analysis verified that the CRISPR-Cas9 mechanism rarely makes errors and the use of this technology in eukaryotic cells is effective, efficient, and accurate [17]. Continuing this work, in 2014 CRISPR-Cas9 was successfully used for gene knockout in HEK-293 cells [18]. Similarly, this system could be employed to create a HEK cell line without PRKCA, the PKCα gene. Because of its use and reliability in genetic modification, CRISPR-Cas9 is important for cancer research and understanding the role of specific proteins, such as PKCα, in cell proliferation. Additionally, our use of CRISPR-Cas9 in this study makes this method accessible as a research and teaching tool at Olivet. The successful use of the CRISPR-Cas9 mechanism will contribute to the development of laboratory protocol so that this tool could be widely used by Olivet biology students.

Cell proliferation and proliferative agents

PKC isoforms are classified into several groups. PKCα falls into the category of classical PKCs (cPKCs). cPKCs are activated at a C1 domain and a C2 domain. The C1 domain is activated by diacylglycerol (DAG), a secondary messenger that is stimulated by membrane receptors, and the C2 domain allows for the binding of other molecules in the presence of calcium [13]. A phorbol ester, such as phorbol 12-Myristate 13-Acetate (PMA), is a proliferative agent known to utilize the PKCα pathway by binding at the C1 domain [11]. Another proliferative agent, sphingosine-1-phosphate, causes proliferation independent of PKCα signaling [2]. The mechanism of proliferation via PKCα can differ depending on the cell type and activity. Activated PKCα has been documented to upregulate cyclin-D1, cdk4 and p21cip1, all of which can enhance proliferation [13]. Commonly, PKCα phosphorylates Raf-1, which leads to the activation of ERK-MAPK (extracellular signal-regulated kinase-mitogen-activated protein kinase cascade) [13]. This enhances proliferation in many cell types, including HEK-293 cells [19]. PKCα dependent and independent proliferation in HEK cells can be evaluated through visual observation and the generation of a cell growth curve with doubling times. This can be calculated using a hemocytometer over a period of several days. In order to evaluate the effects of proliferative agents on cell proliferation, cells can be treated with various concentrations of the proliferative agent, counted, and then used to construct a concentration vs. cell proliferation curve.

PKCα has an important role in cell proliferation, but it is functionally diverse and largely not understood. Because of its involvement in tumor promotion, understanding this protein and its signaling pathway is important and relevant for cancer research and treatment. Investigating the effects of PRKCA knockout on proliferation in a cell line where PKCα is not tumor-suppressive can help fill this gap in research. Specifically, attempting to induce abnormal proliferation by mechanisms that are PKCα independent and dependent in a PRKCA knockout cell line will yield further understanding of its exact role in tumor promotion. We hypothesized that proliferation studies of wild-type and knockout cells under both normal conditions and when treated with PKCα-independent and PKCα-dependent proliferation agents would demonstrate that knocking out protein kinase C-alpha reduces proliferation in HEK-293 cells.

METHODOLOGY

Generation of PRKCA knockout cells

PRKCA knockout cells were produced following the manufacture protocol provided by Santa Cruz Biotechnology [3]. Briefly, HEK-293 cells were seeded at a density of 50,000 cells/well and grown in 24-well culture dishes in Dulbecco's Modified Eagle Medium (DMEM) supplemented with 10% fetal bovine serum. Approximately 48 hours later, cells reached 60-75% confluence, and culture media was replaced with media generated for optimal transfection of HEK-293 cells [14]. This media contained both the CRISPR-Cas9 KO plasmid and the homology-directed repair (HDR) plasmid with a fluorescent tag and also a puromycin-resistant gene insert prepared according to the manufacture's protocol [3]. Briefly, three tubes were incubated then combined and added to each well. Tube A contained 240 μl of Optimem medium and 3.2 μg of the CRISPR-Cas9 KO plasmid. Tube B contained 240 μl of Optimem medium and 3.2 μg of the HDR plasmid. Tube C contained 400 μl of Optimem medium and 16 μl of Lipofectamine 2000. These tubes were incubated individually for 5 minutes at room temperature, then mixed gently and the combined solution was incubated for 20 minutes at room temperature. Following incubation, 115 μl of the final solution was added to each well (twelve total) with rocking. After 24 hours, this media was replaced with standard DMEM and cells were grown in normal culture conditions.

Approximately seven days post-transfection, cells were observed with fluorescent microscopy to confirm transfection efficiency by fluorescence. Cells were then grown and treated with 2.5 μg/mL of puromycin to kill cells lacking the transfected puromycin-resistant gene insert. This selected for cells likely to be PRKCA knockout cells. After growing cells for an additional seven days, they were treated with 10 μg/mL of puromycin to select for highly-expressing homozygous knockout cells.

Western blot analysis of PKCα knockout

Puromycin resistant cells were grown and tested for PKCα presence using standard Western blot techniques [8]. Wild-type and knockout cells were grown in normal conditions in 6-well culture dishes until they reached confluence. Upon reaching confluence, cells were washed with PBS and treated with a lysis buffer containing RIPA buffer (Sigma R0278) and four protease inhibitors: PMSF (100 mM), Luepeptin (10 mg/mL), Aprotinin (10 mg/mL), and Pepstatin A (1 mg/mL). Lysed cells were collected, washed and centrifuged, and a BCA assay was performed to determine protein concentration in the cell lysate for wild-type and knockout cells. Lysates were diluted to a concentration of 1 mg/mL with SDS-PAGE loading buffer. 10% SDS-PAGE gel (Lonza) was loaded with 20 μl of cell lysate per lane. Three lanes were loaded for each cell type, and two lanes were loaded with protein molecular weight ladders. This procedure was run at a constant voltage of 125 V for approximately ninety minutes. Western blot protocol was taken from the Xcell II Blot Module User's Manual. Transfer to the Western blot membrane was performed overnight in a cold room at a constant voltage of 12 V. Following this, the membrane was removed, treated with blocking buffer, and incubated in primary antibody overnight. Primary antibody was prepared at a dilution of 1:500. Following this, the membrane was washed and treated with the secondary antibody for one hour. The secondary antibody was prepared at a dilution of

1:12,500. Remaining western blot procedures took place in a photography dark room. The membrane was incubated in ECL Western Blotting Substrate (ThermoFischer) then exposed to film for times ranging from 10 to 45 seconds. Film was developed in developer solution for two to three minutes, placed in water for 30 seconds, placed in fixer for three minutes, and then rinsed under running water for five minutes.

Treatment with proliferative agents: sphingosine-1-phosphate and phorbol ester

PRKCA knockout and wild-type HEK-293 cells were first grown in normal conditions to determine viability and disruption of the normal cell cycle. Cells were grown in the absence of puromycin to prevent altered proliferation compared to wild-type cells. Cell counts were recorded for each group in duplicate over a four day period. Next, knockout and wild-type cells were treated with proliferative agents. The first of these proliferative agents, sphingosine-1-phosphate, is known to work via PKCα-independent mechanism in HEK-293 cells [2]. Knockout and wild-type cell cultures were treated with concentrations of sphingosine-1-phosphate ranging from 0-5 µg/mL, and observations of percent confluence were recorded. The second proliferative agent, phorbol ester, is known to activate PKCα by mimicking diacylglycerol, the physiological ligand for PKCα that binds along with calcium for normal PKCα activation [11]. Unlike diacylglycerol, phorbol ester does not also require the binding of calcium to induce proliferation [11]. Knockout and wild-type cell cultures were treated with concentrations of phorbol ester ranging from 0-0.5 µg/mL, and observations of percent confluence were recorded.

Statistical analysis

A student's t-test was used to assess significance of PKCα in cell proliferation, with a p-value less than or equal to 0.05 considered statistically significant.
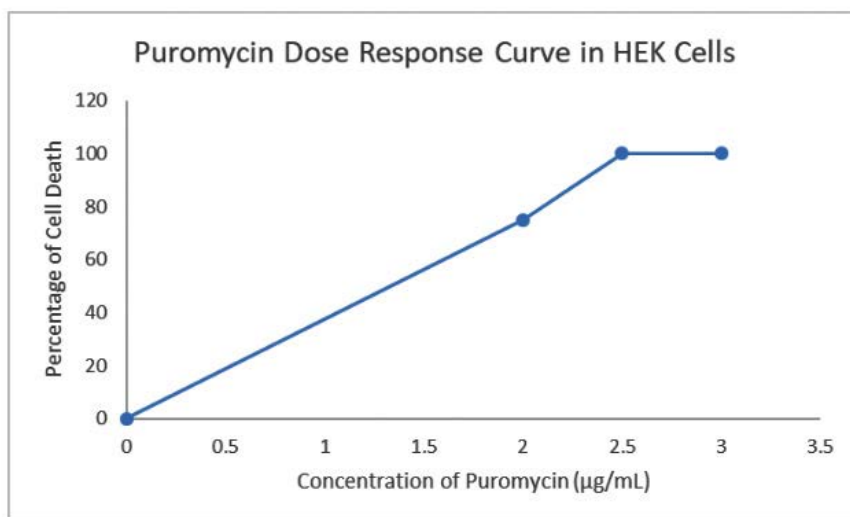
Figure 1. Puromycin dose response curve in HEK cells two days after treatment. Cells were treated with concentrations of 0, 2, 2.5 and 3 µg/mL of puromycin. A concentration of 2.5 µg/mL resulted in 100% cell death.

RESULTS

Establishing a working concentration of puromycin

In order to select for potential knockout cells using puromycin, it was important to establish a minimum level of puromycin that is toxic to wild-type HEK-293 cells. Based on previous literature, a treatment was conducted using concentrations of 0, 2, 2.5 and 3 µg/mL puromycin. Within two days of treatment, concentrations of 2.5 and 3 µg/mL resulted in 100% cell death. A puromycin concentration of 2.5 µg/mL was then selected to be used to treat transfected cells.

Confirmation of knockout

All cells were observed for RFP expression 24 hours after transfection. As expected, wild-type cells demonstrated a complete absence of RFP expression, and RFP was observed at varying levels in transfected cells. Transfected cells treated with 2.5 µg/mL of puromycin resulted in some cell death, but surviving cells displayed normal, healthy growth. Control cells were treated simultaneously with 2.5 µg/mL puromycin and resulted in 100% cell death. The remaining transfected cells were then observed under fluorescent microscopy to analyze RFP expression. **Figure 2** shows photographs depicting RFP expression in transfected cells before treatment with puromycin and one week post-treatment.
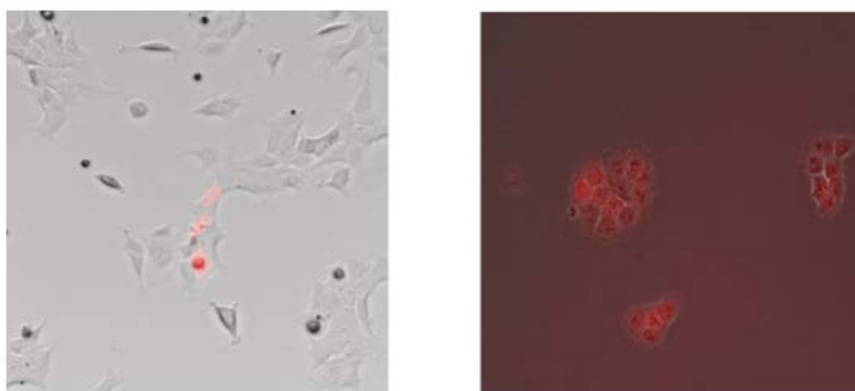
Figure 2. RFP expression using fluorescent microscopy in transfected cells before and after puromycin selection. Few transfected cells expressed RFP before puromycin selection (left), and RFP was observed at much higher levels in transfected cells after selection with puromycin (right).

Observations and cell counts for untreated cells

To monitor the general health of the knockout cell line, observations were made in comparison to wild-type HEK-293 cells. Transfected cells maintained consistent appearances with the wild-type cells and grew without much difficultly. They did, however, appear to grow at a slower rate than control cells. Cell counts were recorded to confirm this observation, where the cell doubling time of wild-type HEK-293 cells was determined to be 1.11 ± 0.04 days, while the doubling time of PRKCA KO cells was over twice as long at 2.27 ± 0.44 days (**Figure 3**, p=0.045).
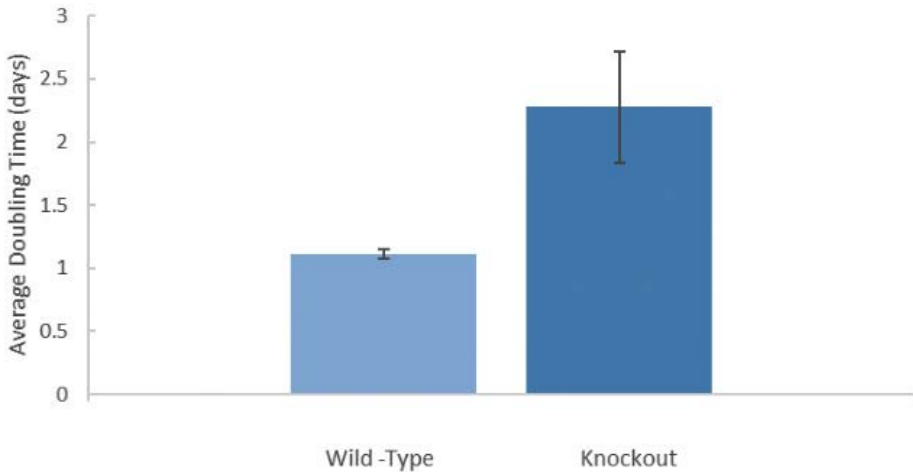
Figure 3. Cell doubling times in PRKCA knockout and wild-type HEK-293 cells. Doubling times were calculating from cell counts over a four day period. Wild-type: mean = 1.11 days, SE = 0.04. KO: mean = 2.27 days, SE = 0.44.

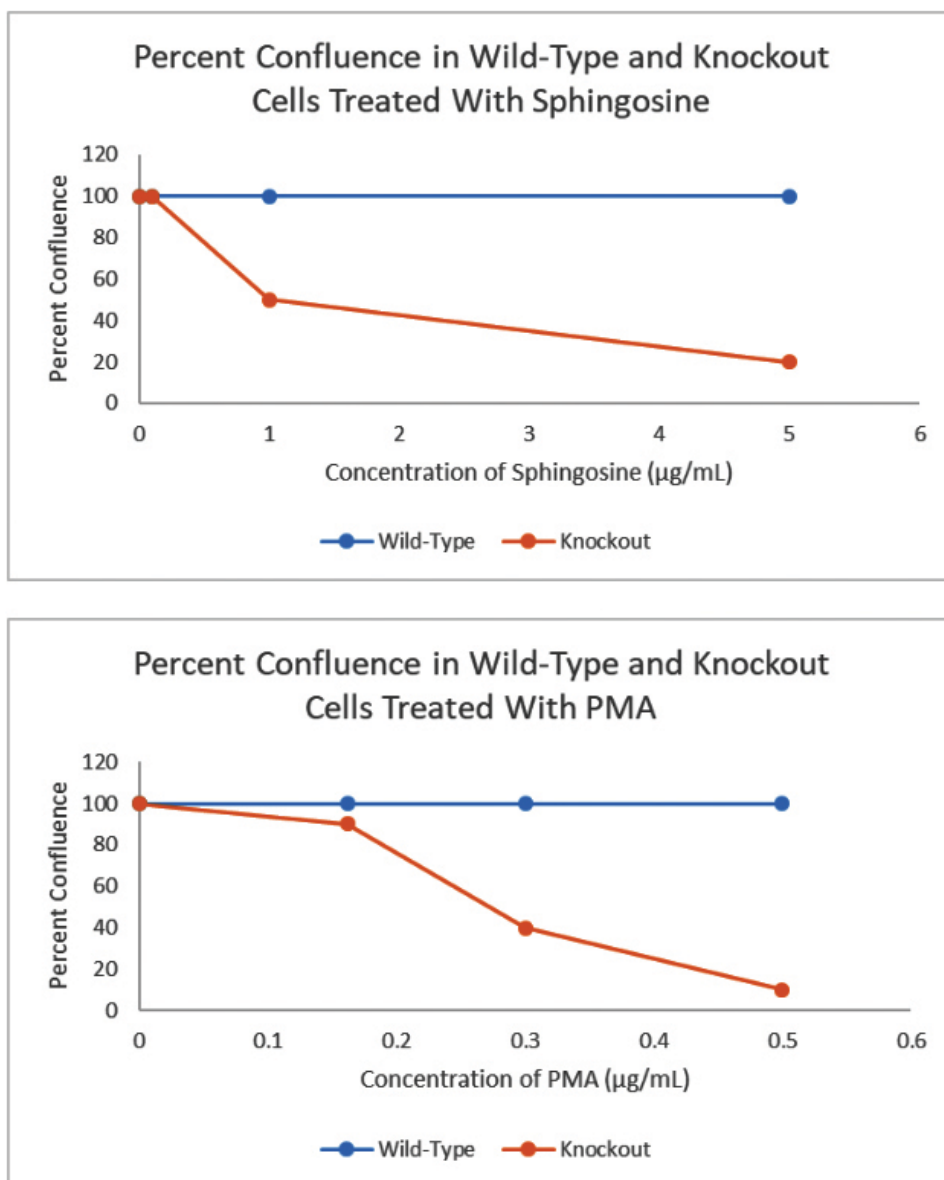**Observations of cells treated with sphingosine and PMA**
As quiescent PRKCA knockout cells grew more slowly, we also sought to determine if inducing proliferation would result in aberrant growth in PRKCA knockout cells. Treatments with sphingosine (Figure 4, top) and PMA (Figure 4, bottom) were completed. As demonstrated in **Figure 4**, these observations resulted in very high levels of growth for control cells treated with all concentrations of PMA and sphingosine. All wild-type cells reached confluence within 48 hours (data not shown). Contrary to this observation, transfected cells treated with PMA and sphingosine did not demonstrate observable growth within 48 hours. By 96 hours (four days), treated transfected cells demonstrated high levels of death ranging from 75-100% (Figure 4, top and 4, bottom). These results indicate that PKCα plays a central role in proliferative induction by both PMA and sphingosine signaling pathways.

DISCUSSION

Determination of the role of PKCα in cell proliferation was desired, so the PRKCA gene knockout was attempted, growth in normal conditions assessed, and the effects of treating knockout cells with PKCα-dependent and independent proliferation agents observed.

Knockout or homozygosity?
Within two days of transfection, RFP expression was observed in transfected cells in varying amounts. Some of this can be attributed to the fact that transfection was not successful in all treated cells. In cells displaying at least some level of RFP, however, one possible explanation for differing levels of expression involves transient expression of the HDR plasmid. Transient expression occurs when the plasmid has not been incorporated into the genome but is actively being transcribed. To account for this possibility, transfected cells were grown for an additional two weeks and

Figure 4. PKCα knockout cells treated with sphingosine (top) and PMA (bottom) exhibit reduced viability over time. Top: Cells were treated with concentrations of 0, 0.1, 1 and 5 μg/mL of sphingosine-1-phosphate. Bottom: Cells were treated with concentrations of 0, 0.162, 0.3 and 0.5 μg/mL of PMA. Confluence was assessed four days post-treatment and was observed in two cell culture wells for each cell type and treatment group.

underwent an additional puromycin treatment. Because transient expression of the HDR plasmid from Santa Cruz Biotechnology lasts a maximum of seven days, any expression of RFP over two weeks post-transfection should be attributed exclusively to genomic expression of the plasmid [3]. The vast majority – approximately 90-95% – of remaining cells demonstrated RFP after this additional treatment, which very strongly suggested transfection success.

Western blot analysis detected PKC expression in both cell lines (data not shown). Bands were observed around 80 kDa, the molecular mass of PKCα and other isoforms of PKC, in lanes containing wild-type cell lysate as well as lanes containing knockout cell lysate. There were no noticeable differences in size or expression between the bands in any exposure times. Though this appeared to contradict other indicators of knockout success, there are many possible explanations for this observed result. The quantity of secondary antibody appropriate for use in this procedure was estimated based on previous literature; however, it is highly likely that the amount used was too high and resulted in non-specific binding. Because the secondary antibody contains the horseradish enzyme that indicates expression during x-ray exposure, non-specific binding of this antibody to other forms of PKC would yield similar band expression on the final x-ray film and result in a false positive. Future studies could replicate this procedure with varying levels of secondary antibody to yield more meaningful results.

An additional explanation for varying levels of expression in RFP positive cells and the Western blot result involves the genomic location of RFP. Expression of PKCα is biallelic. Because of this, transfected cells may have been a combination of hemizygous and homozygous PRKCA knockout cells. In an attempt to select for highly-expressing homozygous knockout cells, we treated transfected cells with 10 αg/mL of puromycin (four times the concentration that is toxic to wild-type cells) before conducting proliferation studies. Cells that survived this treatment were determined to be probable knockout cells and were used for all remaining procedures; however, it is still possible that some of these surviving cells were hemizygous knockout, and this could explain the observed expression of PKCα in the Western blot analysis.

Role of PKCα in homeostatic proliferation

Cell growth calculations yielded doubling times of 1.11 ± 0.04 days and 2.27 ± 0.44 days for untreated wild-type cells and knockout cells, respectively. HEK cells are typically expected to have a doubling time of twenty-four hours, so the calculation of approximately a one day doubling time for wild-type cells is consistent with previous literature. A statistical analysis comparing the mean doubling times resulted in a p-value of 0.045. This suggests that the doubling time of PRKCA knockout cells is significantly slower than the doubling time of wild-type cells. Upon further analysis of the data, there are two main factors that contributed to the p-value: the small sample size and the high level of variance in knockout cells. Though all individual doubling times for knockout cells were slower than wild-type cells, they were less consistent. They appeared to take an especially long time to grow immediately after attachment. This observation is important in our understanding of how PRKCA knockout influences proliferation in HEK cells and how varying growth among knockout cells effects the significance of the data. Overall, observations and cell counts consistently demonstrated reduced proliferation in knockout cells, and a statistical analysis of the data yielded a significant result. In further studies, this data should be replicated with a larger sample, but our preliminary data demonstrating slowed growth supports the hypothesis that PRKCA gene knockout reduces proliferation in HEK cells.

Role of PKCα during induction of proliferation

Treatments of knockout cells in high concentrations of sphingosine and PMA resulted in abnormal levels of cell death. This result was observed in two cell culture wells for each group alongside treatment of the same concentrations on wild-type cells that experienced rapid growth and reached confluence. To assess the significance of this data, it should be replicated with a larger sample size and a wider range of concentrations for each proliferation agent. However, we are still able to discuss several possible explanations for this observation within our study. Cells that have experienced gene knockout are often less stable; gene knockout is an intensive process, and a protein such as PKCα is important in many cell processes [4]. Inducing proliferation in these cells may be received as a stressful signal that the weakened cell cannot endure. Additionally, PKCα often acts as an anti-apoptotic factor, restricting the cell's tendency to default toward death [13]. Cells without PKCα are, then, more likely to begin to progress toward apoptosis after receiving an external cellular signal. Because HEK cells are tumorigenic and PRKCA knockout cells became apoptotic when stimulated with high concentrations of proliferation agents, these data suggest that PKCα is important for normal cell function in a tumor-promoting context. Moreover, since untreated PRKCA knockout cells grew significantly slower than wild-type cells, together, these data further highlight the importance of PKCα as a key regulator of cellular proliferation.

REFERENCES

[1] Arrighetti, N., Cossa, G., De Cecco, L., Stucchi, S., Carenini, N., Corna, E., & ... Gatti, L. (2016). PKC-alpha modulation by miR-483-3p in platinum-resistant ovarian carcinoma cells. *Toxicology & Applied Pharmacology*, 3109-19. doi:10.1016/j.taap.2016.08.005

[2] Blom, T., Slotte, J., Pitson, S., & Törnquist, K. (2005). Enhancement of intracellular sphingosine-1-phosphate production by inositol 1,4,5-trisphosphate-evoked calcium mobilisation in HEK-293 cells: endogenous sphingosine-1-phosphate as a modulator of the calcium response. *Cellular Signaling*, 17(7), 827-836.

[3] *CRISPR/CAS9 Knockout Protocol*, Santa Cruz Biotechnology, Inc. PDF document from SCBT.COM (http://datasheets.scbt.com/CRISPR_protocol.pdf)

[4] Garg, R., Benedetti, L. G., Abera, M. B., Wang, H., Abba, M., & Kazanietz, M. G. (2014). Protein kinase C and cancer: what we know and what we do not. *Oncogene*, 33(45), 5225–5237.

[5] Health, United States, 2016 [Pamphlet]. (2016). US Department of Health and Human Services, Center for Disease Control and Prevention.

[6] Irie, N., Sakai, N., Ueyama, T., Kajimoto, T., Shirai, Y., & Saito, N. (2002). Subtype- and species-specific knockdown of PKC using short interfering RNA. *Biochemical and Biophysical Research Communications*, (298), 738-743.

[7] Lander, E. (2016). The heroes of CRISPR. *Cell*. (164). 18-29.

[8] Mahmood T, Yang P-C. (2012). Western blot: technique, theory, and trouble shooting. *North American Journal of Medical Sciences*. (4), 429-434

[9] Müller, K. M., Tveteraas, I. H., Aasrum, M., Ødegård, J., Dawood, M., Dajani, O., … Sandnes, D. L. (2011). Role of protein kinase C and epidermal growth factor receptor signalling in growth stimulation by neurotensin in colon carcinoma cells. *BMC Cancer*, 11, 421.

[10] Murray, N.R., Baumgardner, G.P., Burns, D.J. & Fields, A.P. (1993). Protein kinase C isotypes in human erythroleukaemia (K562) cell proliferation and differentiation. *J. Biol. Chem.*, (268), 15847–15853.

[11] Nishizuka, Y. (1992). Intracellular signaling by hydrolysis of phospholipids and activation of protein kinase C. *Science*, (258), 5082, 607-614.

[12] Olivier, M., Hollstein, M., & Hainaut, P. (2010). TP53 mutations in human cancers: origins, consequences, and clinical use. *Cold Spring Harbor Perspectives in Biology*, 1-18.

[13] Singh, R., Kumar, S., Gautam, P.K., Tomar, M.S., Verma, P.K., Singh, S.P., Acharya, A. (2017). Protein kinase C-α and the regulation of diverse cell responses. *Biomolecular concepts*. (8). 3,4. 143-153.

[14] Smith, M. (2002). Lipofectamine 2000 Transfection of HEK293 cells. 1.

[15] Stepanenko, A., & Dmitrenko, V. (2015). HEK293 in cell biology and cancer research: phenotype, karyotype, tumorigenicity, and stress-induced genome-phenotype evolution. *Gene,* 569(2), 182-190.

[16] Wauson, E. M., Guerra, M. L., Barylko, B., Albanesi, J. P., & Cobb, M. H. (2013). Off-target effects of MEK inhibitors. *Biochemistry,* 52(31), 10.1021/bi4007644.

[17] Yang, H., Wang, H., Shivalila, C. S., Cheng, A. W., Shi, L., & Jaenisch, R. (2013). One-step generation of mice carrying reporter and conditional alleles by CRISPR/Cas-mediated genome engineering. *Cell*, (154), 1370-1379.

[18] Zheng, Q., Cai, X., Tan, M., Schaffert, S., Arnold, C. P., Gong, X., . . . Huang, S. (2014). Precise gene deletion and replacement using the CRISPR/Cas9 system in human cells. *BioTechniques*, 57(3), 115-124.

[19] Zhou, F., Dong, C., Davis, J. E., Wu, W. H., Surrao, K., & Wu, G. (2015). The mechanism and function of mitogen-activated protein kinase activation by ARF1. *Cellular Signaling*, 27(10), 2035–2044. http://doi.org/10.1016/j.cellsig.2015.06.007.

Hexavalent Chromium-Induced Cytotoxicity and Mutagenicity: A Study of Protection by Ascorbic Acid and Epigallocatechin Gallate

Timothy P. Mayotte

ACKNOWLEDGEMENTS

ABSTRACT

Hexavalent chromium, or Cr(VI), is a potent oxidizer and known carcinogen that is found at varying levels in the water sources of more than 200 million Americans. However, the exact mechanism of carcinogenicity remains unknown, and though the government currently regulates total chromium levels they have yet to determine a permissible exposure limit for Cr(VI). Moreover, there is currently no preventative treatment for Cr(VI). Because of Cr(VI)'s strong oxidative power, we hypothesized that it causes DNA mutation and cell death via oxidation and that antioxidants could prevent this from occurring. To test this, we first assessed the viability of human cell culture exposed to Cr(VI) with or without either of the antioxidants vitamin C or epigallocatechin gallate (EGCG). Further, an Ames test was performed to determine the mutagenicity of Cr(VI) with and without either antioxidant.

We found that Cr(VI) is significantly toxic to cell culture at concentrations of 200 ppb (parts per billion) or more. Both vitamin C and EGCG blocked this effect at 10 ppm (parts per million) and 15 ppm, respectively, while neither antioxidant was observed to be cytotoxic when treated alone. Cr(VI) was also found to be significantly mutagenic at 20 ppb and greater. This mutagenicity was significantly reduced by cotreatment with 20 ppm vitamin C at 200 and 2000 ppb Cr(VI), while vitamin C was not found to be mutagenic when tested individually. With these combined data, we conclude that Cr(VI) is both cytotoxic and mutagenic via an oxidative mechanism and these effects can be abrogated by antioxidants. Though continued study is merited, this information further validates the protective potential of antioxidants against toxicants like Cr(VI).

Keywords: Hexavalent chromium, epigallocatechin gallate, ascorbic acid, cytotoxicity, mutagenicity, antioxidants.

INTRODUCTION

Hexavalent chromium

The toxicological effects of hexavalent chromium (Cr(VI)) compounds have been widely studied over the years. Specifically, data have been collected to assess its carcinogenic effects on humans through case study (Yu, 2013), and its toxicological effects on rats (Geetha et al., 2003) and cell cultures (Majone et al., 2002). Though there exist three different oxidative states for chromium, the hexavalent form has been found to be much more toxic than the quadrivalent form or the trivalent form, which is in fact an essential element for humans (Sun et al., 2015). Unfortunately, the toxicant can be found in hexavalent form in the tap water of nearly two-thirds of the United States' drinking supply (Andrews & Walker, 2016). Though the environmental protection agency (EPA) monitors total chromium levels in drinking water, hexavalent levels are not monitored, and the toxicant is ingested daily. The EPA's current maximum contaminant level for total chromium is 100 ppb, yet it is unclear if Cr(VI) at 100 ppb could have detrimental effects on a population. In humans, hexavalent chromium toxicity through ingestion has been known to cause cardiovascular, gastrointestinal, hematological, hepatic, renal, and neurological damage, and in severe cases, causes cancer or death (Yu, 2013).

Chromium is a naturally occurring element and often found at low levels in both the hexavalent and trivalent states in natural watersheds (Loyaux-Lawniczak et al., 2001). However, chromium compounds are often used for chromium plating and other industrial uses and can elevate these low levels (Kamerud et al., 2013). Disposal of chromium containing commercial products and coal ash from electric utilities are major sources of chromium releases into the soil. Solid waste and slag produced during chromate manufacturing processes can be potential sources of chromium exposure as well (Barceloux 1999). Improper disposal and maintenance of Cr(VI) at these facilities can cause environmental contamination and drinking water pollution (Cone, 2009). A recent study done of Illinois water showed that hexavalent chromium concentrations were actually higher in treated water than those in untreated water. Indeed, Cr(VI) levels on surface water were found to be 0.3 ppb, and levels in bedrock aquifers at 1.1 ppb, whereas those in treated water supplies were 2.4 ppb, indicating that water treatment practices may ironically play a role in increasing concentrations (Mills & Cobb, 2015). Though these levels are well below the EPA-regulated limit, it is still unknown whether these levels are detrimental to human health.

Mechanism of toxicity

The mechanism of toxicity of Cr(VI) has been found to be induction of oxidative stress, which further leads to cell toxicity and cell death (Bagchi et al., 2002; Chiu et al., 2010). In their study, Martindale and Holbrook found that oxidative stress results when reactive oxygen species (ROS), either produced endogenously as a consequence of normal cellular functions or derived from external sources, cause damage that exceeds the cell's ability to resist oxidation (Martindale & Holbrook, 2002). They went on to find that when ROS originate from exogenous sources, they are either taken up directly by cells from the extracellular matrix or produced as a consequence of the cell's exposure to an environmental antagonist, such as Cr(VI). Transient fluctuations in ROS serve important regulatory functions such as in aerobic respiration, but when present in high levels, ROS can cause severe damage to DNA, protein, and lipids. A number of cellular defense mechanisms have evolved to combat the accumulation of ROS. These include various non-enzymatic molecules such as glutathione, and vitamins A, C, and E, as well as enzymatic scavengers of ROS like superoxide dismutase and catalase (Martindale & Holbrook, 2002). Unfortunately, these systems of defense are not always adequate to counteract the production of ROS, resulting in what is termed a state of oxidative stress. Because of its 6+ oxidation state, Cr(VI) is a potent oxidizer that can challenge the limited capacity of natural antioxidative systems.

Ames assay

Previous research shows that not only are hexavalent chromium compounds carcinogenic, but they are also directly mutagenic towards deoxyribonucleic acid (DNA) (Petrilli & Deflora, 1976). In this study, a genetically engineered strain of *Salmonella typhimurium* was exposed to differing solutions to test mutagenic potential. When exposed to a mutagen, this specific strain of bacteria will revert from a state of auxotrophy (inability to produce the essential amino acid histidine) to a state of prototrophy (ability to produce histidine). This genetic reversion allows the bacteria to survive and replicate, whereas a lack of mutation will result in death. Bacterial

survival, observed by colorimetric determination of its growth media, is therefore a direct indicator of DNA mutagenesis. This same study showed that the mutagenic effects were caused directly by Cr(VI) and not due to a metabolic byproduct within the bacteria (Petrilli & Deflora, 1976). This information therefore indicated that not only is Cr(VI) toxic to organisms but is also directly mutagenic toward cellular DNA, with a preventative treatment yet to be elucidated.

Reduction potential

Different approaches have been utilized to reduce the oxidizing potential of Cr(VI). For example, one study showed that the use of certain microorganisms as biological filters could be used to lower chromium levels (Thatoi et al., 2014), while several others have shown that antioxidants are effective (Chrysochoou & Reeves, 2016; Geetha et al., 2003). Antioxidants lower the oxidation state of chromium from hexavalency to the lower, less harmful state of trivalency. One study showed that epigallocatechin gallate (EGCG) directly reduces Cr(VI) in solution (Chrysochoou & Reeves, 2013), whereas another showed that vitamin C also reduces Cr(VI) in solution and in the past has been used as a topical treatment against Cr(VI) skin exposure (Yu, 2013). A third study tested the effect of antioxidants extracted from the plant *Hippophae rhamnoides* on albino rats when co-fed with hexavalent chromium. Results suggested that rats that had been fed antioxidants along with the chromium compounds exhibited declines in tumor growth both in size and frequency compared to those without antioxidants (Geetha et al., 2003). Though this study demonstrates that a plant extract with antioxidant properties prevents Cr(VI)-induced toxicity at the organismal level, little is known about the effects of specific antioxidants at the cellular level. To date, there have been no studies of Cr(VI) and antioxidant cotreatment on human cell culture, and though antioxidants are known to reduce Cr(VI), there is still uncertainty in regard to which antioxidants are most effective. Additionally, the extent to which antioxidants are protective has yet to be elucidated; whether they protect against cytotoxicity upon the cell membrane and within the cytoplasm, or if they protect against mutagenesis within the nucleus as well. We hypothesized that when co-treated with an antioxidant, hexavalent chromium would exhibit less cytotoxicity on a human cell culture. We also hypothesized that when co-treated with an antioxidant, hexavalent chromium would exhibit less mutagenicity towards bacterial DNA.

METHODS

Cell culture, compounds, and storage

Human intestinal epithelial (HInEpi) cells were obtained from the American Type Culture Collection (ATCC) and were sustained on the cell line's respective ATCC media. Human embryonic kidney (HEK) cells were obtained from a secondary passage in nitrogen storage in house at Reed Hall of Science, though the original passage was obtained from Dr. Seth Robia (Loyola University Chicago). These cells were sustained on Dulbecco's Modified Eagle Medium with 10% Fetal Bovine Serum, 1% Penicillin-Streptomycin, and 1% L-Glutamine, all of which were sourced from Sigma Aldrich. Cells were incubated at 37°C and 5% CO_2 and passaged once confluent using trypsin-EDTA. Both L-ascorbic acid and epigallocatechin gallate were obtained from Sigma Aldrich. The Cr(VI) compound used for experimentation was potassium chromate, also obtained from Sigma Aldrich.

Determination of treatment concentration

Experimental Cr(VI) concentrations were tested in magnitudes of ten ranging from 2 ppb (parts per billion) to 20,000 ppb to simulate environmental conditions as well as coincide with previous literature. These concentrations were used for both cell proliferation and Ames procedures. Antioxidant concentrations were determined through experimentation, starting at a 1:1 ratio of antioxidant to Cr(VI) and adjusted accordingly based on response until effects were seen.

Solution preparation

Stock solutions of Cr(VI), EGCG, and ascorbic acid were prepared by dissolving solute in double-distilled water at a concentration of 2000 ppm and then filter sterilizing. Once treatment concentrations had been determined as described above, smaller aliquots of stock solution were mixed with the appropriate cell media to bring the final mixture to the desired experimental concentration. Experimental solution containing both Cr(VI) and an antioxidant for cotreatment were prepared by bringing both a Cr(VI) solution and an antioxidant solution to twice their desired final concentration in media and then adding the two solutions together to dilute the sample down to its experimental concentration. Stock solutions were stored at 4°C and were remade several times throughout experimentation to avoid expiration. Experimental solutions were made within twenty-four hours of use.

Cellular proliferation assay

Both the HInEpi and HEK cells were passaged in T-75 flasks in respective media until confluency was reached. These cells were then passaged onto a 24-well plate and again cultured until wells reached confluence. Treatment groups were then run in quadruplicate, allowing for six sample groups per plate that were exposed to solution for 72 hours. To depict qualitative results, photos were taken of wells at points of interest along the way using a Nikon TXI inverted microscope with phase contrast.

After the 72-hour incubation period, media was aspirated and cells were trypsinized and suspended in solution. 10 μl of solution were taken from each well and mixed with equal parts Trypan blue. After at least a minute to allow for cell staining to occur, 10 μl of cell suspension/trypan stain solution were drawn off and dispensed over a hemocytometer for counting of viable cells to determine number of cells per treatment group.

Ames assay

Ames test kits were purchased from Environmental Bio-detection Products Inc. (EBPI), and the assay was carried out according to manufacturer's instructions. The lyophilized bacterial culture was suspended in a liquid medium (Reagent G) 12 to 16 hours prior to experimentation. Once suspended, the bacteria were placed in a shaking incubator at 37°C to replicate and grow overnight. The following day, experimental samples were prepared by diluting the Cr(VI) stock solution in sterile water to desired concentrations. Turbidity within the bacterial culture verified growth, and the OD600 of the solution was measured by spectrophotometry. This OD (optical density) value was then used to bring the bacterial suspension to a desired concentration through a series of calculations (Appendix 1). Three samples of each treatment group were placed in a 24-well plate for the bacterial exposure period. Positive, negative, and

sterility controls were also included on the exposure plate. Added into each well was the treatment solution, exposure media, and the bacterial suspension, and the plate was incubated at 37°C for 100 minutes. During the incubation period, a reversion medium was prepared for the 96-well plates. After the bacteria had been incubated for 100 minutes, the plate was removed and solution from each well was pipetted into a tube containing the premade reversion medium. Using loading boats and a multichannel pipette, each sample was pipetted into 48 wells of a 96-well plate. The 96-well plates were then placed in an incubator at 37°C for three days to allow for revertant bacteria to grow. After the three day incubation period, plates were scored by colorimetric determination with yellow and partial-yellow wells indicating genetic reversion.

Statistical analysis

The statistical analysis for both the cell proliferation data and the Ames assay data were done by a two-tailed t-test data with p-values < 0.05 determined to be statistically significant. The error bars depicted in the figures below show standard error of the mean.

RESULTS

To determine if antioxidants could prevent Cr(VI)-induced cytotoxicity, we first had to establish Cr(VI) toxicity without cotreatment with antioxidants. This also helped us determine a good concentration of Cr(VI) to use for cotreatment. HEK cells exposed to increasing concentrations of Cr(VI) displayed a marked reduction of cell viability. **Figure 1** shows that Cr(VI) levels of 1000 ppb completely eradicated all cells in the treatment group. These data indicate not only the severity of Cr(VI) exposure but also provide a basis for a range of exposure doses and cellular susceptibility. For this study, we chose to use 500 ppb Cr(VI) as an intermediate dose to elucidate the potency of the antioxidants vitamin C and EGCG.
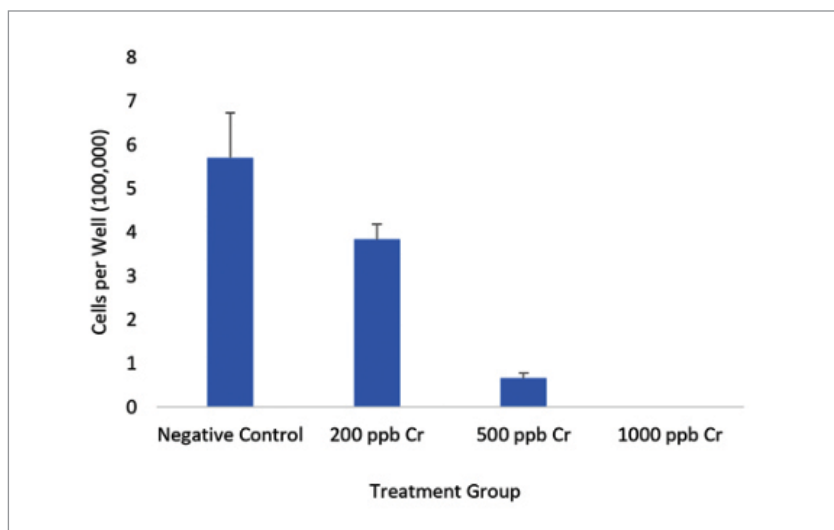
Figure 1: Human embryonic kidney cells display reduced viability upon increasing exposure to Cr(VI). HEK cells were exposed to different doses of Cr(VI) ranging from 200 ppb to 1000 ppb. A negative dose response to Cr(VI) was observed.

Next, we wanted to determine if the presence of vitamin C could prevent Cr(VI)-induced cytotoxicity. To test for this, chromium concentrations were kept constant at 500 ppb while varying concentrations of vitamin C were added as cotreatment. 50 ppm vitamin C was also run independently as a control group and yielded similar cell counts as the negative control, indicating a lack of cellular toxicity of vitamin C alone. Figure 2 shows that 500 ppb Cr(VI) cotreated with as little as 5 ppm vitamin C more than doubled the cells per well from 500 ppb Cr(VI) alone. Furthermore, responses were observed in a dose dependent manner in wells cotreated with 10 and 25 ppm vitamin C. Importantly, there was no significant difference observed between 500 ppb Cr(VI) cotreated with 25 ppm vitamin C and the negative control.
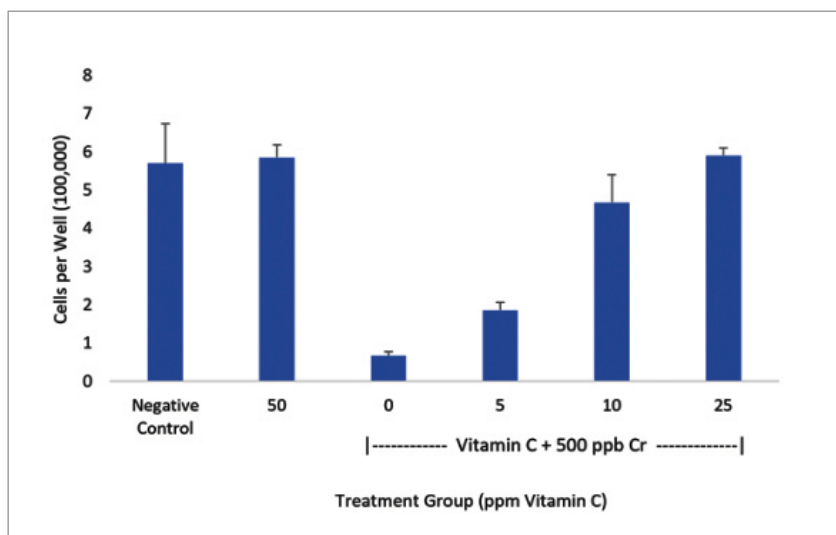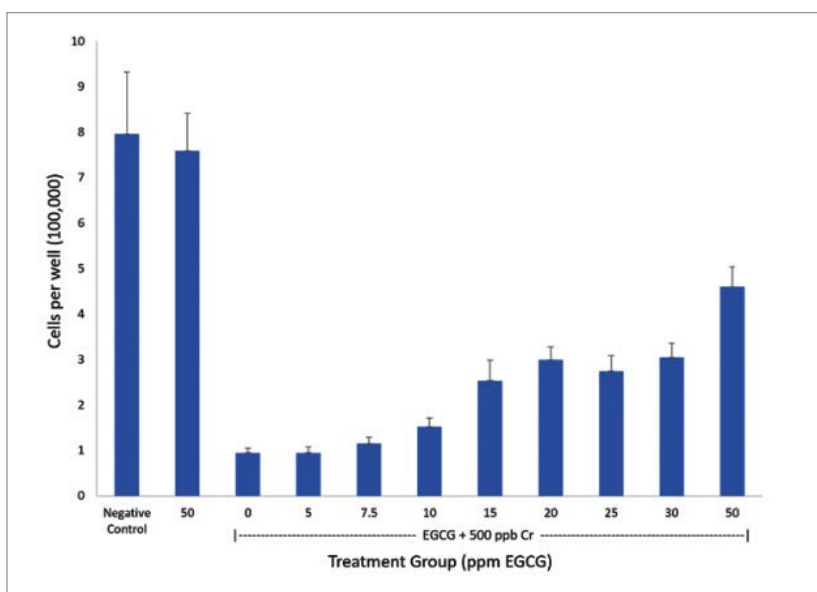

Figure 2: The antioxidant vitamin C can prevent toxicity of Cr(VI). Human embryonic kidney cells were exposed to cotreated samples of 500 ppb Cr(VI) and differing concentrations of vitamin C. Likelihood of survival increased with the addition of vitamin C. Cr(VI) was completely mitigated by 25 ppm vitamin C.

These results were also replicated qualitatively upon a second cell line. Human intestinal epithelial cells were exposed to the same treatment groups as the above mentioned HEK cells. Due to difficulties in the cell counting procedure for this particular line of cells, representative pictures of treatment groups were taken to serve as alternative results to quantification. As shown in **Figure 3**, cotreatment with 25 ppm vitamin C markedly improved cytotoxic effects of 500 ppb Cv(VI). Together, these data suggest that Cr(VI) toxicity and the protective effect of vitamin C can be broadly applied across different cell types.

Not only were we interested in the protective potential of vitamin C, but antioxidants at large. To test this theory, we exposed HEK cells to solutions cotreated with 500 ppb Cr(VI) and varying concentrations of EGCG to compare the efficacy of the two antioxidants (**Figure 4**). As in the case of vitamin C, EGCG demonstrated protective effects in a dose dependent manner starting at 7.5 ppb EGCG. However, unlike the complete protection from Cr(VI) toxicity that was observed with vitamin C at a lower dose, even the highest dose of EGCG was only able to protect approximately 60% of the HEK cells.
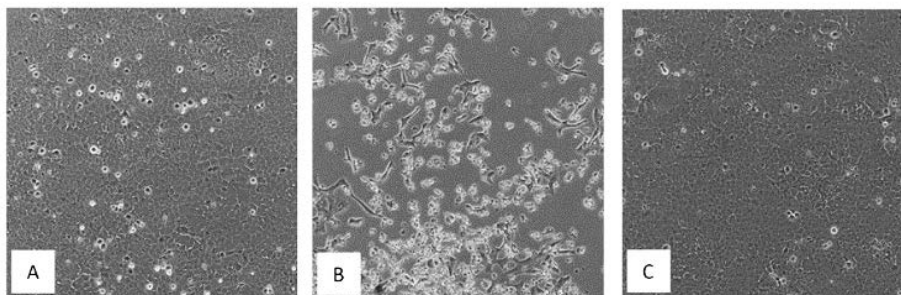
Figure 3: Vitamin C protects human intestinal epithelial cells from Cr(VI)-induced cytotoxicity. Cells were exposed to untreated cell media (panel A), as well as 500 ppb Cr(VI) (panel B) and 500 ppb Cr(VI) cotreated with 25 ppm vitamin C (panel C). Cotreatment mitigated nearly all observed effects of Cr(VI). This result was replicated on human embryonic kidney cells. These images were taken three days after exposure.


Figure 4: The antioxidant EGCG can prevent toxicity of Cr(VI). Human embryonic kidney cells were exposed to solutions of 500 ppb Cr(VI) cotreated with varying concentrations of EGCG. As EGCG concentrations increased, cell survival also increased.

We next wanted to test the protective potential of antioxidants against Cr(VI)-induced mutagenicity. To test this, bacteria were exposed to Cr(VI) as well as Cr(VI) cotreated with vitamin C in an Ames assay. **Figure 5** shows that as Cr(VI) concentrations increased from 20 ppb to 2000 ppb, percent mutagenicity increased. Treatment groups of 20, 200, and 2000 ppb were significantly more mutagenic than the negative control. Cotreatment with 20 ppm vitamin C significantly reduced the mutagenicity of 200 ppb and 2000 ppb Cr(VI). Moreover, 20 ppm vitamin C was not found to be mutagenic itself.

DISCUSSION

After exposing human cell cultures to a range of Cr(VI) concentrations, we observed that increasing concentrations of Cr(VI) was associated with cell death of both HEK
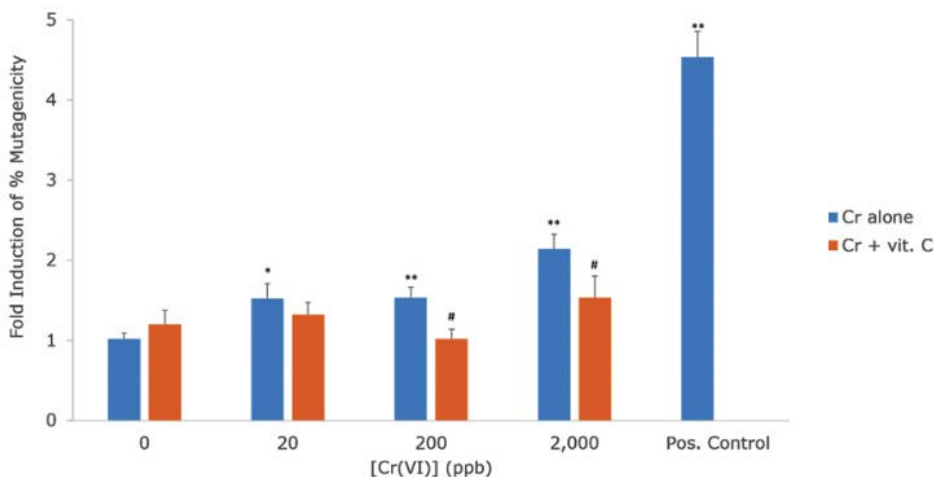
Figure 5: Bacterial cells cotreated with vitamin C and Cr(VI) exhibit less mutagenesis than those without the antioxidant. Bacterial cultures exposed to solution containing higher levels of Cr(VI) were more likely to mutate DNA. Those exposed to high levels of Cr(VI) as well as vitamin C were less likely to mutate. * denotes p-value < 0.05 when compared to negative control, ** denotes p-value < 0.005 when compared to negative control, # denotes p-value < 0.05 compared to that concentration of Cr(VI) alone. The positive control is a 12.5 ppb sodium azide solution.

and HIE cells (Figures 1 and 3). However, we found that the detrimental effects of Cr(VI) were mitigated by the addition of the antioxidants vitamin C or EGCG in a dose dependent manner (Figures 2 and 4). This evidence suggests that Cr(VI) is indeed cytotoxic via an oxidative mechanism, as the presence of an antioxidant reduced cytotoxicity.

Vitamin C was found to be a much more potent protective chemical than EGCG (Figures 2 and 4). This could be due to the vast difference in the size of the two molecules, as ascorbic acid is much smaller than its counterpart. It's unclear where the reduction of Cr(VI) into Cr(III) is occurring, whether inside the cell in the cytoplasm or outside the cell within the culture media, though it is probable that the majority is occurring in the media before the toxicant enters the cell. This is because the Cr(VI) was exposed to the antioxidant in solution hours before being dispensed over the cells. Indeed, metabolic clearance of Cr(VI) may likewise occur prior to cellular interaction. Roughly ten percent of inorganic Cr(VI) is absorbed through the intestinal tract (Yu, 2013). Excretion of absorbed chromium occurs primarily via urine. In humans, the kidney excretes about 60% of an absorbed Cr(VI) dose in the form of Cr(III) within eight hours of ingestion. Approximately 10% of an absorbed dose is eliminated by biliary excretion, with smaller amounts excreted in hair, nails, milk, and sweat (Kiilunen & Kivisto, 1983). Therefore, a majority of the reduction interactions occurring between antioxidants and Cr(VI) likely take place before the two components enter the cell. However, while clearance from plasma is generally rapid (within hours), whereas elimination from tissues is slower, with a half-life of several days (ATSDR, 2012).

Data from the Ames assay further suggests that Cr(VI) is indeed mutagenic by way of oxidation. Though previous studies have shown that Cr(VI) is mutagenic (Petrilli

& Deflora, 1976), the novel cotreatment with antioxidants performed in this study show that chemical reduction decreases mutagenicity, indicating that the oxidative mechanism of Cr(VI) plays a critical role in mutagenesis. As bacterial strains were exposed to increasing concentrations of the toxicant, percent mutation increased as well. When exposed to solution cotreated with antioxidant, however, percent mutation was essentially nullified as levels were brought back down to those observed within the negative control group, regardless of the concentration of Cr(VI). That is, any group treated with vitamin C exhibited no significant change from the negative control, even at the highest concentration of Cr(VI) (2000 ppb).

Furthermore, neither antioxidant tested was found to be cytotoxic or mutagenic in-and-of-itself. Thus, they may serve as a preventative protectant as pre-treatment within a drinking water supply. We cannot pre-treat the water with a level of protectant so high that it itself becomes a harmful contaminant. This concern is needless in this case as both vitamin C and EGCG showed great protective potential at levels at which they themselves were harmless.

It appears that Cr(VI) is more mutagenic towards bacterial DNA at lower concentrations (20 ppb) than it is cytotoxic towards mammalian cells (200 ppb). This result may suggest two things. One reason for this discrepancy may be that bacterial cells are more sensitive to Cr(VI); this is probably a result of the vast differences between prokaryotic and eukaryotic cells. Eukaryotes have several other cellular components that Cr(VI) may interact with before reaching the DNA within the nucleus. The second conclusion may be that mutagenicity is also occurring in the mammalian cells at concentrations similar to that in the bacteria, but that the mutations occurring are nonlethal or nonharmful. This would be a reasonable assumption, as a mammalian eukaryotic cell has far more DNA than a prokaryotic bacterium (Alberts et al., 2015). Additionally, a prokaryotic genome has fewer regions of noncoding DNA (20%) than that of a eukaryote (98%) (Alberts et al., 2015). Therefore, there is a greater likelihood that a mutagen would affect a critical region in the bacterial genome, while eukaryotic cells are afforded a degree of insulation by vast noncoding stretches of DNA that can absorb mutagens such as Cr(VI). In either case, this merits further research into Cr(VI) mutagenicity in a mammalian cell line.

This study focused only on the cotreatment of antioxidants with Cr(VI) as opposed to pre-treatment or post-treatment. Specifically, both bacterial cells in the Ames test and human cells in the cell proliferation assay were exposed to both the toxicant and the protectant simultaneously. In both assays, the cotreated solution was prepared one to ten hours before cell exposure. Because of this, the chemical interaction taking place between the two compounds likely occurs in solution. An interesting continuation of this study would be examining the differences between a cotreatment with antioxidant (as performed in this study) and a pre or post-treatment with antioxidant. This would provide information as to whether antioxidants could protect against impending Cr(VI) exposure or help cells recover from prior Cr(VI) exposure. These assays would also shed more light as to where the majority of the chemical reduction of the chromium is occurring, either in solution or within the cells themselves.

These data come at a time when hundreds of millions of Americans are exposed to hexavalent chromium in their daily water supply (Andrews & Walker, 2016). The protective potential of antioxidants is promising, and applications of this research are numerous. For example, just as many European countries began adding fluoride to public water supplies in the early 1990s to prevent dental caries, antioxidants may be useful additions to water supplies known to have higher concentrations of Cr(VI) or areas at higher risk of Cr(VI) contamination. Moreover, these findings suggest that antioxidants as reducing agents may also be applied in mitigation of other harmful oxidizers. Though continued study is merited, this information further validates the protective potential of antioxidants and will be helpful for government agencies and organizations in determining safe levels of water chromium.

REFERENCES

Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., Walter, P. (2015). *Molecular Biology of the Cell; sixth edition*. Garland Science, Taylor & Francis Group, LLC.

Ames, B., Durston, W., Yamasaki, E., & Lee, F. (1973). *Carcinogens are Mutagens: A Simple Test System Combining Liver Homogenates for Activation and Bacteria for Detection*. Proceedings of the National Academy of Sciences USA, 70(8), 2281-2285.

Andrews, D., & Walker, B. (2016). '*Erin Brockovich' Carcinogen in Tap Water of more than 200 Million Americans*. Environmental Working Group.

ATSDR, Agency for Toxic Substances and Disease Registry. (2012). *Toxicological Profile for Chromium*.

Bagchi, D., Stohs, S.J., Downs, B.W., Bagchi, M., & Preuss, H.G. (2002). *Cytotoxicity and Oxidative Mechanisms of Different forms of Chromium*. *Toxicology*, 180, 5-22.

Barceloux, D. G. (1999). *Chromium*. Toxicology, 37(2), 173-94.

Casarett, L. J., Klaassen, C. D., Amdur, M. O., & Doull, J. (1996). *Casarett and Doull's Toxicology: The Basic Science of Poisons*. New York: McGraw-Hill, Health Professions Division.

Chiu, A., Shi, J., Hill, R., Katz, A., (2010). *Review of Chromium (VI) Apoptosis, Cell-Cycle-Arrest, and Carcinogenesis*. Environmental Science Health Ecotoxicology Review., 28(3), 188–230.

Chrysochoou, M., & Reeves, K. (2016). *Reduction of Hexavalent Chromium by Green Tea Polyphenols and Green Tea Nano Zero-Valent Iron*. Bulletin of Environmental Contamination and Toxicology, 98(3), 353-358.

Cone, M. (2009). *Chromium in Drinking Water Causes Cancer*. Environmental Health News, (February, 20).

Dalcin, M.G., Pirete, M.M., Lemos, D.A., Ribeiro, E.J., Cardoso, V.L., & Resende, M.M. (2011). *Evaluation of Hexavalent Chromium Removal in a Continuous Biological Filter with the use of Central Composite Design*. Journal of Environmental Management, 92(4), 1165-1173.

Division of Public Water Supplies. (2011). *Assessment of Total Chromium in Illinois Community Water Supplies*. Illinois Environmental Protection Agency.

Geetha, S., Sai Ram, M., Mongia, S., Singh, V., Ilavazhagan, G., & Sawhney, R. (2003). *Evaluation of Antioxidant Activity of Leaf Extract of Seabuckthorn (Hippophae rhamnoides) on Chromium(VI) Induced Oxidative Stress in Albino Rats*. Journal of Ethnopharmacology, 87(2-3), 247-251.

Kamerud, K.L., Hobbie, K.A., & Anderson, K.A. (2013). *Stainless Steel Leaches Nickel and Chromium into Foods during Cooking*. Journal of Agricultural and Food Chemistry, 61, 9495-9501.

Kiilunen, M., & H. Kivisto, (1983). *Exceptional Pharmacokinetics of Trivalent Chromium During Occupational Exposure to Chromium Lignosulfonate Dust*. Scandinavian Journal of Work, Environment & Health 9(3), 265-71.

Levis, A.G., Bianchi, V., Tamino, G., & Pegoraro, B. (1978). *Cytotoxic Effects of Hexavalent and Trivalent Chromium on Mammalian Cells in Vitro*. Br. J. Cancer, 37, 386-396.

Loyaux- Lawniczak, S., Lecomte, P., & Ehrhardt, J.J. (2001). *Behavior of Hexavalent Chromium in a Polluted Groundwater: Redox Processes and Immobilization in Soils*. Environmental Science and Technology, 35(7), 1350-1357.

Majone, F., Bianchi, V., Dal Toso, R., Debetto, P., Levis, A.G., Luciani, S., & Tamino, G. (2002). *Mechanisms of Chromium Toxicity in Mammalian Cell Cultures*. Toxicology, 17(2), 219-224.

Martindale, J. L., & Holbroook, N. J. (2002). *Cellular Response to Oxidative Stress: Signaling for Suicide and Survival*. Journal of Cellular Physiology, 192(1), 1-15.

Mills, P.C., & Cobb, R.P. (2015). *Hexavalent and Total Chromium at Low Reporting Concentrations in Source-Water Aquifers and Surface Waters Used for Public Supply in Illinois*. U.S. Geological Survey Scientific Investigations Report 2015–5020, 58.

Oze, C., Bird, D.K., & Fendorf, S. (2007). *Genesis of Hexavalent Chromium from Natural Sources in Soil and Groundwater*. Proceedings of the National Academy of the Sciences, 104(16), 6544-6549.

Petrilli, F., & DeFlora, S. (1976). *Toxicity and Mutagenicity of Hexavalent Chromium on Salmonella typhimurium*. Applied and Environmental Microbiology, 33(4), 805-809.

Strober, W. (2001). *Trypan Blue Exclusion Test of Cell Viability*. National Institute of Allergy and Infectious Diseases, 3, 10.1002.

Sun, H., Brocato, J., & Costa, M. (2015). *Oral Chromium Exposure and Toxicity*. Curr Environmental Health Report, 2, 295–303.

Thatoi, H., Das, S., Mishra, J., Rath, B.P., & Das, N. (2014). *Bacterial Chromate Reductase, a Potential Enzyme for Bioremediation of Hexavalent Chromium: A Review*. Journal of Environment Management, 146, 383-399.

Von Burg, R. (1993). *Chromium and Hexavalent Chromium*. Journal of Applied Toxicology, 13(3), 225-230.

Yu, D. (2013). *Chromium Toxicity*. Agency for Toxic Substances and Disease Registry.

APPENDIX

$X = OD_{600}$ measurement for overnight bacteria, Y = Working concentration (For this specific strain, TA100, the working concentration is 0.05 at OD_{600}), *Final volume* = 6 mL.

Volume of overnight bacteria (mL) required for dilution = Y/X × *Final volume*

Example: TA100 was grown overnight and recorded an $OD_{600} = 0.65$

Volume of TA100 required for dilution = $(0.05)/(0.65)$ × 6 = 0.46 mL

Therefore, 0.46 mL of overnight bacterial solution will be added to 5.54 ml of Reagent N to bring the final volume to 6 mL.

Performance Analysis of an Exhaust Heat Recovery System Utilizing Heat Pipes, Metal Foam, and Thermoelectric Generators

Michael J. Resciniti

ACKNOWLEDGEMENTS

ABSTRACT

Developing efficient thermoelectric generator systems to recover wasted thermal energy from automotive exhaust gasses has potential to improve engine efficiency and reduce carbon emissions. Due to their high thermal transfer efficiency, heat pipes have been used to assist thermoelectric generator systems in these applications. To aid in additional heat transfer, metal fins are often used with heat pipes to take advantage of extended-surface heat transfer. This paper proposes a thermoelectric generator system that employs metal foam as an extended-surface heat transfer aid used in conjunction with heat pipes. Three test conditions were simulated to evaluate the system performance in terms of maximum power output: one with heat pipes with no heat transfer aid, one with heat pipes and aluminum fins as a heat transfer aid, and one with heat pipes and metal foam as a heat transfer aid. The experimental results show that the power output of the system was lowest when using no heat transfer aid and highest when aluminum fins were used. Metal foam proved to be effective at increasing the power output but did not perform as well as aluminum fins. Metal foam helped increase the open circuit steady state voltage by 10.2%, whereas the aluminum fins increased the open circuit steady state voltage by 61.8%.

Keywords: thermoelectric generator, metal foam, heat pipes, waste heat recovery

REVIEW OF LITERATURE

Exhaust heat recovery systems are used to take advantage of otherwise wasted heat produced from an automobile's engine. In modern internal combustion engines only about 30% of the chemical energy in the fuel is converted into mechanical energy used by the automobile. The rest is turned into thermal energy. Though a portion of the heat is dissipated by the coolant, the majority of the heat is evacuated from the engine via the exhaust system. Harnessing this thermal energy and converting it into usable electrical power could allow for the removal of an automobile's alternator. This simple change would help reduce fuel consumption by reducing the parasitic load on the engine, which in turn reduces the amount of harmful CO_2 gases released into the environment. Stobart et al. (2010) determined that such systems could increase fuel efficiency by as much as 4.7%.

Thermoelectric generators

One proposed method for capturing this thermal energy is with the use of thermoelectric generators. Thermoelectric generators consist of two metal plates separated by another metallic compound. As one side of the thermoelectric generator is heated, the temperature difference between the two metal plates increases. This temperature difference induces the flow of electrons in the material from the high temperature side to the low temperature side creating an electric potential, or voltage, which is then harnessed.

In recent years, automotive companies and independent researchers have been testing exhaust gas recovery systems utilizing thermoelectric generators. In the past decade BMW has developed and tested several prototypes. Their first tests, carried out in

2003, resulted in a maximum power production of 80 watts. A later attempt in 2006 resulted in production of 200 watts from a BMW 535i sedan. The same vehicle was equipped with an updated system two years later that was able to produce 300 watts. In 2011, the company tested a BMW X6 SUV equipped with a new system containing updated thermoelectric materials and an updated cooling system. At 125 km/h, the system produced 600 watts (Eder, 2011).

Other automobile manufacturers, including Ford, General Motors, Fiat, Renault and Chrysler have tested exhaust heat recovery systems as well. Tests were conducted on various size automobiles with varying results. General Motors was able to produce 230 watts from a system employed on a Chevrolet Suburban (Meisner, 2012). Renault Trucks was able to produce 350 watts from a truck with an 11 liter engine in 2011 (Champier, 2017).

Though automobile manufacturers have been investigating this technology for nearly two decades, it has yet to been implemented in a production vehicle. This suggests that current systems require further optimization in terms of performance and efficiency.

Heat exchangers

Automotive manufacturers are not the only ones interested in exhaust waste heat recovery. Academic researchers have been modeling and testing prototypes in an attempt to optimize heat exchanger and generator design. The optimization of heat exchanger efficiency is an area of intense interest due to the fact that available thermoelectric materials have inherently low energy conversion efficiencies, between 5 and 10% (Champier et al., 2017). Therefore, to obtain the most usable power from a thermoelectric system without developing new thermoelectric materials, one must use a heat exchanger with high thermal efficiency.

Fin-plate heat exchangers

The most common heat exchanger design in exhaust heat recovery applications is a variation of a fin-plate heat exchanger. Exhaust gas flows into the heat exchanger where it encounters internal fins and plates that direct the gas towards the outside surface of the system. The heat from the exhaust gas increases the temperature of the outside surface of the heat exchanger, which then heats the hot-side surface of the thermoelectric generator. This general design is widely used because it theoretically allows for the transfer of a high percentage of the heat present in the gas.

Su et al. (2014) conducted a simulation and experimental study on the thermal optimization of a heat exchanger used for an exhaust heat recovery thermoelectric system. The study analyzed three fin-plate heat exchangers with varying internal design structures. The goal was to achieve even thermal distribution across the outside surface of the heat exchanger, which would be in contact with the hot-side surface of the thermoelectric generator. The internal designs utilized a fishbone-like structure, an accordion-like structure, and a random structure. Using computer software, each design was modeled and the heat transfer efficiency was simulated. Each system was then applied to the exhaust system of a four cylinder engine. The computer simulations suggested the accordion type design would provide the most even distribution of heat, and proto-

typical tests confirmed this hypothesis. The accordion-like structure produced a 3.5% and a 6.5% higher average temperature than the fishbone-like structure and random structure, respectively.

Liu et al. (2016) completed a multi-objective optimization of a heat exchanger for an automotive exhaust thermoelectric generator. The heat exchanger was a variant of a fin-plate heat exchanger. The system utilized internal fins with varying orientations. The study was conducted to evaluate thermal properties and pressure properties of the gas as it flowed through the system. The study had four optimization targets: average temperature, temperature gradient in longitudinal direction, temperature gradient in transverse direction, and average static pressure drop through the system. Throughout the study, five parameters were optimized: fin length, fin height, fin thickness, fin angle, and interval distance. Sixteen computer-aided models with variances in some or all of the five parameters were created and simulated. The simulations revealed the intricate correlation between all five parameters, though internal fin height had the greatest effect (34%) on thermal flow to the surface of the thermoelectric generator.

Fin-plate heat exchangers are the most common heat exchanger used in exhaust heat recovery systems with thermoelectric generators. Their large surface areas allow for significant thermal energy transfer from the exhaust gas to the external surface. The large external surface also allows for easy mounting of the thermoelectric modules. However, fin-plate heat exchangers have disadvantages. Even with an optimized design it is extremely difficult to achieve even temperature distribution over the surface of the heat exchanger. Also, the internal fins increase the back pressure of the exhaust gas, which decreases engine efficiency (He, 2017). Due to these disadvantages researchers are investigating other ways to raise heat exchanger efficiency.

Heat pipes

Heat pipes provide another solution for increasing heat exchanger efficiency. They are generally very efficient and have high thermal conductivity. Recently, research has been conducted regarding heat pipes being used in exhaust heat recovery systems. Cao et al, (2018) analyzed the performance of heat pipes in this application. Several parameters were tested to achieve an optimized state, including the depth of the heat pipes, the angular position of the heat pipes, and the use of fins to aid in heat transfer. Notably, the addition of fins increased the output by 43%. In this experiment, in the systems optimized state, 81.09 volts were generated from 36 thermoelectric modules. This equated to a thermoelectric power generation efficiency of 2.58%. Remeli et al. (2016) tested a similar system that used heat pipes to heat and cool the thermoelectric generator. In this test, 62 aluminum fins were also used to aid in heat transfer. Modeling showed that the prototype had the capability of recovering 1.345 kW of waste heat, yet, it only generated 10.39 watts of electricity, equating to a 0.77% conversion efficiency.

Metal foam

Metal foam is a porous material made by injecting gas into liquid metal. Metal foam can be made from nearly any metal including aluminum, copper, silver, gold, nickel, etc. Metal foam can vary greatly in pore size and density.

Bai et al. (2017) conducted a numerical investigation on the performance of a thermoelectric generator system employing a heat exchanger externally wrapped in metal foam. The heat exchanger was a simple cylindrical device, with a radius not much larger than that of the automotive exhaust pipe. The heat exchanger had no internal fins or plates. The exterior of the heat exchanger was octagonal and each side was covered with metal foam. An identical heat exchanger without metal foam was also tested so the results could be compared. The researchers also varied the thickness and porosity of the foam in order to optimize the design. The results showed that the use of metal foam increased temperature and distributed heat more evenly across the external surface where the thermoelectric modules were mounted. The tests also concluded that the system utilizing metal foam had an increased power output by 170%, compared to the system without metal foam.

Based on the results of the aforementioned research, it is clear that the addition of aluminum foam increases the heat transfer between the flowing heat source and the outside environment. Similarly, the aforementioned research also concludes that the addition of aluminum fins to a system utilizing heat pipes increases the heat transfer between the heat source and the heat pipes. My study aims to compare the two heat transfer aids (aluminum fins and aluminum foam) when used in conjunction with heat pipes in an exhaust gas waste heat recovery system. This study tests the heat transfer efficiency for thermal electric generation from a system using heat pipes with no heat transfer aid, a system using heat pipes and aluminum fins, and a system using heat pipes and aluminum foam.

This lends further credibility to the use of such systems being employed in vehicles that utilize internal combustion engines. This research creates baseline from which new studies can be conducted to improve these types of systems. Ultimately, the goal of this research is to aid in the creation of a system that will allow for the elimination of a vehicle's alternator, greatly improving fuel efficiency and reducing carbon emissions.

METHODS

To study the detailed parameters of the proposed thermoelectric generation system, an experimental test rig was built. A forced air kerosene heater producing 50,000 Btu with a volumetric flow rate of 175 cubic feet per minute was used to simulate the flow of automotive exhaust gases. The forced air heater was coupled to a four inch diameter metal duct through a series of reducers. This test rig is pictured in **Figure 1**.


Figure 1: Automotive exhaust heat simulation device. A forced air kerosene heater coupled with metal duct was used to simulate an automotive exhaust system.

As shown in **Figure 2**, four 150 mm long, 8 mm diameter copper heat pipes were positioned 30 mm apart and inserted halfway into the duct so that the ends were positioned in the center of the duct. The other end of the heat pipes were inserted into a 150 mm x 50 mm x 12.7 mm aluminum block, seen in **Figure 3**.

Figure 2: Heat pipe positioning in duct. Four heat pipes were separated by a distance of 30 mm and inserted 7 6mm into the metal duct.
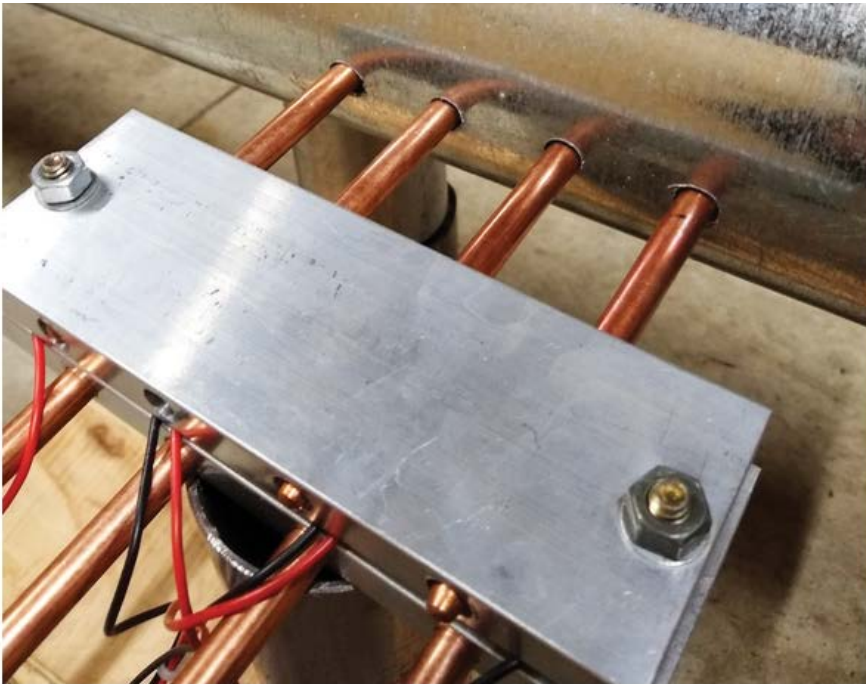
Figure 3: Heat pipe positioning in aluminum block. The opposite ends of the four heat pipes were inserted into an aluminum block.

The hot side of three thermoelectric generators (TEGs) were attached to the face of the aluminum block. The cold face of the TEGs were then attached to another identical aluminum block with four identical copper heat pipes positioned 30 mm apart inside of the block. These heat pipes were left open to the ambient air to act as a heat sink and keep the cold side of the TEGs at a relatively constant temperature.

Three 40 mm x 40 mm x 3.4 mm, Bismuth Telluride (Bi_2Te_3) thermoelectric generators were used in each test. The thermoelectric generators were clamped between the two aluminum blocks. Due to its conductive nature, polysynthetic silver thermal paste was used between the faces of the thermoelectric generators and the aluminum to increase heat transfer.

The experiment was run three times with slight variations. In the first test, there was no heat transfer aid used in conjunction with the heat pipes. The heat pipes in the duct were directly exposed to the hot forced air. In the second test, sixteen rectangular aluminum fins, made of 6101 alloy and measuring 150 mm x 12.7 mm x 1 mm were placed onto the heat pipes that were inserted into the duct. Each fin was separated by a distance of 2 mm. These fins are pictured in **Figure 4.** The fins were used to aid in heat transfer. In the third test, these fins were replaced with a rectangular aluminum foam block measuring 150 mm x 50 mm x 12.7 mm. The aluminum foam had a relative density of 10 to 12%, 20 pores per inch (PPI), and was processed from 6101 alloy. Again, the aluminum foam was used to aid in heat transfer. **Figure 5** shows the heat pipes inserted into the aluminum foam block. **Figure 6** shows the aluminum foam block inserted into the metal duct.

Figure 4: Metal fin positioning. The four heat pipes were placed through holes in sixteen aluminum fins

Figure 5: Aluminum foam positioning. The heat pipes are inserted into the aluminum foam block.
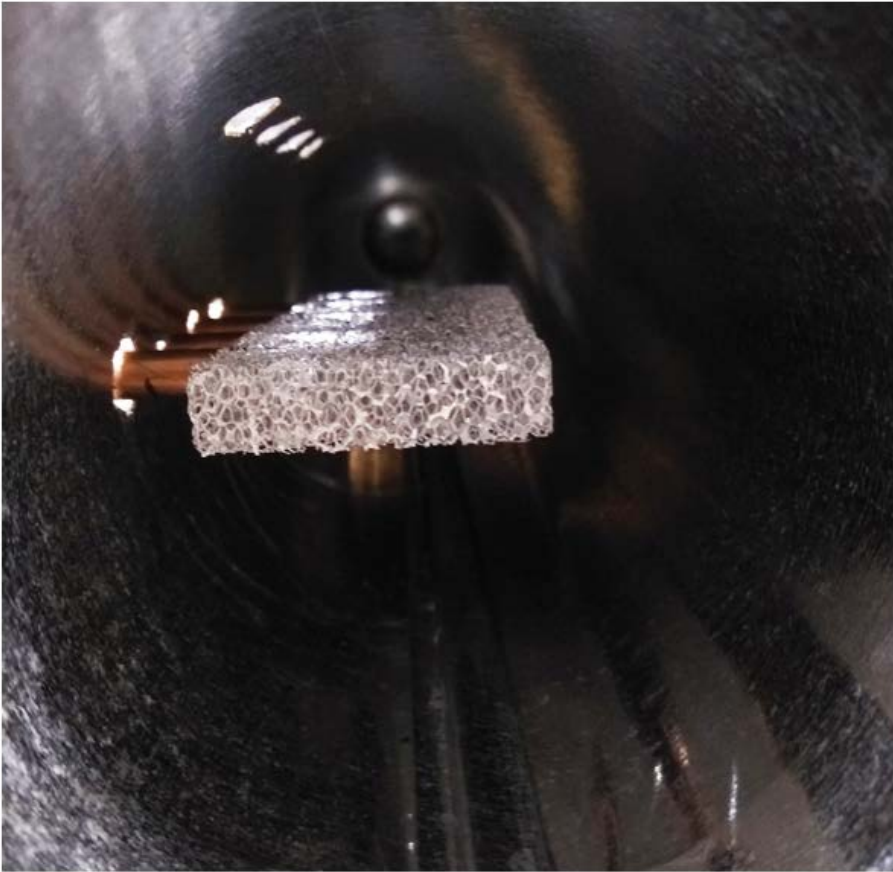
Figure 6: Heat pipe and aluminum foam positioning. The aluminum foam and heat pipes are inserted similarly to the initial test with only heat pipes. The test conducted with aluminum fins was identical as well.

Three data sets were recorded from each test. First, the open-circuit steady-state voltage for each system was recorded using a digital voltmeter. The open-circuit steady-state voltage is the voltage produced by the circuit after the heat pipes have reached their maximum heat transfer potential, transferring a steady amount of heat to the aluminum block and therefore to the hot side of the thermoelectric generators. The time taken

for each system to reach the open-circuit steady-state voltage was also recorded. The temperature at the center of the top surface of the aluminum block was recorded using an infrared thermometer. Using the open-circuit steady-state voltage and the amperage of the system, the power production of the system was found.

RESULTS

The results of the experimentation can be seen in Table 1. The results show that the addition of a heat transfer aid increased the surface temperature of the aluminum block, therefore, increasing the temperature of the hot side surface of the TEGs and the temperature gradient between the hot and cold side surfaces of the TEG. This increase

TABLE 1: TEST RESULTS

Test Conditions	Volts	Watts	Power Density (W/m²)	Time to Reach Steady State (Min:Sec)	Aluminum Block Temperature (°C)
Heat Pipes	2.93	1.54	321	7:36	11.3
Heat Pipes and Aluminum Fins	4.74	3.11	648	7:19	20.7
Heat Pipes and Aluminum Foam	3.23	1.85	385	8:22	15.1

in temperature gradient lead to an increased electrical power output.
The results show that in both instances, the addition of an extended surface heat transfer aid increased the open-circuit steady-state voltage. The addition of aluminum fins increased the voltage by 61.8%, while the addition of aluminum foam increased the voltage by 10.2% over the base test with no heat transfer aid.

The addition of aluminum fins also reduced the time for the system to reach open-circuit steady-state voltage, compared to the system with no heat transfer aid. However, the addition of aluminum foam increased the time for the system to reach steady state by a considerable amount.

The increase in power density is representative of the increase of temperature, and therefore, voltage. Again, the addition of aluminum fins resulted in the highest power density, generating 648 W/m2. The addition of aluminum foam resulted in the second highest power density, yielding 385 W/m2. These results indicate that aluminum fins are a better heat transfer aid than 10% density, 20 PPI aluminum foam when used in conjunction with heat pipes that are exposed to hot, rapidly flowing air.

DISCUSSION

This study assessed the performance of an automotive exhaust heat recovery system utilizing thermoelectric generators, aluminum foam, and heat pipes. The results concluded that the addition of aluminum foam to the system was effective at increasing open-circuit steady-state, as well as power density. However, the addition of aluminum

foam was not as effective at increasing these factors as the addition of aluminum fins. The amount of heat transferred to or from extended surfaces, like fins or porous media like metal foam, is, among other factors, related to the amount of exposed surface area. In this study the fins and metal foam were made from the same material, meaning they share the same intrinsic properties that effect heat transfer such as specific heat and thermal conductivity. The considerable differentiating factor between the fins and the metal foam was the exposed surface area. Predictably, the additional surface area of the fins lead to greater heat transfer.

It should be noted that this study tested one very specific variation of aluminum foam: 10-12% relative density, 20 PPI, processed from 6101 alloy, measuring 150 mm x 50 mm x 12.7 mm. Metal foam is largely variable in relative density, PPI, material, and size. As seen in Bai et al. (2017), variance in these factors lead to a variance in heat transfer effectiveness. A sample of metal foam with a higher relative density would have a greater exposed surface area and would lead to greater heat transfer. The optimization of these factors could be an area for future research.

It should also be noted that this study only tested the influence of the addition of aluminum foam on the electrical power output of the system. Though this is a significant factor in an automotive exhaust waste heat recovery, there are other factors that must be analyzed as well. One specific factor to consider is pressure drop within the exhaust system. As explained in Cao et al. (2018), significant pressure drop within the exhaust system has adverse effects on engine performance and efficiency. In an exhaust waste heat recovery system like the one tested, the electrical power output and effect of pressure lost must be weighed to optimize the system. Metal foam is known for its ability to transfer heat well while minimizing pressure drop in a system. Though the addition of metal foam in this experiment was not as effective as the addition of aluminum fins in terms of increasing electrical power generation, it may prove beneficial in reducing pressure drop in the system. The optimization of pressure drop and electrical power output could also be an area for future study.

The optimization of thermoelectric generator systems to recover wasted thermal energy from automotive exhaust gasses can improve engine efficiency and reduce environmentally harmful carbon emissions. In an attempt at optimization, a new system was created using thermoelectric generators, heat pipes, and aluminum foam. The electrical power produced from this system was compared to existing systems utilizing thermoelectric generators and heat pipes, as well as existing systems using thermoelectric generators, heat pipes, and metal fins. The results showed addition of aluminum foam increased heat transfer, but not as well as the addition of metal fins. The results show promise for systems utilizing metal foam, however, further testing will be needed to achieve optimization.

REFERENCES

Bai, W., Yuan, X., & Liu, X. (2017). Numerical investigation on the performances of automotive thermoelectric generator employing metal foam. *Applied Thermal*

Engineering, 124, 178–184. https://doi.org/10.1016/j.applthermaleng.2017.05.1.
Cao, Q., Luan, W., & Wang, T. (2017). Performance enhancement of heat pipes assisted thermoelectric generator for automobile exhaust heat recovery. *Applied Thermal Engineering*, 130, 1472-1479. https://doi.org/10.1016/j.applthermaleng.2017.09.134.

Champier, D. (2017). Thermoelectric generators: a review of applications. *Energy Conversion and Management*, 140, 167–181. https://doi.org/10.1016/j.enconman.2017.02.07.

Eder, A. & Linde, M. (2011). *Efficient and dynamic–the BMW group roadmap for the application of thermoelectric generators*.

He, W., & Wang, S. (2017). Thermoelectric performance optimization when considering engine power loss caused by back pressure applied to engine exhaust waste heat recovery. *Energy*. 133. 10.1016/j.energy.2017.05.133.

Liu, C., Deng, Y. D., Wang, X. Y., Liu, X., Wang, Y. P., & Su, C. Q. (2016). Multi-objective optimization of heat exchanger in an automotive exhaust thermoelectric generator. *Applied Thermal Engineering*, 108, 916–926. https://doi.org/10.1016/j.applthermaleng.2016.07.175.

Meisner, G. (2012). *Skutterudite thermoelectric generator for automotive waste heat recovery*.

Remeli, M. F., Date, A., Orr, B., Ding, L. C., Singh, B., Affandi, N. D., & Akbarzadeh, A. (2016). Experimental investigation of combined heat recovery and power generation using a heat pipe assisted thermoelectric generator system. *Energy Conversion and Management*, 111, 2016, 147-157. https://doi.org/10.1016/j.enconman.2015.12.032.

Stobart, R., Wijewardane, A., & Allen, C. (2010). The potential for thermo-electricdevices in passenger vehicle applications. *SAE Technical Papers*. 10.4271/2010-01-0833.

Su, C. Q., Wang, W. S., Liu, X., & Deng, Y. D. (2014). Simulation and experimental studyon thermal optimization of the heat exchanger for automotive exhaust-based thermoelectric generators. *Case Studies in Thermal Engineering*, 4, 85–91. https://doi.org/10.1016/j.csite.2014.06.002.

The Relationship Between Faith Maturity and Life Satisfaction

Amanda L. Roche

ACKNOWLEDGEMENTS

ABSTRACT

Background
Studies have been conducted that conclude that having a more mature faith correlates to healthier psychological well-being and healthier personal relationships (Hill & Pargament, 2003; Okun & Stock, 1987; Powell & Pepper, 2015). A significant amount of research has been conducted on life satisfaction; however, fewer studies have explored the relationship between life satisfaction and faith maturity. Hawkins, Tan, and Turk (1999) compared a secular inpatient cognitive-behavioral therapy program to a Christian inpatient cognitive-behavioral therapy program and discovered that there was a negative correlation between spiritual well-being and depression, but little has been done beyond this study to examine this relationship. Alessandri, Caprara, and Tisak (2012) also showed that there is a relationship between life orientation and life satisfaction, as well as self-esteem and life satisfaction.

Methods
A survey was sent to the entire student body of 2,900 students at a Christian liberal arts university in the Midwest, and 717 responses were received. The survey included questions from Benson, Donahue, and Erickson's Faith Maturity Scale (1993), Diener, Emmons, Larsen, and Griffin's Satisfaction with Life Scale (1985), Scheier, Carver, and Bridges' Revised Life Orientation Test (1994), Rosenberg's Self Esteem Scale (1965), and demographic questions.

Results
There was a statistically significant correlation between faith maturity and life satisfaction, although less variability in life satisfaction could be predicted from faith maturity than from self-esteem and life orientation. Using an independent samples t-test, it was found that the life satisfaction of participants in this study was greater than the participants in Diener, et al.'s (1985) study on life satisfaction.

Conclusion
A significant positive correlation was found between faith maturity and life satisfaction, although this correlation was slightly smaller than the other correlations that were assessed. It was also found that 18% of variability in life satisfaction could be predicted by faith maturity.

Keywords: faith maturity, life satisfaction, life orientation, self-esteem

INTRODUCTION

Satisfaction with life, a major component of subjective well-being, has been the focus of an increasing amount of research since the 1980s (Diener, Oishi, & Lucas, 2011). As the popularity of life satisfaction, subjective well-being, and other related measures of quality of life have continued to grow, there have been more and more scales being successfully written to further delve into the relationships between these characteristics and other life experiences. Relationships between life satisfaction and Facebook usage (Blachnio, Przepiorrka, & Pantic, 2016), genetics (Caprara, et al., 2009), and even income redistribution (Cheung, 2018) and cultural perceptions of happiness (Bastian,

Kuppens, De Roover, & Diener, 2014) have been found. But what really contributes to life satisfaction? Studies have shown that life orientation (positivity and outlook on life) and self-esteem are positively correlated to life satisfaction (Alessandri, Caprara, & Tisak, 2012), but are there other factors that are linked to life satisfaction?

One area that has been explored in previous research is the relationship between intrinsic religious faith and psychological well-being. According to Laurencelle, Abell, and Schwartz (2002), when compared to people who indicated lower intrinsic faith scores, people with higher intrinsic faith reported significantly lower scores of depression and anxiety and were also less likely to show signs of character pathology and showed stronger ego strength; however, these relationships were moderate and there was significant variation within each of the groups being correlated. Another more recent study by Leonardi and Gialamis (2009) examined the relationship between religiosity and psychological well-being further in a sample of Greek Orthodox Christians. The researchers found a statistically significant positive correlation between life satisfaction and church attendance, as well as between interest in church and life satisfaction. Conversely, they also found that individuals that prayed more were also more anxious.

The Christians Scriptures claims, "God will supply every need of yours according to his riches in glory in Christ Jesus" (Philippians 4:19, English Standard Version). This verse can be interpreted as meaning that God will provide for the needs of people who believe in him. For those who identify themselves as Christians, therefore, living a satisfying life is found in God and the Christian faith. Some studies have found that having a greater level of religiosity does, in fact, relate to a greater subjective well-being (Ivtzan, et al., 2013; Powell & Pepper, 2015), of which a major component is life satisfaction (Diener, et al., 1985). Does this link hold true for life satisfaction specifically? If so, what is the magnitude of this correlation? Is it significant and how does it compare with other indicators of life satisfaction? On the other hand, research has also shown that the importance of religion to an individual is associated with poor mental health (Ivtzan, et al. 2013), so how do these positive and negative results relate to life satisfaction?

Psychological context

Although scholars and philosophers have reasoned about the meaning of life and happiness for centuries, the first empirical studies of subjective well-being began to take shape in 1925, and the study of subjective well-being has since gained in popularity. Since the 1980s, however, the study of subjective well-being has exploded due to the increase in valid and reliable scales to measure subjective well-being and its components (Diener, Oishi, & Lucas, 2011). During this time, Diener, Emmons, Larsen, and Griffin (1985) attempted to develop a new life satisfaction scale that was more complete than any that had previously been created. This new scale measures general life satisfaction and quality of life in addition to feelings and emotions and considers the theory that other biological and environmental factors may contribute to life satisfaction, rather than just personality or mental health. Cultural perceptions are also a contributing factor to life satisfaction. Diener, Napa Scollon, Oishi, Dzokoto, and Suh (2000) found in their study of people from forty-one different countries that

in countries that emphasize positivity and value positive emotion and happiness, people tended to say that they were more satisfied with their life and had an overall higher subjective well-being. This well-being was measured by asking participants about their satisfaction with both general and specific aspects of their life and society. Because some countries are more religious than others, religion could be a part of this difference in life satisfaction between countries and, therefore, the differences in life satisfaction and subjective well-being.

In 2009, Caprara et al. investigated the genetic underpinnings of life satisfaction, self-esteem, and optimism. The results showed that all three of these are significantly impacted by genetics but that the environment had a substantial impact as well. Other researchers have studied the correlations between positive orientation and self-esteem, life satisfaction, and optimism. Positive orientation is self-confidence or the way that a person views oneself and is positively correlated to self-esteem, life satisfaction, and optimism (Alessandri, Caprara, & Tisak, 2012). So, what other factors contribute to the non-genetic portion of life satisfaction? Aspects of life such as relationship quality, optimism, social self-efficacy, and regulation of negative emotions are predictors of positive orientation, but there may be other factors that account for differences in life satisfaction (Caprara & Steca, 2005).

Religious context

Since 1985, there have been many studies that have focused on the correlation between religiosity and subjective well-being (the overall quality of life); however, there have been no studies that have specifically explored the link between faith maturity and life satisfaction. One study that examined the connection between religiosity and subjective well-being is Leonardi and Gialamas (2009). The researchers focused on the importance of religion and the frequency that participants attended church and prayed. They then looked at the correlation between this and psychological well-being, life satisfaction, and mental health. While they only saw small correlations between these, this could partly be due to the fact that participants' actions did not always seem to match their beliefs. Though 78% of people reported that religion is either important or very important to them, only about 14% of participants reported that they attend church once per week or more, whereas 60% of participants reported attending church only a few times per year (Leonardi & Gialamis, 2009). This means that at least 64% of people who reported that their religion is important or very important to them do not attend church regularly. This discrepancy raises the question of whether results would be different if participants' perception of the importance of religion matched their actions.

Research has indicated that there is a link between spiritual well-being and lower rates of depression (Hawkins, Tan, & Turk, 1999). There is a statistically significant difference between participants that are involved in church-related activities and participants that are not, supporting further research on this subject. A related study was conducted that found a positive correlation between the belief in a kind, caring God and healthy emotional well-being among participants aged 18 to 86. A negative correlation between the belief in a kind, caring God and substance abuse was also found (Ciarrochi & Brelsford, 2009). This shows that both emotional health and addictive tendencies are important aspects of overall life satisfaction and contribute to overall well-being.

Yet another study indicated that there is a positive correlation between intrinsic religious faith and psychological well-being (Laurencelle, et al., 2002). The researchers focused on ego strength, superego strength, anxiety, depression, and character pathology and found that participants with moderate to high religious faith scored significantly better in each of these categories than participants with low levels of religious faith. These results show that there is a link between religious faith and psychological well-being (Laurencelle, et al., 2002). Other studies have shown that there is a relationship between religiosity and positive psychological well-being (Hawkins, Tan, & Turk, 1999). But does this relationship extend to life satisfaction, and if so, how much? A good deal of research has been done to support the link between faith and psychology, but there is a lack of research examining the link specifically between faith maturity and life satisfaction.

If there is a statistically significant correlation between faith maturity and life satisfaction, this could open doors for deeper research into the subject. Further investigation could be done to find what the significant components of faith maturity are that contribute to life satisfaction, as compared to overall faith maturity. For example, is it the community, meditation, or hopefulness that contribute most to life satisfaction? Because there have already been several links found between religion and subjective well-being, this could be further evidence to support the inclusion of faith maturity as a valid measure of life satisfaction.

RESEARCH QUESTIONS AND HYPOTHESES

1. Does faith maturity positively correlate with life satisfaction?

2. How does the correlation between life satisfaction and faith maturity compare to the correlation between self-esteem and life satisfaction and the correlation between life orientation and life satisfaction?

3. How much of the variability of faith maturity is predicted by life satisfaction and how does this compare to other known indicators of life satisfaction?

I hypothesized that participants who scored high on faith maturity would also score high on life satisfaction. It was also hypothesized that the correlation coefficient between faith maturity and satisfaction with life would be significant and equal to or greater than the correlation coefficients between self-esteem and life satisfaction and between life orientation and life satisfaction. The final hypothesis was that faith maturity would predict life satisfaction as much as other known indicators of life satisfaction would.

METHODS

Participants

Undergraduate students from a small, denominationally-affiliated university in the Midwest were asked to participate. An email with a link to the survey was sent to approximately 2,900 students. Seven hundred and seventeen students responded; however, not every participant answered all the questions. Out of the 717 students, six chose not to participate in the survey. Another 62 participants did not answer all the

questions, so their responses were excluded from the data. Six hundred and forty-nine of the students' responses were complete and kept for data analysis. Students between the ages of 17 and 22 made up 88.7% of the participants, and the other 11.3% were between the ages of 23 and 46, with the average age being 20.75 years old. Three hundred eighty-seven of the participants were female, 176 were male, and 86 did not specify their sex. Of the participants, six identified as agnostic, one identified as atheist, 586 as Christian, 16 as non-religious, and 40 did not specify their religious affiliation. Five hundred and sixteen of the participants identified as White, 33 as Hispanic, Latino, or Spanish Origin, 22 as African American, 13 as Asian, four as American Indian or Alaska Native, one Middle Eastern or North African, 10 answered "other," and 14 preferred not to answer.

Materials
Life satisfaction
Life satisfaction was measured using the Satisfaction with Life Scale (Diener, et al., 1985). The five-item-self-report scale used a seven-point Likert scale with endpoints that ranged from 1 (Strongly Disagree) to 7 (Strongly Agree) to measure general life satisfaction. The higher the score, the more satisfied the participant is with his life. The internal consistency for this test was .84.

Faith maturity
The Faith Maturity Scale (Benson, Donahue, & Erickson, 1993) was used to measure faith maturity. The Faith Maturity Scale utilized a seven-point Likert scale ranging from 1 (Never True) to 7 (Always True) to assess indicators of faith rather than faith itself. The "eight core dimensions" that the researchers determined account for indicators of faith and faith maturity are "trusts and believes" in God and Jesus Christ, "experiences of the fruits of faith," "integrates faith and life," "seeks spiritual growth," "experiences and nurtures faith in community," "holds life-affirming values," "advocates social change," and "acts and serves." Four to six questions were then written by the scale's authors for each of these eight dimensions, leading to a 38-item inventory, with five of these items being reverse scored. A higher score meant that the participant had a greater level of faith maturity. Based on Cronbach's alpha, we decided to not reverse score one of the five items that was reverse scored in the original scale, and reverse score two other items that were not originally reverse scored. After these changes, the internal consistency for this scale was .92.

Life orientation
Optimism was measured using the Revised Life Orientation Test (Scheier, Carver, & Bridges, 1994). This test consisted of 10 statements scored on a five-point Likert scale ranging from 0 (Strongly Disagree) to 4 (Strongly Agree). Three of the 10 statements were reverse-coded, and four of the 10 statements were filler items, meaning that the Likert scores of six of the 10 statements (including the three reverse-coded statements) were summed to find an overall life orientation score, with a higher score showing a greater level of optimism. The internal consistency for this test was .77.

Self-esteem
The final scale used was the Rosenberg Self-Esteem Scale (1965) to measure "global self-worth by measuring both positive and negative feelings about the self." The scale

consisted of 10 statements measured on a four-point Likert scale with endpoints that ranged from 1 (Strongly Disagree) to 4 (Strongly Agree) with five of the 10 statements being reverse-scored. After reverse scoring five of the items, an overall score was obtained by summing responses to each of these items, with higher scores representing greater levels of self-esteem. The internal consistency for this was .87.

Demographics
Questions pertaining to age, gender, ethnicity, and religious affiliation were also included.

Procedures
A 67-question survey was emailed to approximately 2,900 undergraduate students. The email contained a brief description of the study, as well as the link leading to the study. The link led participants to an informed consent page where the participants had the option to continue with the survey or not participate with the survey following their consent. The survey included questions from the Satisfaction with Life Scale (Diener, et al., 1985), the Faith Maturity Scale (Benson, Donahue, & Erickson, 1993), the Revised Life-Orientation Test (Scheier, Carver, & Bridges, 1994), the Rosenberg Self-Esteem Scale (Rosenberg, 1965), and four demographic questions. The survey was open for three weeks, with follow-up emails sent at the beginning of the second and third week. SNAP Survey Software was used to house the survey and collect the data.

RESULTS

Table 1 shows the correlations of the Faith Maturity Scale to each of the other three scales (Satisfaction with Life Scale, Revised Life Orientation Test, and Rosenberg Self-Esteem Scale) and the correlations of the Satisfaction with Life Scale to the Rosenberg Self-Esteem Scale and Revised Life Orientation Test. Each of these correlations were positive and statistically significant. These results answered the first research question, that faith maturity is positively correlated with life satisfaction and that this is a medium effect size. These results also answered the second research question, that the correlation between life satisfaction and faith maturity was smaller than both the correlation between self-esteem and life satisfaction and the correlation between life orientation and life satisfaction.

TABLE 1

Intercorrelations and descriptive statistics of the Faith Maturity Scale, Satisfaction with Life Scale, Revised Life Orientation Test, and Rosenberg Self-Esteem Scale.

Variable	Mean	SD	Alpha	1	2	3	4
1. Faith Maturity	185.61	28.73	.92	—			
2. Life Satisfaction	25.66	5.60	.84	.42*	—		
3. Life Orientation	14.73	3.64	.77	.45*	.53**	—	
4. Self-Esteem	28.69	4.82	.87	.39*	.59**	.66**	—

Note. Ns = 584 – 705. All correlations are significant ($p < .01$). *Medium effect size. **Large effect size

To answer research question 3, coefficients of determination were found for life satisfaction. According to the data, 18% of the variability in life satisfaction could be predicted from faith maturity, compared to 28% of the variation in life satisfaction predicted by life orientation and 35% of variation in life satisfaction predicted by self-esteem. Results also showed that 21% of the variability in life orientation could be predicted by faith maturity.

An independent samples t-test was conducted to compare life satisfaction in this study (undergraduate students from a small, denominationally-affiliated university in the Midwest) and life satisfaction in Diener, et al.'s (1985) study (undergraduate students from a large, public university in the Midwest). There was a significant difference in the scores from this study ($M = 25.66$, $SD = 5.60$) and the scores from Diener, et al.'s study ($M = 23.50$, $SD = 6.43$); $t(859) = 4.42$, $p < .01.$, $d = 0.37$. This is a medium effect size.

Further analysis of the data showed a significant difference in faith maturity between Protestant Christian participants and Catholic Christian participants. Protestant Christian participants ($M = 188.79$, $SD = 26.25$) had a significantly higher faith maturity than Catholic Christian participants ($M = 175.41$, $SD = 26.41$); $t(617) = 2.88$, $p = .004$, $d = 0.52$. This is a large effect size. There was no significant difference in life satisfaction between Protestant Christians ($M = 25.77$, $SD = 5.55$) and Catholic Christians ($M = 26.03$, $SD = 5.62$); $t(649) = -.63$, $p = 0.79$.

In addition, a multiple regression analysis was carried out to predict life satisfaction based on self-esteem, faith maturity, and life orientation. It was concluded that all the variables together were statistically significant indicators of life satisfaction, $F(3,560) = 131.12$, $p < .001$, $R^2 = .41$. Specifically, faith maturity ($\beta = .13$, $t(1) = 3.53$, $p < .01$, $\eta^2_p = .02$), self-esteem ($\beta = .42$, $t(1) = 9.51$, $p < .01$, $\eta^2_p = .14$), and life orientation ($\beta = .20$, $t(1) = 4.57$, $p < .01$, $\eta^2_p = .04$) were all positively correlated to life satisfaction. According to this, all three variables were significant predictors of life satisfaction. Because each scale used had different maximum point values, the standardized β coefficients are used. When the variables were standardized, for every point that faith maturity increased, life satisfaction increased .13 points. For every point that life orientation increased, life satisfaction increased .20 points. For every point that self-esteem increased, life satisfaction increased .42 points. According to the multiple regression, self-esteem was the greatest predictor of life satisfaction for the participants, followed by life orientation and then faith maturity.

TABLE 2

Multiple regression predicting life satisfaction from faith maturity, life orientation, and self-esteem.

Variable	B	Std. Error	Std. Coefficients β	df	t	Significance	Partial Eta Squared
Faith Maturity	.03	.01	.13	1	3.53	.00	.02*
Life Orientation	.30	.07	.20	1	4.57	.00	.04*
Self-Esteem	.47	.05	.42	1	9.51	.00	.14**
(Constant)	3.12	1.34	–	–	2.33	.02	–

Note. All correlations are significant ($p < .05$). *Medium effect size. **Large effect size.

DISCUSSION

The purpose of this project was to assess the correlation between life satisfaction and faith maturity and to compare that correlation to other known correlates of life satisfaction, namely self-esteem and life orientation. It was found that as faith maturity increases, life satisfaction also increases and as faith maturity decreases, life satisfaction also decreases. This relationship is statistically significant. It was also found that as self-esteem increases, life satisfaction increases and as life orientation increases, life satisfaction increases. The relationship between faith maturity and life satisfaction is smaller than both the relationship between life satisfaction and self-esteem and the relationship between life satisfaction and life orientation; however, it is still statistically significant, meaning that it is unlikely that these results are due to chance. The data showed that life satisfaction could be better predicted by life orientation and self-esteem than faith maturity. The data also showed that faith maturity was a better predictor of life orientation than life satisfaction. This is consistent with Alessandri, Caprara, and Tisak's (2012) study that found a link between positive orientation, life satisfaction, self-esteem, and optimism. This is also in line with studies examining the relationship between intrinsic religious faith and psychological well-being (Laurencelle et al., 2002). Laurencelle et al. (2002) also found that, while high-faith participants had significantly higher psychological well-being than moderate-faith individuals, there was quite a bit of variability within each group. While these studies focused on psychological well-being and health, it is interesting to note that actual satisfaction with life is linked to faith maturity. Psychological well-being, often measured by physical or psychological health (Hill & Pargament, 2003; Pearce et al., 2015), can be a somewhat objective factor, but the results of this study showed that people with a more mature faith also subjectively viewed their life as more satisfying. This study has also indicated that faith maturity is a significant predictor of life satisfaction specifically among Christian college students compared with all adults of different ages (Leonardi & Gialamis, 2009) and religious beliefs and backgrounds (Laurencelle et al., 2002).

Additional analyses showed that the life satisfaction of participants in this study was greater than the life satisfaction of participants in Diener, et al.'s (1985) study of life satisfaction. We also found that, although Protestant Christians have an average greater faith maturity than Catholic Christians, both groups have very similar life satisfaction scores. This is an interesting finding, especially because there is a lack of research examining the faith maturity of Christian denominations and Roman Catholics. While Benson et al. (1993) examined the results of the faith maturity scale given to several denominations, including the Christian Church, Disciples of Christ; Evangelical Lutheran Church in America; Presbyterian Church; United Church of Christ; United Methodist Church and Southern Baptist Convention, the Roman Catholic Church was not included.

Limitations
Some possible limitations with this study are the extensive use of self-report data. Self-report data is a very efficient way of collecting large amounts of data; however, it may not be completely reliable if participants do not have a solid understanding of themselves. Also, these results cannot be generalized to the entire population because of this study's limited participant demographics. The participant demographics were undergraduate students and the ethnicities of the participants did not reflect the general population. In this

study, the Caucasian ethnic group (84% of participants) was greater than the percentage of Caucasians that make up the United States population (76.6%) while the other ethnicities represented in the study made up a smaller proportion of the participant population than their proportion of the population of the United States. Further, neither the Faith Maturity Scale nor the Satisfaction with Life Scale measure actual activity that shows faith maturity or life satisfaction. Rather, they ask about thoughts and feelings associated with these variables. These scales may become a more reliable reflection of true faith maturity and life satisfaction if activity and behavior are studied in addition to self-report data.

Future research

Future research might seek to further examine the relationship between faith maturity and life satisfaction; exploring which components of faith maturity specifically point to life satisfaction or further exploring the link between these two variables and life orientation. Another useful possibility to examine this relationship would be an experimental study that compares a group of participants who spend a certain amount of time each week doing faith-related activities such as going to church, reading a Bible, or attending a small group bible study to a group that does not participate in any faith-based activities and examining their life satisfaction. The results from the comparison between this study and Diener et al.'s (1985) study brings into question the cause of this difference in life satisfaction and opens the door to research that could explore life satisfaction on different college campuses, among different faith denominations and traditions, and among other age groups.

REFERENCES

Alessandri, G., Caprara, G. V., & Tisak, J. (2012). The unique contributions of positive orientation to optimal functioning: further explanations. *European Psychologist,* 17(1), 44-54. doi:10.1027/1016-9040/a000070

Bastian, B., Kuppens, P., De Roover, K., & Diener, E. (2014). Is valuing positive emotion associated with life satisfaction? *Emotion,* 14(4), 639–645. doi:10.1037/a0036466

Benson, P. L., Donahue, M. J., & Erickson, J. A. (1993). The faith maturity scale: conceptualization, measurement, and empirical validity. *Research in the Social Scientific Study of Religion*, 5(1), 1-26.

Blachnio, A., Przepiorka, A, & Pantic, I. (2016). Association between Facebook addiction, self-esteem and life satisfaction: A cross-sectional study. *Computers in Human Behavior,* 55, 701-705. doi:10.1016/j.chb.2015.10.026

Caprara, G. V., Fagnani, C., Alessandri, G., Steca, P., Gigantesco, A., Sforza, L. C., & Stazi, M. A. (2009). Human optimal functioning: the genetics of positive orientation towards self, life, and the future. *Behavior Genetics*, 39(3), 277-284. doi:10.1007/s10519-009-9267-y

Caprara, G. V., & Steca, P. (2005). Affective and social self-regulatory efficacy beliefs as determinants of positive thinking and happiness. *European Psychologist,* 10(4), 275-286. doi:10.1027/1016-9040.10.4.275

Cheung, F. (2018). Income redistribution predicts greater life satisfaction across individual, national, and cultural characteristics. *Journal of Personality and Social Psychology,* 115(5), 867–882. https://doi.org/10.1037/pspp0000164.supp

Ciarrochi, J.W., & Brelsford, G. M. (2009). Spirituality, religion, and substance coping as regulators of emotions and meaning making: Different effects on pain and joy. *Journal of Addictions & Offender Counseling*, 30(1), 24-36. doi:10.1002/j.2161-1874.2009tb00054.x

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. *Journal of Personality Assessment*, 49(1), 71-75.

Diener, E., Napa Scollon, C. K., Oishi, S., Dzokoto, V., & Suh, E. M. (2000). Positivity and the construction of life satisfaction judgments: global happiness is not the sum of its parts. *Journal of Happiness Studies*, 1(2), 159-176. doi:10.1023/A:1010031813405

Diener, E., Oishi, S, & Lucas, R.E. (2011). Subjective well-being: The science of happiness and life satisfaction. In S.J. Lopez & C.R. Snyder, *The Oxford Handbook of Positive Psychology* (2nd ed.) (187-194). New York: Oxford University Press.

Hawkins, R. S., Tan, S., & Turk, A. A. (1999). Secular versus Christian inpatient cognitive-behavioral therapy programs: impact on depression and spiritual well-being. *Journal of Psychology & Theology*, 274(4), 309-318.

Hill, P. C., & Pargament, K. I. (2003). Advances in the conceptualization and measurement of religion and spirituality: implications for physical and mental health research. *American Psychologist,* 58, 64–74. doi:10.1037/0003-066X.58.1.64

Ivtzan, I., Chan, C. P. L., Gardner, H. E., & Prashar, K. (2013). Linking religion and spirituality with psychological well-being: Examining self-actualisation, meaning in life, and personal growth initiative. *Journal of Religion and Health*, 52(3), 915–929. https://doi-org.proxy.olivet.edu/10.1007/s10943-011-9540-2

Laurencelle, R. M., Abell, S. C., & Schwartz, D. J. (2002). The relation between intrinsic religious faith and psychological well-being. *International Journal for the Psychology of Religion*, 12(2), 109-123. doi:10.1207/S15327582IJRP1202_03

Leonardi, A. & Gialamas, V. (2009). Religiosity and psychological well-being. *International Journal of Psychology*, 44(4), 241-248. doi:10.1080/00207590701700529

Okun, M. A. & Stock, W. A. (1987). Correlates and components of subjective well-being among the elderly. *The Journal of Applied Gerontology*, 6(1).

Pearce, M. J., Koenig, H. G., Robins, C. J., Nelson, B., Shaw, S. F., Cohen, H. J., & King, M. B. (2015). Religiously integrated cognitive behavioral therapy: a new method of treatment for major depression in patients with chronic mental illness. *Psychotherapy,* 52(1), 56-66. doi:10.1037/a0036448

Powell, R., & Pepper, M. (2015). Subjective well-being, religious involvement, and psychological type among Australian churchgoers. *Mental Health, Religion & Culture*, 18(1), 33-46. doi:10.1080/13674676.2014.1003170

Rosenberg, M. (1965). *Society and Adolescent Self-image*. Princeton University Press.

Scheier, M. F., Carver, C. S., & Bridges, M. W. (1994). Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): A reevaluation of the Life Orientation Test. *Journal Of Personality And Social Psychology*, 67(6), 1063-1078. doi:10.1037/0022-3514.67.6.1063

Mental Health First Aid Training: Evaluating a Brief Training Intervention for College Students

Erica D. Sandtorv

ACKNOWLEDGEMENTS

ABSTRACT

Background

Mental health literacy, or the public's knowledge and beliefs about mental health, has been shown to be lacking; therefore, the proper first aid actions are not always taken to recognize and encourage treatment for psychological disorders (Burns & Rapee, 2006; Jorm et al., 1997; Jorm, 2012; Yap, Wright, & Jorm, 2011). This issue is particularly relevant in a university setting where mental health issues are common and students often rely on their peers for support (Hefner & Eisenberg, 2009; Kitzrow, 2009; Morse & Schulze, 2013). Studies have shown mental health first aid (MFHA) training to be successful in equipping people with the skills they need to help others in acute mental health crises (Bulanda, Bruhn, Byro-Johnson, & Zentmyer, 2014; Kitchener & Jorm, 2002; Morse & Schulze, 2013).

Method

To assess the efficacy of a brief mental MHFA training intervention, the current study collected data from 75 undergraduate students at a small, Midwestern university. We tested whether college students who read the Depression First Aid Guidelines would choose more appropriate first aid actions than a control group when responding to a vignette of a peer exhibiting depression.

Results

Data were analyzed using an independent samples t-test. No statistically significant difference was found between the experimental and control groups, indicating that the brief training intervention was not substantial enough to improve knowledge of first aid actions. However, students who had read the guidelines did report a greater sense of confidence in their ability to provide MHFA.

Conclusion

These results indicate that there is a risk of increasing confidence beyond actual knowledge when using such a minimal training procedure. Future research should seek to explore the relationship between knowledge and confidence and devise a training program that is more effective at increasing practical first aid skills.

Keywords: mental health first aid, training, college students, depression

REVIEW OF LITERATURE

Despite the prevalence of mental disorders, they have been stigmatized and misunderstood since ancient times. Recently, some efforts have been made to promote mental health and reduce stigma; however, media coverage still displays the mentally ill in largely negative and inaccurate ways. For the many who suffer with mental health problems, this stigmatization can have detrimental effects on social relationships, limit employment opportunities, and reduce likelihood of help-seeking (Rossler, 2016). College students are not immune to the effects of mental illness and the accompanying pain of being misunderstood by peers. Research shows that students are now entering college with more severe mental health problems than the simple maladjustment issues that were faced in previous decades (Kitzrow, 2009). Not only are the problems more serious,

but they are also more numerous. Campus counseling centers have seen a drastic rise in demand for services, which has led to delays of around two weeks for students seeking help. For Creighton University in Omaha, NE the wait times can reach one month during busy times, which tend to be around midterms and finals. While making an appointment a few weeks in advance to see a specialist might seem typical, this waiting time can be detrimental for students facing a mental health crisis (Thielking, 2017). This increased prevalence of mental health problems at universities may be due to a variety of factors such as instability at home, greater social pressures, and effectiveness of medications that allow individuals with psychological disabilities to attend college who would not have been able to in the past (Kitzrow, 2009).

One of the most alarming problems faced by college students is suicidality. Researchers estimate that suicide is the second most common cause of death for college students (Drum, Brownson, Denmark, & Smith, 2009). This kind of data requires college communities to closely examine the causes of suicidality and how it can be prevented. Hefner and Eisenberg (2009) found that perceived social support was a strong predictor of mental health. Students who perceived a higher quality of social support had a lower likelihood of problems such as depression, anxiety, suicidality, and eating disorders (Hefner & Eisenberg, 2009). Additionally, Drum et al. (2009) found that the first line of defense against suicide is often a person's romantic partner, roommate, or friend— essentially one's peers. Due to this finding, the researchers suggested that students themselves should be educated about mental health issues and how to refer a peer in need to the proper professional services available on campus (Drum et al., 2009).

Mental health literacy
Efforts to increase awareness and understanding of mental health to date have focused around the idea of mental health literacy, a term coined by Jorm et al. (1997) and defined as "knowledge and beliefs about mental disorders which aid in their recognition, management or prevention" (p. 182). Burns and Rapee (2006) sought to assess the mental health literacy of Australian adolescents using vignettes of individuals exhibiting symptoms of depression. The participants were asked a series of open-ended questions including what they "think is the matter" with the person and who they needed to help them cope with their problems (Burns & Rapee, 2006). Over 40% of the sample listed friends as one viable source of support for a depressed person, further emphasizing the need for young people to be informed about mental health so that they can adequately support their peers and point them towards professional help if needed (Burns & Rapee, 2006). Additionally, extensive research has been done on mental health literacy and has uncovered widespread deficiencies in the public's knowledge about prevention, detection, and treatment options (Burns & Rapee, 2006; Jorm et al., 1997; Jorm, 2012; Yap, Wright, & Jorm, 2011). For this reason, Jorm (2012) calls for the implementation of community-wide training programs known as MHFA Training.

Mental Health First Aid
A basic outline of MHFA as used by Kitchener and Jorm (2002) consists of helping people in acute mental health crises and in the early stages of mental disorders using a five-step action plan: (a) assess risk of suicide or harm, (b) listen non-judgmentally, (c) give reassurance and information, (d) encourage appropriate professional help, and (e)

encourage self-help strategies. Morse and Schulze (2013) implemented this model of MHFA training on a college campus with a series of 50-minute classes over six weeks. They found that the program led to a statistically significant improvement in scores for crisis responding skills, stigma reduction, number of counseling consultations, and overall psychological flexibility. A similar strategy was also shown to be effective with younger age groups. In one study, high school students gave a presentation lasting approximately 60 minutes aimed at sixth- through eighth-graders in an after school program. The goal was to decrease the stigma attached to mental illness and to increase knowledge of mental health (Bulanda, Bruhn, Byro-Johnson, & Zentmyer, 2014). The pilot of the program significantly improved the students' answers to knowledge questions, but also showed that they have more to learn.

Each of these previous studies have concluded that there is room for improvement in what is known about mental health and how to react to problems faced by peers. They also show that MHFA training programs can be effective for increasing knowledge of MHFA techniques. Unfortunately, multi-week training courses that require trained faculty can be taxing on resources and limited in the number of students that can be accommodated. However, Bulanda et al. (2014), found a significant increase in mental health knowledge of middle school students after just a one hour presentation. In light of the success of this less involved training, the present research implemented a procedure that required minimal time and resources from students and staff, so as to be a realistic option for training all students in the future. One group of students read a PDF file on depression first aid guidelines (Mental Health First Aid Australia, 2008) while the other group did not read anything. This was chosen because it is free and accessible online, therefore it is readily available to anyone who would like to use it for educational purposes. Additionally, MHFA Australia has been instrumental in researching and developing MHFA training courses that are now in use worldwide (Our Impact, 2019). Our hypothesis was that those who have had exposure to the evidence-based practices in the guidelines would record more appropriate responses to a vignette of a peer exhibiting depressive symptoms than those who were simply relying on their previous knowledge. This study adds to the research on MHFA training by evaluating if a minimalistic intervention, implemented at a small Christian university, could yield the same kind of improvements that have been seen with other MHFA programs.

METHOD

To test these hypothesis, we collected data in the spring of 2018 at Olivet Nazarene University from a sample of Olivet students.

Participants

There were a total of 75 participants (55 women, 17 men), with 38 in the control condition and 37 in the experimental condition. There were 36 freshmen, 27 sophomores, seven juniors, and five seniors. The racial distribution was 53 white, seven Hispanic, six black/African American, four Asian/Pacific Islander, and five other. All participants were undergraduate students recruited from Psychology and Biology classes at Olivet Nazarene University. Some were offered extra credit for participation, at the discretion of individual professors.

Materials

MHFA Depression Guidelines (Mental Health First Aid Australia, 2008)
These guidelines are designed for use by the public and contain the first aid actions that have been deemed important or essential by a panel of experts. The Depression First Aid Guidelines is a three-page document containing the signs and symptoms of depression, such as "an unusually sad or irritable mood that does not go away" and "loss of enjoyment and interest in activities that used to be enjoyable," and tips for how to approach a person who may be exhibiting these signs including "Offer consistent emotional support and understanding" and "Do not blame the person for their illness." This document was read by the experimental group only.

Depression (Young Adult) Vignette (Jorm, 2007) (Appendix A)
This is a short paragraph describing "John," a 21-year-old male who is exhibiting some common signs of depression (fatigue, insomnia, decrease in appetite, weight loss, diminished ability to concentrate, and indecisiveness). This vignette was presented to all participants in an effort to simulate some of the struggles a peer might approach them with and set the stage to determine which first aid actions they would deem helpful for a person like John.

First Aid Options (Jorm, 2007) (Appendix B)
A list of ten possible first aid actions were used in order to assess how participants perceived the helpfulness of each one for addressing a peer like John from the vignette. All participants were asked to label the actions as either helpful, harmful, or neither. Sample items include "listen to problems in an understanding way" and "talk to firmly about getting act together."

Procedure

Students signed up for a 20-minute time slot to participate, with groups of up to six participants going at a given time. Upon arriving to the psychology lab, we informed participants of the purpose of the study, which was to gain a greater understanding of the mental health knowledge of Olivet students, and gave them a verbal overview of the informed consent document, which stated that participation was voluntary, confidentiality would be maintained, and a participant could withdraw at any time without penalty. Then we allowed each participant to choose a room with a computer that was randomly assigned to run either the Control Survey or the Experimental Survey. All participants answered a few demographic questions. They answered a few questions about prior experience with mental health problems in others ("How confident do you feel in helping someone with a mental health problem?" "In the last 6 months have you had contact with anyone with a mental health problem?" "Have you offered any help?") (Kitchener & Jorm, 2002). At this point, the participants in the experimental condition clicked on a link that opened the Depression First Aid Guidelines (MHFA Australia, 2008) and read the entire document before moving forward. The control condition proceeded directly to the outcome measures without requiring any reading. Next, we asked all participants to carefully read the Depression (Young Adult) Vignette (Appendix A) and to "Imagine John is someone you have known for a long time and care about. You want to help him" (Jorm, 2007). We then presented them with a list of possible first aid options (Appendix B) (Jorm, 2007) and asked them to determine whether these actions were harmful,

helpful, or neither. Finally, participants rated their post-test confidence on a scale from 1 (not at all confident) to 5 (extremely confident) in response to the question "Having read and reflected on John's story, how confident would you be in your ability to help John or someone like him?" This is a rewording of the confidence-rating question at the beginning of the survey in order to look for differences in confidence that may occur due to exposure to the topic and the added context of a tangible example.

RESULTS

Using the data obtained from survey responses, we evaluated the impact of the MHFA training on students' knowledge as well relationships between the other variables that were measured.

Effect of training intervention
In order to obtain a concise measure of MHFA knowledge for each of the two groups, we scored responses to each of the first aid actions proposed in response to the depression vignette. For each item, the correct response was determined by the consensus of more than 70% of health professionals of what is actually helpful and harmful for helping a friend or family member with a mental health problem (Yap, Wright & Jorm, 2011). We gave a score of 1 for the keyed response and a score of 0 for incorrect responses. Each participant was then given a total knowledge score out of a possible 10. In order to test the main hypothesis of the study, we conducted an independent-samples t-test to compare knowledge scores of the control group (M=6.54, SD=1.07) and the experimental group (M=6.40, SD=1.14). We found that there was no difference between control and experimental groups in total score earned, $t(68)$=0.54, p=.87, d=0.13.

Other relationships
Next, bivariate correlations were run to look for any significant relationships between the variables that were measured. **Table 1** shows the Pearson correlation coefficients for selected variables. Despite no actual improvement in scores, there was a difference between the experimental and control conditions in terms of post-test confidence with the experimental condition reporting that they would feel more confident in helping out a person like the one in the vignette. An independent samples t test and Cohen's d was calculated to examine the magnitude of the difference between the conditions in post-test confidence. The results confirm that the control condition (M=2.97, SD=0.67) reported higher levels of confidence than the experimental condition (M=3.38, SD=0.68), $t(72)$=-2.55, p=.01, d=-0.59. The experimental manipulation led to significantly higher confidence with a moderate effect size, indicating that a small intervention increased confidence by slightly more than half a standard deviation.

Interest in learning more
When asked to rate their "level of interest in learning more about how to help others who are struggling with mental health," participants responded very positively. The distribution of responses was very similar for both the control and experimental groups, so they were collapsed together to find the total percent frequency for each response. As shown in **Table 2**, the most common response (48.65%) was "extremely interested" in learning more, and over half (51.35%) of respondents were either "a little" or "somewhat

interested." None of the participants said they had zero interest in learning more. A number of factors seem to influence students' level of interest in learning more about how to help others who are struggling with mental health problems. As shown in **Table 1**, interest in learning more increased with years of education ($r=.23$, $p=.05$), and was greater for those who had previous experience helping a friend in need ($r=.27$, $p=.04$). Both pre-test ($r=.40$, $p=<.001$) and post-test ($r=.27$, $p=.02$) measures of confidence were related to level of interest, with those who were more confident in helping peers with mental health problems also having greater interest in learning more.

TABLE 1:
PEARSON CORRELATION COEFFICIENTS FOR SELECTED VARIABLES

Variables	r (p-value)
Condition (1=control, 2=experimental)	
Sex	-.23* (.05)
Year in college	.07 (.54)
First aid actions score	-.07 (.59)
Confidence (pre)	-.02 (.90)
Confidence (post)	.29* (.01)
First aid actions score	
Confidence (pre)	.32** (.01)
Confidence (post)	.07 (.54)
Interest level	
Year in college	.23* (05)
Offered help previously	.27* (.04)
Confidence (pre)	.40** (<.001)
Confidence (post)	.27* (.02)

* denotes significance at the .05 level (2-tailed)
** denotes significance at the .01 level (2-tailed)

TABLE 2: PERCENT FREQUENCY OF INTEREST LEVEL

	Control	Experimental	Total	% Total
1="not at all interested"	0	0	0	0.00%
2="a little interested"	7	4	11	14.86%
3="somewhat interested"	12	15	27	36.49%
4="extremely interested"	18	18	36	48.65%
Total	37	37	74	100.00%

DISCUSSION

My initial hypothesis, which stated that students who read the MHFA Depression Guidelines would perform better on a measure of appropriate first aid actions for depression, was not supported. Rather than the experimental group knowing more about what is helpful and harmful for a friend exhibiting signs of depression, they actually had an average score that was insignificantly lower than the control group who had not read the guidelines; therefore, there was no evidence of a difference in first aid actions score due to the experimental manipulation. It is of note that the two groups differed in

terms of post-test confidence in their ability to help. This is in line with the hypothesis that the experimental group would feel more confident from baseline to post test, after having read clear guidelines on what are helpful first aid actions for depression, while the control group would remain relatively constant in confidence levels. However, considering that the experimental group did not demonstrate more knowledge of appropriate helping behaviors, this could indicate that the training intervention only served to create a false sense of confidence without actually increasing knowledge and skills. This could be due to the brief and non-engaging nature of the training procedure. Perhaps spending a few minutes reading an informational document was sufficient to increase a perceived sense of knowledge, but a more extensive and comprehensive training program that gets students engaged in the topic would be necessary to actually make the first aid guidelines stick. In light of these findings, future program implementers should be cautioned not to rely solely on students' confidence as a valid measure of their knowledge about MFHA.

Overall, students reported high levels of interest in learning more about MFHA. No one said that they were not at all interested in learning more about the topic; rather, an overwhelming majority were either somewhat or extremely interested. This finding validates the initial assumption of this study that students at Olivet not only have a need to know more about first aid actions to help their peers but that they also have a desire to learn these skills. Additionally, students who are further along in their college career reported greater interest, as did students who have offered help to a friend in need in the past six months. One possible explanation is that these people have had more opportunities to encounter peers who are struggling with mental health and have made more attempts to help. These experiences could serve to highlight the importance of knowing effective MHFA strategies, which in turn makes students more apt to seek them out and learn more. Surprisingly, greater confidence for both the pre- and post-test measures was associated with greater interest in learning more. One might think that those who are lacking confidence would be more eager to seek out more information. However, it is encouraging that confidence does not necessarily mean complacency, and the majority of students still believe they have room for improvement.

These findings are somewhat in contrast with previous research that has shown MHFA training for students to be effective; however, many of those other programs were more extensive. For example, Kitchener and Jorm (2002) developed a MHFA training program for adults in the general population that consisted of three 3-hour courses given over three consecutive weeks. The training significantly improved participants' beliefs about effectiveness of treatments, reduced social distance, and increased confidence in helping others. Similar results were found in a university population. Morse and Schulze (2013) reported statistically significant improvement in scores for crisis responding skills and stigma reduction as a result of their Student Support Network program, which consists of 50-minute classes that students attend for six weeks. These examples suggest that MHFA training can be effective but must be more substantial than a few minutes to reap the desired benefits.

Unfortunately, it is not always feasible to provide multiple weeks of training to a large number of participants, and the authors of the previous two studies noted problems with

retention over time as well as limitations in capacity of the courses. The logical next step to bridge the gap between a comprehensive six-week training program and a brief six-minute training program would be a more substantial, one-time presentation. This is modeled by Bulanda et al. (2014) in their work with middle school students. MHFA training was provided during after-school programs and consisted of a PowerPoint presentation, a Q&A session, and showing a short PSA video. The session lasted about one hour and was associated with practically meaningful improvements in knowledge from pre to posttest. This approach would be ideal for a context like Olivet, where it could be integrated into one of the 50-minute class periods of a precursory course. An ideal option would be the Freshman Connections course, which meets once a week and prepares freshmen for success in college by discussing good habits and completing self-discovery exercises.

One limitation of this study is that there was no equivalent activity for the control group to do while the experimental group was reading the MHFA document. This could have potentially introduced a confound due the extra time and effort that the experimental group put in. The fact that there were extraneous differences between the groups limits our ability to attribute the differences in the dependent variables to the independent variable that was manipulated. This study was also limited in terms of diversity of participants; therefore, it can only be said to generalize to small, private universities in the Midwest of the United States. With that in mind, it adds a piece to the body of literature on MHFA and what that might look like in a setting like Olivet Nazarene University. The findings indicate a need for students to become more educated about the first aid strategies recommended by professionals, but fortunately it also appears that students are very willing and eager to learn more about this topic. By working together, faculty and students would be well-advised to create a more extensive MHFA training program that gets students more engaged in learning about this important topic.

REFERENCES

Bulanda, J. J., Bruhn, C., Byro-Johnson, T., & Zentmyer, M. (2014). Addressing mental health stigma among young adolescents: Evaluation of a youth-led approach. *Health & Social Work*, 39(2), 73-80.

Burns, J. R., & Rapee, R. M. (2006). Adolescent mental health literacy: Young people's knowledge of depression and help seeking. *Journal of Adolescence*, 29(2), 225-239. doi:10.1016/j.adolescence.2005.05.004

Drum, D. J., Brownson, C., Burton Denmark, A., & Smith, S. E. (2009). New data on the nature of suicidal crises in college students: Shifting the paradigm. *Professional Psychology: Research and Practice*, 40(3), 213-222. doi:10.1037/a0014465

Hefner, J., & Eisenberg, D. (2009). Social support and mental health among college students. *American Journal of Orthopsychiatry*, 79(4), 491-499. doi:10.1037/a0016918

Jorm, A. F. (2012). Mental health literacy: Empowering the community to take action for better mental health. *American Psychologist*, 67(3), 231-243. doi:10.1037/a0025957

Jorm, A. F., Korten, A. E., Jacomb, P. A., Christensen, H., Rodgers, B., & Pollitt, P. (1997). "Mental health literacy": A survey of the public's ability to recognise mental disorders and their beliefs about the effectiveness of treatment. *Medical Journal of Australia*, 166, 5. https://www.mja.com.au/

Jorm, A. F., Wright, A., & Morgan, A. J. (2007). Beliefs about appropriate first aid for young people with mental disorders: Findings from an Australian national survey of youth and parents. *Early Intervention in Psychiatry*, 1(1), 61–70. doi: 10.1111/j.1751-7893.2007.00012.x

Kitchener, B. A., & Jorm, A. F. (2002). Mental health first aid training for the public: Evaluation of effects on knowledge, attitudes and helping behavior. *BMC Psychiatry*, 2. doi:10.1186/1471-244X-2-10

Kitzrow, M. A. (2009). The mental health needs of today's college students: Challenges and recommendations. *NASPA Journal (National Association of Student Personnel Administrators, Inc.)*, 46(4), 646-660.

Mental Health First Aid Australia. (2008). *Depression: First aid guidelines*. Retrieved from https://mhfa.com.au/mental-health-first-aid-guidelines

Morse, C. C., & Schulze, R. (2013). Enhancing the network of peer support on college campuses. *Journal of College Student Psychotherapy*, 27(3), 212-225. doi:10.1080/87568225.2013-798222

Our Impact. (2019). Retrieved from https://mhfa.com.au/our-impact/our-global-impact

Rossler, W. (2016). The stigma of mental disorders. *EMBO Reports*, 17(9), 1250-1253. doi:10.15252/embr.201643041

Thielking, M. (2017). Surging Demand for Mental Health Care Jams College Services. *Scientific American*. Retrieved March 28, 2019.

Yap, M. B. H., Wright, A., & Jorm, A. F. (2011). First aid actions taken by young people for mental disorders in a close friend or family member: Findings from a national survey of Australian youth. *Psychiatry Research*, 188(1), 123–128. doi:10.1016/j.psychres.2011.01.014

APPENDIX A

Depression (Young Adult) Vignette

John is a 21-year-old who has been feeling unusually sad and miserable for the last few weeks. He is tired all the time and has trouble sleeping at night. John doesn't feel like eating and has lost weight. He can't keep his mind on his studies and his marks have dropped. He puts off making any decisions and even day-to-day tasks seem too much for him. His parents and friends are very concerned about him.

APPENDIX B

First Aid Responses	Keyed Response
1. Listen to problems in an understanding way	Helpful
2. Talk to firmly about getting act together	Harmful
3. Suggest seek professional help	Helpful
4. Make an appointment for person to see GP	Helpful
5. Ask whether feeling suicidal	Helpful
6. Suggest have few drinks to forget troubles	Harmful
7. Rally friends to cheer up	Helpful
8. Ignore until gets over it	Harmful
9. Keep busy to keep mind off problems	Neither
10. Encourage to become more physically active	Helpful

The Japanese Way in America: A Comparison of the Spiritual Beliefs, Habits, and Ideas of the American Religious 'Nones' and Contemporary Japanese Nationals

Jarrett Stalinger

ACKNOWLEDGEMENTS

ABSTRACT

There has been growing interest in the religiously unaffiliated within America. This growing interest has caused a new name to come about, the Nones. The present discussion attempts to give context to the rise of the Nones and to compare the religious beliefs and habits of these American Nones with the Japanese Nationals who inhabit Japan. There are many similarities between these two groups relating to ethics, interactions with people, and connection with nature. These comparisons show that there is a possible connection between people that explains spiritual experience, even outside that of normalized, institutional religions. This "intuition of the sacred" is vital in understanding human spiritual experience and, arguably, what it means to be human. Intuition of the sacred may explain why some spiritual beliefs and experiences of the American Nones are similar to the Japanese Nationals. By looking at the categories of sacred Space, Time, Nature, and Human Experience through the lens of the question, "What does it mean to be human?" it can be discovered that there are interesting similarities between the spiritual lives of the American Nones and the Japanese Nationals. This "Japanese way in America" may show that although the Nones are new linguistically, the concern noted by researchers and religious leaders about the growing group and their irreligiosity is actually unnecessary. With a spiritual focus on relationships and daily living, the American Nones and the Japanese Nationals have a lot in common.

INTRODUCTION

The beginning was just chaos, there was no order at all. The world was like "an ocean of oil."[1] This world was completely unlike our own, yet here is where the incipience of our modern world with airplanes, trains, smart phones, and microwaves occurs. This murky, atramentous sea would proceed to birth a being. This being was known as Kuni-toko-tachi, or the Eternal-Ruling Lord. Along with this deity, the High-Producing-god and the Divine-Producing-goddess were thrust into existence[2] as well. These three would prove to be the originally generative force that would create mankind, the gods, and everything else in existence. This beginning is a mythic one, but that does not mean it is irrelevant to daily society. The sacred is all around us in our lives. Sometimes it is seen, while other times it is not. The sacred nonetheless plays a deep role in the spiritual lives of the American Nones and the Japanese Nationals, the foci of this project.

The Land of the Rising Sun is a truly unique nation. The origins detailed above show the mythic beginnings of Japan as a country. This is quite the contrast with the modern technological marvel that it has become today. Tokyo is one of the most technologically advanced cities in the world. This story contrasts greatly with the advanced nation, and this is why Japan is a good subject for this research. The clash of ideals from both the western and eastern world make Japan a very interesting nation to look at from both a religious and cultural perspective. The myths of the past and the technology of the present collide in a strange and mysterious way. In this paper specifically, the object of study will be Japanese religion and how it compares to the beliefs and habits of the religiously unaffiliated "Nones" that are present in America today. Through a comparison of these

---

[1] J.A. MacCulloch and George Foot Moore, *The Mythology of All Races in Thirteen Volumes* (New York: Cooper Square Publications, 1928), 222.

[2] MacCulloch and Moore, *The Mythology of All Races in Thirteen Volumes*, 222.

different yet also similar views through the lens of what it means to be human, this paper will try to show that there is a deep similarity in the religious beliefs, habits, and ideas of the Japanese Nationals and the American Nones.

The American Nones are a relatively "new" group that have recently claimed a lot of public attention. These are the people who claim to not be affiliated to any particular religion yet do not deny spirituality in their lives[3]. The Nones are not enigmatic people who have come to hate the church. Rather, contemporary religious affiliation is more complex, and in order to help detail the situation, examples of Japanese thought will be presented to show that similar cognitive processes have been around for centuries. The hypothesis of this paper is that the "Rise of the Nones" is not an entirely new movement but has deep similarities to systems of belief that have already been established. These similarities can be seen in the beliefs, habits, and ideas held by the Japanese Nationals within their own religious context. This comparison will be one based on the specific spiritual beliefs and habits within each culture, systematized into the four categories that Mircea Eliade outlines in his book *The Sacred and The Profane*[4].

In order to accomplish all of this the Japanese Nationals and American Nones will be compared after preliminary study is given to both of these groups. The next section covers the historical context of both groups and looks at how each has evolved over time to its present state today. For the Nones, this section will explore past perceptions and names of the group. The history of the Japanese Nationals will be more of an introduction to the culture and religious landscape at large. The following section will look at the actual beliefs systems of the Japanese Nationals and the American Nones. Both groups will be detailed in what they currently believe and give broader relevant context to each group as a whole. Both of these sections will provide historical and religious context to the belief systems that are to be compared. These sections will also answer the question of "what does it mean to be a Japanese National or an American None?"

The fourth section will be the point where both groups' spiritual beliefs, habits, and ideas, are compared to each other. Using Eliade's four categories along with Ethics, the two groups will be compared and contrasted. The results will then be stated at the end of the fourth section before yielding the discussion of final section. This section will then conclude the project looking at the research through the lens of the question "what then does it mean to be human?" The response will consider the comparison and then deliver some practical and theoretical applications. It should also be mentioned that research for this project included a combination of reading books and immersion in both cultures. In this way, the following information will be a combination of experience and study.

HISTORICAL CONTEXT

Context of the Nones

The "American Nones" are those that have chosen "none of the above" when answering surveys about which religious organization or institution they are affiliated with.[5] The key

---

3 Mercadante, Linda, "Belief Without Borders: Inside the Minds of the Spiritual but Not Religious," in William Parsons, *Being Spiritual but Not Religious*, (London: Routledge, 2018), 122-139.

4 Mircea Eliade, *The Sacred and the Profane: The Nature of Religion*, (San Diego: Harcourt, 1987).

5 A quick note should be mentioned here. Though I do my best to describe the context of the Nones, part of the culture and understanding surrounding the American None framework is the idea of self-identification. The Nones are a dynamic group that is difficult to characterize in its entirety.

word here is *affiliated*. The American Nones are unaffiliated but still regard themselves as spiritual, people who are outside the boundaries of traditional religion.[6] Many names have been given to people who have professed similar beliefs in the past. The "unchurched" was a popular one, as was unaffiliated. "Churchless" and "unsaved" were also used in the past. However, some terms were harsher, with titles including "heathen," "pagan," and even "infidel." Some American Nones themselves have even added to this nomenclature, with self-titled names such as "metaphysicals" or "freethinkers." All these are titles that have been used to describe the Nones, or people similar in their beliefs, in the past.[7]

The discussions surrounding the Nones has been vast. Fuller writes about three different types of unchurched people. The term unchurched was accepted in the past referring to those who were outside the normalized boundaries of institutionalized religion. First, there are those who are not religious at all. These are the ones who do not believe in a supernatural force or a divine being. Specifically, Fuller uses the term "Secular Humanist." Next, there are those who are not a part of a church but attend every so often. This group may also include those who attend church monthly, possibly even biweekly, but do not become a member of the church. The third group of the unchurched is the one Fuller titles as those who "should nonetheless be considered religious in some broad sense of the term."[8] These are the "spiritual but not religious" types who believe there are objects outside of the empirical sense of humanity but do not affiliate themselves with a specific religion or denomination of Christianity.[9] For the purposes of this paper, it is important to see how these understandings of the Nones have come to be, as the umbrella term of "None" may apply to all of these categories.

In 1990, Barna Research Group studied the unchurched. They found that 70% of the 906 adults that were studied had "favorable impressions of Christianity as a religion."[10] This finding is not true of the present. "Regarding views of organized religion, a slight majority of atheists, agnostics, and nonaffiliated believers express 'hardly any' confidence in religious institutions."[11] Interesting, however, is Baker and Smith's finding that "62% of atheists, 76% of agnostics, and 86% of nonaffiliated believers report believing there is 'basic truth in many' religions."[12] With this in mind, the American Nones are not defined as irreligious; rather, they are unaffiliated. The Nones are those who still have some semblance of spiritual life but are not within a religious organization. However, they are not altogether denying the ineffable reality of spiritual experience. In the Barna

---

Throughout this paper, unless explicitly identified as otherwise, the understanding is that the descriptions are general, with plenty of room for exceptions or differences. The personal, individualized spiritual life of the Nones cannot be so easily put into bounded terms like Buddhist or Christian doctrine can. Religions and cultures are alive and made up of living people, thus they may change over time and include sub-groups and those who may disagree. This is important to keep in mind throughout the entire paper, not just here.

6 Elizabeth Drescher, *Choosing Our Religion: The Spiritual Lives of Americas Nones* (New York: Oxford University Press, 2016), 10-15.

7 Drescher, *Choosing Our Religion*, 26-27.

8 Robert C. Fuller, *Spiritual, but Not Religious: Understanding Unchurched America* (Oxford: Oxford University Press, 2001), 4.

9 Fuller, *Spiritual, but Not Religious*, 2-4.

10 *Never on a Sunday: The Challenge of the Unchurched* (California: Barna Research Group, 1990), 3.

11 Joseph Baker and Buster Smith, *American Secularism: Cultural Contours of Nonreligious Belief Systems* (New York: New York University Press, 2015), 90.

12 Baker and Smith, *American Secularism*, 90.

study, 53% of the adults studied thought Christian Churches were friendly, and 46% believed that churches were involved in the community.[13] The Barna Group also compared religious beliefs of the Unchurched and the Churched and found that over half of the Unchurched believed that Christ was the Son of God, that he rose from the dead, and that he reappeared after his resurrection.[14] The Unchurched, at least from this Barna Group study, were not ignorant of Christian theology and even agreed with it for the most part. Based off this Barna report, there was still a lively and growing spiritual consciousness within the Unchurched, yet they were still outside the realm of institutionalized religion. Compared to today, however, things have changed a bit. Those who consider themselves agnostic and atheists were extremely unlikely to believe in supernatural beings, scoring close to a zero on a zero to five scale. The unaffiliated were a bit higher and held an average amount of belief in supernatural things at a 2.5 on the scale. Interesting, however, is that some atheists (1.1) and agnostics (1.3) still considered the belief in paranormal activity, such as ghosts or ESP as possible. Actively religious people were at a 1.7 on the scale while the unaffiliated were at a 2.2.[15] Thus, those unaffiliated with a particular religion are almost as equally likely to believe in extraterrestrial life as they are to believe in a supernatural being.

Another important context of the Nones that should be discussed is the fact that western culture, in general, has been shaped by Christianity. Many of the terms understood in the United States, and indeed the West broadly, are terms within the context of Christianity. This is not necessarily bad. Rather, when it comes to spiritual motives, it is especially important to notice the effects of Christianity on not just the childhood development of some Nones but even in their language or the very way they describe their spiritual practices. The Christian influence is prevalent, even to the point of some Nones self-titling themselves as a "Jesus Follower" instead of being called Christian because of the political and social baggage that comes with the term Christian.[16]

The knowledge of the history of the Unchurched is vital in understanding the present-day realities of the American Nones. Those who were originally dubbed "Unchurched" have become a part of the umbrella term "None." While names may vary, the key thing to understand is that the Nones did not just appear all of the sudden. There has been an ongoing transition that has been documented for decades.[17] While the ideas that the Nones are unaffiliated may be shocking to some, it is important to remember that even in America, this is not altogether a novel idea.

Demographics also play a part in understanding who the American Nones are. In a few surveys done by various groups, the majority of Nones are usually younger and male.[18] This is not to say that the only people who claim to be Nones are male or young; but this clarification can show that there may be a consistent thread throughout the Nones.[19] Along

---

13 *Never on a Sunday*, 14.
14 *Never on a Sunday*, 21.
15 Baker and Smith, *American Secularism*, 92.
16 Drescher, *Choosing Our Religion*, 35-36.
17 Baker and Smith, *American Secularism*, 83-87.
18 Joseph O. Baker, and Buster G. Smith, "The Nones: Social Characteristics of the Religiously Unaffiliated" (2009).
19 Barry A. Kosmin, Ariela Keysar, Ryan Cragun, and Juhem Navarro-Rivera, "American Nones: The Profile of the No Religion Population," Trinity College Commons, (2011). http://commons.trincoll.edu/aris/files/2011/08/NONES_08.pdf.

with this, most Nones are politically moderate to liberal. This finding remains consistent for most topics including view of government and view of gender and sexuality.[21] James Emery White cites a Pew Forum research study that showed a significant majority, 71%, of Nones were white in 2012.[22] With this information in mind, hopefully a more comprehensive understanding of the American Nones can be reached.

Self-Identification is fundamental for understanding the Nones. This poses a few linguistical problems. Many traditionally held definitions of words may mean something a bit different within the context of the specific Nones who are describing themselves. Nevertheless, the more prevalent ones will be addressed before continuing. It should be remembered throughout this project that much of the content is nuanced and sometimes topics and groups may be fuzzy or abstract rather than neatly concrete and easily measurable. This is mainly detailed in Elizabeth Drescher's list of terms in her book Choosing Our Religion.

- Atheist: One who does not believe in a transcendental being or force that rules supreme over the universe.
- Agnostic: There can be nuance here, but the term ranges from saying that one does not believe one can know for certain if there is a transcendent being or force to one who humbly admits the lack of evidence and claims doubts of such a being or force.
- Secular Humanist: One who, whether consciously or not, is influenced by the Enlightenment. This view highlights the innate goodness of humanity and the rationality that all humans are capable of. A belief in the "human spirit" may also be present.
- Spiritual: The pursuit of spiritual growth and development. Also, a focus on human relationships.
- Spiritual-But-Not-Religious (SBNRs): One who usually believes in a transcendent being or force, but is usually not affiliated with a religion, even though they may practice the spiritual practices of that religion.
- None: One who claims "none of the above" when asked about religious preferences on a survey or to which religion one belongs to.

As stated in her own book from which these terms are addressed, this is by no means exhaustive or complete.[22] However, all of these terms may fall under the umbrella term of "None." The definitions of these labels may be up for interpretation as well. This is not to say that the Nones are "wishy-washy" or lack resilience in their beliefs. The difficulty arises from, as mentioned previously, the difficulty of describing spiritual experience.

Another reason that the specific terms detailing one's beliefs are so significant yet nuanced is due to the contemporary philosophy of Post-Modernism. Post-Modernism is a critique of the Modernist philosophy that was prevalent in the post-enlightenment period. Post-Modernism is defined mostly by its skepticism of overarching metanarratives and a rejection of the deification that reason received from enlightenment thinking. This skepticism of metanarratives has a few consequences. The first is the denial of religious

---

20 Baker and Smith, *American Secularism*, 188-189.
21 James Emery White, *The Rise of the Nones: Understanding and Reaching the Religiously Unaffiliated*. (Michigan: Baker Books, 2014), 22.
22 Drescher, *Choosing Our Religion*, 28-29.

affiliation that was mentioned before. This translates into the belief that no single religion has a monopoly on truth. There are a variety of places that can help one further their spiritual growth, even if they are considered strange or on the fringes by most people.[23]

The other consequence is the somewhat eclectic nature of a None's spiritual beliefs. Some Nones may draw from Christianity, Buddhism, and pseudoscience. Still, others may speak of personal experience and horoscopes with the same tone of credibility. Since no single religious organization has all the answers, it is perfectly acceptable to try to find answers in other places.

Finally, the last piece of the context of the Nones that will be mentioned is that of individualism. The West, in general, is very individualistic; individualism is understood as the focus on what is good for the individual person and the necessity of personal responsibility. For this group, it can be understood a bit more as the "personalization" of spiritual experiences. This can easily be seen in the ideas held by American Nones. This individualization context allows many Nones to choose for themselves what they believe.[24] This individualism does not mean an absent of community, however. In fact, it would be better to say that "individual religion" is based in the social world. Things are shared and communal experiences enhance bonds. The individual still has a large focus, but no one lives on an island.[25] Ultimately, the individualistic culture of the west is important in allowing the individual the freedom of exploration amongst the plethora of philosophies that have been presented in human history.

Overall, many aspects have contributed to the context of the Nones. They are a new linguistic category, but they did not come into existence just because of a new definition. The Nones have existed as many different titles, sometimes self-described, sometimes not. The context that has led up to the "rise of the Nones," as the title of White's book so claims[26] is vastly different from that of the Japanese. This will be treated in more detail in the next section.

Context of the Japanese

According to Japanese legend, two divine beings were sent down to the earth to procreate and spread life all around them; they were known as Izanagi (the man who invites) and Izanami (the woman who invites). After landing on an island, Izanagi went one way and Izanami went the other. They both met each other on the other side of the island, and there they got married. After getting married, they progenerated many things until Izanami, the wife, died with similar symptoms to a fever. Dragged down to the underworld, Izanami was chased by her husband. When Izanagi reached her in the underworld, his wife pleaded with him to not look upon her. Desperate to see her, Izanagi lit a light in the darkness to gaze upon his beloved's face. The only issue, however, was that she was ugly and decaying and furious that her husband had blatantly ignored her request. In absolute rage and anger,

---

23 "Postmodern Worldview," AllAboutWorldview, 2018. https://www.allaboutworldview.org/postmodern-worldview.htm.

24 It may be possible to make the argument that the reason some Nones are unaffiliated is correlated simply to the fact that their ideas are much more eclectic and nuanced that no single group or association has come about yet that fits their own beliefs. This would be an interesting correlational study but is not discussed much further here. Nonetheless, the idea may help some to understand the cognitions of the Nones and therefore is mentioned in this note.

25 Drescher, *Choosing Our Religion*, 120.

26 White, *The Rise of the Nones*.

she ran from him and summoned dark spirits to attack her once loving husband. Izanagi barely escaped the wrath of the woman and just before leaving earshot heard her threaten his progeny, "I will kill one thousand people every day for as long as the world turns" she exclaimed to her previous lover. Quickly, Izanagi responded: "Then I shall father one thousand five hundred humans every day." And so, Izanagi left his enraged wife behind and, fleeing to Japan, proceeded to birth his number and watch his wife kill her number.[27]

This story describes the origin of humanity in Japanese mythology. While there is no direct parallel to it for the Nones, this story gives us a mythic context for the other people group in this project. The question of relevancy of this myth does have merit, though. The question of "how religious or spiritual is Japan, really?" is an important one to address. Ellwood points out that "[in] Japan, the religious and the secular are not easily separated. What looks to be this-worldly beauty may actually have a religious background—and then that background may turn out to be slippery by Western concepts of religion."[28] The mythic and the present collide in ways that are not so easily ascertained in the Western understanding of religion. The Japanese Nationals, just like the American Nones, have their own context which influences everything from daily life to philosophy and to religion. While the influences may be different, they are nonetheless just as important to examine.

Before getting too far, it would be best to define exactly what is meant by Japanese Nationals in this paper. "Japanese Nationals" will be defined as those who are culturally and ethnically Japanese who inhabit the islands of Honshu, Shikoku, and Kyushu in the country of Japan. Religiously they are those who hold to the teachings of Shintoism, Buddhism, and Confucianism.[29] Thus, the focus will be more on the main island of Honshu. Japanese Nationals are citizens of Japan, but this excludes Koreans, visitors, and Asian-Americans, at least for the definition that is used in this paper, not necessarily in general. Now that the group has been identified, it is important to relate the factors that have affected this group.

The first glaring difference is that Japan is much older than America and is in an entirely different part of the world. The influences on Japan have been much different from those on the western world. Historically, China has been one of the biggest contributors to Japanese culture.[30] The several systems of writing, the kana and the kanji, are based on the original Chinese characters that were brought over to Japan. Kanji literally means "Kan," as in the Chinese dynasty, and character (ji). This is not just delegated to written language. Religion, philosophy, and even art have all been impacted by the influence of the Chinese. Chinese culture has been, and still is, an important factor in the growth of the Japanese nation and culture.

---

[27] MacCulloch and Moore, *The Mythology of All Races in Thirteen Volumes*, 221-224.

[28] Ellwood, *Introducing Japanese Religion*, 3.

[29] For the sake of this study, Christianity in Japan will not be taken into account in the actual comparison of the two groups. However, many sources may include history from a Christian perspective or mention Christianity. The account of Christianity in Japan is worth telling, but there is sadly no such space in this project. Others have done a very good job at detailing the persecution and maintenance of the religion in Japan since its introduction. For further reading on this, Richard Drummond's *A History of Christianity in Japan* (Michigan: Eerdmans, 1971) and Samuel Moffett's *A History of Christianity in Asia* (Volume II, New York: Orbis Books, 2005) would be a good start and informed this project's context.

[30] Paul Varley, *Japanese Culture* (Honolulu: University of Hawaii Press, 2000) 20.

Each religious or philosophical system will be analyzed in a more detailed manner later, but, for now, a quick overview of each would be beneficial. Shintoism is the folk religion of Japan and has an origin along with the country itself. Shintoism is understood in a polytheistic sense. Even to this day Shintoism can be understood as a "civic religion" and is an important part of social life in Japan.[31] The main deities of Shintoism are called the *kami*.[32] These deities may be best understood as "anything that can fill us with wonder and awe"[33] There is a lot more to unpack, but this polytheistic folk religion is fundamental to understanding the religious landscape of Japan. Many *matsuri*, or shrine festivals, include reference to the *kami*. These festivals are all over Japan at various times of the year, depending on the specific *kami* that is enshrined. Offerings may be given and a prayer, called the *norito*, is given along with these presents. Celebrations such as dances and feasts are also present as well.[34] As mentioned prior, these ceremonies are both equally cultural and religious and inseparable into either category alone.

Confucianism is the next belief system to be addressed. Along with Buddhism, Confucianism came from China to Japan. While more of an ethical system than a perfect definition of "religion," Confucianism has its "spiritual" aspects as well. Confucius was a traveling Chinese philosopher who taught more on how people should involve themselves in society rather than the metaphysical mysteries of the world.[35] The early Japanese intelligentsia was intrigued by the teachings of both Buddhism and Confucianism and sought to spread their ideas to the rest of the Japanese. This can be seen in the Seventeen-Article Constitution by Prince Shotoku in 604 CE which was "the first statement in Japanese history of the need for ethical government."[36] Virtue is an important goal in Japanese Confucianism and has had an impact on Bushido, or the samurai honor code, another connection between the philosophical and political. This "way of the warrior" greatly influenced the ethical boundaries of the Samurai warriors, a class during the divided warrior states period of Japan.[37] Another influence Confucianism had on the Japanese was an awakening of the appreciation for the culture of China, which, as mentioned previously, greatly influenced Japanese society.[38] So Confucianism is not just a thought system; it has had its hand in the politics and evolution of Japanese society for millennia.

Buddhism in Japan also had an impact on the political environment of Japan as well as the religious landscape. The Buddhism that exists in Japan is from the Mahayana branch of Buddhism, which traveled from India through Tibet into China and then into Japan. When Kyoto was the capital of Japan, esoteric Buddhism (a sect of Buddhism focused on secret rites related to enlightenment) was extremely intriguing to many upper-class political figures. This sect of Buddhism was introduced by Kukai (also known as Kobo Daishi, or Great Teacher Kobo), who was also given the credit for creating the *kana* syllabary. It is even posited that Sanskrit, the holy language of Buddhism, played a role in the evolution of the *kana*.[39]

---

[31] Robert Ellwood, *Introducing Japanese Religion* (London: Routledge, 2016), 62.
[32] Usually translated as "god" but such a definition may not articulate the nuance of the word or be too reductionistic.
[33] Ellwood, *Introducing Japanese Religion*, 62.
[34] Ellwood, *Introducing Japanese Religion*, 30.
[35] Varley, *Japanese Culture*, 25.
[36] Varley, *Japanese Culture*, 26.
[37] Ellwood, *Introducing Japanese Religion*, 160.
[38] Varley, *Japanese Culture*, 213.
[39] Varley, *Japanese Culture*, 51.

225

Through the history of Buddhism in Japan multiple sects of Buddhism have emerged, making it comparable to the denominations of western Christianity. Influenced by Hindu thought, Buddhism is the teachings of the Buddha, or Siddhartha Gautama.[40] The Buddha taught four noble truths. First, there is suffering in this world. This realization is necessary for the next truth. Second, the suffering that pervades all life is caused by desire. Other words that may be used to describe desire are cravings, thirsts, attachments, or lusts. Thirdly, there can be an end to the suffering of this world. Finally, this end of suffering is brought about by following the eightfold path. The eightfold path includes right views, right intentions, right speech, right conduct, right livelihood, right effort, right mindfulness, and right concentration (or meditation).[41] While this is the historical Buddhism that first sprouted in India, the Buddhism seen in Japan differs in doctrine and rites depending on the sect. For this study, the sects will be emphasized will be Pure Land Buddhism and Zen Buddhism.

Outside of religion, there are other influences as well that affect the Japanese. The people of Japan have an understanding of *Shudan Ishiki*, or "Group Consciousness." This could be understood as the collective nature of the culture that is the opposite of the individual culture of the West. This is a different understanding of the nature of society. Japan is a collective society; therefore, the group is emphasized over the individual. This means that group success is interpreted as personal success, group failure is interpreted as personal failure, and group opinions are interpreted as personal opinions. Individuality is different from an individual based society, such as America. There is individuality, but one ought to conform to the group opinion in order to maintain social harmony. Social harmony is important because it enables personal individuality to flourish. Individuality is understood differently. People have different sets of skills and abilities in different areas. This is inevitable and provides individual variance in society.[42] Therefore, the success that is attained by the group is much greater than the success attained by one person because no one person can do everything.

To help define the group, there are two other concepts related to *Shudan Ishiki*. Those who are uchi are insiders. These people are family and friends. This also includes *shinrai* or acquaintances. These acquaintances may be a friend of a friend of a friend of a close family member. The other concept is *soto*. Those who are *soto* are outsiders. This may refer to a person with whom one does business with or a traveler who asks a question. An outsider to a Japanese does not have to be a foreigner.[43] Fundamentally, *uchi* is an intra-collective idea while *soto* is an extra-collective one.

The influences on Japan are plentiful and detailed greatly in other research. The history of Japan has been influenced greatly by China, but in the most recent centuries by the West. Spanning from the Russo-Japanese War to the Second World War, Japan has been a power that gained awe and criticism from the West. So, one cannot say that Japan is impotent or unimportant to the rest of the world. For the rest of this project a closer look at the three religions of Shintoism, Buddhism, and Confucianism will be detailed.

---

40 Different sects of Buddhism may have different names, stories, or origins of the Buddha. Such historicity of the Buddha, however, is not the focus. The main emphasis is the enlightening knowledge that has been granted to humanity through the Buddha.

41 Ellwood, *Introducing Japanese Religion*, 81.

42 Roger Davies and Osamu Ikeno, *The Japanese Mind: Understanding Contemporary Japanese Culture* (Tokyo: Tuttle Publishing) 195-198.

43 Davies and Ikeno, *The Japanese Mind*, 196.

SPIRITUAL HABITS, BELIEFS, AND IDEAS

Spiritual habits, beliefs, and ideas of the Nones

The spiritual habits, beliefs, and ideas of the American Nones, which are similar to the Japanese, are difficult to pin down and generalize. Nevertheless, in order to compare the general beliefs of the American Nones and Japanese Nationals, a somewhat general idea of the spiritual habits and beliefs of the Nones will be outlined here. As mentioned in the overview, due to self-identification and individualism, the number of habits of the Nones may be the same number of people that claim to be Nones. However, this does not mean that no patterns or similarities arise within this group. This section will be about a broad overview of the main concepts considered sacred and held by the Nones along with some quotidian anecdotes.

Borrowing heavily from Elizabeth Drescher's book Choosing Our Religion, the focus of the Nones' spirituality is around what she calls "the four 'F's." These four 'F's stand for family, friends, Fido, and food.[44] These four topics will be covered in this section, along with another portion dedicated to some specific practices.

The first "F" that most Nones in the interviews done by Drescher mentioned was family. Family is an extremely important aspect of the spiritual lives of many Nones. A key focus on the spiritual experience of the Nones is on the relational.[45] That is, the sacred is seen in the connectedness, or in some cases theophany, between a person and another person. This is easily seen within families. A parent and a child have a significant connection. While it is possible for that connection to be abused, it can also be an important motivation for growth or medium for wisdom. Some Nones mentioned that the very reasons they had left religious organizations previously or were now unaffiliated were because they wished to spend more time with their families. Because family is so important, it is important to spend time with them. This may be difficult to do if the mother is in two different groups after church, the father is an usher and teacher, and the children are all in classes or church sports. The danger of not just overcommitting, but over involvement as well at a church may become a serious problem.

Another topic related to this is raising a family as an American None. One of the interviewees of Drescher explained that they received considerable backlash from family members when deciding not to raise her daughters in a religious tradition.[46] Withdrawal from the church, if one does not return with children, usually means that the children themselves remain outside of the religion. Baker and Smith point out that, "[while] religious retention has fallen, secularity has nearly caught up with organized religion in terms of keeping people in the belief system in which they were raised."[47] This does not mean children are raised in a home without any spiritual experience. Rather, the experience is more based on the individualized spiritual beliefs of the parents. Most American Nones seem to be cautious in bringing up their children in a specific religious tradition so that they have the same freedom their parents did in choosing their religion.[48]

---

44 Drescher, *Choosing Our Religion*, 44.
45 Drescher, *Choosing Our Religion*, 119.
46 Drescher, *Choosing Our Religion*, 220-221.
47 Baker and Smith, *American Secularism*, 82.
48 Drescher, *Choosing Our Religion*, 223-225.

Another thing to mention about family is that it does not necessarily mean blood-related kin. Brotherhood and sisterhood may occur among friends or family friends. Some people may be adopted into families. The relationships, however, are just as important in family gatherings and are nurtured accordingly. Familial relationships are important to the Nones. While family will be understood differently by everyone, the aspect that there is a social community of love and solidarity in one's life could be understood as a religious aspect for the Nones.

Friendship is the next aspect of the four F's that will be addressed. One specific interviewee discussed that he had a friend he considered a "soul-mate."[49] This is not a soul-mate understood within the idea of romance but, rather, a literal spiritual friend. This is a closeness that can really only be described using spiritual terms. Close friendships have an air of authenticity about them. Friends can know the true essence of each other and, as they mature together, can encounter a closeness that may be described as "intimate."[50] Some other words that may be used instead of soul-mate are "brother" or "sister." These are not people within a person's biological family; rather, they are people who have a bond with the person that may come on par to that of familial ties. Closeness is not the only requirement to see the spiritual depth of friendship, however. Another interviewee talked of the "miracle" that occurred when she met one of her good friends who encouraged her.[51] This encouragement, or, if it may be put this way, this granting of life with words, engendered a relationship that may not have normally occurred. Encouragement, presence, closeness, vulnerability, service, compassion, and love are just a few aspects of friendship. Close friendship is a dynamic relationship that can easily have spiritual aspects tied to it.[52]

The third of the four Fs may not be so obvious at first. Fido is an average name for a dog, so the F this time is related to the relationship Nones may have to their pets. This may seem peculiar to some, but the authenticity of these experiences is not to be ignored. Research has shown that "Animals provide medical, therapeutic, and social support in a wide variety of clinical and domestic settings. They serve as expert trackers and identifiers of bodies, chemicals, and explosives for police departments, security agencies, and the military."[53] The social support of life is something that should really be emphasized. If the spiritual lives of the Nones are indeed relational, then these relationships with pets are not just pragmatic ones but possibly religious ones as well. The phrase "dogs are man's best friend" is an old one with plenty of veracity. An interviewee of Drescher's talked of his "therapist cat" who would come in at just the right time during arguments between people and dissolve all sorts of tension.[54] Animals are not just husks that move. They are fundamentally related to the spiritual lives of some Nones. This may not be the case everywhere as not every None has a pet.

---

49 Drescher, *Choosing Our Religion*, 131.
50 Here is another example of the difficulty of language. Intimacy here can be understood in a platonic way, but the true vulnerability that close friendships have is difficult to describe with simple words. Experience is again emphasized.
51 Drescher, *Choosing Our Religion*, 133.
52 The difference between family and friends is very contextual and personal. Someone might see a close friend as a brother, while another person might see a similar person in a similar situation as a friend. Although there is a more subjective line here between these two F's, the point is that relationships between people is extremely important in the daily lives of the American Nones.
53 Drescher, *Choosing Our Religion*, 139.
54 Drescher, *Choosing Our Religion*, 141.

Yet, those who do have pets may count them among their family members. If a pet is counted among family members, it is a short distance to consider that relationship a spiritual one.

Food is the last of the four Fs but exerts influence in all the other three. Some anthropologists have argued that it is very possible that most things in cultures and developed societies can be traced back to an origin in food. Fox makes a very intriguing observation: "Apart from the physiological prediction, we can be sure that eating as display—as a code of messages about selves and status, role and religion, race and nation—will persist in an animal that lives by symbolic communication."[55] Food is a vital aspect of social gatherings. Festivals, get-togethers, even coffee dates are just a few examples. The social lives of humans, not just Nones, are connected to food in some respects. Food preparation and food sharing are important aspects of some American None's lives. Drescher interviewed a baker[56] who found it spiritually moving to share her bread with friends, family, and even strangers if she had some on hand. Drescher herself was even gifted with some of this bread. The kitchen, then, may become something like a church. The intense preparation, possibly with multiple people involved, produces an "atmosphere," if that term may be used, that some might call religious. There can be community and solidarity in having a meal with other people. These are sacred moments which should not be glossed over so easily.

There are two more aspects of the spiritual lives of the Nones that should be mentioned. Prayer is not simply confined to a monotheistic religion. Many different religions have prayers and different ways to do them. This also applies to the Nones but in less orthodox ways. There are many aspects to prayer within the understanding of the American Nones. Some described prayer as a feeling while still others counted it as an actual experience such as "thinking about someone."[57] Some Nones pray to God/Divine Being, while others may pray to a universal Force or energy. Still, others may pray to nothing. Prayer may be used for personal growth or comfort or it may be used to maintain social harmony with other prayerful persons. Most importantly though, prayer may be understood relationally, or connective. This relational connection may be to nature, people, both living and dead, God, or a force.[58] For the Nones, prayer is not just talking to a monotheistic god or pantheistic force. In fact, it may be a nontheistic prayer. Some Nones described prayer as really thinking about someone. Prayer is more than just thinking good thoughts about someone. It is an experience that changes things as if it really does make a difference. This can be seen in embodied prayers.[59] These are not simply prayers that inquire of a supernatural being/force to act, rather they are acts of service that actually make a difference in other's lives. Caring for the earth is one example, as is serving a homeless person. In both cases, the emphasis is on action. Even so, action is not a requirement for prayer. Perhaps a better way to describe it from a None's perspective would be the manifestation of the intention to change the world for the better.[60]

---

55 Robin Fox, "Food and Eating: An Anthropological Perspective," 2014. http://www.sirc.org/publik/foxfood.pdf.
56 Drescher, *Choosing Our Religion*, 145.
57 Drescher, *Choosing Our Religion*, 178-181.
58 Drescher, *Choosing Our Religion*, 163-164.
59 Drescher, *Choosing Our Religion*, 167-168.
60 This manifestation may not be physical. The idea is more of a harmonious balance of the experiential subjectivity of it all and the objective action that causes good to flourish in another's life. Prayer, for the American Nones, may be taken literally in some cases, but in others it cannot be understood that way. Thus, the diction used is done so for the hope that the nuanced idea of prayer is conveyed. "It's more than a simple feeling" is a better way to put it, though that may not be the most formal way.

Morality is the final piece of the puzzle. Some Nones do in fact believe in God and follow moral guidelines similar to Christianity or to the religious organizational context that many Nones came from. However, not all American Nones follow this pattern. Rather, an ethic of care, also known as relational ethics, is the driving force for the morality of Nones. As can be perceived in the four 'F's, relationality is at the core of the morality for Nones. This can be seen in the influence the story of the good Samaritan, told by Jesus of Nazareth. The selfless actions of one man to help another as a foundation for morality says volumes about the ethics of the Nones. Drescher points out that, even though society and norms said otherwise, and others could have responded, the real heroes are the ones who truly make themselves available to those in need.[61] Relationships are to be taken as a priority and helping those in need stems from this idea. Most American Nones do not view humanity as innately evil but focus on the good in people and respond to it likewise.

The core of the spiritual habits, beliefs, and ideas of the Nones revolve around other human beings. Relationships are paramount to them. Drescher in her book says the following about being a None: "However these spiritualities might be theorized or theologized, the spiritual lives of the Nones, as they themselves articulate their understandings about them, are oriented primarily around interpersonal relationships in which intimacy, trust, and personal authenticity are experienced to a heightened degree."[62] That is exactly the point. For Nones, relationships *are* god, at least in a way. Morality, life, even religious experiences all stem from connections to other people. Drescher states, "Unaffiliated spirituality is fundamentally relational, that relationality is expressed through the care of others; and this is a valuable ethical and spiritual orientation in an increasingly cosmopolitan, religiously diverse world."[63] Relationships are religion. The Nones care about the world and its inhabitants and seek to better both themselves and other people through compassion and kindness. There are a lot of variations within the group itself, but that is all part of what it means to be an American None.

Spiritual beliefs, habits, and ideas of the Japanese

The spiritual beliefs, habits, and ideas of the Japanese are similar to the American Nones but somewhat difficult to completely describe. The dynamics of Japanese religion are nuanced and changing as well. Most importantly, however, just like the Nones, the religious landscape of Japan exists somewhat between institutionalization and unaffiliation. A traditional saying in Japan says, "a Japanese person is born to Shinto rites, married with Christian rites, and buried with Buddhist ones."[64] Among these rites, one is expected to live according to the ethical standards of Confucianism.

Before going any farther, it is important to discuss the true "religiosity" of Japan. The western understanding of religion is much different from the Japanese understanding. In the west, the understanding may that one consistently follows the doctrines and thought of a specific institution. Ones is a Christian because he or she follows the teachings of Christ. This is not necessarily the wrong view of religion, but it looks a bit different

---

61 Drescher, *Choosing Our Religion*, 203.
62 Drescher, *Choosing Our Religion*, 137.
63 Drescher, *Choosing Our Religion*, 244.
64 "Japan: The Most Religious Atheist Country," GaijinPot Blog, Matthew Coslett, February 8, 2015, https://blog.gaijinpot.com/japan-religious-atheist-country/.

for Japanese Nationals. Religion is not seen as such a detachable thing from life. "For [the Japanese] practices such as those of shrine festivals, temple rites, Buddhist funerals, or New Years are considered 'natural,' just part of being Japanese. They go along with growing up in a Japanese family and being part of a Japanese community."[65] Religion is not absent, it is considered holistically. It is more integrated in life. The meaning may be more cultural, but this does not separate it from its religious meaning or significance.

Along with this idea is the Japanese concept of "synthesized religion." What is meant by this is that both Buddhism and Shintoism, along with Confucian cultural values, coexist together. Ellwood explains that "new religions can be added, 'stacked up," without necessarily displacing the predecessor. In such ways as this, the experienced history of a culture's religion bears its own message."[66] This "synthesization" is an important aspect of Japanese religion. The integration of religion into culture is a vital, if not *the key component*, that needs to be remembered when discussing the context of Japanese religion.

Confucianism in Japan is not like a normal religion. In Japan, "it seems that religionists can preach and practice a variety of doctrines and methods of worship so long as they inculcate Confucian virtues; get outside that frame, and they may find themselves in serious trouble."[67] Although Ellwood is talking about "new religions" in Japan, it is a good starting point. Confucianism is not an organized, doctrinal, and spiritual religion like Christianity or even Buddhism. It is much more of a practical religion that permeates daily life through its ethical philosophy. This is precisely why it is discussed in this project. The goal is to catch a glimpse of quotidian spirituality of the Japanese Nationals, and if Confucianism contributes to that even a little bit, it is worth discussing.

The core values of Confucius, although they have grown and adapted since the founding philosopher's death, are based upon society. Humans are innately social creatures. We all have family, at least to some extent, and interact with other social beings. Confucius believed that humans' true nature came from relationships. Once those were extended to a society, he believed the community at large began to speak into human nature. Thus, loyalty and social obligations to one's relationships were expected from citizens and inhabitants. Those relationships could then be extended to society as a whole.[68] Filial piety is one of the greatest examples of this philosophy. Even to this day, this ethic can be observed. It is the duty of the oldest son to take care of his parents in their old age. Sons are also expected to bring honor to their family name. This sentiment, honor, has a remarkable impact in Confucian thought,[69] and the moral implications of living out of duty and service for others rather than for oneself are easy to see with respect to the benefits to

---

65 Ellwood, *Introducing Japanese Religion*, 19-20.
66 Ellwood, *Introducing Japanese Religion*, 18.
67 Ellwood, *Introducing Japanese Religion*, 9.
68 Ellwood, *Introducing Japanese Religion*, 15-16.
69 The ideas of honor and respect have been debated for a while. The western ideas of respect and honor are not quite the same as the eastern ideas. Ultimately, it may be best to describe them with their opposites, guilt and shame. Respect is earned and if lost, causing guilt, it is not entirely impossible to gain back more. Honor is not really "gained," at least not it the whole sense of the word. Honor may be able to be "regained" by an act that society considers honorable, but it is not exactly accrued over a person's lifetime like respect. Japan is a shame-based society, so public consequences come with inappropriate actions. This leads into the Bushido idea of Honor and why *seppuku*, or honorable suicide, was considered somewhat of a redemption of the person and family name. There is much more nuance and others have written more than what is swiftly described here.

society. This showed itself in government too. While governments could become corrupt, ideally the monarch or ruler would work with his advisors, or people of the ruled class, to create a better society. The ruler, in the view of Confucius, should be one with virtue and circumspect.[70]

Confucianism came to Japan around the same time Buddhism did.[71] The difference is that while one is more social and political in nature, the other is a full-fledged religion with its spiritual experiences that lead to the understandings of the universe. This is not to say these do not exist in Confucianism, but Buddhism is much more than a simple philosophy; it is a way of experiencing the divine and attaining enlightenment.[72] While there are many different types of Buddhism in Japan, the ones that will be focused on here will be the Jodo School and the Jodo Shin Sect of Amida Buddhism. These are Pure Land and True Pure Land Buddhism respectively. Along with these two sects, Zen Buddhism will also be the subject of some study. These sects were specifically chosen due their origin and explicit effects in Japan itself.

Pure Land Buddhism was founded by Honen Shonin, a teacher who began preaching Amida Buddhism in 1175 CE. For a long time, Buddhism was an elite religion. Attaining enlightenment, at least originally, meant spending a lot of time meditating, and for the normal farmer or intense laborer, such time did not exist. Honen Shonin, or Shonin-sensei, held that anybody could be reborn into "The Pure Land" regardless of whether they were monk or peasant. The way to do this was to recite the *nembutsu*, an absolute incantation that did not require meditation or work, only faith. The *nembutsu* is simply the recitation of the Buddha Amida's name in faith that through his mercy one will be saved and brought into the Pure Land by Amida's merit. Ultimately, Shonin-sensei made Amida Buddhism a "by faith alone" religion.[73]

Shonin had a promising pupil named Shinran who took Pure Land Buddhism a step further. True Pure Land Buddhism (Jodo Shin school) holds that the recitation of Amida's name is not mandatory. Rather, Shinran presented the truly shocking idea that Amida gifted faith to those who believed in his name. Even if one did not say out loud the name of Amida, as long as the person had faith and gratitude for that gift of faith, that person would be saved by Amida.[74] The revolutionary ideas of Shonin and Shinran for the Japanese have changed the understanding of faith in that time for many people.

A key difference of True Pure Land Buddhism from Pure Land Buddhism is that, although there is assurance of faith in this life, true enlightenment does not occur until the next life when one is in the Pure Land.[75] The original teachings of Buddha were that the goal of this life was enlightenment and that anybody could attain it. The difficulty came into how

---

70 Varley, *Japanese Culture*, 20.

71 Ellwood, *Introducing Japanese Religion*, 93-95.

72 It has been argued that Buddhism is not a true religion and more of a philosophy of life. While many of the topics in this project lie in the ether between definitions, Buddhism is absolutely a religion to the same degree that Christianity is. This will be especially obvious when talking about, in Bunce's words "Amida Buddhism" as faith will be a major emphasis of the sect. Nevertheless, this distinction is important to separate Buddhism from the misunderstanding that it is simply another Confucianism.

73 William Bunce, *Religions in Japan: Buddhism, Shinto, Christianity* (Rutland: Charles E. Tuttle Company, 1955), 80.

74 Bunce, *Religions in Japan*, 83-84.

75 Bunce, *Religions in Japan*, 85.

one attains enlightenment since many did not have time for meditating. Thus, this sect in the Mahayana branch of Buddhism sought to redeem those who could not meditate all the time and lived a normal daily life.

While the concept of the Pure Land sounds a lot like heaven, it is in fact not the same thing. The Pure Land is rather a place where one remains in enlightenment in *order* to enter nirvana. While it is indeed described as a type heaven, with all sort of various music and jewels among the sublime spirit of the Buddha, the goal of the Pure Land is not to remain there forever but rather to grant a place for people to achieve nirvana than spend all their earthly life chasing after a seemingly impossible goal for most.[76]

Zen Buddhism is much different from the two other sects mentioned. The goal of Zen Buddhism is "transmitting Buddha's mind directly to the mind of believers."[77] In Zen Buddhism, the practices that are most prevalent are silent meditation and abstract contemplation. The truth is not something from scripture to be passed down orally. Rather, it was believed the meditators had to be transmitted the knowledge from the Buddha. The problem was that even when they had achieved this knowledge, there was no real way to convey it. This can be best seen in the *koan*. A *koan* is an abstract riddle that practitioners of Zen are expected to master. Acolytes are given these riddles by their masters and are expected to meditate on them for days, weeks, months, or however long it might take to solve them. These riddles are extremely difficult, and it would be surprising to find someone who could complete their riddle in a day. One example of *koan* would be "what does a clap with one hand sound like?" The paradoxical abstract riddles are, in Zen thought, one of the gateways to understanding the mind of the Buddha.[78] In addition to religious thinking, Zen Buddhism has contributed to politics, architecture, theatre, ethics, and the daily life of the Japanese.[79]

The third, but most innately Japanese religion to discuss is Shintoism. To start, it may be prudent to tell another story. Amaterasu, the sun goddess, was deeply offended by her brother Susanoo, the god of storms, and hid in a cave. Since the sun goddess was hiding in a cave, the sunlight had gone out, and there was no light in the world. The rest of the *kami* (gods) got together and deliberated amongst themselves until a solution came about. The goddess of dance, Uzume, started to dance and the rest of the *kami* that were present began to laugh. Amaterasu, curious about the cause of this revelry, poked her head out of the cave and, by seeing her beauty reflected in a mirror, gradually left the safety of the cave. Thus, light was returned to the sky and the heavens.[80]

While there is no clear hierarchy of gods, Amaterasu is an important one. She, along with Susanoo and Tsukiyomi, the moon goddess, was born from the body of the bathing Izanagi, who is credited for the creation of the Japanese people. To this day, it is believed the emperor is descended from the blood-related line of Amaterasu. This is an extreme honor and therefore the emperor is implicated in many religious rites in Shinto.[81] This

---

76 Ellwood, *Introducing Japanese Religion*, 35-37.
77 Bunce, *Religions in Japan*, 88.
78 Ellwood, *Introducing Japanese Religion*, 144-145.
79 Bunce, *Religions in Japan*, 90.

80 Ellwood, *Introducing Japanese Religion*, 74-75.
81 Ellwood, *Introducing Japanese Religion*, 74-75.

makes Shinto different from both Confucianism and Buddhism. There are a multitude of festivals for various gods or goddesses that are different from village to village. Some villages have multiple shrines in the area that people take care of, so this possibly means multiple deities. These *kami* are related to life and vitality, even marriage, rather than death, which is related to Buddhism.[82] The emphasis on the joys of this life are ultimately the prevailing ideas of Shinto. Life is a joyous occasion, indeed, and the parties that surround this knowledge create a very unique culture and religion.

The final topic to mention is the importance of cleanliness versus uncleanliness. Shrines, in Japan, are designed with a *torii*, or gate, at the front, designating that the shrine is separate from the common world. Inside the compound, there is a cleansing station. This station is used to wash one's hands, face, and even sometimes the insides of one's mouth. This is a symbolic cleansing as water is considered purgative of uncleanliness. This can even be seen in normal Japanese homes or living spaces. Many Japanese have separate slippers for the bathroom than for the rest of the house. While there is a practical application for this, the spiritual aspect of cleanliness versus uncleanliness is an important note.

The Japanese vary widely in their religious understandings. There are indeed zealous Buddhist monks and traditional Shinto believers. Even today some still faithfully hold to the original teachings of Confucius. Yet, most Japanese hold to a combination of all those. Shinto is optimistic about this life but says little about the next. Buddhism is hopeful about the next life but talks mostly in terms of suffering in this one. This interesting dynamic between multiple belief systems affects everyday life for the Japanese and show that there is much to explore with reference of the religious landscape of Japan.

COMPARISON OF THE AMERICAN NONES AND JAPANESE NATIONALS

Introduction

At this point in the project the question is, "How are the spiritualities of the American Nones and the Japanese Nationals similar or different?" This section will attempt to answer that question using four different concepts of Sacred Space, Time, Nature, and Human Experience. In addition, this project attempts to answer this question through the lens of another question: "What does it mean to be human?" Before answering this question, a brief introduction to the context of this methodology will be discussed.

Mircea Eliade, author of *The Sacred and The Profane: The Nature of Religion*, discusses four different aspects of sacredness that religions have in common. Eliade himself works with less popular religions and more primitive or older ones. One example of these groups would be the Achilpa, an Arunta tribe from Australia. Another example would be a Native American tribe called the Kwakiutl. Both of these people groups have a distinct religious system from any of the world's major religions. But this also means they have a unique perspective from the lens of "what does it mean to be human?" This allows him to truly get at the core of the issue of what is sacred and what is profane. While the Japanese and the Nones are sophisticated and culturally diverse, the ideas of Eliade still, arguably, apply to these spiritual understandings of the world as well. [83]

---

82 Varley, *Japanese Culture*, 9.
83 Eliade, *The Sacred and the Profane*.

First, it is important to know what exactly the four areas are in which Eliade finds similarities among religious systems. Sacred Space is the first one. This is simply a place that is set apart from the profane. This can be done in many ways. Some religions construct buildings, while others prepare a shrine. Still others wrap a rope around a place that is considered sacred. The key idea here is that the space that is considered sacred is completely, whether truly physically or symbolically, set apart from the outside world, the profane world.[84] The profane world is simply that which is not sacred. It does not necessarily have to be evil or malevolent. Normal, everyday items are part of the profane world. Pots, pans, televisions, roads, houses, and even tire swings are all examples of items from the profane world. While that doesn't mean these objects cannot be sacred, they are more or less a part of daily life rather than distinctly set apart by theophanies.

The second aspect is Sacred Time. Sacred Time is a moment in existence that has significant meaning or a measure of awe that is then considered to be sacred. Sacred Time is not mundane like the rest of life that is filled with work or play. Instead, these moments are special. They can be celebrations or memorials. They can be happy or sad times. Whatever the case may be, they are celebrated in a way that separates them from the rest of time. This separation can be obvious, or it can be a blurry gradient rather than a thick line. One such example may be Christmas in Japan. While Christmas was originally introduced as a Christian holiday, it has become extremely commercialized. There is still an aspect of sacred time as the common event of being with a special someone over this holiday is held by the public consciousness of the culture. It may not be a complete connection to the birth of Christ like it would be in Christianity, thus slightly blurred, but the longing for a person to be with is succinctly present. Sacred Time can also be combined with Sacred Space to create a special moment that occurs at a special place on the planet.[85]

The third and fourth aspects are a bit different from the first two. The third aspect is the Sacredness of Nature. This will become clearer later in this paper but for now, it can be described as the power of nature. A mountain, valley, or a volcano are great examples. A windstorm or a bolt of lightning are also evidence of the sacredness of Nature. These are all examples of the power of nature, and while that is an aspect of the sacredness of Nature, there is much more to it than just raw elemental power.[86] Nature is related to the sacred in symbols. Water is given purifying capabilities in Christianity, Shintoism, and Buddhism. Mother earth yields food that sustains humanity and allows them to continue to survive. This is not the end to the symbol of the mother, however. Eliade states: "In a number of languages man is called the earthborn. It is believed that children 'come' from the depths of the earth, from caverns, caves, ravines, but also from ponds, springs, rivers."[87] Mother earth then does not just mean a natural symbol of provision, but also origin.

Finally, there is the sacredness of life and human existence. Life and death are very interesting topics within religions, even still to this day. This power of life, this sanctified living, is one aspect of sacredness that all humans witness on this planet. Religions have various creation stories of humanity. Some talk of a single creating God, still others say a karmic force simply birthed man into existence in this universe. Life and human existence

---

84 Eliade, *The Sacred and the Profane*, 62-65.
85 Eliade, *The Sacred and the Profane*, 68-72.
86 Eliade, *The Sacred and the Profane*, 116-118.
87 Eliade, *The Sacred and the Profane*, 140.

235

are sacred things within themselves which is a vastly different reality than the profanity and danger of death.[88] Each one will be discussed in detail, but it is important to notice the fluidity of each category.

As previously mentioned, a sacred time and a sacred place can be combined into something much more awe-inspiring. However, nature and sanctified life can also be implemented into this sacred moment. A brilliant example of this is the creation of the world. At a sacred time, in a sacred place, nature and life are at once created. This act is almost holy in comparison with all other things. Another example would be the birth of Jesus Christ or the Buddha. This event is a sacred moment in a sacred place that brings forth a savior figure that will lead humanity to salvation and ease the suffering of profane existence. This sanctified life is remembered in a sacred place annually at a sacred time. It is important to remember though that these aspects of the sacred all affect each other in many ways.

The following four categories will be used to compare and contrast these two spiritual realms of thought from the Japanese Nationals and the American Nones. Each category will include examples from the Japanese and then examples of the American Nones with reference to the specific category in question. Following this, a conclusion will be drawn from these examples to show how similar or different these two groups truly are. The context in the preceding chapters were meant to introduce the separate worlds. Now that these doors have been opened, these worlds can be explored in a deeper way and yield specific examples of how both the Japanese Nationals and American Nones view the world. The results shown from these comparisons will be examined from the perspective of the question, "What does it mean to be human?" Since the categories are so broad, as are the subjects of comparisons, for the sake of space, only a few examples will be used at most for the categories.

Sacred space

Sacred space, most simply, would be a place like a shrine or holy monument. It is a space where a spiritual experience has or can occur. The sacred is felt and experienced as a reality in a physical location. Perhaps even a relic would be a good example. This can be seen in the spiritualities of both the Japanese Nationals and the American Nones.

Sacred space can easily be seen in the architecture of the Japanese. Upon visiting a Shinto shrine, a person will first see a Torii. This gate is a physical object that, along with a rope with paper (in some places this rope is more symbolic or replaced with a fence), separates the shrine from the rest of the space around it. After walking into this sacred space, a cleansing area is given to sojourners so that they may cleanse their hands and mouths before worshipping the deity that is enshrined at this shrine. After cleansing oneself with water, that person would approach the main worship hall. However, the key thing to note here is that the holy item that is enshrined is not within the worship hall itself. Instead, this sacred item, belonging either to a deity or to a deified human, is kept behind the main hall. This keeps it far away from the eyes of the worshippers who have come to pay offerings and request wishes from the enshrined god. Here, it is evident in multiple places that the sacredness of this space is separated from the profane. Firstly, there is a physical barrier between the outside and inside. The normal world is no place to keep a holy relic, thus a

---

88 Eliade, *The Sacred and the Profane*, 162-179.

sacred dimensional plane is required to house the item. Even more so this item is kept in an enclosed building behind the main worship area. Instead of it being cheaply displayed like a trophy, there is another separation between the follower and the holy item. In this way, even their eyes are not shown the sacred item. The washing of hands and mouth is not entirely a sacred space issue in itself, but because of the space set apart from the world, it is tantamount that a person who wishes to worship cleanses himself of the ungodliness that he brings in from the profane world.

This is seen in a more pragmatic sense too. Upon entering a Japanese home, one will immediately notice the "Genkan" or the foyer. This entrance place is where one takes off his or her shoes before stepping into the inner sanctuary of the house. While this does indeed keep dirt and grime from being stepped into the soft carpet, it is also reminiscent of entering a sacred and safe citadel where one is set apart from the dangers of the outside world. This is also seen in Japanese hotel rooms. A person is granted slippers with which to walk around the room. There are also slippers that one is expected to use in the restroom. Even if the restroom is only big enough for a single person to go in and is cleaned multiple times a week, it is still understood that one will wear these special shoes when using the bathroom. Even within a house, one must deal with the sacred and the profane. Here the profane is the bathroom which is considered "unclean." While this is practical, it is most certainly not only that. Even if the bathroom is cleaned and scientifically without germs, the association is still there. The threshold between the floor outside the bathroom and the tile within the water closet is a Torii of its own kind. While not a literal gate for the gods, it separates the entrance of the sacred and the profane.[89]

In contrast, Sacred space is a bit different for the American Nones. There are no shrines or churches for the Nones specifically. This is because places are dedicated to being sacred spaces by the Nones themselves. The process is much more subjective and based on the experiences of individual Nones rather than objective criteria. Theophanies, or experiences of "god," for the Nones are much more versed in daily lives. Places may be sacred because of memories or because they yield spiritual peace. With this in mind, many Nones may see their own homes as sacred. There is security or protection in such a place.[90] The house is where one lays him or herself to rest, it is where meals are cooked, laundry is done, and life, just in general, is lived. It can be seen as a reprieve from work, school, society, or any other outside forces. Since relationships and daily life are so important, the house might be the best example of a sacred place for the Nones.

A labyrinth may also evoke spiritual experiences for some Nones, thus causing it to be a sacred space. However, there is a softening of the boundary between sacred and profane for the Nones making this is a more personal experience and therefore no true of every None. Other examples may be real church buildings or synagogues. Still other Nones might find a gym or a library to be a sacred place. Many places in this world can yield a peaceful presence to a person. Some Nones may have places they considered sacred within nature though that will be addressed later on in the corresponding category. The core of what makes a place sacred for the Nones is not if it is aesthetically pleasing or if it is unique. With the Nones, the sacred intersects with the mundane making everyday objects or things

---

89 Ellwood, *Introducing Japanese Religion*, 28-31.
90 Drescher, *Choosing our Religion*, 155.

into relics and sanctuaries. What makes a sanctuary sacred? Is it because of the stained-glass windows or the wooden pews? It is because of the atmosphere or "vibe" that it puts off? Most likely, it is because of a theophany (a spiritual encounter); there is a presence of the sacred there that puts the place on the map.

In conclusion, there is a distinct difference between the Japanese Nationals and American Nones with respect to sacred space. One of the most contrasting differences between the Japanese Nationals and the American Nones is cleanliness. The concept of clean and unclean is more of a pragmatic issue for the Nones, and there are no consistent holy places to generalize. Likewise, some Japanese Nationals may find a difficult time seeing how a simple house is the sacred building equivalent to a shrine. This does not mean there are no similarities. Some Nones would indeed find the shrines of Japan capable of being the place of a religious experience. But sacred spaces for the Nones may be more about memories or relationships than about truly holy sites. Relationships are not unique to the Nones, as those are definitely aspects of Japanese religious systems as well. The key difference is that many Japanese Nationals may go to actual shrines, churches, or sacred places that are designated as such by an institutionalized religion. For the Nones, that demarcation is a lot more fluid. With respect to Sacred Space, there is not much that is very similar between the American Nones and the Japanese Nationals.

Sacred time
Sacred time is the second topic that will be compared. Just as above, after a few examples have been given for Japanese Nationals and American Nones, a conclusion about the similarities or differences between the groups will be given. Time is sacred in this context because mythic time, such as the creation of the world or the time when the gods and titans fought for control, is reversible. That is, the time of the present is fundamentally related to the ancient time when important events occurred. As previously mentioned, the creation of the universe is an excellent example of this.

The Japanese have many festivals that are celebrated throughout the year. It is most likely the case that if one village is not celebrating, then another somewhere is instead. "Matsuri" or festivals occur all year round. One excellent example of this is a celebration of the new year's inception. New Year's Day is a celebration of that mythic time relating back to creation because the world is reborn. The old world of the previous year has been lost to the annals of history and this new world of the present has taken its place. The world has been "recreated" in a way by breathing life into a "dying" year that creates a whole new world of opportunities. This time is sacred because it is fundamentally related to the creation of the universe. This rebirth of the whole world at the beginning of the year repeats the creation of the universe and thus is cause for celebration.[91]

A good example of sacred time in Japanese culture is also New Year's Day. Many people will go to a shrine on this day to show their respects to a deity as well as draw a fortune for the coming year. There is an interesting relationship between fortune and future on this sacred day. All throughout the year normal time where one must work or complete other tasks of life's fortune is considered a part of daily life. However, because the world is considered as being reborn, many go to seek a pleasing fortune for their future. The

---

91 Eliade, *The Sacred and the Profane*, 95, 104-105.

rebirth of the world is a symbolic rebirth of their own fortune. The shrine-goer is granted the opportunity to have a rebound in luck and wishes. Thus, it is perceived that heading to a shrine on this day grants a wish more power to come true. Fortune and Future become entangled in the same web and the sacred time adds to the sacredness of positive luck and the profanity that comes with negative condemnations by fortune. This rebirth of the world also brings closer the world of the gods, similar to Halloween in which the spirit world and the physical world comes close. The New Year's celebration is significant as it allows the gods to be in proximity to the realm of humans. This can be seen in the presence of the *namahage* in various Japanese New Year's traditions. These are ogres who come to villages to take away naughty children. In an interesting juxtaposition to Santa Claus, adults dress up as these ogres to keep children in line with the ethical norms. Instead of being good to receive a reward, the *namahage* provide incentive for children to be good to avoid punishment. While these are simply dressed up adults, the characters are very real to the children with various dances and activities that include them. This time is remembering a mythological one that has an ethical basis for the present.[92] Mythic time then becomes a reality in the present through these traditions.

Sacred time for the American Nones can be related to holidays and celebrations, just like the Japanese. However, Nones are more open than simply holidays and celebrations.[93] One example that Drescher used was the celebrations of Wednesday at one of the interviewee's homes. In order to further community and solidarity with family and the neighborhood, a celebration on Wednesdays occurred with food, drink, and merry socialization. This Wednesday could also be considered sacred time.[94] Time spent talking, helping, instructing, or listening to other people could also be considered sacred time as well. While this is just one example, it shows that relational ethics are important to the Nones. These types of events may be the foundation of sacred time for the Nones rather than just plain holidays. This isn't to say holidays have no importance, as holidays are good reasons to get together with family. The distinction is that the holiday is not what is most important, but rather the "get together with the family" is the key motivator.

Mythic time is a bit different too, since not all Nones believe in the creation story in Genesis or in a creation story at all. Some believe there was a large bang that created all things in the universe while others believe something entirely different. This does not make mythic time irrelevant to the lives of the American Nones, but, similar to the cleanliness issue, daily life is focused more on the pragmatic side of things than mythic ones. Mythic events may still be encountered, like in the New Year's example, but these are not very common due to a lack of ancient mythology to draw from.

In conclusion, both these groups are about equally similar and different. The New Year's celebration is still just as important to the American Nones culturally as it is for the Japanese. Thus, there are more similarities with respect to New Year's than there are differences. Nevertheless, the mythology of the Japanese and the incredible abundance of

---

92 Ellwood, *Introducing Japanese Religion*, 48-49.

93 By open, it is meant that there is more fluidity or less structure in the lives of some Nones as to what, specifically, is considered sacred time. Holidays, in general, are the easiest to see the connections as most holidays (literally, holy day) can be easily traced back to the origin event. For the Nones, not all holidays are meaningful in the same way, and some Nones may even find days more sacred than others regardless of whether they are holidays or not. This is not exclusive to the Nones by any means, but as a general rule, sacred time is more attached to daily life than specific, planned holidays.

94 Drescher, *Choosing our Religion*, 143.

festivals that the Japanese Nationals have make these two groups a bit different in practice. For the Japanese Nationals, myths become related to the present world. For the American Nones, while not impossible, myths are less likely to lead the way in sacred time as much as relationships are. While these differences are great, the emphasis on relationships is still extremely important for both groups. Communities in both Japan and America come together to celebrate victories or milestones. Both Japanese Nationals and American Nones show that relationships in these events are important and shouldn't be ignored.

Sacredness of nature

The sacredness of nature will be compared next with respect to both groups. Nature is unbridled and unpredictable. This supposed chaos is intriguing yet dangerous. However, there are also patterns and consistencies within nature that give it a sense of calm and soothing embrace. This mysterious aspect of nature may be worshipped or seen as something to be feared. Even to this day nature is unpredictable. Many technologies have come about in which one may try to predict the patterns within nature to keep those on this planet safe, but these instruments and tools are not all-knowing. Storms are unpredictable, and the United Nations has understood this well. It is against international law to conduct experiments for weather control for the purpose of war.[95] This shows just how much power nature has with respect to humans. Volcanos spit forth fire that can destroy cities. Earthquakes break open the very ground humans build homes upon and tsunamis destroys pillars of civilization without any difficulty. This power is mysterious but awe-inspiring. Thus, a sacredness of Nature is understood by many people groups. Whether it is dangerous or whether it is helpful, nature is still considered home.

In Japan this perhaps is shown no better than by Mount Fuji itself. Colloquially known under the title "Fuji-san," this volcano is quite large. It stands 3,776 meters above sea level and is quite a trial to climb.[96] This tribulation though is very rewarding, as the top of the mountain yields a beautiful sight of the sunrise. Something interesting to note is the various Torii (gates) that one passes to get to the top of the mountain. There are multiple Torii on the top, and there are even shrines at the top for the spirit of the mountain. This titan that reaches into the sky is thus home to mountain spirits and evokes spiritual awe in people. This spiritual awe has attracted pilgrims from all over, regardless of religious background. In the past, many have climbed the mountain to be spiritually renewed and to feel connected with the earth.[97] This is a perfect example of the sacredness of nature for the Japanese people.

Mount Inari is also an excellent example of this. The mountain is not even close to the height of Fuji but is nonetheless high enough to give a comprehensive view of Kyoto City and the surrounding mountains of the area. This mountain is famous for the one thousand Torii gates around the mountain to the top. These gates are built in such a way that they give the feeling of being transported to another world. The beauty of the nature around the shrine is a very part of the shrine itself. This is also evidenced by the two metal temples, Ginkaku-ji and Kinkaku-ji. The Kinkaku-ji is a gold temple that, while impressive itself, is greatly enhanced by the beautiful gardens that surround it. The same can be said of the silver Ginkaku-ji. In both areas, the temple is magnificent, but the nature around it

---

95 "Environmental Modification Convention." U.S. Department of State. https://www.state.gov/t/isn/4783.htm

96 "Mount Fuji." National Geographic Society. November 09, 2012. https://www.nationalgeographic.org/media/mount-fuji/

97 Ellwood, *Introducing Japanese Religion*, 169.

is what enhances the feeling of greatness. Truly, it could almost be argued that nature is the focus of the area rather than the temples themselves. Even when visiting them, one walks around the temples in very little time in comparison with the amount of time one traverses the beauty of the surrounding hills and gardens. This natural beauty is beloved by the Japanese.[98] These gardens are important though. Elwood explains that "these gardens, like so much Japanese art combining both aesthetic and spiritual meaning, are neither raw nature norhuman geometry, but rather like minimalist abstractions of nature."[99] These gardens are meant to serve as a means of reaching the Buddha. The meditator would focus on these gardens and, after penetrating to the essence of this sacredness of nature, would experience the wisdom of the Buddha in all of its glory.[100]

Many cities, including Tokyo, are excellent examples of a synthetization of nature and modernity. Instead of simply leveling the whole area and building many tall skyscrapers, there are many trees and parks within cities that are notably given a lot of care. The cohabitation of man and nature in Japanese cities is evidence just how much the Japanese have an intuition of the sacred aspect of Mother Earth.

The Japanese show much of their appreciation for the earth through artistry and skilled painting. "The Japanese … have never dealt with nature in their art in the universalistic sense of trying to discern any grand order or structure; much less have they tried to associate the ideal of order in human society with the harmonies of nature."[101] Landscapes and completely natural scenery are preferred. The gentle but fierce beauty of the ocean's waves are looked on with admiration. Raw sincerity was nature of the artist's brush when depicting nature.[102] This love of the natural or worn beauty of things can be considered another piece of the celebration of the sacredness of nature.

In comparison to the Japanese, the sacredness of nature can also be observed in the American Nones. The Nones have the same appreciation of nature and many, as mentioned previously in this project, enjoy meditating in natural areas or taking walks in nature. There is a connection between the spiritual experience of the None and the presence of nature. There may be a connectedness or a mysterious bond that forms. Gardening is a good example of this. Although seasonal, gardening is an example of an everyday experience in which Nones come into contact with nature by, literally, "getting their hands dirty."

This can also be seen in one of the four F's. Cats and dogs are good examples of nature in the daily lives of American Nones. Other pets are also the objects of connections and interactions that may hold meaning for some Nones.[103] These pets are alive and interact with their human owners or companions in unique ways. They are not robots or "husks" without souls. They have life to which humans can also relate. If it can be said this way, there is a type of sacredness in interacting with the world around us. Nature is part of the relational connectivity that one can see in the Nones.

Between both the Japanese and the American Nones, there are quite a few similarities. It cannot be understated that both groups can see nature as holding something important and the connection humans have to the earth, our home. Both Japanese and American Nones

98 Varley, *Japanese Culture, 121-122.*
99 Ellwood, *Introducing Japanese Religion, 154.*
100 Ellwood, *Introducing Japanese Religion, 154.*

101 Varley, *Japanese Culture, 132.*
102 Varley, *Japanese Culture, 133.*
103 Drescher, *Choosing our Religion, 140-142.*

care for the Earth, and the political issues that surround that category are topics about which many feel passionate. With regards to political policies and the environment, 68% of unaffiliated believers, 77% of atheists and 79% of agnostics believe the government should have stricter environmental protection laws according to the results of a Pew survey.[104] The embrace of Mother nature can be seen in cities, villages, and everywhere in between. The difficulty in America is sometimes seeing that beauty in major cities. The silent, and sometimes not so silent, beauty of nature can easily be forgotten in urban, quick-paced societies, but both the American Nones and many Japanese remember Mother Earth fondly. That connection has meaning for everyday life and even can shape a person's worldview.

Sacredness of human existence

As with many definitions, the knowledge of life is due to the knowledge of death. A hot drink is hot because it is not cold. There is an understanding of the concept of cold then as not hot. The knowledge of the word comes from not just knowing the word but its opposite as well. The same thing can be said of life. A being who is alive is thus a being who is not dead. Likewise, a person who is dead is thus not alive. This is why death, at such a young age, is difficult to grasp, since life is all that is known. Because death is profane, life is sacred. Negation of the opposite is not the only way to look at death. Death is not just "not alive" but rather can be seen as an absence of life. However, even this absence of life shows how important the sacredness of life can be, since life has now left the body as opposed to death inhabiting it. Eliade sees that, "for religious man, death does not put a final end to life. Death is but another modality of human existence."[105]

Death is a transition from this world into the next, the afterlife. This can be seen in general but can also be seen in rituals. Many rituals have an initiatory death that leads to a "resurrection" or "renewal" of a person. There is a new birth that takes place. Death is profane but is overcome by a transformation of being. Once the person is reborn, they may experience new things or have a new perspective on the world. Wisdom may be given that was previously inaccessible[106] Death plays an important role in religious symbolism, making its prevalence in this world something that must be discussed in religions.

In Japanese culture, there is an understanding that death is unclean and those who work with the dead are sometimes ostracized by the living due to their line of work since they are in close proximity to the profane. These are the Burakumin, literally the "hamlet people" and include such vocations as undertakers, sanitary workers, and even those who simply work with leather.[107] Here the idea of cleanliness is brought up again. However, this time it is not a separation of space, such as physically separating clean from unclean, but of life and death. Rites of passage are excellent examples too. As a person continues to live, he or she grows older. These rites are milestones that everyone goes through. The sacredness of life is fully shown by the celebration of the rites of passing from one era to another.

---

[104] Baker and Smith, *American Secularism*, 178-179.
[105] Eliade, *The Sacred and the Profane*, 148.
[106] Eliade, *The Sacred and the Profane*, 198-201.
[107] "Japan's Hidden Caste of Untouchables," *BBC News*, October 23, 2015. https://www.bbc.com/news/world-asia-34615972.

An excellent example of a rite of passage within the understanding of the sacredness of life is the coming of age ceremony in Japan. In January every year, any person who has turned twenty in the previous year takes a part of the coming of age ceremony. This is not a small-scale celebration, however: this includes everyone who can attend and includes many events and activities that celebrate the passing of the era of adolescence into adulthood. In Kyoto, many girls who are skilled in the art of the "Yumi" (A Japanese bow) proceed to the Sanjusangen-do temple the day before the celebration. These young maidens participate in an archery tournament to commemorate their passing into adulthood. This is just one example of the activities that occur to celebrate the coming of age of a human being in Japan.[108] The coming of age ceremonies are held all around Japan and include celebration of the transition of children to adults when they turn twenty. This new stage of life includes things like legally being able to drink alcohol, drive automobiles, and gamble. Men usually dress up in suits and women dress up in attractive *kimono*[109] and after many pictures and public celebrations, there are usually private after parties. The whole day is a celebration of life and the joys of becoming an adult. While there is no magical transition, the event still holds meaning for those in attendance and those who watch.[110] The sacred can be found in this celebration of life and growth. Human experience can be seen on full display during these celebrations.

Marriage is another example of celebration of life. This is quite interesting, as in Japanese culture a standard Shinto wedding involves the wife symbolically dying to her old family and becoming a part of the husband's family. Although this celebrates the sacredness of another passing from one segment of life to another, it includes the ritual of dying to an old family and being reborn into a new one. Sometimes a woman is even removed from her family tree and added to her husband's tree, in order to finalize the symbolic death to her old family. This celebration though is still considered a special event and celebration of the union of two people, albeit usually in a more secular manner. As a variation it is interesting to note that many wedding chapels have cropped up in the past few decades. Western weddings have become fairly popular in the recent years and although they are not the same as the Christian weddings they are based upon, they still account for a celebration of life.[111]

Of course, marriage, life, and death are all things that are a part of the daily lives of American Nones. Some will hold traditional Christian or religious funerals, but this is of course not required. Each None will have his or her own way of dealing with the spiritual aspect of death. The same can be said of life and marriage. While some have traditionally religious weddings, many Nones choose to have private, non-religious ceremonies to save money or not make a big deal about it. The same is true of Japanese. Although there is a separation between religion and marriage, the spiritual sacredness of that experience still holds meaning. Other personal reasons may account for such a decision as well. Fewer people in general are getting married in contemporary society. Divorces and cohabitation

---

108 "Kyoto's 400 Year Old Archery Competition," Japan Talk, July 31, 2015.
    https://www.japan-talk.com/jt/new/kyotos-400-year-old-archery-competition.

109 A kimono is a Japanese-style of "dress" that is a staple at many celebrations. It is layered and usually tied with an obi, or a sash that will keep the kimono closed and in place. There is no direct western equivalent, but it can be used in both formal and informal ceremonies.

110 Alicia Joy, "Everything You Need To Know About Japan's Coming Of Age Day," *Culture Trip*, December 28, 2016. https://theculturetrip.com/asia/japan/articles/everything-you-need-to-know-about-japans-coming-of-age-day/.

111 Ellwood, *Introducing Japanese Religion*, 68-69.

are climbing as well, making marriage an experience that not every None may go through or even desire.[112] It is also true that some American Nones have chosen not to get married or are single. For Nones, the real sacredness of humanity comes in the relationships and social contact that occur on a daily basis.

This is also true of the Japanese and is where the closest similarities between each group occurs. Both Japanese Nationals and American Nones have a focus on relationship with others as a sacred experience. The influence of Confucianism for the Japanese Nationals and the relational ethics for the American Nones are possibly the greatest explanations for this occurrence. The care for one's fellow human as not a religious maxim, but more of a spiritual posture. This does not mean that the religions of Japan or the spiritual lives of the American Nones are the same. But the focus on others and their well-being is an important part of the daily spiritual lives of both the Nones and the Japanese. This makes this similarity very interesting and very important. This is important because relationships become the basis of spiritual reality, to some extent, for both the American Nones and the Japanese Nationals.

Ethics

Before wrapping up, there is one more area in which I would like to compare these two groups that lies outside of Eliade's four areas of sacred and profane. A comparison of ethics, with respect to the Japanese Nationals and American Nones, would be extremely interesting with reference to both groups. Much of the ethical practices of the Japanese come from Confucianism and Buddhism. The collective aspect affects it as well and can be seen in the Confucian concept of *ren*, or love for one's fellow man. From this ethic, a Confucian rule known as the silver rule (because it focuses on negatives, not positives) has come into the present time. The rules states, "whatever you do not want to happen unto you, do not treat others in that way." Linguistically this is the negative version of the golden rule that many American Nones cite as one foundation for their ethical systems. The golden rule states: "do unto others as you would have them do unto you." This similarity is extraordinary. Both the Japanese and American Nones have a basis in ethics that are worlds apart yet have come to almost exactly verbatim conclusions of what relational ethics looks like.

It should be mentioned, however, that there is a difference between treating someone how one would desire to be treated and refraining from doing harmful things because one does not desire those harmful things to be inflicted upon oneself. This difference is philosophically important. While these two rules are linguistically related, their implications may lead to different results. People do not love others because they don't wish to be hated, the opposite of both hate and love is apathy, or a lack of passionate emotions. Thus, if there is to be a true similarity, there needs to be a bit more to this than two rules plated in precious metals.

Linda Woodhead looked at the "no religion" population in Britain and, while the United Kingdom is not the same as the United States, she brings an insight into the ethical norms of the Nones that may bring this comparison into a clearer light. Woodhead states: "Ethically, the normality of 'no religion' is evident in the non-negotiable view that all human beings have a duty and a right to fulfil their own potential and help others to do the same."[113] Both groups do not just look at a golden or silver rule but also look at social

---

112 Baker and Smith, *American Secularism*, 68.

113 Linda Woodhead. "The Rise of 'no Religion' in Britain: The Emergence of a New Cultural Majority." *British Academy Lectures*, 2015-16 (January 2016).

censure as well. As explored early, *Shudan Ishiki*, or group consciousness, looks to the betterment of the group, not just the individual. A person has a social duty to act morally for the betterment of the group.[114] Social obligation plays a big role as well, then, for the ethical norms of both groups.

This similarity transcends both time and space. The ethics of Jesus and the ethics of Confucius have passed on to groups that are only now somewhat related to them. This adds even more weight to the similarity already seen between each group with respect to relationships. The silver and golden rules are related, but with idea of social obligation and ren involved, there is an ethical context to these two rules. The ethics of these two groups come from somewhat sacred and religious backgrounds along within the community that each group is immersed.

Conclusion

The earlier comparisons show that there are three specific areas in which the Japanese Nationals and American Nones are similar. Relationships, the sacredness of nature, and ethical understandings are all extremely similar across these two groups. These are not the only similarities, and there are plenty of differences as well, because neither of these groups are completely unlike the other.

There is not much evidence that there is a significant similarity between the Japanese Nationals and the American Nones when it comes to the ideas of sacred space or sacred time. Because of the nature of both spiritual systems, sacred space is understood in different ways, and sacred time does not hold the same meaning for each group. This does not mean that there are no connections among these things, as each group applies Eliade's concepts in different ways. This difference is noticeable and therefore there is no real similarities to conclude.

On the other hand, both Japanese Nationals and American Nones see the sacred in human (and sometimes not-so-human) relationships. The sacredness of human life comes to a head in which relationships become the theophanies themselves. These relationships even affect their ethics. While not identical, each group has similar ethical rules that are demarcated by the obligation these groups feel to their personal and global communities. Relationships are the most significant similarities as both groups have a heightened focus on the importance of social capital and connections.

Nature also has its role to play in these spiritualities as well. The connection between humans and nature is a mythic one that goes back to the origin of humanity. Spiritual experiences have a relationship to nature. As shown earlier, there is a focus on being in nature in the temples of Shintoism and Buddhism and the spiritual experiences of the Nones.

There is also a similarity between these groups in the understanding of religion in general. The American Nones incorporate different aspects of spiritualities in their lives that they have experienced. This is not just an arbitrary "pick-and-choose" type of spirituality. The intersection of multiple faiths come together with experience to produce a personal conglomeration of ideas in the spiritualities of the Nones that is practical in daily life and based in social relationships. For the Japanese, religions have built on each other over

---

114 Roger Davies and Osamu Ikeno, *The Japanese Mind*, 195-198.

time. New religions do not replace the old ones but rather build on top of them. This is what makes Japanese Religions so interesting to study "In this special country, as religious history rolls along down the centuries, new "layers" of religion are added one on top of the other, but the old—even the oldest forms—seem never quite to disappear."[115] Both groups seem to build upon older religious traditions to form a unique and personalized spiritual world. One that is individuated but still addresses the sacred.

The similarities of the American Nones and Japanese Nationals are seen in relationships, nature, and ethics. These three aspects pervade the quotidian experiences of both groups, making them very important to observe. With these similarities in mind, the next section will look at the possible reason for these similarities while trying to find part of the essence of humanness in daily life.

WHAT DOES IT MEAN THEN TO BE HUMAN?

What then does it mean to be human? What is the deeper meaning of these similarities and differences between the American Nones and the Japanese Nationals? These similarities have implications for human experience that will be discussed heavily in this section. From this discussion, some practical and theoretical applications will be given to conclude this project.

For the question of "what does it mean to be human?" the answer proposed in this project will be the following: to be human is to have an intuition for the spiritual. It does not seem to be the case that animals construct religions, cults, or other structured religious institutions. Humans have an intuition for the spiritual in the sense that humans can sense and experience the sacred and find it different from everyday life. The really interesting idea that is seen somewhat in the Japanese Nationals but a lot in the American Nones is the breakdown of this distinction between the sacred and the profane. The sacred can occur every day in mundane life. This blurring of the lines is quite important with reference to the understanding of the sacred then for both the Japanese and the Nones. There are similarities in the spiritualities of both groups in which this occurs. This means the dichotomous understanding that there is only an "in-group" and an "out-group," with respect to religion, is somewhat of a roadblock to understanding groups with a more holistic approach to spirituality.[116] The evidence for this spiritual intuition can be seen in the universality of religion and the spiritual experiences that occur outside religiously affiliated organizations.

This intuition for the spiritual should not be overlooked or glossed over. The possibility that people have an intuition for the supernatural has a good many logical consequences. For one, it means that spiritual experience is not just dedicated to one "right" religion. Some people may be more intuitive than others in this regard. Those who are more intuitive in the spiritual realm may become priests, presbyters, imams, rabbis, monks, teachers, or leaders in religious organizations. It would probably be safe to say that historical people like Mohammad, Moses, Jesus, Siddhartha, and Shinran are examples of people who

---

115 Ellwood, *Introducing Japanese Religion*, 7.

116 This is not to say that institutional religions are not holistic. Nor is it to say dichotomies are always useless. Membership in a church or institution arguably should indeed be a dichotomous thing. But spiritual experience is more fluid and dynamic and thus does not always fit neatly into categorized boxes. Not everyone has the same religious experience as shown by the American Nones.

have had an above average intuition for the spiritual. Assuming that such an intuition is normally distributed, then most people are in the average. This also means there are very few people with little intuition for the spiritual, and it could be argued every single person has at least some intuition for the spiritual. This means that *all* people have the ability to interact with the supernatural realm, at least to some degree.

This also would mean that the postulation that there is no such thing as a supernatural realm holds less sway. The goal of science is to observe the empirical realm, and while religion does not entirely deal with empiricism, it would be difficult to argue a biological basis for an "intuition of the sacred." It is understandable that some may feel there is no depth in concepts like God, karma, or magic, but the prevalence among people, even outside normalized religions, is a very good counterargument to this idea that would need to be addressed. Even with a more secular world, the intuition of the sacred and the profane does not seem to be dying out but rather changing and evolving.[117] This can be seen by the very fact that the spiritual lives of people are growing outside the boundaries of institutionalized religion. This growth cannot be so simply explained by either adherence to a specific tradition or the lasting effects of Christianity. There is something deeper at work that has just as much value in people's daily lives outside of the church as those within it. Job 32:8-9 says "But it is the spirit in man, the breath of the Almighty, that makes him understand. It is not the old who are wise, nor the aged who understand what is right."[118] The context to this verse is that Elihu, who is younger than Job and his three friends, has found the prior conversation unsatisfactory. He has waited for his turn to speak and, in order to show he means well and has authority, he defends himself. He knows that he is young and not as wise as the other men. Nevertheless, he points out that there is something more important than age that lends itself in understanding. The "breath of the Almighty" is within all people. I think that the very intuition for the spiritual is what Elihu is referencing here. There is a deeper reality beyond human, empirical sense.

Humans are animals that have an intuition for the spiritual. Perhaps it could be seen as the desire to create meaning, perhaps it is simply delusional. But these arguments would state then that most, if not all people, are delusional and pathological liars. Spiritual experience is not dominated by one religion, and there are things that occur in this would that evoke awe. Ineffable experiences that simply cannot be described academically, or even verbally, are present all over the world. The unaffiliated, at least in the argument in this paper, are key to understanding this phenomenon. There is simply "more to it than meets the eye" and this is vital to understanding unaffiliated points of view and, arguably, humanity in general.

Some other conclusions may include things like creating relationships with the American Nones. Indeed, this is not a unique idea, but the devil is in the details. Seeker-sensitive churches may have good intentions, but just saying a church is "welcoming" does not mean people will suddenly come. Real relationship means pursuit of the other person. Just as Jesus leaves the ninety-nine sheep for the one lost lamb, so too ought the church pursue the Nones. The real focus, however, is not on relationships, but on relational experiences in everyday life. The church needs to meet the Nones in the mundane of quotidian existence. Daily life is considered sacred to many Nones, and that is the keystone in the archway of our bridge. The church cannot talk about relationship with a God who is "out there," as

---

117 Baker and Smith, *American Secularism*, 216-217.
118 *Holy Bible ESV* (Crossway Books, 2016).

such an impersonal God is of no interest to those who see relationships as sacred. Rather, the church needs to be intuitive as well and see God in everyday reality. The church needs to foster relationships with the Nones by showing them that the God we worship too is part of the everyday, not just on a Sunday.

Many people, in the present research, have begun sounding "alarm bells" in institutionalized religions. There is a general fear that people are leaving the church and promptly becoming either anti-church or anti-religious.[119] While it is true people are migrating out of the church in some ways, hopefully, this project has shown that such irreligiosity may not be the case. Another hope is that this project has shown the importance of qualitative research about this subject. While many Nones spoke of their disconnect from the church, their positive outlooks towards spirituality is a blessing that needs to be addressed as well as affirmed. There are bridges religious teachers can make to these unaffiliated. Although the purpose of this project is not to provide strategies to religions to attract converts, one example may be to follow some of the strategies of Japanese missionaries. Word of mouth from a friend is one of the most effective ways of spreading the gospel in Japan and many house churches and bible studies exist and are successful in creating disciples of Christ that honor God. Ethics may be a good way too. Appealing to the ethical values of the Nones and possibly showing that there are similarities and just what those similarities mean would be an excellent start as well. James Emery White in his book the *Rise of the Nones*[120] talks a lot more about strategies that church leaders can use to reach the Nones. His focus is on a "reimagining of the church." While discussing ecclesiology, White says that Christians need to reaffirm their own dedication to the church especially if that is what it takes to attract the Nones.[121] We must become "one, holy, catholic, apostolic" church that is united with Christ in being a compassionate light unto the world.[122]

The American Nones and Japanese Nationals have a similar view of relationships and sacredness. Even with all of the differences between the groups, ethical and religious matters emphasize interpersonal connections. This social web of relationships is the primary catalyst for many spiritual experiences. There can be an experience of the divine outside of other people, this is to be sure. However, the theophanies yielded by friends, family, and community have a life-changing impact on many members of both these groups. American Nones and Japanese Nationals connect with existence and daily experience on a social level. In a very real way, the sacred is seen primarily through other people in community. They have similar views of how religion changes. The evolution is careful, and never quite removes the old from the new. This new still witnesses the theophanies of relationships all while still addressing the sacred from the soul.

Prayerfully, this project has shone a light on the spiritual lives of both the American Nones and the Japanese Nationals. Both the Japanese Nationals and the American Nones are interestingly similar with respect to the sacredness of human life and of nature. There are also similarities within sacred space and sacred time, but there are of course differences as well. The goal of this project is not to equate these two groups as the same. In fact, some may find it difficult to see how applying spiritual experiences from one culture to another makes sense or is useful. The argument of this project is not that these groups are the same,

---

119 Baker and Smith, *American Secularism*, 85-87.
120 White, *The Rise of the Nones*.

121 White, *The Rise of the Nones*, 165.
122 White, *The Rise of the Nones,* 167-168

but that the unaffiliated nature of the American Nones is not exactly new. The reported rise is actually somewhat of a consequence of the enlightenment and postmodernism. But similar things have been going on in Japan for quite a long time. There is a holistic understanding of religion and culture in Japan and indeed much of the Far East. While it may seem new to the west, it is not entirely new unto the world. Indeed, it almost seems as if there is a Japanese way of doing religion in America that is subtly growing. This Japanese way in America is extremely intriguing and may yield more results if truly studied more closely.

BIBLIOGRAPHY

Baker, Joseph O., and Buster G. Smith. *American Secularism: Cultural Contours of Nonreligious Belief Systems*. New York, NY: New York University Press, 2015.

Baker, Joseph O., and Buster G. Smith. "The Nones: Social Characteristics of the Religiously Unaffiliated." *Social Forces* 87, no. 3 (March 01, 2009): 1251-263. doi:10.1353/sof.0.0181.

Bunce, William Kenneth. *Religions in Japan: Buddhism, Shinto, Christianity*. Rutland, VT: Charles E. Tuttle Company, 1955.

Coslett, Matthew. "Japan: The Most Religious Atheist Country." GaijinPot Blog. February 8, 2015. Accessed December 14, 2018. https://blog.gaijinpot.com/japan-religious-atheist-country/.

Davies, Roger J., and Osamu Ikeno. The Japanese Mind: *Understanding Contemporary Japanese Culture*. Tokyo: Tuttle Publishing, 2002.

Drescher, Elizabeth. *Choosing Our Religion: The Spiritual Lives of Americas Nones*. New York, NY: Oxford University Press, 2016.

Drummond, Richard H. *A History of Christianity in Japan*. Grand Rapids, MI: W. B. Eerdmans, 1971.

Eliade, Mircea. *The Sacred and the Profane: The Nature of Religion*. San Diego, CA: Harcourt, Brace, 1987.

Ellwood, Robert S. *Introducing Japanese Religion*. Second ed. London: Routledge, 2016.

"Environmental Modification Convention." U.S. Department of State. Accessed December 14, 2018. https://www.state.gov/t/isn/4783.htm.

Fox, Robin. "Food and Eating: An Anthropological Perspective." 2014. Accessed March 29, 2019. http://www.sirc.org/publik/foxfood.pdf.

Fuller, Robert C. *Spiritual, but Not Religious: Understanding Unchurched America*. Oxford: Oxford University Press, 2001.

Holy Bible ESV. Crossway Books, 2016.

"Japan's Hidden Caste of Untouchables." BBC News. October 23, 2015. Accessed March 21, 2018. https://www.bbc.com/news/world-asia-34615972.

Joy, Alicia. "Everything You Need To Know About Japan's Coming Of Age Day." Culture Trip. December 28, 2016. Accessed March 29, 2019. https://theculturetrip.com/asia/japan/articles/everything-you-need-to-know-about-japans-coming-of-age-day/

Kosmin, Barry A., Ariela Keysar, Ryan Cragun, and Juhem Navarro-Rivera. "American Nones: The Profile of the No Religion Population." Trinity College Commons. August 2011. Accessed March 21, 2018. http://commons.trincoll.edu/aris/files/2011/08/NONES_08.pdf.

"Kyoto's 400 Year Old Archery Competition." Japan Talk. July 31, 2015. Accessed March 29, 2018. https://www.japan-talk.com/jt/new/kyotos-400-year-old-archery-competition.

Lee, Samuel. "Why Is Christianity Not Widely Believed in Japan?" Project Japan. August 16, 2013. Accessed March 22, 2018. http://projectjapan.org/pj/Article/Entries/2013/8/16_Why_Is_Christianity_Not_Widely_Believed_in_Japan.html.

MacCulloch, J. A., and George Foot Moore. *The Mythology of All Races in Thirteen Volumes*. Vol. 8. New York: Cooper Square Publications, 1928.

Mercadante, Linda A. *Belief Without Borders: Inside the Minds of the Spiritual but Not Religious*. New York, NY: Oxford University Press, 2014.

Moffett, Samuel Hugh. *A History of Christianity in Asia*. Vol. II. Maryknoll, NY: Orbis Books, 2005.

"Mount Fuji." National Geographic Society. November 09, 2012. Accessed December 14, 2018. https://www.nationalgeographic.org/media/mount-fuji/

Never on a Sunday: *The Challenge of the Unchurched*. Glendale, CA: Barna Research Group, 1990.

Parsons, William B. *Being Spiritual but Not Religious: Past, Present, Future(s)*. London: Routledge, 2018.

"Postmodern Worldview." AllAboutWorldview. 2018. Accessed December 15, 2018. https://www.allaboutworldview.org/postmodern-worldview.htm.

Varley, H. Paul. *Japanese Culture: 4th Pa* (Updated and Expanded). University of Hawaii Press, 2000.

White, James Emery. *The Rise of the Nones: Understanding and Reaching the Religiously Unaffiliated*. Grand Rapids, MI: Baker Books, 2014.

Woodhead, Linda. "The Rise of 'no Religion' in Britain: The Emergence of a New Cultural Majority." *British Academy Lectures*, 2015-16, January 19, 2016.

Study of Alpha Mangostin as a Chemoprotective Agent for Breast Cancer via Activation of the P53 Pathway

Vanessa V. Van Oost

ACKNOWLEDGEMENTS

ABSTRACT

Breast carcinoma is the most frequently diagnosed cancer among women and causes over 400,000 deaths each year worldwide. Current treatments such as chemotherapy are not selective for cancerous tissues but are destructive to normal tissues as well. This causes a range of side effects including pain, nausea, hair loss, weakness, and more. Inactivation of p53 is a very common mutation within human cancer cells. The ability to activate the p53 pathway, which protects cells from tumor formation, is lost in 50% of cancers. Due to the prevalence of this mutation, p53 is a uniquely valuable target for applied research. Alpha mangostin is an extract from a southeast Asian fruit, *Garcinia mangostana*. It has potential to be an effective p53 activator in which the small molecule disrupts the binding of p53 to MDM2, a negative regulator, inducing the p53 cascade, which results in cell cycle arrest for low level stressors. This protects the cells from paclitaxel, a chemotherapy agent that only kills actively dividing cells. Here, we hypothesized that alpha mangostin protects wild-type, but not p53 (-/-), MCF10A breast cancer cells from the chemotherapeutic agent paclitaxel. When MCF10A wild-type cells were cotreated with alpha mangostin and paclitaxel, alpha mangostin exhibited a protective effect on the cells. However, when MCF10A P53 knockout cells were treated with alpha mangostin, cell viability decreased, indicating a loss of protective effect in the p53 distressed cancer cells. These results further support treatments that target chemoprotection via p53 pathway in wild-type cells, and the use of alpha mangostin warrants further study.

LITERATURE REVIEW

Breast carcinoma and treatments

The development of cancer is a multistep process that involves complex interactions between host and tumor tissue. The process involves oncogene activation as well as immunosuppression, leading to uncontrolled cell growth despite damaged DNA (Wang 2010). Genome instability contributes to cancer development due to mutations in DNA damage response pathways, which are mediated through the tumor suppressor p53 (Reinhardt & Schumacher, 2012).

Breast carcinoma is the most frequently diagnosed cancer among women and causes over 400,000 deaths yearly worldwide (Walerych, Napoli, Collavin, & Del Sal, 2012). Metastasis accounts for a large majority of the deaths that result from breast cancer, mostly to lymph nodes, lungs, and bones. The complexity of cancer leads to difficulties in treatment. Many of these difficulties are due to the nonselective nature of the treatment, which cause cell toxicity in noncancerous cells. Treatment plans are dependent on the stage and characteristics of the cancer as well as the age, menopausal status, and risk benefit analysis associated with each option. Based on a study in 2017, stage I and II patients most often receive breast conserving surgery. Stage III patients most often receive a mastectomy, radiation therapy, as well as chemotherapy with a five-year survival rate of 72%. Stage IV patients most often receive radiation therapy and or chemotherapy with a five-year survival rate of about 22% (American Cancer Society, 2017).

In order to delay the progression of breast cancer and increase the longevity of patients, less toxic yet effective chemotherapeutic agents are needed to limit the debilitating side effects while also improving outcomes (Shibata et al., 2011). These side effects include pain, lymphedema, musculoskeletal symptoms, bone loss and osteoporosis, heart problems, new cancers, blood clots, infertility, and loss of memory and cognitive function. (American Cancer Society, 2017).

Currently, conventional treatments such as radiation, chemotherapy, and surgery have not been entirely effective against the high incidence and low survival rates of breast cancer due to its complex nature (Moongkarndi et al., 2004). Research has established that combinations of drugs are more effective than one drug alone for the treatment of early-stage breast cancer. An example of such treatment is Trastuzumab, a monoclonal antibody that directly targets the human epidermal growth factor 2 (HER2) protein.
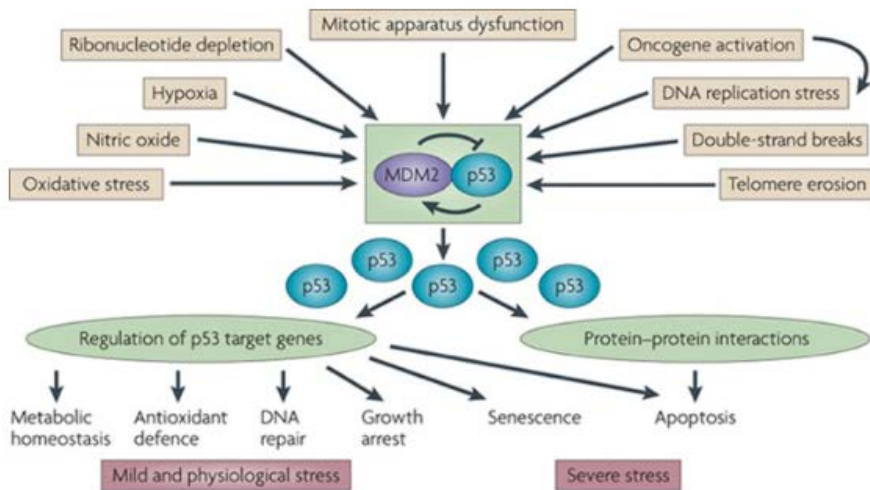
Figure 1. Various outcomes of the p53 pathway. Different causes, such as those of mild physiological stress or severe stress, interrupt the mdm2 and p53 binding and result in various outcomes such as DNA repair, growth arrest, apoptosis, and more (Vogelstein, Hughes, Kimmel, & Cancer, 2013).

When combined with chemotherapy, this treatment was found to reduce the risk of recurrence by 52% and death by 33% for patients who overproduce the growth promoting protein HER2/neu (American Cancer Society, 2017). This leads the scientific community to search for other potential therapeutic approaches including drug combinations to treating this malignancy and many other cancers that continue to evade conventional treatments.

P53 gene and cascade
The main function of p53 is to promote genetic stability and prevent the formation of tumors. When a cell is under stress, it induces cell death through apoptosis for severe stress or cell arrest and subsequent DNA repair for mild stress in order to prevent malignant growth. Under normal conditions, p53 levels are low and the binding to mouse double minute 2 homolog (MDM2) targets it to the proteasome for rapid degradation and inhibition of its transcriptional activity (Burgess et al., 2016).

When stress occurs, binding to the regulatory protein MDM2 is disrupted due to P53 phosphorylation, which leads to p53 accumulation and subsequent transcription of numerous genes, including the gene that encodes the cyclin-dependent kinase inhibitor (CKI) protein p21. P21 binds and inactivates G1/S-Cdk complexes, arresting the cell in G1 for DNA repair.
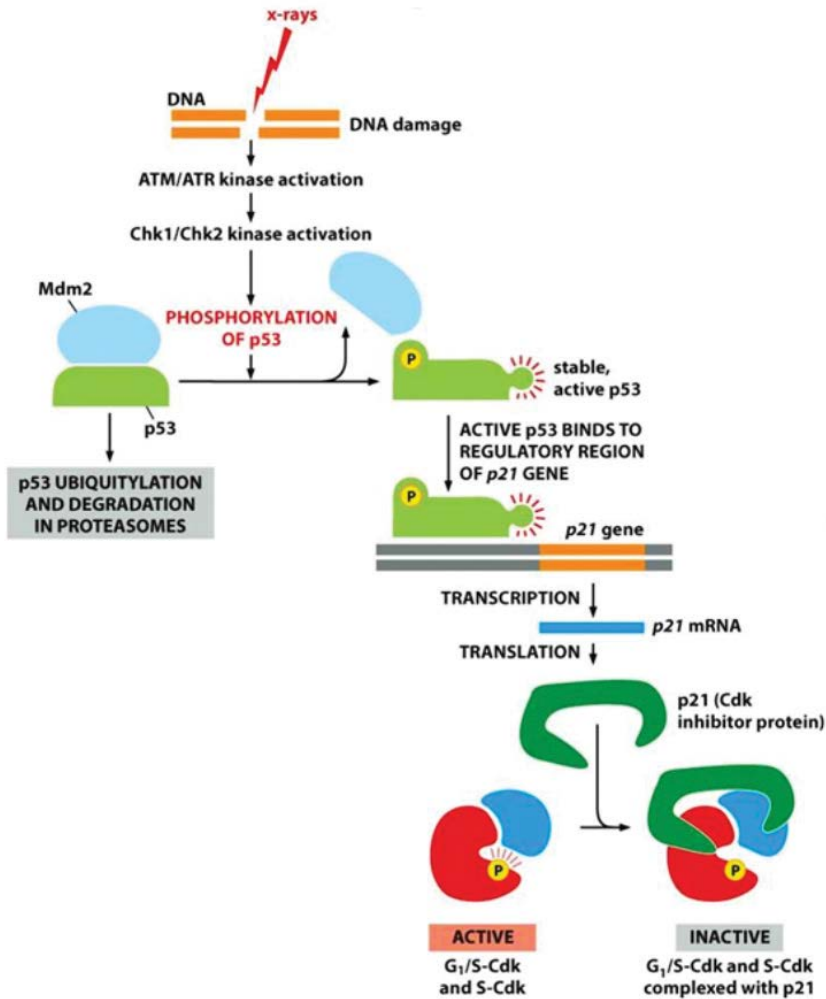
Figure 2. The p53 cascade. This figure is a simple representation of a cell's response to stress that result in DNA damage. The first step is phosphorylation of p53 to affect its binding to mdm2. This process also includes a key player in the process, p21, which is a Cdk inhibitor. The end result is an inactivation of the G1.S-Cdk and D-Cdk complex with p21. (Vogelstein, Hughes, Kimmel, & Cancer, 2013).

P53 mutation and treatments

Inactivation of p53 is a very common feature of human cancer cells (Lane, Cheok, & Lain, 2010). About 50% of adult cancer has p53 inactivated (by mutation or deletion), while the other 50% has suppressed wild-type p53 function (Choong, Yang, Lee, & Lane, 2009). On average, p53 is mutated in 20% of tumors in breast cancer. Though the frequency of mutation is lower in breast cancer cells, p53 inactivation has been seen in some breast cancers without a mutation. The pathway has been shown to be affected by alterations in upstream regulatory proteins and downstream p53-induced

proteins (Gasco, Shami, & Crook, 2002). In breast cancer, this mutation is associated with a more aggressive disease and worse overall survival according to several studies (Gasco et al., 2002).

The ability to activate the p53 pathway that protects cells from tumor formation is lost in cells with p53 mutations. Most of these mutations occur as a result of a substitution of single amino acids in the central region of the p53 protein, which causes many variants (Walerych et al., 2012). Indeed, rapid malignant cell growth, which leads to many different cancer types, often involves a defective p53 gene, which is the transcriptional activator that works to suppress tumors in normal tissues (Muller & Vousden, 2014). In breast cancer, mutant p53 is involved in many processes associated with cancer development such as early tumorigenesis, tumor growth and development, and metastasis (Walerych et al., 2012). In clinical practice, molecular pathological analysis of the tumors of the structure and expression and constituents of the p53 pathway is likely to have value in diagnosis, in prognostic assessment and, ultimately, in treatment of breast cancer (Gasco et al., 2002).

Chemotherapy and mechanism of chemoprotection
Chemotherapy induces many adverse effects in patients because of normal cell toxicity, resulting at least in part from p53 activation and apoptosis induction in normal proliferating cells/tissues such as bone marrow, lymphoid organs, hair follicles, and epithelium lining of the small intestine (Wang & Sun, 2010). An important aspect of chemotherapy is that it kills actively dividing cells. In particular, paclitaxel inhibits microtubule function, which kills cells as they enter mitosis (Blagosklonny, 2002). Microtubules are essential to the process of mitosis, as they separate chromosomes to opposite sides of the cell during anaphase. When paclitaxel inhibits the ability for the chromosomes to be separated during the division process, the cell is inactivated and eventually is killed. Therefore, wild-type cells treated with the p53 activator are arrested in G1 and do not enter into mitosis; therefore, the chemotherapy selectively kills p53-deficient cancer cells. This mechanism can be experimentally controlled with the use of p53 activators to arrest p53 wild-type cells and protect against the harmful effects of chemotherapeutic agents on noncancerous cells.

P53 activator current research
Due to the prevalence of this mutation, p53 is a uniquely valuable target for applied research (Vogelstein et al., 2013). Therefore, much research has gone into both therapeutic strategies to restore mutant to wild-type p53 and pretreatment of cancer cells with p53 activators that arrest noncancerous p53-normal proliferating cells without impacting the cell cycle of cells with a p53 mutation, thus allowing for selective killing of cancerous cells.

Current research on this type of treatment has led to the discovery of small molecules that directly or indirectly activate p53. Some p53 activation has been achieved in the clinic. The most advanced of these are the p53 mdm2 interaction inhibitors. The first class of small molecule mdm2 inhibitors discovered was nutlin-3a, which binds to the hydrophobic cleft in the N-terminus of mdm2, preventing its association with p53 and initiating the cascade. Since this discovery of nutlin-3a, many more related compounds

have been tested, some of which have now made it to the preclinical stage. This stage will better assess the biological effects and toxicity of the treatment to patients (Burgess et al., 2016). As research continues and understanding of p53 response increases, development will continue allowing for powerful drug combinations that may increase the selectivity and safety of chemotherapy by selective protection of normal cells and tissue (Lane et al., 2010).

Alpha mangostin as a chemoprotectant

Alpha mangostin is a p53 activator that is isolated from the carp of the Garcinia mangostana (Mangosteen fruit), which is native to Thailand and traditionally used for antioxidant, antitumoral, antiallergic, anti-inflammatory, antibacterial, and antiviral medicinal purposes (Pedraza-Chaverri, Cárdenas-Rodríguez, Orozco-Ibarra, & Pérez-Rojas, 2008). This extract is known to inhibit the binding of p53 to MDM2, a negative regulator of p53.

In one study in 2011, alpha mangostin was used to reduce tumor growth and lymph node metastasis in an immunocompetent xenograft model of metastatic mammary cancer with a p53 mutation. The study showed that treatment with 20 mg/kg/day alpha mangostin resulted in prolonged survival rates and increased inhibition of tumor growth and lymph node metastasis (Shibata et al., 2011). This reveals that this extract at high concentrations can potentially be a successful treatment for p53 mutated cancer types. Meanwhile, at lower concentrations, alpha mangostin has the potential to act as a chemoprotectant to wild-type cells. One study tested the chemoprotection of alpha mangostin on wild-type BHK cells. The results supported the hypothesis that alpha mangostin can be used to protect cells from the cytotoxic effects of chemotherapy (Wojciechowski, 2017). However, the effect on breast cancer cell lines at low concentrations is not known. Here, this research seeks to determine whether or not the alpha mangostin pretreatment would be an effective strategy for chemoprotection of wild-type cells by testing whether or not the cancer cells are also protected. If the data indicate that the cancerous cells are not protected, this p53 activator could potentially be a successful pretreatment before chemotherapy for selective cancer killing. I hypothesize that alpha mangostin, a p53-dependent chemoprotectant, protects wild-type cells but not those with a p53 mutation from the chemotherapeutic agent paclitaxel.

MATERIALS AND METHODS

Culturing of MCF10A cells

Cell culture protocol was based on the ATCC© Thawing, Propagating, and Cryopreserving Protocol ("Thawing, Propagating, and Cryopreserving Protocol: MCF10A-JSB Breast epithelium," 2012). MCF10A p53 Wild-type and p53 knockout (-/-) human breast cancer cells were cultured in Dulbecco's Modified Eagle's Medium supplemented with cholera toxin from V. cholera, insulin solution, epidermal growth factor, 50 uM hydrocortisone solution, and horse serum at 37°C. PBS was used to rinse the wells before lifting. Trypsin-EDTA solution was used to lift cells.

Determining the toxicity of alpha mangostin and paclitaxel
Cells were treated at various levels of alpha mangostin and paclitaxel to create a dose response curve and toxicity curve and determine workable concentrations for the dual treatment experiments. For the dual treatment, cells were treated with various concentrations of alpha mangostin, ranging from 0 to 0.25 uM, for twenty-four hours followed by a twenty-four-hour dual treatment of alpha mangostin and 15 nM paclitaxel.

Differentiating between viable, apoptotic, and necrotic cells
Cells were stained with Hoechst, YO-PRO 1, and propidium iodide to differentiate between viable, apoptotic, and necrotic cells. Data was collected on cell viability using differential fluorescent staining. The differences were shown through fluorescent microscopy with Hoechst, propidium iodide, and YO-PRO-1 stains. The Hoechst stain only stains normal healthy cells. The next two, propidium iodide and YO-PRO-1, only stains necrotic and apoptotic cells, respectively. Through these three stains, I will be able to only evaluate the attached cells for comparison. Quantitatively, the cells stained with Hoechst stain were used for the results section. However, the two other stains are shown in the figures with photos. Representative pictures at 10x were taken blindly by a professor in order to eliminate bias and counted using the fluorescent cell counting program.

Development and use of cell counting program
The program used to count the cells was developed by Evan Dexter using Microsoft Visual Studio in C# language. The code for this program is shown in Appendix 1. It works by use of an algorithm that examines the color values of the picture's pixels. Pixels with high values of the color being counted are flagged as potential cell locations. Various user-controlled parameters are then used to refine the number of cells from the initial list. Changing the parameters makes it possible to count the number of cells for different types of cells and conditions. The resulting count is displayed to the user as both a sum total and a marker on each cell location (Dexter 2019).

RESULTS

Data shown in the results section come from representative photos taken at 100x on a fluorescent microscope and analyzed using a double-blind method. Typical methods such as the cell hemocytometer were not able to be used due to difficulties lifting the cells without killing them. Therefore, a program was developed that would count representative photos to have an idea of cell viability in each of the treatment wells (Appendix 1). Viable cells were counted as indicated by the blue Hoechst stain. Concentration ranges for toxicity curves and dose response curves were based upon previous research using these treatments with baby hamster kidney cells (Wojciechowski, 2017).

Single treatment results for wild-type cells (p53 pathway intact)
We first wanted to determine the effect of the chemotherapeutic drug, paclitaxel, on the MCF10A wildtype cells. This procedure allowed for the determination of a concentration that would be suitable for dual treatment with alpha mangostin.
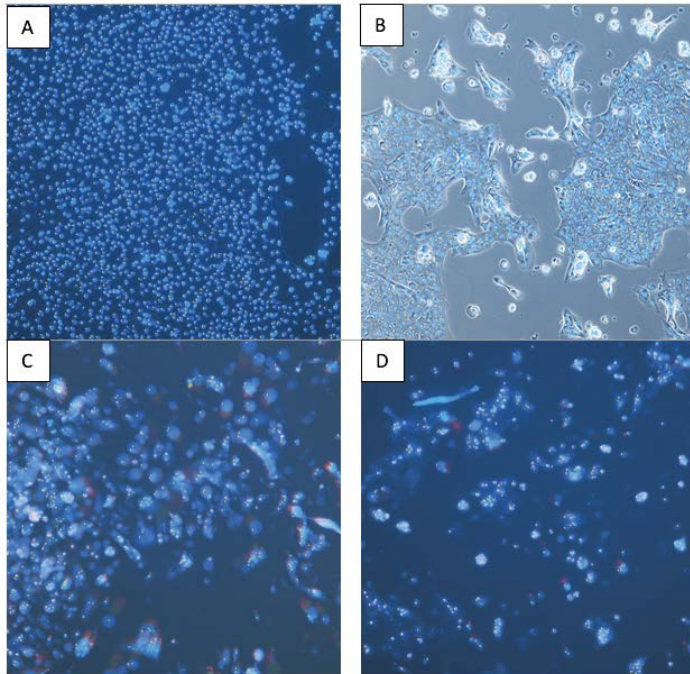
Figure 3. Fluorescent microscopy of MCF10A wild-type cells after treatment with paclitaxel. A is the control, B is 10 nM, C is 25 nM, and D is 35 nM. Increase in concentration led to a decrease in live cell count.

Increasing concentrations of alpha mangostin caused a decrease in the number of cells in the well (**Figures 3** and **4**). There were not many floating dead cells in the wells, which indicate that the decrease in cell number was likely due to cell cycle arrest. The control well had a variable number of cells in each well, as indicated by the large error bars in **Figure 4**. If experimental error did not have an effect on the results of the control well then very low concentrations of paclitaxel had a mitogenic effect on the wild-type MCF10A cell line. The chosen concentration of paclitaxel for the dual treatment was 15 Nm, as higher concentration did not give a sufficient number of cells to allow for variable cell counts with lower standard error.
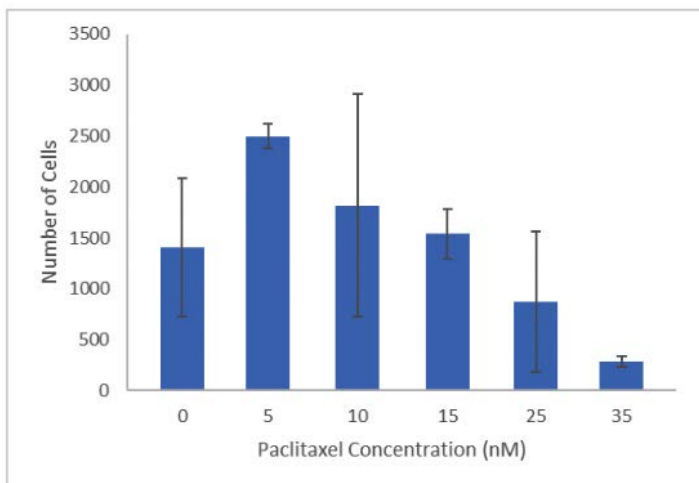
Figure 4. Wild-type MCF10A paclitaxel toxicity curve. Cells were treated with concentrations ranging from 0-35 nM for twenty-four hours, and the cell count per field of view was recorded per well. The 5, 10, and 15 nM concentration of paclitaxel had a mitogenic effect on the cells with toxicity beginning at 25 nM.

We next sought to determine the effect of alpha mangostin on cell viability for the wild-type MCF10A cells. This experiment was also done in order to determine an acceptable range for the dual treatment for this cell line with the chemotherapeutic agent, paclitaxel.

Figure 5. Fluorescent microscopy of MCF10A wild-type cells after treatment with alpha mangostin. Top left is the control, top right is 0.05 μM, bottom left is 0.15 μM, bottom right is 0.25 μM. Increase in concentration led to a decrease in live cell count
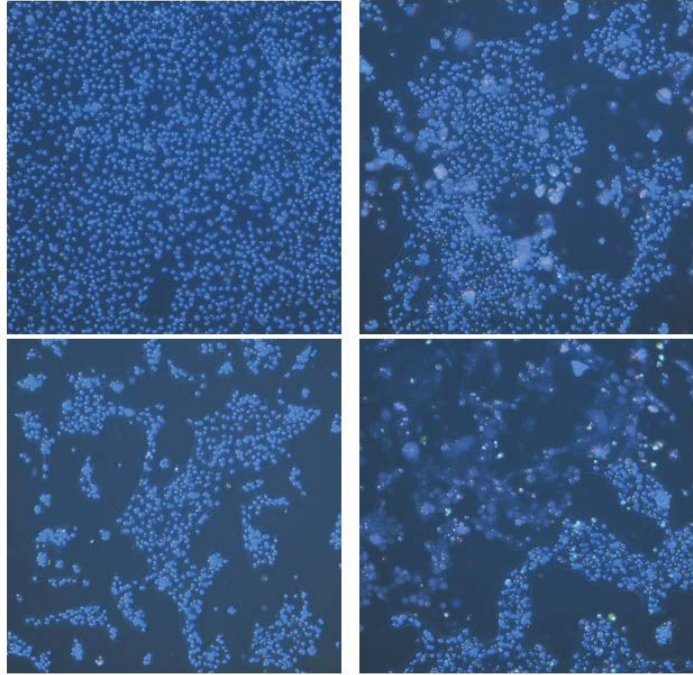
The MCF10A wild-type cells responded in a dose dependent manner (**Figure 5** and **6**). In addition to the control, varying concentrations ranging from 0.05 to 0.25 were used because it gave a suitable range that had variable cell counts.

Figure 6. Wild-type MCF10A alpha mangostin dose response curve. Cells were treated with varying concentrations of alpha mangostin for twenty-four hours and counted using the fluorescent cell counting program.
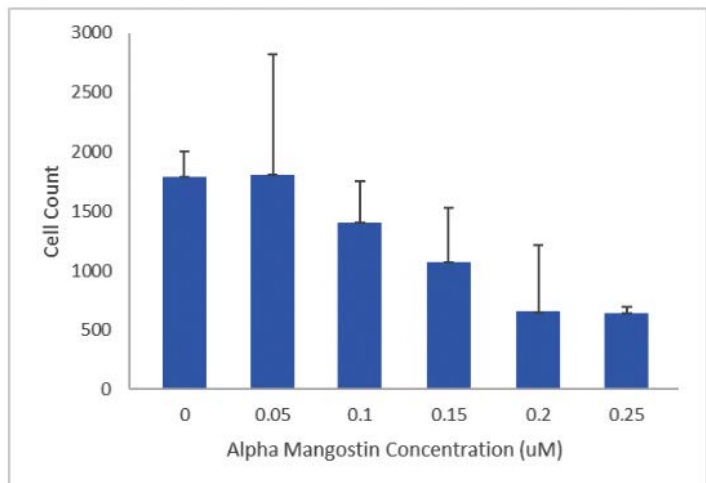
Dual treatment results for wild-type cells (p53 pathway intact)
The final experiment for the wild-type cells was the dual treatment with alpha mangostin for twenty-four hours followed by a combination of alpha mangostin and paclitaxel for another twenty-four hours.
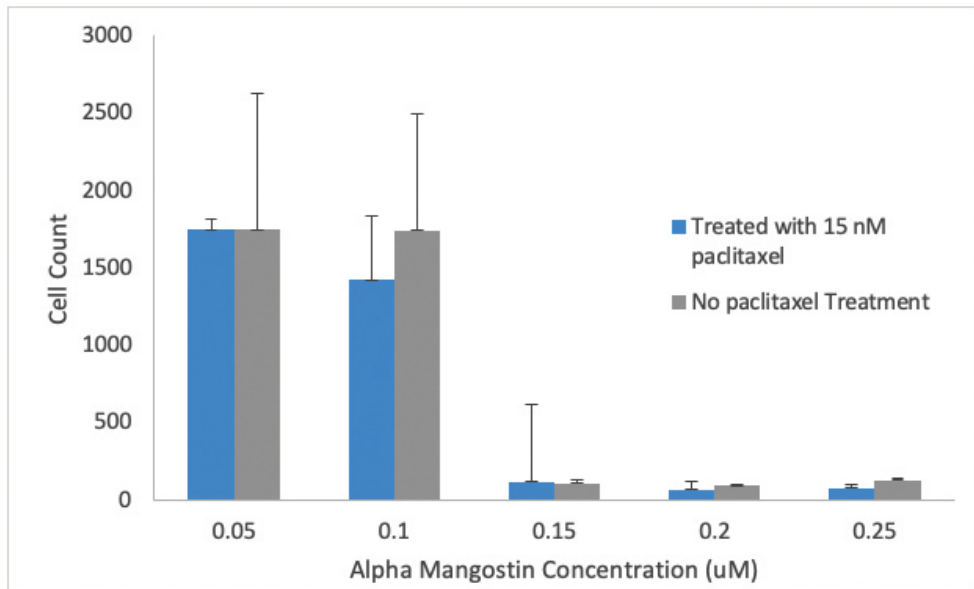
Figure 7. Wild-type MCF10A alpha mangostin and paclitaxel dual treatment. Cells were treated with varying concentrations of alpha mangostin for 24 hours and counted using the fluorescent cell counting program.

Cells treated with alpha mangostin alone and those cotreated with paclitaxel yielded similar cell counts (**Figure 7**). While these results indicate a negligible effect of alpha mangostin as a chemoprotectant, we also observed a wide variety of experimental error as will be discussed further below.
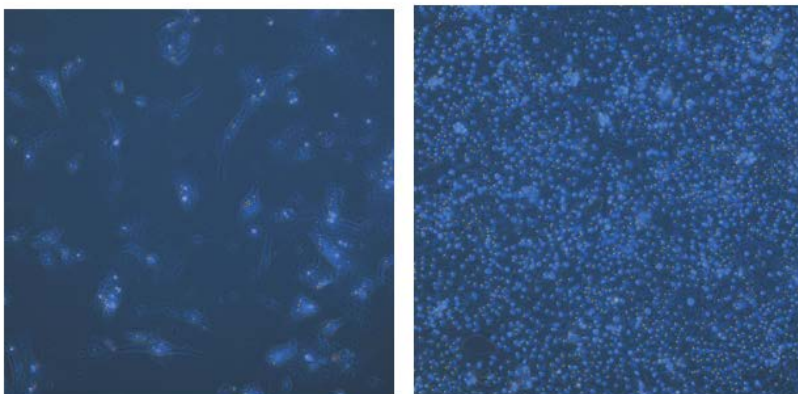
Figure 8. Fluorescent microscopy of wild-type MCF10A paclitaxel treatment vs dual treatment with alpha mangostin. Left is the paclitaxel only treatment and right is the alpha mangostin paclitaxel dual treatment.

Single treatment results for MCF10A p53 (-/-) cells

P53 is known to be an important regulator of cell cycle arrest and as noted above is often absent in numerous cancers. We therefore wanted to determine the role of a chemoprotectant such as alpha mangostin on p53 knockout cells (**Figures 9** and **10**). The concentration range used was slightly larger than that used for the wild-type cells to gain a better understanding of the effect of the concentration on the treatment.
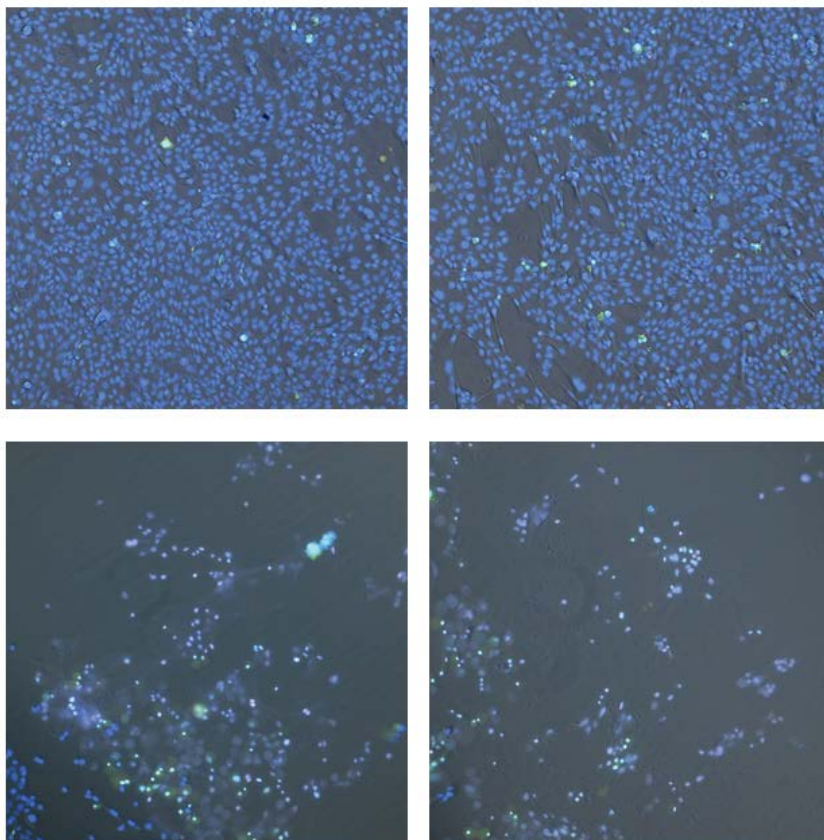

Figure 9. Fluorescent microscopy of MCF10A p53 (-/-) cells after treatment with alpha mangostin. Top left is the control, top right is 0.1 μM, bottom left is 0.5 μM, bottom right is 1 μM. Dark grey cells indicate live cells stained with Hoechst, and light grey cells indicate apoptotic cells, and black cells indicate necrotic cells. Increasing concentrations led to a decrease in live cell count.

In addition to quantitative data, the wells were qualitatively assessed through a blinded observation to determine the approximate cell viability (**Figure 11**). It was important to perform this study for this experiment because the obtained counts for **Figures 9** and **10** were not particularly representative. This is because photos were taken at the edges of the wells since the middle of the well had limited consistency in all treatments. Viability was greatly diminished at concentration of 0.25 or greater, which is in contrast to what was observed with MCF10A wild-type cells.
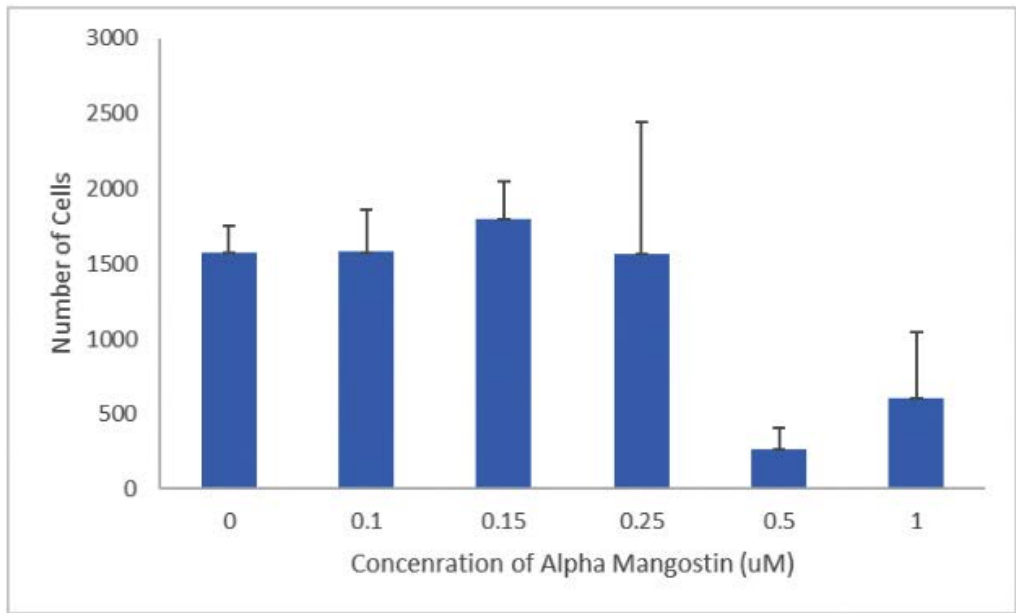
Figure 10. MCF10A p53 (-/-) alpha mangostin dose response curve. Cells were treated with varying concentrations of alpha mangostin for twenty-four hours and counted using the fluorescent cell counting program.
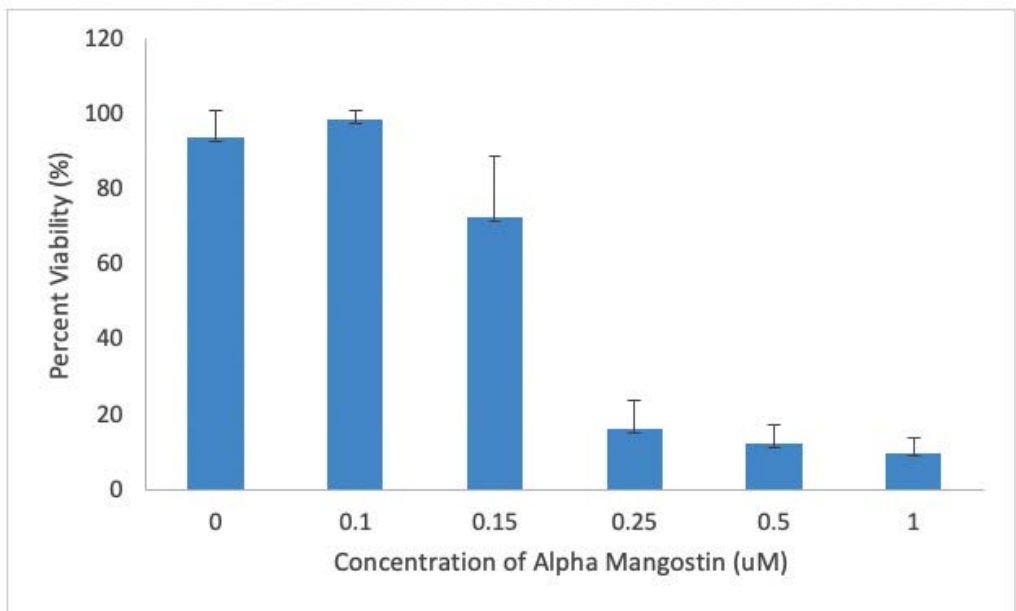
Figure 11. Qualitative observation of percent viability for increasing treatments of alpha mangostin on MCF10A p53 (-/-) cells. Observations of this percentage were estimated using a blind study method.

DISCUSSION

Through induction of p53-dependent G2 arrest, pretreatment can prevent cell death caused by microtubule-inhibiting drugs such as paclitaxel. This would allow for selective killing of p53 mutant cancer cells (Blagosklonny, 2002). In order to assess the chemoprotective abilities of alpha mangostin, we performed several experiments on MCF10A wildtype and p53 (-/-) breast cancer cells. When working with this cell line, a lot of troubleshooting and method alterations went into the process of creating the experiments. This is important to note because the major time commitment for this troubleshooting did not allow for duplication of the experiments. In order to fully draw conclusions from this research, one must duplicate the data in order to gain confidence in the results presented. Also, it is important to note that the key findings presented in **Figure 11** came from a double blinded study to avoid bias.

To begin, the MCF10A wildtype cells were treated with both alpha mangostin and paclitaxel separately to create a toxicity and dose response curve in order to determine a workable range of concentrations for alpha mangostin and an optimum concentration of paclitaxel for the dual treatment. As shown in **Figure 4,** a 15 nM concentration of paclitaxel had higher confidence, shown by smaller error bars, and had a significant fraction of less cells than the 5 nM treatment. The mitogenic effect of lower doses in contrast to the low number of cells in the control well may be a result of experimental error. This concentration has the potential to give room for variation of cell number when pretreated with alpha mangostin. Thus, the 15 nM concentration was chosen to be the fixed paclitaxel concentration for the dual treatment.

Figure 6 shows that alpha mangostin responds in a dose dependent manner. These concentrations were shown to be effective to be used for the dual treatments. Therefore, the next experiment included a dual treatment in which cells were treated with concentrations of 0.00 μM to 0.25 μM of alpha mangostin on day 1 and treated with both alpha mangostin and 15 nM paclitaxel on day 2 (**Figure 7**). The results of this dual treatment show similar cell counts for cultures treated with and without paclitaxel, indicating that alpha mangostin is able to effectively protect cells from the normally cytotoxic effects of paclitaxel. This conclusion is based on the paclitaxel toxicity curve that shows that adding each subsequent concentration of paclitaxel should decrease cell number. However, the cells treated with alpha mangostin and no paclitaxel and the cells that were dual treated had very similar values. Overall, the wells that were pretreated with alpha mangostin had a much larger live cell count than the well that received no alpha mangostin pretreatment before it was treated with paclitaxel (**Figure 8**). Because the wild-type cells are also representative of typical human breast cells with wild-type p53, these experiments indicate that human breast cells will be protected from paclitaxel by alpha mangostin.

The second section of results evaluates the effect of pretreatment of p53 knockout MCF10A cells to ensure that these cells are not protected by the alpha mangostin. If the alpha mangostin showed a similar protective effect, then it would not be a useful selective treatment for breast cancer. To explore the relationship between the knockout cells and the alpha mangostin, a dose response treatment, ranging from 0 to 1 μM alpha

mangostin, was administered to knockout cells for twenty-four hours (**Figure 10**). Based on the mechanism of p53 activators, which includes inhibition of mdm2-p53 interaction in the normal pathway, cell count numbers were expected to be consistent in different concentrations of alpha mangostin. However, number of cells decreased with increasing alpha mangostin concentration. Further analysis revealed that the wells with higher concentrations of alpha mangostin had many dead cells that were floating and thus not recognized by the fluorescent microscope. These dead cells indicate that the low number of cells at high concentrations is not due to cell arrest, but rather from cell toxicity. The decrease in cell number is shown in **Figures 9, 10** and **11**. **Figure 10** contains quantitative data that shows a relative decrease in cell number correlates to an increase in concentration. **Figure 11** contains a qualitative observation of percent viability for increasing treatments of alpha mangostin on MCF10A p53 (-/-) cells. The percent confluence decreased as alpha mangostin increased. Overall, these data show that the number of cells depends on the concentration of the alpha mangostin in a dose dependent manner.

Overall, the range of concentration of alpha mangostin between 0.1 μM to 0.25 μM showed a protective benefit to wild-type MCF10A breast cancer cells. Furthermore, the same concentration range decreased cell viability of the MCF10A p53 knockout cell line. This indicates that alpha mangostin has potential as a selective cancer treatment when paired with the chemotherapeutic drug paclitaxel. While these results are encouraging and suggest that alpha mangostin is a potential chemoprotectant for chemotherapy, it is important to acknowledge the limitations of this research. Due to difficulties and troubleshooting, only one trial for each of these various treatments was completed. Therefore, in order to fully validate this research, it must be replicated to eliminate any results which came from experimental error. Along with replication of this experiment, it would be beneficial to continue the knockout MCF10A p53 (-/-) study and perform a toxicity curve with paclitaxel in order to perform a dual treatment study. Furthermore, these experiments should be performed on several different cell lines to evaluate the effectiveness of alpha mangostin on different cell types and cancers. Further research is required to explore the promising pretreatment to chemotherapy, alpha mangostin.

Although many treatments exist for cancer, scientists are always looking for better and more effective options for patients. When evaluating treatment plans, patients must consider both the effectiveness of the treatment and the negative side effects of each treatment option. While chemotherapy has shown to be an effective and aggressive treatment option, it is not selective for that tissue, and therefore has many harsh side effects including pain, lymphedema, musculoskeletal symptoms, bone loss and osteoporosis, heart problems, new cancer development, blood clots, infertility, and loss of memory and cognitive function (American Cancer Society, 2017). This research, as well as other studies, show that alpha mangostin has potential as a p53 activation pretreatment before chemotherapy to limit these side effects.

The p53 gene is a great potential target for cancer treatment because it is the most frequently altered gene in human cancers (Shibata et al., 2011). If alpha mangostin can be used as a tool for chemoprotection in a p53-dependent manner in breast cancer development, then it would enable doctors to treat patients with higher concentrations

of chemotherapy without harming healthy tissue. It would also potentially have implications in treatments of other types of cancer, such as some uterine, ovarian, and lung cancers, which also have a high prevalence of p53 mutations. Alpha mangostin offers a more natural treatment option that can be easily translated to clinical use because it is already FDA approved. Overall, this study shows that alpha mangostin warrants further research to better understand its effectiveness as a pretreatment for chemotherapy.

REFERENCES

American Cancer Society. (2017). Breast Cancer Facts & Figures 2017-2018. *Breast Cancer Facts & Figures*, 1–44. https://doi.org/10.1007/s10549-012-2018-4. Mesothelin

Blagosklonny, M. V. (2002). Sequential activation and inactivation of G2 checkpoints for selective killing of p53-deficient cells by microtubule-active drugs. *Oncogene*, 21(41), 6249–6254. https://doi.org/10.1038/sj.onc.1205793

Burgess, A., Chia, K. M., Haupt, S., Thomas, D., Haupt, Y., & Lim, E. (2016). Clinical overview of MDM2/X-targeted therapies. *Frontiers in Oncology*, 6(January), 1–7. https://doi.org/10.3389/fonc.2016.00007

Choong, M. L., Yang, H., Lee, M. A., & Lane, D. P. (2009). Specific activation of the p53 pathway by low dose actinomycin D: A new route to p53 based cyclotherapy. *Cell Cycle*, 8(17), 2810–2818. https://doi.org/10.4161/cc.8.17.9503

Gasco, M., Shami, S., & Crook, T. (2002). The p53 pathway in breast cancer. *Breast Cancer Research*, 4(2), 70–76. https://doi.org/10.1186/bcr426

Lane, D. P., Cheok, C. F., & Lain, S. (2010). P53-based cancer therapy. *Cold Spring Harbor Perspectives in Biology*, 2(9), a001222--a001222. https://doi.org/10.1101/cshperspect.a001222

Moongkarndi, P., Kosem, N., Kaslungka, S., Luanratana, O., Pongpan, N., & Neungton, N. (2004). Antiproliferation, antioxidation and induction of apoptosis by Garcinia mangostana (mangosteen) on SKBR3 human breast cancer cell line. *Journal of Ethnopharmacology*, 90(1), 161–166. https://doi.org/10.1016/j.jep.2003.09.048

Muller, P. A. J., & Vousden, K. H. (2014). Mutant p53 in cancer: New functions and therapeutic opportunities. *Cancer Cell*, 25(3), 304–317. https://doi.org/10.1016/j.ccr.2014.01.021

Pedraza-Chaverri, J., Cárdenas-Rodríguez, N., Orozco-Ibarra, M., & Pérez-Rojas, J. M. (2008). Medicinal properties of mangosteen (Garcinia mangostana). *Food and Chemical Toxicology*, 46(10), 3227–3239. https://doi.org/10.1016/j.fct.2008.07.024

Reinhardt, H. C., & Schumacher, B. (2012). The p53 network: Cellular and systemic DNA damage responses in aging and cancer. *Trends in Genetics*, 28(3), 128–136. https://doi.org/10.1016/j.tig.2011.12.002

Shibata, M. A., Iinuma, M., Morimoto, J., Kurose, H., Akamatsu, K., Okuno, Y., … Otsuki, Y. (2011). α-Mangostin extracted from the pericarp of the mangosteen (Garcinia mangostana Linn) reduces tumor growth and lymph node metastasis in an immunocompetent xenograft model of metastatic mammary cancer carrying a p53 mutation. *BMC Medicine*, 9, 1–18. https://doi.org/10.1186/1741-7015-9-69

Thawing, Propagating, and Cryopreserving Protocol: MCF10A-JSB Breast epithelium. (2012). *ATTC*, 1, 1–27.

Vogelstein, B. B., Hughes, M. D. H., Kimmel, S., & Cancer, C. (2013). p53 : The Most Frequently Altered Gene in Human Cancers How Do We Know p53 Is a Tumor Suppressor Gene ?, 1–8.

Walerych, D., Napoli, M., Collavin, L., & Del Sal, G. (2012). The rebel angel: Mutant p53 as the driving oncogene in breast cancer. *Carcinogenesis*, 33(11), 2007–2017. https://doi.org/10.1093/carcin/bgs232

Wang, Z., & Sun, Y. (2010). Targeting p53 for novel anticancer therapy. *Translational Oncology*, 3(1), 1–12. https://doi.org/10.1593/tlo.09250

Wojciechowski, A. C. (2017). Using α-Mangostin from Garcinia mangostana to Block Cell Death Caused by Paclitaxel in Proliferating BHK Cells.

APPENDIX 1

Please see the complete version of this paper on Olivet Nazarene University's Digital Commons for the fluorescent cell counting software code.

The Role of Endangered Oak (*Quercus* spp.) Savanna Characteristics in Supporting Red-Headed Woodpecker (*Melanerpes erythrocephauls* L.) Populations

Kimberly J. Zralka

Presented as Abstract only

ACKNOWLEDGEMENTS

ABSTRACT

Declines in animal populations worldwide are of critical conservation concern. However, without an understanding of optimal habitat preference, it is often difficult to determine what factors are driving these losses. Red-headed woodpecker (*Melanerpes erythrocephalus* L.) populations have declined by over 70% in the last fifty years, yet in some areas the birds seem to maintain stable populations. The aim of this study was to empirically test the effects of various habitat factors on red-headed woodpecker presence and abundance in both the summer and winter seasons. As oak acorns are a critical food source for this bird, we were particularly interested in whether the oak species (*Quercus* spp.) present in savanna environments (an endangered ecosystem in the Midwestern United States) affect woodpecker presence and abundance, as this has not been tested to our knowledge. After conducting 414 point-count surveys and habitat analysis at five sites throughout northeastern Illinois, generalized linear and multiple regression models using backwards elimination were used to show how habitat factors affected presence and abundance of red-headed woodpeckers. Our models indicated that decreasing canopy cover, increasing dead limbs, increasing red oak group trees, and decreasing white oak group trees at a site were significant factors in predicting woodpecker presence and abundance during the summer months. However, in winter our models indicated that mainly tree size, and potentially number of snags, number of dead limbs, and percent canopy cover play a role in predicting red-headed woodpecker habitat selection. These results confirm and expand upon previous studies, suggesting that mature oak savanna environment is important to the success of red-headed woodpecker populations. Our findings that a greater number of red oak group trees, but a smaller number of white oak group trees, may be positively related to woodpecker abundance at a site is of interest, as this may indicate that the optimal habitat requirements of red-headed woodpecker populations are more specific than previously thought. Together, these factors should help inform managers in conservation planning for this iconic species.

Olivet Nazarene University Honors Program Graduates for 2019. From left to right - *5th Row (top):* Timothy Mayotte, Cole Doolittle; *4th Row:* David Kok, Kimberly Zralka, Emma Kuntz, Michael Resciniti; *3rd Row:* Amanda Roche, Elisa Klaasen, Evan Dexter; *2nd Row:* Marlena Kalafut, Erica Sandtorv, Amy Kaczor, Jarrett Stalinger; *1st Row:* Dr. Stephen Lowe, Honors Program Director; McKenna Conforti, Katherine Dickey, Vanessa Van Oost, Dr. Stephen Case, Honors Program Associate Director.

OLIVET
NAZARENE UNIVERSITY

OFFICE OF ADMISSIONS

ONE UNIVERSITY AVENUE

BOURBONNAIS, IL 60914

800-468-6400

OLIVET.EDU

Exploring the Effects of Protein Kinase C Alpha Gene Knockout on the Proliferation of Human Embryonic Kidney Cells

Hexavalent Chromium-Induced Cytotoxicity and Mutagenicity: A Study of Protection by Ascorbic Acid and Epigallocatechin Gallate

Performance Analysis of an Exhaust Heat Recovery System Utilizing Heat Pipes, Metal Foam, and Thermoelectric Generators

The Relationship Between Faith Maturity and Life Satisfaction

Mental Health First Aid Training: Evaluating a Brief Training Intervention for College Students

The Japanese Way in America: A Comparison of the Spiritual Beliefs, Habits, and Ideas of the American Religious 'Nones' and Contemporary Japanese Nationals

Study of Alpha Mangostin as a Chemoprotective Agent for Breast Cancer via Activation of the P53 Pathway

The Role of Endangered Oak (*Quercus* spp.) Savanna Characteristics in Supporting Red-Headed Woodpecker (*Melanerpes erythrocephauls* L.) Populations (Abstract)