Volume 2

Morgan Milledge is a senior studying English and public relations. Throughout her time as the editorial intern for ParkWrites, she has blinded and copyedited manuscripts. She has also designed the new logo and cover for *The Navigator*. After graduating in December 2022, Morgan plans to pursue a career in publishing–hopefully as a literary or technical editor. She has always been passionate about reading and writing and would love the opportunity to help aspiring authors tell their stories.

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The Navigator's Cover Art Contest Winner: **Rafael Segovia**

Rafael Segovia is pursuing a degree in business and logistics to support his thirteen-plus years working in the logistics field. He enjoys being a father and husband more than anything. As a hobby, he enjoys exploring photography; he hopes to evolve his work into photojournalism projects aimed at educating and creating awareness of underserved communities and social issues in his hometown. Rafael's photograph captures a plaza that at one point was a trolly stop for migrants crossing from Mexico to the United States. Rafael's grandfathers, both paternal and maternal, would have stopped here during their participation in the Bracero program. Rafael's parents would have also come to this point prior to relocating to California. Rafael shares with us memories of his youth and begins to explain how this place connects three generations in search of the American Dream.

About the Submission by Rafael Segovia
My mother's first job, after relocation to El Paso from Los Angeles, was at Kress on the corner of Mills and Oregon, photographed. Her career in retail began here in downtown El Paso and spanned over thirty years across several major stores. As far back as I can remember our lives revolved around the bustling downtown plaza. I have memories of running across the plaza to catch a bus on transfer tethered by my mother's tight grip, eating my first happy meal at the two-story McDonalds, and window shopping as we walked. My mother made many sacrifices and never shied away from back-breaking work leaving a legacy of hard work, integrity, respect, and civility. Although she encouraged my siblings and myself to put education first, we followed in her footsteps as earners as soon as we could. I'm grateful to be a Pirate at Park University now; I've come to find my way back to completing my education. I feel that Park University's accessibility is designed for me and allows for continuing my education while being a parent and raising a family. When I look at the Kress photo, I think of the day when I'll be pictured in front of its doors in cap and gown fulfilling my mother's wish when she began working there with me in her belly and dreams of a college degree.

Contents

Volume 2 ● 2022

English

Business

Finance

History

First-Year Writing

Information for Contributors

About ParkWrites

ParkWrites is a university-wide Writing Across the Curriculum (WAC) program aimed at improving writing and writing instruction across the university. Writing Across the Curriculum is an educational approach used by a majority of universities to develop student learning about content (writing to learn) and to develop student learning about writing across all disciplines (learning to write). WAC programs increase student engagement and retention, critical thinking, effective communication across a range of audiences and purposes, and better prepare students for communicating in the workplace. These benefits are even greater for international students and students from underserved populations. ParkWrites consists of multiple initiatives including faculty development and support, a journal of excellent student writing called *The Navigator*, a student writing fellows program which places trained students in classes for extra writing support, and a curricular initiative, the Writing Intensive program. In addition to taking 3 required writing courses at Park, students also take at least 2 writing intensive courses both inside and outside their majors ensuring students get effective instruction in writing throughout their entire degree program.

From the Editor…

Dear Readers,

Welcome to the second volume of *The Navigator: Excellent Student Writing Across the Disciplines*. This volume reflects the growth and innovation of our Park University undergraduates that has followed more than two years of isolation and hardship. I am thrilled to share with you twelve pieces of writing across the disciplines from the 2021 calendar year that remind us of our capacity as humans and scholars to remain forward-looking even when we feel we're at a standstill.

Volume 2 begins and ends with a look at the future of our planet—a research paper in interior design, winner of *The Navigator's Best Writing Award*, examines the role sustainable design in education facilities will play in preserving it. It goes further to suggest that what's good for our planet's climate also positively affects student academic growth and development. Continuing the climate conversation, a first-year writing research paper proposes an innovative use of a natural resource.

Research into the future of sports helmets and research into the effects of probiotics both offer possibilities for a healthier world. While closely examining the advantages of emerging technology in business analytics, a case study on Netflix acknowledges the ethical concerns for the future of our privacy.

Several pieces look to the past in order to look forward. A finance research paper looks back at the 2008 housing crisis, and two history papers question precedents that were set during the Cold War and in ancient Rome in order to think of a better future. A history of mathematics paper reminds us that even a mathematical genius had to survive the more mundane aspects of life to achieve greatness.

Finally, three timely pieces, one from English, one from art, and one from mathematics, encourage readers to use literature and art not only to find beauty in our everyday lives, but to use literature and art to understand our experiences, even as we struggle to face them.

This second volume wouldn't have been possible without the talent and creativity of our editorial intern Morgan Milledge. In addition to designing the cover, copyediting papers, and creating a new logo for *The Navigator*, Morgan's efficiency, attention to detail, and initiative were largely responsible for getting this volume completed on time. Thanks, once again, to Dr. Jamie Els for her continued support, expertise, and patience, and to Dr. Amy Mecklenburg-Faenger for her continued leadership. Finally, to our contributing authors, thank you for sharing your exceptional work and inspiring me, and likely your readers, to keep moving forward.

—Brandi Handley, MFA

More Acknowledgements…

The Navigator's editorial team would like to thank the executive staff of Park University; their leadership and support in providing faculty resources makes this publication possible. A special thank you is given to Shane Smeed, president, Dr. Michelle Myers, provost, Dr. Emily D. Sallee, associate provost, Brian Shawver, associate provost, and Cathy Boisen, administrative assistant to ParkWrites.

Winner of* The Navigator's *Best Writing Award

Impacts of Sustainable Design in Education Facilities

Sonja N. Gormley

INTRODUCTION

The change towards sustainable design continues to accelerate in this post-pandemic culture. Federal policy changes, education campaigns, and marketing have all been pointing to green design, and now more than ever, society realizes the importance of healthy buildings. Education facilities arguably play the most vital role in a sustainable future. By the time a child finishes high school, they will have spent an average of 15,600 hours inside a school building (Eitland, et al., 2017). Thus, it is imperative to understand how these sustainable environments impact student academic growth and development.

The link between school buildings and the health and safety of students is not a new development, as the National Research Council points out in their publication, *Green Schools: Attributes for Health and Learning* (2007)*:*

> A report on the State of Maine's Schools in 1886 linked moisture, lighting, and ventilation of school buildings to health and learning: Nearly one-sixth of the population of our State spends about six hours daily during a large part of the year in our school rooms. This necessary confinement within the schoolroom walls, coming as it does during the growing period of the body, and while it is most susceptible to harmful influences, entails certain evils which have been too generally regarded as necessary accompaniments of school life. It is generally well known, however. . . that most of the diseases incident to school life are in quite a high degree preventable (p.15).

Nevertheless, over a century later, states are still struggling to provide healthy environments for students. Over 50 million children are regularly attending public schools within the United States. Previous estimates show that 46 percent of those public schools have environmental conditions that create poor Indoor Environmental Quality (IEQ) (Eitland, et al., 2017).

"All states require children to attend school. But no state ensures that those schools are environmentally safe and healthy" (Healthy Schools Network, 2016). The Environmental Protection Agency (EPA) and the Centers for Disease Control and Prevention (CDC) have created guidelines to assist states in establishing and implementing environmental health programs for K-12 schools (United States Environmental Protection Agency, 2021). Though, at this point, implementation and participation in these programs are still voluntary. Considerable research exists that correlates building health with student health. The challenge, however, is that many factors affect overall student performance, including socioeconomic status, time of day, amount of sleep, and other environmental influences. Most of which are outside the control of educators. Still, with the understanding that students will spend most

of their developmental years within the boundaries of educational infrastructure, it is imperative that those buildings provide the safest and healthiest learning environments possible. With this awareness, decision-makers need to have the information necessary to apply funding to the most impactful areas appropriately.

Significance

The purpose of this study is to explore the relationship between sustainable interior environments and students' overall health and academic success. First, we will examine existing statistical data regarding students' health and its impact on academic performance to establish a reference point for comparison. Second, we will explore the areas of sustainable design as follows: acoustics, indoor air quality (including ventilation, moisture management, and thermal health), lighting, space planning, and aesthetics. Then, through researched-based evidence, relate those effects on students' academic growth. The information gathered in this study should enable designers, educators, and public officials to identify which areas of sustainable design have the most impact and how they can apply those principles to improve overall student development.

LITERATURE REVIEW

In 1987, the United Nations Brundtland Commission defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 2021). This definition places educational facilities at the nexus of sustainable design. How we raise and educate our most vulnerable citizens will define the future of our society. It is imperative that the buildings in which these students spend most of their developmental years provide them with safe and healthy environments.

School buildings and their effects on occupant health have been researched and studied for hundreds of years. "Reports dating back to the 1800s have documented the link between school conditions to childhood illness (National Research Council, 2007) . The first major report in modern history detailing the characteristics that can contribute to student health and performance was published in 2007 by the National Research Council. Their breakthrough report *Green Schools: Attributes for Health and Learning* launched the groundwork for evidence-based research, demonstrating that the school building is foundational in student health and development and that we can no longer afford to neglect the condition of these buildings (Eitland, et al., 2017). Since then, numerous studies have been conducted on the sustainability of educational infrastructure and its impact on student health and performance.

This literature is categorized into four major topic areas relating to Indoor Environmental Quality (IEQ): (1) acoustics, (2) indoor air quality (IAQ), including ventilation, moisture management, and thermal health, (3) lighting, and (4) space planning and aesthetics.

Definitions and Organizations

According to the Center for Disease Control (CDC, 2013): IEQ "refers to the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it. IEQ is determined by many factors, including lighting, air quality, and damp conditions."

Indoor Air Quality (IAQ) measures air quality within the built environment, predominantly concerning the health and comfort of building occupants (EPA, 2021).

The American National Standards Institute (ANSI) is a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States. The organization also coordinates U.S. standards with international standards so that American products can be used worldwide (ANSI, 2021).

The Center for Disease Control and Prevention (CDC) is the national public health agency of the United States. It is a United States federal agency under the Department of Health and Human Services.

The Environmental Protection Agency (EPA) is an independent executive agency of the United States federal government tasked with environmental protection matters.

The U.S. Green Building Council (USGBC) is a non-profit organization that promotes sustainability in building design, construction, and operation.

Leadership in Energy and Environmental Design (LEED) is a green building certification program developed by the USGBC. It includes rating systems for designing, constructing, operating, and maintaining green buildings, homes, and neighborhoods.

Acoustics

In the classroom setting, most of the learning environment is based upon the talking and listening model, especially in younger age categories. "Students learn by listening to the teacher and each other" (National Research Council, 2007). Maintaining appropriate noise levels and listening conditions is vital to student performance (Eitland, et al., 2017).

Student Health and Performance

There are several factors that contribute to noise levels within a classroom setting: heating, ventilation, air conditioning (HVAC) systems, outdoor noise, noise from adjacent spaces, and reflected speech sounds (National Research Council, 2007). The effects of noise on student health involve auditory and emotional consequences (Eitland, et al., 2017; National Research Council, 2007). A report by Earthman and Lemasters (1997, as cited by Ketchum, 2015) evaluated 53 studies related to school facilities, student achievement, and behavior. The results found a link between acoustics and learning. It also concluded that high levels of excessive noise caused stress in students, and 70% of teachers reported that those high volumes affected their ability to teach (p.25).

Barrett et al. and Brill et al. point out that external background noise such as traffic, airplanes, other children playing nearby, and reverberation are the leading causes of distraction and have detrimental effects on comprehension and academic performance (Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019; Brill, Smith, & Wang,

2020). HVAC systems are a common source of background noise within the classroom environment. Brill et al. noted that 91% of classrooms studied did not meet the current ANSI standards for noise levels (Brill, Smith, & Wang, 2020). In addition to hindering learning, the physical effects of noise exposure can include higher blood pressure and increased adrenaline (Eitland, et al., 2017). Students are aware of the impact poor acoustic quality can have on their learning. A combined total of 53% of students surveyed by Pulay reported that "low noise levels influenced their academic success above the rest of the classroom architectural interior design elements listed" (Pulay, 2010).

Sustainable Improvements

"The best way to ensure quiet background noise levels from building mechanical systems is to design for them and not rely on post-design solutions…" (Brill, Smith, & Wang, 2020). The ANSI and the Acoustical Society of America published the first classroom acoustic standard in the United States in 2002. The ANSI S12.60 recommends that the sound level in an unoccupied classroom should not exceed 35 dB(A) (Brill, Smith, & Wang, 2020). Classroom design should include considerations for materials and finishes that enhance the overall acoustic quality within the space as well as separation from other areas and appropriately designed HVAC systems (National Research Council, 2007). The newest edition of the LEED program developed by USGBC, LEED (v4), requires that unoccupied background noise level meets the ANSI S12.60 standard in order to receive certification. However, schools are not required to obtain LEED certification.

Indoor Air Quality

Indoor air quality encompasses the exchange of outdoor and indoor air (ventilation) and the pollutants within them, as well as moisture and humidity, thermal comfort, and sensory loads (odors or "freshness") (National Research Council, 2007).

Ventilation

Indoor air quality and its effects on occupant health have been studied for hundreds of years. Edwards documents that in the early twentieth century, the open-air school movement was started to benefit students in urban areas with higher levels of ventilation. The evidence gathered from observing these schools indicates that increased ventilation positively affects students' general health and academic performance (Edwards, n.d.). "Ventilation rate is the flow of outside air into a building per unit of time" (Eitland, et al., 2017). Currently, there are standards set by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) to control ventilation rates within the classroom in order to keep carbon dioxide (CO_2) levels low. When CO_2 levels increase beyond the recommended level of 1000 parts per million (ppm), so do the chances of increased concentrations of various irritants (Eitland, et al., 2017). The National Research Council (2007) lists irritants such as pollutants and allergens in indoor air: mold, dust, pet dander, bacterial and fungal products, volatile organic compounds (VOC), and particulate matter. All of which are associated with asthma and other respiratory symptoms

(Eitland, et al., 2017; Healthy Schools Network, 2016; National Research Council, 2007).

According to the CDC, childhood asthma is the leading cause of absenteeism (2015, as cited in Foundations for Student Success, 2017), with 13.8 million missed school days each year (p.6). As stated by the EPA, inadequate ventilation is one of the most often cited reasons for sick building syndrome. Sick Building Syndrome (SBS) "is a term used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building" (United States Environmental Protection Agency, 2021). Symptoms often include headache, fatigue, shortness of breath, sinus congestion, cough, and sneezing, as well as eye, nose, and throat irritation (Ketchum, 2015; Healthy Schools Network, 2016; Eitland, et al., 2017).

Through their research, Barrett et al., Lopez-Chao et al., Toyinbo et al. identified that low ventilation rates are directly correlated to low mathematical test scores (Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019; López-Chao, Lorenzo, Saorín, De La Torre-Cantero, & Melián-Díaz, 2020; Toyinbo, et al., 2016). Proper ventilation also maintains quality sensory loads (smells) and supports protection against infectious disease (Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019; Edwards, n.d.; Eitland, et al., 2017; Healthy Schools Network, 2016; National Research Council, 2007)

Moisture Management

"Entrance of water into damaged, poorly designed, and improperly maintained buildings has been identified as the main source of building-related illness from mold exposure in a review of over 120,000 indoor air quality documents published between 1994 and 2001 "(OSHA, 2006, as cited in Eitland et al., 2017). The National Research Council (2007) concluded that seventy-five percent of all building envelope problems are caused by excess moisture (Ch. 3). Eitland et al. documented the link between the presence of mold and an increase in respiratory symptoms.

In addition to mold, damp conditions increase the presence of pests such as cockroaches and mice (Eitland, et al., 2017; Healthy Schools Network, 2016; National Research Council, 2007; United States Environmental Protection Agency, 2021). Eitland et al. introduced the evidence that cockroach allergies exacerbate asthma symptoms, particularly in inner-city students (Foundations for Student Success, 2017).

Thermal Health

In relation to thermal health, often referred to as thermal comfort, Eitland et al. and the National Research Council identified that though thermal health can be highly subjective, there are several conditions that the built environment has on thermal health, such as air temperature, ventilation speed, and humidity. ASHRAE has set standards related to thermal health; however, both authors also noted that most studies on thermal comfort are conducted with adults in commercial office spaces. Studies have acknowledged that children are at a higher risk of being affected by heat stress and younger age categories tend to be more comfortable in cooler environments than adults. They identified that current ratings related to office

buildings do not account for the higher occupant density of educational facilities or the students' activity level (Eitland, et al., 2017; National Research Council, 2007).

Researchers have determined that the effects of thermal health on students' productivity and academic performance are significant (Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019; Eitland, et al., 2017; Healthy Schools Network, 2016; National Research Council, 2007; Choi, Guerin, & Kim, 2013). Park (2016, as cited by Eitland et al.), documented a study involving 75,000 high school students and found that "for every increase of 1° F, test scores fell by 0.2%; for the average student, the likelihood of failing an exam taken on a 90° F Day versus a 75° F Day would be 12.3% higher" (Foundations for Student Success, 2017, p. 21)

Lighting

Researchers agree that quality lighting plays a dynamic role in the health and performance of students within school environments (Choi, Guerin, & Kim, 2013; Edwards, n.d.; Eitland, et al., 2017; Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019; Ketchum, 2015; López-Chao, Lorenzo, Saorín, De La Torre-Cantero, & Melián-Díaz, 2020; Moyano, Fernández, & González, 2020). Light affects both the visual and the circadian systems, and both must be taken into consideration when evaluating interior lighting systems (National Research Council, 2007).

Learning environments require various lighting types, such as dimming during media presentations or bright light for reading and projects. If the lighting system is inadequate, it can have noticeable physical and psychological effects on occupants (Ketchum, 2015). Sustainable lighting designs include both daylighting and artificial light.

Daylighting

Several studies have been conducted on the benefits of daylighting in classrooms, and the evidence concludes that the use of daylighting in educational environments improves academic performance by 21% (Choi, Guerin, & Kim, 2013; Moyano, Fernández, & González, 2020; Pulay, 2010; Eitland, et al., 2017; Edwards, n.d.). Along with academic performance, daylighting and views within the classroom aid in proper circadian rhythms. Studies have determined that balanced circadian cycles are necessary for proper sleep and influence basic cognitive processes, including attention, working memory, and executive function (Eitland, et al., 2017; Moyano, Fernández, & González, 2020; National Research Council, 2007).

As Barrett et al., Eitland et at., and Moyano et al. point out; traditional daylighting analysis methods may be inadequate in determining the best options for meeting occupants' needs within educational facilities since they currently do not account for the biological impact of lighting (Eitland, et al., 2017; Moyano, Fernández, & González, 2020; Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019). Moyano et al. further suggested that Climate-based Daylight Modeling (CBDM) would be an improved way of designing daylighting systems to meet the needs of adolescents' circadian cycles.

CBDM integrates light variations with natural seasonal changes within the local climate and time of day (Moyano, Fernández, & González, 2020). Dynamic lighting design must be used to avoid common issues that can arise from an improper

daylighting application, including glare and overheating (Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019; Ketchum, 2015; National Research Council, 2007; Pulay, 2010).

Artificial Light

The use of artificial light also plays a significant role in the health and performance of students. Poor lighting can lead to decreased visual comfort and eye fatigue (Moyano, Fernández, & González, 2020; Ketchum, 2015). Color temperature and lamp types are other factors that can impact the quality of the interior environment and occupants' level of alertness. Eitland et al. documented the results from a nine-month study involving 110 primary (grade 3) and secondary (grade 10) students. The study concluded that using a warm 3500K light setting was significantly associated with reduced restless behavior. It also noted that users under artificial daylight (6500K) reported significantly higher alertness and performance levels (Eitland, et al., 2017).

Since artificial lighting represents the most significant portion of schools' electricity use, it is often the first area of sustainable improvement. However, researchers agree that to have the most significant impact on student's health and academic performance, a holistic approach to lighting design should focus on energy conservation and occupants' visual and biological needs.

Space Planning and Aesthetics

Barrett et al. introduced three categories related to school design elements: naturalness, individualization, and stimulation (Clever classrooms: Summary report of the HEAD project, 2015).

Naturalness

Naturalness encompasses the aforementioned elements of IEQ (light, sound, and temperature), but they also include views and links to nature as a component of successful sustainable designs. (Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019). Eitland et al. and Determan et al. note that biophilic design can aid students in their recovery from stress and offer respite from mental fatigue.

Studies have also shown that students in classrooms with nature views performed significantly higher on tests of attentional functioning than students in classrooms with no windows or with views of other building facades (Eitland, et al., 2017; Determan, et al., 2019).

Individualization

Individualization refers to the elements of ownership, flexibility, and connection. For example, classroom layouts that allow for customization for each activity and student's needs with the aim of creating a student-centered environment (Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019).

Flexibility. Following this line, Choi et al. found that "furniture plays a strategic role in addressing different learning styles and pedagogical delivery methods" (Choi, Guerin, & Kim, 2013). They also emphasized that human factors should be used to assess the learning experience and how the design of the classroom is meeting those needs. "Ergonomics cannot be understated when one considers the

amount of time that is spent in seated positions throughout the day" (Choi, Guerin, & Kim, 2013).

Ownership. Ownership offers distinct design characteristics that give students emotional stimulation and pride in their facility. The HEAD Project (2015) indicated that research regarding physiology and psychology highlights that "personalization of space is an important factor in the formation of an individual's identity and sense of self-worth." The authors noted that when students' projects and achievements are displayed, it promotes greater participation and involvement in the learning process (Clever classrooms: Summary report of the HEAD project, p. 30).

Connection. Connection incorporates wayfinding and corridor layouts that provide opportunities for collaboration between classes and additional areas for learning (Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019).

Stimulation

Stimulation represents color and visual complexity (Barrett, Zhang, Davies, & Barrett, 2015). Grube investigated the effects of white-valued walls in classrooms and stated that "white used on classroom walls gives the appearance of being sterile and depressing." She also observed that the use of colored walls reduces eyestrain and can alter a personal perception of temperature (Grube, n.d.). Taheri also found that the use of color can significantly impact the happiness of occupants within the built environment and concluded that good design could reduce anxiety, lower blood pressure, and reduce pain. (Studying the Effect of Classroom Interior Design on the Happiness and Mental, 2019).

Additional Design Elements

Safety and security are vital elements in educational facility design and impact occupants' health and welfare within schools (Eitland, et al., 2017). However, they constitute an in-depth analysis of elements beyond the scope of sustainability and therefore not further discussed in this study.

Conclusion

These authors concur that students' multidimensional experience within classroom spaces will significantly impact their academic growth. Furthermore, research has proven that proper attention to these design elements will improve students' health and the welfare of other occupants within educational facilities. However, as the Healthy Schools Network has pointed out, legislation regarding the maintenance and inspections of educational facilities needs to change to ensure these buildings provide safe places for students to learn and grow (Healthy Schools Network, 2016, p. 56).

While the literature supports the importance of sustainable design in educational environments, it neglects to categorize the most critical areas. Additionally, further research and considerations need to be taken in light of the COVID-19 pandemic. The aim of this study will be to determine which design elements should be at the forefront of educational infrastructure upgrades and how schools can improve their environments in a post-pandemic society.

FINDINGS

Students spend the majority of their developmental years within the walls of educational facilities. With the increasing awareness of the vital role that sustainable design plays in the health and welfare of the population and its ability to reduce the human impact on the environment, schools should be at the forefront of innovation regarding its application and implementation. This study outlines the primary elements of sustainable design and investigates their impact on students' academic growth and development. These findings will enable educators and decision-makers to identify which areas of sustainability provide the most significant benefits to the students they serve.

A thorough review of the research indicates that IAQ plays the most significant role in students' academic growth. Children, especially in younger age categories, breathe in larger quantities of air relative to their body size (Eitland, et al., 2017) and are more susceptible to the pollutants and irritants contained in improperly ventilated air (Ketchum, 2015; Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019; Healthy Schools Network, 2016). Multiple studies have concluded that poor IAQ accounts for lower test scores from students, particularly in the area of mathematics (López-Chao, Lorenzo, Saorín, De La Torre-Cantero, & Melián-Díaz, 2020). Poor IAQ can also exacerbate asthma symptoms in occupants (Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019; Choi, Guerin, & Kim, 2013; Eitland, et al., 2017; National Research Council, 2007). According to the CDC, asthma is the leading cause of absenteeism in students in America (CDC, 2013; Barrett, Treves, Shmis, Ambasz, & Ustinova, 2019).

Proper ventilation and filtration are also necessary to limit the spread of infectious diseases (National Research Council, 2007). Emerging research shows that "classrooms with more outdoor air dilution relative to the number of occupants will be more effective at interdicting transmission. Therefore, schools with proper ventilation can reduce the social distancing spaces to three feet instead of the standard six feet regarding preventing the spread of COVID-19" (Lynch, Favata, & Gochfeld, 2021).

CONCLUSIONS

The EPA has implemented a set of standards regarding IEQ and school health that outlines specific steps educational institutions can take to improve their IAQ and the wellness of students within their facilities. These guidelines include five key components: (1) Practice Effective Cleaning and Maintenance, (2) Prevent Mold and Moisture, (3) Reduce Chemical and Environmental Contaminant Hazards, (4) Ensure Good Ventilation, (5) Prevent Pests and Reduce Pesticide Exposure (United States Environmental Protection Agency, 2021). However, these are only guidelines and not mandatory for schools to implement. According to the National Data Summary provided by the Healthy Schools Network in their Report Towards Healthy Schools: Reducing Risks to Children, as of 2016, only twenty-three states have adopted an IAQ policy (p. 7). This report alone shows that over fifty percent of America's schools could be placing their occupants at risk.

Extensive evidence demonstrates how the school building affects student health and success. Acoustics, indoor air quality (including ventilation, moisture management, and thermal health), lighting, space planning, and aesthetics are vital

elements for successful sustainable design. Each factor impacts occupants in multifaceted ways, both in the short term and throughout their academic careers (Eitland, et al., 2017).

While indoor air quality is not the only sustainable design element that affects students, evidence suggests that it has the most significant impact on students' overall health and academic growth.

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The Effect of Dietary Probiotics on Tight Junction Gene Expression in *Danio rerio*

Grace Little

Abstract

Probiotics are microbes found within the diet which partake in positive interactions with their host via the digestive tract (Roberfroid, 2000). Recent research on probiotics has shown that they induce improvement to the intestinal tight junctions by bolstering the commensal bacteria of the colon (Karczewski et al., 2010; Maldonado-Galdeano et al., 2019). Probiotic research of this nature often sees results through administration of probiotics throughout a period of prolonged stress or disease state, but with the recent popularization of probiotic supplements as a health trend, more research is needed to understand the effects of probiotics on a healthy gut. Male zebrafish were fed a diet supplemented with *Lactobacillus plantarum* for a period of eight weeks. Gene expression levels of *claudin-12* and *occludin* were then analyzed by PCR. Results indicated that consumption of probiotics in a non-disease state does not alter the expression of *occludin* and *claudin-12* with any statistical significance, suggesting that dietary probiotics only exhibit a direct influence on intestinal tight junctions during a disease state.

Introduction

Intestinal Function and Probiotics

The alimentary canal represents the barrier between the external environment and the body's vital metabolic and physiological functions. The lining of the digestive tract is structured to serve as a semipermeable veil between the external environment of the canal's lumen and the internal metabolic and physiological pathways of the body. This selective permeability prevents unwanted substances, such as disease-causing pathogens, from entering the bloodstream while allowing for the absorption of beneficial nutrients. The discrimination between which substances are absorbed makes the gut, and subsequently the diet, a targeted medium for regulating overall health through alteration of gut permeability. Commensal bacteria present on the epithelial lining of the colon significantly impact which materials are permitted to cross the intestinal walls (Buffie & Pamer, 2013). These commensal bacteria are often referred to collectively as the gut microbiome or microflora. It has been hypothesized that altering the population size or diversity of the gut microbiome can impact overall health by regulating the permeability of the intestines (Buffie & Pamer, 2013; Ohland & MacNaughton, 2010).

Probiotics are living microbes found in the diet which maintain positive interactions with their host via the digestive tract (Roberfroid, 2000). Numerous strains of probiotic bacteria have been identified as beneficial to human health, with the two most common groups being *Bifidobacterium* and *Lactobacillus* (Gibson and Roberfroid, 1995). The *Lactobacillus* family in particular is often included in dietary probiotic supplements because it has been shown to alter the intestinal environment,

promote the proliferation of existing gut bacteria, and increase the production of intestinal enzymes (Maldonado-Galdeano et al., 2019). Probiotics have become a growing field in diet and health research because of their hypothesized benefits to human health.

Epithelial Tight Junctions

Innate immune defense is a crucial function of epithelial tissue, and this defense is largely governed by the tight junction. Located near the apical face of columnar intestinal cells, tight junctions serve as impermeable points of contact between the membranes of adjacent cells. More than 40 proteins compose tight junctions in order to pinch cell membranes together to form a barrier against paracellular transport (Anderson and Van Itallie, 2009). Transmembrane proteins, such as claudins and occludins, extend from the interior of the cell through the cell membrane to connect to one another in the extracellular matrix, joining adjacent cell membranes (Anderson & Van Itallie, 2009). Intracellularly, claudins and occludins are anchored to cytoskeletal actin by scaffold proteins, such as zonula occludins (Anderson & Van Itallie, 2009). The resulting structure forces pathogens to attempt to enter the bloodstream through transcellular transport, which allows for the pathogens to be identified and destroyed within the cell (Anderson and Van Itallie, 2009).

Increased permeability of tight junctions is often referred to as "leaky gut," and this condition has been observed in many inflammatory conditions such as inflammatory bowel disease, irritable bowel syndrome, celiac disease, and early colon cancer (Karczewski et al., 2010). Heightened permeability of the intestinal wall can also be present in those with diabetes, HIV-related diarrhea, atopic eczema, and food sensitivity (Karczewski et al., 2010). Probiotics, especially *Lactobacillus plantarum*, have been shown in previous research to increase the concentration of proteins that compose the tight junction, claudins, and occludins, near the area of the cell at which the junction would be located (Karczewski et al., 2010). The increased concentrations of transmembrane and scaffold protein strengthen tight junctions, thereby bolstering the intestinal barrier to inflammatory agonists which could otherwise enter the bloodstream through the leaky junction.

Probiotics in Popular Culture

In recent years, probiotic bacteria have been exploited by health and diet companies as a fitness trend marketed toward those pursuing a healthy lifestyle. Popular media sources present the consumption of probiotic supplements and food products as a passive way to boost the immune system and improve overall health. In this context, probiotics are administered through manufactured tablets and pills to be taken orally, or as live cultures in fermented foods such as kombucha. Research, on the other hand, may contradict the idea that this method of consuming probiotics is effective, as studies that observed the increased localization and expression of tight junction proteins due to probiotics delivered the live bacterial cultures grown in a lab directly to the intestine through a duodenal catheter (Karczewski et al., 2010). Furthermore, many of the probiotic studies conducted on humans as well as other model organisms have been conducted in the presence of an existing or induced disease state, usually, an inflammatory condition (Pérez-Ramos et al., 2018). Probiotics, though, are marketed as a diet trend to already healthy individuals

looking to boost their immunity or digestive health. More research is required to better understand the physiological effects of dietary probiotics in those without an inflammatory condition and how that relates to the reputation of probiotic supplements as a diet trend.

Model Organisms

Danio rerio, more commonly known as zebrafish, are small, freshwater teleosts that have become popular both as pets and research subjects (Briggs, 2002). Molecular biologist George Streisinger pioneered the use of zebrafish as a model organism, identifying the traits of the species which made them optimal candidates for research, such as ease of care and clarity of observation throughout development (Briggs, 2002). The species' genome is sequenced, with many gene sequence and gene map resources available (Briggs, 2002). Genomic sequencing has illuminated that 71% of human genes share an ancestral root with zebrafish, and 69% of zebrafish genes have a minimum of one human ortholog (Howe et al., 2017). Additionally, 82% of disease genes found in the catalog "Online Mendelian Inheritance in Man" have a zebrafish ortholog (Howe et al., 2017). These genetic similarities between humans and zebrafish, in both diseased and normal specimens, in tandem with the practical benefits of studying and caring for zebrafish, make *Danio rerio* an important vertebrate model upon which to study human physiology.

Recent studies observing the influence of probiotics on overall health have been conducted utilizing zebrafish as model organisms. Research has also confirmed that many strains of probiotic bacteria which colonize the human colon can colonize the colon of zebrafish as well (Valenzuela et al., 2018). *Lactobacillus plantarum* has been shown to induce local and systemic benefits in *Danio rerio,* such as improving the local intestinal environment as well as attenuating anxiety and preventing oxidative damage to cells (Davis et al., 2016; Zang et al., 2019). Many studies observing the impact of probiotics on the overall health of zebrafish utilized live cultures of probiotics to inoculate larval or juvenile zebrafish rather than adults (Pérez-Ramos et al., 2018). Few studies have been conducted utilizing adult zebrafish as model organisms for dietary probiotic administration; however, adult zebrafish have demonstrated physiological changes, such as reduced systemic inflammation, after dietary administration of *Lactobacillus plantarum* (Wang et al., 2019).

Specific Aims

This study aims to establish a methodology for studying changes in gene expression for the tight junction proteins *occludin* and *claudin-12* in a non-diseased, adult zebrafish model system. Adult, wild-type zebrafish are intended to represent a non-diseased adult human, and they can be considered an acceptable model organism due to their gene orthologs and previous research outcomes indicating their susceptibility to probiotic-induced health changes. Changes in the tight junctions will be determined by using PCR to quantify mRNA expression levels of *occludin* and *claudin-12* genes in the intestinal tissue of zebrafish that have been exposed to a dietary probiotic supplement. Fish who have been exposed to the dietary probiotic will be compared to a control group that was not given a probiotic. The system being observed is intended to model the effects of non-diseased humans taking dietary probiotics recreationally for a short-term period of time. Establishing a methodology

for studying the effects of probiotics in a non-diseased model organism will provide insight into whether probiotics are effective or necessary to an average, healthy human gut.

Materials and Methods

Animal Care and Housing

Male zebrafish were purchased from Carolina Biological Supply ®. The fish were randomly distributed into three separate tanks for a control period of one week. After this week, all fish were removed, three fish were randomly selected and sacrificed as the zero-control, and the remaining fish were randomly assigned to two tanks: a control tank and an experimental tank, respectively. The purpose of the zero-control is to serve as a point of comparison to identify differences or lack thereof in the control group at the end of the study. A total of seven fish composed the control group, and seven fish composed the experimental group. Care guidelines were determined according to the RSPCA's guide for the care and housing of zebrafish (Reed & Jennings, 2011). Each 20L tank was kept full to two centimeters from the top of the tank. The water temperature was maintained to 28.5 °C and AquaSafe ® Plus water conditioner was used anytime water was added or changed to remove chlorine and heavy metals. The full volume of water was changed weekly, with partial water changes occurring weekly or as needed if the water became clouded. In the case of a partial water change, approximately 50% of the water was removed and replaced. Fish were removed and placed in an interim container during total water replacements but remained in the tank during partial water replacements. The aquarium lights were controlled in a 12-hour light/dark cycle, and water filters were changed every two weeks.

The bottom of each tank was lined with gravel to approximately 2.5 cm. Tanks were empty aside from the gravel during the control period, but two small plants were added to each tank during week two of the eight-week experimental runtime to curtail aggressive behavior. Fish in both tanks were observed biting each other's fins, so two plants were added to each tank adjacent to one another on the side of the tank opposite the filter.

Monday through Friday, the fish were fed 0.01g of powdered food twice a day. Feedings on weekdays occurred at 7:00 am and 5:00 pm. On Saturdays and Sundays, fish were fed once a day at 5:00 pm. Fish food was handmade in order to incorporate and control probiotic culture counts into the food. Detailed methodology is contained in the *Food Synthesis Methodology* section which follows.

Food Synthesis Methodology

1g of powdered cichlid fish food was mixed with the contents of 1 Swanson ® *L. plantarum* capsule containing 10^9 CFU of *L. plantarum*. The casing was removed, and the powdered probiotic was stirred into the dry powdered food pellets. This mixture was converted to a paste by the addition of 30 mL of deionized water and extruded through the 3 mm diameter insert of a stainless-steel potato ricer and left to dry while covered for 24 hours on paper towels. Control food received the same treatment without the addition of the probiotic for consistency. Once dry, the food was ground again using a mortar and pestle and given to the fish as powder. At each

feeding, the fish received 0.01g of food, with each dose of probiotic food containing an approximate concentration of 10^6 CFU of *L. plantarum.*

Euthanasia and Sample Collection

Upon the completion of the 8-week experimental runtime, fish were euthanized by rapid transfer into ice water between 2 ℃ and 4 ℃ (Leary et al., 2020). Death was determined to be complete 10 minutes after the cessation of operculum movement. Euthanized fish were patted dry and weighed prior to dissection. The intestine of each fish was removed by dissection under a stereoscope, and the weight of each intestine was calculated. Sample tissue was flash-frozen in RNase-free microcentrifuge tubes by placing the tube containing the sample in a slurry of dry ice and 100% EtOH. After flash freezing, frozen samples were stored at a temperature of -70 °C until mRNA isolation was conducted.

mRNA Isolation

To isolate mRNA from intestine samples, the SurePrep™ Nuclear or Cytoplasmic RNA Purification Kit was utilized with the following modifications: 50µL additional lysis buffer and binding solution were added to each solution out of extra caution, and the amount of **β**-mercaptoethanol added to each was adjusted accordingly. The protocol was modified to better lyse the large tissue samples: the lysis buffer was directly applied to smaller flash-frozen samples in the microcentrifuge tube. Samples whose mass was greater than the suggested 15mg limit were lysed in multiple fractions as follows: the 200µL of lysis buffer was added to the sample as per the kit instructions. After initial homogenization with an RNase-free micropestle, the sample was divided in half and an additional 200µL of lysis buffer was added to ensure complete homogenization.

Reverse Transcription PCR

Reverse transcription (RT) was conducted utilizing Promega GoScript ™ Reverse Transcription Mix, Random Primer Protocol. RT reactions were tailored individually for each sample based on the mRNA concentration. The volume of RNA in ng/mL for each reaction was calculated for each sample from the spectrophotometer concentration reading. A subsequent volume of deionized water was added based on mRNA concentration in order to yield a total reaction volume of 20µL. The primers used can be seen below in Figure 1. The protocol used for reverse transcription was as follows: primers annealed at 25 °C for one cycle of five minutes, extension occurred at 42 °C for one cycle of 60 minutes, inactivation occurred at 70 °C for one cycle of 15 minutes, and the hold temperature was 4 °C for one cycle until removal from the thermocycler.

mRNA concentrations varied throughout the isolation process, so only samples with significant yield were utilized for PCR. Two zero control samples, four control samples, and seven experimental samples were utilized for the PCR process. Primers for *β-actin*, *occludin,* and *claudin*-12 were amplified, and the information on the three primers can be seen in Figure 1 below. The primers for PCR were diluted 10x from a 100µM stock solution to yield a 10µM working solution. PCR was conducted using a 0.3µM final primer concentration. Three protocols were utilized for PCR. Protocol A consisted of the following: 95 °C denaturation for 30 seconds, 56 °C annealing for 30 seconds, and 72 °C extension for 30 seconds. These steps were

repeated for 40 cycles, followed by a final seven-minute extension at 72 °C. Protocol B consisted of the following: one 30-second extension at 95 °C, annealing at 57 °C for 30 seconds, and a 72 °C extension for 30 seconds. These steps were repeated for 40 cycles, followed by one 7-minute cycle at 72 °C. After PCR was completed, the samples were stored at -70 °C until further use.

Gene	**Accession Number**	**Forward Sequence**	**Reverse Sequence**	**Protocol**
β-Actin	M25013	5'-GGCTGTGCTGTCCCTGTA-3'	5'-GGGCATAACCCTCGTAGAT-3'	B
Occludin	KF193855	5'-TATCTGTATCACTACTGCGTC-3'	5'-CATTCACCCAATCCTCCA-3'	A
Claudin-12	KF998571	5'-CCCTGAAGTGCCCACAA-3'	5'-GCGTATGTCACGGGAGAA-3'	B

Figure 1. Forward and reverse PCR primer sequences. Primers were adapted from a study by Wang et al., 2019.

Gel Electrophoresis

Gel electrophoresis was conducted utilizing 1.5% TAE agarose gels which were run for 20 minutes at 80V. Gels were placed on a UV lightbox and documented for later quantitation with photographs.

Quantitation of Gene Expression

Gene expression was quantified using ImageJ software, which quantitated pixel concentration of gel bands. Images were converted to black and white, and blue content was altered to minimize background interference on band intensity. Bands representing *occludin* and *claudin-12* were normalized according to *β-actin* once pixel concentrations had been calculated. Average pixel concentrations were calculated for the control and experimental gene expression of *occludin* and *claudin-12* data sets.

Statistical Analysis

Average pixel concentrations of zero control samples, control samples, and experimental samples were compared using a two-sample t-test assuming unequal variances. Two sets of t-tests were conducted: one to compare the zero control samples to the control samples, and one to compare the control samples to the experimental samples for each gene.

Results

Gel

Electrophoresis

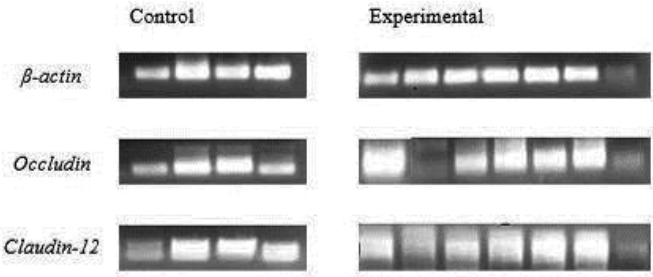
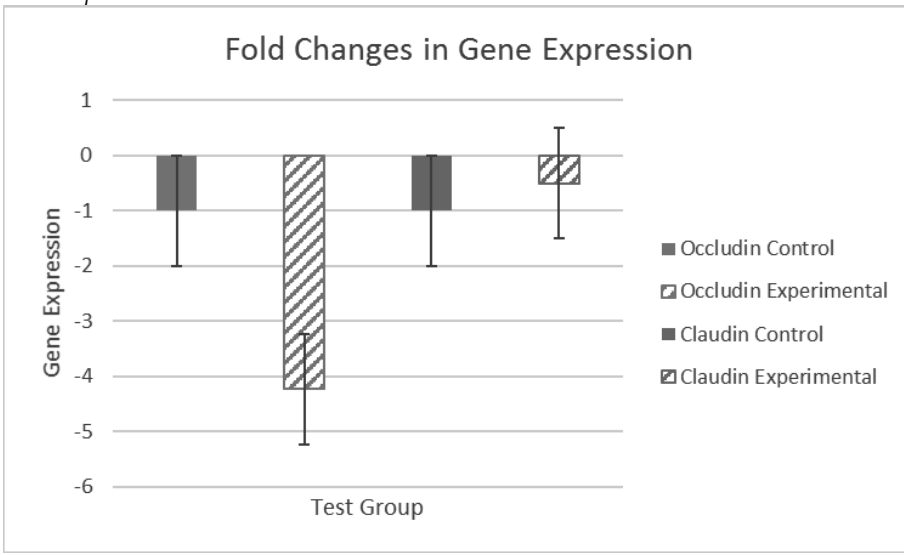


Figure 1 Gel electrophoresis. Bands were quantitated with ImageJ software.

Gene Expression



Images in Figure 2 show bands representing raw data from PCR results after gel electrophoresis. Following quantitation with ImageJ software, gene expression results were normalized to **β**-actin. The data illustrate no significant difference between zero control samples and control samples for either the *occludin* or the *claudin-12* controls (*occludin* expression, P = 0.39, and for *claudin-12* expression, P = 0.66). Control and experimental samples were normalized to one, and fold changes in gene expression for *occludin* and *claudin-12* were plotted in Figure 3. Figure 3 appears to show a significant fold increase in *occludin* expression and no significant change in *claudin-12* expression. Statistical analysis revealed no significant differences in fold

gene expression between control samples and experimental samples for both o*ccludin* and c*laudin-12* (*occludin* expression, P = 0.62, and for c*laudin-12,* P = 0.71).

Discussion

While research on probiotics has extensively explored the use of probiotic cultures to alleviate inflammatory damage to intestinal tissue, studies to explore the effects of probiotics on non-stressed or non-diseased subjects are lacking. Due to the presence of probiotics in trend dieting, this study attempted to use a model which mimics an average, health-focused individual taking probiotics as a diet supplement for a short-term period of time and with no inflammatory conditions. Studies that induce a disease-state to observe intestinal effects have noticed upregulation of tight junction protein genes, indicating that the mechanism by which probiotics influence intestinal permeability during an inflammatory state is through regulating gene expression. This study sought to explore whether these results occurred only in the presence of inflammation, or whether individuals without inflammatory bowel conditions would see similar changes in gene expression for tight-junction proteins. Results indicated that subjects without inflammatory conditions consuming a single-species probiotic supplement for a short-term period of time did not experience upregulation of tight junction protein genes. Further research should explore this result in conjunction with intestinal permeability to confirm not only the lack of increased gene expression, but also to understand whether this mechanism is the means through which probiotics influence intestinal permeability.

This methodology could be repeated for further study on probiotics in healthy individuals. Repetition of this study should include modifications to overcome the restrictions this study faced due to the COVID-19 pandemic, such as increasing both the sample size and the length of the study period. Despite limitations, the results achieved indicate that further study is warranted to understand the relationship between dietary probiotics and a healthy gut, an area in which current literature is lacking due to a focus on disease models. The lack of increased gene expression found in this study suggests that inflammation may serve as positive feedback to elicit upregulation of tight junction proteins mediated by probiotics, while lack of active inflammation may serve as negative feedback to prevent unnecessary translation of intestinal tight junction proteins. This suggests that probiotics may be essential to the diet rather than assistive, maintaining the commensal bacteria of the colon in times of stress without inciting negative long-term effects due to their activity being directly proportional to inflammation levels. This relationship is significant, especially when considering the spectrum at which stress-induced inflammation can be experienced.

Studies on probiotic supplementation prioritize models with inflammatory bowel conditions, suggesting that probiotics are of negligible benefit to those without diagnosable conditions. These conclusions imply a binary system in which an individual taking probiotics is either diseased or not. This conclusion neglects the commonality of inflammation-inducing stressors, which include such common experiences as exposure to environmental toxins, lack of sleep, antibiotics, among others which are of day-to-day relevance (Camilleri 2019). The consideration of daily environmental stressors generates a spectrum at which inflammation can be

experienced, but which is not being fully exploited in research on probiotics. Inflammatory bowel conditions are worsened in the face of these daily stressors, but individuals without diagnosed bowel diseases experience them as well, suggesting the "average" gut is still often subjected to increased intestinal permeability due to inflammatory damage to the gut microbiome. Furthermore, health-conscious individuals tend to habitually minimize daily stressors through diet and exercise habits and therefore may minimally benefit from probiotics, yet they are exposed to significant amounts of non-medical marketing in diet media which insinuates that probiotics, similar to collagen or other fad diet supplements, may enhance their current healthy lifestyle. These three demographics form a spectrum at which the effects of intestinal inflammation, and therefore probiotic supplements, may be experienced and should encourage the diversification of studies on probiotics to include a wider range of inflammatory and non-inflammatory models.

Understanding the effects of probiotics in a non-diseased gut may reveal the need for a change in marketing: health-conscious subjects may require less supplemental probiotics, while individuals subjected to day-to-day stressors may benefit from probiotics just as much as those with diagnosable inflammatory bowel conditions. Overall, expanding probiotic research to cover the full spectrum of intestinal environments, from diseased, to average, to health-conscious would play a crucial role in expanding the field of nutrition and improving public health knowledge as a whole.

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Mathematics and the Arts: The Beauty Behind the Math

Yousef Raslan

Reading the title of this paper, you might ask yourself, "What does the study of mathematics have to do with art?" Furthermore, "How would something so analytical and scientific be related to an entire form of study based on creativity and the abstract?" I ask myself the same questions still, but within mathematics there is a beauty of elegance, of simple proofs, and so on. I will split the topic into two sections for this paper: the first deals with art and beauty found in mathematics. The second is the mathematics found in all forms of what can be considered art. The definition of art is difficult to summarize, so I thought it would be only reasonable to include mathematics in the visual and architectural arts.

I want to start this essay with a quote by Bertrand Russell, a British polymath and logician known for his contributions in set theory, linguistics, and artificial intelligence. In his book *Mysticism and Logic*, he encapsulates the beauty of math perfectly.

> Mathematics, rightly viewed, possesses not only truth but supreme beauty—a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than Man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as poetry. [**9**, p. 48]

Beauty in mathematics itself can be divided into different areas. These include the beauty in technique, method, pattern, and results. For this paper, I will primarily focus on well-known topics such as the golden ratio and the Fibonacci sequence. I will give examples of them in art ranging from that of the ancient Egyptians to the renaissance age to the modern-day. However, not all mathematics is as complex and intricate as the golden ratio and the Fibonacci sequence. Before diving into both of those, let me start with the simple connections between math and art.

Perspective, proportion, symmetry, and lines are all standard terms and techniques used when composing art, but they are also mathematical. This is not limited to modern art; art from all eras involves mathematics. A famous example of proportion in historic art would be Polykleitos's *Doryphoros*, a sculpture depicting a muscular warrior. In *The Canon Of Polykleitos: A Question Of Evidence*, Andrew Stewart states, "The system adopted appears to have taken the form of a series of ratios, which related all the parts of the body proportionally to each other and to the whole…" [**10**, p. 126]. The ratio mentioned does not refer to the golden ratio, but rather to the ratio that signifies "perfect" body proportions according to Polykleitos,

which was roughly around 1.14142 [**11**, p. 308] His influence on Roman, Greek, and Renaissance sculpture was immeasurable and his sculptures, while none survived, expressed mathematical beauty and physical perfection in the male physique.

Perspective is another common mathematical concept used in art. Of course, the composition would look wonky and unnatural if the perspective was out of control and chaotic. Perspective is essentially trying to depict a three-dimensional object on a two-dimensional canvas; it is a way to show depth. Algebra can be used to determine the correct position of the object at hand according to the different viewing points or perspectives. Perspective is an art concept that is heavily influenced by mathematics. However, there are other important concepts that I would like to focus on in this paper.

Considered the most natural and beautiful, the golden proportion, also known as the divine ratio in the Renaissance and currently known as the golden ratio, is a concept that was first studied by Pythagoras (569-500 B.C.E) and the Pythagorean school for its aesthetic value. To help define the golden ratio, let's visualize it. Let a line AB of length (l) be divided into two segments by point C, where C splits the segment unequally. Let the lengths AC and CB be a and b, respectively. If C is a point such that l:a as a:b, which is equivalent to $\frac{a+b}{a} = \frac{a}{b}$, then C is the "golden cut" or the golden section of AB. [**4**, p. 25]

The ratio of $\frac{l}{a}$ or $\frac{a}{b}$ is known as the golden ratio and is denoted by phi (φ).

*Figure SEQ Figure * ARABIC 1 Line segment DB* [**4**, p. 25]

We can calculate the numerical value of the golden ratio. let AC = x, CB = 1, so that AC/CB = x = φ. We get:

$$\frac{x+1}{x} = \frac{x}{1}, \text{ i.e., } x^2 - x - 1 = 0$$

$$\text{The positive solution is } x = \frac{1+\sqrt{5}}{2} \approx 1.61803$$

Check [**4**, pp.25-26] for further information on the reciprocal of Phi (φ) and the negative solution (φ') of the above equation.

One cannot describe the golden ratio without mentioning the Fibonacci sequence. It may not seem obvious, but the Fibonacci sequence has much to do with art composition. It is also closely related to the Golden Ratio as the sequence of ratios of consecutive Fibonacci numbers converges onto Phi (φ).

$$\frac{f_n}{f_{n-1}} \to \varphi$$

To help define and visualize the Fibonacci sequence, I'll use the explanation given in David M. Burton's *History of Math: An Introduction*. Fibonacci originally posed this question about a rabbit pair's offspring:

> A man put one pair of rabbits in a certain place entirely surrounded by a wall. How many pairs of rabbits can be produced from that pair in a year, if the nature of these rabbits is such that every month each

pair bears a new pair which from the second month on becomes productive? [**1**, p. 287]

On the basis that none of the rabbits die, a pair is born during the first month so that there are two pairs present. During the second month, the original pair has produced another pair. One month later, both the original pair and the firstborn pair have produced new pairs, so that two adult and three young pairs are present, and so on. It is important to observe that the young pairs grow up each month and become adult pairs, making the new "adult" entry the previous one plus the previous "young" entry. Each of the pairs that were adults last month produces one young pair, so that the new young entry is equal to the previous adult entry. [**1**, pp. 287 - 288] So, when continued indefinitely, the sequence looks like this:

1, 1, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, … and so on.

This specific pattern of numbers is known as the Fibonacci sequence, and the rule for its *N*th term can be written as:

$$f_1 = f_2 = 1,\ f_n = f_{n-2} + f_{n-1} \text{ for } n \geq 3$$

To put it in words, each term after the second is the sum of the two terms preceding it. Now, what's beautiful about such a series of numbers? It turns out we can use the series of numbers to calculate Phi. We can do this by dividing a Fibonacci number, let's call it f_n , by the number preceding it, f_{n-1}. This will result in a sequence that approaches Phi. The larger the terms used, the closer to Phi we get. [**3**, p.17]

$$\frac{f_5}{f_4} = \frac{5}{3} = 1.66667\ldots$$

$$\frac{f_{10}}{f_9} = \frac{55}{34} = 1.61764\ldots$$

$$\frac{f_{15}}{f_{14}} = \frac{610}{377} = 1.61803\ldots$$

$$\frac{f_n}{f_{n-1}} = \phi = 1.6180339887\ldots$$

For a more detailed view on proving that the sequence of the ratios of the Fibonacci terms converges to the Golden Ratio, see [**1,** pp. 289-292] and for proof that this is true [**3**, pp. 17-18].

The Fibonacci sequence also appears in the golden spiral, which is also known as the logarithmic spiral. The logarithmic spiral is a spiral whose polar equation is: $r = a \cdot e^{b\theta}$, where r is the distance from the origin, θ is the angle from the x-axis, and a and b are arbitrary constants. This spiral is related to almost all of the topics discussed in this paper: the Fibonacci sequence, the golden ratio, and the golden rectangle. [**13**]

The golden rectangle is also closely related to the golden spiral and the Fibonacci Sequence. A rectangle is considered golden if the ratio of its length to its width is equal to ϕ. In other words, the rectangle's sides would have a ratio of 1: ϕ. The golden ratio is defined such that partitioning the original rectangle into a square, with the new rectangle that is formed also having the ratio of its sides equal 1: ϕ. [**12**]

As you can see in figure 2, the sequence and its terms can be directly placed into the areas of both the spiral and rectangle, resulting in a golden spiral that also involves the sequence itself that is bordered by a golden rectangle. Its beauty comes

from the fact that its form remains relatively the same even as it grows in size. When the length of the spiral increases, the radius also increases proportionately, and so the actual shape/form of the spiral remains the same. [**3**, p. 20] For this reason, it is also known as the equiangular spiral due to the nature of its intersection angles. It has been shown that the acute angle formed between any radial vector to a point on the curve and the tangent line to the curve at that point remains the same for all values of θ, which is roughly around 73° [**5**]. The spiral continues inwards and outwards indefinitely and approaches a point known as a center. You can find the center of this spiral by finding the intersection points of the diagonal lines *BE* and *AC* as shown in the picture.

Now that we've established the basics of the golden ratio, the golden rectangle, and the Fibonacci sequence, we can further discuss the beauty and "divinity" that surrounds it. There is not much spectacular about the golden ratio itself (unless you consider φ' being its own negative reciprocal spectacular). It is only when you apply it to architecture, or visual arts does its beauty shine. From Pythagoras's days until modern times, the golden ratio can be seen throughout

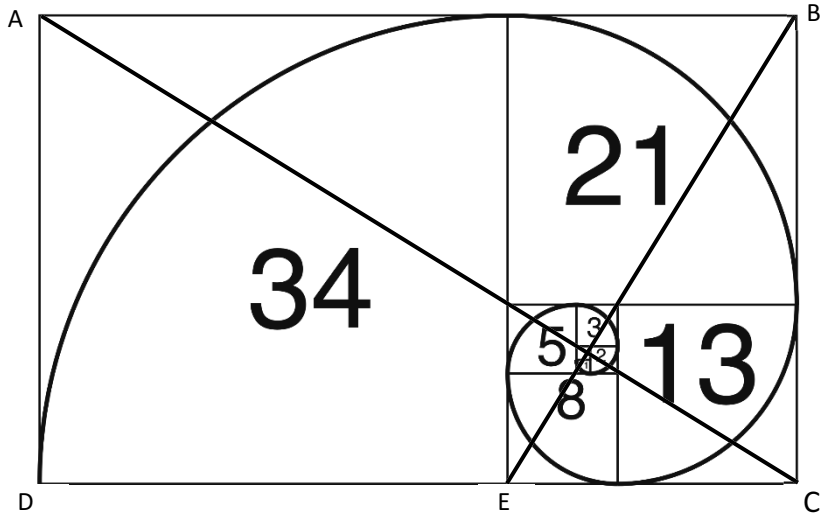


*Figure SEQ Figure * ARABIC 2 Fibonacci Sequence in the Golden Spiral bordered by a Golden Rectangle*

nature and the art humans have produced. Some well-known examples of the artistic rendition of the golden ratio include Leonardo da Vinci's *Vitruvian Man*, *The Last Supper*, and Michelangelo's *The Creation of Adam* (images included at the end) The dimensions in the *Vitruvian Man* include the golden ratio. The measurements of the man's arm length and height, which correspond to the square and circle, respectively, are in a golden ratio. In Michelangelo's *Creation of Adam*, the point where the fingers of God and Adam touch is found to be at the golden ratio of both their horizontal and vertical dimensions. [**2**, p. 704]

Leonardo da Vinci's *Mona Lisa* is another famous painting brought up whenever the golden ratio and visual arts are discussed. It is by far one of da Vinci's

most popular pieces and arguably the most controversial when discussing its golden ratio implementation. As Meisner states in his work, you can find multiple evaluations of the golden ratios, spirals, and rectangles, and there's no possibility that all of them are correct. However, using the measurements of the canvas itself to base the golden ratio on, we can see that there is still evidence of its appearance (shown in the images at the end) [**8**, p.68] We can see that the top of her head is clearly bound by the golden rectangles, while the sides of her hair are approximately bound as well. Furthermore, we can see that her left eye is almost exactly in the center of the frame. Her left and right arms stay mainly on the left and right rectangles, while her chest remains centered.

It is unsure how much of this was actually intended. However, it seems that for the most part, Leonardo da Vinci's and Michelangelo's applications of golden rectangles and the golden ratio were by no means accidental. Based on the detailed inspections of the proportions and sections of the aforementioned artists by Gary B. Meisner, it seems very plausible to assume that the golden proportions, rectangles, and ratios were considered in many drawings from the Renaissance era, though we still do not know for certain. [**8**, pp. 66-74 and 84-89]

The golden ratio and spiral can also be found as a reoccurring natural phenomena. The reasoning behind the "divinity" of the golden ratio can be argued behind its common occurrence in nature. One could question why Mother Nature would design anything less than efficient and "perfect" that could be found so commonly spread around our world. Seen in the formation of animal and seashells, the arrangement of petals on flower buds, and in animal patterns such as butterfly wings, the golden ratio can be seen everywhere if one looks hard enough for it. The beauty of the golden ratio comes not only from mathematics, but from the fact that it can be found in almost everything, both natural and artificial. A ratio so standard that it elegantly tells us the world we live in is built on mathematics and patterns. To lead off with a quote by Mario Livio:

> Some of the greatest mathematical minds of all ages… have spent endless hours over this simple ratio and its properties. But the fascination with the Golden Ratio is not confined just to mathematicians. Biologists, artists, musicians, historians, architects, psychologists, and even mystics have pondered and debated the basis of its ubiquity and appeal. In fact, it is probably fair to say that the Golden Ratio has inspired thinkers of all disciplines like no other number in the history of mathematics. [**6**, p. 6]

Mario describes the golden ratio perfectly. While it is a mathematical concept, its applications and effects range out to almost everything.

Returning to man-made structures, architecture is another big subject where you can physically see the applications of the golden ratio and the Fibonacci sequence. The literal combination of "math and art," or to put it more realistically, art that cannot exist without math, has much room for mathematical expression. The Great Pyramids of Giza are commonly the first pieces of ancient architecture that

have boggled mathematicians, historians, and Egyptologists for centuries; with the immense size and weight of the limestone blocks used to build it, it is only fair to question the techniques and technologies used in the primitive days of the ancient Egyptians.

However, focusing on the architectural value behind the Great Pyramid of Khufu, we see that there is a lot more than what meets the eye. Herodotus, an ancient Greek writer and geographer, learned from the ancient Egyptian priests that the square of the Pyramid's height is equivalent to the area of its triangular lateral side.

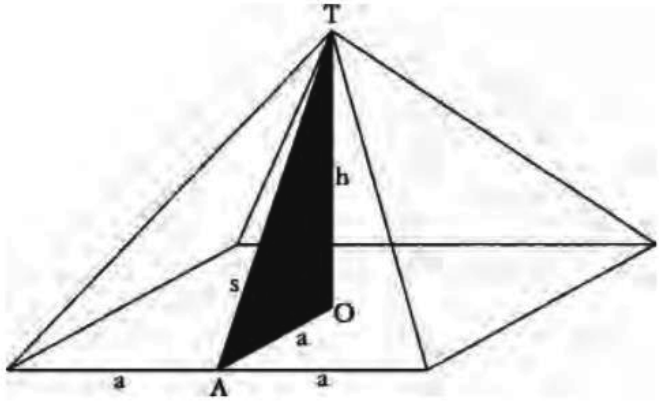


*Figure SEQ Figure * ARABIC 3 Measurements of the Great Pyramid of Giza* [**7**, p. 56]

While this statement might not have been of much use during its time, it essentially tells us that the Pyramid was explicitly built so that the ratio of the height of its triangular face to half the side of the base is equal to the golden ratio. [**6**, p. 56]

Using the figure above, we can see that a is one half of the length of the base, and s is the height of the triangular face. To quote Livio, "If the statement attributed to Herodotus is correct, this would mean that h^2 (the square of the Pyramid's height) is equal to $s \cdot a$ (the area of the triangular face). Some elementary geometry shows that this equality means that the ratio $\frac{s}{a}$ is precisely equal to the Golden Ratio." While it might not be exact, as the sides of the Pyramid are not all exactly equal in length, it still comes very close to the golden ratio. The error margin is relatively small and could be negligible. In *The Golden Ratio: The Divine Beauty of Mathematics*, Gary B. Meisner states that a pyramid based on the number Phi only varies by 0.07% from the Great Pyramid's estimated dimensions. [**8**, p. 95] Using the average measurements of the Great Pyramid of Khufu, we get the calculations:

$$2a = 755.79 \text{ feet}$$
$$h = 481.4 \text{ feet}$$
$$s = \sqrt{h^2 - a^2} = 612.01 \text{ feet}$$
$$\frac{s}{a} = \frac{612.01}{\frac{1}{2}(755.79)} = 1.6195 \approx \varphi$$

As mentioned before, we still would not know if this was intentional or purely coincidence. Livio states, "just from the dimensions of the Great Pyramid alone, it would be impossible to determine whether phi or pi, if either, was a factor in the pyramid's design." [**6**, p.59] However, one can lean more towards believing it was not intentional. According to statements made by Dr. Charlie Smith, a professor of mathematics at Park University with a Ph.D. in mathematics, the ancient Egyptian scrolls which have survived to this day contain zero evidence of knowledge of the golden ratio.

However, using [**8**, pp. 93-102], we can see that the argument that the ancient Egyptians used the golden ratio by pure chance becomes less and less valid. The golden ratio not only appears in the Great Pyramid of Khufu itself, but also in the building site of the Pyramids, at the apexes of all three of the Pyramids, and even in the Sphinx. With the consistent repetition of the golden ratio found in the Pyramid complex, it becomes very difficult to argue against the ancient Egyptian's implementation of the golden ratio in their architecture.

Another famous piece of ancient architecture we must mention would be the Parthenon. Indeed, Greek architects carried out the building of the Parthenon with the golden ratio in mind. The proportions of the Parthenon's exterior and floor plan meet the golden ratio on numerous occasions. It was a sacred temple dedicated to the Goddess Athena and was built on the Acropolis of Athens. Livio states that Adolph Zeising, the author of *"Der Goldne Schnitt"* a book on the golden section published in 1844, believes that the height of the façade from the top of its tympanum to the bottom pedestal below the columns is divided in the golden ratio by the top of the columns. [**6**, p. 73] However, once again, it is not certain whether the use of the golden ratio by the ancient Greek architects was purposeful. Mathematicians such as George Markowsky say that the information presented in articles about architecture, art, and other applications represents false or misleading formation. [**7**, p. 2] However, other mathematicians, aptly named "golden ratio enthusiasts" by Markowsky, state otherwise. In support of these enthusiasts, the current day Parthenon has partially collapsed, and so its features and dimensions might not be as accurate as they were during its construction. As such, the argument of the golden ratio being used could still very much be valid. According to Livio:

> Whether or not the golden ratio features in the Parthenon, what is clear is that whichever mathematical "programs" concerning the Golden Ratio were instituted by the Greeks in the fourth century B.C.E, that work culminated in the publication of Euclid's Elements, in around 300 B.C.E. Indeed, from a perspective of logic and rigor, the Elements was long thought to be an apotheosis of certainty in human knowledge. [**6**, p. 75]

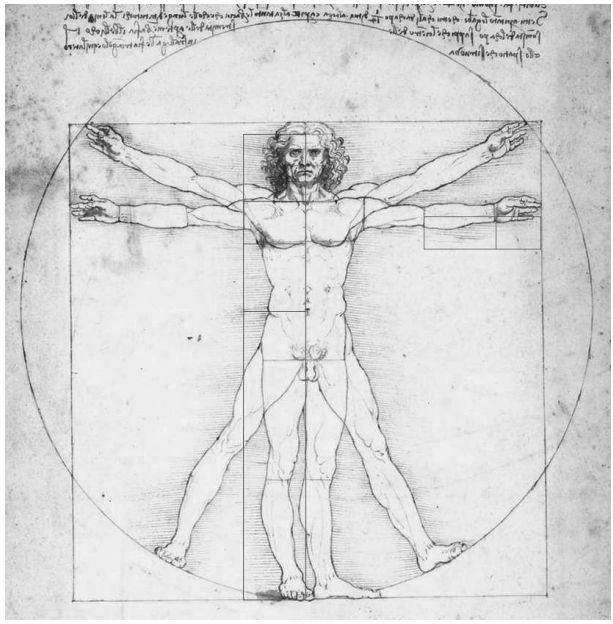
Meisner also has a detailed and beautifully done analysis of the Parthenon in his book cited [**8**, pp. 103-108].

For the third example of man-made architecture, I'd like to cover something a little more recent than the previous two: the Notre Dame Cathedral. The Notre-Dame de Paris began construction in 1163 AD and was not completed until 1260 AD. The cathedral is one of the most widely recognized buildings in France. It is a significant tourist attraction, and reasonably so, as it's one of the most beautifully designed (both mathematically and aesthetically) cathedrals of its time.

The cathedral can be split into different sections, such as the western and eastern façade and the areas of different gothic stained-glass windows. The golden ratio can be found in both the dimensions of these windows and in the western façade, which is also the main entrance into the cathedral. [**8**, p. 111] The exact numbers might be slightly skewed due to the large margin of error while measuring Notre Dame. However, compared to the Parthenon and the Great Pyramids, it is believed that the cathedral's proportions were built based on the golden ratio. So, this tells us that its inclusion was intentional and not pure coincidence.

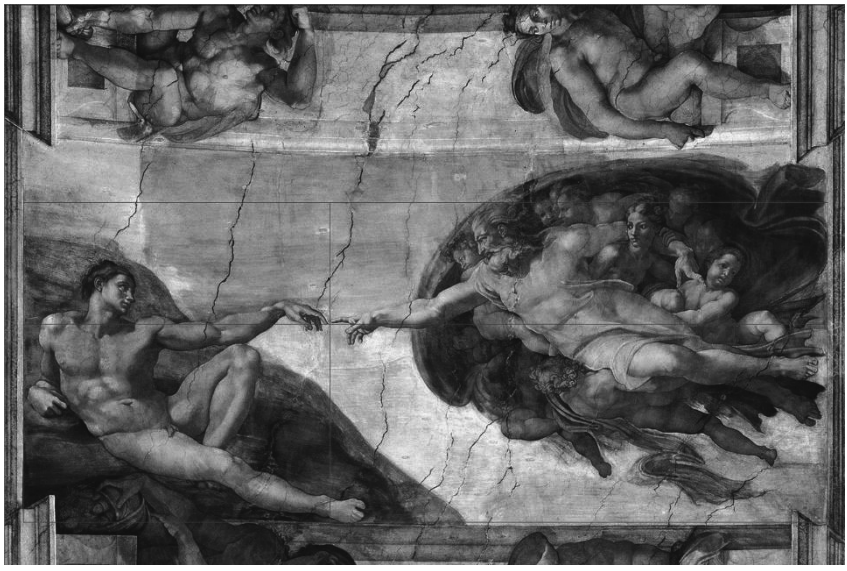
The golden ratio has been studied and analyzed by many mathematicians, historians, architects, artists, and others in the past, and is still a topic of great importance in the current day. Whether or not the intentions and the outcomes of such architects in the past, present, or future were obvious, the fact that the golden ratio can still be seen in such artworks is a testament of its beauty. As previously mentioned, the definition of "art" can be a little vague and different from one person's perspective to another, and so I thought it would be fitting if instead of focusing on art formed by mathematics, I'd focus on the physical applications of mathematics in the real world, both natural and man-made. As such, I would be capturing the beauty of the math while still maintaining the focus on the objects in question.

Somewhat of a recurring theme was evident in almost every real-life application I had presented: We don't know for sure that the artists used the golden ratio intentionally. While it does leave the position open for debate, it should not be mistaken as evidence that its occurrence is merely coincidence. The artistic nature of humans is intricate and complicated to determine. As most of these pieces are hundreds to thousands of years old, it's impossible to say what the creator was thinking during the creation process. However, one thing is certain: The beauty of the underlying mathematics behind all these structures and paintings remain as beautiful and aesthetically pleasing as initially intended.

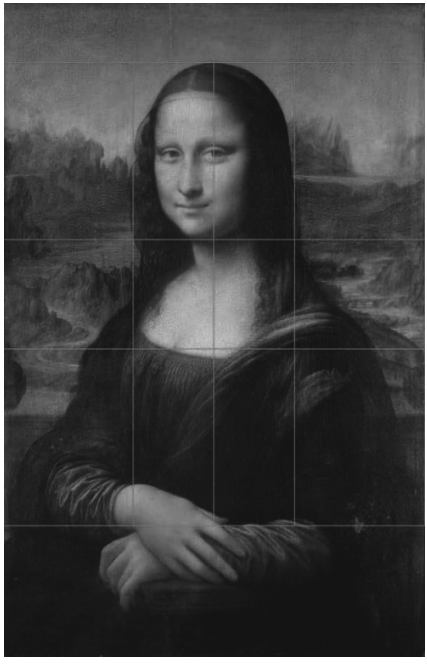


Vitruvian Man, Leonardo da Vinci (1490)

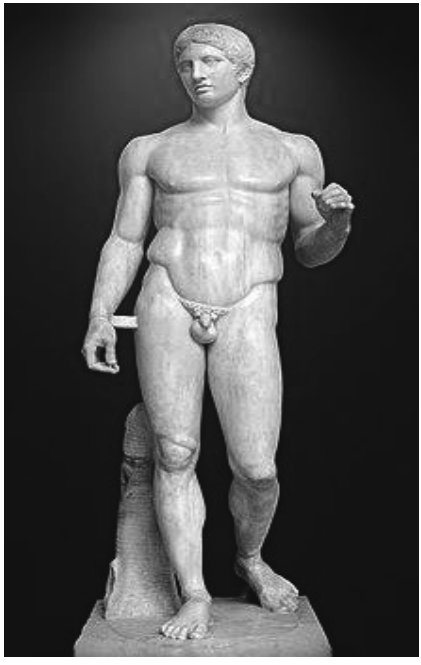
Last Supper, Leonardo Da Vinci (1495-1498)



The Creation of Adam, Michelangelo (1512)



Mona Lisa, Leonardo da Vinci (1503)



A replica of Doryphoros of Polykleitos

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Life and Works of Johann Bernoulli

Grace Wallace Tull

Johann Bernoulli was born to Nicolaus and Margaretha Bernoulli on July 27th, 1667, in Basel, Switzerland. Johann was their tenth child and was one of the five children that lived to adulthood (see [**2**, pg 5]). Johann's father pushed him to follow in his own footsteps in hopes that Johann would take over his spice business. However, at the age of 15, Johann knew this was not the career he wanted to pursue. Johann convinced his father to let him study medicine and began his studies at the University of Basel in 1683. Johann's father allowed him to study medicine thinking that Johann would still follow in his footsteps in the spice business (see, e.g., [**7**]).

While Johann studied medicine, he favored mathematics and would study alongside his older brother Jakob Bernoulli. Jakob, like Johann, was pushed by his father to study subjects he despised, such as philosophy and theology. Despite this, Jakob still managed to include mathematics and astronomy in his studies and would become an important mathematician (see e.g., [**4**]). When Johann joined the university, his brother Jakob was already lecturing on experimental physics. Even though Jakob was twelve years older than Johann, it only took Johann two years at the university to become equal to his older brother on the subject of mathematics. The brothers quickly became partners, studying and working on topics together. In the beginning of their mathematical journey, Johann and Jakob seemed to have a close brotherly relationship, as they even lived together alongside Paul Euler (father of Leonhard Euler) while Paul Euler and Johann were undergraduates at the University of Basel (see e.g., [**10**]).

Johann and Jakob became one of the first mathematicians to understand and apply Leibniz's differential calculus. While studying Gottfried Wilhelm Leibniz's theories, Johann would successfully form a close correspondence with Leibniz. This would become the most important correspondence for Johann (see, e.g., [**2** pg. 8]). Alone, Johann would go on to produce many papers on mathematical topics, even whilst working towards his doctoral dissertation in medicine. These papers would include significant results that were encompassed in his correspondence with Leibniz (see, e.g., [**7**]).

After graduating from Basel University, Johann Bernoulli began lecturing on differential equations in Geneva in 1691. From Geneva, Johann would travel to Paris, where he would be introduced to the Malebranche's circle--a leading mathematics and science group in France built by Nicolas Malebranche. Here, Johann would meet many notable mathematicians, one of them being Guillaume de l'Hôpital. This was the start of Johann's engagement with l'Hôpital. This engagement would last many years and involve intense mathematics. l'Hôpital was mainly interested in Johann's knowledge of Lebneiz's newly published calculus methods. This prompted l'Hôpital

to request that Johann teach him his methods. Johann agreed on one condition: that l'Hôpital would pay lavishly for his teachings. l'Hôpital was delighted, as there were not many other mathematicians who could offer this great opportunity to lecture on newly discovered mathematics. These lessons would take place in Paris and at l'Hôpital's country home in Oucques. Even when Johann returned to Basel, he was still receiving a great sum of money from l'Hôpital by continuing their correspondence through letters (see, e.g., **[10])**.

l'Hôpital would use the knowledge he learned from Johann's lectures in his own work, which would forever give l'Hôpital a place in the history of mathematics. l'Hôpital published the first calculus textbook *Analyse des infiniment petits pour l'intelligence des lignes courbes* (Analysis of the infinitely small to understand curves) in 1696 that only included a small statement in the preface acknowledging Bernoulli as in **[10]**

> *And then I am obliged to the gentlemen Bernoulli for their many bright ideas; particularly to the younger Mr. Bernoulli who is now a professor in Groningen*.

This book would introduce for the first time, the well-known, l'Hôpital's Rule. The theorem of this rule says:

> Let f and g be functions that are differentiable on an open interval (a,b) containing c, except possibly at c itself. Assume that $g'(x) \neq 0$ for all x in (a,b), except possibly c itself. If the limit of f(x)/g(x) as x approaches c produces the indeterminate form 0/0, then
>
> $$\lim_{x \to c} \frac{f(x)}{g(x)} = \lim_{x \to c} \frac{f'(x)}{g'(x)}$$
>
> Provided the limit on the right exists (or is infinite). This result also applies when the limit of f(x)/g(x) as x approaches c produces any one of the indeterminate forms ∞/∞, (-∞)/∞, ∞/(-∞), or (-∞)/(-∞)
> Proof:

Consider the case

$$\lim_{x \to c^+} f(x) = 0 \quad \text{and} \quad \lim_{x \to c^+} g(x) = 0 .$$

Define:

$$F(x) = \begin{cases} f(x), & x \neq c \\ 0 & x = c \end{cases} \quad \text{and} \quad G(x) = \begin{cases} g(x), & x \neq c \\ 0 & x = c \end{cases}$$

.For any x, $c < x < b$, F and G are differentiable on (c,x] and continuous on [c,x]. From the Extended Mean Value Theorem, there exists a point z in (c,x) such that

$$\frac{F'(z)}{G'(z)} = \frac{F(x) - F(c)}{G(x) - G(c)} = \frac{F(x)}{G(x)} = \frac{f'(z)}{g'(z)} = \frac{f(x)}{g(x)}$$

Letting $x \to c^+$, you have $z \to c^+$ because $c < z < x$, and

$$\lim_{x \to c^+} \frac{f(x)}{g(x)} = \lim_{x \to c^+} \frac{f'(z)}{g'(z)} = \lim_{z \to c+} \frac{f'(z)}{g'(z)} = \lim_{x \to c^+} \frac{f'(x)}{g'(x)}$$

see [**5**]. This rule is particularly important for mathematicians because it helps us evaluate indeterminate limits of the form 0/0 or ∞/∞.

Johann was reasonably vexed that l'Hôpital would take credit from his own lectures and would later go on to make claims that he was the true author of l'Hôpital's book after l'Hôpital's death in 1704, likely to avoid breaking agreements that had been set between the mathematicians. Johann would not be recognized or believed to be the author until 1922 when evidence was found that Johann had indeed written the proofs for l'Hôpital's book. It has been proved, though, that l'Hôpital corrected some of Johann's mistakes, such as his belief that the integral of $1/x$ is finite (see, e.g., [**5**]). Although it was upsetting for Johann's work to be "stolen," he would later, ironically, and hypocritically, accomplish similar schemes.

Johann's schemes first started with his older brother, Jakob. As noted previously, Johann and Jakob studied together at the University of Basel. For a time, the brothers made an unstoppable genius duo in the mathematics world. However, due to Johann's fiery and jealous nature, their bond soon broke. Their work became competitive and hostile, as both worked on problems to prove who was the better

mathematician. In one instance in 1691, the brothers became intrigued by the shape of a ship's sail and raced against each other to be the first one to solve the problem. Jakob had written in a letter to Johann exclaiming that he had solved the problem, but did not explain his solution. Johann immediately solved the problem, too, and published his work before Jakob did, belittling his older brother by publicly announcing that Jakob had apparently given up, despite the fact Jakob had already solved the problem. This would only be the beginning of the quarrel between the brothers, as well as the many other quarrels for Johann (see, e.g., [**11**]).

The conflict and competition between the brothers were petty and childish, as they were rooted in getting the most recognition. However, it must be noted that one could consider their conflict and competition extremely beneficial to other mathematicians, as both brothers made very important contributions to mathematics that were motivated mainly out of spite. Johann and Jakob Bernoulli's final break in their relationship would happen after Johann's brachistochrone challenge in 1696. Johann challenged mathematicians around the world to solve the problem with the question, as seen in [**8**]:

> *Given two points A and B in a vertical plane, what is the curve traced out by a point acted on only by gravity, which starts at A and reaches B in the shortest time.*

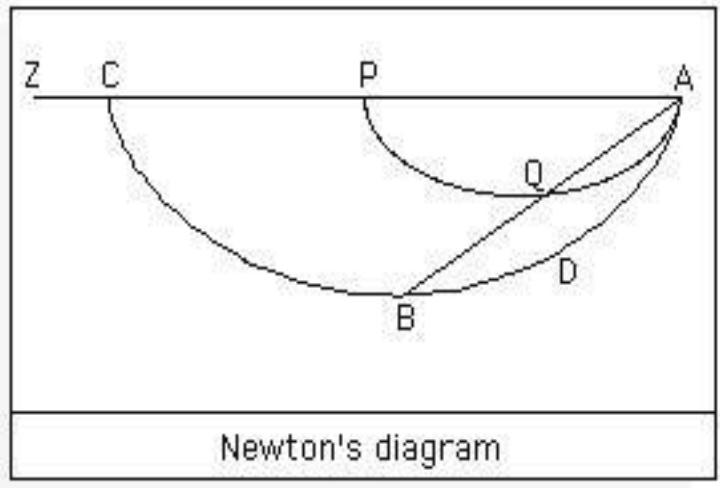
This problem was related to Pascal's challenge regarding the cycloid, of which Johann knew would bring forth the solution to the brachistochrone using the methods of Fermat. The brachistochrone had been attempted before Johann's challenge, such as by Galileo in 1638. However, Galileo had made an error in his work by deducing that the quickest path of descent from A to B would be the arc of a circle, which is false (see, e.g., [**8**]). Johann, along with Leibniz, would intentionally entice their rival, Isaac Newton, which can clearly be seen in his boastful announcement of the challenge [**8**],

> *...there are fewer who are likely to solve our excellent problems, aye, fewer even among the very mathematicians who boast that [they]...have wonderfully extended its bounds by means of the golden theorems which (they thought) were known to no one, but which in fact had long previously been published by others*

The pokes toward Newton in Johann's challenge were successful, and Newton took the bait. Newton's niece, Catherine Conduitt, whom he had been living with, told the story in [**3**]

When the problem in 1697 was sent by Bernoulli - Sir I.N. was in the midst of the hurry of the great recoinage and did not come home till four from the Tower very much tired, but did not sleep till he had solved it which was by four in the mourning

Newton felt had he ignored the brachistochrone challenge, his reputation and honor would be put on the line. This is a reasonable fear for Newton, as it would have been inevitable that both Johann and Leibniz would have mocked his mathematical abilities had he avoided it. It seems that Newton's motivation was fueled by spite, as to make a mockery out of Bernoulli's extended challenge. Newton was able to solve the brachistochrone problem in a matter of hours, while it would have taken other notable mathematicians months. It is reported that Newton said, "I do not love to be dunned and teased by foreigners about mathematical things…" (see [**8**]). Newton sent in his work unsigned and anonymously; however, with an English post and a solution that bore undoubtedly signs of utmost genius, it would be clear that it came from none other than him.



Newton's Solution: From the given point A let there be drawn an unlimited straight line APCZ parallel to the horizontal, and on it let there be described an arbitrary cycloid AQP meeting the straight line AB (assumed drawn and produced if necessary) in the point Q, and further a second cycloid ADC whose base and height are to the base and height of the former as AB is to AQ respectively. This last cycloid will pass through the point B, and it will be that curve along which a weight, by the force of its gravity, shall descend most swiftly from the point A to the point B. See [**8**]

There is a legend that when Johann received the anonymous solution, he both chastened and admired it, placed the document down, and made the remark, "I

recognize the lion by his paw," as seen in [**3**]. Whether or not this legend is true, it showcases Newton's abilities seen by his rivals in a humorous light.

Johann's solution to the brachistochrone takes a more creative path by incorporating Fermat's Principle of Least Time, which states that a ray of light will always take the path of shortest time, so light travels faster in materials with higher refractive index, and vice versa (see, e.g., [**12**]). Johann modeled his brachistochrone curve as a ray of light traveling through numerous layers of varying refractive indices, that becomes a continuous spectrum of varying refractive indices. After applying extensive calculus, the equations are composed of a differential equation, which Bernoulli recognized as the differential equation of a cycloid.

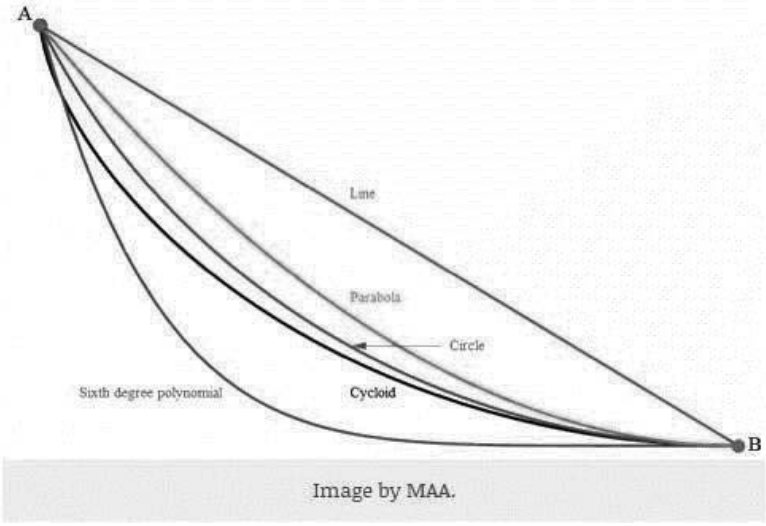


Image by MAA.

See [**12**]. Johann had figured out that the path of shortest time is indeed a cycloid. Johann ended his solution by making the statement, as seen in [**3**],

> *Before I end I must voice once more the admiration I feel for the unexpected identity of Huygens' tautochrone and my brachistochrone. I consider it especially remarkable that this coincidence can take place only under the hypothesis of Galileo, so that we even obtain from this a proof of its correctness. Nature always tends to act in the simplest way, and so it here lets one curve serve two different functions, while under any other hypothesis we should need two curves …*

Only five solutions were retrieved: those of Jakob Bernoulli, Leibniz, Newton, l'Hôpital, and, of course, Johann Bernoulli. Excluding l'Hôpital's solution, all were published in the 1697 publication of *Acta Eruditorum.* Johann praised these solutions by making the statement in [**8**]

> *...the three great nations, Germany, England, France, each one of their own to unite with myself in such a beautiful search, all finding the same truth.*

While it seems that Johann praised Jakob's solution, a bitter argument erupted between the brothers after the publication of *Acta Eruditorum.* Jakob, who did not want to be outdone by his younger brother, challenged Johann to Galileo's original question concerning the time to reach a vertical line rather than a point. Jakob posed the isoperimetric challenge to Johann in [**8**]

> *Given a starting point and a vertical line, of all the cycloids from the starting point with the same horizontal base, which will allow the point subjected only to uniform gravity, to reach the vertical line most quickly*

This would become a detestable episode for the brothers that would lead Johann to never step foot in Basel again until his brother's premature death from tuberculosis (see e.g., [**6**]). However, for other mathematicians, this would become a conflict of great value, as the problems argued between the brothers led to the founding of calculus variations (see e.g., [**8**]).

Johann married Dorothea Falkner in 1694. Their first child, Nicolaus (II) Bernoulli, was born in 1695 and was Johann's favorite child. His second child, born in 1697, only lived for six weeks. During this time in 1697, Johann became so severely ill that he was falsely reported to have died. He had two other children, Johann (II) and Daniel Bernoulli. All his children would become prominent mathematicians (see e.g., [**7**]).

Later, it seems as though Johann would have a relationship with his son, Daniel Bernoulli, that was similar to that of his brother, Jakob. Daniel would become the most distinguished of the second generation of Bernoulli as a mathematician. However, it is clear that his father would try to discourage him from mathematics, just as his own father did, insisting his son should be a merchant. Daniel would ironically end up following the same path his father did, studying medicine while his heart longed for mathematics, and would apply mathematical physics to medicine in order to gain his medical doctorate just like Johann had (see e.g., [**9**]). One of the examples of Johann's jealousy towards his son Daniel is seen in 1738, the year Daniel's reputation was first established as a fine mathematician when he published *Hydrodynamica*. In it, Daniel discussed the properties of basic importance in fluid flow, particularly pressure, density, and velocity, and set forth the fundamental relationship between them all. Then, later in 1738, Johann published *Hydraulica* as an attempt to take away his son's spotlight, yet another instance of Johann's antagonism toward his son.

Johann's bold, jealous, and pompous nature would be seen as a constant theme throughout his life, and not just toward his family and rivals. Johann could be best described by William Dunham given in [**1**]

> *(Johann) was a proud and arrogant man, as quick to demean the work of others as to praise that of himself. Second, any such praise was probably deserved.*

In one humorous instance in 1702, Johann was accused by one of his own students at the University of Groningen. Petrus Venhuysen published a pamphlet that accused Johann of supporting Descartes' philosophy and accusing him of opposing the Calvinist faith. In response, Johann wrote an extensive and humorous 12-page letter to the Governors of the University, which still exists today. It contains the following excerpt

> *... I would not have minded so much if [Venhuysen] had not been one of the worst students, an utter ignoramus, not known, respected, or believed by any man of learning, and he is certainly not in a position to blacken an honest man's name, let alone a professor known throughout the learned world... all my life I have professed my Reformed Christian belief, which I still do... he would have me pass for an unorthodox believer, a very heretic; indeed very wickedly he seeks to make me an abomination to the world, and to expose me to the vengeance of both the powers that be and the common people…*

See [**7**]. This demonstrates Johann's aggressive and understandably petty behavior, and would not be his only dispute while at Groningen, as scientists of the Cartesian persuasion held a strong distaste toward Johann introducing physics experiments in his teaching. Nevertheless, Johann did not let this discourage him from including physics experiments in his mathematics lectures.

Despite Johann's many strong quarrels, he was able to keep some relationships that were important to him, such as his friendship with Leibniz, whom Johann supported over Isaac Newton throughout the dispute over who discovered calculus first. This relationship would serve him well throughout his life as he was able to learn from Leibniz and apply what he learned from Leibniz to his own work.

Johann also had a meaningful correspondence with Leonhard Euler, having an important impact on the life of one of the greatest mathematicians in history. As mentioned before, Johann had lived with Euler's father, so it would make sense that Euler had known about him before entering the University of Basel. After earning his general education at the age of 14, Euler would convince Johann to give him private

lessons, and through these lessons Johann would over eminent potential in Euler's abilities. In Euler's own unpublished autobiography, it is seen that this was true, as he wrote in [**10**]

> *... I soon found an opportunity to be introduced to a famous professor Johann Bernoulli. ... True, he was very busy and so refused flatly to give me private lessons; but he gave me much more valuable advice to start reading more difficult mathematical books on my own and to study them as diligently as I could; if I came across some obstacle or difficulty, I was given permission to visit him freely every Sunday afternoon and he kindly explained to me everything I could not understand ...*

In fact, it was Johann who convinced Euler's father to consent to Euler changing his study from theology to mathematics. Obviously, without Johann's friendship with Euler's father since they were undergraduates, this persuasion would not have been so easy. As such, it is important to note that not all Johann's friendships turned sour. Without Johann's encouragement, influence, and help, Euler's mathematical journey would have been more difficult to achieve so quickly and his greatest work would have been longer delayed had he continued studying theology under his father's wishes. During Euler's time in Basel, he reconstructed numerous pieces of work that he had read with the help of Johann, such as those of Varignon, Descartes, Newton, Galileo, van Schooten, Jacob Bernoulli, Hermann, Taylor, and Wallis (see e.g., [**10**]). Euler would hold close ties with the Bernoulli family, and they would play an important role throughout the rest of his life.

Johann made several important contributions to mechanics with work on kinetic energy, which had been a topic that mathematicians had argued over before Johann's time. Throughout Johann's life, he obtained prominent fame through his work. He was elected a fellow of the academies of Paris, Berlin, London, St. Petersburg, and Bologna. Johann died at the age of eighty on January 1st, 1748. Johann was such an influential and phenomenal mathematician that "Archimedes of his age" was engraved on his tombstone (see e.g., [**7**]).

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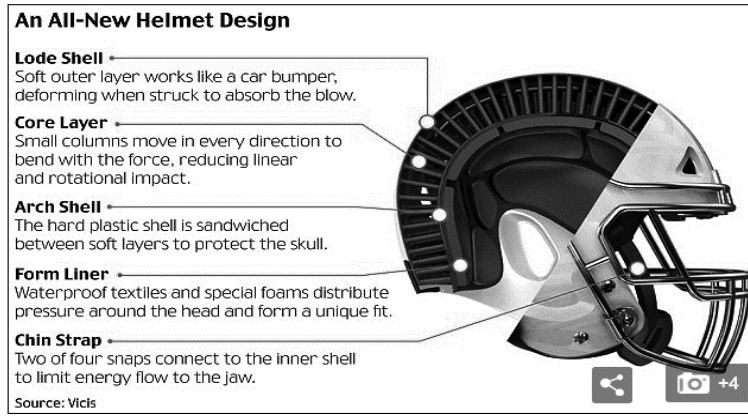
Helmet Safety Innovation

Harleigh T. Scott

The technology I decided to research is the new helmet innovation being used by many football organizations across the United States, including the NFL. The new helmet innovation is built by data that has been studied on and off the field to determine the impact of hits and what positions are more susceptible to those hits. Injuries are a very serious concern in the sports world, and some of the most serious injuries in the sports world are concussions. This is because of the long-term effects we have seen develop as a result of concussions. With the rapid increase in technology, many companies are searching for a way to help athletes continue to play the games they love while also lowering their risk of a serious long-term injury. A company called VICIS is working to develop a helmet that can help soften the blow an athlete might receive. They have developed an outer shell that is meant to absorb some of the impact. This outer shell has proven to reduce the number of concussions a player might sustain. However, there are still other issues VICIS must solve in order to prevent concussions together.

VICIS has partnered with the National Football League and the National Football League Players Association to develop better helmets that will help prevent concussions. VICIS is trying to eliminate the quick jerking motion of one's head during impact. Whether that be from side to side or from a player's head slamming on the ground. This is the hardest concussion to prevent because the amount of padding or cushion needed to stop this from happening would prohibit the athletes from playing to the best of their ability. The design and functionality of these helmets are game-changing. “The rigid structure acts as a penetration resistance and initial shock absorber. The second part is attached inside the helmet’s shell–the energy-absorbing material, usually polyurethane foam” (Dymek et al., 2021).

A team at the University of California is attempting to solve the issue by developing helmets that have about an inch of give in them to prevent the athlete’s head from twisting or coming to an abrupt stop. These helmets would have an inner and outer shell that moves to allow the head a small amount of movement. These helmets would also not add any extra weight to the already prescribed helmet and could be interchangeable for various contact sports. Tim Feaster, an equipment manager at the University of California tried on a helmet and stated, “I have never seen anything like it: an outer shell that moves over the inner shell was intriguing to me. It was so inventive, it made sense the way it moved. I thought they might actually have something here.” (Sanders, 2020). This technology is helping to improve player safety in contact sports.



Here is a link to a video on the helmet design:
https://www.youtube.com/watch?v=axQRM3bQOuU&t=99s

There are several positives that come from trying to reduce the amount of head trauma that football players receive. For example, it allows athletes to play the game of football a lot longer with less fear of developing major head trauma. Concussions have been a part of sports since the beginning. Only recently, though, has there been a massive increase in researching concussions and their long-term effects. Companies are constantly using data to help monitor concussions and find ways by which they can prevent them. VICIS is using RFID tags. These tags are placed in various areas on players to track how their bodies react to different hits and falls. RFID tags placed on shoulder pads, chinstraps, and mouthguards can help determine how fast and in what direction the head moves in the helmet after a hit. "Using this device, the present study sought to identify factors [e.g., player position, helmet model, the direction of head acceleration, *etc*.] that are associated with head impact kinematics and brain strain in high school American football athletes" (Cecchi et al., 2021). The mouthguard sensors play a big role in the new helmet technology, as they are able to detect the amount of force from the impact. These tags are all vital to ensure that they can develop technology that can reduce the severity of the impact these athletes receive. "Zebra's RFID tags are attached to players' shoulder pads and in footballs to transmit real-time location data to gather metrics such as player speed, distance traveled, orientation and acceleration" (NFL, 2021). Helmet technology is advancing in a positive way. This new technology is allowing athletes to play the game they love and live longer, healthier lives. However, the challenge with this technology is still allowing athletes to perform at very high levels. These athletes must be able to move, jump, sprint, catch, throw, and all sorts of other motions. These motions cannot be limited by the gear they wear. Another drawback is that they haven't developed position-specific helmets just yet. However, that is the goal with their emerging technology.

How might this technology impact the future of sports? It is clear these advancements would positively impact the world of contact sports. The technology of helmet innovation that VICIS provides is a flexible outer shell. These helmets are very

similar to new cars, due to the flexibility on the outside which allows it them to absorb the impact of a hit. The impact these helmets can absorb are used to protect the player's head--for football as well as every other contact sport. This technology could be used by a variety of different players. For instance, baseball, softball, soccer, hockey, and rugby. These helmets will improve the safety of the game and allow players to remain playing the game they love. "Linemen experience more than twice as many impacts as other players, with the largest percentage of hits to the front of the helmet" (VICIS, n.d.). The design of the helmet will continue to change and develop in the future. The softshell of the helmet acts like a car bumper, absorbing the impact of a hit before the forces can reach the head. As this technology grows more, innovations will be made to lower the risk of concussions in contact sports. Lowering the risk of concussions and head trauma in contact sports is the ultimate goal in the future of sports and helmet technology, and innovation can make that happen. "If there's one thing more important to protect than the ball, it's what's underneath that helmet" (NFL, 2021).

VICIS (2021)

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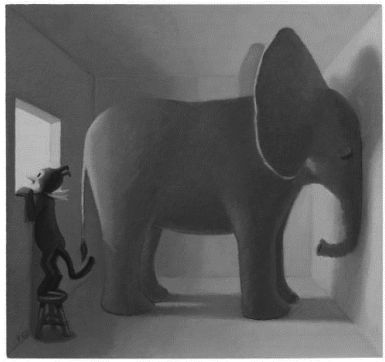
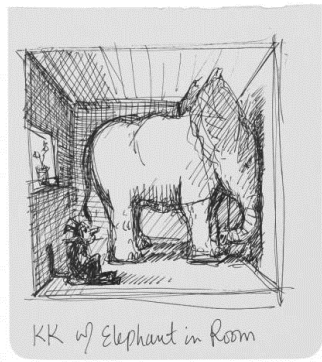
Elephant in the Room

Brandi Welch





Not just a common phrase, *Elephant in the Room* is also a captivating piece of art. I had the pleasure of seeing *Elephant in the Room II*, 2020, by Vonn Cummings Sumner at the Jan Shrem and Maria Manetti Shrem Museum of Art. The piece is oil on canvas over panel, with its size being 15 x 16 in. (38.1 x 40.6 cm). This piece conveys how we all, as people, have "elephants" in our rooms of life. The "elephant" refers to something we can choose to ignore or face regarding the sanctity of our own sanity. In this paper, I will breakdown this meaning by discussing the background of the piece and its message while also describing the artistic elements used.

To start, it is necessary to discuss the artist Vonn Cummings Sumner. Sumner was the son of a picture framer and teacher, and he grew up in the San Francisco Bay Area. Traveling to different countries and seeing the art his father framed helped shape Sumner's visual aesthetic during his formative years. He attended the University of California, Davis, earning both a bachelor's degree and an M.F.A. in painting with highest honors.

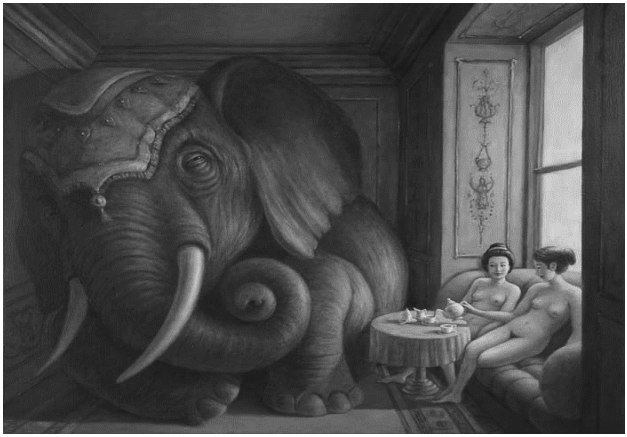
In order to break down this piece of art, we will begin with some history about the character, Krazy, that you see in the artwork along with the elephant. The figure is a 2020 version of Krazy Kat, the protagonist of the comic created by George Herriman in the early 20th century that is beloved by many artists, including Philip Guston and Jess. Wayne Thiebaud has passed along his love of Krazy Kat over the years to his students, including Sumner. As Grace Munakata recounts in a video interview, Thiebaud compared Herriman to Francisco Goya (1746–1828), emphasizing the importance of Herriman's work and elevating him and his genre — comics — to a status usually accorded only to the great painters of art history. (Vonn Cummings Sumner, 2021b)
Sumner's version of Krazy is not a replication of the comic strip. Rather, his version is gender-fluid and explores his own identity.

To break this piece down, let's begin with what is happening—specifically with the two characters Krazy and the Elephant. Krazy, looking out the window, has a sense of innocence about him. You can interpret this from the gleam of the light and

what appears to be a smile across his face. Using the color white, when his body is more grayscale, brings out that element. Along with the smile, he stands on his toes on a stool like most children do when they are too short to see or reach high things. Sumner, using different lines to produce dimension and shape, creates the appearance of a window in this two-dimensional painting. Krazy is looking out the window, and although it seems like nothing is out there, it appears as though it is bright outside. A contrast of light with darkness is created beautifully with shading. "Shading is a technique that allows for depth and character to be added to an illustration. In drawing it shows the levels of darkness by placing darker shades to show shadows and less dense shades to highlight lighter areas." (The Power Of Shading - How To Bring Illustrations To Life, n.d.). On the side of the piece where the window is, it is shaded deeper and darker because, realistically, the light from a window wouldn't hit those walls. As you look towards the right side, it gets brighter where the window would hit, and a shadow was even created for the Elephant.

The Elephant is quite the opposite of Krazy, specifically in size and aura. At first glance, you can see how the Elephant is quite literally the Elephant in the room. When you think of the common phrase, the Elephant is usually a symbol for a sizeable issue that everyone can feel but chooses to ignore because the conversation or confronting it makes them uncomfortable. In this piece, the Elephant is taking up most of the space in the room. Although you would think it quite noticeable, a naïve Krazy goes unphased. In contrast to the happiness Krazy feels, the Elephant is quite somber. "Lines are used to create shape, pattern, texture, space, movement and optical illusion in design. The use of lines allows artist to demonstrate delicacy or force." (Ontavilla, 2021) With the Elephant's head against the wall, the use of lines creates the illusion of closed eyes that look sad. Overall, the piece also has a dull-like texture. "Texture is the perceived surface quality of a work of art. It is an element of two-dimensional and three-dimensional designs and is distinguished by its perceived visual and physical properties." (Wikipedia contributors, 2021) In this piece, the texture not only displays the dimension, but the gray dullness gives a similar feeling to a prison cell symbolizing being trapped with your "elephant".

A similar piece that gives the contrast between two elements is *Elephant in the Room* by Mark Bryan. In his piece, he illustrates a similar scenario. One where an elephant, taking up the majority of the space, looks sorrowful. Meanwhile, there are two women, who look unphased and enjoying their lives, being this piece's version of "Krazy".



Although aesthetically different, the messages of both pieces have quite similar meanings. The situation being displayed is a symbol for what we as people struggle with every day. You can interpret it as the everyday person being Krazy, going through life trying to look for the brighter things ahead. On the other hand, the Elephant can be the issues, both internally and externally that we face on a daily basis. We encounter many elephants in this room we call life. This is where we must make the choice to confront the issue or live in ignorant bliss at the cost of our own sanity.

What is the elephant in your room?

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Trauma Studies in Chickamauga

Carson Lau

Artists of all crafts are unique in the sense that their creativity is typically a reflection of an event or feeling they are expressing. Painters express themselves on canvas, musicians express themselves via instrumental majesty, and writers express themselves on paper through words. Personal experiences heavily influence the art or message an artist intends to portray. Fascist regimes influenced George Lucas's galactic empire, a bad break-up influenced Lindsey Buckingham's "Go Your Own Way", and in the case of Ambrose Bierce's "Chickamauga", traumatic war experience influenced the themes within his short story.

Ambrose Gwinnett Bierce was an American writer in the Civil War era. Bierce was a journalist, poet, and novelist. He also penned short stories. Bierce was born in Meigs County, Ohio on June 24th, 1842 to Marcus Aurelius Bierce and Laura Sherwood Bierce. He was one of twelve brothers and sisters growing up in Kosciusko County, Indiana, and ended up leaving home at 15 to become a printer's apprentice for a newspaper called "The Northern Indiana" before enlisting in the Union Army's 9th Indiana Infantry at the age of 18. Bierce experienced several battles during the Civil War, including the Battle of Rich Mountain, where he rescued a fellow wounded soldier, and the Battle of Shiloh, which was an experience that became a source for the memoir "What I Saw of Shiloh" and various other short stories. Eventually, Bierce would suffer a traumatic brain injury at the Battle of Kennesaw Mountain in June of 1864. This injury ultimately ended his military career, and he was discharged from the army the following January.

Through the invocation of Literary Trauma Theory, I will investigate and frame how Bierce's traumatic experiences in the army greatly influenced his writing, specifically "Chickamauga" (1889), a short story about battle that ultimately tells of his underlying traumas--whether it be consciously or subconsciously. First, though, let's define trauma.

The Center for Treatment of Anxiety and Mood Disorders defines trauma as "a psychological, emotional response to an event or an experience that is deeply distressing or disturbing." Furthermore, the center states "Post-Traumatic Stress Disorder can develop after a person has been exposed to a terrifying event or has been through an ordeal in which intense physical harm occurred or was threatened" (Center For Treatment of Anxiety and Mood Disorders). Literary Trauma Theory is a relatively new study that focuses on the concept of trauma, the complex psychological and social factors that impact comprehension of a traumatic experience, and how that experience affects and is affected by language. Cathy Caruth, professor of English at Cornell University and leading scholar in the field of trauma studies, produced theories regarding psychoanalytic post-structural approaches that suggest trauma causes irreversible damage to the psyche and manifests itself in the inherent contradictions of experience and language. In "Literary Trauma Theory Reconsidered", Assistant Professor of English at Washington State University, Michelle Balaev, writes that this approach creates a concept of trauma as a recurring sense of absence that sunders knowledge of the extreme experience, preventing

linguistic value other than a referential expression. In other words, the knowledge of the experience is split from conscious thought, and this particular theory suggests that it is only accessible through unconscious expression or indicates a Freudian-type theory that suffering is unrepresentable.

Sigmund Freud ultimately developed the notion that trauma causes dissociation, or a gap in the psyche (Mambrol). Dissociation is the disconnecting from one's thoughts, feelings, memories, or sense of identity; essentially, it is the "splitting" of conscious thought. Later in Freud's career (1920), in *Beyond the Pleasure Principle*, he writes, "2 Traumatic events create conflicts in the ego which 'split off' from the unity of the ego and are repressed but return later often in dreams" (Freud 8). This turns the discussion back to Bierce and the relationship between his trauma and the dreamlike states depicted in his short stories. Kyle Keeler, a contemporary scholar of Bierce, writes of these sleep states,

> ...Bierce's characters fall into a deep and often unexplained sleep, similar to what scholar Laura Doyle has called a "swoon moment" in transatlantic slave narratives, wherein a character "faints or momentarily collapses" and "loses its old social identity… only to reawaken… 'born again' from its own ashes. (Keeler 452)

Doyle's "swoon moment" is analogous to Bierce's characters' sleep states in the literal sense of the context, but also to Bierce's desire to face, express, and heal from the trauma he's experienced.

Bierce sets the scene in "Chickamauga" with a description of a young child who strays from his home and into a forest. "It was happy in a new sense of freedom from control, happy in the opportunity of exploration and adventure" (Bierce). The new sense of freedom from control alludes to Bierce's wanting to break free from the terror caused by his trauma. He continues to write of the boy's spirit and defines a scene within the imagination of the child of a glorious and victorious battle. The boy comes upon a small animal, "Advancing from the bank of the creek he suddenly found himself confronted with a new and more formidable enemy: in the path that he was following, sat, bolt upright, with ears erect and paws suspended before it, a rabbit!" (Bierce).

The boy flees from the area in terror and eventually comes to rest where his sleep state begins. In essence, the rabbit in this scene is significant because it becomes the first representation of the monster of trauma that Bierce must face.

> Then, for more than an hour, he wandered with erring feet through the tangled undergrowth, till at last, overcome by fatigue, he lay down in a narrow space between two rocks, within a few yards of the stream and still grasping his toy sword, no longer a weapon but a companion, sobbed himself to sleep. (Bierce)

The child, "…breathless, blind with tears-- lost in the forest" (Bierce), desperately wandering through countless barriers to escape the rabbit that terrorized him, is figurative for Bierce himself, desperately trying to escape the traumas of his past

experiences. Grasping the toy sword, Bierce depicts that those experiences are no longer weapons, but that they feel like companions; something he has grown to desire, but that nonetheless drags him down as he sobs himself to sleep. Relating this to trauma theory, Freud writes,

> ...because the patient "cannot remember the whole of what is repressed in him, and what he cannot remember may be precisely the essential part of it" the patient "is obliged to repeat the repressed material as a contemporary event instead of… *remembering* it as something belonging in the past. (Freud, 18)

Freud's point is evident in Bierce's case, as his narrative of suppressed traumatic events is crucial to his recovery from trauma. He may have intentionally written this narrative as a representation of the trauma he's attempting to process. If he didn't, then Freud's theory of dissociation and Cathy Caruth's theory of trauma as fragmenting consciousness and preventing direct linguistic representation suggest that his repression of those events is subconsciously expressing itself in the forest of Chickamauga.

On the other side of that dream state, Bierce juxtaposes peace and serenity against gloom and the morbidity of men creeping on hands and knees, dragging their legs behind them in an attempt to escape the terror and brutality of battle. As the men attempt their escape, the young boy does not note them as being terrible. He moves among them "peering into their faces with childish curiosity" (Bierce). So too, does Bierce ignore his own terror as his repressed trauma moves among *him* with the same demeanor, as he himself attempts to escape the brutality of battle. "Something in this-- something too, perhaps, in their grotesque attitudes and movements-- reminded him of the painted clown whom he had seen last summer in the circus, and he laughed as he watched them" (Bierce). The boy's ignorant laughter at the terror, based on Caruth's dissociative theory, acts as Bierce's defense mechanism for navigating, or rather avoiding, the terror of his experience. Michelle Balaev writes,

> …the innate causality between trauma and dissociation, the idea that an extreme experience directly produces a dissociative consciousness wherein the truth of the past is hidden, supports Caruth's claim that history functions the same as trauma insofar that "history can be grasped only in the very inaccessibility of its occurrence. (Balaev 6)

The dissociation of the boy represents Bierce's awareness of his own dissociation in which the reality and truth of his experiences are hidden.

As the scene progresses, the boy continues his own dissociation and treats the situation as a merry spectacle, pretending the men are his horses.

> He now approached one of these crawling figures from behind and with an agile movement mounted it astride. The man sank upon his

> breast, recovered, flung the small boy fiercely to the ground as an unbroken colt might have done, then turned upon him a face that lacked a lower jaw .(Bierce)

The child, jolted by the buck, is finally conscious of the terror and retreats to a nearby tree to get a better look at the situation. The landscape becomes brightened by a distant red light, which, despite symbolizing indications to stop, the child innately moves toward with his maculated, militant companions. This is figurative for Bierce's progress to process his trauma. Even though he is fearful of the outcome, and despite ultimately wanting to avoid it (the red light), he won't resist his desire to face it. The representation shows itself in the boy's sudden awareness of reality, or Bierce's awareness of previous traumatic experience.

The child, still with his toy-sword companion, leads the desolate charge of wounded men through the woods and toward the red light. "He placed himself in the lead, his wooden sword still in hand, and solemnly directed the march, conforming his pace to theirs and occasionally turning as if to see that his forces did not straggle" (Bierce). As the child leads his monsters-of-men, Bierce leads his own demons toward a fire at the edge of the forest, which just so happens to represent his showdown with the traumatic experience in his subconscious. Using Caruth's model, the traumatic experience can't be represented directly, but rather takes the form of another identity within the mind; in this case, the fire. "Although the experience may never be narrated or identified clearly, it acts like a tumor in consciousness and memory that prevents the past from becoming incorporated into a life narrative (Mambrol). This acts as a clear explanation for Bierce's trauma represented in "Chickamauga".

As they continue, the boy comes to discover that the land in which they are traveling had been traveled once before. He notices the rubble of battle and realizes that battle must have been exactly what had taken place there, and that he slept through the entirety of it. This supports the notion that the traumatic experience of battle caused the dissociation to occur within Bierce's mind and become represented in the narrative of the boy sleeping through the very thing that traumatized him in the first place.

The boy then approaches the fire and, as he gets closer, he comes across several soldiers drowning themselves trying to drink from a nearby creek. Bierce writes, "Three of four who lay without motion appeared to have no heads. At this the child's eyes expanded with wonder; even his hospitable understanding could not accept a phenomenon implying such vitality as that" (Bierce). It is no coincidence that things become more terrorizing as the boy approaches his fiery destination. This represents Bierce's repression in fear of coming face to face with the memory of his traumatic experiences and the pain of his psyche pleading with him to turn back.

We pick back up with the boy as he passes through the woods, across a field, and toward the fire. As he approaches, he once again ignores the horror and desolation and "danced with glee in imitation of the wavering flames" (Bierce). He wants to fuel the fire but all of the objects he reaches for are too heavy to heave. Then, Bierce writes, "In despair he flung in his sword-- a surrender to the superior forces of nature. His military career was at an end" (Bierce). The ignorance of the desolation is

the dissociation from the trauma. Ultimately, Bierce recognizes that it is time for him to surrender to his trauma and acknowledge it so that he can move on. In writing that his military career was at an end, he portrays no longer having the will to fight with his trauma.

Suddenly, the boy realizes that he sees some buildings within the blaze that look familiar. Bierce writes in his narrative:

> He stood considering them with wonder, when suddenly the entire plantation, with its inclosing forest, seemed to turn as if upon a pivot. His little sword swung half around; the points of the compass were reversed. He recognized the blazing building as his own home! (Bierce)

The significance of the boy's realization that it is his own home burning is that Bierce too is recognizing that his struggle is within himself, and he must face his past, painful as it may be.

Next, the boy begins to frantically run around the area to search it. He comes upon a dead woman, who turns out to be his mother, lying in the grass. Bierce depicts the horrific scene of the boy holding his mother, bloodied and mutilated. The fact that the boy discovers his own mother is dead is not significant in itself. Rather, the way in which Bierce writes about it, using incredible detail, is: "The greater part of the forehead was torn away, and from the jagged hole the brain protruded, overflowing the temple, a frothy mass of gray, crowned with clusters of crimson bubbles-- the work of a shell" (Bierce). This is significant because it relates to Cathy Caruth's theory that the suffering caused by a traumatic event is prevented from being incorporated into a life narrative, so it changes its identity within normal consciousness (Mambrol). In other words, the trauma of battle that Bierce must face becomes represented, in this case, by the boy's mutilated mother.

Finally, Bierce writes, "The child moved his little hands, making wild, uncertain gestures, he uttered a series of inarticulate and indescribable cries-- something between the chattering of an ape and the gobbling of a turkey-- a startling, soulless, unholy sound, the language of a devil. The child was a deaf mute" (Bierce). This is an emphatic and shocking end to Bierce's classic narrative that puts the reader in a state of confusion. Although he came all this way in an attempt to process and heal from it, in the end, the child's wild gestures, the unholy sound, and the fact that he was a deaf, mute boy was just Bierce's way of scribbling it all out; and that the trauma of his experience was too painful, and he was ultimately unsuccessful facing it in totality.

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Business Analytics at Netflix

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Abstract

The purpose of this paper is to examine the Business Analytics course topics by applying them to a case study report on Netflix. Netflix demonstrates exemplary business processes by implementing data analytic technology and techniques into every business decision. Netflix is a strong contender in the application of Big Data through data management in data warehouses and data lakes. Data mining tools like Apache Spark and Tableau allow Netflix to apply descriptive, prescriptive, and predictive analytics to business processes and decisions. Netflix remains at the forefront of emerging technologies to sculpt the future of the company through informed decisions with the best data. This paper considers the ethical concerns of data collection, analytics, and emerging technologies.

Netflix Executive Summary

Created by Reed Hastings and Marc Randolph, Netflix is the world's most popular online streaming platform. What started as a mail-in DVD rental business in 1997 with a unique business model of no due dates, late fees, or rental limits, quickly grew (Netflix, n.d.). Through innovative initiatives, Netflix became the first organization to offer subscription-based, over-the-top content platform entertainment services in 2007 (Netflix, n.d.). Netflix now streams to over 190 countries (Rama-Poccia, 2018). Certain viewing content is restricted by location and each region operates a subcategory of Netflix. Again, Netflix continued to set itself apart by providing personalized recommendations to users for content based on their individual profiles and viewing habits, providing different lists to each user even if they were on the same plan. The company became even more popular when it partnered with popular electronic brands to stream directly to their devices, often with a Netflix button that takes the consumer directly to the application, like Xboxes, TVs, and Blue Ray Players (Netflix, n.d.).

The company's dedication to growth does not end there. It continued to grow its business model through the production of its own materials, making original shows and movies that trend globally and provide more creative control with lifetime licensing (Netflix, n.d.). Most of Netflix's content falls within three major sources and each provides a different profit margin: content created and owned by other companies that is viewed on Netflix and potentially other sources, content created by others that is exclusively viewed on Netflix, and content created and owned by Netflix that is exclusive to their services (Rama-Poccia, 2018). More recently, the company has made efforts to improve its public outreach and corporate reputation by moving two percent of its cash holdings to financial institutions supporting Black communities and announcing a net-zero greenhouse emissions plan to be instituted by the end of 2022 (Netflix, n.d.).

Netflix Data Warehouse Use Case

The future of Netflix's analytical capabilities is endless with the application of a data warehouse to consolidate, normalize, and store key data points. Netflix's viewer preferences, varied content procurement, market analysis, social responsibility, and social media presence all provide unique and powerful opportunities to analyze data already being captured in various parts of the company. Implementation of an operational data store (ODS), extract, transform, load (ETL) process, data warehouse (DW), data marts (DM), and potentially data lakes (DL) will increase the productivity and profitability of the company.

Viewer Preference and User Profiles

Netflix prides itself on being the first streaming service to offer predictive suggestions for user profiles. But viewing preferences go far beyond the suggestion of what someone may or may not like. Netflix, unlike traditional television networks, can view data on show completion rates and user viewing behaviors such as when a show is paused, rewound, or fast-forwarded. In addition, Netflix can view data on what day and time content is viewed, the location of viewing, which device the platform is accessed on, ratings assigned by users, and browsing behavior (Bulygo, n.d.). Netflix streams in over 190 countries and each country has uniquely available shows, bringing unique analytics (Rama-Poccia, 2018). Collecting this data from an ODS on viewers' preferences, interactions, and habits provides valuable information in real time before being prepped for ETL and storage in the DW. The data collected on user behavior and preferences can be utilized in decision-making on content creation or acquisition methods.

Content Creation or Acquisition

All of the data from Netflix's large user base allows it to identify trends in the market and, therefore, best identify what shows are most likely to be watched (Bulygo, n.d.). As an example, Netflix outbid HBO in 2011 to create two seasons of House of Cards because the company knew the director's movies were watched from beginning to end, the British version of House of Cards was popular and watched regularly, and those who watched the British version also watched Kevin Spacey films and/or films directed by the same director (Bulygo, n.d.). This is a great example of what Netflix is capable of when using data from global user profiles, data from financial systems on costs for production, and data on competitors in the market all stored in the DW to drive their Decisions Support System (DSS).

Netflix has three major content sources: content created and owned by others but exclusive to Netflix, content created and owned by Netflix, and content created and owned by others viewed on Netflix and other sources (Rama-Poccia, 2018). Netflix has to rely heavily on data collected in the DW from Netflix viewership, the market, and financials to decide which projects to take on at Netflix and give the company more creative control, as well as which titles deliver enough viewership in relation to licensing cost to purchase from others (Bulygo, n.d.). Each form of content creation would be usefully stored in a DM since they are a subset of the data stored in

the DW that focus on a particular department or subject (Sharda et al., 2021). Utilizing a DW to store market information on competitors, their top producing shows, and the metadata of those shows or movies, allows Netflix to focus on content outside the scope of its own.

Social Responsibility

Netflix has a strong commitment to social responsibility and utilizing a DW can only increase the company's capability to succeed in this area. For instance, the company has pledged to achieve net-zero greenhouse gas emissions by the end of 2022, and every year thereafter (Stewart, 2021). Data for this initiative comes from several different DBs on the company's operations, and optimizing a DW to collectively store this data in a way that can be used for the analysis of this huge project provides great value. Taking time to understand Netflix's footprint, determining ways to offset, reduce, or eliminate it, and putting together a detailed course of action were powered by data. Roughly 50% of the footprint was from physical production, 45% being from corporate operations and purchase goods, and 5% from cloud providers for content (Stewart, 2021). Netflix has a plan to reduce its emissions, retain existing carbon storage, and remove carbon from the atmosphere (Stewart, 2021). This effort will be a move-forward approach and requires continued support, data, and analytics from multiple databases in the company.

Netflix Data Mining Tools and Introduction to Descriptive Analytics

Netflix collects and records inordinately large amounts of data: 500 billion events per day in fact, with a peak hour reaching 8 million events per second (Wetzler, 2021). Collecting, recording, processing, mining, and analyzing this data is essential to the success of Netflix. Netflix will use Apache Spark and Tableau to mine their data and for data visualization. These tools, in partnership with another, provide ample support in further analyzing and reporting to develop a strategic advantage.

Apache Spark

Due to the overwhelming amount of data collected and processed by Netflix, the organization will utilize data mining technology through Apache Spark. The program is a multi-language engine for executing data engineering, data science, and machine learning (Apache Spark, n.d.). It is a great tool for large, complex organizations that utilize data technology in predictive analysis. Capable of implementing Python, SQL, Scala, Java, and R, Apache Spark provides opportunities for data analytics in multiple applications (Apache Sparks, n.d.). Utilizing this technology provides benefits through enhanced speed by using an in-memory computing system and reports a speed over 100 times faster than top competitors. Apache Spark supports advanced analytics through 'MAP', 'reduce', machine learning, graph algorithms, streaming data, and SQL queries and has well-built libraries to support these functionalities. The application is open-source and has a large community behind it (KnowledgeHut, 2019).

While there are many benefits to the access to big data and powerful analytics behind Apache Spark, there are concerns with the tool as well. The application does not have an automatic code optimization process, which becomes a concern when other industry tools are moving towards automation. The program does not have its own file management system and depends on other platforms for this, this can also cause issues with small files for certain program collaborations. Apache Spark has fewer algorithms present for machine learning and falls behind competitors in this area. Lastly, because of the way the application divides data into predefined time intervals, it does not support record-based window criteria, only time-based (KnowledgeHut, 2019).

Tableau

In addition to Apache Sparks, Netflix will make use of Tableau for data mining and visualization. Tableau is a data visualization tool that even non-technical users can utilize to simplify raw data into a consumable format and customized dashboards (Taylor, 2021). Tableau supports large amounts of datasets and allows for interactive reports that are often more meaningful than reports created using spreadsheets. The software offers very easy-to-use software that is learned quickly by technical and non-technical staff alike and is therefore easily implemented. This technology also supports R and Python and can easily be implemented with the technology and tools the organization has in those scripting languages. The application is supported on both desktop and mobile devices and automatically optimizes the report for the best viewing (Padma, 2021).

While Tableau is widely used throughout large organizations, the technology still has some disadvantages that may be of concern to the company. Unlike Apache Spark, Tableau is not a completely open platform and therefore does not support importing visuals so reports already built in other applications would have to be recreated (Padma, 2021). Also, in contrast to the functionality built into Apache Spark, Tableau is unable to support data modeling and data dictionary capabilities, so analysts will have to maintain these metrics in another location. Additionally, the program can't work with uncleaned data so all data must be pre-processed before analysts can utilize the information. Perhaps one of the biggest concerns in working with this application is the lack of version control and collaboration (To, 2021). This puts the analysts' work at risk and previous work is unable to be recovered. Collaboration is a huge part of Netflix and the lack of being able to work collaboratively within the tool is a concern.

Descriptive and Predictive Analytics

With around 209 million memberships worldwide and just under 90 million followers on its main accounts on social media, Netflix has an abundance of data available to assist in predictive analysis (Kats, 2021; Chamat, 2019). At the heart of Netflix is the goal to provide content that moves the viewers, makes viewers feel more, sees new perspectives, and brings people closer together (Netflix, n.d.). Utilizing Netflix's vast amounts of data to better understand what content most connects with viewers, how to reach new customers, and determine deterrents in

watching content helps Netflix continue to provide superior service. This superior service, made possible through predictive analysis, provides Netflix with a competitive advantage that will bring more viewers that stay longer--leading to higher profits.

Social Media

For those willing to dig deep enough, social media is a treasure trove of information that can guide organizations both large and small into success. At Netflix, data and text are mined for descriptive analytics, social network analysis, and advanced analytics. Descriptive analytics makes use of account activity characteristics and trends, like how many followers a company has, the number of reviews that were generated on different platforms, and which channels are the most popular (Sharda et al., 2021). Netflix benefits from collecting this data by gaining insight into the preferences and dislikes of their users. As an organization, Netflix will collect information not only on their own accounts, but their competitors' accounts, individual shows' accounts, and actors' pages in the industry. This statistical information informs Netflix on the trends in the market for their own social awareness, their top competitors, and provides insight into which shows are most frequently interacted with.

Social network analysis follows the connections between friends, fans, and followers across social media (Sharda et al., 2021). These connection points are essential in determining where the biggest associations of influence are in the connections (Sharda et al., 2021). Arming a powerhouse content creator with this information allows them to direct their marketing accordingly, plan for content that aligns with the biggest points of connection or influence, and measure the impact of their competitors amongst this line of influence. In addition to the data collected from social media, Netflix will combine information from the census data. Determining the connections between related networks of influence with census data provides powerful predictive analysis on upcoming content, as well as planning the course and direction for new content. As an example, the top three titles viewed in Netflix history are *Squid Game* – Season 1 (142 million household views), *Extraction* (99 million household views), and *Bird Box* (89 million household views) (Tapp, 2021). Determining points of influence that encouraged the view counts for these shows/movies and combing that with census data will tell Netflix what content is most popular amongst certain household groups (jobs, household income, size of family, etc.). Lastly, advanced analytics will be applied to information obtained from both data mining and text mining to explore and investigate content within online posts, conversations, and interactions to identify themes, sentiments, and connections (Sharda et al., 2021). Analyzing posts made on a particular actor's, content's, or competitor's social media page and applying text clustering will allow Netflix to understand the sentiment of the viewers toward the show, actor, or competitor (Jadhavar & Komarraju, 2018). Text clustering is applied by grouping together objects into natural groups without any prior knowledge of what content is meaningful (Sharda et al., 2021).

Personalized Content

Personalized content recommendations are the bread and butter of Netflix's culture and success. Netflix prides itself on bringing relevant, meaningful content to its viewers. The company mines for data on watch pattern events such as when a user: pauses, rewinds, fast forwards, what day content is most viewed on, what time, where content is watched (zip code), what device is used, the ratings, searches, and browsing behavior (Bulygo, n.d.). This data lets Netflix know when and what type of content to suggest for the user. For instance, during the week users watch more TV shows and, on the weekends, they watch more movies--and the recommendations reflect accordingly (Bulygo, n.d.). Netflix gathers data surrounding what genres a user likes, what actors they are consistently watching, if they are family-oriented shows, etc., and use this to create a completely customized experience (Amatriain & Basilico, 2012). Starting with a personalized home page, where each row and its title reflect a meaningful connection to one another, Netflix creates and sorts these rows according to customer preferences (Amatriain & Basilico, 2012).

Because Netflix knows its users' preferences, a user who watches a lot of Christmas movies starting in November, but also watches many movies starring Johnny Depp, would likely have a row for each of these categories. Even deeper personalization comes from the development of providing personalized artwork to represent each video, which may highlight the actors a user is familiar with and has watched before, an action scene that a user has shown a tendency toward in previous titles, or a dramatic moment that captures the attention of users who prefer content with high emotional impact (Chandrashekar et al., 2017). In addition to the content recommendations provided to a user on the home page, Netflix utilizes data mining and text analytics in its search algorithm (Netflix, n.d.). The search capabilities in Netflix use natural language processing, text analytics, and machine learning to bring new connections to its users (Netflix, n.d.). Even when Netflix does not have a particular piece of content, it utilizes data points from the content (the actors, genres, ratings) to suggest content to viewers.

Ethical Concerns

One of the ethical concerns Netflix has with mining data and text is creating equal opportunities for viewing for all. For instance, Netflix utilizes text mining and natural language processing for extracting information on issues relating to closed captioning for the hearing impaired (Harris, 2014). By looking for keywords relating to closed captioning, Netflix can further analyze trends in the theme of the online content. If there is a particular show that keeps coming up in connection with closed caption complaints and/or a shop drop-off in viewing, Netflix acts on the information accordingly to keep all viewing content an equal opportunity for watching (Harris, 2014). Additionally, Netflix is considerate of the content it provides as new connections. It ensures all content has a fair shot at coverage to provide new ideas or perspectives to its viewers that still align with content they've previously liked or watched (Netflix, n.d.). With much of Netflix's content is available worldwide, there are shows originating from all over the world and in different languages. As the mission statement attests, Netflix is committed to bringing people together and that is

reflected in its business practices (Netflix, n.d.). Lastly, data integrity is of huge importance to Netflix. Netflix works with its data analysts and engineers to ensure the whole picture is being captured and to quickly identify breakdowns in analysis.

Prescriptive Analytics

Prescriptive analytics provides a unique opportunity to make data-driven decisions for future business process implications. As Netflix continues to expand, it is important to make strategic decisions on how to produce content, what content to produce, and how best to advertise this content to its viewers. To best support the company in these endeavors, several new prescriptive analytic tools will be implemented in the coming year. The Content Modality Decision Tree will be used when deciding which content should be produced by Netflix, which should be licensed, and which should be exclusively licensed. The Genre Simulator will be utilized by the Creative Content Team to decide which titles will bring the highest viewership based on customer watch patterns, ratings, and overall library content. The targeted approach to advertising to assist in the customer retention goal will be implemented. Lastly, ethics regarding prescriptive analytics will be discussed.

Content Modality Decision Tree

Netflix has been increasingly expanding its production of original content. However, much of Netflix's content library is still licensed from another producer, which includes content that is exclusive to Netflix and content this is available on other platforms, in addition to Netflix. The Creative Content Team has requested a way to better analyze when content should be created and produced by Netflix and when an external source is more profitable. To perform this analysis, a decision tree and corresponding table should be used to determine the best content creation modality by measuring the greatest profit yield. Decision trees show the relationship between problem inputs graphically and can handle multiplex problems in a compressed form (Sharda et al., 2021).

The content modality decision tree will analyze which titles deliver the biggest viewership relative to the licensing or production cost in comparison with creating content with some of the key parameters (actors, genre, plot, etc.) or obtaining content (Bulygo, n.d.). Producing original content provides more creative control, greater profits for shows that are a success, and keeps customers coming back (Ball, 2013). Exclusively licensing costs are less than that of producing on a per-show basis, but increases in licensing costs, up by 700% from 2011 to 2013, will continue to be an expense for however long the content is available (Ball, 2013). Non-exclusive licensing is even less lucrative, as the content is available elsewhere for consumers. However, shows that are extremely popular and watched repeatedly like *The Office* and *Friends* can keep customers viewing the content with their subscription. Choosing what content modality to produce or license with is an important decision and can be used in conjunction with the multitude of other Netflix analytics.

Genre Simulator

Much of Netflix's success is due to the high volume of materials available to customers. In an effort to produce or acquire content that aligns with Netflix's customer base, the Genre Simulator will be introduced in 2022. The Genre Simulator takes inputs from previously recorded data on watch patterns across Netflix's expansive content library to determine which genres are most watched, in what sequence, and at what volume. The Genre Simulator will be utilized to determine titles in which genre the Content Creative Team should take on during a time frame given specific budgetary constraints. This simulator assists with keeping customers of each genre satisfied with their subscription, especially those within family accounts that have multiple genres viewed in one household. Simulations involve building a representation of reality with feasible expectations of practicality to conduct experiments on the effects of inputs on various outputs (Sharda et al., 2021). A simulation was chosen for this analysis to predict the effects of providing certain genres because it is an assumption based on data, but the outcome is dependent on many other variables. Simulations allow the Creative Content Team to pose what-if questions, and through trial and error, reasonably ascertain which genres would bring the most value to the Netflix library (Sharda et al., 2021).

Promotional Materials for Customer Retention

As a company, Netflix already collects data regarding which customers are likely to cancel their subscriptions based on how many hours of content they watch. If users watch at least 15 hours of content, they are 75% less likely to cancel (Bulygo, n.d.). If that number is reduced to less than 5 hours in a month, a user is 95% more likely to cancel their subscription (Bulygo, n.d.). Combining these analytics with the particular viewer's watch history, Netflix would be able to apply mathematical programming to determine where the advertising department should allocate budget and which advertisement would be the most effective. Linear programming is the optimal solution for this problem because it relates to a limited amount of budgeting resources for advertisement which is used to create content-specific promotional materials for consumers which can be used on thousands of shows produced or obtained by Netflix (Sharda et al., 2021). As an example, if a viewer's watch history was down the previous month between 5-14 hours, Netflix's analytics would be prompted to send an advertisement to that individual over the content they have shown a preference for in the past. This is in contrast to sending a blanket advertisement to all consumers of the application for 10 new shows coming out. This would allow the advertising department to narrow its target audience for specific content recommendations and advertisements to those at risk of ending their subscription. This would reduce advertising costs and increase profits from renewed subscriptions that would otherwise leave the service. This budget can then be reallocated to innovative endeavors in the advertisement department, such as personalized advertisements, recommendations, and art.

Ethical Concerns

The major ethical concerns with prescriptive analytics are data privacy, objectivity, transparency, and social responsibility. Netflix's customer's data protection is and should remain one of its main priorities. Minimizing bias is difficult for humans but eliminating it from process design and implementation for objectivity in data analytics is essential. Transparency with data builds confidence in consumers and allows them to make informed consent about the use of their data. Netflix prides itself with its efforts to be more transparent with data analytics in use at the company. Netflix should take care to promote social goals and avoid discrimination in its prescriptive analytics. There are also concerns in the field of prescriptive analytics about using these models to manipulate human behavior (Khandavilli, 2021).

Big Data at Netflix

Netflix is known for its vast data collection and the advanced analytics it applies to business processes and decisions. Big Data is a widely used term to demonstrate the data from many various sources and in greater quantities than have ever seen before. At Netflix, collecting this data to support business operations means collecting all data from user interactions and its streaming platform provides a perfect opportunity. This data supports personalized recommendations, marketing, and content creation. With Big Data comes big storage, and Netflix led the charge in establishing new technology to support its comprehensive data lakes. Utilizing cloud solutions for storage and open-sourcing Apache Iceberg to address issues with speed, performance, and accuracy, Netflix once again rises above its competitors. Data storage and warehousing applications will continue to develop through automation and iterations of cloud computing.

Big Data

Big Data refers to data that comes in greater variety, increasing volumes, and more velocity (Oracle, n.d.). However, the term Big Data means different things to different people and the essence of Big Data is finding meaningful connections and new value within and outside conventional data sources (Sharda et al., 2021). While most people think of Big Data as data collected from social media, and Netflix indeed utilizes this data as well, Netflix's main source of Big Data is its users' interactions. Moving to a streaming platform provided an opportunity to collect and analyze superior data and realize instantaneous feedback in comparison to competitors' box office feedback or TV viewing numbers (Dans, 2020). This Big Data along with watch history and title analysis for actors, genres, storylines led to a personalized recommendation system. The recommendation system accounts for 80% of user activity and leads to 33 million personalized versions of Netflix (Dixon, n.d.). These personalized versions of Netflix and recommendation system lead to a 93% customer retention rate, far succeeding competitors (Pahalyants, 2021).

This personalized data is also used to create customized marketing. As an example, ten different trailers for House of Cards were shot, and depending on the data your user profile generated, you probably saw a different one than your

neighbor. (Dixon, n.d.). If a user-preferred woman-led shows, they would see the trailer with mostly female characters (Dixon, n.d.). If a user watched a lot of content directed by David Fincher or with Kevin Spacey, the trailer might have focused on them in particular (Dixon, n.d.). These customized advertisements cultivate the perfect viewing experience each time a consumer signs into Netflix (Pahalyants, 2021). Another way Netflix chooses to use Big Data is in deciding which content to greenlight. While 70% of the decision to greenlight a show is based on signing opportunities, contracts, and creative ideas, much of the decision lies in Big Data (Dans, 2020). As an example, because of the success in viewership and engagement for the show *Weeds*, directed by Jenji Kohan, Netflix greenlit *Orange Is the New Black*, directed by the same, knowing it would be a hit (Dixon, n.d.). Big Data allows Netflix insight into user preferences that enables them to make the best decisions on content and marketing to create maximum return on investment for their projects (Dixon, n.d.). Big Data and analytics are so crucial to Netflix's uncharted success, it could be considered an analytics company instead of a media company (Dixon, n.d.).

Data Lakes and the Future of Data Warehousing Applications

The advent of Big Data has led to data lakes, or storage locations for expansive volumes of both structured and unstructured data in their native/raw format for potential use (Sharda et al., 2021). Netflix utilizes a combination of data lake applications and data warehousing to collect and store massive amounts of data from many sources while also providing high-level data to analyze and explore (Perez, 2017). Netflix data lakes implement cloud services such as AWS S3 and Azure Data Lake Storage (Woodie, 2021). However, many of these data lakes hit a wall with scaling to petabytes of data through costs to maintain or performance issues (Sinai, 2021). The problem resided in the meta stores which created a speed bottleneck when translating SQL queries before sending the tables to the correct container (Sinai, 2021). Tables were costly to update, and this would often cause concern for data engineers regarding the accuracy of data (Woodie, 2021).

To address the large and demanding data lake environment, Netflix open-sourced Apache Iceberg (Woodie, 2021). Apache Iceberg corrected the accuracy issue and enabled the operation of tables at hundreds of petabytes (Woodie, 2021). Apache Iceberg manages table definitions and file metadata in files located adjacent to the data in the object store bucket (Sinai, 2021). This revelation brought scalability possibilities by allowing meta stores to be distributed across several resources in the object store, thereby avoiding the bottleneck issue for meta-stores housed in the compute level of an application (Sinai, 2021). Query planning performance times from the old system to Iceberg were reduced from 9.6 minutes to 42 seconds (Sinai, 2021). This is only the beginning of what applications like Apache Iceberg will bring to the table in the coming years. With data at volumes never seen before, data scientists and engineers are creating applications that can collect, store, and analyze data more collaboratively. Data warehousing automation continues to be a source of interest. Data warehouse automation uses next-generation technology to automate the planning, modeling, and integration steps of the data lifecycle by relying on advanced design patterns and processes (Beatrice, 2021). Cloud computing, storing, and collecting will continue to advance data warehouse technology for years to come.

Emerging Technologies and the Future of Netflix

Emerging technologies will change the future of every company, but most especially a company that focuses so heavily on data and analytics. Through the development of technologies that focus on the Internet of Things (IoT), cloud computing, computer vision, computer graphics, and machine learning, Netflix stays heavily involved in emerging technologies. These technologies will continue to change the landscape of Netflix's business operations for years to come.

IoT refers to the connection of physical devices, that capture data on the operation, location, and state of a device, to the internet (Sharda et al., 2021). This is an important technology for Netflix, which already captures so much of the data from its users' watch patterns from the applications and devices that consumers are watching on. A common example of technological advances in the IoT is self-driving cars, where the vehicle can monitor its surroundings through sensors and adjust accordingly in speed, direction, etc. (Sharda et al., 2021). Even this common example could drastically change viewership for Netflix. If consumers no longer have to drive cars, their attention could be directed elsewhere--and watching content on Netflix could be a great way to pass the time. The device (the car in this instance) could choose appropriate content based on the length of the drive or destination. For instance, family trips to the summer lake house could have family content whereas a trip to the office might show a documentary on corporate success stories. The future of Netflix could be changed through the emerging technology of the IoT by something as simple as a sensor on a home door. As soon as a door opens in a particular user's room, the TV may one day turn on to that user's profile on Netflix and pick up where they most recently left off in a show.

Netflix is at the forefront of another emerging technology, cloud computing. Beginning the transition to cloud services in 2008 after a major database corruption disrupted business for three days (Izrailevsky et al., 2016). By 2016, Netflix had completely migrated to the cloud and shut down data centers (Izrailevsky et al., 2016). Netflix's business logic, distributed databases, data processing, data analytics, recommendation system, transcoding, and more all rely on cloud computing (Izrailevsky et al., 2016). Cloud computing allows for better business performance through the combination of experience data and operational data (Ghosh, 2020). With cloud computing being relatively new, there will be many changes, iterations, and innovations to the technology in the years to come. Netflix will continue to be an industry leader in not only embracing this technology, but also discovering it, finding ways to develop competitive advantages from it, and ultimately doing better business than competitors because of it.

Netflix recently created a new role for a Director of Research said to oversee research and development around emerging technologies in computer vision, computer graphics, and machine learning (Giardina, 2021). These new areas of study for the company are said to apply to production areas across the company such as visual effects, virtual production, and animation (Giardina, 2021). Computer vision is a sector of artificial intelligence that focuses on instructing computers to interpret and understand the visual world (SAS, n.d.a). With computer vision, devices can interpret

images and videos from cameras to identify and label objects to react to what they "see" (SAS, n.d.a). Computer graphics consists of the technology that bridges computer science and design, allowing for computer-generated imagery (Cornell CIS, n.d.). The future of Netflix could drastically change with this technology, being a content producer may mean something different with this technology. Machine learning is a data analysis method through automating models of analytics by utilizing artificial intelligence to "learn" data, recognize patterns, and make decisions with minimal human involvement (SAS, n.d.b). The intersection of being a content provider and a data analytics-focused company will change the trajectory of Netflix as these technologies continue to expand.

Ethical Concerns

The ethical concerns for emerging technologies are similar to other areas of this paper. They include apprehension in part to privacy, transparency, and social responsibility. As these devices are more and more connected to both us and the internet, the electronic surveillance of humans increases. With increased surveillance, there is more data being collected on people than ever before and what companies choose to do with this data is important. Even more important is being open about the types of data being collected and what is being done with it. Companies must be responsible for the accuracy of data, information, and knowledge (Sharda et al., 2021). Another aspect of ethics within these emerging technologies is intellectual property rights. As these devices "watch" more and more of what users do, what becomes of the ideas individuals write on online journals or the art that people create in applications? Does the consumer own the product or does the app that made it possible? Lastly, a huge ethical quandary that pertains to Netflix is how much decision-making to delegate to computers (Sharda et al., 2021). For a company so ingrained in technology and efficiencies, this is something that will be a concern in the future.

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The Zero-Sum Fallacy of Housing: Accounting for the 2008 Housing Crisis

Alexander Steininger

Abstract

The 2008 housing crisis is often attributed to the actions of a few bad actors, but that does not tell the full story. Depending on whom you ask, it may have been the deregulation of the financial industry, a mortgage market vitiated with moral hazards, irresponsible financial intermediaries, or some combination of the above. That, if not for the actions of the few, the United States housing market would be booming to this day. However, these neat explanations of complex economic problems are misleading. For over 75 years, intellectuals proposed solutions to problems while lacking the capacity to understand these solutions' consequences. These solutions accumulated from the Great Depression to present day and are on display in the Library of Congress. While not intentional, the dangers of this vast array of housing legislation were cloaked in altruism and auspicious promises of prosperity. Nonetheless a welcomed sentiment at the time, it should now be examined according to the facts of the outcome. The assertion that life, liberty, and the pursuit of property only being achieved through government intervention has made homeownership a zero-sum game. The slow erosion of a free housing market by means of legislation is what led to the 2008 housing crisis.

The Zero-Sum Fallacy of Housing: Accounting for the 2008 Housing Crisis

James Madison recognized the crucial role of property rights in a developed society, and its power to create distinct factions within it. Madison emphasized the importance of a government to protect these rights without bias by writing, "The diversity in the faculties of men, from which the rights of property originate, is not less an insuperable obstacle to a uniformity of interests. The protection of these faculties is the first object of government." (Madison, 1787). The United States navigated with this compass for over 150 years, until the Great Depression.

In the wake of this depression, Franklin Delano Roosevelt ushered in the most expansive era of government the United States had seen. In his inaugural address, Roosevelt said, "So, first of all, let me assert my firm belief that the only thing we have to fear is fear itself – nameless, unreasoning, unjustified terror which paralyzes needed efforts to convert retreat into advance." (Rosenman, 1938). Ironically, fear played a large role in allowing such autocratic fiscal power to be realized. The citizens of the United States saw the American dream slipping away, so they turned to their elected leaders for guidance and wisdom. However, before this event forever changed the economic climate of America there was another depression, an often forgotten one.

The Forgotten Depression

As Americans returned home from the Great War, they were greeted with high unemployment, a disoriented economy, and a pandemic. This transition from

the Great War to the roaring 20s is often overlooked, hence the name. The forgotten depression lasted from 1920 to 1921 and was a period of perseverance in the face of adversity by the American people.

Analyzing Response: The 1920s vs 1930s

The fiscal responses to the depression of the 1920s and the Great Depression demonstrated two different paragons of behavior and culminated in two very different outcomes.

Table 1 Fiscal Response of the 1920s vs 1930s

Year	Unemployment	GNP ($M)	Outlays ($M)	Receipts ($M)	National Debt ($M)
1919	1.38%	$ 75,027.00	$ 18,493.00	$ 5,130.00	$ 27,391.00
1920	5.16%	$ 86,815.00	$ 6,358.00	$ 6,649.00	$ 25,953.00
1921	11.72%	$ 71,081.00	$ 5,062.00	$ 5,571.00	$ 23,978.00
1922	6.73%	$ 71,825.00	$ 32,889.00	$ 4,026.00	$ 22,963.00
1923	2.41%	$ 83,711.00	$ 3,140.00	$ 3,853.00	$ 22,350.00
1924	4.95%	$ 84,954.00	$ 2,908.00	$ 3,871.00	$ 21,251.00
1925	3.22%	$ 88,530.00	$ 2,924.00	$ 3,641.00	$ 20,516.00
1926	7.60%	$ 95,021.00	$ 2,930.00	$ 3,795.00	$ 19,643.00
1927	3.28%	$ 93,409.00	$ 2,857.00	$ 4,013.00	$ 18,512.00
1928	4.21%	$ 95,537.00	$ 2,961.00	$ 3,900.00	$ 17,604.00
1929	3.25%	$ 101,465.00	$ 3,127.00	$ 3,862.00	$ 16,931.00
Year	Unemployment	GNP ($M)	Outlays ($M)	Receipts ($M)	National Debt ($M)
1930	8.94%	$ 87,841.00	$ 3,320.00	$ 4,058.00	$ 16,185.00
1931	15.90%	$ 71,489.00	$ 3,577.00	$ 3,116.00	$ 16,801.00
1932	23.60%	$ 53,373.00	$ 4,659.00	$ 1,924.00	$ 19,487.00
1933	24.90%	$ 50,993.00	$ 4,598.00	$ 1,997.00	$ 22,537.00
1934	21.70%	$ 59,465.00	$ 6,541.00	$ 2,955.00	$ 27,053.00
1935	20.10%	$ 67,316.00	$ 6,412.00	$ 3,609.00	$ 28,701.00
1936	16.90%	$ 77,941.00	$ 8,228.00	$ 3,923.00	$ 33,779.00
1937	14.30%	$ 85,845.00	$ 7,580.00	$ 5,387.00	$ 36,425.00
1938	19.00%	$ 79,889.00	$ 6,840.00	$ 6,751.00	$ 37,165.00
1939	17.20%	$ 85,086.00	$ 9,141.00	$ 6,295.00	$ 40,440.00

(Romer, 1985, p. 58) (Margo, 1993, p. 43) (National Bureau of Economic Research, 2020) (Office of Management and Budget, 2010, p. 21) (Treasury Direct, 2020)

Table 1 shows that the unemployment from 1920 to 1921 rose by 6.56% and GNP fell by 18.1%. It also shows that from 1929 to 1930, unemployment rose by 5.69% and GNP fell by 13.8%. In response to the 1920 depression, the federal government reduced both tax outlays and receipts. In response to the Great Depression, the federal government increased tax outlays and receipts. From 1919 to 1929, the national debt was nearly cut in half, and from 1929 to 1939 it more than doubled. The forgotten depression led to one of the most prosperous periods in American history, while the Great Depression was ended only by what many believe to be WWII.

The point here is not to determine why America responded differently to each depression, but to show that the outcomes resulting from each response were different. The solution to the depression of 1920 was to return power and resources to

the citizens. This allowed decisions to be made by those involved in the transaction. Experienced individuals who had accumulated wisdom and proven themselves through years of dedication and sacrifice could effect change in the fields that they were most specialized to command. The consumer was given the freedom to choose from goods and services as producers competed with one another freely and efficiently for their business. Removing the burden of government and injecting the freedom of choice allowed the economy to quickly recover.

The proposed solution to, and the subsequent outcome of, the Great Depression was nearly the opposite. Power and resources were diverted away from the rational actors of the economy and given to the intelligentsia. Those who are given the responsibility of solving the problem, yet are not involved in the transaction themselves, are described by Thomas Sowell as occupational intellectuals. Sowell affirmed that "[a]t the core of the notion of an intellectual is the dealer in ideas, as such—not the personal application of ideas…A policy wonk whose work might be analogized as "social engineering" will seldom personally administer the schemes that he or she creates or advocates." (Sowell, Intellectuals and Society, 2011, p. 15). Thus, ideas were generated and imposed, but little consideration was given to the cascading effects of such ideas. Sowell explains why this method appears so clumsy and crude when compared to the actions of rational actors:

> 'Experts should be on tap, not on top.' For broader social decision-making, however, experts are no substitute for systemic processes which engage innumerable factors on which no given individual can possibly be expert, and engage the 99 percent of consequential knowledge scattered in fragments among the population at large and coordinated systemically during the process of their mutual accommodations to one another's demand and supply. (Sowell, Intellectuals and Society, 2011, pp. 36-37)

Of great consequence to society, the intellectual is never held accountable because they are "insulated from material consequences" and "free even from even from social standards, while setting social standards for others" (Sowell, Intellectuals and Society, 2011, pp. 14, 20, & 24). What follows is a fraction of the solutions proposed by occupational intellectuals.

Responding with Ideas

Home Owners' Loan Act of 1933

Reflection I. "The finding that HOLC loans were more likely to end in foreclosure if the borrower had little or no equity has important implications for HAMP. It suggests that borrowers with less equity or negative equity will be more likely to redefault on their modified loans, and thereby underscores the importance of principal reductions to the program's long-term success" *(Congressional Oversight Panel, 2010, p. 348)*.

The Home Owners' Loan Act of 1933 created the Home Owners' Loan Corporation, or HOLC. The HOLC was to be responsible for amortizing the home loans of distressed homeowners. A typical home loan before this act would range

from three to five years in length. These short durations had much higher payments, and when tragedy struck, it became difficult to make those payments. By amortizing home loans over 15-year periods, the monthly payments would be reduced. The smaller monthly payment would provide relief to the distressed homeowners. Later, this would be amended to allow the amortization period to extend beyond 15 years, further mitigating the strain homeowners felt.

The HOLC successfully prevented many home loans from defaulting through their amortization program. However, as the length of the loan increased, so did the time that it took to achieve important equity ratios. A study of HOLC loans in the New York region showed that the number of defaults rose as the borrower's equity got smaller.

Table 2 HOLC Sample for New York

Borrower's Equity as Percentage of Loan Amount	Loans Made	Foreclosure Rate (Percent)
Less than 0%	561	46
0-24%	968	40
25-49%	920	37
50-74%	498	22
75-99%	258	22
100% or more	405	12

(Congressional Oversight Panel, 2010, p. 421)

This suggests that by extending the period a homeowner had equity ratios at levels below the homeowner's reservation price for default, they were more likely to default at a later date.

Another reason that important equity ratios took longer to achieve comes from the HOLC's appraisal process. Jonathan Rose was cited in the same Congressional Panel as saying, "the HOLC set appraisals at high levels, which benefitted private lenders, since they received more than they expected to earn from their delinquent mortgages, and resulted in fewer principal reductions for homeowners than would have occurred at lower appraisal values" (Congressional Oversight Panel, 2010, pp. 404-405).

So, while the HOLC provided a short-term boost, it was not in a way that truly benefited the homeowner. Instead of encouraging true homeownership in the sense that one might someday own their home free and clear, homeowners were encouraged to prolong the process of such an achievement by burdening themselves with debt for a longer period. Prospective home buyers were also impeded from homeownership. To their surprise, they found home prices rising as a result of the appraisal process, whereas all other prices in the wake of the depression were falling.

National Housing Act of 1934

Reflection II. "The Commission believes that complete elimination of the FHA-VA interest ceilings - statutory as well as administrative - is a desirable long-run goal…The commission believes that discounts on FHA and VA mortgage originations have become so ingrained that they no longer serve simply as a mechanism to adjust

yields into line with market conditions" *(Commission on Mortgage Interest Rates, 1969, p. 65)*.

The National Housing Act of 1934 allowed for the creation of the Federal Housing Administration. This agency was tasked with insuring commercial and investment banks, trusts, companies, loan associations, and other lending institutions. In addition, this act amended the Federal Home Loan Bank Act to allow Federal Home Loan Banks to make advances that could finance home repairs and improvements on homes whose mortgages were insured by the FHA. The intelligentsia recognized that the HOLC accounted for far too many mortgages, and this act was their solution. It was intended to bring lending institutions back into the mortgage market, make it easier for homeowners to increase the value of their homes through improvements, and induce demand for homebuilding supplies and services.

Sizeable improvements were made in a short period of time. In a review of the Treasury's foreclosure prevention programs, the oversight panel said, "In 1933, the HOLC accounted for 12 percent of all new mortgages on one-to-four-family homes. That figure rose to 71 percent in 1934 before falling to 26 percent in 1935" (Congressional Oversight Panel, 2010, p. 415). The magnitude of the FHAs involvement is illustrated in Table 3, with total FHA insured mortgages reaching $19,772,154,000 by June of 1953.

Table 3 Home Mortgages Insured by FHA (Dollars in Thousands)

Year Insurance Written	Number	Amount (Thousands)	Units
1935	23397	$ 93,862.00	25453
1936	77231	$ 308,945.00	83920
1937	102076	$ 424,373.00	110850
1938	115124	$ 485,812.00	122160
1939	164530	$ 694,764.00	171232
1940	177400	$ 762,084.00	132974
1941	210310	$ 910,770.00	215777
1942	223562	$ 973,271.00	235766
1943	166402	$ 763,097.00	189733
1944	146974	$ 707,363.00	157138
1945	96776	$ 474,245.00	103378
1946	80872	$ 421,949.00	85751
1947	141364	$ 894,675.00	150091
1948	300034	$ 2,116,043.00	320725
1949	305705	$ 2,209,842.00	319506
1950	342582	$ 2,492,367.00	351528
1951	252642	$ 1,928,433.00	261231
1952	234426	$ 1,942,307.00	246109
Jan-Jun 1953	135319	$ 1,167,932.00	141389
As of June 30, 1953			
Mortgages Insured	3296726	$ 19,772,154.00	3474711
Mortgages Termed	1396201	$ 6,712,852.00	165
Mortgages in Force	1854410	$ 12,932,692.00	19324
Amortization	-	$ 1,562,077.00	-
Insurance in Force	1854410	$ 11,370,615.00	19324
Properties Acquired	15159	$ 92,551.00	18315
Properties Sold	13671	$ 81,981.00	16435
Properties on Hand	1488	$ 10,569.00	1880
Net Loss to Insurance Fund	-	$ 5,069.00	

(Advisory Committee on Government Housing Policies and Programs, 1953, p. 101)

In the short run, the intended effect was achieved. The FHA guarantee reduced the financial institution's cost of giving high-risk loans. The necessary interest compensation, or the price of borrowing, was being held lower than it otherwise would be. The popularity of this program grew over time, as is evident in Table 3, with the FHA insuring an average of more than 150,000 mortgages per year over the period. However, in the long run, it created an adverse selection problem.

With minimal barrier to prevent the individual from consuming beyond their means, over time, the average risk of the pool is slowly increased. The National Housing Act was intended to stabilize the supply of credit by enticing private investment through guarantees. However, the act of providing these guarantees weakened the natural forces that govern the marketplace for credit. Even with these guarantees, the saver recognized these properties as overvalued and high risk, and was unwilling to entrust their savings to institutions that were overweight on mortgages. Again, society turned to the intellectual who is never short on ideas.

An amendment to the National Housing Act would create the Federal National Mortgage Association [FNMA], or Fannie Mae. FNMA could buy and sell mortgages, providing a secondary mortgage market when the saver was unwilling. Thus, financial institutions were no longer bound by their ability to attract investors through marketable securities, and the problems seemingly disappeared. However, as Milton Friedman once said, "There you are always sitting on a keg of dynamite. If nobody lights the fuse, you wouldn't even know that what you had been sitting on was a keg of dynamite instead of a stuffed armchair. On the other hand, at any time a fuse can light and blow up" (Friedman, New Administration Policies, Surtax Possibilities, 1969).

Nonetheless, homeownership rose by roughly 20% from 1940 to 1960 (Census, 2017), and home prices rose by roughly 30% over the same period. (Shiller, 2019). Over the years, private investment in mortgages continued to decline, and the burden on the federal government to maintain its commitment increased. In 1953, two solutions were proposed. The first was to allow interest rates on FHA- and VA-insured loans to float with the market. The second was to privatize FNMA. The goal was to level out the peaks and valleys, provide an even flow of funds, and distribute them according to their demand.

The committee said that "only those mortgages should be purchased which are believed by the management of the corporation to have marketability under normal conditions" (Advisory Committee on Government Housing Policies and Programs, 1953, p. 441). However, Fannie Mae was still holding $2.5 billion of the total $3.9 billion in mortgages that it purchased from 1938 to 1953. Was the mortgage market truly so broken that it could no longer allocate society's scarce resources efficiently, or were the vast majority of these mortgages unmarketable?

Table 4 Federal National Mortgage Association Activity (Millions)

Year	Mortgage Transactions During Period			Mortgage Holdings (Year-end)
	Purchases	Sales	Net Purchases	
1955	$86	$0	$86	$86
1956	575	5	570	649
1957	1,021	3	1,018	1,636
1958	260	466	−206	1,381
1959	735	4	731	2,050
1960	980	42	938	2,903
1961	624	522	102	2,872
1962	548	391	157	2,847
1963	181	780	−599	2,062
1964	198	78	120	1,997
1965	757	46	711	2,520
1966	2,081	*	2,081	4,396
1967	1,400	12	1,388	5,522
1968	1,944	0	1,944	7,167
1969	4,121	0	4,121	10,950
1970	5,078	0	5,078	15,502
1971	3,574	336	3,238	17,891
1972	3,699	213	3,486	19,891

(HUD, 1974, p. 63)

Table 4 shows that the total number of mortgages held by FNMA only continued to grow, with total mortgage holdings reaching $19.8 billion by 1972.

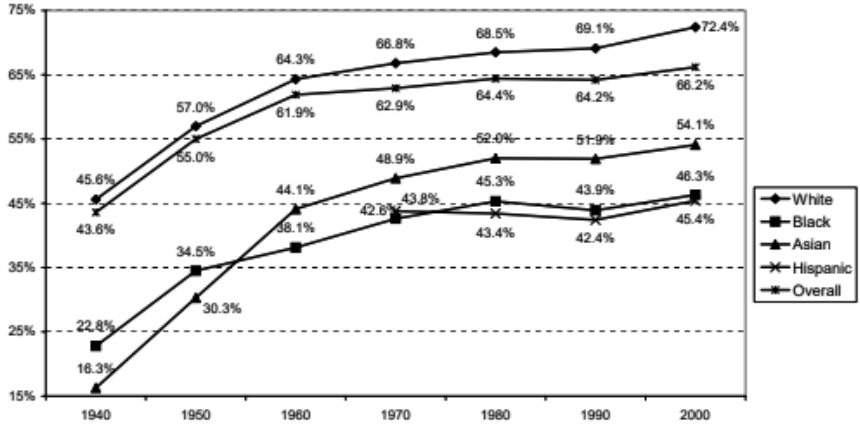
If the saver was not willing to purchase these mortgages because they recognized that the FHA merely disguised risk and amplified behavioral problems, then the only purpose of the FNMA was to purchase those securities which were unsafe. Acknowledging this disheartening possibility would have frightening consequences, but overlooking it would displace America's trust in the financial system. The National Housing Act was succeeding, but only by making home financing a national problem.

Fair Housing Act of 1968

Reflection III. "Apparently little consideration was given to the economic and social costs and benefits, the equity aspects, and the overall impact on local housing markets of subsidizing large numbers of newly built units for lower income families" *(HUD, 1974, p. 83)*.

The Fair Housing Act of 1968 was enacted to combat discrimination and provide fair housing opportunities. Refusing to rent, lend, or advertise based on race, color, religion, nationality, sex, disability, or familial status was now explicitly prohibited in most housing transactions. The U.S. Department of Housing and Urban Development [HUD] is responsible for administering these provisions and protecting buyers and renters of housing from discrimination. While it is difficult to quantify the precise results, it is safe to say that discrimination was made more difficult by this act. However, did the act provide fair housing opportunities?

Figure 1 Trends in Homeownership Rates by Race and Ethnicity 1940-2000



Notes: White and Black rates for 1970 through 2000 exclude Hispanics. "Asian" rate for 1950 is proxied by non-White, non-Negro urban households, which comprise a large majority of the Asian population. (The comparable rate for 1940 was 15.4 percent compared to the 16.3 percent actual rate.)

Sources: 1940-1990 from IPUMS microdata for Decennial Censuses 1940-1990. 2000 from U.S. Census Bureau, 2000 Census Summary File 1.

(Herbert, Haurin, Rosenthal, & Duda, 2005, p. 85)

Figure 1 shows that homeownership has risen, but the gaps in homeownership amongst classes have risen by greater magnitudes. From 1940 to 1970, homeownership for White, Black, and Asian Americans rose by 21.2%, 19.8%, and 32.6%, respectively. Then, from 1970 to 2000 homeownership for White, Black, Asian, and Hispanic Americans rose by 5.6%, 3.7%, 5.2%, and 1.6%, respectively. In addition to the disparity in homeownership rising after the Fair Housing Act, the disparity in the distribution of household income also rose.

Table 5 Distribution of Households by Race-Ethnicity and Income as a Percent of Area Median Income

Race/ Ethnicity	Year	Income as Percent of Area Median Income <50% (Very Low)	50-80% (Low)	80-100% (Low Mod)	100-120% (High Mod)	>120% (High)	All Households
White	1970	25.3%	18.0%	13.4%	11.9%	31.3%	100%
	1980	27.8%	19.2%	12.2%	10.7%	30.2%	100%
	1986	25.4%	18.3%	11.4%	10.0%	34.9%	100%
	1993	27.0%	18.5%	11.1%	9.6%	33.8%	100%
	2001	28.3%	18.2%	10.3%	9.5%	33.7%	100%
Black	1970	46.4%	22.6%	10.8%	7.6%	12.7%	100%
	1980	48.3%	19.9%	9.7%	7.2%	14.9%	100%
	1986	48.3%	20.0%	9.1%	6.4%	16.2%	100%
	1993	51.7%	18.0%	9.2%	7.2%	13.8%	100%
	2001	46.6%	21.6%	9.4%	6.8%	15.6%	100%
Hispanic	1970	33.6%	24.7%	13.7%	10.3%	17.7%	100%
	1980	38.4%	22.1%	11.7%	9.1%	18.7%	100%
	1986	41.1%	21.5%	10.5%	7.6%	19.3%	100%
	1993	44.3%	21.6%	9.9%	7.1%	17.1%	100%
	2001	39.2%	23.4%	10.6%	8.1%	18.6%	100%
Asian	1970	27.4%	19.0%	13.7%	10.6%	29.3%	100%
	1980	28.3%	18.2%	11.5%	10.4%	31.6%	100%
	1986	NA	NA	NA	NA	NA	NA
	1993	28.3%	17.8%	12.8%	8.3%	32.8%	100%
	2001	28.1%	15.8%	10.7%	8.7%	36.7%	100%

Note: NA: Asians were not identified separately in 1986 so this data is not available.

Sources: Authors' tabulations of the 1970 and 1980 IPUMS and the 1986, 1993, and 2001 Current Population Surveys, March Demographic Supplement.

(Herbert, Haurin, Rosenthal, & Duda, 2005, p. 99)

Table 5 shows that minorities have a larger concentration of households with incomes below 50% of the area median income. Also, the distribution of minority households whose income was within 50-120% of the area median income declined from 1970-2001.

If discrimination was the cause for disparity in homeownership, then prescribing equal treatment by law should have equalized homeownership. The classes this act was supposed to protect were encouraged to purchase the homes that were made unaffordable by earlier initiatives and interventions, leading them to spend a greater percentage of their incomes on housing expenditures. Discrimination undoubtably exists, but this idea left the true problem undiagnosed and may have been a further hinderance to actual progress:

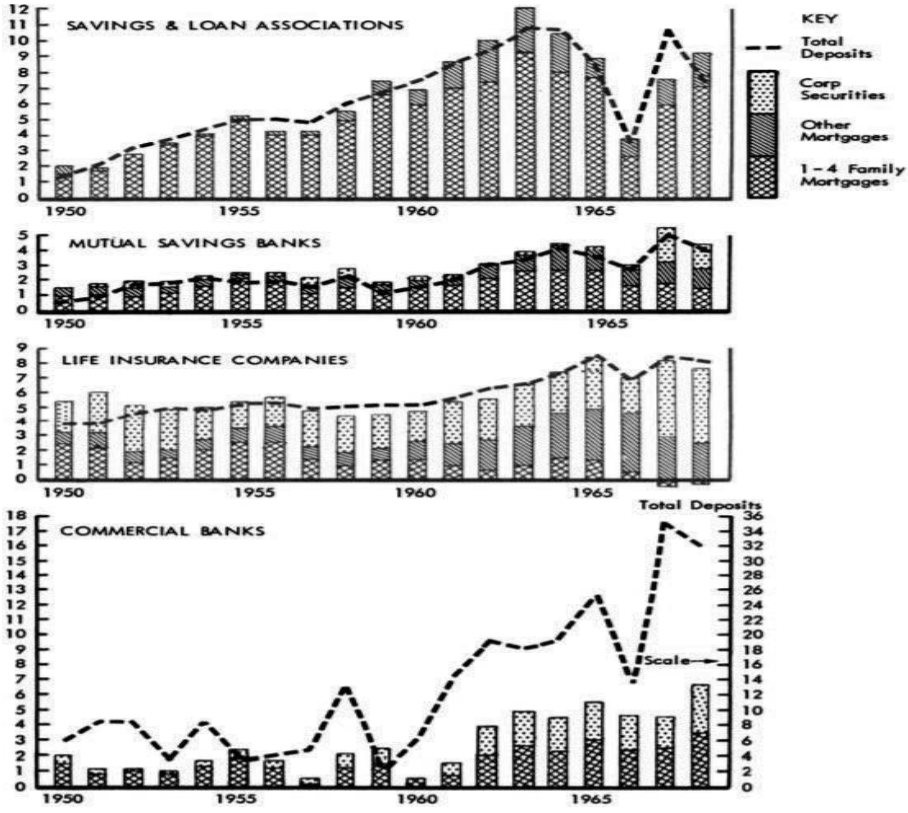
> To suggest that 'society' can simply 'arrange' better outcomes somehow, without specifying the process, the costs or the risks, is to ignore the tragic history of the twentieth century, written in the blood of millions, killed in peacetime by their own government that were given extraordinary powers in the name of lofty goals. (Sowell, Intellectuals and Society, 2011, p. 159)

Emergency Home Finance Act of 1970

Reflection IV. "The Nation's housing laws today, after almost 40 years, are a hodgepodge of accumulated authorizations for some 46 unsubsidized programs and some 20 which are subsidized" *(HUD, 1974, p. 22)*.

Fannie Mae was quasi-privatized via the Housing and Urban Development Act of 1968, but the secondary mortgage market continued to struggle for adequate capital.

Figure 2 Assets and Liabilities by Lender Type



(Commission on Mortgage Interest Rates, 1969, p. 24)

Figure 2 shows how investment alternatives affected savings flows. As other investments became more competitive relative to mortgage lending, savings diverted to those opportunities. This is seen with the volatility in the savings and loan associations, the largest providers of capital for home loans. In addition, institutions with greater regulatory freedom were able to adjust their holdings into more profitable investments and see an uptick in deposits:

> as corporate bond yields rise relative to mortgage yields, some lenders switch some of their portfolio investments away from

> mortgages and toward corporate bonds. Some also shift to equities. Life insurance companies and mutual savings banks shifted their portfolios in these ways in 1957 mutual savings banks began diversifying their holdings, allowing corporate securities and other mortgage holdings to rise relative to 1-4 family mortgages. (Commission on Mortgage Interest Rates, 1969)

The Emergency Home Finance Act of 1970 was meant to satiate the mortgage market's need for capital as it fled to more appropriately priced investments.

This act created the Federal Home Loan Mortgage Corporation, or Freddie Mac, to compete with Fannie Mae. Freddie Mac was not limited to FHA mortgages in the same way that Fannie Mae was and would not hold its loans as Fannie did. Freddie would be more focused on repackaging and selling mortgages on the secondary market. The belief was that new competition in the mortgage market would keep prices competitive. However, this only amplified the unintended equalization that was already occurring.

Figure 3 Market for Mortgages

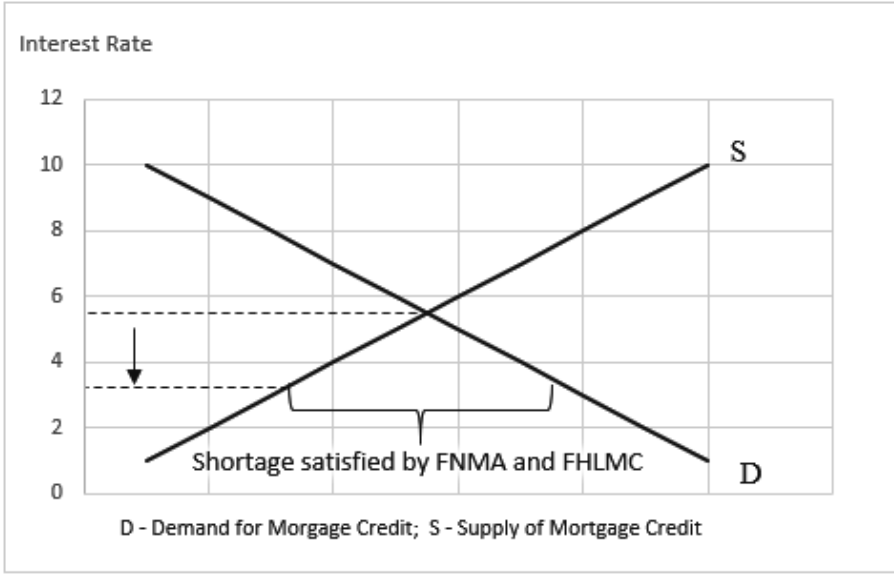
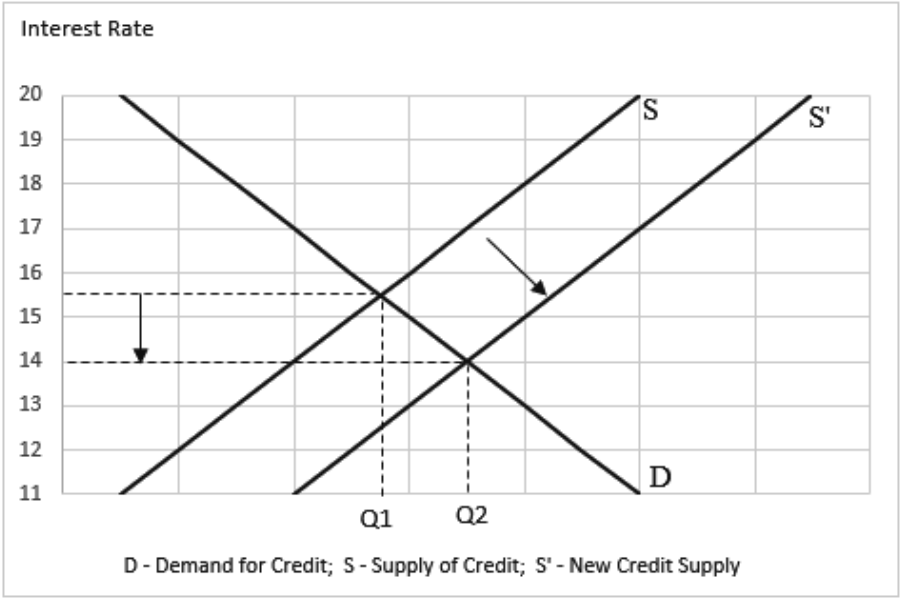


Figure 3 is an illustrative example of what was occurring in the mortgage market. All federally insured loans had price controls that set maximum interest rate limits. As noted earlier, it was recognized that these federal discounts on home loans "no longer serve[d] simply as a mechanism to adjust yields into line with market conditions" (Commission on Mortgage Interest Rates, 1969, p. 65). If the interest rate ceiling is placed below the market-determined rate, then any saver not willing to supply at the ceiling price will pull their capital from the market. In addition, the

federal guarantee that allowed loans to be made at below market-interest rates encouraged a greater demand. This shortage was then satisfied by FNMA and FHLMC.

Figure 4 is another illustrative example of what was occurring within the credit market. With interest rates on home loans capped, the supply of credit for mortgages was shifted to areas yielding higher interest rates. The supply of credit shifted to the right along the demand curve, creating a new equilibrium at Q2. The increased supply reduced the price of credit consumption, or the required rate of return for these more speculative investments.

Figure 4 Market for Speculative Investment



The Emergency Home Finance Act temporarily relieved the plight of the mortgage market, but this new, inefficient distribution of resources would prove disastrous for more than just the mortgage market.

Community Reinvestment Act of 1977

Reflection V. "Institutions should give particular consideration to the possibilities of increasing their lending to low- and moderate-income families. They should realize that the Congress has become increasingly concerned over the shortage of mortgage money at reasonable costs and may become even more impatient if availability of mortgage credit continues to be inadequate" *(Commission on Mortgage Interest Rates, 1969, p. 13)*.

The Community Reinvestment Act of 1977 [CRA] required banks and savings and loan institutions to meet the needs of the community in which they operated. This meant investing in low- and moderate-income neighborhoods and addressing inequities in credit access. This did not address the crowding out of

private investment by fiscal policy or rising prices. Instead, the intellectual believed that these communities were intentionally underserved through practices such as redlining, causing an unequal distribution of credit.

Redlining is the practice of raising prices to prevent access to goods and services. This is not to be confused with the HOLC's appraisal process of inflating home prices for the lender's benefit, rising prices as a result of HUD prohibiting land use and structure size, preventing approval of Section 8 rental assistance in high-rise projects for families with children, or the Public Housing Agency preventing the demolition of unused public housing units unless it could be replaced within six years. The CRA was suggesting that financial institutions had formed cartel-like facilities to conspire against a particular group of people. However, applying a simple pragmatic and basic economic analysis, Sowell points out:

> During the period of the earlier study alleging mortgage loan discrimination, banks and savings & loan associations were struggling to avoid going bankrupt and many lost that struggle. To believe that they were turning down qualified blacks whose checks in the mail could have saved their hides is to believe that the mere knowledge that the checks coming in from people they never saw were from black people would have been enough for these bank officials to cut their own throats financially. (Sowell, Economic Facts and Fallacies, Second Edition, 2011, p. 213)

Moving away from the possibility that this act had an agenda different than advertised, it also had many unintended consequences, one being cost. This included the costs associated with the adopting of formal policy statements, appointing community relations officers, training employees on the legal requirements, holding meetings with community groups, record keeping, and reporting. Another unintended consequence was the reduction in competition. In an article examining the "CRA experience", Bowsher said, "The longer-run anticompetitive implications of creating what are essentially lending cartels, however, may be unfavorable for borrowers" (Bowsher, 1982, p. 10). The subsequent decline in the total insured commercial banks from 1977 to 2007 can be seen in Table 6. Instead of achieving reinvestment in the community, every community lost access to nearly 50% of their financial intermediaries. If the banks didn't have monopolistic power before the CRA, they certainly did after.

Table 6 Historical Banking Data

Year	Total Commercial Banks (Total Insured)	Failures: Paid Off	Failures: Assisted Merger
1977	14411	0	6
1978	14391	1	5
1979	14364	3	7
1980	14434	3	7
1981	14414	2	5
1982	14451	7	25
1983	14469	12	33
1984	14496	4	74
1985	14417	22	93
1986	14210	21	120
1987	13723	11	176
1988	13137	6	201
1989	12715	9	196
1990	12347	8	151
1991	11927	4	101
1992	11467	11	87
1993	10961	5	56
1994	10453	0	12
1995	9943	0	6
1996	9530	0	5
1997	9144	0	1
1998	8775	0	3
1999	8582	0	7
2000	8315	0	6
2001	8082	0	3
2002	7887	4	6
2003	7767	0	2
2004	7628	0	3
2005	7523	0	0
2006	7397	0	0
2007	7279	0	1

(Federal Deposit insurance Corporation, 2019)

Summary of Ideas

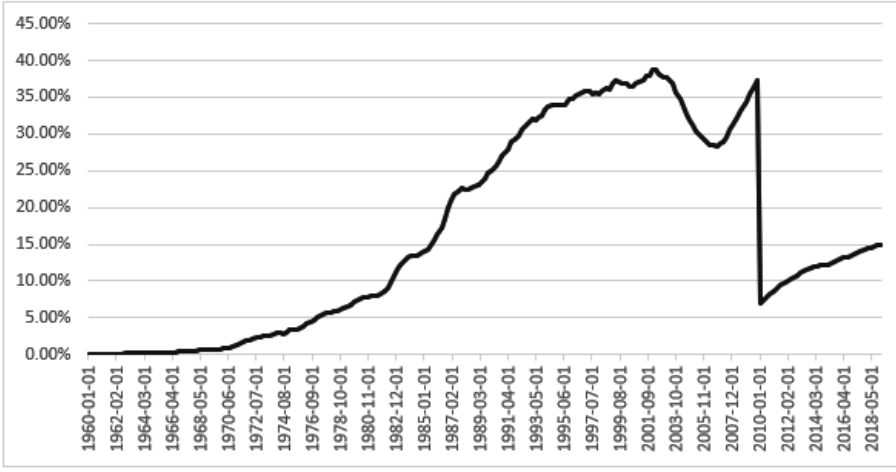
Reflection VI. "The approach has been to regard any market failure, however minor, as a sufficient excuse for government intervention. The market has failed therefore the government should step in, but this is a basic error because it involves a double standard. There is not only such a thing as a market failure, there is also such a thing as a government failure. That's not unknown in the modern society, and hence the cure may be worse than the disease" *(Friedman, The Role of Government in a Free Society, 1978)*.

This list is by no means comprehensive of all the legislation affecting housing, but presents the shaky foundation for which additional legislation could be built upon. Surrounding these acts were several others that contained amendments which expanded the directives, powers, or budgets of the HOLC, FHA, FNMA, GNMA, HUD, and FHLMC. Also, new agencies like the NHF, PHA, FFB, CBO,

FHFB, and HHFA were created and saw their directives, powers, and budgets expanded. The following theme of changes exist throughout:

- Increasing the area of coverage and the limits of coverage for insurances
- Increasing income limits, reducing required down payments, and capping the interest rates for participants in these programs
- Preventing early repayment, while encouraging refinancing
- Preventing entrance to neighborhoods when income was above a certain threshold
- Raising the limit on outstanding balances for mortgages eligible for purchase by GSEs, which Figure 5 shows as the percent of total mortgages held by GSEs rose from less than 1% in 1970 to over 35% before collapsing in 2008

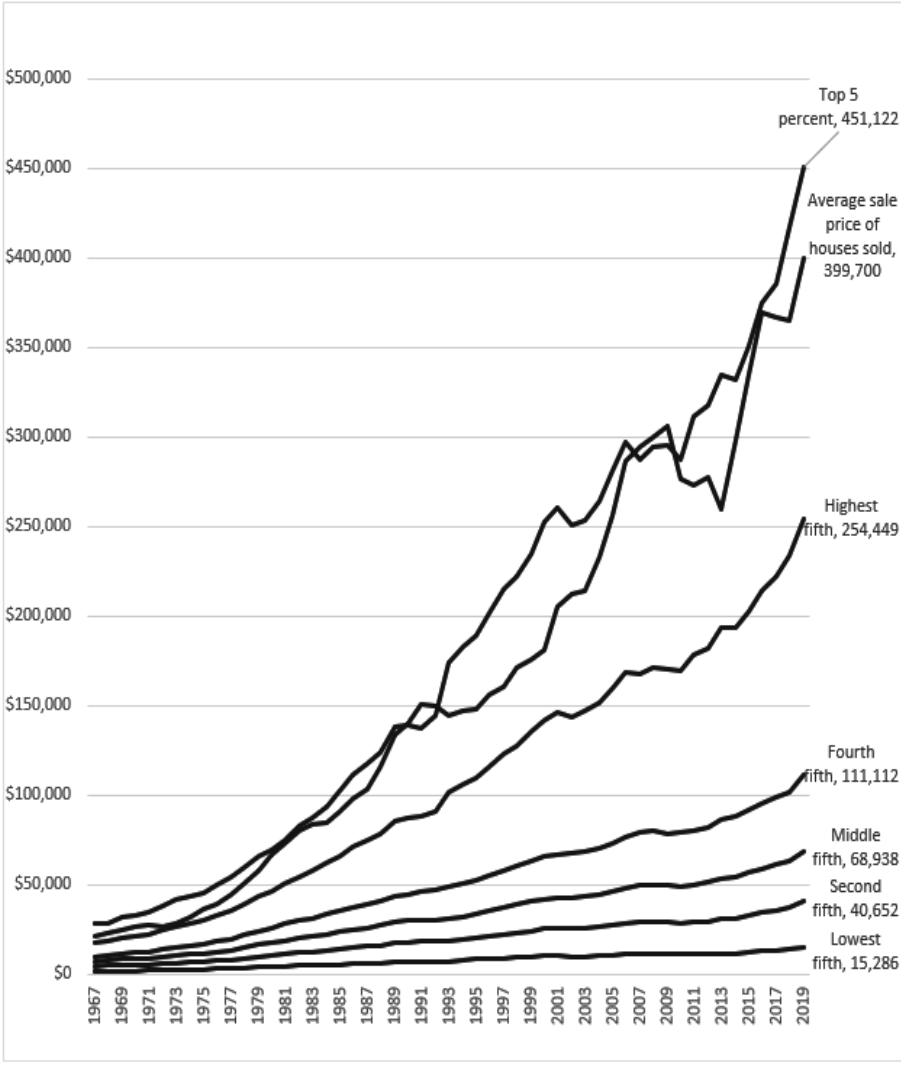
Figure 5 GSEs as a Percent of Total Mortgages



(Board of Governors of the Federal Reserve System, 2020) (Board of Governors of the Federal Reserve System, 2020)

Exponential force and a constant changing of methods were necessary to continue this depression-era crusade of intervention. However, each of these new iterations left the old problems intact, while creating a host of new ones to go along with them. The occupational intellectual became more fervent and the negative effects became more pronounced.

Figure 6 Mean Income Received by Each Fifth and Top 5 Percent of All Households & Average Sales Price of Houses Sold for the United States



(U.S. Census Bureau and U.S. Department of Housing and Urban Development, 2020) (U.S. Census Bureau, 2020)

Figure 6 is an example of these negative effects becoming more pronounced, and they are being pronounced in the very area in which they meant to provide relief. It shows the mean incomes received for each quintile and the average sale price of houses sold in the United States. The rate of growth in home prices exceeds the rate of growth in income for the bottom four quintiles by many times. Thus, prospective

homebuyers whose income does not keep pace with home prices face an ever-increasing financial barrier to homeownership. This is the price of allowing the zero-sum fallacy to dominate housing in America and represents the costs now borne by her citizens. The end result is worse than the initial problem.

Accountability

Final Reflection. "Constraints which apply to people in most other fields do not apply even approximately equally to intellectuals. It would be surprising if this did not lead to different behavior. Among those differences are the ways they see the world and the way they see themselves in relation to their fellow human beings and the societies in which they live" *(Sowell, Intellectuals and Society, 2011, p. 21)*.

The persistent conjuring of ideas by the occupational intellectual in Washington without a complete understanding of the intricacies of a complex marketplace is what led to the 2008 housing crisis. By imposing what they believed the terms should be, they obstructed the variability of what the terms could have been and prevented the opportunity for differentiation according to individual differences and more mutually favorable terms. The free market did not fail--it was constrained before it had time to succeed. Then, we were led to believe that despite the strenuous efforts of the central planners, speculators, predatory lending practices, and creatively engineered financial assets destabilized the housing market to a point that was beyond their capacity of control.

However, speculators could not exist at such a scale if the cost of speculating was determined by the market. Instead, the cost of speculating is acutely subsidized by some form of government guarantee. The predatory lending practices were created in, and encouraged by, each successive Congress that occupied the U.S. Capitol Building. These rules were followed by every bank and those who acted responsibly and did not engage in subprime lending went out of business, leaving only those irresponsible banks deemed too big to fail. The creatively engineered financial assets were necessary to compete with Fannie Mae and Freddie Mac. They aligned with the nation's goal of spreading the costs of home financing across the country so that mortgage capital, which was becoming ever scarcer in supply as a result of public policy, was not limited by geographic location.

Without regard to consequence, the well-intentioned intellectual enabled a constant and progressive wave of moral hazard and adverse selection problems, forced an unnatural reshaping of the credit market, extracted surplus by inducing an inefficient allocation of resources, and centralized choice and preference. Under this augmented reality, a housing bubble expanded, the financial stability of households decayed, and the public deficit ballooned. The precariousness of this position could not have been reached by free market participants alone. Simply put from a paternalistic view, it was only achievable because our actions were guided by the natural elite who believed they knew better than we did.

This lesson should be cause to re-examine the belief that calling upon government when the market fails is justifiable. There are real issues, and the decision to defer the responsibility of resolving these issues on government is an easy one to make. However, it is beyond a government's capacity to have responsibilities--

only people can have responsibilities. Perhaps Madison, in addition to recognizing the importance of protecting the rights comprised by a diversity of interests, foresaw the propensity of people to want their mind made up for them. Further, we quickly forget how capable we can be in the face of adversity. If we are ever coerced into believing that we must sacrifice individual liberties because our abilities our inadequate, allowing that 'famous road' to be paved with government's good intentions, Madison warns, "Hence it is that such democracies have ever been spectacles of turbulence and contention; have ever been found incompatible with personal security or the rights of property; and have in general been as short in their lives as they have been violent in their deaths." (Madison, 1787).

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America and the Cold War: Containment or Hegemony?

Alexia McCleary

During World War II, the Allied Powers included Great Britain, Free France, and China, along with the United States and the Union of Soviet Socialist Republics (USSR). Because of the previous civil relationship between the United States and the Soviet Union, it may come as a shock to learn that the two countries were facing a war against one another, just shortly after the end of World War II, when the United States was characterized as:

> The most powerful nation on the earth. It alone possessed the atomic bomb. It alone possessed a navy that could project power across the oceans and an air force that could reach across the continents. The U.S. was also the richest nation in the world. It possessed two-thirds of the world's gold reserves and three-fourths of its invested capital. ("Cold War and Global Hegemony")

To the American people, the Cold War was commonly represented as one of containment, with the United States attempting to fight and prevent the spread of communism throughout the world. However, the United States was ultimately attempting to dominate the international scene and saw the Soviet Union as a threat to the sense of hegemony that they were trying to achieve. The United States had everything needed to establish a state of hegemony; they had money, power, population, and representation in multiple countries. The scholarly consensus now reflects the belief that "Stalin had no master plan to spread revolution or conquer the world. He was determined to establish a sphere of influence in Eastern Europe where his communist minions would rule" ("Cold War and Global Hegemony"). With this information and other recent scholarly research in mind, it is the belief that the Cold War was born out of the United States' desire to achieve hegemony and not out of the desire to contain the spread of communism, though containment did play a role in the reasoning behind the Cold War.

The concept of hegemony is a bit more complex than the notion that one group is in charge of multiple other groups. According to sociologist Nicki Lisa Cole, "Cultural hegemony refers to domination or rule maintained through ideological means. It is usually achieved through social institutions, which allow those in power to strongly influence the values, norms, ideas, expectations, worldview, and behavior of the rest of society" (2020). Cole believes hegemony to be successful because it takes the worldview of the ruling class and makes it seem as though it is designed to benefit everyone, not just one group or individual. Regarding the Cold War, the United States attempted to show the Soviet Union in a negative light, as a country where most people do not benefit from the systems put in place. At the same time, the United States was showcasing itself as the opposite, as a country of possibility and freedom, think "the land of the free and the home of the brave" or the ever-popular "American dream".

Containment, which differs drastically from hegemony, "was the first major policy during the Cold War and used numerous strategies to prevent the spread of

communism abroad" ("The History of American Foreign Policy"). Containment was a middle ground between the era of peace, known as détente, and the withdrawal of forces, known as rollback. Containment was used in response to the Soviet Union's attempt to spread communist influence to Eastern Europe, as well as parts of Asia, of Africa, and of Latin America. Containment is often associated with President Harry S. Truman's policies. Though Truman is the most notable president to use containment policies, many other presidents, including Dwight D. Eisenhower, Lyndon B. Johnson, and Richard Nixon all had experiences with attempted containment as well.

The start of the Cold War can be traced to a 1945 meeting in Potsdam, Germany. The meeting consisted of Winston Churchill, the Prime Minister of Britain, Joseph Stalin, the Soviet Premier, and Harry Truman, the United States president. During this meeting, there were notable disagreements between the Allied Powers, which inevitably would lead to a cold war occurring after World War II concluded. Perhaps the most notable differences were the economic and political systems that the United States and the Soviet Union had in place and wanted to spread throughout the areas that their soldiers occupied. According to what is now known as the 'Long Telegram', sent to Washington D.C. in 1946 by George Kennan, a Russian-based U.S. foreign service officer, "Stalin needed to believe in a triumph of communism over capitalism to legitimize his bloody dictatorship. He would do everything possible to undermine the major Western powers, but would not risk major war" ("The Start of the Cold War"). This message, and the observations of Kennan, would eventually lead to containment, formalized by the Truman Doctrine in 1947, when "Truman supplied aid to Greece and Turkey and set in motion a worldwide fight against Soviet Communism" ("The Start of the Cold War"). In this instance, Truman's providing aid to Greece and Turkey can be applied to the sense of hegemony because it makes the United States appear as a country that is helping people around the world instead of working against them in their time of need, with Truman declaring, "I believe that it must be the policy of the United States to support free peoples who are resisting attempted subjugation by armed minorities or by outside pressures" (Truman). By saying this in the Truman Doctrine, addressed to Congress, President Truman ensured that his message would be heard by everyone and that it would be clearly understood. He showed what he wanted to show to the people.

Any hope of avoiding the Cold War disappeared with the Marshall Plan, also known as the European Recovery Program, launched by U.S. Army General and Secretary of State George C. Marshall. Following World War II, Western Europe was destroyed and in desperate need of recovery--in more ways than one. Multiple industries within Europe were struggling and there was no solution in sight, "Much of Europe was on the brink of famine as agricultural production had been disrupted by was. Transportation infrastructure was in shambles. The only major power in the world that was not significantly damaged was the United States", meaning that the United States was more than likely the only country in the world that could successfully provide aid to those in need around Europe ("The Marshall Plan"). The Marshall Plan provided loans and assistance to countries in need of help recovering from the aftermath of World War II. The plan "exemplified 'empire by invitation,' an interpretive framework that emphasized that American economic assistance and political influence were welcomed by the western European governments and the

majority of public opinion" ("Cold War Evolution"). The Marshall Plan was able to successfully assist in aiding European economic recovery, as well as put the United States on the pedestal as the world leader, advancing the idea of American hegemony. The Soviet Union feared the success of the Marshall Plan. During the initial stages of planning for the Marshall Plan, the Soviet Union was part of the discussion. During this time:

> "Stalin and his foreign minister, V.I. Molotov, understood all too clearly that they would be left, by design, on the outside looking in. With American economic clout dwarfing that of the devastated Soviet Union, Stalin and Molotov understood that the Marshall Plan posed a grave threat to the budding 'people's democracies' of East-Central Europe." ("Cold War Evolution")

The Soviet Union saw the Marshall Plan as an existential threat to the success of communism. They felt as though it would only make it more difficult to persuade other countries and populations of people to be on their side in the inevitable and looming Cold War.

Before the Cold War, officials from the United States and Britain were usually fairly eager to work with the Soviet Union, Joseph Stalin included. President Truman once wrote in a letter to his wife, "I like Stalin… He is straightforward. Knows what he wants and will compromise when he can't get it" ("Cold War and Global Hegemony"). W. Averell Harriman, the U.S. ambassador to Moscow even said that he believed working with Stalin more often would make many difficulties amongst the countries easier to overcome.

In order to fully understand American fears and the development of the Cold War, scholars have begun examining postwar American and Soviet diplomacy. Scholars characterize the struggle between the United States and the Soviet Union as one of freedom versus totalitarianism, as well as belonging to the international economic and political conditions of the twentieth century. According to AP Central, "After World War II… U.S. leaders assumed the role of hegemon, or leader, of the international economy and container of Soviet power" ("Cold War and Global Hegemony"). The United States' ability to assume the role of hegemon was not just dependent on its economic or political power, but also on "the appeal of its ideology, the vitality of its institutions, and the attractiveness of its culture of mass consumption" ("Cold War and Global Hegemony"). The United States was presented, on a global level, as something to aspire to be. With many other countries destroyed following World War II, the fact that the United States was still as strong as ever was a very attractive quality and only furthered the idea of hegemony.

Following the end of World War II and the start of the Cold War, the Soviet Union wasn't very strong. In fact, they were rather weak. Much like many other European countries at the time, mass casualties as a result of World War II greatly weakened the Soviet Union. Though leaders around the world knew that Stalin did not want war, the Soviet Union, weak as it was, was still feared by other countries and leaders. Many leaders were worried that Stalin would capitalize on the state of affairs following the end of World War II. Because of this fear, "Truman acted in the

international arena… he feared Stalin would exploit conditions to aggrandize Soviet power" (Leffler 70). On top of the fear of Stalin exploiting global conditions, many people feared that the United States' capitalist economy would not be able to flourish outside of times of war, where its track record was less than stellar:

> "Its performance during their lifetimes had bred worldwide economic depression, social malaise, political instability, and personal disillusionment. Throughout Europe and Asia, people blamed capitalism for the repetitive cycles of boom and bust and for military conflagrations that brought ruin and despair." ("Cold War and Global Hegemony").

In Czechoslovakia, specifically, many people even believed capitalism was obsolete and no longer a viable economic system. The post-World War II world was seen in black and white, as a crisis in capitalism or the superiority of socialism.

Because of the weak economy of the Soviet Union, the United States was able to further instill a sense of hegemony: "The Soviets – who had suffered far more devastation, both human and material, in World War II than the United States (or any other country) – sought loans, grants, and reparations to rebuild" ("Cold War Evolution"). The United States, during World War II, had promised a postwar loan to help with the recovery effort in the Soviet Union but never made the loan, claiming political issues as the reason for not helping. This was economic leverage that the United States was able to hold over the Soviet Union--another way to instill hegemony.

According to a Kennedy-era public opinion poll, Americans believed the United States was getting stronger over time and could still achieve a Cold War victory, "When asked if an agreement with the Soviet Union was possible, 49 percent of Americans polled said yes; 37 percent said no" (Leffler 186). In addition to the belief of the American people, many members of the State and Defense departments were on a similar page. They, however, believed that a combination of détente and containment would be the key to the United States' success during the Cold War. Some even believed that détente was just a sophisticated form of containment, "encouraging the Soviets to put down their guard, relax, accept (it was hoped) the unification of Germany, and honor the national sovereignty and independence of the East European nations" (Leffler 191). In a perfect world, détente would have been enough to control Cold War tensions, but unfortunately, it was not.

The inability to control Cold War tensions can be linked to the existence of hot wars, or conflicts related to the Cold War; most notably, the Korean War and the Vietnam War. The invasion of South Korea by North Korea was the first military action of the Cold War. The Korean War lasted three years with the United States supporting South Korea and the Soviet Union supporting North Korea. Similar to the war in Korea, the Vietnam War was fought between a split Vietnam made up of North Vietnam and South Vietnam. The Vietnam War lasted nearly twenty years with South Vietnam being supported by the United States and North Vietnam being supported by the Soviet Union.

When President Jimmy Carter took office in 1977, he wanted to run an administration that took a different approach to the Cold War:

> Rather than Kissinger's affinity for balances of power, or Kennedy's invocation of strength, or Truman's quest for containment, Carter aimed to restore faith in an 'old dream – the dream of human liberty'... The passion for freedom is on the rise… Because we are free, we can never be indifferent to the fate of freedom elsewhere. (Leffler 263)

Out of this idea, and following the Soviet Union's invasion of Afghanistan, the "Carter Doctrine was born, containment revived, and the Cold War resurrected" from a period of détente (Leffler 336).

By the time President George H.W. Bush took office in 1989, he knew that something had to be done and a new strategy had to be presented in an attempt to end the Cold War once and for all:

> We are approaching the conclusion of a historic postwar struggle between two visions: one of tyranny and conflict and one of democracy and freedom…. Our goal is bold, more ambitious than any of my predecessors could have thought possible…. It is time to move beyond containment to a new policy for the 1990s – one that recognizes the full scope of change taking place around the world and in the Soviet Union itself. (Leffler 426)

The United States also had a goal that would attempt to transition the Soviet Union into a democratic capitalist country, "The Cold War could end, Bush was saying, if the Kremlin accept and integrated itself into a democratic capitalist world order" (Leffler 426). Essentially, the Bush administration was saying that the Cold War could end if the Soviet Union surrendered and assimilated to the American way of economics and politics, a true example of the push toward hegemony. The Bush administration ultimately "looked beyond containment, embraced Western European economic integration, and envisioned a Europe whole and free" (Leffler 428).

In 1948, to put an end to the Cold War, George F. Kennan, the creator of containment, noted that a few things had to be done by the Soviet Union:

> The Cold War was over because Gorbachev previously had withdrawn Soviet troops from Afghanistan, de-ideologized international politics, ceased competing in many third world trouble spots, accepted free-market ideas and democratic political reforms at home, and permitted the overthrow of communist governments in Eastern Europe. The Soviet Union no longer had the capacity or will to compete ideologically or militarily for the soul of mankind. (Leffler 448)

Though it took many decades for these requirements to take place, by 1991, they ultimately had taken place. This would lead to the dissolving of the Soviet Union on December 26, 1991. The country, founded in 1922, lasted nearly 69 years before its eventual and somewhat forced collapse.

Throughout the many decades of the Cold War, the United States and the Soviet Union never came to physical blows. The two countries remained in a constant state of readiness and fear. Faced with many conflicts, both with each other and with proxy countries, the United States and the Soviet Union simply could not come to an agreement that would put an end to the war. Through economic recovery plans, promises that were not kept, and the fear of losing control [from both sides], containment was eventually achieved by the United States. Additionally, hegemony made a slight achievement, though it could be argued it was due to the collapse of the Soviet Union. The United States made a consistent and persistent argument throughout the Cold War era that containment was the goal and hegemony had nothing to do with their actions. Though it seemed as though containment was the main goal of the United States throughout the Cold War, one could argue that hegemony was the goal that the United States didn't want to admit.

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Livy's Republic: A Curious State of Affairs

Julia Pind

Throughout history, many amongst the older generations of people have lamented the loss of the way things used to be. These people are often characterized as stuck in their ways, refusing to accept the changes they face. They are forever recounting a time before the present when everything was "just better". Maybe a modern American grandfather expresses contempt at the price of food by mentioning that, in his youth, he could get a hamburger and a bottle of Coca-Cola for a nickel. Someone of the same age could lay into the younger generations, stating that they are less moral, more sensitive, or flat out doing everything wrong. Then they could say how these things never happened in their day. All because everything was "just better". Rome was no exception to this, and many citizens of the later Republic, and even into the Empire, had similar sentiments (albeit probably not about Coca-Cola).

The early Republic, especially, was seen as a glorious and virtuous time by later Romans, a time when the citizens upheld virtues to the letter and demonstrated an unwavering dedication to the state. The historian Livy wrote accounts of many of these citizens, on top of providing details about the fall of the Republic and the rise of the empire. He laments the ending of the Republic, seeing it as a time when morals and virtues were falling apart. He writes,

> I would then have him [the reader] trace the process of our moral decline, to watch, first, the sinking of the foundations of morality as the old teaching was allowed to lapse, then the rapidly increasing disintegration, then the final collapse of the whole edifice, and the dark dawning of our modern day when we can neither endure our vices nor face the remedies needed to cure them[P]

This, therefore, begs the question of what the old teaching was. As mentioned previously, these accounts mention several model citizens, each setting precedents for the virtues that every other citizen ought to follow. Take the story of Lucretia, for instance. In life, she was considered by Roman standards to be the perfect wife. She worked wool, managed the home, and was perfectly chaste. The temptation of decadence would not make her loyalty falter. However, she would find herself blackmailed into being raped by her husband's acquaintance. When she was told the incident was not her fault, though, neither her dedication to the state, nor virtue, nor chastity wavered. She was cited as saying to her father and husband, "As for me, I am innocent of fault, but I will take my punishment. Never shall Lucretia provide a precedent for unchaste women to escape what they deserve." With that, she drove a dagger into her heart and ended her life.

Another story is that of Horatius Cocles. Rome was under attack by the Etruscans, and much of the Roman force feared that the city would be lost. Horatius, however, would not be intimated. He stood before the Etruscans on the bridge that led into the city and announced that he would defend it on his own if he had to. He then taunted each invader to single combat and managed to hold his ground on his

own. As he fought, the other Romans found their courage and began to fight alongside him. As more and more Romans joined the fray, others were able to demolish the bridge and stop the Etruscans in their advance. The Romans, holding true to their ideal of liberty, were allowed to live another day.

Finally, there is the tale of Cincinnatus. Through no fault of his own, the Patrician fell from his position as a Senator to a farmer. After his change of station, however, Rome found itself in conflict with the Sabines. The Senate, which was already dealing with many domestic issues, was in desperate need of assistance. As such, the aging Cincinnatus was nominated as dictator to help with the conflict. While he held power, however, he did not abuse it or use it for personal gain. He did not pardon himself, punish those who wronged him, or even raise his station. Rather, when his work was done and the conflict was solved, he saw himself to the plow once more.

These model citizens of the early Republic provide a vivid picture of what was important to the Romans. Roman women were to be chaste, modest, and good keepers of the home. Men were to uphold a level of humility, honor, and a sense of liberty. A good Roman was dedicated to the state and the gods above all else; they even had to be willing to give their lives and reputations for them--and many did. Finally, they had to be dedicated to tradition, as looking to the old ways was the best way forward.

Again, according to Livy, the fading of these virtues in the later Republic was to blame for its demise. The people were immoral, selfish, and thought of themselves before the state. The Senate and the people they governed, were breaking *mos maiorum*, or the way of the ancestors. Thus, the Republic lost its way.

However, modern historians would disagree, suggesting the reasons for the fall were more political and less moral. Many point to the Gracchi brothers' tribuneships as the beginning of the end. They both had attempted to redistribute land back to the farmers who lost it, as well as supply cheap grain and free bread to the poor. However, both brothers were murdered by the Senate before their visions could be realized. The older brother, Tiberius, had attracted the ire of his colleagues by potentially running for a second term as tribune. This had never been attempted before, thus breaking *mos maiorum*. He was promptly beaten to death on Capitoline hill. The younger brother, Gaius, met a similar fate mere years later after an attempt to restore the plans Tiberius had for Rome. Again, many, including Livy himself to an extent, argue that the tribuneships of these brothers were what set the fall of the Republic into motion. Thus, there is an argument to be had that their deaths were the true reason for the fall. Before the Gracchi brothers, Rome had been ignoring important land distribution rules that, again, caused the poor farmers to lose their livelihoods. Upper-class Romans would take their lands from underneath them, and since the cap on how much land a Roman citizen could own was being ignored, much of that land belonged to elite men. While the motives of the Gracchi brothers were questionable, it is without a doubt that they had every intention of limiting the more elite classes. This upset the Senate, who were all members of these classes; thus, the brothers were disposed of. History would go on to blame their breaking of tradition for the Republic's collapse, though the inability of the Republic to accept necessary

changes was truly at fault. This would be seen time and time again in the coming years, all until the age of the Empire.

This leaves one last point of discussion: what the Roman Republic was. At one point, it may have truly been that glorious and virtuous time that Livy and others speak of so fondly. It could have been a time when the citizens gave their lives to the state and to the gods. It could have been "just better". However, the Republic, and the people governing it, could not keep up with the times. They clung to tradition with such vigor that they forgot what was really important--the citizens. They let their system of government become crowded and so complicated that others could come in and find loopholes under the Senate's nose. A nation that refuses to change is a nation that is doomed to fail. This is what the Republic was, a nation that didn't change. It was truly a curious state of affairs.

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Going Green: Livestock's Gas-Powered Potential

Trevor M. Bradford

> Agriculture is one of the biggest causes of greenhouse gases in the atmosphere. Cars? Planes? Trains? Nope. Cow Farts.
>
> – Zazie Beetz

There is little argument over whether the food industry as a whole is harmful to the environment. Rampant use of pesticides infiltrates soil, creating non-sustainable, food-growing land. Stripping crops from the soil releases metric tons of carbon dioxide into the air, while methane and nitrous oxide produced from livestock agriculture contribute more to greenhouse emissions than all the cars in the world. While there has been some traction on the topic of agricultural reform with regards to produce, there has been little to no movement in cleaning up the damage done to the atmosphere from livestock agriculture. In an essay written by Anna Lappé, NASA scientist Cynthia Rosenzweig was quoted as saying, "If we don't drastically reduce greenhouse gas emissions by 2080, farming in New York could feel like farming in Georgia" (Lappé 702) because temperatures will have risen so drastically. By utilizing technologies already available, we can transform waste produced by livestock into biogas, a renewable resource that can be used to power our homes and infrastructure while reducing greenhouse gas emissions. The fact that our farmers aren't doing this already is a failure of the entire industry. To put it bluntly, our current model for producing food, the very sustenance our species grows to survive, is directly contributing to reshaping our planet, and not in a way that's positive for humankind.

Some have taken it upon themselves to attempt a grassroots campaign to reform the food industry. Michael Pollan, a professor at the University of California in Berkley, suggests that if more people were to make the small change to just grow a small garden it would create "a chain reaction of behavioral change" (Pollan 719). In other words, if more people led by example, it could potentially create a ripple effect throughout communities. Not only would more people see and emulate the planting of a garden, but more folks would be leading healthier lives by eating their own produce, and would be more appreciative of what goes into growing food. By proxy, this would eliminate so much demand for industrial farming, therefore reducing the impact to the environment. McKay Jenkins takes a more reasoned approach to the conversation in his essay on the sustainability of genetically modified organisms (GMOs). He holds up Jenny Schmidt's farm in Maryland as an example of regenerative farming. According to Jenkins and Schmidt, this kind of farming utilizes GMO seeds for planting and minimizes the use of pesticides needed for crop growth,

resulting in farmland that does not need to be stripped, which severely lessens the amount of carbon dioxide produced (Jenkins).

While reduction in emissions as a result of producing vegetation is vitally important, it doesn't capture the entire picture of agriculture's impact on global warming. The other half of producing food for consumption is the livestock industry. According to Lappé, "the sector is responsible for 37 percent of methane and 65 percent of nitrous oxide," released into the air in the United States (Lappé 707). While carbon may be the most proliferated greenhouse gas, nitrous oxide and methane are much more potent. "For example, one ton of nitrous oxide – emitted by agricultural processes including the use of nitrogen fertilizers in crop production – is equivalent to nearly 300 tons of carbon dioxide. Methane is approximately 30 times more potent in its ability to absorb and trap heat in the atmosphere than carbon dioxide" (Bridgeman para 15 & 16). In the past, livestock farming was nearly a 0% impact due to its very nature; cattle would graze on grass, aerate the soil with their hooves, and naturally fertilize the soil with their manure. Nowadays, in an effort to mass produce dairy, beef, chicken, and pork, massive farms hold livestock in pens as they are fed copious amounts of grain and corn, which takes away all the environmental positives of raising livestock. The manure is collected into huge tanks where it is collected in such vast amounts that it is unable to oxidize and releases enormous volumes of methane and nitrous oxide into the air (Lappé 707).

With the diets of most Americans in some way, shape, or form dependent on the livestock industry, there is little chance in scaling back on production. One thing that can be done however, is to utilize most of the gases produced by these livestock farms in a manner that would limit the amount released into the air while producing a new source of renewable biogas energy. According to the fact sheet, *Biogas: Converting Waste to Energy*, "After biogas is captured, it can produce heat and electricity for use in engines, micro turbines, and fuel cells. Biogas can also be upgraded into biomethane, also called renewable natural gas or RNG, and injected into natural gas pipelines or used as a vehicle fuel" (Tanigawa). As of October 2018, the United States was only utilizing 16% of its capability to produce biogas from livestock waste. In addition, maximizing our ability to generate biogas would reducean amount of atmospheric emissions equivalent to that produced by 11 million vehicles. Furthermore, it would "create 335,000 temporary construction jobs and 23,000 permanent jobs" (Tanigawa).

With all the benefits and very few drawbacks, one might ask themselves, "How is this not a mainstream practice yet?" There are two simple answers. First, "For facilities treating organic waste for energy production, resistance from the local population has been identified as the biggest problem when it comes to siting a biogas plant" (Bourdin et al. 1656). According to Bourdin et al, many people support

renewable energy initiatives on a national and global level, however, they tend to adopt a "not in my backyard" mentality when those changes happen locally. Second, there is little to no incentive, other than a moral obligation to the environment, for livestock farmers to spend money on biogas systems. A search through 2014's *Guide to U.S. Environmental Policy* reveals zero mentions of biogas or methane in the entire report. Without the promise of revenue being generated or some sort of legal requirement, farmers aren't going to voluntarily take on the added burden of financing agricultural reform. If U.S. citizens are serious about reducing greenhouse gas emissions and global warming, then they need to start reaching out to their elected officials. Our government has a responsibility to form laws and policies that make it attractive to responsibly and safely dispose of gases generated by the industrial agricultural industry as well as find safe sources of renewable energy. It is imperative that our representatives become involved in a top-down approach to incentivize greener practices in our livestock production, just like they have been doing in traditional produce-generating farms. This will incentivize our agriculture industry to continue to produce food products while simultaneously correcting the industries' impacts on our environment.

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Author Biographies

Trevor M. Bradford is pursuing his undergraduate degree in interdisciplinary studies with minors in military science and international business. He is currently serving in the United States Air Force as the Senior Enlisted Leader of a Special Warfare unit. Through his studies, he has developed an interest in how energy, both as an economic commodity and as a political tool, can affect geopolitical spheres of influence. He wrote his essay for the First-Year Writing course taught by Dr. Emily Grover. He would like to thank Dr. Grover for her encouragement to continue his research and writing on renewable energy in an effort to generate awareness and promote change in local and national policy.

Sonja N. Gormley is graduating from the Parkville campus in May 2022 with a B.F.A. in interior design. Sonja is a designer who is committed to bringing excellence into every project by successfully merging beauty with functionality. As a full-time mom turned full-time college student, she has developed a unique perspective on designing for real life. She is passionate about sustainable design and focuses on creating spaces that cater to the user experience.

She would like to thank her classmates and professors for their friendship while sharing this journey with her these past few years. She would also like to express her love and gratitude to her husband Joshua and their four boys for their unyielding support and, most importantly, gives thanks to Jesus Christ for the grace and strength He has given her to achieve this goal.

Carson Lau is in pursuit of his B.A. in education with an emphasis in English. He follows literature closely and plans to pursue a master's degree in creative writing. After graduating, he will work in education and aspires to be a novelist. He wrote his literary analysis for Professor Glenn Lester's *Dreams and Identities: American Literature* course and would like to give thanks to Professor Lester for his patience and relentless encouragement in making the piece expressional. Carson would also like to thank the people he keeps close for always supporting him and facilitating his evolving dreams.

Grace Little graduated from Park University in May 2021 with a B.S. in biology and a minor in chemistry. She currently works as a medical scribe for a rural primary care clinic and hopes to attend medical school and become a forensic pathologist. Her interest in nutrition and biochemistry inspired her to conduct this research and write this paper for her Honor's Academy project. Grace was mentored by Professor Brenda Royals, whose unwavering support, guidance, and contributions helped Grace to complete her project. Grace would like to thank Professor Royals for keeping her sane during the research process and reminding her never to underestimate herself.

Alexia McCleary is pursuing a B.A. degree in English with a minor in history and will be graduating in December 2022. She plans to go into a career in publishing, writing, or communications and hopes to earn her graduate degree in English. She wrote her paper for Jodie Cumming's History 325 course, *The Cold War*. Her research

regarding the Cold War combines her passions for both history and writing. Alexia's time at Park University has allowed her to improve upon her writing skills while also pursuing the things she is passionate about. She would like to thank her professors for encouraging her to always improve and her friends and family for encouraging her to continue to follow her dreams.

Julia Pind is currently working towards a B.A. in psychology with a minor in social work. After completing her undergraduate degree, her current plan is to work towards her master's degree in counseling. She also wants to earn her PsyD, potentially. Career-wise, she is keeping her options open, though she knows she wants to do something related to therapy. This paper was initially written for Dr. David Hill's *HIS 111: Introduction to World History I* class. She would like to thank Dr. Hill for assisting her with writing the paper, providing feedback, and answering her questions as they came up. She would also like to thank her classmate and friend, Matt Thomas, for encouraging her to send her paper to *The Navigator* as well.

Yousef Raslan is an international student from Egypt currently attending Park and studying towards a bachelor's degree in mathematics. Fascinated with math and physics, Yousef has always been passionate about learning how math is connected to nature and hopes to pursue a career as an astrophysicist and continue his education in studying the universe. He wrote his essay for Dr. Charlie Smith's *History of Mathematics* course and, in his writing, connected the world of mathematics to some of the most well-known pieces of architectural and visual art. While interested in pure mathematics, Yousef is more intrigued by the real-life applications of math and how we can use it to further understand the world around us.

Kaci P. Schroeder graduated Summa Cum Laude with a B.S. in business administration with a concentration in computer information management. Kaci currently works for the Federal Reserve Bank of Kansas City and plans to continue growing her career. She wrote her research paper for the *Business Analytics* course taught by Dr. Donna Ehrlich. She would like to thank Dr. Ehrlich for her encouragement and dedication to teaching in a thought-provoking, meaningful manner. She would also like to thank her husband, Justin, who has selflessly supported her while she worked late nights and weekends to finish her degree.

Harleigh T. Scott graduated with a B.S. in fitness and wellness in December 2021. She hopes to become a health coach/educator. She would like to serve in the field of health and athletics while sharing her knowledge and the importance of exercise science, health, and wellness in a meaningful way. She wrote this essay for Dr. Mike Swoboda's *Athletic Injuries* course. She would like to thank Dr. Swoboda and Gini Fite for going above and beyond while pursuing her degree at Park University.

Alexander Steininger graduated Magna Cum Laude earning a B.S. in business administration in December 2020. This included a minor in economics and a concentration in corporate financial management. He is currently employed in the field of finance and working to deepen his understanding of economics in preparation for a Master of Science in applied economics program. This paper was

written for a *Principles of Real Estate* course led by Senior Adjunct Instructor Martin Harrison, who insists you call him Marty. Marty required students to go beyond the text to be successful in his class and expected everyone to analyze, hypothesize, and defend the positions they took. Alex would like to thank Marty for his irreplaceable insights which proved so valuable, and for challenging him to do more. He will apply this experience to future projects, including those which challenge long-held convictions such as those held concerning the cause of the housing crisis.

Grace Wallace Tull is a junior at Park University pursuing a degree in mathematics with a minor in statistics. Grace enjoys taking classes in her major while also tutoring mathematics to high school and college students both privately and while working athe Maple Woods Learning Center. Grace hopes to pursue her master's degree in mathematics so that she can apply her knowledge and skill in the classroom either as a high school teacher or as a professor at a community college. During her free time, Grace enjoys playing bagpipes and performing and competing with her pipe band, the Kansas City St. Andrews Pipes and Drums. Grace wrote her essay for the *History of Mathematics* course taught by Dr. Charlie Smith. She would like to thank Dr. Smith for giving guidance while she worked on her paper and for encouraging her throughout the semester to be a better mathematician. She would also like to thank Professor Terry Hobbs of Metropolitan Community College Maple Woods for going the extra mile to help revise and strengthen her paper.

Brandi Welch is currently pursuing a bachelor's degree as a criminal justice major with a focus in law enforcement while serving in the United States Air Force. She hopes to become a homicide detective to continue serving her country after her military career. She wrote her essay for the *Introduction to Visual Arts* course taught by Professor Aliza Lelah. She would like to thank Professor Lelah for giving her the opportunity to write this essay as well as her mom for being her biggest supporter.

The Navigator

The Navigator is a scholarly journal intended to highlight the best and brightest work from Park University undergraduate students. Work is accepted across the disciplines from any undergraduate course.

Students are encouraged to submit research projects, essays, and other scholarly work. Faculty may also nominate student work. An email will be sent to the student notifying of the nomination and requesting their consent.

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- We accept submissions from currently enrolled Park University undergraduate students.
- Submissions must have been completed during the student's undergraduate career at Park University.
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- Images, tables, and graphs are accepted and encouraged as long as they can be reproduced in print and online.
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- While creative spins on academic writing are accepted, pure creative writing (poems, short stories, etc.) is more suitable for Park's literary journal the *Scribe*.

How to Submit:

- Submit your work as a Word document to navigator@park.edu.
- In your submission email, include the following:
    - Your full name
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    - Title of your piece
    - The course and instructor the piece was written for
    - A short description of the assignment the piece was written for

Submission Deadline:

All submissions must be received by December 31, 2022 to be considered for *The Navigator's* third volume. However, we do accept submissions on a rolling basis. All submissions received after December 31, 2022, will be considered for the following volume.

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