

MURR

Mountaineer Undergraduate
Research Review

Volume 7

Spring 2022



MOUNTAINEER UNDERGRADUATE RESEARCH REVIEW

Volume 7, Spring 2022

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ISSN 2769-1756

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Illustration by Emery Kronemeyer

Cover Synopsis:

When mentioning undergraduate research, or simply just research in general, many picture someone in a lab coat with goggles, mixing some different colored liquids together. Where that may be the case in some instances, simply saying that image sums up undergraduate research here at West Virginia University is a disservice. There are so many different and unique disciplines that our undergraduate researchers participate in, and that is something that I feel MURR is trying to tell the public too. I wanted my cover art to reflect this. I started with the idea of trying to fit as many different “categories” of research as I could into the drawing. I liked the idea of somehow incorporating a computer into the piece, as it is most likely that some of the research shared in this volume had occurred over the pandemic and “zoom university”. I then fell down a rabbit hole of the person in this workspace being a collector and keeping all of the different disciplines somewhere around the computer. I came to the conclusion that like insects kept in jars, I wanted to have a representation of each discipline in jars, like caught specimens to research and observe. (Jars From Left to Right: Art, Music, Engineering, Life Sciences) Going off of that idea, I also added more disciplines in windows in the computer to act as additional research. (Windows From Left to Right: Math and Physics, Business and Statistics, Theater and Literature, and Philosophy) The back cover is inverted and shaded to make it look like the silhouette of the workspace from behind. This is an original digital art piece that I created by myself. I picked jewel tone color pallets, mostly focusing on light greens, teals, and purples, because it gives a cohesiveness throughout the piece. Instead of a normal, wide color pallet, this color pallet emphasises the idea that all of these different disciplines are able to fit comfortably in this research setting. The most important thing to me is for people to understand that the undergraduate research being done here at West Virginia University is not in just all sizes, shapes, and colors, but in all different disciplines as well.

Mountaineer Undergraduate Research Review Indigenous Land Acknowledgement

West Virginia University, with its statewide institutional presence, resides on land that includes ancestral territories of the Shawnee, Lenape (also known as the Delaware), the Cherokee, the Haudenosaunee (also known as the Iroquois Six Nations, including the Seneca, Cayuga, Onondaga, Oneida, Mohawk, Tuscarora), and many other Indigenous peoples.

Furthermore, as a land-grant institution, the sale of lands including lands of the Wahzhazhe (or Osage), Ojibwe (also called Chippewa), Menominee, Kaw, Dakota (Wahpeton, Sisseton, Medewakanton, and Wahpekuta bands), and 29 other tribes¹ helped to fund the establishment of West Virginia University.

It is important that we understand both the context that has brought our university community to reside on this land, and our place within this long history.

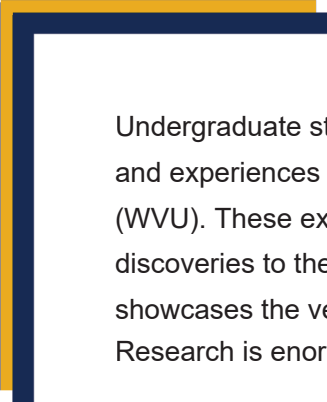
In acknowledging this, we recognize and appreciate all those Indigenous nations whose territories we are living on and working in. Indigenous peoples have been in the land currently known as West Virginia since time immemorial. Indigenous people are not relics of the past. We seek to acknowledge, honor, and appreciate those people who once lived on these lands and those who now live elsewhere through our actions and support.

We also recognize that colonialization and genocide against Indigenous people are current, ongoing processes, and as scholars seeking truth and understanding, we need to be mindful of our present participation in this process.

Through this land acknowledgement, we hope to inspire all researchers and members of the West Virginia University community to stand in solidarity with Native nations. This can look like donating time and money to Indigenous organizations, amplifying and supporting the voices of Indigenous people, returning land, and ensuring that we contextualize our research with Indigenous people in mind.

Adapted by Wren King from the WVU Native American Studies Land Acknowledgement with input from the WVU Native American Studies Program Coordinator Bonnie Brown to be included within our published journal and to start a conversation about the land we reside and work upon within our journal and the research community as a whole. We will continue to consult with the Program Coordinator to be as inclusive, relevant, and accurate as possible, modifying this acknowledgement as needed.

¹ Lee, Robert and Tristan Ahtone. "Land-grab universities." *High Country News*, March 30, 2020. <https://www.hcn.org/issues/52.4/indigenous-affairs-education-land-grab-universities>.




Undergraduate students who engage in research, scholarly, or creative work gain life-changing skills and experiences seldom found outside of research-intensive universities like West Virginia University (WVU). These experiences elevate the career trajectories of our students and contribute important discoveries to the Mountain State. The Mountaineer Undergraduate Research Review (MURR) showcases the very best of undergraduate research at WVU and the Office of Undergraduate Research is enormously proud to support the student-led efforts that have resulted in this publication.

MURR provides an outlet for students to publish scholarly and creative works while deepening their engagement within their fields of study. From internet imagery to the design of a first person perspective robot, this issue of MURR epitomizes the breadth of research conducted by undergraduates at WVU. MURR enables students to participate in the full editorial process from article submission, review and revision to formatting, proofreading, and publication. Through publication of MURR, students play an active and critical role in solidifying WVU's reputation as an institution with very high research activity and in building the creative culture where innovation thrives.

At MURR, students lead all aspects of the publication. Not only do students create the cover art and write the articles, student-editors determine MURR's focus, timeline, and publication standards. They interview and approve volunteers, recruit reviewers, and typeset journal articles. They work together with faculty and staff in the Honors College and across the university to foster institutional partnerships and mechanisms to enhance the sustainability of the journal. The benefits of participating in MURR by contributing work or leading its publication, cannot be overstated.

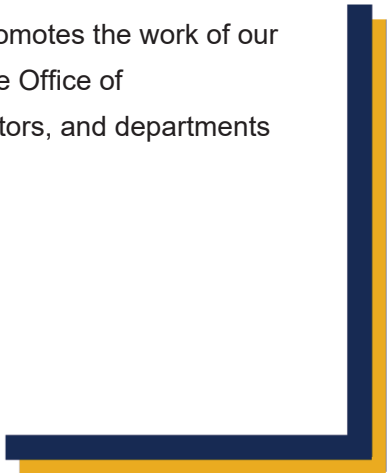
MURR has demonstrated itself to be an incubator for student success. Former editor-in-chief Jeffrey Petty was recently hired as an editorial coordinator with the American Association for the Advancement of Science (AAAS), publisher of the journal Science. Teagan Kuzniar, the current editor-in-chief, was named WVU's 2021 Udall Scholar. Managing editor Wren King was selected to serve as an associate editor of URecA--the National Collegiate Honors Council's undergraduate research journal. Savannah Hays, a 2021 graduate and STEM editor, was named WVU's 2021 Newman Civic Fellow. When students lead MURR, they publish a journal and launch their careers.

WVU benefits tremendously from MURR. It elevates research within WVU, promotes the work of our students, and connects our research enterprise to the world outside WVU. The Office of Undergraduate Research sincerely thanks all the students, faculty, administrators, and departments that have contributed their support to this endeavor.



Dr. Amy Hess

Director, Office of Undergraduate Research
Professor of Geography



Dear Mountaineers,

I am thrilled to have been asked to provide an opening letter for Volume 6, Issue 2 of the Mountaineer Undergraduate Research Review (MURR).

According to the Carnegie Classification of Institutions of Higher Education, West Virginia University is a “Very High Research Activity” institution. This designation in combination with WVU’s land-grant status makes research an undisputed focal point of the university’s mission. Thus, the continued publication and circulation of MURR, in my opinion, demonstrates WVU’s ongoing and unequivocal support for undergraduate research.

Nowhere is this support more evident than in the plethora of opportunities available for undergraduate students to become actively involved in research at WVU. I recently met a prospective student who indicated that one of the reasons they were drawn to WVU, was due to their ability to become involved in undergraduate research as a first-year student. WVU diverges from other universities, where such opportunities are only available for upper-class students.

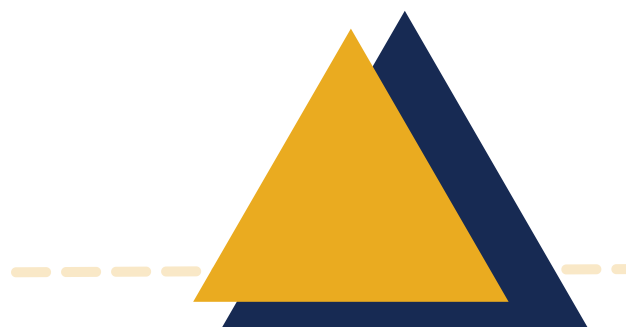
At WVU, undergraduate student opportunities to be involved in research include, but are not limited to, the Research Apprenticeship Program, Chemistry Research Experiences for Undergraduates, Summer Undergraduate Research Experience, Undergraduate Robotics Research in Human Swarm Interaction, KY-WV Louis Stokes Alliance for Minority Participation, and Summer Undergraduate Cancer Research Fellowship Program. While this is truly an impressive list of opportunities, more noteworthy is the fact that these programs have produced tangible outcomes by undergraduate students which include 46 WVU students presenting their research at the 18th annual Undergraduate Research Day at the Capital, 62 peer review publications co-authored by Summer Undergraduate Research Experience participants from 2017 - 2020, 183 presenters at West Virginia University’s 4th annual Undergraduate Spring Symposium and 944 students involved in scholarly activity via research coursework in 2019 - 2020.

As evidenced by the above-mentioned programs and numbers, undergraduate students’ involvement in research at West Virginia University is in a very good place. As such, I invite you to read, and enjoy, a subsection of these students’ scholarly activity in this edition of MURR.

Sincerely,



Dr. Damien Clement
Associate Dean, Honors College
Professor of Sport, Exercise and Performance Psychology



**7-12 SHITPOSTS AS A
NEO-DADAIST
MOVEMENT**

An examination of where the ongoing "shitpost" trend fits within historical art movements and how it is unique.

Griffin S. Nordstrom

**13 ASHLEY EBY
STUDENT
SPOTLIGHT**

14-21 LIFE AFER STEEL

A nontraditional archaeological inquiry which is assisted by archival research and emerged from research limitations during COVID-19.

Daniel D. Dillon

**22 HOSA FUTURE
HEALTHCARE
PROFESSIONALS
SPOTLIGHT**

**23-32 GEMINI
TELEPRESENCE
ROBOT SYSTEM
DESIGN**

A Low-Cost Solution for Manipulation and Enhanced Perception of Telepresence Robots.

Trevor R. Smith

**33 BIOMEDICAL
ENGINEERING
SOCIETY
SPOTLIGHT**

**34-40 UTILIZING
PHARMACOLOGY
TO TARGET
TRANSCRIPTION
FACTORS
INVOLVED WITH
CANCER ONSET
AND DEVELOPMENT**

Studies on disrupting TF-DNA interactions and TF-cofactor interactions with hopes of treating cancer are discussed.

Tristan D. Sanders

41 ACKNOWLEDGEMENTS

Shitposts as a Neo-Dadaist Movement

Griffin S. Nordstrom

West Virginia University College of Creative Arts

This paper explains and investigates a genre of internet imagery that has been termed as “Shitposts” and where they place in the history of art. Pre-existing research has defined the movement as a “Neo-Neo-Dadaist” movement (Dadaism being an art movement of the early 1900’s emphasizing irrationality, most popularized by Marcel Duchamp’s *Fountain*). However, it is questioned if the motivations and core aesthetics of Dadaism and the Neo-Dadaist movement of the 1960’s (a movement that included artists such as Robert Rauschenberg and Yoko Ono) are really akin to what is behind the Shitpost style. This essay goes through manifestoes of the historical movements as well as artwork from the three periods to analyze where the similarities and differences lie, and whether Shitposts should be defined as Neo-Neo-Dada. It is ultimately deemed an unfit title due to significant distinctions in fundamental ideas and the direction and platform Shitposts exist in, also noting the context that the Dadaist movement has largely not been informing or guiding creators of Shitposts.

Keywords: Shitpost, Dada, Neo-Dada, Neo-Neo Dada, Meme, Fluxus

Introduction

In the internet-age, the growth of online communication networks has led to an establishment of an internet culture most familiar to the Millennial and Gen-Z generations. These online networks developed a new form of comedy, referred to as memes. A branch of memes, labeled Shitposts, extend into the realm of art and are often compared to the earlier Dadaist (1) and Neo-Dadaist (2) movements and are sometimes referred to as a Neo-Neo-Dadaist movement. However, this is not an accurate description of the movement. Despite the visual similarities and comparable attitudes and situations of artists, there are significant differences in the fundamental ideas and responses of contemporary Shitpost creators when compared to their predecessors.

In this essay the difference between the general meme and Shitpost will be established as well as the distinction between the artistic Shitpost and the Shitposting argument style before a visual examination and discussion of works from the Dadaist, Neo-Dadaist Fluxus,

and Shitpost movements. Manifestos of Dadaism and Fluxus will be analyzed to better understand the motives and direction artists of these periods were taking. Tristan Tzara’s ‘Dada Manifesto 1918’ and George Maciunas’ ‘Neo-Dada in Music, Theater, Poetry, Art’ will be examined and will provide the primary background understanding for their respective movements. Tzara and Maciunas’ writings state the goals and significant ideas of their movements and will be useful when comparing the movements on a larger scale and analyzing the selected works. Shitpost artist Jeff Wysaski’s *Childless Couples - Matching Jetskis* (Figure 2), Fluxus artist Robert Filliou’s *Optimistic Box no. 3* (Figure 4), and Dadaist Man Ray’s *Cadeau (Gift)* (Figure 5), will be compared and discussed. The focus will be on recognizing the similarities and highlighting the critical differences between the Shitpost movement and the Dadaist and Fluxus movements. They will range from the specifics of the individual pieces being discussed to the general expectations and fundamental ideas of the movements.

Shitposts

The term “Shitpost” or “Shitposting” has been applied to a range of online media, most commonly the Shitposting argument style and the Shitpost art style which this essay deals with. The Shitposting argument style is the disruption in online conversations, usually of significant issues of discourse such as political and social issues, by making proofless and inflammatory claims that derail the conversation. The arguments are just reasonable enough that they come across as genuine beliefs and move the conversation to an irrelevant discussion. In a discussion about the border control policies of former Presidential nominees Donald Trump and Joe Biden, a shitpost argument may be that “All Mexicans are rapists.” This fact is completely incorrect and does not stand up in the most limited of examinations, but it moves the conversation from the policies of Trump and Biden into debating the morals of the Mexican populace and any other discriminatory beliefs related to the Mexican culture.

A (Internet) “Meme” is a concept, usually humorous, that is spread through social media or online forums. It can be purely text, image, video, or any combination of the three (3). Memes can easily be divided into several branches based on format, time, and style (4). Shitposts are a particular style of memes. They revolve around the creation of visually unsettling and upsetting imagery with a strong familiarity (5). Shitposts are primarily image-based and make common use of photography. There is a wide variety in the content, but some of the best known involve the degradation of household objects with baked beans, examples include; filling a pair of ballet shoes with baked beans, putting baked beans in an ice cube tray and freezing them (Figure 1), and dumping baked beans on a park swing. Many Shitpost creators are anonymous or credit is lost due to the reposting or sharing the image without providing the source (6). The pieces are created without expectations of compensation or praise. Some artists, however, break from this trend and create work to be sold and much of

their work is credited online. Jeff Wysaski, artist and sculptor, is responsible for the social media profile and online store Uncommon Plant. In his work, Wysaski parodies children’s toys and media with highly specific adult issues and language and reflects nihilist attitudes towards society in an abstracted method to achieve a comedic product. The particular work, *Childless Couples - Matching Jetskis* (Figure 2), will be used to represent his work and Shitposts in this essay.



Figure 1. Baked beans in an ice tray. Artist and date unknown.



Figure 2. *Childless Couples - Matching Jetskis*, 2020. Jeff Wysaski, plastic and cardboard.

Childless Couples - Matching Jetskis is a 3-D piece created in 2020, parodying and made using Playmobil toys. It consists of two ready-made figures riding matching jet skis in a fabricated box emulating the design style of Playmobil packaging. The box has text reading; “Childless Couples - Matching Jetskis, we can

afford it!, they have the time and money! it is very less stressful” on the front, and on the back it reads; “so much extra income! no diapers! no braces! no college tuition!” It also has a small warning; “WARNING: No one will take care of you when you’re old”

The Nihilistic attitude and absurd imagery of Shitposts often gets them compared to the early 20th century Dadaist movement and the Fluxus movement of the 60’s and 70’s. Artists of the three periods lived in socially, economically, and politically tense situations that led to grim views of society and its future, and the Fluxus movement has been accepted as a Neo-Dada movement due to the similarities and inspiration of the two. A deeper understanding of these earlier movements and works from them will enable a more critical analysis of whether Shitposts should be categorized as a Neo-Neo-Dadaist movement.

Dadaism

For a better understanding of Dadaism, Tristan Tzara’s 1918 ‘Dada Manifesto 1918’ will be examined. Tzara was a very significant writer of the movement and his manifesto is commonly used to represent the ambitions of the Dadaists (7). Tzara’s attitude in ‘Dada Manifesto 1918’ is very relaxed, he makes it clear that his goals are not to convince others to join the movement or follow the limited rules he presents about art. The only rule or guideline he presents is a fear of marrying art to logic; he is disgusted by science, objectivity and the current search for an ultimate truth or universal experience of all people. Tzara asserts the opposite that absolutely nothing has universal understanding or a single definition. Due to this idea, he encourages artists to ignore the audience to their artwork, and instead focus on art as a private affair and independent process. Tzara defines the disunity among Dadaists and the lack of a common theory. He describes Dadaism as a product of spontaneity, freedom, refusal of logic and history, and the embracing of contradictions.



Figure 3. Marcel Duchamp Fountain, 1917.
Photograph by Alfred Stieglitz.

Applying the ideas of Tzara to Wysaski’s *Childless Couples - Matching Jetskis*, there is a significant dissimilarity; the relation of the artwork to the audience. *Childless Couples - Matching Jetskis* focuses on familiarity and an understanding of its references from the audience. It builds upon the recognition of Playmobil toys and the financial difficulties of raising children in the USA with the high costs of college and medical treatment. Tzara emphasizes ignoring the audience and making the piece a private experience. While it is possible that all the imagery is specific to Wysaski, considering the range of his work and his highly commercialized practice, this is highly unlikely and irrelevant due to the widespread recognition of the imagery and ideas behind the piece. The Dadaist and Shitpost movements both lack common theories and have little to no organization or unity. Shitposts typically involve a rejection of logic, embrace contradictions, and have a level of spontaneity, but the movement doesn’t have a strong positioning towards objectivity, science, or a universal truth.

Neo-Dada (Flexus)

To understand the ideas of the Neo-Dadaist movement Fluxus, George Maciunas’ 1962 manifesto ‘Neo-Dada in Music, Theater, Poetry, Art’ should be analyzed. Maciunas was

a leading figure in the loosely organized Fluxus movement and his 1962 manifesto focuses on the separation of life and art, and the resulting Fluxus goal of overcoming it (8). Maciunas defines the Concretists, who unite the form and content of their work. A Concretist sees and depicts nothing more than a rotten apple when presenting a rotten apple. They do not search for symbolism or pure, fully controlled work. Concretists reject pre-determination in art and value improvisation and the indeterminant characteristic of nature. Thus, a method of the movement is to provide only a framework from the piece, and let the choices of a performer or non-controllable methods create the finished work. Maciunas describes the most radical Concretists as the art-nihilists who reject art in its entirety and turn to anti-art. Anti-art is defined; “anti-art is life, is nature, is true reality- it is one and all. Rainfall is anti-art, a babble of a crowd is anti-art, a sneeze is anti-art, a flight of a butterfly, or movements of microbes are anti-art.”

There is very little to connect between Maciunas’ ideas and Childless Couples - Matching Jetskis. Childless Couples - Matching Jetskis is more than the pure object it is. The piece is not purely a repackaged mass-produced children’s toy. Wysaski isn’t considering the separation of life and art in his work or making any attempts to challenge it. There isn’t any natural indeterminism or lack of control in the piece, nor any improvisation. Shitpost creators do not engage in non-controllable creation methods beyond the inherent restrictions of their media. In reference to ‘Neo-Dada in Music, Theater, Poetry, Art’, Shitposts and Fluxus have nothing in common.

Visual Analysis

To further the discussion of Childless Couples - Matching Jetskis and its relation to the Dadaist and Fluxus movements, sculptural works from both periods will be introduced and analyzed. Representing Dadaist sculpture is Man Ray’s Cadeau (Gift), originally created in 1921 using a readymade clothing iron and

carpet tacks. Robert Filliou’s Optimistic Box no. 3 (Figure 4), represents Fluxus and was



Figure 4. Optimistic Box No. 3, 1969. Robert Filliou, wood and labels.

created in 1969 presumably with a readymade wood box and displays the text “so much better if you can’t play chess” and “you won’t imitate Marcel Duchamp”. All three artworks rely on the use of readymade products and involve a corruption of the original object’s intended audience and purpose. Both Optimistic Box no. 3 and Childless Couples - Matching Jetskis involve the use of text that adds additional context to the piece. The message of Wysaski’s and Ray’s pieces comes across clearly and makes use of very familiar objects. Filliou’s readymade object is less clear in nature: is it a box? A chessboard with a box for pieces? The text additionally leads to questions: who won’t imitate Marcel Duchamp? Filliou, a specific viewer, or the widespread audience? Why is that text included? Is it referencing Duchamp’s use of readymades or perhaps the relations of the Neo-Dadaists to the Dadaists? The confusion and lack of straightforwardness in Filliou’s piece distances it from Wysaski’s Childless Couples - Matching Jetskis, again building a distinction between Neo-Dadaist Fluxus and the Shitpost movement.

Returning to Ray’s Cadeau (Gift) (Figure 5), background context explains that the work was made seemingly on a whim by the artist before a solo exhibition, and displayed as a “gift” for a random visitor to his show (9). The spontaneity of this creation aligns with Tzara’s

ideas for the movement but provides a significant distinction between it and Wysaski's work. *Childless Couples - Matching Jetskis* is a highly planned and thoughtfully processed piece. Wysaski started with a single kids product and built a narrative and social commentary around it and fabricated highly realistic packaging for the new art object. Ray's free "gift" element of *Cadeau (Gift)* does find a similar final treatment of the art object with Wysaski's work. Although *Childless Couples - Matching Jetskis* was a work that sold for \$350, Wysaski commonly places a copy of his smaller pieces in a store that can be taken by whoever gets to it first.

Conclusion

Based on the analysis of Maciunas' 'Neo-Dada in Music, Theater, Poetry, Art' and Filliou's *Optimistic Box no. 3*, there cannot be drawn any connections or comparisons between the Fluxus and Shitpost movements. The attitude, focus, and rules of the movements have no similarities or even a base point to build off of beyond their mutual comparison to the original Dadaists. Considering the larger span of artists of the Fluxus movement and the level of influence and common knowledge of their work in this era only weakens the possibility that the Fluxus movement has had a significant (if any) impact on the Shitpost movement.

When considering the original Dadaist movement, the significance of the influence and connections are less clear. Tzara's 'Dada Manifesto 1918' and Ray's *Cadeau (Gift)* present similar themes and ideas to the Shitpost movement, but these similarities are not overwhelming when considering the large differences. Additionally, the context of the situation is that many Shitpost creators are not referencing or building off of the work of Dadaists (10). Fluxus artists were very aware of the Dadaists and made references to them in their work, like in Filliou's *Optimistic Box no. 3*, and when they referred to themselves as Neo-Dadaists, they did so with a good understanding of the movement and their own

(11). By comparison, Shitpost artists may be aware of Duchamp's *Fountain* (1917) but they haven't read Tzara's manifesto or had an adequate education in the movement holistically. Shitpost art does not require an education in the arts; it thrives on poor understanding of color theory, photography, and digital art skills. Creators come from a range of artistic skill and education and are being inspired predominantly by other Shitpost creations. If this movement is developing organically without the framework of Dadaism, should it really be considered a Neo-Dadaist movement?

It is with those distinctions and important context that it is concluded that there is a separation between Shitposts and Dadaism. Those who refer to Shitposts as Neo-Neo-Dadaism are coming from an outsider's perspective and don't fully grasp the nature of both movements. The Shitpost movement is still very active and its future cannot be determined at this time, rushing to categorize it under other movements only serves to limit future growth and stretch the definitions of Dadaism to accommodate more art. If in the future it embraces a larger amount of spontaneity and relates more heavily to the artist's individuality and specific thoughts, then this movement can comfortably be held within the confines of Dadaism. Until then, it should be identified separately and allowed to develop without premature terminology.

Acknowledgements

Competing Interests

The author declares no competing interests.

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About the Author:

Griffin Nordstrom is an undergraduate student planning on graduating in the spring of 2022 with dual degrees in Sculpture and Art History, with minors in Printmaking and Engineering in Society. He hopes to attend grad school in the fall for a Masters degree in Sculpture. Griffin is the Vice President of the Art History Club and Printmaking Club. His art and research interests lie in highly current themes such as global warming and the impact of the internet, and Medieval European Religious art and architecture. Griffin hopes to pursue a career in teaching at the collegiate level and continue researching and writing on the influence the internet will have on fine arts in years to come.

How to Cite This Article:

Nordstrom, G.S. (2022). Shitposts as a Neo-Dadaist Movement. *Mountaineer Undergraduate Research Review*, 7, 4-9.

Student Spotlight

Ashley Eby

As a 5th generation West Virginian, I've spent my life witnessing the perils of Appalachia. Substance abuse, generational poverty, and widespread healthcare disparities had crippled my community for too long, so when I arrived at WVU, I committed to fighting for West Virginians and combatting the adversity they faced. I was initially drawn to public policy, since I felt that political advocacy held the most potential for widespread change. As a result, I traveled the state and surveyed over 10,000 West Virginians about the issues that mattered most to them. I also served as a Legislative Intern for Senator Shelly Moore Capito, where I conducted a legislative research project on Liquefied Natural Gas. Following a year of political advocacy regarding healthcare, environmental regulation, and broadband internet access in WV, I recognized that public policy wasn't right for me, and I changed my path.

With a passion for STEM and a desire to combat healthcare disparities, I was drawn to the medical field and aspired to become a physician scientist. Supporting my mother through her battle with Stage IV lung cancer had opened my eyes to the struggles of cancer patients, and I wanted to contribute. For this reason, I joined the Hazlehurst Lab Group at the WVU Cancer Institute in August 2020. As an undergraduate researcher under Dr. Lori Hazlehurst, I have conducted experiments, both in-vitro and in-vivo, that investigate the mechanism, biochemical properties, and pharmacological interactions of the first-in-class anti-cancer therapeutic MTI- 101. I also served as a WVU Cancer Institute Summer Research Intern and had the opportunity to develop my own research project. During this experience, I designed a project to identify pathways and biomarkers contributing to MTI-101's mechanism of action, with a specific focus on the role of cAMP activation and Calcium signaling in MTI-101 induced cell death. Not only did this opportunity enable me to apply the concepts I learned in my courses to advance scientific understanding, but it also solidified the importance of resilience, creativity, and adaptability in research.

In addition to my research, I have continued healthcare advocacy through serving as a volunteer at the WVU and Mon General Cancer Centers, as well as serving as the Chief Medical Officer in the WVU Global Medical and Dental Brigades. I have also served as a Presidential Student Ambassador, President and Vice-President of Chi Omega, President of the Order of Omega Greek Honorary, Senator-at-Large in the WVU Student Government Association, Psychology TA, and as a tutor in the Chemistry Learning Center. In my free time, I love to cook, hangout my with family and friends, and explore new places in West Virginia.



Life After Steel: How COVID-19 Shed Light on Canton Township's Industrial Past

Daniel D. Dillon

West Virginia University Eberly College

Undeniably, the COVID-19 pandemic has changed the ways in which life carries on, whether this manifests in the forms of altering how people interact or how individuals work to further career goals. In the field of archaeology, attending an accredited field school takes central importance to developing much needed skills; however, the virus made such opportunities nonexistent. Seeking a remedy for this rapidly changing situation, I decided to run a “field school” in my parents’ backyard. Beyond the nearly 300 artifacts recovered, a largely unexplored history of Canton Township in Washington, Pennsylvania was uncovered. Just a few feet below the suburban landscape lies the remnants of an industrial past—one that speaks to the revolutionary steel technology that once dominated the land and permeated into the lives of nearly all of those living there. Through archaeological inquiry assisted by archival research, what started out as a nontraditional attempt to gain basic archaeological experience developed into a narrative of transformations from rural landscapes to mill-dominated complexes to modern suburbs. Moreover, this article reveals the idea that history is all around us and, in some cases, may lie right under our backyards.

Introduction

As a student of anthropology looking to work in the field of archaeology, field schools over the summer are a must. By March of 2020, prospects of gaining real archaeological experience dwindled, leaving many with no opportunities to delve into the world of the past. Even smaller, local schools had officially canceled their summer digs by the early summer months and an all-too-typical sense of pandemic-induced dread and disappointment overtook once optimistic attitudes. Desperate times call for desperate measures indeed, so I eventually worked up the courage to ask my family if excavating the backyard was an option. I found myself fortunate enough to ask during a time of stasis where every member of my family was itching to find something new to do. The backyard was too plain to ignore during this time and my family responded by explaining that they had always wanted a fire pit area where they could meet with neighbors and relax. This would require a substantial amount of digging and they had finally found someone overwhelmingly eager to get their hands dirty.

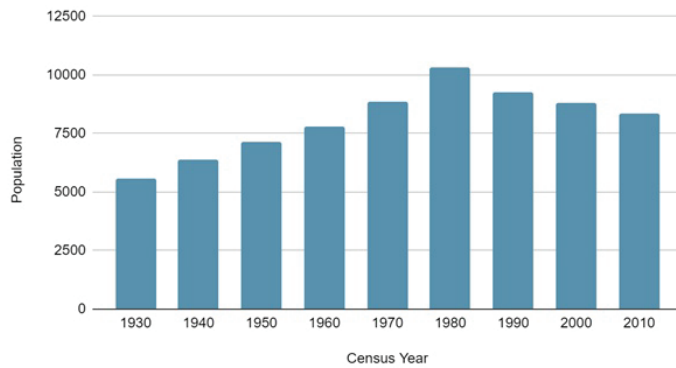
Thus marks the beginning of the excavation work in what would come to be known as The Canton Storeyard.

It should be noted that the nature of this archaeological work maintains an ethical design, taking into consideration the recent nature of the artifacts and being a member of the descendant community. Regardless of the fact that the property owners are my parents, I still received consent to dig on their property—especially since digging in a random backyard is not advisable.

Historical Background and Context

Tucked away in the suburbs of Canton Township, Washington County, Pennsylvania, the site is situated in the rolling hills of what once was a rural landscape. As early as the 19th century, Canton Township developed as a stronghold of farming that was slowly overtaken by building projects and, more importantly, factories and mills. This development is reflected in the population trends of Canton Township, during which the steel industry grew and collapsed. Since

Figure 3. Canton Township Population per Census Year



1930, the population of 5,598 quickly grew during the mill's construction and operation, peaking in 1980 at 10,331. Once the mill had closed in the early 1990s, the population fell to 8,375 as of 2010, see Figure 3.³

Moreover, maps dating as far back as 1897 reveal a continued industrial presence, note Figures 1 and 2.1

Canton Township is currently designated as an area of R-3 medium density, intersecting with a C-2 general commercial area and an M-2 heavy industrial sector. To clarify, any "R"

designation refers to a residential area while "C" is a commercial area with shops and "M" is an area where one can expect industrial complexes. The location of the site is within a decently dense residential area, essentially meaning a suburb. This coincides with the past designations of where the mill was located, just off Jefferson Avenue and on Woodland and Griffith Avenues at the intersection of main roads, industrial buildings, and suburbs.² The site of the dig is pictured just to the right of the top-left factory in Figure 2, which speaks to the fascinating point that the area has always been used in some capacity for hundreds of years.

Methods

The specific site of excavation is located within a residential sector of Canton Township in the backyard of a home built in 1955 (Figure 4).⁴ One pit measuring roughly five by five meters was excavated at a maximum depth of approximately one meter. Certain areas of the site were dug at much smaller depths of less

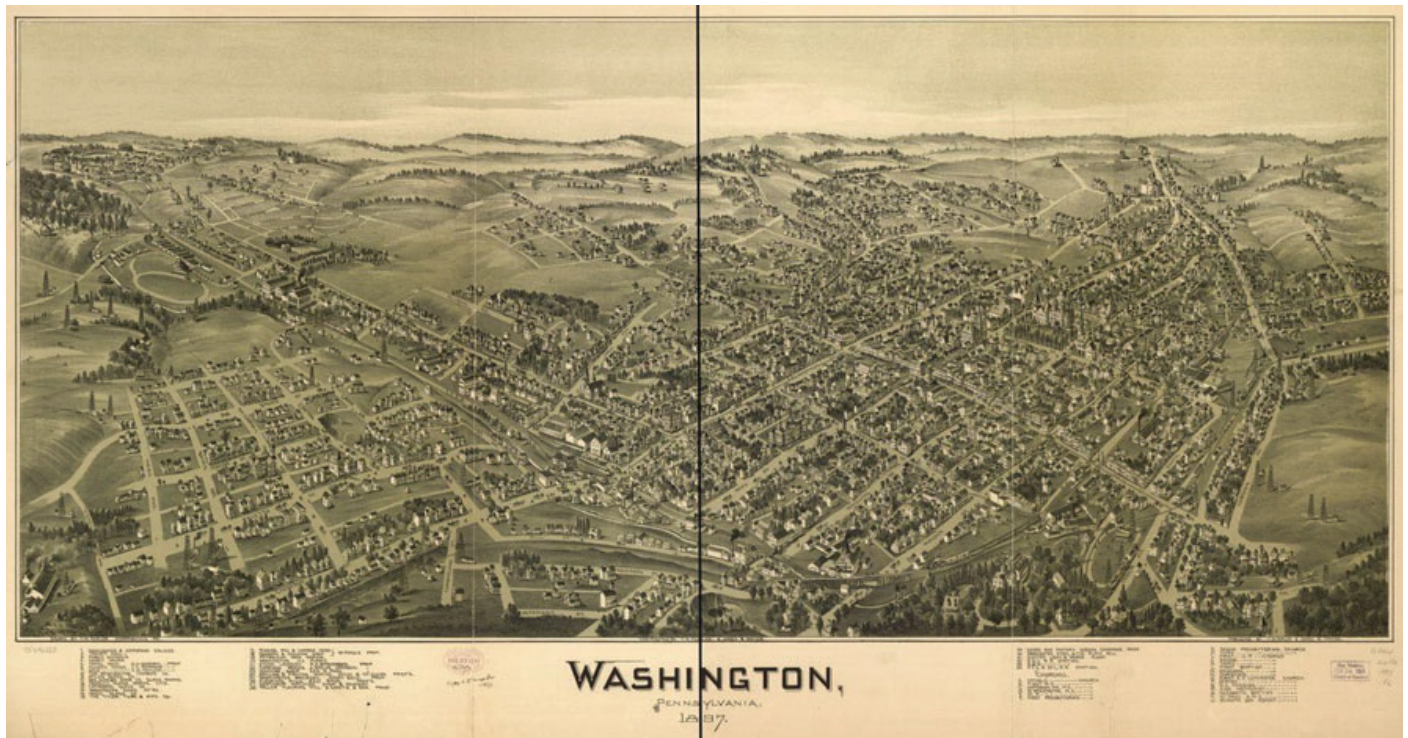


Figure 1. An 1897 Drawn Map of Washington, Pennsylvania



Figure 2. A Close-up on Canton Township, which is located in the upper left corner of the 1897 map. Of particular interest is the continued presence of mills, the smoke billowing from them can be noted in the upper-left corner.



Figure 4. Washington county, Pennsylvania. The city of Washington is located in the center of the county.

soil composed of heavy clay accumulations. As is standard with archaeological procedures, this began with a triangulated square (Figure 5) that was then dug as a test pit. The promising finds in the immediate area, initially coal and other lithics, warranted digging in all directions, namely west, north, and south. The main control over the time period was through the pit terminating at the lower layer of clay. The topsoil was removed and excavation was only in the podzolic layer. Slight deviations from standard procedures did occur, mostly due to the fact that the excavation was not just for personal interests, but also to fulfill digging out a suitable area for a fire pit as per my family's request. The fascinating intersection of personal archaeological inquiry and familial desires for beautifying the backyard cannot be understated throughout this work.

Following excavation, archival research was conducted to contextualize the artifacts and build potential interpretations of the site's use

than one-quarter of a meter for the sake of keeping the pit level, since it was on an 8.33-degree slope westward. From May 2nd to June 27th of 2020, the site was dug predominantly through a topsoil layer of fescue grass, terminating at a layer of podzolic soil, which is



Figure 5. Establishing a Test Pit via Triangulation, the process of digging a test pit involves creating a “perfect” square using triangulation/the Pythagorean Theorem, which is then dug out before expanding in other directions. The old fire pit cover is pictured but holds no particular significance.

prior to the house’s construction in 1955. Sources ranging from the Library of Congress to the local newspaper, *The Observer Reporter*, were used for information on the steel mill and the historic uses of the area that the suburb stands on today.

Results

The Canton Storeyard churned up quite the discussion in the small suburban neighborhood. Calling back once again to the COVID-19 pandemic, official surveys and teams of archaeologists were absent due to the nature of this research, although discussions were at one point underway to officially register the site with the Society for Pennsylvania Archaeology (SPA). This process eventually was halted later in the year, as the property owners did not wish for any further excavations at the site.

As I dug through the summer, neighbors would approach me to tell stories about what they recall Canton looking like during the mid to late steel mill era, circa the 1960s - 1980s. The large mill stood not far from the site, roughly 1.8 kilometers to the southeast.

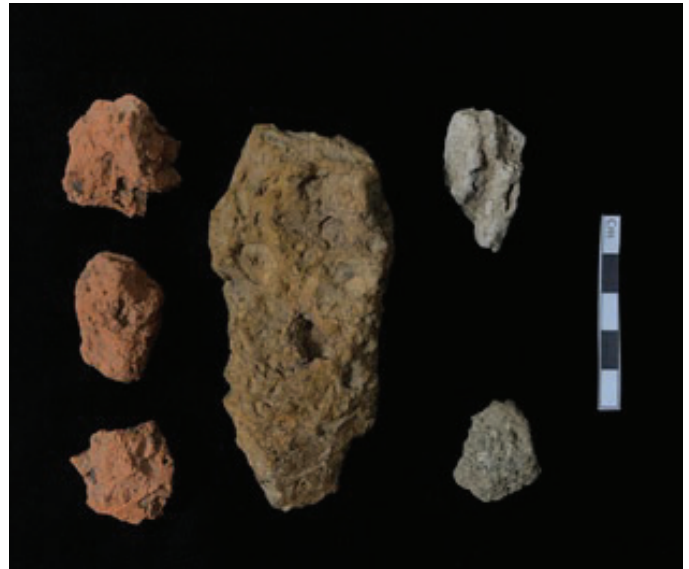


Figure 6. Photograph of excavated red dog variations.

Storeyards dotted the area and covered the rolling hills further up the road from the mill, approximately around where the site was dug. It was common, so people in the area say, that the mills would find unoccupied areas to place excess or waste coal and any other byproducts that were unwanted in the immediate vicinity. The stories shared during this time seemed at first casual and interesting, but ultimately became valuable sources for later interpretations.

Excavation Results

Initial artifact processing yielded a substantial amount of lithics ranging from shale and slate to mill slag and “red dog” (Figure 6). It is worth noting that red dog is a colloquial term that refers to lithics and coal that were accidentally burnt. Coal waste was usually placed in large piles and heat would build up internally. The resulting heat caused internal combustion, with the low-oxygen environment then turning the rocks red. Red dog was commonly used to pave roads and driveways throughout southwestern Pennsylvania as well. Companies used this inexpensive material and laid it on top of mud to create roads, all the while getting rid of the masses of waste and saving large amounts of

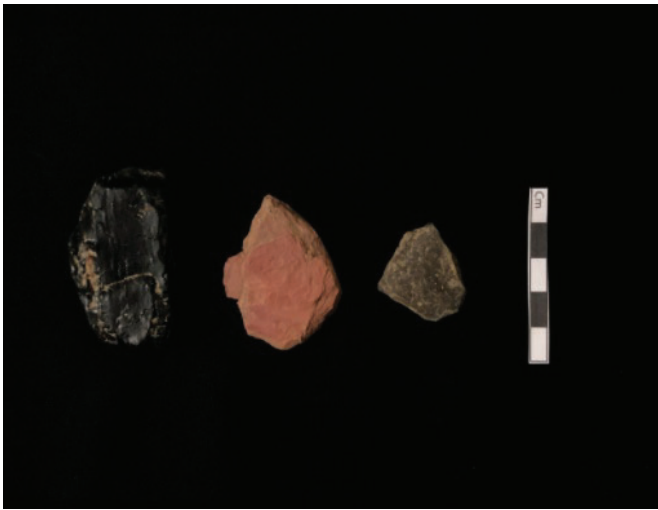


Figure 7. Artifact Recovery, pictured beneath the graphic includes a grouped image of geologic materials followed by excavated barbed wire fencing. Stones from left to right are coal, shale, and slate..

money.⁶ Classification of red dog was tricky given that it is rather versatile in appearance. Any carbonaceous shale or coal waste that has even slightly reddened is classified as red dog.

Table 1 best catalogs the findings at the site, including identifications of geologic materials among other fragmented ceramics, glass, and barbed wire, some of which are pictured with the accompanying graphic (Figure 7). Artifacts designated as “likely pre-construction” were associated with the byproducts and structures

from the steel mill period, pre-1955. Those that are “likely during/post-construction” were primarily materials associated with suburban living, including beer bottle and tarp fragments that are likely post-1955.

Fragments of one glass beer bottle, amber in color and with a notably small punt, likely date to the 1950s. One fragment in particular yielded sufficient information to identify it as part of a class of amber-colored bottles that were quite common in the decade. Given the limited information from the fragments

Artifacts Recovered (Number and Type)					
Likely Pre-Construction		Likely During/Post-Construction			
30 "Red dog"	4 Barbed Wire Fragments	1 Potsherd	15 Wood Pieces	3 Beer Bottle Fragments	1 Plastic Fragment
81 Coal		1 Ceramic Fragment		1 Jar Fragment	2 Tarp Fragments
19 Slate				1 Glass Shard	
43 Shale					
7 Slag					
78 Sandstone					

Table 1. Catalog of findings at the site, including identifications of geologic materials among other fragmented ceramics, glass, and barbed wire.

themselves, the closest available match would be a 1958 Coors bottle, which was tentatively identified using both the Society for Historical Archaeology and research into antique beer bottles.^{6,7} This pairs well with the interpretations of pre- and post-construction periods, since the bottles line up temporally post-1955.

Archival Research and the Industrial Past

Canton Township has been generally disenfranchised when it comes to historical coverage and research. Why this might be remains a mystery, but it even goes so far that the innovation of Z-mill steel was a major part of NASA's Project Mercury, but the city in which this steel was manufactured goes unrecognized. For reference, Washington Steel Corporation was the first of its kind to utilize the process of the Z-mill, which made thinner sheets of steel. Despite the general consensus that the steel industry dominated life in Canton, the 1990s bankruptcy appeared to nearly expunge detailed records regarding the specific mill. Newspapers dating to the 1980s do discuss Washington Steel Corporation but, as a whole, information is scarce. The discovery of this general underprivileged representation further drove my research into the city's past, though at present, adequate documentation of the mills in Canton Township has been somewhat difficult to find and will likely require further work.⁸

Another find that occurred not with the excavation but within archival research deals with the potential correlation between the mill's activity and the population of the township. Interestingly, the population of Canton Township coincides with the rise and fall of the steel industry in the area. The interpretation of the population changes in the area are elaborated in the following discussion section.

Discussion

The likely explanation of the site's use is that it was a storeyard during the steel mill's operation. The findings of barbed wire along the southern wall indicate that the area could have been fenced off to prevent locals from getting into the materials belonging to the corporation. Closer evaluations of the coal found also reveal that the coal itself is not likely to be entirely waste. One piece of coal was burnt, despite protestations, and showed promise that pointed toward the masses of coal being useful and not necessarily part of a "boney" pile.

Despite the destruction of artifacts being highly unethical, this article once again must blend archaeological standards with colloquial ones. In this case, my father lit a piece of coal on fire despite me telling him not to do so. Regardless, the process still generated useful data. For further clarification, boney is a western Pennsylvanian term for waste coal and byproducts of mining. This coal would not be used. Perhaps in the past, prior to roughly 1955, this area was used for easy-access storage and waste disposal. As the decades progressed, a suburban home was built where it still stands today and activity from this site can also be found in the higher levels of the dig. These interpretations are strengthened through personal evidence in the sense that speaking with my parents about the history of their home revealed that the materials excavated underneath the podzolic layer likely predate 1955 and those on top are likely somewhat within the 1955 - 1960 range. This is supported by the fact that the house was built on the property in 1955 and during that year, the backyard was filled in with new soil and covered in fescue grass.

Expanding on the Canton Township population trends found in archival research, perhaps the recent 2020 census would reveal a similar decline as the mill no longer stands and the original residents have aged considerably. From the perspective of someone who had lived in Canton from ages nine to 21, the children of Canton residents appear to have a tendency to

leave after college now that job prospects in the mills have dwindled significantly. My friends, as well as myself, no longer live permanently in the area and sought to go to school in various places, namely in larger Pennsylvania cities or other states such as West Virginia and Illinois. Residents appeared to flock to this area when the Washington Steel Corporation implemented the novel Z-mill, which promised new techniques and, more importantly, more jobs in the growing industry.³ Though this is not necessarily in direct relation to the interpretation of the storeyard, it does assist in understanding the context surrounding it. As the township developed, past storeyards were potentially covered up quickly as houses were built, which could explain the presence of the artifacts just beneath the surface.

The multiple lines of evidence used for interpretation all assist in the creation of a more representative narrative of land use in the area before, during, and after the steel mill era. While the archaeological information is a valuable line of evidence, the oral histories and archival research enrich the story and provide details about the sudden population booms and declines in Canton Township. Though this represents a highly nontraditional response to a nontraditional period of time, the multiple methodological approaches structure a narrative that highlights the complexities of life in smaller rural communities that became suburban.

Conclusions

The ongoing situation with the pandemic has called for turning inward and evaluating the environment around individuals on a much smaller scale than before. With this, looking inward at the immediate landscape of Canton Township yielded information regarding an industrial past that today is overshadowed by modern suburbia. The excavation conducted potentially revealed a previous storeyard, including deposits of both the inputs and outputs of steel manufacturing, and then showed a higher layer of refuse, perhaps from the construction of the house that occurred in

1955. Equally worth noting are the fascinating circumstances that this excavation took place under and the blending of academic standards with informal methods coming from anthropologists and non-anthropologists alike. Conducting archaeological and historical work with the local community in this sense was of great value and created a sense of community during a difficult time, which cannot be understated. Continuing this work can grant further insight into the shift from the steel industry boom to the quiet structures of suburbia and can continue to speak to the fact that, yes, history is all around us. Though it may go unnoticed, objects and artifacts appear to be lurking around every corner and may, after all, be just under our feet.

Acknowledgments

I absolutely have to thank my family for giving me the opportunity to dig up the backyard and must thank several of my professors, including Dr. Jones, Dr. Hirshman, Dr. Thornton, and Dr. Donaldson for recognizing the constraints of the virus, the needs of my career, and for giving me the resources to interpret my findings. I would also like to thank MURR for their dedication and hard work in getting this article published! For the sake of brevity, I cannot thank everyone enough for giving me all of the resources to complete such an exciting project and I cannot wait to continue delving into my hometown's past.

Competing Interests

The author declares no competing interests.

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About the Author:

Daniel Dillon is a 2021 graduate of West Virginia University, having finished his Anthropology BA in the spring. Originally from a small township outside of Washington, PA (the subject of this article), Daniel now lives in Starkville, MS and attends Mississippi State University. He currently studies bioarchaeology and focuses on the ancient Mediterranean in an Applied Anthropology master's program, though this article was written during his senior year. With his WVU degree finished and a master's degree underway, Daniel plans on continuing his education to eventually teach and research within the scopes of biological anthropology, bioarchaeology, and ancient Greece.

How to Cite This Article:

Dillon, D. (2022). Life after steel: How COVID-19 shed light on Canton Township's industrial past. *Mountaineer Undergraduate Research Review*, 7, 10-17.

HOSA

Future Healthcare Professionals

HOSA - Future Healthcare Professionals is a professional student organization that works to connect respective students with resources in the career field of their choosing and unite aspiring healthcare professionals. HOSA is inclusive to all health professions and works to help students with various opportunities like scholarships and internships. HOSA works to promote involvement in current healthcare issues, environmental concerns, and survival needs of the community, nation, and world.

Various events including guest speakers and panelists from different health professions are held throughout the semester to connect students and help them obtain more information about their passions. HOSA also works to match students with the Pre-Health office to utilize their various resources for resume review, mock interviews, as well as general planning throughout their college career. Different events including competitions are pursued throughout the semester, allowing students to travel and meet other like individuals while competing in different medical and STEM-based content.

Within this school year, HOSA is working to provide in-person events with hands-on events and guest speaker opportunities to provide leadership and character-building skills. The requirements to join are minimal, only needing a GPA of 2.5 or higher and aspirations to go into a healthcare-related professional field.



*Student Organization
Spotlight*

Gemini Telepresence Robot System Design: A Low-Cost Solution for Manipulation and Enhanced Perception of Telepresence Robots

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West Virginia University

Current telepresence robots are costly and only allow the operator to see the environment on a 2D screen and move around on a wheelbase. Thus, these telepresence devices are severely limited because of the high barrier of entry, and the operator is unable to manipulate objects or easily perceive the world in 3D. Therefore, to address these gaps in capabilities, Gemini, an open-source telepresence humanoid robot and interface station, was designed to grant the operator the ability to manipulate objects, expand the human interface by putting the user in the 3D world with the use of a virtual reality (VR) headset, and be low-cost. The simplistic, low-cost, and intuitive controls of Gemini promote early adoption by businesses and medical personnel to grant increased telepresence needs. In addition, this platform can be utilized by robotics enthusiasts and university researchers studying humanoid robotics or human-robot interaction. This paper presents an overview of the Gemini robot's mechanical, electrical, and programmatic systems. Upon completion of this study, it was found that Gemini was able to grant the ability to manipulate objects, increase user perception with intuitive controls, in addition to costing approximately 30% less than commercial telepresence robots. Furthermore, the paper is concluded with remarks on future iterations of the project.

Introduction

Due to the recent effects of COVID-19, remote teleoperation has been increasingly important to businesses and medical care. However, current telepresence robots are costly and only allow the operator to see the environment on a 2D screen and move around on a wheelbase. Therefore, they severely limit the operator's perception and lack the ability to manipulate objects. Thus, to address these gaps in capabilities, Gemini, a telepresence humanoid robot and interface station was developed to provide the operator with increased perception, the ability to manipulate objects, and utilize intuitive controls. In addition, Gemini was designed to be a low-cost open-source alternative to commercial products to promote widespread use. Furthermore, since mobile platform telepresence devices commercially exist, Gemini's design (shown in Figure 1) focuses on the manipulation aspect of telepresence robots and the mobile platform is abstracted.



Figure 1. Lower right quadrant of the mural. An inscription on the cartouche dates the its competition (1941-42)

One example of an existing first-person perspective robot is the Bimanual Dexterous Robotic Platform (BDRP) Explosive Ordnance Device (EOD) disposal robot from John Hopkin's University¹. BDRP is a two-armed robot on a wheelbase that is controlled in first person with a VR headset and serves as the foundation for Gemini. However, BDRP was designed for rugged outdoor environments and

utilizes high-cost components for EOD1. While Gemini, is designed to be low cost and in indoor environments for telepresence.

In addition, human machine interfacing has also been extensively studied. For example, the De Vito human mimicry interface consists of a passive exoskeleton to measure the operator's pose². The exoskeleton is a backpack device that has two passive 7 DOF arms that attach to the human operator. At the joints of this device, potentiometers are used to provide the joint angles that get sent to the robot². The main benefit of this design is the increased information frequency and accuracy that potentiometers have in comparison to other sensors used to measure human pose. Furthermore, J. Koenemann used a human mimicry interface that consisted of a body suit of straps that housed electronic sensors which transmit data to the robot³. A major drawback of these designs is that it is inconvenient and awkward to have the operator wear a full body suit when controlling the robot. Therefore, to eliminate the body suit from the human interface a depth camera was utilized to perceive the human pose.

Furthermore, camera research has been conducted to grant depth perception with monoscopic cameras. Z. Kuang describes the use of two cameras to create a stereoscopic view of the world⁴. Stereoscopic vision has the benefit of being able to discern distance based on the angles of the camera. Furthermore, if the human operator was to look through this camera view it would feel more natural⁴ due to humans naturally have stereoscopic vision. The difficulty of this design is that the robot would have to determine what the human operator is looking at without tracking the operator's eyes due to the VR headset. Therefore, a single 360-camera will greatly simplify the design.

Gemini consists of a humanoid robot with a 360° camera connected over the internet to an interface station that utilizes a Red Green Blue Depth (RGBD) Camera and a VR headset, as shown in Figure 1. The interface station utilizes the RGBD camera to discern the operator's pose and then transmit that information to the humanoid robot. The robot then mirrors the

user and transmits the 360° video back to the operator's VR headset. This grants the operator the robot's perspective and effectively allows the operator to become the robot. Furthermore, Gemini was manufactured using a 3D printer and common household products for a low-cost solution. The advancements of telepresence robots from this study are:

- Ability to manipulate objects
- Enhanced operator 3D environment perception via 360 camera and VR headset
- Intuitive and unencumbering control interface via Xbox One Kinect® camera
- 30% reduction in cost compared to commercial telepresence devices

The author contributions to this paper are TS mechanical, electrical, and programmatic design, construction, and implementation.

Methods

Gemini consists of two main components: the robot and the base station. The body was built out of a salvaged steel rack to create a high moment of inertia of the body promoting a stable frame for mounting the dynamic manipulators, electronics box, and the 360-camera shown in Figure 1. While the base station simply consists of a computer and Xbox Kinect.

The manipulator of the Gemini robot, shown in Figure 2, was designed to mimic the motion capabilities of human arms to allow the operator to use their natural movements to control the robot. Therefore, each manipulator is composed of six degrees of freedom separated evenly into the shoulder, elbow, and wrist. In addition to the arm of the manipulator, the end-effector is a humanoid hand composed of five individually controlled fingers and an additional actuation on the thumb is utilized to improve dexterity.

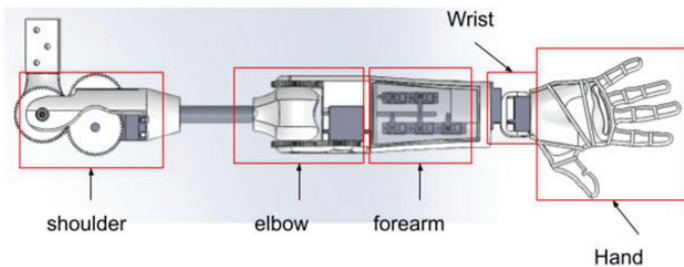


Figure 2. Components of Manipulator. The manipulator consists of a spherical shoulder, elbow, and wrist joints. Connected to a hand with 5 individually controlled fingers with an additional thumb actuator. The motors for the hand are housed in the forearm.

The shoulder and elbow joints of the manipulator are differential spherical joints to mimic the ball-socket joint and the roll / pitch motion of human shoulders and elbows, respectively. Differential spherical joints as shown in Figure 3 utilize a backwards driven differential to control the roll and pitch of the joint.

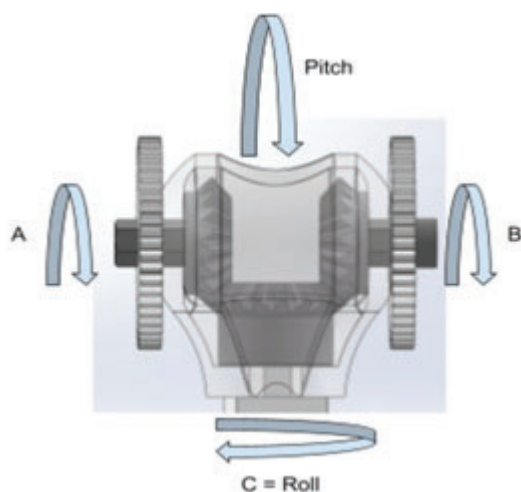


Figure 3. Components of Manipulator. A and B serve as the motor input angles to the joint, with the output angles of Roll, on axis C, and Pitch angle about the joint housing.

To control this type of joint, the forward kinematics of differentials are described in Equations (1 and 2).

$$\text{Roll} = (A-B)/2 \tag{1}$$

$$\text{Pitch} = (A+B)/2 \tag{2}$$

Where the output angle of middle shaft C (Roll) is half the difference between motor inputs A and B (shown in Figure 3). While the pitch angle of the housing is the average of A and B. Furthermore, the inverse spherical kinematics are shown in Equations (3 and 4).

$$B = \text{Pitch} - \text{Roll} \tag{3}$$

$$A = \text{Pitch} + \text{Roll} \tag{4}$$

Combining both the shoulder and elbow together an anthropomorphic spherical arm workspace is generated with each major joint (shoulder and elbow) consisting of local Roll-Pitch spherical coordinate frame kinematics.

Counter to the shoulder and elbow joints the wrist joint was simplified to a direct roll and pitch motor configuration to fit the smaller form factor required to accurately mimic the geometry of humanoid arms and to provide housing space for the electronics and hand motors in the forearm (as shown in Figure 2). In addition to this the humanoid hand is actuated by a nylon line attached to the fingertips and runs through the fingers and hand to the motors in the forearm, similar to tendons in a human hand⁵.

Gemini’s base station consists of an Xbox® Kinect that interprets the pose of the operator and transmits the data over a USB serial cable to a computer. The computer then connects to the robot over Wi-Fi to send commands. The base station electronics diagram is shown in Figure 4.

Gemini is initially powered by U.S. standard 120V 60Hz AC power so battery lifetime can be abstracted from the design. Furthermore, the AC power is first converted to a variety of DC voltages to be supplied to the main components as shown in Figure 5. Therefore, to convert Gemini to a mobile platform simply replace the wall power and AC/DC converters with batteries and voltage regulators.

The power system then feeds into the body electronics which consists of two computing resources: a raspberry pi 4, an android phone, and a 360 camera all of which receive 5V DC power. The raspberry pi serves as the main computer for the robot, while the android

phone solely serves to transmit the video from the 360-camera by connecting to the camera over Bluetooth. Furthermore, the raspberry pi receives input from the base station computer over Wi-Fi and transmits commands through a USB serial cable to each Arduino Mega that serve as the main computing resource of the arms. In addition to receiving serial commands

the Arduino Mega also receives 9V power from the power subsystem. The Arduino Mega then sends PWM signals to the motors to specify their rotational position. The shoulder, elbow, and wrist motors all receive 7V DC power while the hand motors receive 5V power from the Arduino Mega. The full electronics diagram for Gemini is shown in Figure 5.

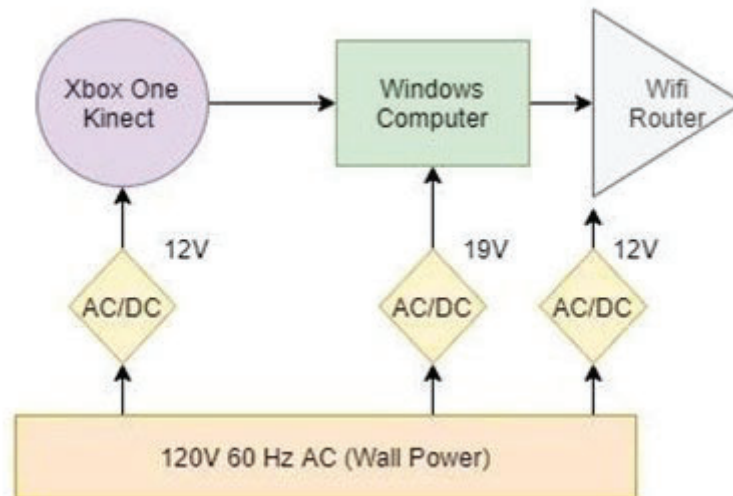


Figure 4. Base Station Electronics Diagram. Consists of standard United States wall power that is supplied to the Xbox one Kinect, windows computer and Wi-Fi router. In addition, the communication links from the Kinect to the computer then to the Wi-Fi Router are also shown.

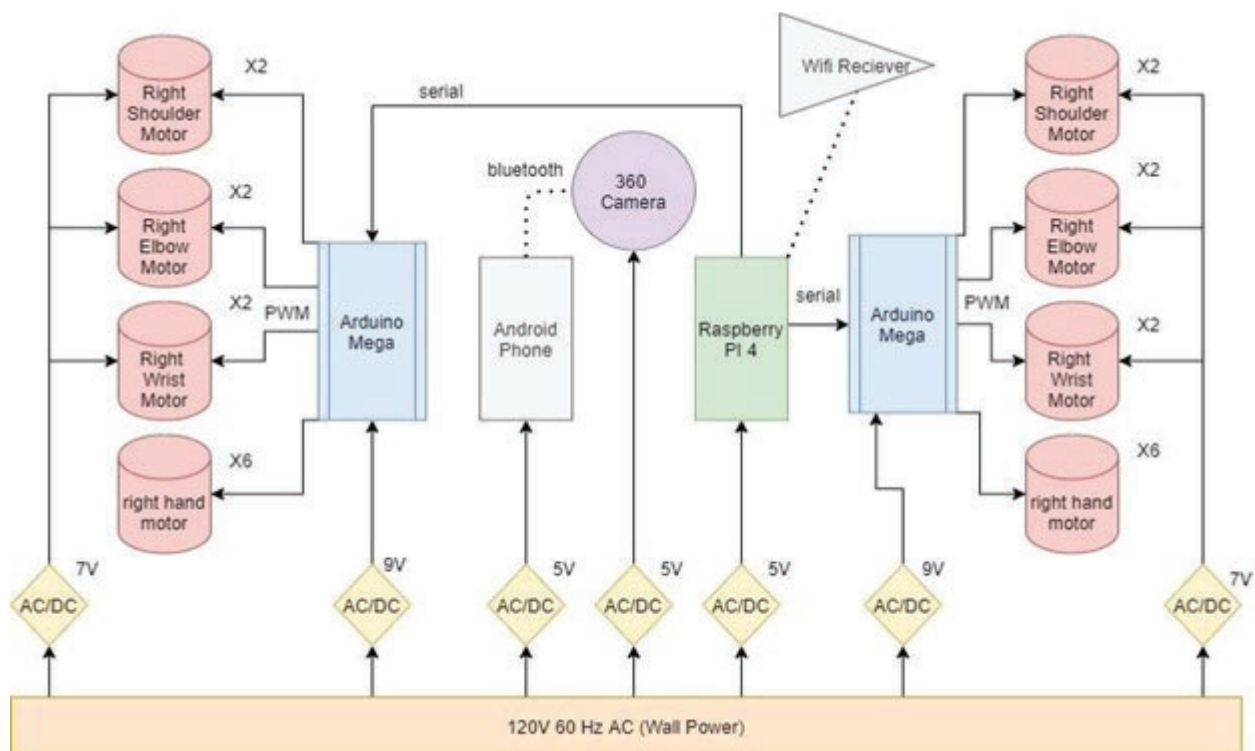


Figure 5. Gemini Robot Electronics Diagram. Starts with standard United States wall power supplied to each of its main components. The Raspberry PI serves as the main computer that sends signals to left and right Arduinos that control the left and right arm motors. In addition, an Android phone is used to control and transmit the 360 video from the camera.

Programmatically, Gemini utilizes distributed computing to separate the computation power across multiple devices to improve the modularity of the design and to allow repurposing of different components. One example is the manipulator can be removed from the body and still have full functionality if the proper signal and power is supplied. Furthermore, Gemini can be completely separated from the base station and function autonomously. Thus, allowing it to be a test platform for other humanoid robotic studies. The full programming architecture is shown in Figure 6.

Starting from the base station Windows computer, the Xbox Kinect observes the pose of the operator. It is important that the computer is running Windows due to the Xbox Kinect software development kit (SDK) only being available on Windows. Next the skeleton of the operator is extracted and published to a Robot Operating System (ROS) topic, using M. Peng's skeleton tracking package⁶. ROS is an open source robotics library that aids users sending information between software processes called nodes via topics. Furthermore, the software then transmits the topic over local Wi-Fi (LAN) to Gemini, as shown in Figure 6.

Gemini then receives the operator's pose on the raspberry pi 4 running Ubuntu 20.04 and ROS Debian on the Kinect bridge node. This node then extracts the shoulder, elbow, and wrist xyz coordinates of the left and right arm, transforms them from the Xbox Kinect's coordinate frame to Gemini's coordinate frame, and publishes them to the left and right Arduino bridge nodes that forward the topics to Arduinos on each of the arms. This is done by using the roserial python package.

Each of the Arduinos then computes the inverse kinematics and required motor

commands to mimic the operator by first transforming the cartesian xyz shoulder, wrist, and elbow points to the local roll-pitch spherical coordinates of the shoulder and elbow joints. The transforms are computed using homogeneous transformation matrices, which are a mathematical tool used to convert coordinates from one frame to another and shown in Equation 5.

$$H_{12} = R_{3 \times 3} V_{3 \times 1} \begin{bmatrix} 0 & 0 & 0 & 1 \end{bmatrix} \quad (5)$$

Where H is the 4x4 homogeneous transformation matrix from coordinate frame 1 to coordinated frame 2, R is the 3D rotation matrix that describes the angular difference between the coordinate frames and V is the 3D displacement vector that describes the difference of the position of the origins of the frames. The next step is to define the elbow's position from the shoulder's point of view. This is done by transforming the elbow position from the robot's coordinate frame to the shoulder's coordinate frame using the homogeneous transformation matrix and elbow position vector, as shown in Equation 6.

$$ES = HRS^{-1} * ER \quad (6)$$

Where ES is the elbow's xyz position column vector in the shoulder frame and ER is the elbow's xyz position column vector in the robot frame. Now that the elbow position is defined with respect to the shoulder, the cartesian xyz coordinates can be converted to Roll-Pitch spherical coordinates of the mechanical joint using Equations 7 and 8.

$$\text{RollS} = \text{Esy} \sqrt{\text{Esx}^2 + \text{Esz}^2} \quad (7)$$

$$\text{PitchS} = \frac{\text{Esx}^2 + \text{Esz}^2}{\sqrt{\text{Esx}^2 + \text{Esz}^2 + \text{Esz}^2}} \quad (8)$$

Where Esx, Esy, and Esz, are the elbow's

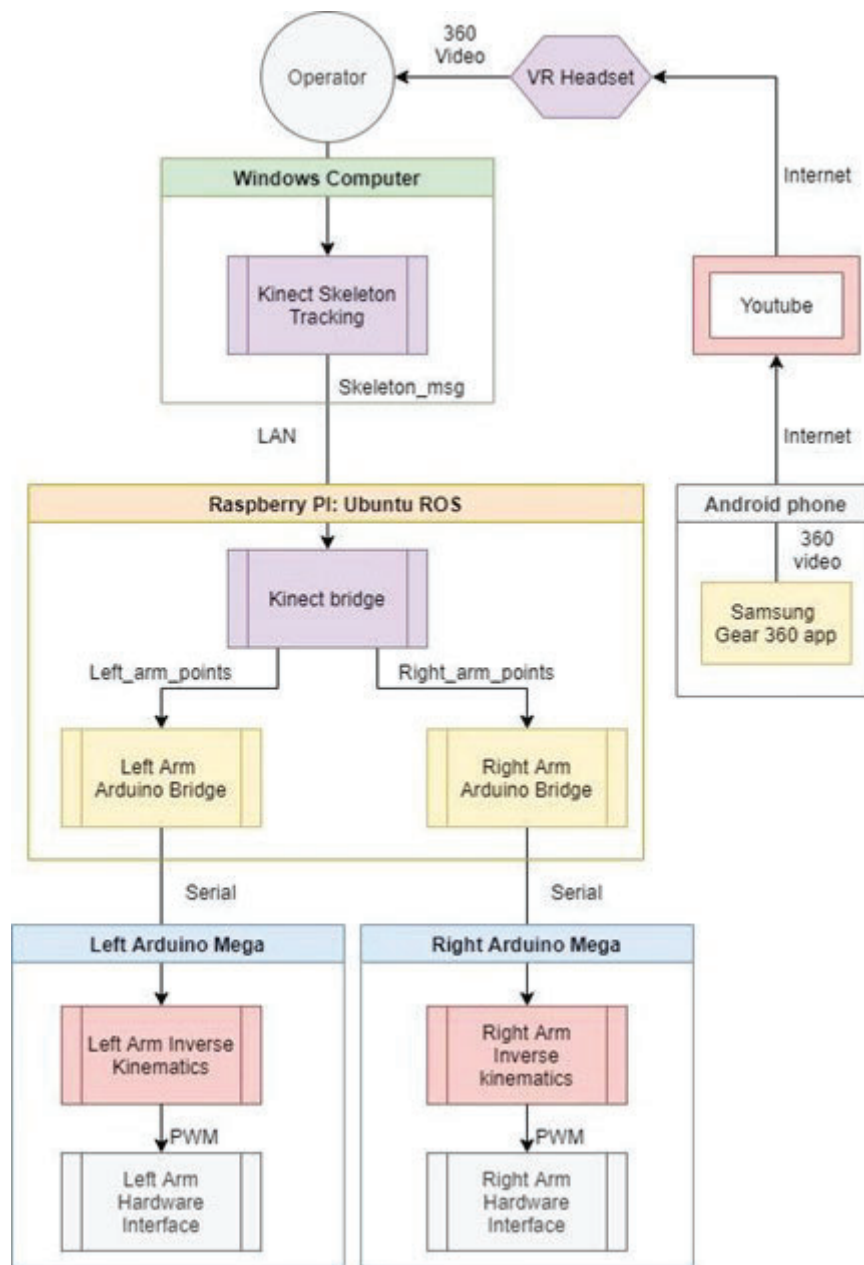


Figure 6. Gemini Programming Architecture. Starts with the operator, whose skeletal pose is measured by the Kinect on the windows computer. Then transmitted to the robot's Ubuntu computer that sends the left and right arm coordinates to each manipulator's Arduino. That then controls the motors positions.

xyz coordinates in the shoulder frame and Rolls and PitchS are the roll and pitch spherical coordinates of the shoulder joint. Now that the shoulder spherical coordinates (Rolls and PitchS) have been found the process is then repeated for the elbow to calculate its spherical coordinates. After the shoulder and elbow roll and pitch values are found, they are input into Equations 3 and 4 to calculate the motor rotation angles A and B. Which in turn are

converted to motor control Pulse Width Modulus (PWM) signals using a linear empirical fit and sent to the motors in the Arm Hardware Interface on the Arduino Mega as shown in Figure 6.

Next to transmit the 360 video of the camera the android phone runs the Samsung Gear 360 app that live streams the video to a private YouTube channel. The operator then views the private live stream at the base station

through the VR headset.

Results

From this design the Gemini robot was able to mimic the human operator from a first-person perspective. Therefore, the Gemini robot was able to allow the manipulation of objects following the intuitive controls of the human operator, via the Xbox Kinect. While also providing enhanced perception to the operator through the VR headset and 360-camera. Figure 7 displays Gemini actively grasping and holding on to a ball and Figure 8 displays Gemini being controlled by the operator's movements.

Furthermore, Gemini costs approximately

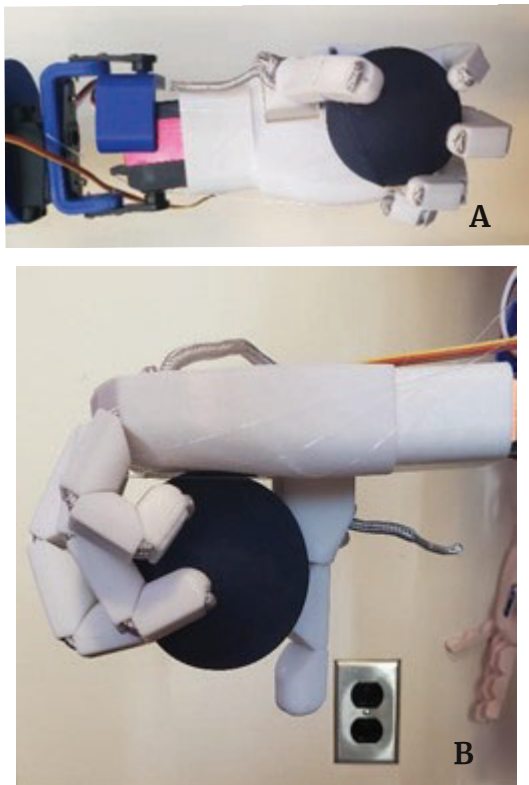


Figure 7. Gemini Grasping a Ball Front View (A) Side View (B). Gravity is acting downwards in both photos, as the hand grasps around the ball due to the nylon strings pulled taut.



Figure 8. Gemini in Operation. Gemini mirrors the operator's hand moving up, while the operator views from the VR headset.

\$1,000 which is at a minimum 30% cheaper than current telepresence robots such as PadBot P2 and BotEyes-Pad. The cost breakdown of Gemini is displayed in Table 1.

Table 1. Cost Breakdown of Gemini. Note that a majority of these parts are common components hobbyists would have on hand.

Discussion

From this work, it is shown that Gemini grants the operator the ability to remotely manipulate objects in first person perspective with advanced perception and control. Using a VR headset and Xbox One Kinect, respectively. Thus, solidifying Gemini as a 30% cheaper opensource† alternative to commercial telepresence robots. The current limitations of Gemini are “jittering” and back driving servo motors under heavy loadings. To further improve this work, the shoulder and elbow motors will be replaced with worm-gear driven DC motors with encoders. This change will prevent back driving of the joints under loading, in addition to lowering the cost. However, this will require an additional motor control electronics board and more in-depth controls programming. In addition, a passive elastic support would be added to the joints similar to tendons on the human body to reduce the loading on the motors to allow the operator to lift heavier objects. Furthermore, lack of touch feedback, as seen in BDRP1, presents a limitation in operator’s ease of manipulation. Therefore, ergonomic gloves with haptic touch feedback will be developed to allow the operator touch perception and the ability to have individual finger control over the current open / close hand control. Gemini is also currently limited to local Wi-Fi connections, while commercial products can be accessed globally. This limitation will be mitigated by using a remote server to allow global access.

Competing Interests

The authors declare no competing interests.

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Trevor Smith is a 2021 graduate of West Virginia University, having finished his Mechanical Engineering BA, Aerospace Engineering BA, and Minor in Computer Science in the Fall. Originally from a small township outside of Johnstown, PA Trevor Smith now lives in Morgantown, WV and working in the Interactive Robotics Laboratory at WVU. Where he currently studies swarm robotics and focuses on developing fundamental elements of robotics to utilize computational methods, though this article was written during his senior year. With his WVU degree finished, Trevor plans on continuing his education to earn a Ph.D. in Robotics to eventually teach and research within the scopes of swarm robotic system design, cooperative morphological computing, and dynamic reconfiguration of swarm networks.

How to Cite This Article:

Smith, T.R. (2022). Gemini Telepresence Robot System Design: A Low Cost Solution for Manipulation and Enhanced Perception of Telepresence Robots. *Mountaineer Undergraduate Research Review*, 7, 19-28.

Biomedical Engineering Society



The Biomedical Engineering Society (BMES) is a professional student organization at WVU that encourages the dissemination, integration, and utilization of knowledge within the field of Biomedical Engineering. The organization fosters the development of social relationships, leadership abilities, and professional qualities among members of all majors while allowing them to explore undergraduate, graduate, and professional opportunities in related disciplines.

The organization is very involved within the Statler College of Engineering and Mineral Resources. Besides participating in volunteer and outreach efforts through the college, such as EngineerFest, High School Visitation Day, Trunk or Treat, and Discover WVU, the organization also hosts its own social and professional events. This semester, BMES has organized a social hike at Cooper's Rock, along with organizing an undergraduate research panel, and a medical school panel in collaboration with the American Chemical Society Student Affiliates and the Biochemistry Club.

The organization hopes to bring in guest speakers from the industry, along with providing members with a presentation on graduate school. Regardless, BMES aims to connect current students with alumni along with collaborating with the American Institute of Chemical Engineers (AIChE) for departmental events next semester. The organization is also in the process of being a certified chapter of eENABLE, a not-for-profit 3-D printing prosthetic donation organization that aims to help local communities by providing free 3-D printed prosthetics.

With most members currently involved in undergraduate research, along with encouraging members to present their research findings at the annual BMES national conference, BMES and its members greatly benefit from research as it not only supplements their in-class learning, but it also provides them with the opportunity to gain hands-on experience in testing hypotheses, conducting statistical analyses, interpreting complex trends in data, and drawing conclusions.

*Student Organization
Spotlight*



Utilizing Pharmacology to Target Transcription Factors Involved with Cancer Onset and Development

Tristan D. Sanders

West Virginia University

Transcription factors (TFs) are a vital part of every living organism on Earth as they allow for the correct genes to be expressed. However, TFs can fall victim to mutations or manipulations that lead to the deregulation of many genes within a cell. If specific genes are over/under-expressed, a cell may become cancerous and begin replicating into a tumor. It has been demonstrated that common TFs associated with cancer can be targeted using small-molecule drugs. A popular target of these drugs is the DNA binding site on the TF along with the DNA sequence that the TF binds to. Disrupting a cancerous TF's ability to associate with DNA will stop it from wreaking havoc on the organism. Most TFs are also regulated by small molecules called cofactors which have unique binding sites on their respective TFs. This spot also presents a potential target for drugs as many TFs cannot function without their cofactors bound. In this review, studies on disrupting TF-DNA interactions and TF-cofactor interactions with hopes of treating cancer will be discussed.

Biological Role of Transcription Factors

The human genome is massive, and most of it (~99%) is never used to create proteins.¹ In order for life to work, proteins called transcription factors (TFs) do the job of sifting through the genome and allowing for the proper genes to be expressed to the correct extent. TFs can be activators or repressors of specific genes. Throughout one's life, the expressed genes change based on one's developmental stage, diet, and even exposure to UV light.^{2,3,4} Without TFs, the human body would not be able to carry out biological functions properly or respond to stress from the environment. While TFs do play vital roles in the body, it is not uncommon for their function to become altered in a way that leads to the onset of diseases such as cancer. Due to significant improvements in cancer research, it is becoming more feasible to design specific molecules that can interact with the cancerous TFs to treat the disease.

TFs perform their duties by chemically interacting with DNA at a specific target sequence or binding to other proteins that are already interacting with DNA. The interactions between TFs and DNA can be broken down into a few categories that include most of the

observations that have been made: helix-turn-helix, zinc fingers, and leucine zippers.⁵ All of these protein shapes generally interact with the major groove of DNA (Fig. 1), which is the double helix's open side. The major driving forces for these chemical reactions are hydrophobic interactions, hydrogen bonds, and ionic bonding between the protein and DNA sequence.⁶ When the DNA and proteins interact, energy is stabilized due to less hydrophobic surfaces being exposed to water (the hydrophobic effect). Charged residues on the protein can also orient to ionically bond to oppositely charged atoms on the DNA molecule.

How Transcription Factors Become Cancerous

TFs are evolved to bind specific sequences by interacting with the nucleotides in the DNA double helix. They must be highly specific, so they influence the correct gene. Suppose a critical amino acid is replaced in the TFs binding site or a nucleotide in the recognition sequence of DNA is changed. In that case, there is a high chance that the binding will be affected, and the cell/organism's physiology could be compromised. The real issue is when these genes are associated with the cell cycle or

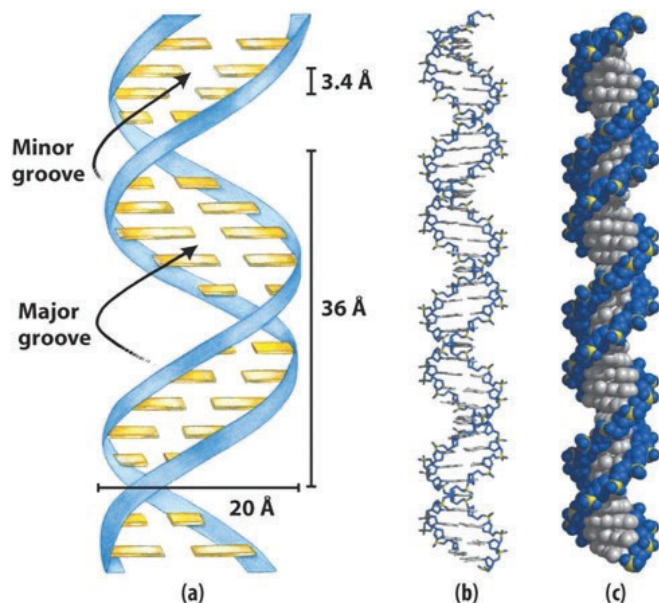


Figure 1: Structure of DNA Double Helix⁷

Major grooves are around 36 angstroms (3.6 nm) apart, which has caused TFs to evolve their geometries accordingly to bind to multiple major grooves at once when interacting with DNA. The minor groove is not targeted by TFs nearly as often due to steric hindrance.

the cell's quality control system. Tumor suppressing genes are the primary type of defense cells have against mutations and cancer, so when they are mutated or under-expressed, DNA mutations can occur easily.⁸ For example, if a tumor suppressor gene's promoter (where the TF binds to DNA sequence) acquires a mutation and the TF cannot allow for the gene's expression, then a tumor will be able to grow more rapidly.

Down-regulating tumor suppressor genes is a direct cause of cancer, but for cancer to occur, there is also the need to upregulate genes that lead to cell division, such as cyclins⁹ and epidermal growth factors.¹⁰ These genes are considered proto-oncogenes because they can cause cancer if they acquire the correct mutation. There are several ways a proto-oncogene can become overactive from a mutation. A different TF may recognize the new promoter sequence and begin expressing this gene when it should not. There is also the chance that a mutation causes a gene's normal TF to bind even tighter to the promoter, which would also lead to overexpression because the

TF would not be able to detach after a cell division. Some additional classes of genes that are commonly involved with cancer development are angiogenesis (blood vessel forming) genes and metastasis genes that allow cancer to spread to different organs through the bloodstream.

When a cancerous mutation happens inside a single cell, the defense mechanism is generally a tumor suppressor gene called p53 that recognizes the mistake and induces apoptosis (cell suicide). This stops the cell replication process. Many cancers are due to a combination of mutations, and p53 being mutated is extremely common in cancer because it renders the cells defenseless against the mad proliferation and growth of a tumor.¹¹ When p53 is defective and cannot recognize genetic mistakes, these errors begin accumulating in the cancerous cells. This allows for the disease to reach the fourth stage and ultimately spread throughout an organism.

Targeting Cancerous Transcription Factors with Drugs

TFs are heavily regulated inside a cell due to the power they possess. Some of the most common methods of regulation include cofactor binding and phosphorylation/dephosphorylation. Cofactors are non-protein chemical molecules that bind to a site on an enzyme or protein (such as a TF) and change its function. Phosphorylation of a protein alters its shape because the only three amino acids that can be phosphorylated are serine, threonine, and tyrosine. All three are non-charged amino acids with a hydroxyl group that the negatively charged phosphate is attached to, which alters the protein's electronic forces in a way that can activate or repress its activity. Both cofactor binding sites and amino acids in phosphorylation sites are potential targets for drugs to interact with, along with the more obvious DNA binding motif of the TF and the actual DNA recognition sequence that the TF binds to.

The extreme specificity of binding sites makes creating a drug to block a TF difficult,

and the success rate is low. However, now that protein imaging and protein folding are better understood, the development of these drugs is becoming more of a possibility. Most cancers are dependent upon TFs not functioning correctly, which leads to uncontrolled cell growth and proliferation.¹² Designing a drug that fits precisely in the binding pocket of a TF without altering any other physiological process can be challenging, but if successful, this could be the future of cancer treatment. One of the best things about this form of cancer treatment is it will be exponentially less destructive to healthy cells when compared to the other forms of cancer treatment that are prevalent today, such as radiation and chemotherapy. A downside to this type of treatment is that each TF that is associated with causing cancer will need to have its own drug developed because they are chemically different. So, focusing on the most common TFs involved with cancer will provide the most benefit to society without being too uneconomical in the research process. In this review, some of the most common cancerous TF mutations will be discussed in detail, along with attempts to create drugs that interfere with these mutated TFs.

Interrupting Protein-Protein Interactions to Treat Cancer

Many studies have attempted to disable the interactions between TFs and their cofactors by designing a molecule that will fit directly into this site or alter the site covalently.^{13,14,15} The association of CBF β -SMMHC with the TF RUNX1 has cancerous implications, and a potential treatment has been found.¹³ RUNX1 is a TF that normally only binds CBF β as a cofactor. However, chromosomal mutation results in CBF β and SMMHC complexing and binding RUNX1, which downregulates the TF compared to its regular activity. This results in the onset of acute myeloid leukemia. Previous studies scanned the NIH database for a molecule that could inhibit the association of CBF β -SMMHC with the TF RUNX1 using a fluorescence resonance energy transfer (FRET)

assay. A molecule (AI-10-49) was found and tested to show it could prevent the formation of the CBF β -SMMHC to restore the normal function of RUNX1 (Fig. 2). The drug was deemed successful as it delayed the onset of leukemia in mice significantly. Furthermore, they used nuclear magnetic resonance (NMR) to show that the molecule (AI-10-49) binds to tryptophan and a tyrosine amino acid on the CBF β -SMMHC complex to prevent its association with RUNX1. If it is possible to employ this technique to find inhibitors for other improperly functioning TFs, that should be pushed for in the future.

The estrogen receptor (ER) is commonly studied due to its implications in breast cancer. Shiao et al. worked with the drug tamoxifen and its derivatives which are molecules that interrupt the binding site of estrogen, which is on hER α .¹⁴ In many instances, there is an overexpression of ERs in breast cancer cells which leads to hypersensitivity toward a typical concentration of estrogen. This pathway results in rapid cell division. Developing a drug to block the estrogen binding site was of utmost importance due to its direct implication

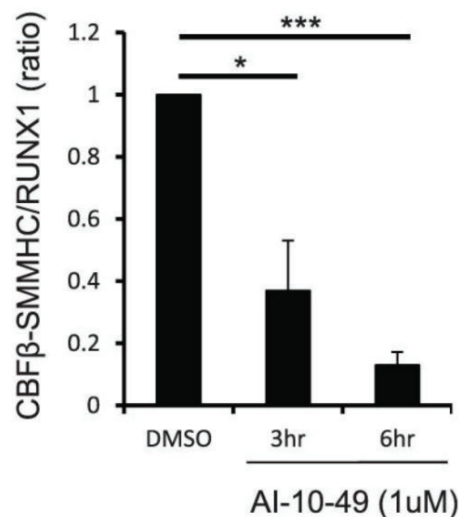


Figure 2: Concentration of the CBF β -SMMHC Complex

This bar graph shows that after the drug AI-10-49 was applied, the concentration of the CBF β -SMMHC complex decreased while the amount of free RUNX1 increased.¹³ This should allow for RUNX1 to resume its normal transcriptional activities.

in several types of breast cancer. X-ray protein crystallography was performed on the ligand-binding domain (LBD) of hER α when it was bound to DES (synthetic estrogen). It was found that the drug 4-hydroxytamoxifen was also bound to the same site but in a different orientation.¹⁴ Fig. 3 below shows the two molecules and compares their interactions with the hER α receptor's LBD. The molecules appear different, but the main forces for interaction in this receptor are hydrophobic interactions (shown in green). However, both molecules have hydrogen bonds between an -OH group and arginine residue 394 on the ER (shown in red). DES has an additional hydrogen bond with glutamate 353. Using X-ray crystallography to decipher the LBD of TFs is a helpful technique that will give us powerful insight into the types of molecules and functional groups that need to be on the drugs being designed as inhibitors.

CDK7 (Cyclin-Dependent Kinase 7) is a common protein that can become faulty in blood cancers and is directly involved with the cell division process. This enzyme is part of a TF complex (TFIIH) and activates many other proteins that aid in cell division through phosphorylation. So, when TFIIH becomes

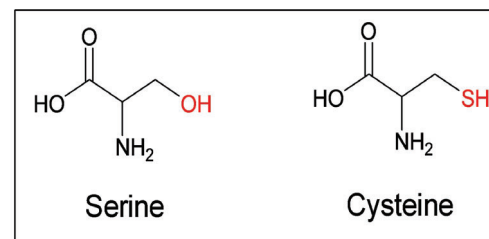


Figure 4: CDK7 Mutation

This illustrates the mutation in CDK7 that rendered THZ1 ineffective. The mutation was subtle enough for CDK7 to remain functional, but the S atom must be present for THZ1 to bind.

overactive, the consequences are dire. A successful study has been published showing that a molecule (THZ1) can covalently bind to a non-active site of CDK7 and inhibit its activity thus causing specific cancer cell lines to stop proliferating.¹⁵ The binding of this drug must have some allosteric effects on CDK7 as it was shown through mass spectroscopy that the molecule binds to a remote cysteine amino acid on the enzyme. To further support this point, the proposed binding site of THZ1 was mutated from cysteine to serine on CDK1, and the molecule could not bind or inhibit the proliferation of the cancer cell lines.¹⁵ Using subtle mutations to show how a drug interacts with its target protein is a great strategy, especially if the mutation does not alter the chemistry enough to disrupt the normal protein function, such as in this case (Fig. 4).

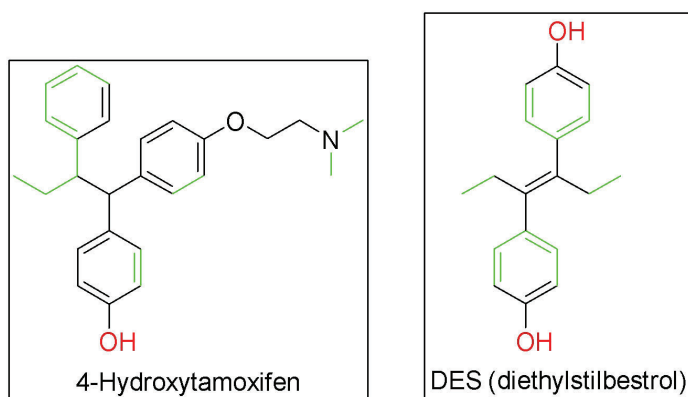


Figure 3: Synthetic Estrogen (DES) and Its Competitive Inhibitor (4-Hydroxytamoxifen)

The green atoms are participating in hydrophobic interactions with non-polar amino acids in the hER α ligand-binding domain. The red atoms are hydrogen bonding with Arg394 and Glu353; both hydroxyl groups of DES are highlighted because they are symmetrical and can orient either way in the binding pocket.

Interrupting Protein-DNA Interactions to Treat Cancer

Interfering with an active TFs function is as effective as blocking the TF activation altogether. This is why many studies have been done with intentions of hindering the TF's ability to recognize and bind to its specific sequence of DNA.^{16,17,19} Flavopiridol has been extensively studied as it was shown to kill cancer cells in culture, so the mechanism behind its ability needs to be elucidated.¹⁶ Using DNA cellulose affinity chromatography, it has been shown that Flavopiridol binds to a DNA sequence that prohibits the binding of STAT3; STAT3 is a TF involved in many different cancers, and it is a crucial gene to

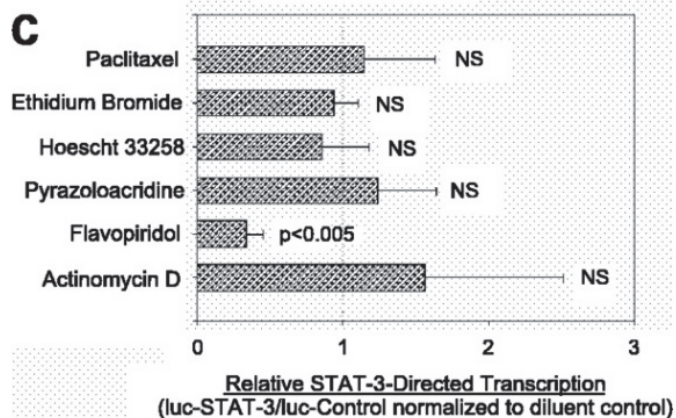


Figure 5: Expression of STAT3 Induced Genes
This chart shows the different drugs tested to reduce the expression of STAT3 induced genes.¹⁶ Flavopiridol was the only one successful at significantly reducing STAT3 activity.

allow cancer to spread and new blood vessels to form.¹⁸ To further prove this point, the expression level of the genes that STAT3 induces was evaluated, and it was found that the induced genes were all expressed less when the cells were treated with Flavopiridol (Fig. 5).¹⁶

AP-1 is a gene involved with metastasis (the ability of cancer to spread) and tumor suppression involved with highly aggressive breast cancer.²⁰ Breast cancer can spread to other vital organs such as the lungs and brains easier than most other types of cancer. NMR was used to show that MLN944 was directly interacting with the DNA sequence (ATGCAT)₂.¹⁷ Even further, electrophoretic mobility shift assay (EMSA) was utilized to show that MLN944 was binding to a sequence that was inhibiting the binding of AP-1, which is a TF involved with metastasis and tumor

suppression. They found that MLN944 lays flat through the DNA sequence's major groove. Additionally, one phenazine ring of the molecule (Fig. 6) anchors down between the thymine and guanine while the other ring goes between the cytosine and adenine nucleotides. When designing a molecule that is meant to bind to DNA, adopting a symmetrical form around the length of the gap between adjacent major grooves may be a great option. Many natural biological molecules that bind DNA have evolved this geometry; learning from this and designing symmetric DNA binding drugs should improve success.

HIF-1 is a TF that allows for angiogenesis to occur when the tumor environment becomes hypoxic (low oxygen). Therefore, it is crucial that cancer cells produce new blood vessels to acquire nutrients. A study has been conducted that identified a compound (echinomycin) able to bind directly to the DNA sequence HIF-1 binds to when activated.¹⁹ EMSA was used to show that the drug did indeed bind the correct sequence of DNA. The main gene that HIF-1 increases the transcription of in tumors is vascular endothelial growth factor (VEGF). It was shown that echinomycin inhibited the expression of this gene in a dose-dependent manner (Fig. 7). The unique thing about HIF-1 is that it does not need to be mutated to help cancer. It is automatically activated in the cell when oxygen levels drop, and oxygen levels plummet when tumors start to form with no blood vessels to provide them with O₂. That makes this study applicable to all solid tumors which use angiogenesis to secure nutrients from the host and grow.

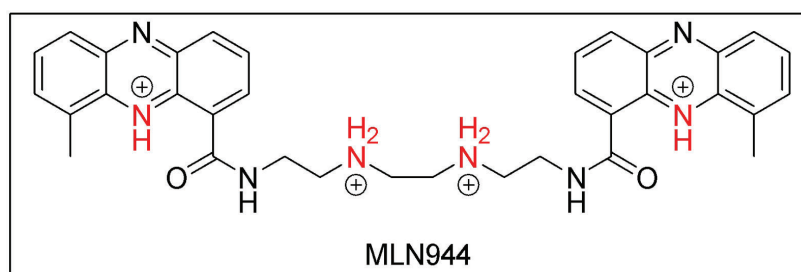


Figure 6: Structure of the Anticancer Drug MLN944¹⁰

This molecule has a substantial positive charge (shown in red) that aids in its ability to anchor tightly to DNA which is negative because of its phosphate backbone. This molecule's symmetrical nature also helps strengthen the interaction due to the DNA double helix being antiparallel in sequence.

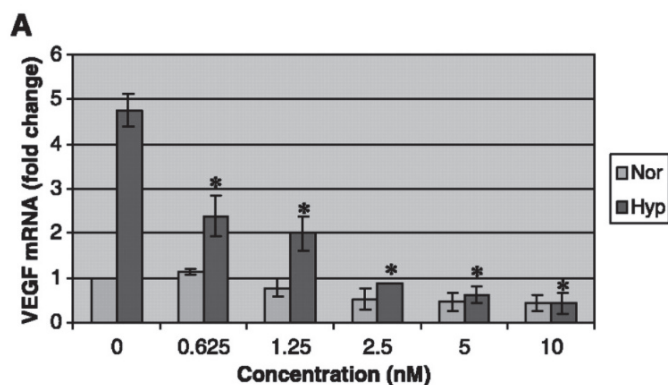


Figure 7: Echinomycin Concentrations and VEGF Transcription

This graph shows how different concentrations of echinomycin influence the transcription of VEGF.¹⁹ Echinomycin blocks HIF-1 activity strongly in hypoxic conditions, which are common in tumor cells but not in normal cells.

Conclusions

Many laboratories worldwide have overcome a once impossible feat of designing drugs to inhibit the cancerous activities of deregulated TFs. Inventive strategies have been devised to find potential drugs for specific binding sites of TFs along with methods that help confirm the drug is doing its intended job. Applying fluorescence resonance energy transfer (FRET) is one strategy that allows for thousands of potential drugs treatments to be explored.¹³ In addition to FRET, electrophoretic mobility shift assay (EMSA) is an excellent method to show that the designed drug successfully binds the correct sequence of DNA. EMSA can also be used to show that the drug is inhibiting the TF of interest from binding to its target DNA sequence. After confirming that the drug indeed binds with the TF, mutating key residues involved with this interaction is a method to obtain even more detail of the binding mechanism. Finally, one of the most appropriate ways to test these drugs' abilities against cancer is to compare the expression levels of the TF's target genes before and after administering the drug to see if there is any influence. If the levels of proliferation genes are dropping with the drug dose then one can conclude the treatment is working.

In today's society, the dominant forms of

cancer treatment are radiation and chemotherapy. Both of these treatments have extreme side effects. They can increase the chances of the patient developing a second type of cancer in the future by causing many mutations.²¹ The side effects of inhibiting cancerous TFs are not as harmful as radiation and chemotherapy side effects. However, it should be noted that not many human trials have been done with these drugs, so the effects are not completely known. In the future, more TF-DNA interactions should be targeted utilizing symmetrical molecules that have DNA interaction sites ~3.6 nm apart. This allows the molecule to avoid steric hindrance and bind to the major groove of DNA in attempts to block TF binding. The methods reviewed in this paper could outcompete the current forms of cancer treatment if the experiments associated with them continue to succeed as they have been.

Acknowledgements

The author would like to acknowledge his capstone professor, Dr. Osbourn for helping give structure and feedback for this review.

Competing Interests

The author declares no competing interests.

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How to Cite This Article:

Sanders T. D. (2022). Utilizing Pharmacology to Target Transcription Factors Involved with Cancer Onset and Development. *Mountaineer Undergraduate Research Review*, 6(2).

Acknowledgements

We at MURR are indebted to the countless researchers that have contributed to the extensive research community at West Virginia University. For this reason, we dedicate this volume to the undergraduate researchers at WVU who have made MURR a possibility and reality. We extend our gratitude to the Office of Undergraduate Research (UGR) for its continued support of MURR over the past 3 years since its re-establishment. We would like to thank our project director Kevin Walden for his hard work and dedication throughout the publication process. We also would like to thank Dr. Ken Blemings, Colleen Good, Dr. Eugen Nagy, and Dr. Dana Huebert-Lima from the Honors College and Honors EXCEL program for their support. Furthermore, we would like to thank our faculty reviewers for MURR Volume 6 Issue 2: Drs. Ashok Bidwai, Amber Brugnoli, Elizabeth Claydon, Yu Gu, Amy Hirshman, Guilherme Pereira, Rhonda Reymond, Michelle Richards-Babb, and Stephanie Young. Finally, MURR would not be possible without the students who have worked tirelessly to create this publication; we would like to extend our deepest gratitude to Editorial Review Board members, copy editors, typesetters, student authors, cover art contest participants, and our graduate advisor David Sokolov.

Sincerely,

The image shows five handwritten signatures in cursive script, arranged in two rows. The top row contains three signatures: 'Teagan Kuzniar', 'Wren King', and 'Ellena Gemmen'. The bottom row contains two signatures: 'Caitlyn Wilczek' and 'Daniel Esguerra'.

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