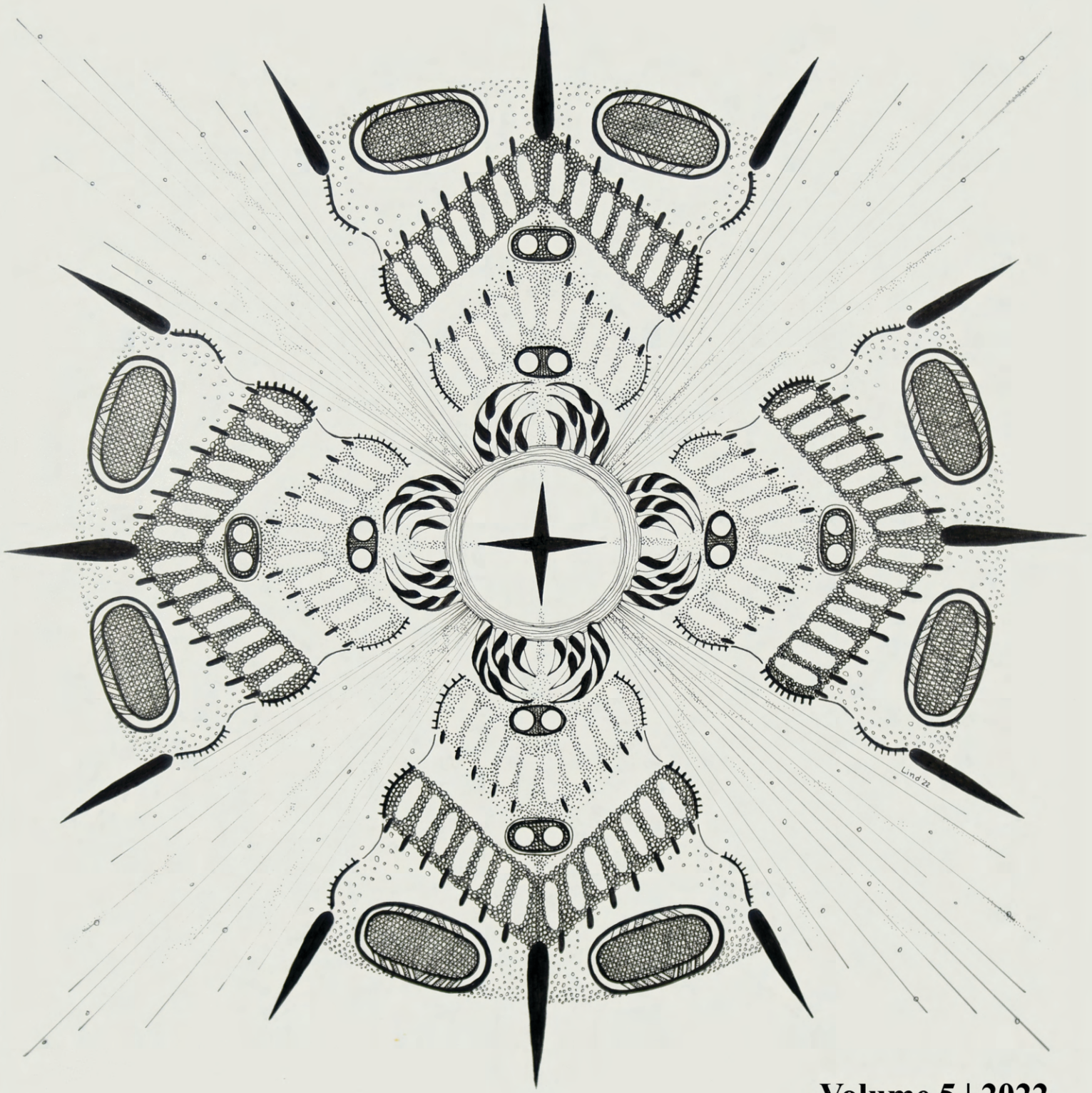
JRIP Journal of Research in Progress

at Howard Community College



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10901 Little Patuxent Parkway
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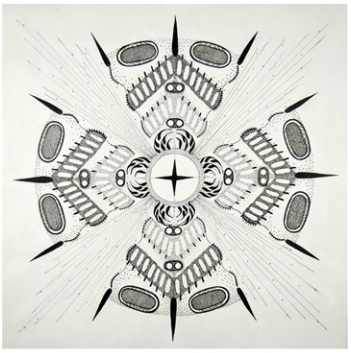
On the Cover: Lind Stevens has enjoyed making art since childhood, but it was not until retirement loomed, that she firmly committed herself to developing and exploring her potential as an artist. Fascinated by line, shape, and form, pattern has emerged as a strong exploration within her art.Since enrolling at HCC, several of her pieces have been included in the Student Invitational Exhibitions.



A Note from the Editorial Team...

This volume of Howard Community College's Journal of Research in Progress (JRIP) marks the fifth year that a group of dedicated student researchers and artists, mentors, faculty, staff, and all of their support systems has worked together to bring a volume of peer-reviewed articles and artwork to fruition. Launched in 2017, the idea of JRIP was first conceived by a Faculty Professional Learning Community (FPLC) that initially gathered to discuss undergraduate student research. Since then, 44 papers representing the work of 76 student researchers and their advisors have been published in JRIP alongside the artwork of 18 students. Even with an uncertain return to campus in the midst of a global pandemic, the emergence of COVID variants and resulting spikes in infection, and changes in campus and journal administration and personnel, the numbers of papers and represented researchers and artists in JRIP continued to grow this year to almost 50, 90, and 25, respectively. What was first imagined by STEM folks as a publication of STEM undergraduate research has since expanded to also include exceptional student work in the health professions, social sciences, arts, and humanities whose publication is overseen by an editorial team with representatives from an equally varied collection of academic disciplines and departments on campus. It is with great anticipation that we look forward to what the next five years will bring.

In gratitude and service,

The JRIP Editorial Team

Students interested in submitting articles for next year's volume of JRIP should contact the editorial team at JRIP@howardcc.edu.

An electronic copy of this journal is available at
https://pressbooks.howardcc.edu/jrip5

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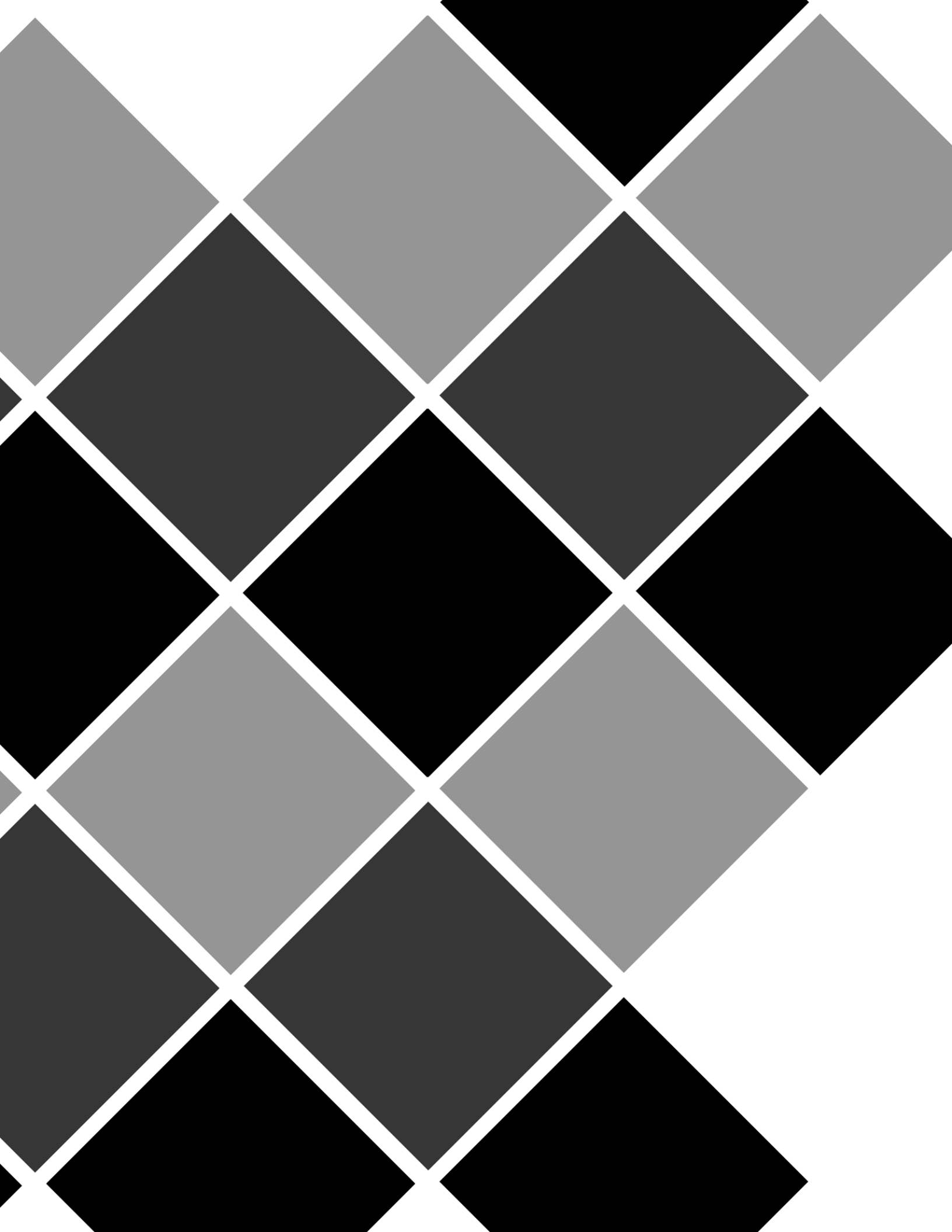
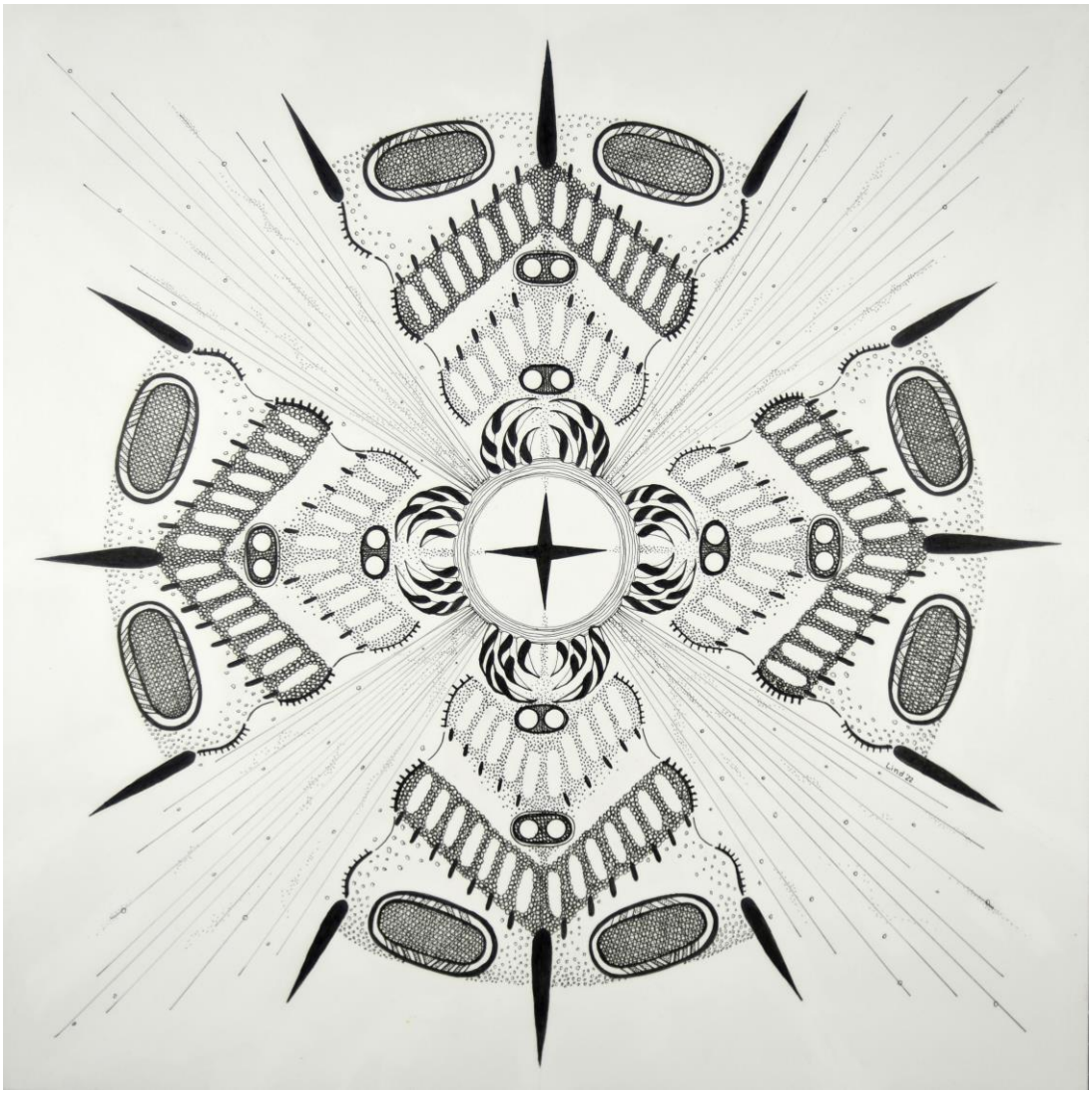
EDITORIAL TEAM





“Inspections of a Hornworm”

Lind Stevens

Pen and Ink on Bristol

I was drawn to this study due to the notable physical characteristics of the hornworm. I thought they would work well as design elements, based on the many images I saw online and from photos shared with me by the researcher. The circular composition ties into the circadian rhythm aspect of the study. The pattern consists of the hornworm's physical elements, in four sections. The adjacent sections feature carefully spaced lines that symbolize light and time, to further connect with circadian rhythm biology. My decision to draft this composition using pen & ink forced me to work carefully and diligently, just as the horn worm does as it feeds.

Mentored by: Thomas Engleman

Manduca sexta Larvae Exhibit Rhythms in Feeding Behavior and Rhythms in Gene Expression of the Circadian Gene period

Donovan Waters, *Howard Community College*
Mentored by: Ellena McCarthy, Ph.D. and Hannah Pie, Ph.D.

Abstract

*The tobacco hornworm (*Manduca sexta*) is considered an agricultural pest due to its predation on agriculturally significant Solanaceous plants, such as tomatoes and tobacco, making the behavioral and molecular mechanisms underlying its feeding behavior of great interest to agriculture. Circadian rhythms are daily biological rhythms endogenous to an organism that can be reset by environmental cues and have been shown to influence the behavioral output of organisms. The molecular basis for these approximately 24-hour rhythms is a transcriptional/translational feedback loop in individual cells, involving a gene called* period *(*per*). While circadian rhythms have been shown to be functional in the adult* Manduca sexta *and to affect behavior, the presence of a functional circadian clock has not yet been described in the larvae. In this study, we explored whether the tobacco hornworm exhibits rhythms in feeding behavior and whether the circadian gene* per *is rhythmically expressed. When we tested larvae at different times of day, we found that there were significant differences in the amount of leaf they consumed at different timepoints. In addition, when tissue samples were harvested at these same time points, the expression level of* per *also significantly differs at different times of the day. Our data is indicative of the tobacco hornworm exhibiting rhythmic feeding behavior and circadian gene expression, but further investigation will be necessary to determine if their feeding behavior is indeed modulated by circadian rhythms.*

Introduction

Mammals, fish, insects, various plants, and even some cyanobacteria [1]-[5] exhibit oscillations in their biological systems and behaviors over the period of a terrestrial day and night. The word circadian itself is Latin for about (*circa*) a day (*dies*) [6]. Genetic and molecular signal underpinnings for this cycling have been explored from many angles in numerous model organisms. There are genetic transcriptional and translational feedback loop (TTFL) mechanisms that account for much of this cyclicity [7], which includes various genes such as *period (per), timeless (tim),* and *cryptochrome (cry)* [8], [9]. The molecular clock then

affects metabolic physiology downstream [10]-[12], such as insulin production. The desynchronization of circadian rhythms has been shown to cause impairment of metabolic processes in several adult insects, including the standard model insect *Drosophila melanogaster* [13].

The rhythmic nature of an organisms' internally driven (endogenous) biological timing can be synchronized by external (exogenous) stimuli. This process is called entrainment. The most well understood of these entrainment influences are light, temperature, and metabolism of food, collectively referred to as zeitgebers, the German word for "time givers" [8], [9], [14]. It has been shown that observable feeding behavior will affect and be affected by an organism's daily biochemical oscillations [14] and similarly, conservation of circadian mechanisms over evolutionary time would synchronize between a pollinator or consumer and the plants upon which it feeds [15].

The tobacco hornworm (*Manduca sexta)* in its larval stage is known to be an agricultural pest and feeds primarily on Solanaceous plants such as tomato and potato [16]. Its oligophagy, specific food preference, for Solanaceous plants has been well described [17]. After *M. sexta* hatches from its egg, which is laid on a Solanaceous leaf, it rapidly develops through five instar larval stages in approximately two weeks. In the 5^{th} instar, *M. sexta* are entering their final larval growth phase and must eat voraciously to reach their threshold body weight before pupation [18], but the molecular drivers of their feeding behavior have not been well characterized. Other endogenous and exogenous factors that are synchronous with or after feeding behaviors remain to be discovered in detail, and effective management of a pest species requires an understanding of its physiology.

Robust circadian rhythms have been shown to control rhythmic physiology in the adult *M. sexta*, the hawkmoth. Hawkmoth express the *per* gene in their antennae, which are used to sense the presence of dietary phytochemicals (bioactive plant chemical) [19]. In addition, responsiveness to floral scent is modulated by the circadian clock in adult *M. sexta* [15], but the presence of a function circadian clock has not yet been described in the larvae. In previous research from our lab, *per* gene expression has been found in the midgut of 5^{th} instar *M. sexta* [20], but it is not yet known if this expression is rhythmic. It has also been unclear whether the feeding behavior of 5^{th} instar larvae is continuous or rhythmic, and if its feeding is rhythmic, is it then related to the whether its rhythmic feeding is controlled by circadian oscillation.

Our study seeks to investigate whether *M. sexta* larvae exhibit rhythmicity in feeding behavior and whether they have a functional circadian clock. Therefore, our team performed an experiment to observe feeding behavior on tomato leaves to observe whether leaf consumption varied by time of day. We also assessed the *per* expression levels by quantitative polymerase chain reaction (qPCR) at the same behavioral timepoints to see if *per* levels fluctuated at different times of the day.

Methods

Caterpillar husbandry

Tomato plants were grown in the HCC greenhouse for caterpillar feeding. After the Spring 2021 cohort, tomato plants were given fertilizer to improve nutritional value and tomato plant usage was rotated after each harvesting to prevent plant stress reactions from affecting nutritional value of leaves.

Manduca sexta eggs were sourced from Carolina Biological Supplies. Rearing began with placing clusters of eggs on petri dishes with lids in a controlled environment at 22-24ºC. Daily checks for larvae health and instar (periods between molts) progress were conducted. Instar progress was determined by a combination of physical features and the presence of head capsule shedding. New leaves were provided daily following the removal of fecal matter and old food. Rearing methods continued until larvae reached 5th instar pre-molt. The Fall 2021 cohort was reared entirely in a 16:8 LD (light/dark) cycle, while the Spring 2021 cohort was placed in a 16:8 LD when molted to 4th instar.

Behavioral feeding paradigm

Cohorts were tested for feeding behavior at different zeitgeber times (ZT): ZT 1 & 13 (Spring 2021) and ZT 3 & 15 (Fall 2021). ZT 0 is the beginning of the light period of the cycle. Time points were chosen 12 hours apart with the first time point being close to the start of the light portion of the cycle (ZT 1 & 3) and the second being close to the end of the light portion of the cycle (ZT 13 & 15). A two-hour shift between Spring and Fall time points allowed for better definition of the rhythmicity of *per* expression levels. Shortly before cohort ZT designations, the larvae were removed from petri dishes to be weighed as well as new leaves provided for feeding. Larvae were left to feed for one hour. After one hour, the larvae and leaf were each weighed again, and mass changes were calculated.

Tissue harvesting

Following the end of behavioral testing, larvae were placed in ice baths for approximately 15 minutes for anesthetization. Dissections began after anesthetization was complete. The dissection kits used were sterilized with 95% ethanol and cleaned with RNase-free wipes to prevent RNase or nucleic acid contamination of tissue samples harvested from the larvae. Incisions were made starting behind the first pair of legs down to the midsection for removal of a portion of the midgut. Midgut samples were suspended in RNAlater (Thermofisher) to maintain stability of mRNA. Samples were kept in RNAlater at 4ºC overnight, after which they were stored at -80ºC.

RNA extraction and cDNA synthesis

Molecular analysis of samples began with the extraction and purification of mRNA from midgut samples as outlined in RNeasy Mini Kit [1] manual (Protocol: Purification of Total RNA from Animal Cells Using Spin Technology, page 27). Deviation from protocol occurred during the centrifugation of collection tubes by removing genomic DNA (gDNA) with an eliminator

column. Additionally, all steps in the protocol that called for 15 seconds of centrifugation was increased to 30 seconds due to instrument limitations and 39.2 mM dithiothreitol (DTT) was added to the RLT buffer to improve lysing. Sample RNA purity was verified using a Nanodrop with A260/280 and A260/230 ratios. The 230, 260, and 280 represent the wavelengths of light (nm) at which absorbance was measured. To ensure that the nucleic acid extracted was RNA and not DNA a A260/280 ratio of ~2.0 is required [2]. To ensure that there isn't protein or other reagent contamination a A260/230 ratio in the range of 2.0-2.2 is recommended [2]. These parameters help ensure that the product isolated is pure RNA and is free of protein and other contaminants.

The extracted mRNA was converted into single-stranded complementary DNA (cDNA). The cDNA synthesis protocol was used as outlined in the RevertAid First Strand cDNA Synthesis Kit (Thermo Scientific) [3]. From the kit, the provided *Gapdh* RNA was used as a positive control for efficacy of the cDNA synthesis and the oligo $(dT)_{18}$ primers were used for the synthesis reaction. The cDNA synthesized in this protocol was used as a template for quantitative polymerase chain reaction (see next section).

Quantitative polymerase chain reaction (qPCR)

Our qPCR was conducted on cDNA samples from the Spring caterpillar cohort as outlined in [13] using the SsoAdvanced Universal SYBR Green Supermix kit (Bio-Rad). qPCR was used for the relative measurement of gene expression levels of *actin* and *per*. The *actin* cDNA was used as the reference gene, as it is constitutively expressed in the tissues examined [4]. The *gapdh* cDNA is used as a positive control in qPCR as well due to its early amplification as an indicator of successful replication of cDNA in the previous step. Primers for *gapdh* were provided by the RevertAid First Strand cDNA Synthesis Kit (Thermo Scientific). Primers for *actin* and *per* were designed and tested by previous URSC research students [13], [21]. Reactions containing no cDNA template, no template control (NTC), were performed for quality control. All *per* and *actin* reactions were performed in triplicate. Product specificity and product size was confirmed with both sets of primers.

Cycle threshold (CT) is the number of thermal cycles of amplification that it takes for the fluorescence signal of SYBR green bound to cDNA to cross the threshold. As cDNA is amplified, the fluorescence signal increases until all of the nucleotides are utilized in the test tube. The threshold is set at an arbitrary value within the linear amplification of fluorescence signal to allow for consistent comparison between samples. In order to examine gene expression changes in *per,* we compared its amplification to *actin*'s amplification by calculating the difference in CT value between them, delta (**Δ**) CT. To find **Δ**CT for a sample, we subtracted the *actin* CT from the *per* CT. A higher **Δ**CT signifies lower gene expression, whereas a lower **Δ**CT signifies higher gene expression.

Statistical analysis

Results from Spring 2021 and Fall 2021 cohorts' leaf consumption data were analyzed using R software (R Project Core Team). Testing for normality was completed first by using a Shapiro-Wilk normality test. Homogeneity of variance was then examined by using both Bartlett's test and Fligner-Killeen's test. The Spring 2021 cohort's qPCR results were analyzed

through the comparison of **Δ**CT values between time points ZT 1 & 13 for significant difference in expression levels using Welch Two Sample T-test. Significant differences in leaf consumption for both cohorts were also determined using the Welch Two Sample T-test. A p-value of less than 0.05 was considered significant.

Results

Behavioral feeding test results

Feeding behavior was examined for a 1-hour period and the change of leaf mass over that period was calculated for both the Spring and Fall cohorts of 5th instar caterpillars. Mean leaf mass changes and standard error of the mean for the Spring cohorts were measured at -0.054 ± 0.021 g for ZT 1 and -0.079 ± 0.012 g for ZT 13 (Figure 1). Fall cohort mean leaf mass changes and standard error of the mean were measured at -0.205 g ± 0.012 for ZT 3 and -0.133 ± 0.015 g for ZT 15 (Figure 2). Caterpillars tested at ZT 1 exhibited significantly less leaf consumption than caterpillars at ZT13 ($p < 0.05$). Caterpillars tested at ZT 15 exhibited significantly less leaf consumption than caterpillars at ZT 3 ($p < 0.05$). Furthermore, when all the time points tested are considered, our data show that the caterpillars consumed more of the leaf in the time points closer to the middle of the light period (ZT 3 and ZT13) in relation to their counterpart time point closer to the light/dark transition (ZT 1 and ZT 15).

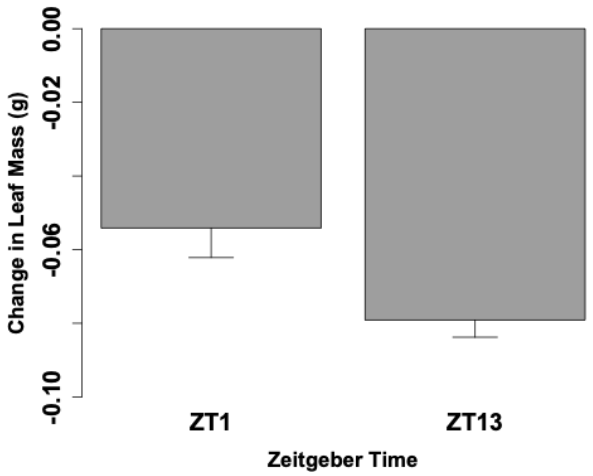


Figure 1: *Mean change in leaf mass for Spring 2021 time points ZT 1 and ZT 13. Standard error of mean indicated in error bars. Negative values indicate a reduction in leaf mass due to feeding. N=7 for each time point.*

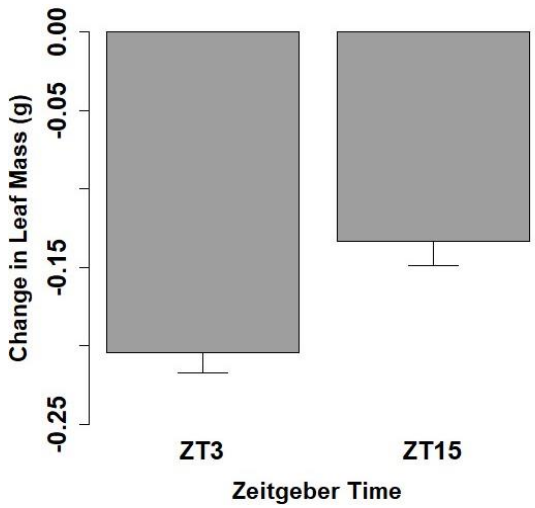


Figure 2: *Mean change in leaf mass for Fall 2021 time points ZT 3 and ZT 15. Standard error of mean indicated in error bars. Negative values indicate a reduction in leaf mass due to feeding. N=18 for ZT 3 and N=15 for ZT 15.*

Analysis of qPCR results

In order to investigate *per* expression at different timepoints, qPCR analyses were conducted for midgut samples of the Spring cohort. Due to the number of samples and replicates needed, two separate qPCR analyses were performed. All the samples for a given time point (ZT 1 or ZT 13) were analyzed at the same time. The SYBR green fluorescence amplification graphs for both are shown in Figures 3 and 4. Early amplification of *gapdh* cDNA was seen as expected due to high concentration of starting mRNA, followed by *actin* (reference gene), and then *per* (Figures 3 & 4). The NTC replicates for both analyses did not have appreciable amplification as expected. The melting curves (not shown) further verified that only a single qPCR product was produced for each gene analyzed at the expected melting temperature. A threshold relative fluorescence units (RFU) level of 3 x 10^3 was set on both graphs for consistency as it was in the linear range of amplification for all samples analyzed.

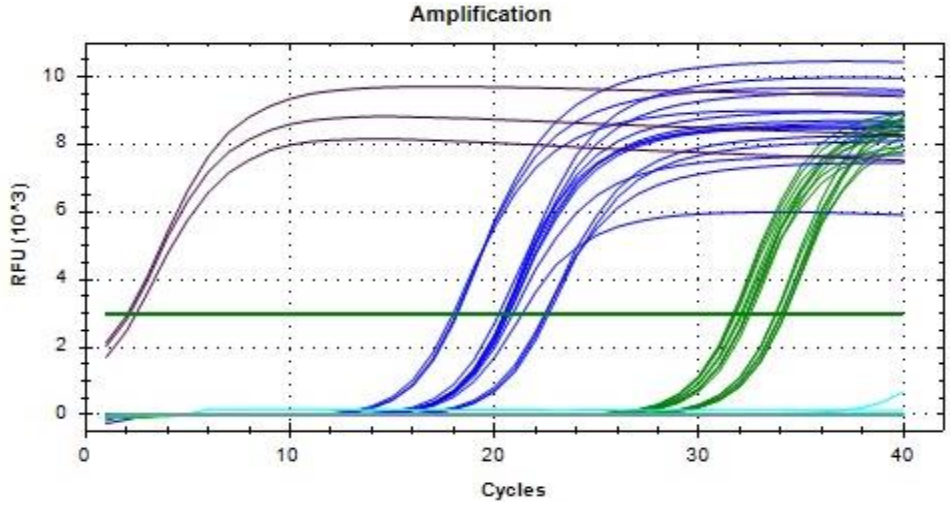


Figure 3: *qPCR results for gapdh (purple, left most grouping), actin (dark blue, middle grouping), and per (green, right most grouping) expression in ZT 1 caterpillar midgut samples. The no template controls are in light blue (mostly flat line alone 0 RFU). The horizontal green line at* $3x10^3$ *RFU represents the threshold for calculating CT.*

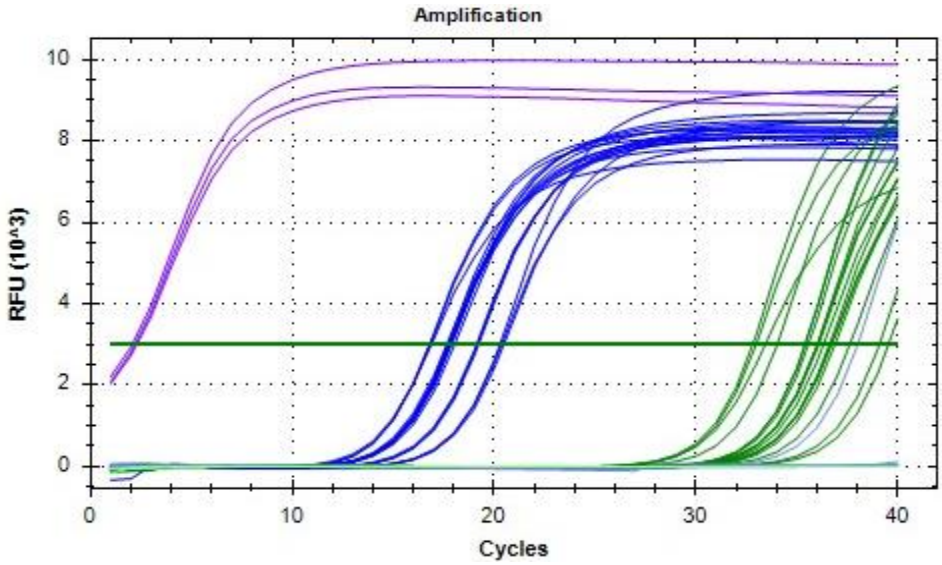


Figure 4: qPCR results for gapdh (purple, left most grouping), actin (dark blue, middle grouping), and per (green, right most grouping) expression in ZT 13 caterpillar midgut samples. The no template controls are in light blue (mostly flat line alone 0 RFU). The horizontal green line at $3x10^3$ RFU represents the threshold for calculating CT.

For each 5th instar caterpillar midgut sample, the mean CT value for *per* and mean CT value for *actin* were calculated from the three replicates. The overall mean **Δ**CT and standard error of the mean for all the caterpillars tested at each time point (ZT 1 and ZT 13) were then calculated. The mean **Δ**CT for Spring midgut samples was 17.70 ± 0.86 for ZT 13 and 12.34 ± 1.09 for ZT 1, respectively (Figure 5). Lower **Δ**CT values indicate higher gene expression of *per* in tissues. The expression level of *per* at ZT 1 was significantly higher than the expression level of *per* at ZT 13 ($p < 0.05$). This demonstrates that *per* expression levels differ at different times of day, indicative of rhythmicity.

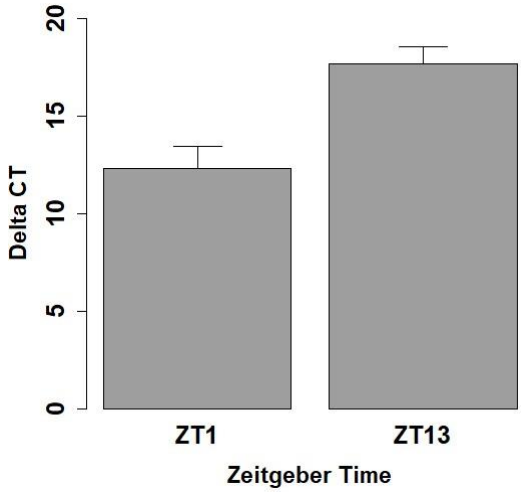


Figure 5: *Bar graph displaying mean ΔCT values for ZT 1 and ZT 13 caterpillar midgut samples. Standard error of mean indicated in error bars. Lower delta CT values indicate higher gene expression levels.*

Discussion

Through the experiments conducted in this paper, we sought to determine the presence of rhythmic feeding behavior and gene expression in the 5th instar *Manduca sexta* larvae. To find evidence of a functioning circadian clock, *per* expression and feeding behavior were quantified over different time points throughout the light period. Previous research in the adult hawkmoth has shown evidence that circadian rhythms influence pollination behavior [15]. As *Manduca sexta* larvae are known as pests for Solanaceous plants, establishing whether circadian rhythms are functional and influencing behavior in the larval stages of this organism may provide assistance in the management of it.

The larval stages of Lepidopteran species seek to consume maximal amounts of food in preparation of pupating. Our analysis of feeding behavior at time points ZT 1, 3, 13, and 15 show significantly more feeding occurring during the time points closer to the middle part of the day for each cohort compared to the counterpart time points closer to the light/dark transition. This is surprising since the adult hawkmoth is known for being nocturnal with feeding, flight, and pollination behavior reduced in light conditions [15]. While our experiment does not preclude nighttime feeding activity, the larval feeding behavior quantified in this experiment shows significant day time feeding in the larvae. In addition, our data is the first to suggest that the larval feeding behavior or *Manduca sexta* is rhythmic, although rhythmic feeding behavior has been described in the midgut of another caterpillar species: the cotton leafworm caterpillar, *Spodoptera littoralis* [22].

Another focus of our study was to determine whether the larvae of *Manduca sexta* have a functional circadian clock exhibit rhythmic circadian gene expression like the adult. The midgut samples from ZT 1 and ZT 13 cohorts show significant changes in *per* expression at different hours of the day, but to establish a profile of rhythmicity more time points would need to be examined. In addition, these data are consistent with circadian rhythms being present in the larvae. However, persistence of these rhythms in constant darkness would need to be established before calling the rhythms circadian.

Results for feeding and *per* gene expression both point towards a functioning circadian clock within the 5th instar *Manduca sexta* larvae. However, there were limitations in the scope of the data collected. The molecular evidence for circadian rhythms in this species may be furthered examined through the processing of the ZT 3 and 15 gut samples in order to increase our sample size and expand our time points. Due to the time constraints of the project those samples have yet to be analyzed. The relative expression of *per* to *actin* during those hours may help to establish a better image of trends in expression and possible correlations between *per* expression and feeding behavior. Furthermore, behavioral testing at additional time points is needed to verify the robustness of our findings of rhythmicity in feeding. To expand on the results of this research, it should be further investigated as to whether the behavioral phenomenon we are seeing is a direct effect of light or indeed modulated by circadian rhythms. It is possible that the presence or absence of light may directly inhibit consumption of leaf matter. Duplication of the experiment in constant darkness may be used to determine if rhythmic feeding is controlled by the circadian clock or a direct effect of light.

Acknowledgements

In writing this paper it is important to first acknowledge the mentors through whom it was possible to complete. This project would not be possible without the guidance of Dr. Ellena McCarthy and Dr. Hannah Pie. The knowledge shared by them was invaluable. Thank you to Keighley Hayes, Zawn Nyaui, and Susan White for their help in initiating the writing of this paper as lab partners. An additional thank you is owed to Tylen Darling and Caitlyn Beckjord for providing healthy plants with which the caterpillars received nourishment.

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Asteroid Tracking with a Small Telescope

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Mentored by: Brendan Diamond, Ph.D.

Abstract

Asteroid observation is vital for the future of space research. Tracking asteroids and determining their positions is key to preventing possible asteroid impacts with Earth and can also lead to future missions dedicated to researching their composition. Since asteroids have not been sampled due to their fast, ellipsoidal trajectories, having accurate position data can decrease the risk of spacecraft missing their asteroid targets. This, in turn, can help researchers discover new information about our solar system and universe. During fall 2021, our team initiated asteroid observation at HCC by performing observations for asteroid astrometry. To make these observations, the team used data from the Minor Planet Center (MPC), which is the primary data site for all astrometry (position) data for comets, asteroids, and other minor planets.

The team hopes to establish an observation program for asteroid tracking at HCC. This would allow HCC to report astrometric observations of minor planets, comets, or irregular natural satellites, all of which would contribute to global knowledge of position data and be stored in the MPC. Contributing to the MPC requires an official observatory code from them, so this became the short-term goal. To accomplish this short-term goal, as many other colleges have done [1], we demonstrated the ability to gather position data on at least eight asteroids from magnitude 14 to 18 by tracking their trajectories using a research telescope. Then, we compared the predicted trajectories of the studied asteroids with the team's data on those same asteroids. If prediction and observations agreed within 2 arcseconds as stipulated by the MPC, HCC would receive an official observatory code from the MPC and be able to submit observations for less well-known orbits.

In this paper, by method of telescope observation and plate solving, we successfully tracked our target asteroids and obtained position data on these asteroids with an error margin of 1.40 arcseconds. This puts HCC on track to receive an official observation code in the coming months. However, our newly established process is not without its flaws, with the error in Declination (latitude) being double that of the error in Right Ascension (longitude) for a currently unknown reason and with inconsistent measurements in magnitude.

Introduction

Asteroids have been extremely important to astronomers ever since we could look up at the sky and identify "falling stars". Today, though, they are of even more critical importance due to the numerous satellites orbiting Earth that are used daily for almost all basic needs. Asteroids, if not tracked, could crash into Earth or the satellites around Earth without warning, causing loss of communication at minimum and possibly loss of life at worst, as seen with the Chelyabinsk meteor in 2013.

Observing asteroids allows scientists to determine their orbits, thus allowing scientists to analyze if, when, and where asteroids could impact humanity. These asteroid observations are also pertinent due to the possibility of discovering new objects in our universe and confirming objects already discovered. Asteroids are made from the same substances as the planet, hence by studying asteroids, not only can we better understand our solar system and the origin of life on the planet, but we could also discover beneficial resources buried in the asteroids and mine them for resources. While most of these benefits look to the future, a current benefit of tracking asteroids is for the people who track them. Tracking asteroids benefits the individuals studying them: determining the position of an asteroid, requires knowledge, skills, and abilities in using a telescope and sky imaging software.

The Minor Planet Center (MPC) is a leading authority in the discovery and confirmation of asteroids, which are scientifically known as minor planets. The MPC stores position data gathered by observers from all over the world and computes the orbits of small solar system bodies using the gathered data [2]. The MPC then updates its computations based on new observations. Amateur astronomers play a critical role in the MPC. The International Astronomical Union, which founded and oversees the MPC [3], is an astronomer group. Ten major amateur astronomer groups, including college groups, that submit to the MPC have helped discover 1194821 (and counting) minor planets [2]. We plan to contribute to this international database of asteroid orbital information by using resources from the MPC to utilize HCC's telescope to observe and track asteroids.

The team plans to establish an observation program for asteroid tracking at HCC. Since contributing to the MPC requires an official observatory code from them, our short-term goal is to obtain this code. To do this, organizations needed to demonstrate the ability to gather position data on at least eight asteroids from magnitude 14 to 18. The team will obtain and compare the MPC's predicted trajectories of the eight or more asteroids with the acquired data on those same asteroids. If prediction and observations agree within 2 arcseconds, HCC will receive an official observatory code from the MPC and be able to submit observations for less well-known orbits.

Methods

The research consists of collecting images, analyzing the images, and submitting the results to the Minor Planet Center. Our research requires establishing a process at HCC for each of these steps. Throughout the course of our research and planning, we utilized a few specialized pieces of equipment that were used in prior exoplanet photometry research on campus [4]. The set of equipment used is comprised of a 14" PlaneWave telescope, an AstroPhysics 1100GTO

equatorial mount and an SBIG STXL-6303E camera (Figure 1). The equatorial mount shown has a motor aligned with rotation axis of the earth to counteract the earth's rotation making it possible for the telescope to precisely follow the star [4]. MaximDL was used to capture the images remotely, and the image processing and data analysis was carried out using AstroImageJ. The assembled unit is covered with a protective outdoor cover when not in use.

Figure 1: *14" PlaneWave telescope, AstroPhysics 1100GTO equatorial mount, and SBIG STXL-6303E camera [4]*

We used a research telescope located on the roof of the SET building to get astronomical images of the sky, and the location and positioning of our target asteroids. Observation occurred over the time span of several hours on multiple days.

To ensure a high signal-to-noise ratio, the targets were observed on clear nights. The images were taken using the camera attached to the telescope which we controlled virtually using Zoom. After this, the telescoping imaging software, AstroImageJ was employed in the alignment and plate-solving of these images, after which position data was acquired from these images such that meaningful information could be gathered and interpreted in terms of right ascension (RA) and declination (Dec). RA and Dec measures the east-west and north-south positions of the stars

respectively on the celestial sphere. They are the sky coordinates that correspond to the earth coordinates known as longitude and latitude.

Target Selection

An asteroid catalog on asteroid.lowell.edu was utilized in determining the desired targets. This website allows for the filtering of target asteroids based on magnitude, type, and size. Magnitude refers to the brightness of an asteroid, while type refers to where an asteroid is located in the solar system.

These targets are determined based on the requirements and specifications of the Minor Planet Center (MPC). As such, one of the targets was a near earth asteroid (NEA), the other targets were in the asteroid belt, with the desired magnitude range being between 14-18.

Observation

Images were collected using the 14" Planewave telescope at HCC on clear nights for asteroids in the desired magnitude range and region of the sky. Observations for an individual asteroid were completed multiple times in the same night, at least 30 minutes apart. The software MaximDL was used for image collection and telescope guiding. The website asteroid.lowell.edu provides asteroid predictions from the Minor Planet Center.

It can be verified that the four objects observed are in fact asteroids and not just white spots caused by cosmic rays, as those would be significantly smaller than our asteroids, since they are just a few pixels in size. Additionally, our studied asteroids appeared to follow the same motion as the predicted trajectories from online databases.

During observation, a series of calibration images were obtained after the science images were completed but were not applied as they were not required for positional information, but may be used for magnitude calculations.

Data Reduction

Data Reduction involves the processing of each asteroid image to obtain meaningful information from them. This includes the position, magnitude and the coordinates of the asteroids observed.

After all the necessary images are taken during observation using the telescope and the camera, data analysis and reduction were performed using the imaging software, AstroImageJ.

The process involves aligning the science images such that the target stars in each image are in the same position and coordinate system to account for any imprecise tracking. Aligning of the images allows for better visualization of the path of the asteroid. The next step is to plate solve, which is a process which involves finding the precise coordinates of the center of the science image based on the location of the pattern of stars [5]. When plate solving, we were prompted to select the target star, as well as comparison stars. For this, we arbitrarily selected

surrounding stars of the same visibility as the target star. The selected stars are circled red and the option to constrain the search to a particular coordinate in the sky is available. This option was used because it allows for a smaller search region, hence, saving more time.

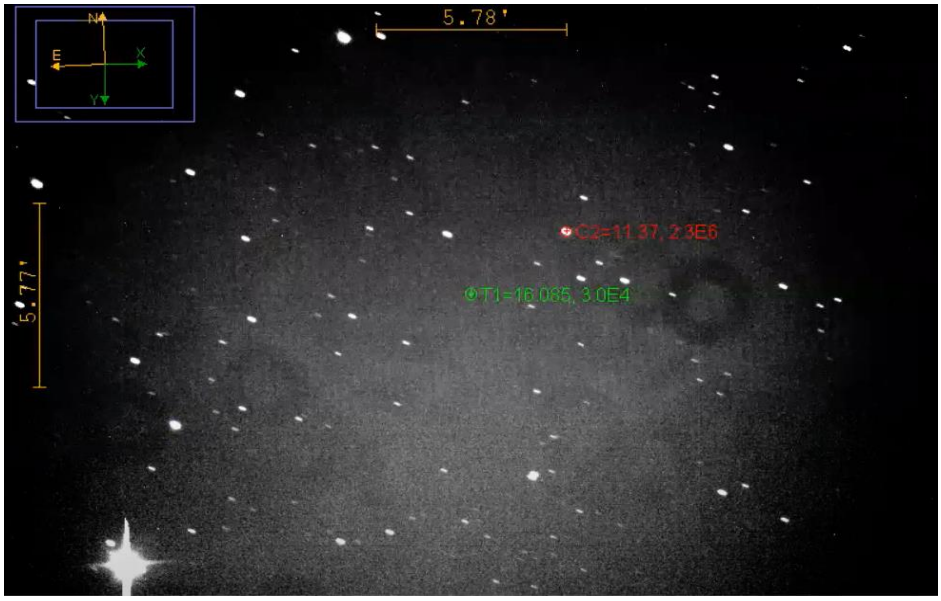

Figure 2: *A plate solved image of Asteroid 7341 taken using the PlaneWave 14" telescope and loaded into the AstroImageJ software which displays our target star (green circle). North is up, and East is to the left in the image. The T1 circle (green) shows our target star. The C2 circle (red) shows the comparison star. The vignette effect and large dark circles are telescope artifacts that can be removed with calibration adjustment.*

Lastly, a measurement log is generated which contains the specific RA and Dec of the stars, as seen in Figure 3.

	Label	Slice	RA1 (hrs)	DEC1 (deg)	X1(IJ)	Y1(IJ)	X1(FITS)	Y1(FITS)	PixValue	Source_1	NAperPixels_1	Peak_1	Mean_1	Source_Err_1	Source_SNR_1	Sky/Pix_1	NBackPixels_1	JD_UTC	FWHM_1	Width_1
1	6200 H---0001lig	1	1.172282	-6.538248	1381.170311	662.932834	1381.670311	1384.567166	6591	69855.90528	1963.495408	6591	35.57732	3474.739693	20.103925	4451.459213	5259	2459489.818	4.813033	15.965358
2	6200 H---0002lig	2	1.172239	-6.538256	1384.171982	662.264657	1384.671982	1385.235343	6793	64297.58017	1963.495408	6886	32.746489	3488.038566	18.433735	4482.739546	5237	2459489.82	4.39386	8.431302
3	6200 H---0003lig	3	1.172203	-6.538293	1386.946758	660.694816	1387.446758	1386.805184	6445	63297.57572	1963.495408	6593	32.237191	3483.649991	18.169901	4511.114418	5410	2459489.822	4.899786	8.413105
4	6200 H---0001ligl	4	1.174354	-6.538842	1404.526211	1073.500021	1405.026211	973.999979	6330	65186.81335	1963.495408	6330	33.199371	3324.306327	19.609148	4100.178797	5386	2459489.702	4.876655	8.028548
5	6200 H---0002ligl	5	1.174308	-6.538902	1401.474277	1074.152603	1401.974277	973.347397	6422	68684.94882	1963.495408	6422	34.980957	3313.762702	20.727178	4077.985033	5412	2459489.705	4.586536	10.774232
6	6200 H---0003ligl	6	1.174267	-6.538876	1398.412271	1074.584684	1398.912271	972.915316	6304	62452.75991	1963.495408	6304	31.806929	3308.595206	18.875914	4076.47462	5457	2459489.707	4.790307	3.957431
7	6200 H---0004ligl	7	1.174225	-6.5387	1394.958883	1075.020369	1395.458883	972.479631	6260	62421.11755	1963.495408	6260	31.790814	3307.493518	18.872635	4038.559909	5263	2459489.709	4.921899	7.279461
8	6200 H---0005ligl	8	1.174182	-6.538741	1391.813522	1075.513086	1392.313522	971.986914	6240	62148.19746	1963.495408	6240	31.651817	3295.625426	18.857786	4032.445515	5396	2459489.712	4.741208	4.931749
9	6200 H---0006ligl	9	1.17276	-6.538285	1384.794253	653.521313	1385.294253	1393.978687	6394	73130.34921	1963.495408	6443	37.244981	3404.861643	21.478215	4229.342733	5071	2459489.791	4.581767	15.604963
10	6200 H---0007ligl	10	1.172721	-6.538306	1387.848251	653.180474	1388.348251	1394.319526	6729	75060.35129	1963.495408	6729	38.227923	3411.807859	22.00017	4252.768235	5100	2459489.793	4.464398	16.513077
11	6200 H---0008ligl	11	1.172676	-6.538267	1390.890265	652.643799	1391.390265	1394.856201	6677	73652.71163	1963.495408	6677	37.511018	3418.178155	21.547359	4281.067948	5151	2459489.795	4.540742	16.15736

Figure 3: *A measurement log for the asteroid 6200. Generated using AstroImageJ.*

Submission

Submitting the results to the Minor Planet Center requires a minimum data submission in a plain-text format [6]. It was required to have observed at least six numbered minor planets each on pairs of nearby nights as well as one numbered Near-Earth object observed on two distinct nights. It was also advised not to observe very low numbered objects or very bright objects, for this reason, all our studied asteroids were of magnitude 14-18. For new observing sites, the Minor Planet Center requires the astrometric accuracy of the observations to be within 2 arcseconds from the predicted ephemeris before designating an official observatory code for HCC. While arcseconds may sound like measurements of time, they are measurements of angle. It is formally known as a unit of angular measure equal to 1/60 of an arcminute and 1/3600 of a

degree. Submission of this project will allow for future astrometric contributions to the Minor Planet Center.

Results

The team analyzed four asteroids using the data reduction methods listed previously and constructed a spreadsheet from the generate measurement logs to analyze the data [7]. Note that "Target" means what we calculated and "Predicted" is what we would consider the actual value – it is the value given by the MPC.

We used the mid-exposure time of our images to search for the actual coordinates of the asteroids through asteroid.lowell.edu and used the coordinates nearest in time for our spreadsheet [7]. Conversion from hours:minutes:seconds form and degrees:minutes:seconds form for RA and Dec, respectively, to hour decimal form was required for the coordinates received from asteroid.lowell.edu. This was to calculate the Δ arcseconds of RA and the Δ arcseconds of Dec. The respective conversion equations are below.

$$Predicted\ RA\ converted\ to\ decimal\ form = \left(hours + \frac{minutes}{60} + \frac{seconds}{3600}\right) \quad (1)$$

where *hours*, *minutes,* and *seconds,* represent the numbers in the corresponding sections in the hours:minutes:seconds form for RA.

$$Predicted\ Dec\ converted\ to\ decimal\ form = \left(degrees + \frac{minutes}{60} + \frac{seconds}{3600}\right) \quad (2)$$

where *degrees*, *minutes,* and *seconds,* represent the numbers in the corresponding sections in the degrees:minutes:seconds form for Dec.

To find the average total Δ arcseconds for each image, we used the equation below.

$$\Delta arcseconds = \sqrt{\left(3600 \cdot R + cos(d)\right)^2 + (3600 \cdot D)^2} \quad (3)$$

where in the above equation *R* stands for Δ arcseconds of RA, *D* stands for Δ arcseconds of Dec, and *d* stands for the predicted Dec converted into radians [8].

In the following graphs, the Δ arcseconds, as well as the Δ arcseconds of RA and the Δ arcseconds of Dec are visualized according the asteroid they were taken from.

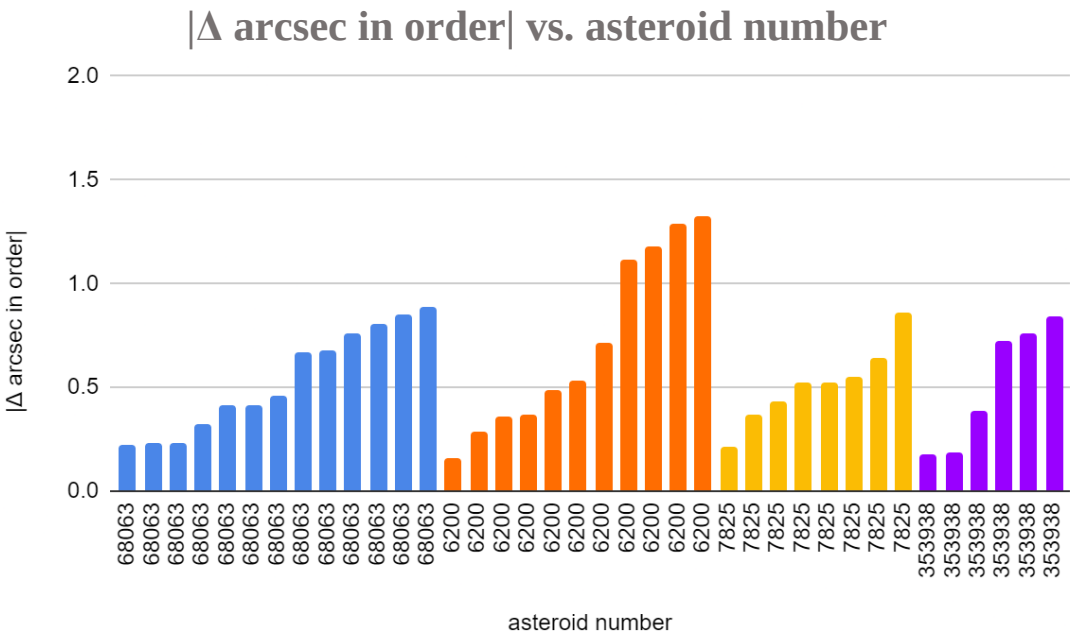

Figure 4: *The difference in arcseconds between predicted and observed ("target") position for all observations of four asteroids (ordered by size of error).*

The average Δ arcseconds for each image are graphed and grouped according to their respective asteroid (Figure 4). Within each asteroid's section on the graph, the Δ arcseconds are ordered by the magnitude of the error. Since the values fall below the MPC guidelines of 2.0 arcseconds or less error, this chart affirms that HCC can accurately track and predict asteroids' positions.

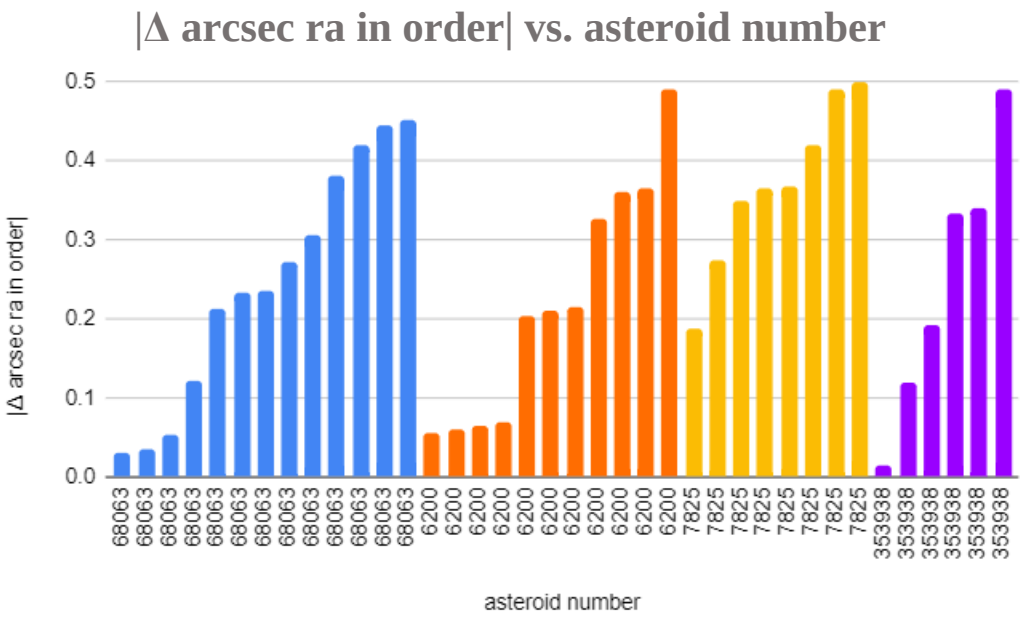

Figure 5: *The difference in arcseconds between predicted ra and observed ("target") ra for all observations of four asteroids (ordered by size of error).*

The average Δ arcseconds for ra for each image are graphed and grouped according to their respective asteroid (Figure 5). In each asteroid's section, the Δ arcseconds for ra are ordered by the magnitude of error. Well within the MPC guidelines of 2.0 arcseconds or less error, this chart affirms that HCC can accurately track and predict asteroids' ra.

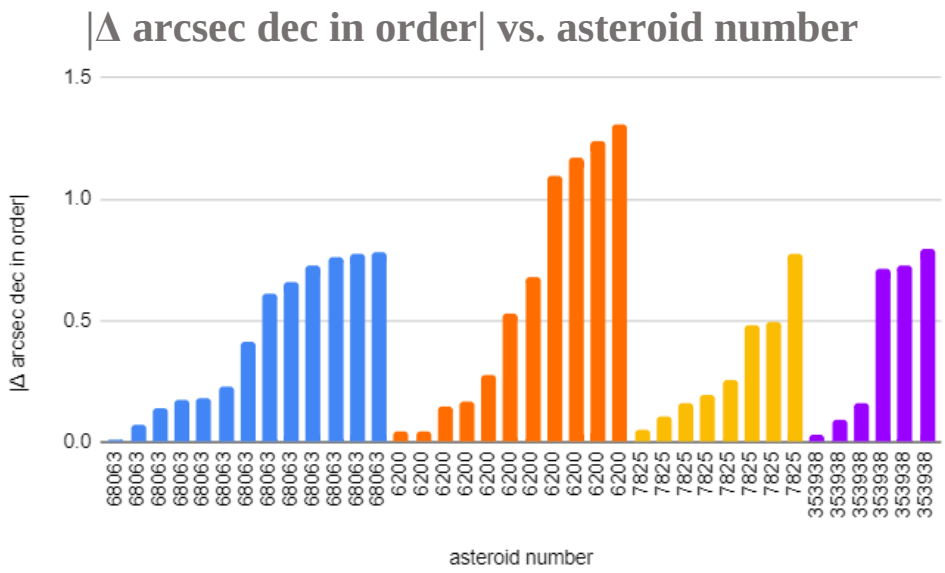

Figure 6: *The difference in arcseconds between predicted dec and observed ("target") dec for all observations of four asteroids (Ordered by size of error).*

The average Δ arcseconds for dec for each image are graphed and grouped according to their respective asteroid (Figure 6). In each asteroid's section, the Δ arcseconds for dec are ordered by the magnitude of error. Well within the MPC guidelines of 2.0 arcseconds or less error, this chart affirms that HCC can accurately track and predict asteroids' dec. Note that the error with respect to dec is, at its max, 2.6 times greater than the error with respect to ra.

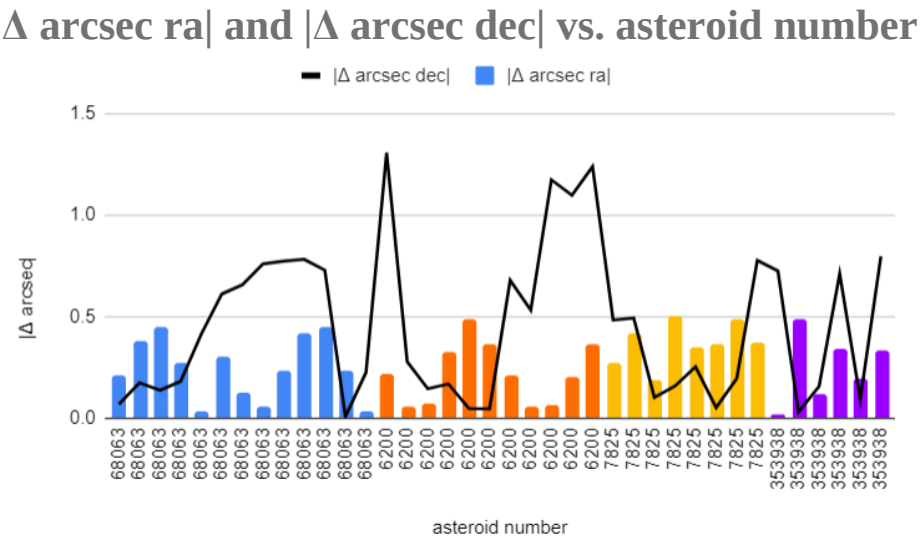

Figure 7: *An overlay of the data from Figure 5 and Figure 6 (Ordered by time in each asteroid group). The bars represent the difference between predicted and observed ("target") ra. The line represents the difference between predicted and observed ("target") dec.*

The average Δ arcseconds for ra for each image are graphed and grouped according to their respective asteroid (Figure 7). The average Δ arcseconds for dec for each image are also graphed and grouped according to their respective asteroid. Well within the MPC guidelines of 2.0 arcseconds or less error, this chart affirms that HCC can accurately track and predict asteroids' ra and dec. No direct corellation between error in ra and error in dec is apparent from this graph.

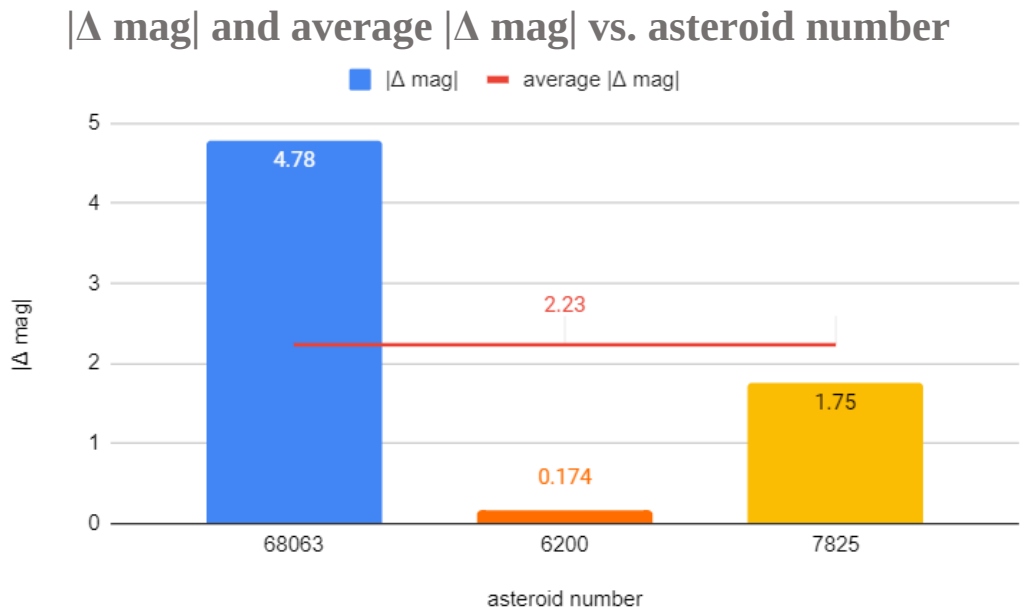

Figure 8: *A graphical representation of the error in magnitude for three asteroids. The average error (2.23) is plotted as a horizontal line. While MPC doesn't require magnitude error to be below a certain amount [9], our varying data means we cannot accurately measure and predict an asteroid's magnitude.*

The error of each of our asteroids' magnitude measurements are graphed using the formula for Δ arcseconds, with the line between the three representing the average error of our magnitude measurements (Figure 8). While MPC doesn't require magnitude error to be below a certain amount in order to receive an observatory code [9], our varying data means we cannot accurately measure and predict an asteroid's magnitude.

The team is confident that the four objects shown in this paper are asteroids and not just white spots on our images that are caused by cosmic rays. This is for two primary reasons. First, the white spots caused by cosmic rays are very small, just a few pixels in size. Our asteroids were several times this size. Second, white spots from cosmic rays are random. Meanwhile, we determined using star charts of the sections of sky our images were of that our asteroids followed a trajectory very close to the recorded trajectory for those asteroids.

Conclusion

From our results, it can be concluded that we are capable of measuring and determining position data, in terms of RA and DEC with an accuracy of <2 arcseconds. By nature of this, our research is substantial to the Minor Planet Center which in turn, allows us to contribute to the international database of asteroids.

In terms of questions left unanswered, the error presented in the Dec is twice that of RA. The reason for this is yet to be determined. Additionally, the estimation of the magnitude is imprecise and unreliable, with some targets being as much as 4.78 degrees of magnitude off, while others are comparatively closer to the expected value. In regards to this wide variabilty, a couple ideas could be suggested. For instance, optimization of the data reduction process could narrow down the wide variability. This would involve being more quantitatively selective about the choice in comparison stars, in terms of star radius and/or brightness; as opposed to the current method where comparison stars are selected arbitrarily, rather than numerical radii and brightness. This means selecting stars that are of similar radius to the target star and stars that are of similar magnitude to the target star.

Another concern worth exploring might be the radial pixel distance of the comparison stars to the target star. Perhaps comparison stars closer to the target star yield different results than comparison stars which are further away from the target star and each other. Comparison stars act as constants since their movement is so slow when compared to the asteroid in the image and the universe in general, that they appear to be standstill. Hence, movement of a comparison star is improbable and not a possible source of error.

Concerning future work, we propose attempting a light curve analysis of an asteroid [10]. Asteroids shine as sunlight reflects off their surface, hence the asteroids phase varies as it orbits around the sun. The greater the surface area of the asteroid that is exposed to sunlight, the brighter it appears and vice versa. Also, the distance of the asteroid to us affects its brightness, as closer objects appear brighter and farther objects appear dimmer. A light curve will especially be useful because, if the orbit of the asteroid is known, other confounding determinants, such as the asteroids distance from us, as well as the asteroid's phase as it orbits around the sun, can be numerically calculated. Those factors can then be removed from the measured light curve; resulting in an light curve which is affected only by the spinning of the asteroid on an axis.

By refining the skills needed to track asteroids using a small telescope, we hope to achieve the precision and consistency needed to acquire an observatory code and carry out official follow-up observations for the Minor Planet Center. This is a pivotal step to allow for the possibility of future research seeking to contribute more knowledge to the field of astrophysics.

If you wish to access the data the authors collected, please contact them using the information provided below.

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“Bullish Chances”

Claudia Jones

Digital Drawing in Procreate

While mathematics was never a strong suit of mine, I always had a curiosity for the study of probability. That is why I was interested in contributing artwork to The Effect of Different Strategies of Winning 6 Nimmt! Researched by Nathanael Bickel, 6 Nimmt, also called Take 5 in the United States, originated in Germany. After researching the game design elements, I noticed its iconic use of a bull as its representation. I focused on thus as the concept of this drawing. Using textured digital brushes on Procreate, I drew a minimalistic take of the bull symbol, using traditional neutral colors reminiscent of an American Bull. For the background, I drew a series of yellow, red, and black arrows similar to the ones found in the Take 5 logo to represent the multiple directions that the game could go in.

Mentored by: Rebecca Bafford

The Effect of Different Strategies on Winning 6 Nimmt!

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Mentored by: Kristel Ehrhardt

Abstract

The German card game "6 Nimmt!" is a game where the player begins with ten cards, playing one card each round until there are no cards left. The 104 cards are each numbered from 1-104 and have a specific number of "bullheads" or point values attached to them. The goal of the game is to finish with the least number of bullheads. In this paper, we examine different strategies that the participants developed to acquire the least number of bullheads per game and the strategy's effectiveness in multiple rounds of 6 Nimmt!. This experiment was conducted as a randomized, blind study to control for the participant's knowledge of multiple strategies. Each player independently developed and implemented their own strategy. Ultimately, we found the best strategy to be one where the low numbered cards were played first and the high number cards last. This, in combination with targeting other players who were doing well, was the most effective strategy.

Introduction

Math is everywhere, from technology and art to the sciences. You can see math unfold even on the simplest of things such as a card game. For this research paper, we wanted to use what we learned in our Statistics class and apply it to a regular card game. From a selection of multiplayer games, we decided that *6 Nimmt!* would be our study game. Once we were associated with the game mechanics and rules, we came up with individual strategies to compete against each other in random groups. We wanted to test how effective each of our various strategies was, so we randomly split into two groups of five players each week in order to see who was the most successful. Throughout the study, all ten of us recorded our data at the end of each game to determine who was the most successful.

Background

6 Nimmt! or *Take 5* is a German card game designed for 2-10 players. It was originally created by Wolfgang Kramer in 1994 and published by Amigo Spiele (*6 Nimmt!*). The game has 104 cards, each numbered 1-104. The goal of the game is to end up with the least amount of picked up cards.

To begin, each player is given 10 shuffled cards, then four are randomly placed face up in a vertical row. During each round, each player simultaneously reveals one of the numbered cards from their hand, which are then placed on the established row of cards in ascending order. The cards can only be played in a row where the last card has a lower value.

Figure 1*: A game of 6 Nimmt! in progress.*

For example, if the four cards facing up were numbered 101, 53, 1, and 69, the person with the lowest number card—let's say it is 10—would place their card next to the number 1 since 10 is a lower number than 53, 69, and 101. The cards are always played in a row that has the next lowest card.

There are two ways a player can pick up cards: by playing a number that is lower than all the top cards in the rows (the cards furthest to the right in the picture above), or if a sixth card is played in a row. If the sixth card is played, that person must pick up the five cards in the row and replace the first card with the last card played. If a player's card is lower than the four top row cards, that player is allowed to choose which row to pick up and replace with their card. Every card that a player picks up is put to the side and will *not* be used in play. Furthermore, each card

has a certain number of bullheads on it that are counted as penalty points at the end of each game. The player with the lowest number of bullheads wins.

Methods

We began our experiment by having each of the 10 players independently create a strategy that they believed would allow them to win. For disclosure the strategies were created based on games played before the experiment took place, each player playing the same number of games beforehand to eliminate any advantages. When we conducted our experiment, we divided the 10 players into two groups using a random number generator. Before each class session, we switched up the groups to collect the data with different individuals.

These distinct strategies were the foundation of our study since we were trying to determine which strategy was the most effective or if having a set strategy was necessary. Each player recorded their strategy and how they performed each game throughout testing. This included how many bullheads they ended the game with and if they won or lost. This data was utilized to analyze the success of each strategy through various metrics such as win rate, the number of bulls collected on average, the proportion of bulls compared to other players, and determining whether there was a superior strategy used to win the game. The strategies used can be placed in three main groups: those who started by playing all their higher cards first, those who started by playing their lower cards before their higher cards, and those who played their cards based on the cards already on the table.

The first strategy archetype was playing the lowest cards that the player had as early as possible. Though there were slight variations among these players, they all shared the common denominator that their small cards were used first. Andrew, Emily, Rolando, and Marcela all implemented this approach in their games. Their thought process behind this was to avoid having the lowest cards by the end of the game, which would almost always ensure at least one card being picked up. In doing this they attempted to avoid a problematic late game situation that could cost them a win. This is because a player must pick up cards when they are playing one that has a lower number than the rest of the cards in any row. Knowing this, they can strategically choose which stack with the lowest bulls. This strategy was effective, as these 4 players accounted for 12 out of the 20 wins. Marcela was the one notable exception among this group. Before the group began recording data, Marcela won multiple games. Unfortunately, these games are not recorded in our data and her data during testing was far different than beforehand. This can be explained by misfortune rather than an ineffective strategy, showing that there is indeed some luck involved while playing *6 Nimmt!*.

While close to half of the players used lower cards in the early part of the game, two out of the ten participants instead played higher cards early in the game and saved their low cards for the end of the game. Abigail and Nathanael implemented playing higher cards early on because they wanted to avoid completing a row at the end of the game. This idea came from previous experience, obtaining rows in the late game, which did not happen as often when lower cards were played later. Both players thought that choosing the row that they would pick up was a better option than being forced into “taking five.” Both players that had this *6 Nimmt!* philosophy combined for three wins and three ties were Abigail with 2 wins and 2 ties and Nathanael with 1

win and 1 tie, showing moderate effectiveness in avoiding bulls. These results came at the cost of never having a game where either player picked up zero bullheads.

The remaining group of players did not use the strategies of getting rid of the cards with the highest or lowest values first. Instead, these players decided to play their cards based on the cards already on the table. Stefan, for example, would play his cards based on what card was closest to the cards in his hand. Jose would get rid of outliers as soon as he was able to and then play close to the cards in his hand, allowing him to reduce the chance of having to pick up more cards later in the round. Aiden would focus on playing cards from her hand that were as close in number to the column she would play them on. The goal with this approach was to have as consistent a playable hand as possible. Lastly, Matthew was focused on playing cards that were close to the column they would be placed but also in columns that had as few cards as possible. He wanted to always play on a column that had two or fewer cards in order to avoid picking up. This group of players combined for the remaining 5 wins out of the 20 total, with 2 of the players in this group never achieving victory. This type of strategy was the most volatile and was heavily affected by luck, this being proven later by some of the group members having a "good" average amount of bullheads picked up but failing to win a game.

Five-Number Summary Results

To determine the most efficient strategy, multiple tests were used including the Chi-Squared Goodness of Fit test and the five-number summary. The five-number summaries were calculated for all players. By entering the number of bulls received for one individual into the TI-84 calculator and then calculating the one-variable statistics, the mean, median, first quartile, and the third quartile were calculated. This was repeated for each individual and the group total so that we could determine if there were any outliers.

Participants	Minimum	Quartile 1	Median	Quartile 3	Maximum
Emily	0	3	9	18	28
Andrew	0	5.5	12.5	17	25
Jose	0	8	12.5	21	38
Aiden	0	3	11	25	32
Marcela	14	19	25	30	38
Rolando	1	2	5	13	20
Abigail	1	6	11	23	39
Matthew	1	7	15.5	20	24
Nathanael	3	9	10	20.5	30
Stefan	0	8	12	18	34
Whole Group	0	5	12.5	23	39

***Table 1**: Table holding the five number summaries for each individual player and the five number summary for the entire group as a collective.*

Interquartile Range (IQR) Results

To calculate the outliers, the interquartile range (IQR) was needed. This was found by subtracting the third quartile from the first quartile. The upper fence was calculated by multiplying the IQR by 1.5 then adding the third quartile. The lower fence was found by once again multiplying 1.5 by the IQR, then subtracting that from the first quartile. These two numbers were used as the boundaries, and if a number was outside of the boundary, it was considered an outlier.

IQR: 18
Upper Fence: 50 Bulls
Lower Fence: 22 Bulls

While some players like Jose, Marcela, and Abigail had 38 or even 39 bulls picked up at most, they are not considered outliers. On the other hand, every player had at least 1 game where they picked up less than 22 bulls. According to the lower boundary they had outlier games. These "outlier" games mean that the player had a small number of bulls, indicating that they either won the game or they were close to winning the game. Players with more of these outlier games were also the ones who had a winning strategy. An example of this scenario is Rolando who had all 5 numbers under 22. He also won the most games individually with 6 and including ties with 7.

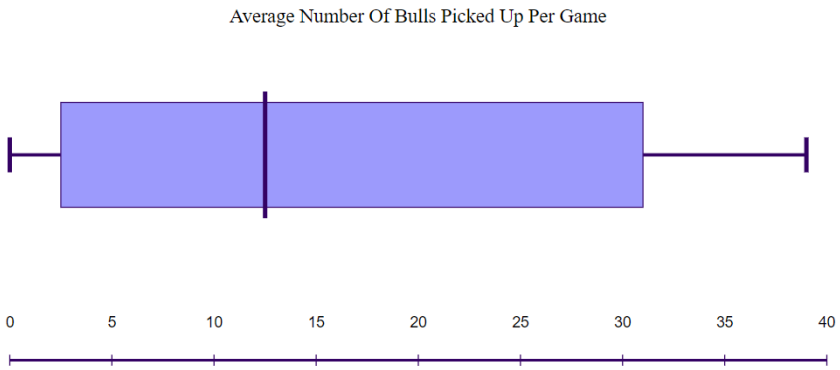

Figure 2: *Box plot of the Average Number of Bulls Picked Up Per Game.*

In our datasheet, we recorded the average number of bulls each player had at the end of each game. The minimum number of bulls on average was 7.55, and the maximum average number of bulls was 24.82. We found that the IQR of the data set was 2.94, and using that, we found the upper and lower fence to be 18.68 and 6.92, respectively. Only Marcela, who had an average number of 24.82 bulls, was outside of either the upper or lower fence. All other players were within the upper and lower fences. While all of the players other than Marcela were within the upper and lower fence, the group of players that played low cards first generally did better as you can see by the green group in Figure 3. Both of the remaining groups fell within the upper and lower fences and had an average that was considered "average".

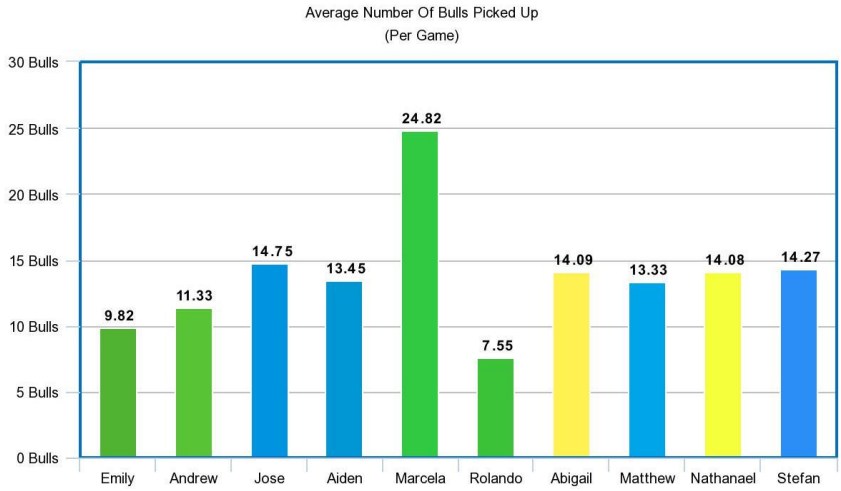

Figure 3: *The average number of bullheads each participant had at the end of the recorded matches.*

Chi-Squared Goodness of Fit Test Results

The Chi-Squared Goodness of Fit test is calculated by totaling the number of bulls an individual received at the end of a round and then using those sums to run calculations. Because there were 10 individuals, the sample size used is 10. Each data point was entered into a TI-84 calculator to calculate the test. From the various options available to us, we decided to use the Chi-Squared Goodness of Fit test as it would provide us with necessary information about the success of each strategy.

The null hypothesis for the Chi-Squared Goodness of Fit test was that each person had a uniform number of wins and ties. The alternative hypothesis for the Chi-Squared Goodness of Fit test was that at least one method received a greater average number of wins and ties than any other method.

$$\chi^2 - \text{GOF test}$$
$$\chi^2 = 14 \qquad p = 0.1223 \text{ (Including ties)}$$
$$\chi^2 = 16 \qquad p = 0.0669 \text{ (Not including ties)}$$

Out of the 24 games played, the expected win rate per person (including ties) was 0.1, or 10 percent. This would mean that we would expect each participant to win 2.4 times total out of the 24 games that we played.

Not including ties, we only recorded 20 individual wins which is 4 short of what we originally expected. This means that in our expected win percentage model, each participant would have won 2 games each not including ties.

In Figure 4 below, both Abigail and Jose met this requirement by getting 2 wins each. The other 8 participants were split evenly between having an above average amount of wins or having a below average total. Aiden, Andrew, and Emily won 3 games each with each player winning 15 percent of total games and the only outlier within this group was Rolando who doubled their win totals by winning 6 games which was 30 percent of the total wins. Nathanael, Marcela,

Matthew, and Stefan combined for a total of 1 win. This group of participants who accounted for 40 percent of the players only won 5 percent of the games individually.

Using this data, we can conclude that the 4 players who had an above average win rate had an effective strategy for winning *6 Nimmt!* games. The p-value with ties is 0.1223, and the p-value without ties is 0.0669. When the ties are not counted, this p-value is close to being unusual, under 0.05, and this aids in the conclusion that the 4 players had a repeatable, winning strategy.

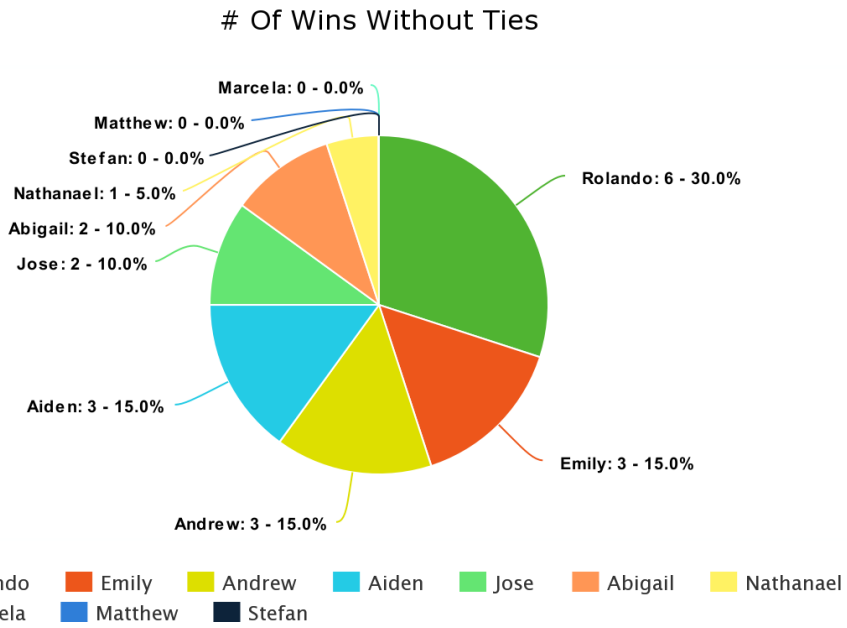

Figure 4: *The pie chart demonstrates how successful each strategy was without taking ties into account.*

While recording the data from our games we realized that we recorded 10 ties alongside the 20 wins. By the time we were compiling the data, our group decided to separate the wins from the ties but also count the ties as wins.

Each tie occurred because 2 or more players ended the game with the same number of bulls. Sometimes there were 3- or 4-way ties which led to there being more wins shared among the group than games that were played and recorded.

Unlike the individual wins, the results from the win totals including ties were less extreme than the total number of wins without ties. Previously a player only needed 2 wins to meet the expectations of an average winning strategy. When ties were included in the results, a player needed to win 3 games in order to meet expectations.

The players with effective, non-effective, and average strategies mostly stayed the same except for Abigail and Andrew. Abigail, who had 2 ties, doubled her total wins, and was placed in the higher group while Andrew, who did not have any ties, had the average number of wins. This made it so Andrew and Jose both had 3 wins total and had the expected number of wins. Just like the win totals without ties, 4 players had an above average amount of wins and 4 players had a below average amount of wins by the end of the 24 games.

Rolando, Emily, Aiden, and Abigail all won more than 3 games and made up 20 out of the 30 wins that were earned. This time Rolando had 7 wins total, and he had an average win rate of 0.583. While only having 2 more wins than the runner up (Emily) and 1 more win than he did without ties, Rolando won 58.3 percent of the games he played in with ties included versus only winning 50 percent of games without ties recorded.

This time the below average group quadrupled their win totals with a total of 4 wins out of 30. This was accomplished by Nathanael having a tie and Stefan having 2 ties. The unlucky players were Matthew and Marcela who unfortunately could not get a win with ties included. The below average group went from having only 5 percent of total wins to 13 percent with ties included.

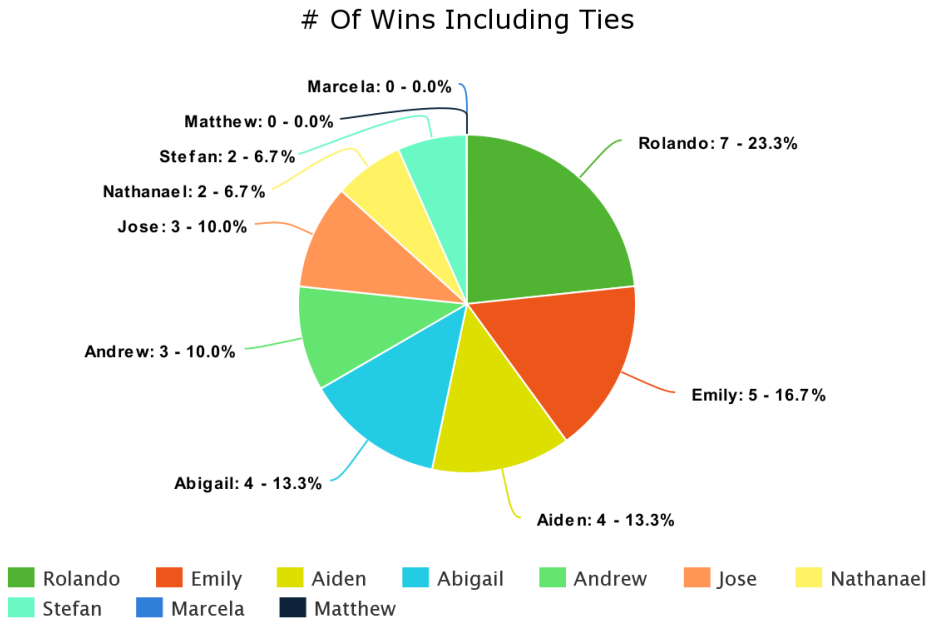

Figure 5: *The success rate changes significantly when the ties are included in the overall data.*

Conclusion

Which strategy was the best?

The most effective strategy over the period of the 24 matches was Rolando's. With a total of 6 victories and 1 draw, he had an average of 7.55 bullheads. In his strategy, he played lower cards earlier in the game and saved the higher cards for the end, carefully analyzing the playing field and cards in hand. He tried to bring down his opponents and didn't give up a chance to be at the top. Based on our data analysis, Rolando's strategy was statistically the most effective.

While the other types of strategies were capable of winning games for each player, the best type of strategy was to play lower numbered cards at the beginning of the game.

Is the use of a strategy always effective?

In bullheads, the most significant difference was between Rolando and Marcela. Both players had the same type of strategy, but Rolando had an average of 7.55 bullheads overall, while Marcela had an average of 24.82. Even though having this type of strategy was proven to be the most effective, there was a portion of luck involved in each round of *6 Nimmt!* played. The rest of the participants averaged between 9 and 15 bullheads, which was found to be the average range of bullheads picked up each round. While the group of players with the low to high strategy won more, one can claim that luck played some role in the misfortune of the other players.

Our study concludes that playing lower cards earlier in the game leads to more victories. Overall, it was Rolando's strategy that emerged victoriously among the participants. Although his strategy was like other participants, it is necessary to note that outside factors like luck and the random shuffling of the card deck can significantly change the results between rounds so it is not possible to calculate the effectiveness precisely.

For future studies, since our sample size only had ten subjects, we could add an additional control group and have an even number of people in each strategy group for more conclusive results. We could also add more total rounds played to increase the amount of data compiled. Additionally, we could apply the Chi-Squared Goodness of Fit test to other card games to calculate the effectiveness of their strategies to see if our testing method still applies in other settings.

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A Year In The Life Of Two Campus Streams: Impact From Road Salt, Ground Water, And Surface Water Contributions

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Abstract

Freshwater rivers and streams are as essential to our environment as blood vessels are to the human body, and because of its fluid nature, water chemistry and quality can be influenced by naturally occurring and anthropogenic events. From February 2021 to January 2022, our research team assessed freshwater chemistry at five locations on the campus of Howard Community College (HCC). We observed trends in water quality parameters, including chloride (Cl), pH, turbidity, temperature, conductivity, and dissolved oxygen levels as well as concentrations of manganese (Mn) and copper (Cu) ions. We found a positive correlation between manganese and conductivity levels when examining all samples collected throughout the year. The concentration of manganese appears to be highest during the winter months; the highest observed reading occurred in December 2021, and was nine times above the Environmental Protection Agency (EPA) drinking water recommendation of 50 µg/L [1]. The concentration decreases through spring. The lowest levels we observed were in summer, which for some sites were below the EPA recommendation. Correspondingly, chloride concentrations were highest during the winter months. These trends suggest the streams on campus may be impacted by the use of de-icing salts containing chloride in winter, according to a study that examined the effects of salt on the mobilization of metals like manganese [2]. Concentrations of copper generally remained consistent and below 2 µg/L, which is considerably lower than the EPA limit of 1.3 mg/L in drinking water [3]. Our data will serve as a baseline and allow us to observe changes in water quality and levels of trace metals that may occur as a result of road salt use and planned campus construction.

Introduction

Two streams begin near the campus of Howard Community College [4]. These streams are fed by local groundwater and stormwater runoff from on-campus and nearby surfaces, and supply the Little Patuxent River [5]. Columbia, Maryland is a densely populated suburb located

between Baltimore and Washington DC, and within the watershed of the Patuxent River. Much of the Patuxent River basin is significantly urbanized, with population centers like Columbia experiencing rapid development over the last several decades. Developer James W. Rouse promised that the planned community would "fit naturally into the Howard County landscape, preserving the stream valleys, protecting the hills and forests, and providing parks and greenbelts" [6]. The Rouse vision capitalized on the natural beauty, weaving community into the landscape. Although streams and ponds, such as those on HCC's campus, are aesthetic, recreational, and sociocultural assets to communities [7], research has shown that human activity in and around streams decreases the quality of freshwater and can threaten the health of the aquatic and terrestrial ecosystems they sustain [8].

The ecological value of freshwater is contingent upon its quality, and several global studies have found that anthropogenic activity decreases the quality of surface water [9] and groundwater [10-12]. Anthropogenic events such as rapid urbanization and development [9], industrial activities [11], the application of fertilizers [13], and stormwater runoff from impervious surfaces can alter the chemistry of nearby streams and rivers. Chemical changes can include contamination of heavy metal ions [10-12], an increase in chloride ion concentration, and conductivity [13-14]. Changes such as these can be caused by a combination of anthropogenic and geogenic occurrences [2, 15-16].

Freezing precipitation typically occurs from December to March in Maryland [17], and road salts are used ubiquitously. Research suggests that the application of road salts and de-icing substances are environmentally damaging anthropogenic activities because of their potential to increase the conductivity of freshwater and cause the mobilization of naturally-occurring metal ions in soil [2, 15]. After de-icing salt is applied to roads, melting ice and snow wash the salt onto the earth adjacent to the road surface. The water, now with a high salt concentration, is absorbed into the earth where it becomes dispersed through soil and, in time, percolates into the groundwater [10]. The sodium (Na^+) and chloride (Cl^-) ions from the dissolved salts promote the dissolution of metals, such as manganese [15], from soil or bedrock [18]. The metal ions can then become dissolved into the groundwater [2], which supplies freshwater streams [10] (Figure 1), such as those that begin around HCC's campus. The salts can also lead to an increase in conductivity of freshwater [15-16]. Elevated concentrations of heavy metals and chloride ions can alter ecosystems and reduce biodiversity as species that are unable to adapt do not thrive and reproduce [5, 16]. Periodic testing of at-risk freshwater is recommended to maintain the integrity of the ecosystem it sustains and protect other river networks it supplies.

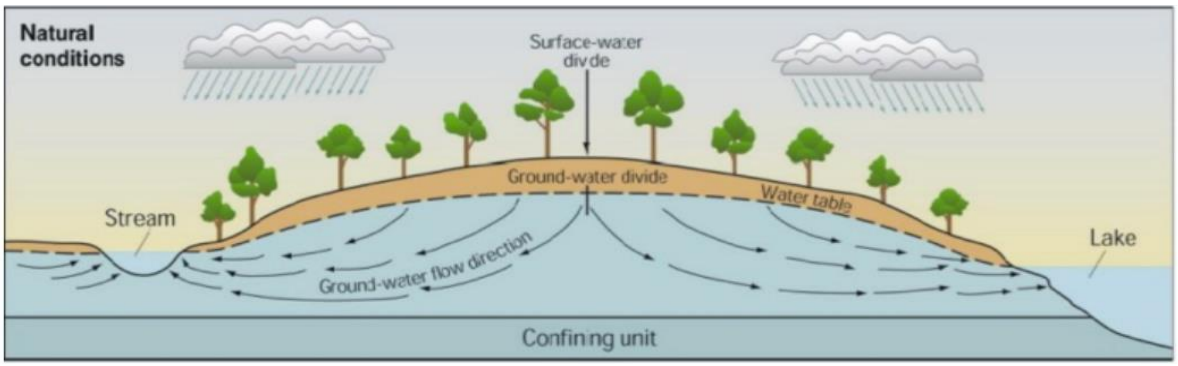

Figure 1: *This diagram shows the movement of groundwater, and how it supplies streams and bodies of water. This is one course of action for how freshwater can become contaminated with dissolved metals. Diagram by College of Earth and Mineral Sciences, Pennsylvania State University [19].*

The Maryland Stream Waders, a volunteer group under the direction of the Maryland Department of Natural Resources, conducts monitoring of the freshwater rivers and streams in the area. The group evaluated the water quality of one of the streams on HCC's campus in March 2019, and found elevated conductivity and nitrite concentration, and rated the campus streams with a score of 2 (out of 5) indicative of "poor" water quality after assessing collected water samples [20]. The streams on HCC's campus flow into the Little Patuxent River. The Little Patuxent River is one of the major tributaries of the Patuxent River basin, an ecologically and economically crucial watershed in Maryland [21]. The basin supplies the Triadelphia and Rocky Gorge reservoirs [21-22], which according to the Washington Suburban Sanitary Commission (WSSC) supplies drinking water to 650,000 Maryland residents [23]. The Patuxent River empties into the Chesapeake Bay, the largest estuary in the United States, and NOAA fisheries estimates that the Bay produces about 500 million pounds of seafood each year [24]. In 2019, the Patuxent Rivers Watershed Group stated in their annual report that between 1990 and 2019 levels of chloride and sodium ions have increased two to three times in the Rocky Gorge Reservoir, and the group issued a recommendation to limit and manage the use of road salts in the Patuxent River Watershed, "before water quality standards are exceeded" [21].

Copper is a soft, naturally-occurring metal that is used in electrical wiring, plumbing, and industrial settings [25], and aids in biological function [26]. As a trace metal, it is essential for human health and homeostasis, yet has a cumulative effect in mammalian organs and tissues if consumed in excess. On the biochemical level, copper toxicity can cause free radical-induced oxidative damage to cells; affected organisms experience gastrointestinal and neurological disorder [26]. Without chelation therapy to remove copper from the body, an accumulation of copper can lead to renal and cardiac failure, hepatic necrosis, and death [26]. The EPA has identified that most copper found in drinking water originates from copper plumbing, and has classified copper as a regulated drinking water contaminant [3] because of its toxicity, and as a nuisance chemical because of its metallic taste and blue-green staining [1]. The EPA permits a maximum of 1.3 mg/L in drinking water [3].

Manganese is also considered a biologically essential nutrient, and is vital for hormone signaling and the function of connective tissues such as cartilage and bone. Unlike copper, manganese has a low potential for acute toxicity and is considered noncarcinogenic, but it has biological potential to cause homeostatic disturbance [27]. If consumed or inhaled over extended

periods of time, such as in the case of occupational exposure or drinking from contaminated well water [28-29], elevated concentrations of manganese in the body can cause nervous system disorders such as manganism and parkinsonism, which are characterized by movement abnormalities, deterioration of motor skills, and speech difficulties [27]. The occurrence of manganese toxicity is low [28], and the EPA has set the maximum allowable level of manganese in drinking water at 50 µg/L on the basis of aesthetics; it can cause unattractive staining on surfaces and fabrics [1]. At this time, the EPA does not have a recommendation for concentrations of manganese in freshwater [30] and research on the chronic effects of manganese toxicity on freshwater systems in the United States is limited.

Our investigation of heavy metals and conductivity levels of the soil and water of the streams and pond on HCC's campus continues and expands the scope of research conducted by three other groups of staff and students of HCC. Between fall 2017 and 2020, the teams observed conductivity levels exceeding the ideal range for freshwater streams and concentrations of chloride that are above what is recommended for aquatic life [13-14], which corroborates the 2019 assessment by the Maryland Stream Waders. Additionally, Beckjord and Straube noted pollution-level concentrations of NO_3^- between 2017 and 2018 [13], and Carmody and Mai found elevated concentrations of manganese in the spring of 2020 [31]. Each group recommended further monitoring of the streams and pond, and our research goals were designed under this direction. We hope that the cumulative results of all research groups can be used for future comparative studies regarding how the water quality and concentrations of heavy metals changes on campus as the campus itself evolves, such as the current construction of the new Mathematics and Athletics Center (MAC) building, which began in 2021.

Methods

Preparation of materials

Prior to use all sampling and filtration materials are washed with lab detergent and tap water, rinsed three times with deionized water, soaked in 4% nitric acid (HNO_3), rinsed three more times with deionized water, and oven dried at 50ºC. This thorough process was developed based on procedures utilized by similar studies in Turkey in 2016 [11] and India in 2013 [32], and is intended to remove dissolved metallic residues and other impurities that may interfere with the sensitive metal analysis of the samples. During transport to sample locations, sample bottles are kept in plastic bags to prevent contamination in the field.

Sample collection

Samples of freshwater were collected from four locations on the campus of HCC once a month from 2/25/2021 to 1/13/2022, between 10:00 am and 3:00 pm. Sampling at Site B′ began on 6/10/2021, and this location was added to gather more data about the input into Site B from the water flowing in from the adjacent culvert, which is a concrete tunnel that passes under Little Patuxent Parkway. The locations (Figure 2) were selected because of their accessibility and proximity to impervious surfaces and stormwater drainage culverts. Environmental conditions at each location were measured, including time of sampling, air temperature, air pressure, dissolved oxygen (DO) levels, and the maximum depth of the water. Air temperature was measured with a Vernier LabQuest temperature probe, air pressure was measured with a Vernier LabQuest

Barometer, DO was measured with a Vernier LabQuest Optical DO Probe, and water depth was measured with a standard ruler. Between measurements the probes are rinsed with deionized water to minimize microbial contamination between sample locations. Environmental notes and observations were also recorded at each location.

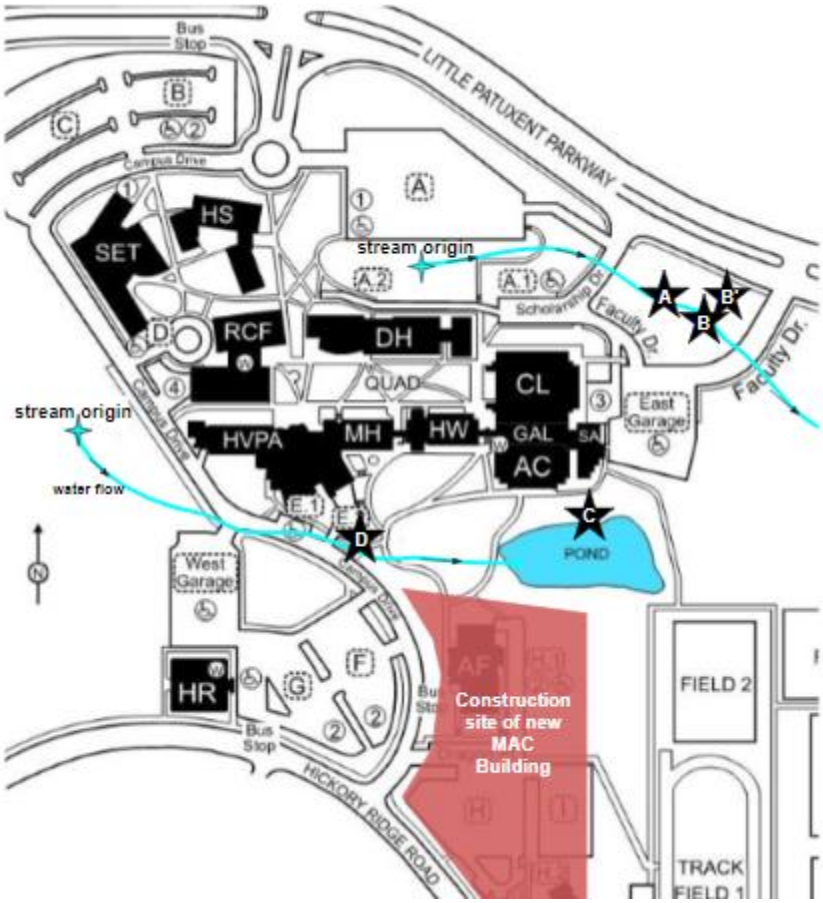

Figure 2: *A map of HCC's campus, with sample locations and streams annotated. Note that Sites A, B, and B′ are surrounded on three sides by roads. The pond and Site D are next to the construction site.*

Site A and Site B are located in a small wooded area on campus between Scholarship Drive and Faculty Drive, south of Little Patuxent Parkway. A stream begins just west of this location, and runs parallel to the parkway, and continues off campus. Site A is located closest to the stream origin. Throughout most of the year, especially during extended periods of low precipitation in the summer, the stream at Site A often had low water flow.

Site B is situated about 18 meters downstream of Site A, and is characterized by higher water flow and stream depth than Site A. At Site B, a culvert empties into the stream (Figure 3a), and sample water was collected downstream from the culvert. Beginning in June 2021, water samples were also collected from the water flowing from the culvert to allow us to characterize both sources of water that combine at Site B and about how water from this culvert may affect water quality and metal ion concentrations in the stream at Site B. This location was named Site B′.

Another stream crosses through HCC's campus, beginning off-campus near a medical office complex and continuing south of the quad. The stream crosses under Campus Drive via metal culverts, and runs through a low-lying area before emptying into the campus pond. Site C is located on the north shore of the pond, a location with significant wildlife activity. Throughout the year, Canada geese were seen around the pond, and frogs and small fish were observed in the pond in the summertime months. Felled and damaged trees on the shore of the pond and a visible dam were evidence of a local beaver population.

Site D is located at a culvert (Figure 3b) that allows the stream to pass under Campus Drive before the stream feeds into the pond. At this location water flows year-round, with increased water volume noticed following heavy precipitation events. Despite its proximity to campus buildings, a high-volume road, and frequent evidence of human trash, wildlife was seen numerous times throughout the year, and included ducks, geese, frogs, and crayfish.

Figure 3a: *Dr. Pie measures water depth and dissolved oxygen, 2/25/2021*

Figure 3b*: Site D, 2/25/2021*

Two samples were collected at each primary location: one in a 1 L polyethylene bottle and another in a 250 mL polyethylene bottle for additional water quality analysis. Samples from Site B′ were collected with two 250 mL bottles. To collect a sample, nitrile gloves were worn, and the bottle was submerged to a depth of 10 cm where the lid was removed, and the lid was replaced while underwater to prevent contamination from the air or surface of the water. At Site C, to accommodate deeper water, rubber dishwashing gloves are worn during sample collection and water quality measurements. After collection, the bottles were stored on ice until returned to the lab.

Sample filtration, acidification, and storage

Sample water collected in 1 L polyethylene bottles was used for testing the presence of heavy metal ions. Polyethylene was selected to avoid contamination of samples via metal leaching from the container [32]. Samples were filtered via vacuum filtration to remove organic particulates and sediment, allowing us to examine dissolved metals. A MF-millipore filter with 0.45µm pore size was used. Before sample water was filtered, 100 mL 2% HNO_3 was run

through the apparatus and filter paper to remove any metal ions that may have contaminated the equipment after washing and drying. This volume is then transferred to a clean 250mL polyethylene bottle, labeled as a filter blank with the date and location of the sample that was to be filtered in the apparatus. The filter blank was later tested for metal contamination from the lab. Sample water from one location was then filtered through the filtration apparatus, and if necessary, the filter was changed as many times as needed to fully filter each 1 L sample. The first filter from each location was saved, labeled, and refrigerated in polystyrene petri dishes for analysis in follow up research. For this project, the filters were not analyzed and only used for filtration.

Each filtered sample from Sites A, B, C, and D was then transferred to a new, clean 1 L polyethylene bottle and acidified with 2 mL 70% HNO_3, and samples collected from Site B′ were acidified with 0.5 mL 70% HNO_3 to bring the pH in the filtered samples to below 1. Acidifying the samples eliminates any remaining microbes that passed through filtration, as microbe metabolism can alter the chemistry of the samples, and helps keep metal ions suspended in water and not accumulate into precipitate. The samples were then labeled and refrigerated until ion analysis.

Water quality analysis

Water collected from each location in 250 mL polyethylene bottles were used to assess the original water quality of each location, and therefore were not filtered or acidified. For each sample, several parameters were measured, including pH, turbidity, conductivity, and chloride ion concentration, using pre-calibrated sensors and probes. The pH was quantified using a Vernier LabQuest pH Sensor, turbidity was measured using a Vernier LabQuest Turbidity Sensor, conductivity was measured using a Vernier LabQuest Conductivity Probe, and chloride ion concentration was measured using a Vernier LabQuest Chloride Ion-Selective Electrode Probe. A new chloride sensor was introduced on 1/13/22, and new conductivity standards were used for a more complete calibration curve.

Metal ion analysis with AAS

Atomic absorption spectroscopy (AAS) was used to determine the presence and concentration of metal ions in samples [33]. These analyses were conducted using a Shimadzu AA-7000 spectrophotometer equipped with a graphite furnace with either a high density graphite tube or a pyrolytic graphite tube as well as manganese and copper hollow-cathode lamps. For manganese analysis, a wavelength of 279.5 nm was used [34]; for copper, the wavelength was set to 324.8 nm [35]. In order to increase the sensitivity for measuring copper in the water samples, the graphite tube used was switched to a pyrolytic graphite tube in August 2021. Data was sent directly from the spectrophotometer to an adjoining computer, where calculations were completed and graphs were generated via Shimadzu WizAArd software [34]. The software was also used to set parameters for analyzing different metals.

Samples were pipetted into labeled cuvettes, which were then seated in the rotating cassette of the spectrophotometer autosampler. A micropipette tip was inserted into each individual sample, and a small volume was transferred via capillary inlet tube into the

spectrophotometer. The autosampler micropipette was automatically rinsed by the instrument between samples to prevent cross-contamination. The sample was heated via graphite tube and the metal ions were atomized and irradiated with light from the hollow-cathode lamp specific for that elemental analysis. The amount of light that was absorbed by the atomized metals in the sample is detected and sent to the computer [33]. AAS was used to determine the concentration of specific metals in solution by measuring the absorbance of a particular wavelength of light by each sample. According to Beer's Law (Equation 1), the absorbance of light is directly proportional to concentration in solution, and therefore a formula can be used to determine concentration from absorbance [33].

$$A = \varepsilon b C \quad (1)$$

where A is absorbance, ε is molar absorptivity, b is length of light path, and C is concentration.

The sample was analyzed three or four times depending on the reproducibility of the first three measurements, and the absorbance was averaged and recorded by the WizAArd software. When analyzing manganese, after each water sample a sample of trace metal grade 2% HNO_3 was run through the system three to four times to remove any residual metal ions from analysis of the previous sample. This was not needed when analyzing copper concentrations in water samples as those concentrations were low enough not to carry over between samples. When testing for manganese, samples had to be diluted by a factor of 2 to 50 depending on the starting concentration to bring the absorbance into the linear, calibrated range of the AAS. A trace metal grade solution of 2% HNO_3 was used to dilute samples, as HNO_3 is recommended for keeping metal ions suspended in solution. The concentration values obtained from the absorption of diluted samples was then multiplied by the appropriate dilution factor to determine the undiluted concentration of metal in the original sample.

Calibration curve

A calibration curve (Figure 4) is a display of data from analysis of known quantities of analyte [33], and this linear approach was used to determine the unknown concentration of metal ions in freshwater samples. Calibration curves for manganese (Figure 4) and copper (Figure 5) were created based on the analysis of a series of standard solutions created from 1000 mg/L stock solutions from Inorganic Ventures. Manganese standard solutions containing 0.5, 2, 5, 10, 25, and 40 μg/L were used; copper standard solutions had 0, 0.24, 0.80, 2.4, 4.0, 10, and 20 μg/L. Spectrophotometer data for each series of solutions showed a linear response [33], allowing us to determine the absorption of unknown samples with linear regression.

On August 16, 2021 the high density graphite tube in the AAS was switched to a pyrolytic graphite tube to obtain better sensitivity when analyzing copper. This resulted in a shift in measurable manganese concentrations and new standards containing 0.5, 1.0, 2.5, 5.0, 10.0, and 15.0 μg/L were created and used. All water samples were appropriately diluted to account for this new range.

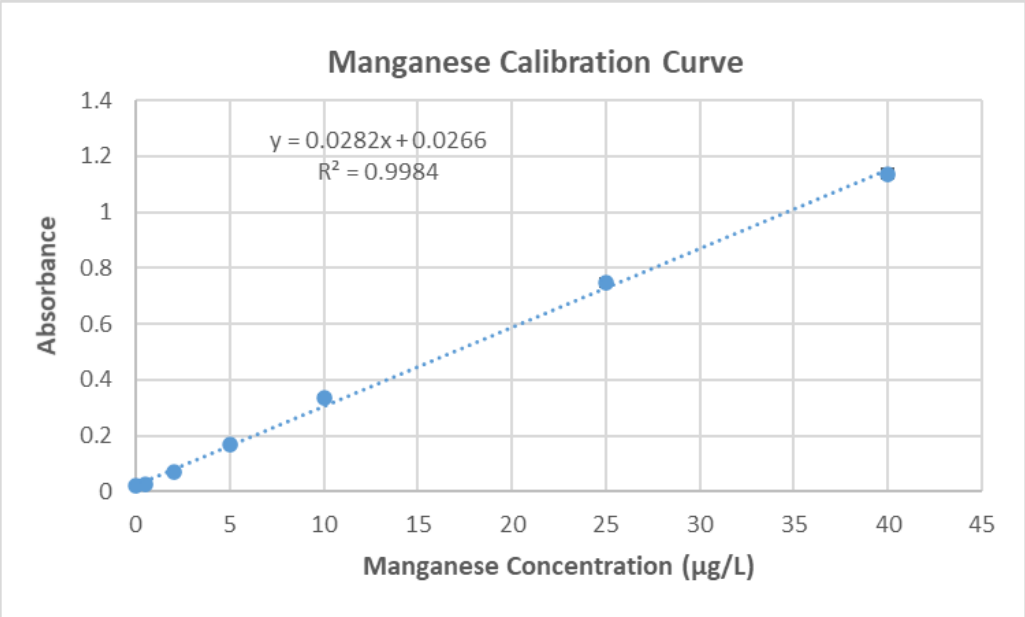

Figure 4: *A calibration curve of manganese, reflecting the absorption of standard solutions containing 0 - 40 µg/L manganese, measured at a wavelength of 279.5 nm.*

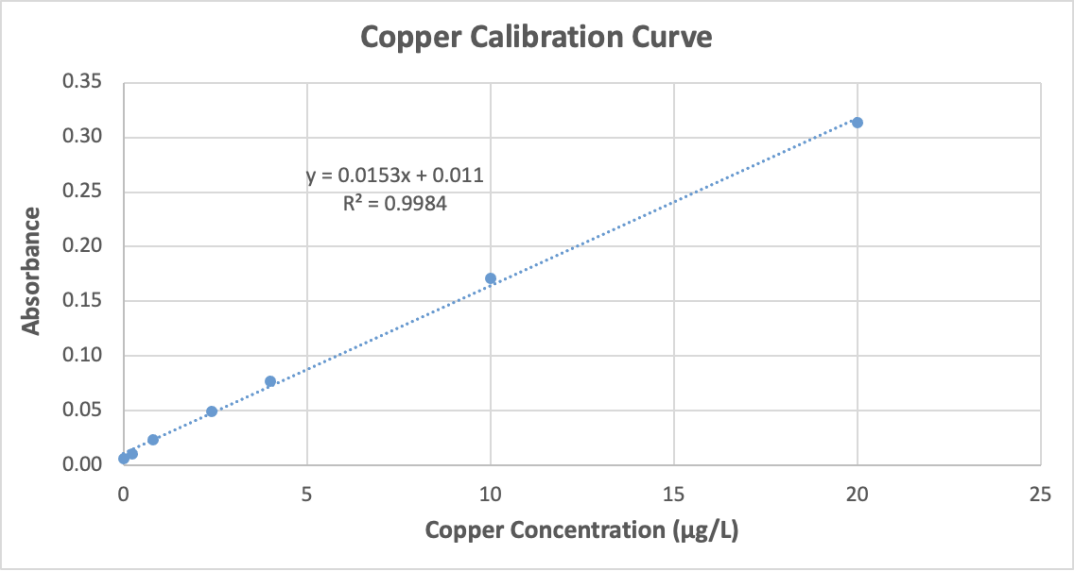

Figure 5: *A calibration curve of copper, reflecting the absorption of solutions containing 0 - 20 µg/L copper, measured at a wavelength of 324.8 nm.*

Results

Manganese levels & trends

Ranges of manganese concentrations varied between the different sites from February 2021 to January 2022. Sites A, B, C, and D all displayed a trend of decreasing concentration from winter into summer, however, only sites B and C displayed an increase again in late fall of 2021 and early winter 2022. Site C, the pond, appeared to have the lowest concentration of

manganese overall with an average and standard error of 44.40 ± 17.30 µg/L, and was the site of the lowest observed concentration during the observation period (2.60 µg/L on 7/2/2021). Manganese was consistently highest at Site B, and the highest observed reading overall was at this location, recorded at 458.74 µg/L on 12/9/2021. This location had an average year-round manganese concentration and standard error of 247.00 ± 34.29 µg/L. The lowest manganese concentration for Site B occurred on 8/17/2021 where sampling occurred after a precipitation event.

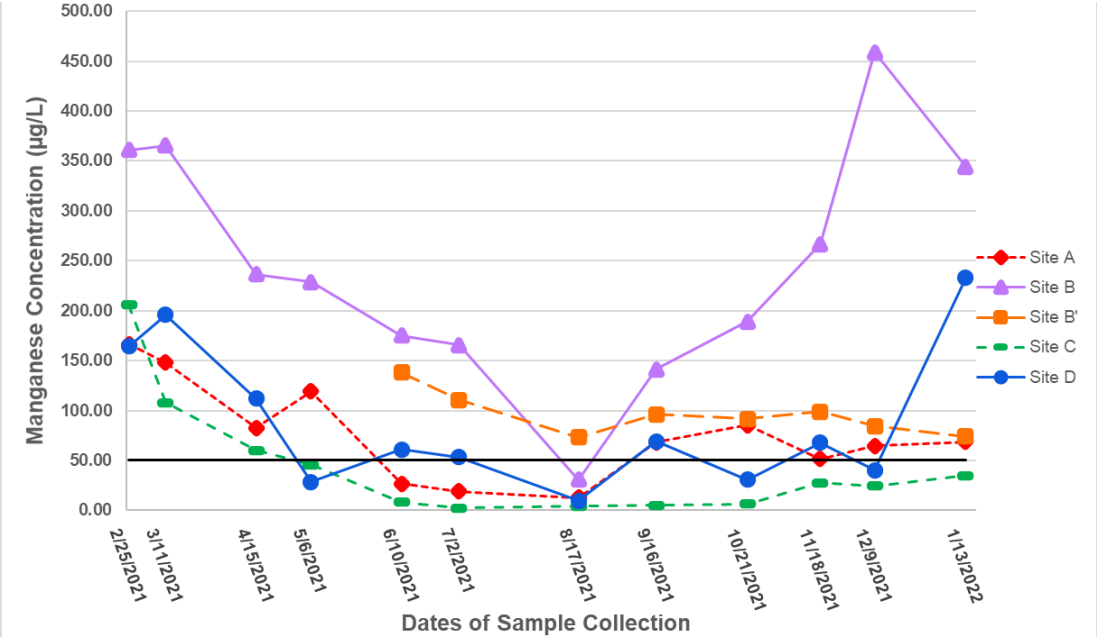

Figure 6: *Manganese concentrations from 2/25/2021 - 1/13/2022. The bold horizontal bar designates the EPA recommendation of 50 µg/L [1].*

Copper levels & trends

Concentration of copper at all locations from February 2021 to January 2022 remained far below the EPA limit of 1.3 mg/L for drinking water [3]. The highest concentration observed was 8.35 µg/L at Site A on 8/17/2021 (Figure 7), and the second-highest concentration overall also occurred that day at Site B (6.99 µg/L). It should be noted that samples were collected during a precipitation event on this day. For the most part, on days without precipitation, concentrations of copper at our sampling sites remained below 2.00 µg/L throughout the year. Excluding data from Sites A and B on 8/17/2021, the average and standard error for all samples was 0.86 ± 0.08 µg/L. The lowest detectable concentration was 0.02 µg/L at Site B′ on 11/18/2021. However, there were three samples that contained concentrations of copper below the detection limit: Site B’ on 9/16/21, Site B′ on 12/9/21, and Site B on 12/9/21.

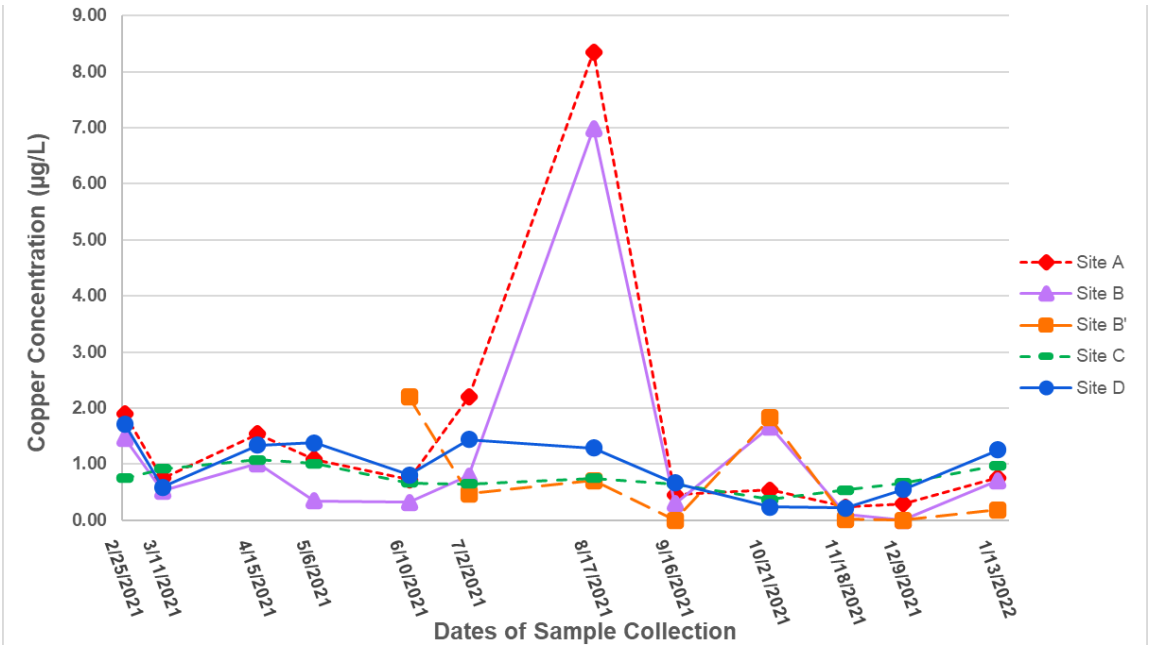

Figure 7: *Copper concentrations from 2/25/2021 - 1/13/2022. It should be noted that the EPA recommendation for drinking water is not depicted on this graph because the range of our data is far below that amount.*

Chloride levels & trends

Chloride concentration demonstrated a trend similar to that of manganese, as seen in Figure 8. Concentrations of chloride at all sites examined in March 2021 were above the recommended chronic exposure limit of 230 mg/mL [36] with the highest measurement being 791 mg/L at Site C. A general trend of decreasing chloride concentration from March 2021 through late summer was observed, and lowest concentration recorded was 0.70 mg/L on 6/2/2021 at Site C. It should be noted that testing for chloride began in March 2021, although sampling and data collection began in February of that year. Chloride levels increased again the following late fall and winter. In January 2022, the highest recorded concentration was 830 mg/L (Site D), and all sites that day had chloride levels that were above the chronic exposure limit of 230 mg/L [38], except for Site C at 229 mg/L. Overall, all samples measured for the year were below the acute exposure limit for chloride of 860 mg/L [36].

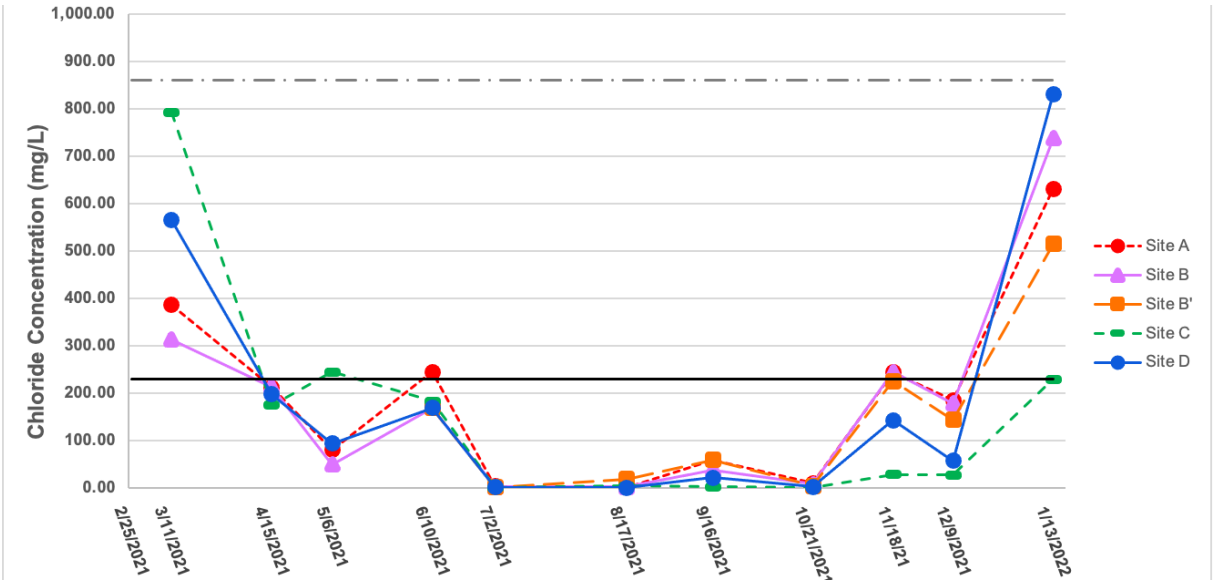

Figure 8: *Chloride concentrations from 2/25/2021 - 1/13/2022. The chronic exposure limit (black, solid horizontal line) and the acute exposure limit (gray, dashed horizontal line) for chloride concentrations in healthy freshwater ecosystems are indicated [36, 38].*

Conductivity levels & trends

Conductivity varied annually with a trend similar to that of manganese and chloride, with variations throughout the observation period. Overall the highest levels were observed in winter months, and the highest reading of all locations was 6450 µS/cm at Site D on 2/25/2021. Despite increases in levels on 6/10/2021 and again on 9/16/2021, the lowest readings generally occurred in summer and fall; the overall lowest reading observed was 144 µS/cm on 10/21/2021 at Site C. Conductivity averaged 1623 µS/cm from February 2021 to January 2022, which is above the upper range of what is considered typical and healthy for freshwater. The EPA notes that conductivity of rivers and streams in the United States typically ranges from 50 to 1500 µS/cm [37], and conductivity under 300 µS/cm is considered ideal for a healthy freshwater environment in the central Appalachian region [38].

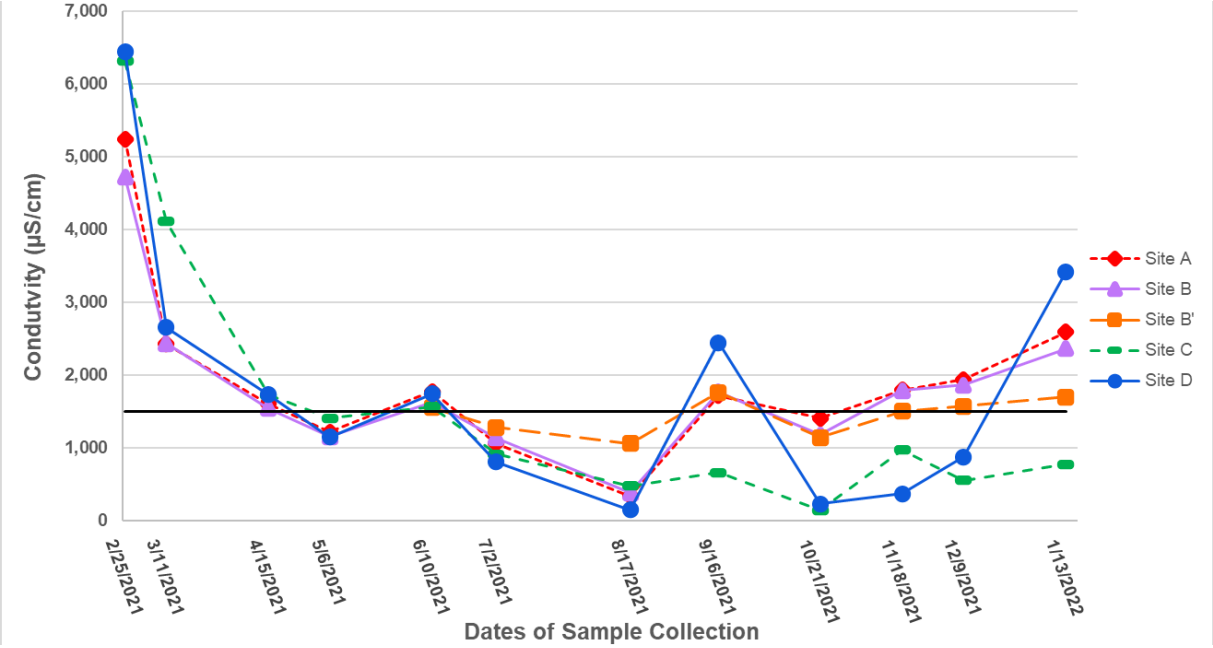

Figure 9: *Conductivity levels from 2/25/2021 - 1/13/2022. The bold horizontal bar labels 1500 µS/cm; the EPA notes that freshwater rivers and streams in the United States have an average conductivity of 50 - 1500 µS/cm (37).*

Other measures of water quality

Water quality parameters were measured at each location, and include pH, water temperature, dissolved oxygen levels, and turbidity. We have chosen to provide pH and other measures of water quality not shown here within supplementary data present at the end of this paper. This data was collected to provide more information on the complete health profile of the streams and pond and for comparative analysis in future research. In this investigation, these parameters were not used in correlation analysis.

Site A

	Conductivity (µS/cm)	[Cl-] (mg/L)	[Mn] (µg/L or ppb)	[Cu] (µg/L or ppb)
Highest	5245	630	166.60	8.35
Average	1927	186	76.15	1.69
Lowest	341	1.60	12.79	0.30

Site B

	Conductivity (µS/cm)	[Cl-] (mg/L)	[Mn] (µg/L or ppb)	[Cu] (µg/L or ppb)
Highest	4725	737	458.74	6.99
Average	1832	178	247.00	1.19
Lowest	385	1.90	30.98	0.99

Site B′

	Conductivity (µS/cm)	[Cl-] (mg/L)	[Mn] (µg/L or ppb)	[Cu] (µg/L or ppb)
Highest	1767	514	138.00	2.20
Average	1449	142	95.95	0.80
Lowest	1060	1.70	73.24	0.02

Site C

	Conductivity (µS/cm)	[Cl-] (mg/L)	[Mn] (µg/L or ppb)	[Cu] (µg/L or ppb)
Highest	6316	792	205.70	1.08
Average	1636	153	44.40	0.75
Lowest	144	0.70	2.60	0.37

Site D

	Conductivity (µS/cm)	[Cl-] (mg/L)	[Mn] (µg/L or ppb)	[Cu] (µg/L or ppb)
Highest	6450	830	232.91	1.72
Average	1837	189	88.86	0.96
Lowest	152	0.30	9.49	0.22

Table 1. *The highest, average, and lowest values of parameters analyzed for each site for the full 12 month study. No chloride data was collected 2/25/2021.*

Correlation between manganese concentration and conductivity

A comparison of manganese concentrations and conductivity were plotted via scatter plot (Figure 10). A Spearman's correlation test was conducted using the R statistical software. This revealed a significant positive correlation between the conductivity and manganese concentrations (rho=0.653, p-value <0.001). This plot shows that as conductivity increases, manganese concentration also increases, which suggests that the primary ions that drive conductivity levels could be causing manganese concentrations to increase in the stream systems on campus. Furthermore as shown in Figure 10, chlorine concentrations were positively correlated to conductivity levels (rho=0.652, p <0.001), which suggests that chloride ions are a primary driver of conductivity. Figure 11 shows that there is a weak positive correlation between manganese and chloride; more data is needed to further define this relationship. It is also possible that this correlation is less strong than that between manganese and conductivity because there are other ions in addition to chloride that influence the concentration of manganese.

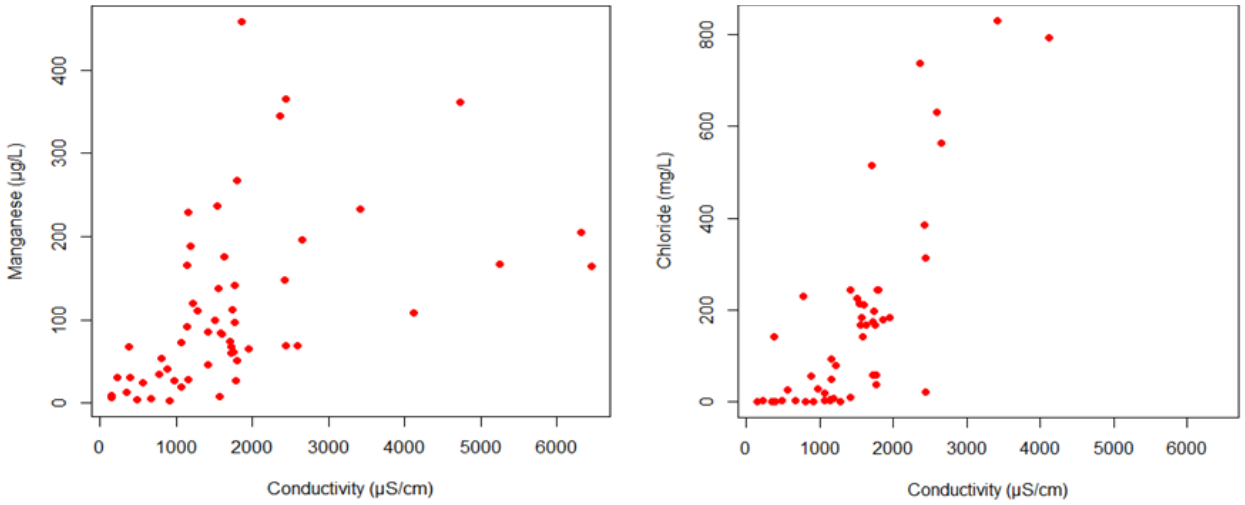

Figure 10: *A scatter plot of conductivity and manganese (left), displaying a correlation between manganese and conductivity (rho=0.653, p <0.001); the graph on the right shows the correlation between chloride and conductivity (rho=0.652, p <0.001).*

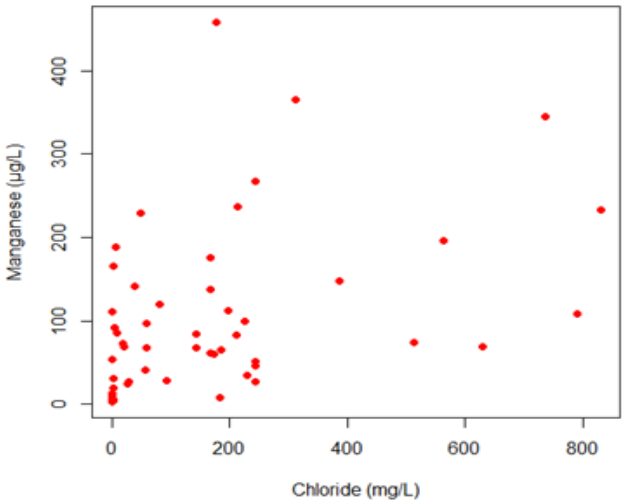

Figure 11: *A scatter plot of manganese and chloride, showing a weak positive correlation ($p<0.01$, $rho=0.478$).*

Discussion

Past studies conducted by faculty and students of HCC have monitored freshwater on campus and have explored the effects of anthropogenic activities on the water quality. Beckjord and Straube monitored the streams on campus from fall 2017 to spring 2019 and observed an average conductivity of 6256 µS/cm that winter. It was suggested a cause could be the use of de-icing salts [13]. The following year, Wortman and Erickson further explored the effects of anthropogenic activities, and specifically assessed the impact of legacy pollution on conductivity levels in the soil and freshwater on campus. They observed median conductivity levels of 1733 µS/cm and 1973 µS/cm in the freshwater on campus, and identified a correlation between conductivity levels and chloride concentration. They suggested de-icing salts as the primary source of elevated chloride contamination, and suggested that the higher concentrations of chloride correlate with higher conductivity concentrations [14]. Our analysis of conductivity and chloride concentrations revealed trends similar to those observed in campus freshwater from 2017 to 2020. It appears that conductivity and chloride ion concentrations are highest in the wintertime months, which suggests contamination of de-icing road salts from the many roads, walkways, and parking lots on and around the college campus. More data is necessary to clarify this correlation.

In March, August, and October 2020, Carmody and Mai assessed surface water quality and also began documenting the presence of heavy metals in the streams on campus. Manganese and copper ions were identified and preliminary trends in concentrations of these metals were discovered. The concentrations measured during their observation period are similar to what we observed: higher concentrations that were above the EPA recommendation in late winter and lower concentrations in late summer and fall. During our monitoring, we noted manganese concentrations were above EPA recommendations for much of the year at all sites except Site C, which was only observed above the recommendation in February to April 2021. Site C could perhaps have lowered concentrations due to being a pond and the largest body of water on campus. Manganese concentration trends over time could be caused by a combination of anthropogenic and geogenic occurrences, and this trend was also observed in studies conducted

by Wen [2], Hintz et al. [15] and Hintz & Relyea [16]. These authors found evidence that the use of road salts can lead to the leaching of heavy metal ions such as manganese from affected soil where they can be carried via groundwater into freshwater rivers and streams.

The combined data from multiple observations of HCC's freshwater streams and pond shows that conductivity and chloride concentrations are elevated at certain times throughout the year, particularly the winter months, and often these concentrations exceed what is considered ideal for freshwater ecosystems [38]. Although the EPA has not set specific guidance for conductivity levels at this time, an EPA-funded study of freshwater streams in West Virginia in 2011 established a limit of 300µS/cm for chronic exposure for aquatic life [38], with the intent to protect freshwater species from unhealthy exposure to ions that contribute to excessive conductivity levels. According to the EPA, within fisheries, 50-500µS/cm is considered ideal [37], and levels outside of that range could prove harmful. Cormier [38] found that conductivity could be affected by different salts that are prevalent in the region and also harmful to aquatic life. While we did not observe chloride concentrations above the acute exposure limit, we did observe levels that were above the chronic exposure limit in all locations in March 2021 and all locations but Site C in February 2022. As we only collected samples during a single time-point one day during that month, it is unclear if the concentrations observed persisted for the four days necessary for these concentrations to have appreciable impacts on the biota within the stream systems. Daily water quality measurement would need to be collected in the future to identify if the organisms are exposed to chronically harmful concentrations of chloride during winter months.

Conclusions

We found that freshwater chemistry of HCC's streams and pond is affected by natural and anthropogenic occurrences on and around campus, and reached this conclusion after observing chemical trends that align with seasonal anthropogenic activities. Conductivity and concentrations of chloride and manganese ions are generally highest in January, February and March, which is typically when Maryland experiences winter weather and road salts are used. We noted a decrease in ion concentrations through the spring and summer into the fall, then increasing again in winter when frozen precipitation began. It appears that together natural and anthropogenic occurrences are contributing to seasonal changes in freshwater chemistry on HCC's campus.

Direction for Future Research

Time limitations prevented a thorough analysis of nickel (Ni); by the writing of this paper only a few samples had been analyzed for their nickel concentration. It is recommended that the samples that we collected for this study be analyzed for nickel and other heavy metals, especially those that similar investigations have indicated can be elevated along with manganese and conductivity. Some of these co-existing metals, such as chromium (Cr), lead (Pb) [32], cadmium (Cd), cobalt (Co), arsenic (As), and iron (Fe) [9-12], have a greater toxicological potential than manganese and copper.

It should also be noted that most samples were collected on dry, sunny days, which was due to the random occurrence of this weather happening during pre-scheduled sampling times.

The only time samples were collected during a rain event was on 8/17/2021, and there was a sudden significant increase in copper concentration at Sites A and B. This suggests that copper is being carried into the streams by stormwater runoff, possibly with contaminants originating from parking lots and other impervious surfaces. In contrast, the runoff appeared to dilute the concentration of manganese in samples collected during precipitation, suggesting that most of the manganese in these groundwater systems comes from groundwater input to the streams. More data is needed to verify this hypothesis. We recommend that more samples be collected during or immediately after precipitation events to gain a better understanding of the natural trends in water quality and heavy metal concentration in the streams and pond on campus and the influences of anthropogenic inputs as a result of such events. Additionally, close monitoring of the campus streams before, during, and after winter precipitation in particular is recommended to provide more information about the correlation between road salt application and changes in levels of manganese and chloride.

Groundbreaking for the new Mathematics Athletics Center occurred in 2021 and construction began shortly thereafter on the south side of campus. Because the water quality on campus is already poor according to the water quality parameters we measured, it is recommended that water quality be closely monitored during and after construction to assess any increase in conductivity or heavy metal contamination. It is crucial to maintain the health of the campus freshwater out of concern for the local campus ecosystem and larger state and regional watersheds and tributaries.

Supplementary Data

A more comprehensive data set, including water parameters data not included in this paper, can be found at https://sites.google.com/view/hcc-streams-research.

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“The Search for Olive Trees”

Ji Young Park

Acrylic on paper and Adobe Photoshop

Mental health in the Muslim community; a topic I was unfamiliar with. After reading the abstract, I was immediately interested in learning about Muslim culture and the negative stigma of mental health within the community. Introducing different resources and ideas, the researcher, Wajhee Zaidi, has been the source of my inspiration. The figure in the artwork and the idea of drawing the brain are both his own. With these main elements, I added olive trees, which represent peace and a gift from Allah in the Qur’an. The hoopoe bird, also mentioned in the Qur’an, symbolizes the belief in which birds are protectors. Furthermore, both a representation of life and nature, and the prophet Mohammed’s favorite color, the theme of green serves as a symbol of Islam. The combination of these elements illustrate an idea of harmony and serenity when feeling accepted for mental health issues in the Muslim community.

Mentored by: Rebecca Bafford

The Long-Awaited Conversation: Mental Health in the Muslim Community

Wajhee Zaidi, *Howard Community College*
Mentored by: Matthew Van Hoose, Ph.D.

Abstract

A significant body of literature has addressed mental-health issues within the Muslim community, including specific causes and challenges related to treatment. This study expands upon this literature by examining how attitudes about mental health vary across generations among Muslim communities in Maryland. Data were gathered through multiple semi-structured interviews to gain first-hand perspectives from within these communities. Interviewees' responses highlighted three main themes shaping inter-generational relations around mental health: fear of judgment from parents, family, friends, and other community members; a prevalent ideology that mental health is not perceived as a real issue in Muslim households; and a lack of adequate communication on several different levels regarding mental-health conditions. Based on these results, this paper concludes by outlining specific recommendations for action suggested by the younger participants in the study.

Paper

According to the Pew Research Center, there were about "3.45 million Muslims of all ages living in the U.S. in 2017, making up about 1.1% of the total U.S. population" [1]. Founded 1400 years ago, Islam is a major monotheistic religion based on the revelations of the Prophet Muhammed. There are over 1.65 billion followers of Islam, known as Muslims, worldwide, and this number is expected to increase, making Islam the second-largest religion in the world [2]. Islam is a universal religion that, like most other major religions, teaches that God is merciful and compassionate and promotes concepts such as world peace, equality, doing good, and forbidding evil [2, 3]. It can also be argued that Islam, at its roots, emphasizes and values the importance of good mental health and emotional stability [4]. Verses from the Quran, the holy book of Muslims, are often used as a remedy for those in distress and as a guide to lead people to a meaningful quality of life. Islamic values and beliefs, in other words, can be beneficial in the treatment of mental illnesses, and some have suggested that Muslims can use the Quran as a tool to exercise psychotherapeutic techniques to remedy their inner turmoil [2]. In many contemporary Muslim communities and households, however, the term "mental health" itself carries markedly Western connotations and mental-health conditions and treatment are stigmatized within many parts of the Muslim community [5]. The resulting lack of resources for managing mental-health challenges constitutes the focus of this paper.

It is important to first consider the factors that shape mental health in the daily life of contemporary U.S. Muslims. Islamic methods and ideologies follow the leaders of the religion, as well as the Quran. Additionally, nowadays one's parents play a major factor in their children's lives in Muslim households. Many Muslim households in the United States are composed of immigrants, who have immigrated with their families within the past 20 years, with the children being first-generation college students pursuing an American education. Within this context, one factor that significantly affects Muslim mental health is discrimination. According to Ahmed and Reddy, "In addition to the trauma associated with being a refugee, an American Muslim refugee's experience is exacerbated by feelings of insecurity, uncertainty, and hopelessness due to real or perceived religious discrimination in the United States. Cultural taboos regarding the use of mental health services and the lack of education on common mental health illnesses and their symptoms also prevent many refugees from obtaining necessary mental health services and often contribute to an increased risk of anger, depression, and domestic violence" [5]. These observations reflect the negative effects of living in a new world for immigrating Muslims and the physical and psychological toll it takes on them. Migrating to a new land, not knowing the language or currency, and lacking access to assistance can drastically affect a person's mental health, on top of the circumstances that prompted refugees to flee their home countries in the first case. This situation is further compounded by discrimination stemming from the events of September 11, 2001, as the majority of individuals entering the country that are being interrogated by the Federal Bureau of Investigations have been primarily Muslims, which has resulted in "many American Muslim immigrants feeling unfairly targeted by the government because of their religious beliefs" [5]. These same people are seen by their own neighbors and colleagues as a threat years after the events of September 11th.

Another factor tied to the mental health of Muslim Americans has been their faith and religion. According to Hall and Livingston, "Islam is by far the prevailing expression of spirituality among families of Arab descent. In Middle Eastern villages, individuals are born into it and expected to remain committed for life. Their commitment to Islam is so old and deep-rooted that it has permeated all aspects of family life (Al-Krenawi & Graham, 2000). Islam is most evident in the belief system held by persons dedicated to the faith. These beliefs are considered canons and not subject to debate" [6]. Transferred to the U.S. context, this core tenet of Islam can lead to conflicts between older and younger generations of Muslim Americans. Many cultural and religious practices do not make logical sense to the younger generation of Islam. The religion of Islam will say one thing, and generational customs and culture will say another. Some examples of this include what to eat, drink, and smoke. Under Islamic law, for example, consuming alcohol is strictly forbidden; however, some cultural leaders in 2021 not only consume alcohol but attempt to influence others in their communities, as well. These intergenerational tensions and conflicts constitute another key part of the context for this paper.

The topic of mental health is controversial, as well as a sensitive one, as everyone deals with it differently. Taking this into account, this paper will address two main questions. The first question is: How is mental health perceived in Muslim households by young people (age 18-25) versus older adults (age 35+), especially in relation to levels of stigma and support for professional assistance with mental-health conditions? The second, related question is: Do attitudes about mental health issues vary by generation, and if so, what do interviewees' responses suggest about possible strategies for addressing this discrepancy? This project

explored these questions through semi-structured interviews of approximately one hour in duration with eight Muslim individuals residing in the state of Maryland, varying in age from 18 to 50+. Each interviewee's name was changed to a pseudonym for protection of privacy, as well as to provide unbiased and free answers. Interviewees' responses highlighted three main themes: fear of judgment from parents, family, friends, and other community members; a prevalent ideology that mental health is not perceived as a real issue in Muslim households; and a lack of adequate communication on several different levels regarding mental-health conditions.

One of the driving factors of mental-health challenges among Muslim Americans is fear of judgment. Judgment takes a heavy burden on many people. Interviewees frequently expressed that they were afraid of being judged for their conditions or feelings by their parents and members of the community. For example, one of the interviewees, Aamirah, a 21-year-old Pakistani woman, stated that every member of her friend group, composed of seven Pakistani girls all within her age range, has mental-health issues. Of one of her friends in particular, she shared that "her older brother believes her to be lazy, her parents don't understand about mental health and often have scolded her for overreacting to her anxiety and depression." Aamirah continued, "Mental health can be taken the wrong way, as my friend in her depression ghosted us, and if I hadn't known about her depression, I could've taken it the wrong way, as a friend. She expressed that she has a fear of expressing her emotions with her parents and extended friends due to rejection, and immediately jumping to the conclusion that something is incurable about her." Aamirah related that her friend has tried to reach out to a variety of people within her Muslim community, as well as her parents, but to no avail, as they immediately think that these issues are the cause of something else and fail to hear her cries of need.

Asad, a 22-year-old Pakistani American male who suffers from depressive and anxiety-induced episodes, related a similar experience. Throughout his life, he feels that he has not received the support he has needed. When asked how older generations in Muslim households perceived mental-health issues, he stated that "mental health to elders in our culture is perceived as insanity, as these elders immediately jump to thoughts such as 'this guy is crazy, he belongs in an insane asylum, you have a mental disorder? This is very weird for me.' If we tell our parents, 'I'm taking antidepressants,' they're going to act shocked, and think 'what is wrong with my child, they're crazy.'" "My perception," says Asad, "is there's nothing wrong with getting a little help. The brain is a very complex organ. Sometimes depression is a chemical imbalance in your head, as you don't have enough serotonin and need drugs prescribed from a doctor to help you out. This is perfectly normal. In today's society, it is not uncommon for anybody to suffer through depression, and I feel it should be normalized in our culture, in the Pakistani atmosphere."

Ahmed and Reddy, following Daneshpour (1998), provide some context for Asad's experience in noting that "...immigrant parents are more likely to be authoritarian and focus on the collective good and family honor, as opposed to valuing the individual" [5]. Asad links this broader phenomenon specifically to Muslim parents' attitudes toward mental health, noting their resistance to the idea that mental-health challenges may result in part from imbalances within an individual's brain and genome that can be addressed with medication. In the absence of this recognition, younger Muslims are often told that they should simply be able to control the way they are feeling.

He also attributes many of his challenges to not being able to express himself freely to his family concerning mental health. “A hostile environment has been created,” he says, “for young kids such as myself to reach out. It is very hard to talk about issues due to familial factors such as embarrassment and neglect, which inevitably results in children silently suffering.” Another interviewee, Iqra, a 21-year-old Pakistani woman who suffers from anxiety and panic attacks, said, “Muslim friends that I know have to sneak around to go to therapy and often use excuses that would be justified in their household to mask their true intentions. My friends often tell their parents ‘I’m going to the library,’ but in actuality, they’re going to a therapist.”

One explanation for this hostility toward therapy could be, as younger interviewees frequently observed, that their parents and grandparents do not believe that mental health is a real issue. This dismissive position heightens the sense of isolation for individuals struggling with mental-health conditions. Some interviewees attributed these attitudes within the older generation to ignorance or a lack of education, while others cited broader cultural factors in their relatives’ home environments. For example, Samia, a 24-year-old Pakistani American who suffers from constant negative thoughts and obsessive-compulsive disorder (OCD), said, “Many Pakistani adults think depression is a myth, and there’s no reason to be hard-depressed in someone’s life. Most, if not all, people are going through some sort of distress, and most of the time they don't understand it or realize it. Our parents, I’m sure they went through mental trauma as well, but didn’t realize it or think it was a priority based on the environment that they grew up in.” Along similar lines, Aamirah theorized that “older generations such as aged 50+, I believe don't know how to cope with mental health, as it has never been discussed back in Pakistan in relation to today in the U.S. I don't think I’ve ever heard of an older person of Pakistani descent talking about mental health. They just worried about getting a roof over their head, and didn’t know how to deal with it.” Younger interviewees perceived that their parents came from a completely different world back in the Middle East and sensed that the adults currently living in the U.S. are still treating their surroundings and ideologies as if they had never immigrated. This phenomenon can be related to Maslow’s hierarchy of needs, which posits that an individual can only grow to greater lengths and achievements once more basic needs are met. The first two levels of needs are physiological, which focus on the person’s hunger, thirst, and bodily comforts, followed by safety and security, which deals with the individual being out of any danger [7]. Interviewees’ responses can imply that older generations in their households never made it past the first couple of levels of Maslow’s pyramid, even as their material circumstances improved.

Amir, a 52-year-old Pakistani American father of two, shared insights that seemed to affirm the assertions of the younger interviewees for this project. When asked for his opinions on mental health, Amir responded by saying, “What is mental health?” Upon hearing the explanation provided to him, and the rest of the responses from the other interviews, Amir stated, “This cannot be real, as when I was younger and migrated, and got sad, I got over it. Stress is normal for me, as I’m sure it is for everyone. My children are 22 and 25 and have never struggled with what you are saying. Just like me, when they were sad, they got over it.” Upon being asked if his children ever brought up the issue of mental health, he responded, “Yes, they have addressed that they think something may be wrong, other than sadness, but I dismissed it and told them to get over it as it seemed to me that they were overreacting, and it was never

brought up again." After further conversing, Amir realized that he had shunned and suppressed his sons' cries for help.

After the interview, Amir chose to call his sons to apologize and offered to listen in the future, realizing that mental health is real. In his conversation with them, he expressed how sorry he was, and felt that he had failed as a father to nurture them properly. He said, "If only I had seen the warning signs sooner and listened, you both may have been able to get professional help and would not have had to suffer alone. I'm so grateful to Allah that you both are so strong and looked past the barrier that was your father to be happier, regardless of the issues that tormented your mind. I'm so proud to call you my sons." Both of his sons had similar responses, each expressing their gratitude and love toward their father. One son visited Amir the next day after conversing, and the other gathered the courage to tell his father that he has been going to therapy for years. His two sons fully appreciated his realization of the truth behind mental health, which resulted in a closer bond between their family. This leads into a third possible factor as to why perceptions of mental health differ in the Muslim community, which is as simple as miscommunication.

Barriers to communication with their parents, most interviewees expressed, were a defining component of their struggles with mental health. Samia reflected, "What is therapy? Therapy is communication. You are having a conversation with somebody else who does not know you, and will not think any differently of you. I don't know of many who go to therapy in the Pakistani community, as therapy is not something that is accepted or seen as normal, which is stupid because a lot of Americans go to therapy, and it's nothing for them and helps their mental health." While reservations about therapy are surely present in many sectors of the non-Muslim U.S. population, the perception that Americans were more accepting of mental-health care was common among the Muslim participants in this study. Regardless of different regions and classes among interviewees, a common point brought up was that Middle Eastern elders don't acknowledge or understand mental health in contrast to different areas of the world. Another interviewee, Zaki, a 36-year-old Afghanistani man, said, "I grew up in a joint family household, and there were a lot of us (over 3 large families). Due to the large influx of people, there was always so much going on. As a child, I didn't know what the issues were between my parents, their siblings, in-laws, etc. As I grew older, these issues sometimes got worse, and I know now that it was due to a lack of communication. For the most part, it was a very family-orientated household, but having that many people live in one house at a time can take a toll on some more than others." Zaki described a situation in which people did not express themselves or their problems with one another, which led to issues escalating and progressively becoming far worse.

There is no question that there are differences in perceptions of mental health among the various members of the Maryland-residing Muslim community interviewed for this study. Individuals that compose the younger generation feel that their voice is not heard, and that mental health is a real issue. Inversely, older members of the community are still struggling to understand the words "mental-health," even after years of living in the U.S. context. Because of this, participants were also asked about the factors that shaped their beliefs on mental health. A very common answer received among the younger interviewees was derived from their own experiences, as well as their peers' experiences. The emphasis on the authenticity of this subject is that people are coming forward with their stories without any fear of being judged. These are

real people with stories of their own being silenced throughout their lives. The participants in this study have experienced these horrors and aim to prevent others from experiencing them as well. Asad said in his interview, “I’ll reach out to my peers before I reach out to older people in my culture; we understand each other. We’re all in this together in our generation. We have the same factors that rule our lives such as social media, bullying, interpersonal relationships with a new generation, etc. You find a sense of community in others suffering through the same things as you, as it helps to know you’re not alone.” This makes sense for members of the younger generation. Everyone around you can help you in some way, and Asad captures well why children tend to go to their trusted friends first. Since they are all younger and exposed to essentially the same environment, they undergo similar experiences and understand each other more. They converse with and confide in one another and listen. Mental-health is very real to Muslims, and in trying to please others who do not understand the struggles, those suffering tend to drown alone.

Another prime factor that has shaped the younger generation’s views on this topic is education. In America, mental health is far more emphasized in the classrooms, and multiple sources of assistance are at students’ disposal, such as guidance counselors, stress-relievers, recovery programs, etc. These resources were not available to the elders during their time in countries such as Pakistan, Afghanistan, India, etc., which are notable causes for their lower levels of understanding of the severity and significance of mental health issues.

So, what does all this mean? Where is all the information conveyed by these interviews leading, and what can be done? All the interviews point in a single direction: change. A general trend found was that young Muslims would like to see change within the community, so the community overall is healthier as it evolves and progresses. After one generation passes, there will be countless others that should be guided on a healthy path. The most recurrent piece of advice interviewees gave has been targeted at communication. Communication encourages understanding, safety, and unity among individuals. To the younger generation, Samia offers this advice: “The most important thing to do is communicate with someone that you can trust. It doesn’t matter if you’re an introvert or an extrovert. If you let your condition take control over you, it will have a hold on you forever. Even if the person isn’t understanding at first, at least you’re letting out.” By not keeping these feelings bottled in, it releases a great deal of tension within. It is unsurprising that young adolescent Muslims experience mental-health issues such as depression. They experience significant pressure in their households to get married, get a high-paying career, and provide for their families; and they deserve to be heard and supported when their mental health suffers.

To members of the older generation in the Muslim community, Asad advises, “Offer all possible sources of help and be a homing beacon to your children. Take notice and watch out for the signs. Understand the warning signs that your son or daughter is conveying to you. There is a massive lack of outreach with brown parents. When the signs are first given, parents believe children are showing attitude or being disrespectful.” Many of the young Muslims interviewed for this study experienced their households as environments concerned with reputation and pride to the point that relationships suffered. The message conveyed in these interviews could well be summarized as: There is a better way, there are cures, and there are vast quantities of help. Start the discussion.

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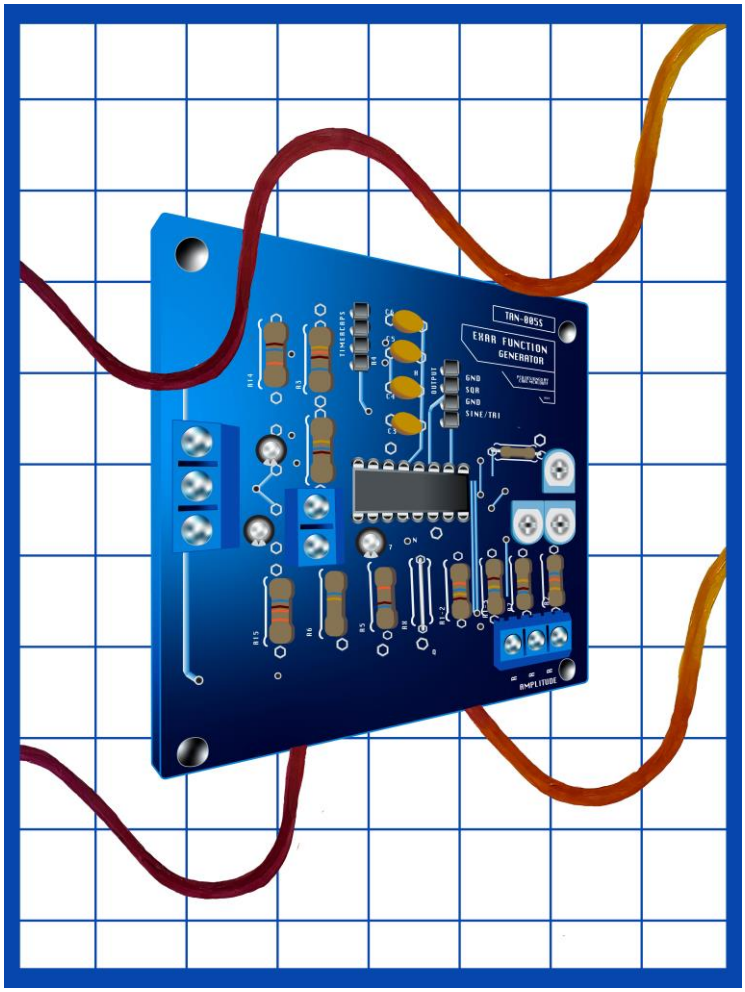
“Honed”

Lily Cortes

Digital Illustration

Since before the beginning of the pandemic, I had been quietly pondering my place in the LGBTQ+ community. I hoped that exploring the topic in my art would give me some new insight. The language of flowers is the foundation of the composition while the comic format allows for the exploration of the resilience of the LGBTQ+ community through narrative. The character’s main colors reference lavender and violets, which have been continuously linked to LGBTQ+ dating back to the lyrics of the Greek poet Sappho. She is gifted a wolf’s bane, a poisonous plant used only as a warning for danger. Instead of succumbing to the person’s hate, she plants the flowers and they grow into a gladiolus, signifying her strength and courage.

Mentored by: Neil C Jones



“Sounds and Synthesizers”

Sofia Medillin

Mixed Media Digital Illustration

My initial thought going into this project was that I wanted to challenge and expand my artistic abilities so I chose to create something digitally. After reviewing the abstracts, I had a notion that the combination of technology and engineering in the “Constructing and Testing an Analog Synthesizer” would be portrayed through a digital illustration. I learned from the creator that his project inspiration came from his hobby of making music after he was inspired to merge his knowledge of electrical engineering and music together. After hearing this, I felt as though there was something very innate about it because he took two of his passions and literally combined them together. His passion for music and engineering gave me the idea to create a mixed media piece because it would look more dynamic with two different mediums. I wanted there to be a clear distinction between the technology and sound in order to demonstrate the creator as well as his project.

Mentored by: Steven H Silberg

It is only fitting in this anniversary year to look back and acknowledge some of the groups and individuals who helped JRIP to reach forward and beyond its inception.

In addition to members of the initial FPLC, all of whom were STEM faculty, staff and administrators who have long been advocates for undergraduate research at HCC, much of the funding that made the first four volumes of the journal possible was provided by The Kahlert Foundation. Thanks in part to the infrastructure established through their financial support, JRIP is able to publish its fifth volume independently for the first time this year.

Former Deans of the Science, Engineering, and Technology and Mathematics Divisions, Patti Turner and Mike Long, inexorably championed for JRIP, making sure to provision for its continuation by apportioning time, resources, and manpower in whatever ways were possible. While both have moved on from their positions at HCC, they leave behind a legacy of incomparable advocacy. Former Editorial Team Chair and Physics faculty member, Alex Barr, led the charge with calm, competence, and an analytical eye until the end of the Spring 2021 semester when an out-of-state move necessitated his departure from both the college and the journal. And such folks as Math faculty, Adrian Kuhlman, Loretta Tokoly, and Carol Howald, provided steadfast support by expertly attending to such things as final formatting and event and peer review coordination, all with efficacy and care.

You'll likely notice the striking and thought-provoking artwork in this volume which has become a hallmark of JRIP. This would not have been possible without the organizing done by a number of Art faculty and staff over the years to engage students in the process of collaboration between artists and researchers. Much gratitude and appreciation to Fahimeh Vahdat, Jeremy Bomberg, and especially Steve Silberg for his commitment in the last year to connecting student artists and researchers in creative and innovative ways.

Thank you

CELEBRATING ORIGINAL STUDENT RESEARCH FOR 5 YEARS

JR IP Journal of Research in Progress

at Howard Community College