INSPIRE
INTERACTIVE NASA SPACE PHYSICS
IONOSPHERE RADIO EXPERIMENTS

The INSPIRE Journal

VOLUME 25 SPRING 2021

A publication of The INSPIRE Project Inc.

Contents

COVER IMAGE: Illustration depicting Mars Helicopter Ingenuity during a test flight. Ingenuity was taken to Mars strapped to the belly of the Perseverance rover (seen in the background). NASA's Jet Propulsion Laboratory built and managed operations of Perseverance and Ingenuity for the agency. Caltech in Pasadena, California manages JPL for NASA.
Image credit: NASA/JPL-Caltech

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INSPIRE'S LEGACY
Dr. William (Bill) W. L. Taylor was a leader in the field of space science education and public outreach. He co-founded and was president of INSPIRE, one of the pioneering successes in NASA Sun Earth Connection Education. NASA Goddard Space Flight Center honored the late William W. L. Taylor with an *Excellence in Outreach in Science* Award for his accomplishments.

CO-FOUNDER/EMERITUS
William E. Pine

IN MEMORIAM
Kathleen Franzen, President 2005 – 2010
Jack Reed, INSPIRE Board Member 1992 – 2009
Jim Ericson, INSPIRE 1st Vice President 1981 – 2006

MISSION
The INSPIRE Project Inc. is a non-profit scientific, educational corporation whose objective is to bring the excitement of observing natural and manmade radio waves in the audio region to high school students. Underlying this objective is the conviction that science and technology are the underpinnings of our modern society, and that only with an understanding of science and technology can people make correct decisions in their lives, public, professional, and private. Stimulating students to learn and understand science and technology is key to them fulfilling their potential in the best interests of our society. INSPIRE also is an innovative, unique opportunity for students to actively gather data that might be used in a basic research project.

– *William W. L. Taylor and William E. Pine, Co-Founders*

In 2009, The INSPIRE Project expanded its STEM educational programs to provide scholarships and internships to educators, middle/high school students, and university students to ensure the next generation of space science and technology explorers.

From the Editor/Program Manager

Eva Kloostra

Audemário Prazeres, founding president of AAP, with his 10-year-old daughter who dreams of becoming a space engineer for NASA

For thirty-two years, The INSPIRE Project has engaged students of all ages in Science, Technology, Engineering and Mathematics (STEM) by bringing the excitement of observing natural and manmade radio waves in the audio region. To date over 3,800 INSPIRE Very Low Frequency (VLF) radio receiver kits have provided students worldwide a hands-on opportunity to experience the sounds of space firsthand. INSPIRE's VLF-3 kit continues to be incorporated in middle/high school science curricula and university programs both nationally and internationally. INSPIRE recently donated a VLF receiver kit to the Astronomic Association of Pernambuco (AAP) in the State of Pernambuco, Brazil. For 36 years, the organization has dedicated itself to the social project "Astronomia Solidária" which introduces and engages students living in rural peripheries and disadvantaged areas to STEM disciplines (*see page 29)*. We look forward to sharing their VLF observations in our next issue.

In 2009, INSPIRE expanded its STEM programs to include internships at NASA Goddard Space Flight Center for undergraduate and graduate students, the William W.L. "Bill" Taylor Memorial STEM Scholarship for college/university students in Washington DC, and scholarships for middle/high school educators and students to participate in the U.S. Space & Rocket Center's Space Academy programs in Huntsville, Alabama. Over the past decade, INSPIRE has awarded 164 STEM scholarships and internships. Though due to the pandemic the Space Academy program has been temporarily suspended until summer 2022, past space camp students who were members of the INSPIRE NASA 2017 Solar Eclipse Team continue to excel and share some of their many recent (and impressive!) endeavors *(see page 30)*.

"Astronaut Rick" at INSPIRE's 2015 graduation luncheon with Space Camp recipient Clark Gray

Someone who knows the majority of INSPIRE's Space Camp alumni is INSPIRE board member Rick Chappell, fondly known as "Astronaut Rick" to our students and educators. Rick has inspired dozens of students to pursue an education in STEM disciplines at our interactive graduation lunches over the years. Rick was selected by the American Geophysical Union (AGU) to be featured in "Perspectives of Earth and Space Scientists" and shares his amazing journey, unbridled passion and impressive career – thank goodness he did not become a baseball player *(see page 15)*.

In February 2021, I was asked by the NASA District of Columbia Space Grant Consortium to be a judge for the Student Research Competition which was held virtually this year via YouTube. INSPIRE invited the students to share their exciting DC college/university research projects with our readers *(see page 6)*. *The INSPIRE Project is an affiliate member of the NASA DC Space Grant Consortium which helps to fund many of our educational STEM programs.*

The NASA Jet Propulsion Laboratory tweeted on April 19, 2021: The #MarsHelicopter made history today by being the first craft to achieve controlled, powered flight on a planet beyond Earth. On April 30 NASA announced, "For the first time, a spacecraft on another planet has recorded the sounds of a separate spacecraft. NASA's Perseverance Mars rover used one of its two microphones to listen as the Ingenuity helicopter flew for the fourth time. A new video combines footage of the solar-powered helicopter taken by Perseverance's Mastcam-Z imager with audio from a microphone belonging to the rover's SuperCam laser instrument." INSPIRE Chief Technical Advisor Dennis Gallagher of NASA Marshall Space Flight Center submitted a spectrogram of a portion of the audio *(see page 14)*. Thank you, Dennis! To view visit: https://mars.nasa.gov/resources/25892/listen-to-nasas-ingenuity-mars-helicopter-in-flight/

NASA's Ingenuity Mars Helicopter is viewed by one of the hazard cameras aboard the Perseverance rover during the helicopter's 4th flight on April 30, 2021
Photo: NASA/JPL-Caltech

On behalf of the Board of Directors, thank you for your continued support of The INSPIRE Project's mission and STEM programs!

Never Stop Exploring and Stay Safe ~ Eva

On behalf of the Board of Directors, thank you to our friends, colleagues, volunteers and corporate partners for your continued support of The INSPIRE Project's mission of inspiring our next generation of scientists and explorers. Without your support, our programs would not be possible.

Special thanks to the following for their contribution to this volume of The INSPIRE Journal:

Technical Editing:
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Mitzi Adams – NASA Marshall Space Flight Center
Dr. Phillip Webb – INSPIRE Board President
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And to all who submitted articles and content for inclusion.

Natural Radio & VLF Group

Visit: https://groups.io/g/VLF

Formerly Yahoo VLF Discussion Group

Shawn Korgan, Founder/Group Moderator & Mark Karney, Group Administrator/Moderator

The Natural Radio & VLF Group, formerly the Yahoo VLF Discussion Group, was founded by Shawn Korgan in 2001. It is a discussion group dedicated to those who enjoy monitoring radio frequencies in the VLF (very low frequency) radio spectrum (3-30 kHz) and the surrounding radio frequencies.

We listen to the amazing Natural Radio sounds created by planet Earth such as whistlers, chorus, tweeks, risers, sferics and hiss on simple VLF receivers (Whistler Receivers). This is a form of radio astronomy. You can listen to beautiful bird-like sounds created by the northern lights on your whistler receiver while watching them at the same time! Or hear an incoming solar flare impact our planet's ionosphere and magnetosphere in real time! Listen to distant lightning's metallic ring during nighttime hours. Study sprites and jets and learn about Space Weather. Discuss VLF receiver designs. Some members monitor Military and Government and VLF stations to assess the effects of solar activity on the ionosphere. Others experiment with transmitting on certain VLF frequencies.

Become a member today by simply sending an email to: VLF+subscribe@groups.io from the e-mail account you wish to have subscribed to the Natural Radio & VLF Group. Membership is open to anyone interested in any aspect of VLF.

Please note that we conduct our discussions within the bounds of proven science. Discussions of fringe science, speculative science and conspiracy theories are considered off-topic and out of place on this forum.

We encourage new members to visit our website at https://naturalradiolab.com/ for introductory information to the world of Natural Radio listening.

About Shawn Korgan

Shawn Korgan was born and raised in northern Colorado. He became interested in radio astronomy while in middle school during the 1980's in large part due to reading a magazine article advertising VLF receivers which could tune into the amazing sounds of the Northern Lights and whistling sounds generated by lightning. In the late 1990's when the Internet became available where he resides, he discovered how to construct a VLF receiver and listen to the amazing sounds of nature personally. His most active period of VLF monitoring was between 1998-2009. Shawn has always enjoyed the VLF discussion group as it allows members to work together to accomplish otherwise impossible tasks such as designing software to eliminate power line interference and setting up almost a dozen online VLF audio streams from around the world. Visit: http://www.abelian.org/vlf/

INSPIRE Project's Bill Taylor Memorial Scholarship Recipient Fulfilling Her STEM Dreams

Morgan Brinson

Morgan Brinson in her graduation cap and gown at American University (May 2021)

Every day I think about how college is a stepping stone for my dream career and if I could not attend, then I would lose several opportunities to attain the level of success. Receiving The INSPIRE Project's Dr. William W.L. "Bill" Taylor Memorial STEM scholarship, has allowed me to continue on this pathway in reaching my goal.

STEM is not just an acronym widely used in the educational arena; it has been a huge part of my life in creating the person I am today. My influences in this area have come from the women in my family who are engineers and doctors. Throughout my life, It has been ingrained in me that anything is possible as long as you put in the time and effort. This has led to my studies in Physics with a Biomedical Engineering focus. My career goal is to create medical devices that enable others to get back to living a more "normal" life or getting back to the activities they enjoy through rehabilitation medicine.

This scholarship has not only supported my studies, greatly reduced the financial burden, but has also permeated a level of focus and success. It has allowed me to incorporate extracurricular activities (conferences, research work, design and build lab) thereby giving me a chance to acquire real-world experiences that will impact and enhance my overall learning. The summer of 2019, I received an internship with MacroGenics in their manufacturing department. I was able to explore the field of biotechnology and understand cell culture and purification for pharmaceuticals. This opportunity was eye-opening and truly brought more excitement as to what my future holds. I have become inspired to start manufacturing my own device tailored to customers as well and I am eager to see what that journey will look like! As a scholarship recipient, this helped to create a stable environment at school and opened up windows of opportunities to fulfill my dreams in STEM.

To learn more about the William W.L. "Bill" Taylor Memorial College/University Scholarship or to apply online, visit: http://theinspireproject.org/default.asp?contentID=5

About Morgan Brinson

Morgan Brinson is currently a graduating senior at American University. She is a Physics major specializing in biomedical engineering and a student athlete on the women's soccer team. Morgan enjoys playing golf, volunteering, traveling, and photography. Morgan's accomplishments include: 2019 MacroGenics Manufacturing Intern, 2019 AU/NASA ThinStats research project, 2019-2021 Design and Build Lab Creative and Technical Specialist, 2019 & 2020 Patriot League Academic Honor Roll, 2020 Black Student-Athlete in Leadership Certificate, 2020 Biophysics Researcher at Georgia Tech, 2021 Dean's List, 2021 SASP Academic Success Award, and 2021 AU Physics Student Award for Outstanding Researcher.

Morgan wants to become a part of the movement of creating life-changing medical devices and products. She hopes to explore developing and advancing affordable medical devices and prosthetics. Her vision has been inspired by numerous years of volunteering with Children's Integrity Fund, The Grassroot Project, Habitat for Humanity, and Teen SWAG bags for the Homeless. When life throws a rock, one can feel defeated or choose to face adversity that will lead them to get the help they need that will allow them to take care of themselves. One of the ways of support can be through innovative medical designs. To fulfill her dream career in the Fall of 2021, she will be attending Rice University for her Ph.D. in Electrical and Computer Engineering.

A quote that resonates with Morgan in achieving her dreams is "Average is the disease, your [vision] is the cure" by WrldinVsn. Due to Morgan's creative mind and big heart, she aspires to advance technology for all social classes. Another one of her favorite quotes by Dana Linn Bailey reminds her: "If you have discipline, drive, and determination...nothing is impossible." No matter how hard the task is that day, it will be completed. Standing by those three words to conquer what appears to be impossible has built the resilience to stay with her passion and not stray.

2021 NASA DC Space Grant Consortium Student Research Competition

This competition held in March 2021 was sponsored by the NASA District of Columbia Space Grant Consortium (DCSGC), one of 52 members of a national network known as "Space Grant," which encompasses more than 1,200 universities and organizations in every state, the District of Columbia, and Puerto Rico. The Space Grant Program is administered by NASA. The DCSGC offers DC university students opportunities for internships, fellowships and scholarships, as well as research opportunities. It's all part of NASA's overarching mission to increase public knowledge, support educators, and attract and retain students to pursue STEM advanced degrees and careers. "For American University which serves as the lead institution of the Consortium in the District of Columbia, it provides opportunities to students to have authentic research experiences while supporting NASA missions in science and space technology," says Nathan Harshman, AU Professor of Physics and DCSGC Director. "One goal of the program is to broaden the pipeline of students prepared for joining the NASA workforce. The DCSGC also provides matching support to professional development activities to outreach and education projects and programs that build community and excitement around NASA missions. This year, students presented their research posters remotely by making videos and posting them on YouTube. "We are very proud and highly impressed at both the caliber and depth of research our Space Grant-supported students are conducting," says Eric Day, Program Manager of the DCSGC.

The INSPIRE Project is an affiliate member of the DC Space Grant Consortium which helps to fund many of INSPIRE's educational STEM programs. Program Manager Eva Kloostra served as a judge for the competition and was so impressed that INSPIRE invited students who competed to submit their research for publication in The INSPIRE Journal. Below are some of the exciting research projects students are working on at DC colleges and universities.

FIRST PLACE: Annotation and Homology Modeling of the Multidrug Transport Protein P-glycoprotein (ABCB1) of Equus caballus

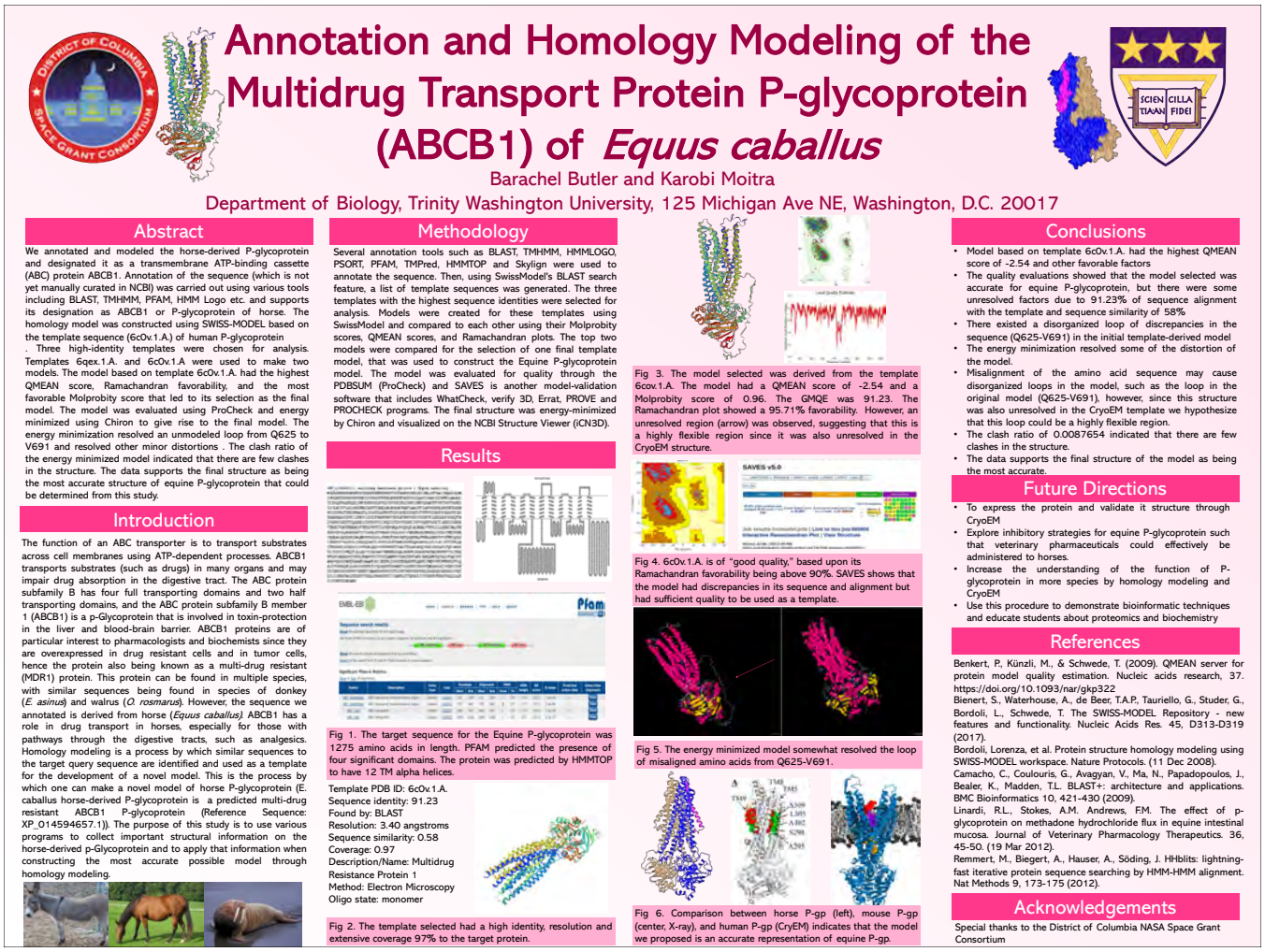
Barachel Butler, Trinity Washington University (Junior)

As a forensic science student, it was indeed serendipitous to embark on a project that was slightly outside of my prior experience and interest. With COVID-19, the ability to complete the NASA Grant internship was in question, but thanks to the creativity and resourcefulness of my mentor, Dr. Karobi Moitra, and that of the other professors and advisors involved, I and my fellow interns were able to do our own research completely virtually. So when my project turned out to be about proteomics and bioinformatics rather than forensic DNA analysis, I had to learn and adapt quickly. That was in the summer of 2020, almost one year ago.

This year, I am able to enjoy the success of my research, which was to build a novel model of horse P-glycoprotein using homology modeling through SWISS Model software. The model was based on the BLAST template 6c0v.1.A., a human P-glycoprotein that was similar enough in structure to base a model of the horse P-glycoprotein on. This template had the highest QMEAN score of -2.54 and other favorable factors. The quality evaluations showed that the model selected was accurate for horse P-glycoprotein, but there were some unresolved factors due to 91.23% of sequence alignment with the template and a sequence similarity of 58%. There existed a disorganized loop of discrepancies in the sequence (Q625-V691) in the initial template-derived model.

The energy minimization, which uses the online program Chiron to produce a more stable model, resolved some of the distortion of the model. Misalignment of the amino acid sequence will cause disorganized loops in the model, such as the loop in the original model (Q625-V691), however, since this structure was also unresolved in the CryoEM template, it was hypothesized that this loop could be a highly flexible region. The clash ratio of 0.0087654 indicated that there are few clashes (discrepancies) between the structure of the model and the actual protein sequence of P-glycoprotein. The data supports the final structure of the model as being the most accurate.

In the future, I hope for the expansion of this research to include the expression of the protein through CryoEM to validate its modeled structure and to explore inhibitory strategies for equine P-glycoprotein such that veterinary pharmaceuticals could effectively be administered to horses. Increasing the understanding of the function of P-glycoprotein in more species by homology modeling and CryoEM is another important endeavor that can further contribute to proteomic literature.



Barachel Butler's poster from the 2021 NASA Space Grant Competition

I was so thankful for the opportunities to present my research in both the ABRCMS Virtual Research Fair, as well as in the NASA Space Grant Consortium presentation contest, in which I won first place. I am currently working on an article that I hope to publish in an undergraduate research journal, and I look forward to continuing my education after graduating from Trinity Washington University. Thank you INSPIRE for allowing me to share my experience!
To view Barachel's presentation, visit: https://youtu.be/DUFUENbZBuk

SECOND PLACE: The Influence of Human Mobility and Meteorology on PM2.5 Using Crowdsourced PurpleAir Sensors

Joseph Minnich, American University (Senior)

I'm a senior Computational Physics major from American University and I've been researching air quality over the past two years with Valentina Aquila. Valentina and I discovered Low-Cost Air Quality Sensors (LCAQS) in 2019, a relatively new way of detecting the concentration of fine particulate matter in the air (also called PM2.5). The introduction of LCAQS has democratized air quality monitoring, providing an alternative to expensive regulatory monitors. We became interested in the devices because their low cost makes it feasible to deploy dense sensor arrays and investigate new problems.

In early 2020, we deployed 10 sensors around American University, intending to measure air pollution across campus from winter into summer. Our goal was to quantify the improvement in air quality-related to deciduous trees growing leaves. However, not long after the initial deployment, COVID-19 restrictions went into place making maintaining the network of sensors unfeasible. Back at home, I spent lots of time brainstorming how we could turn this problem into a possibility.

Luckily, PurpleAir sensors are wifi-connectable meaning data was available to me from hundreds of sensors across the world. This got me thinking about what I could do using solely free, open data. Not long after, I discovered SafeGraph's COVID-19 data consortium which provides academic researchers access to anonymized cellphone mobility metrics. Then it dawned on me, COVID-19 stay-at-home orders have created a unique scenario where automobile usage suddenly plummeted, creating a perfect opportunity to study how human mobility is related to PM2.5.

With a great research question in mind, I set out to find a statistical model that fit my needs. I considered using 10s of different models but none were exactly what I was looking for. I needed a model that was suitable for highly complex big data problems but gave results that are easily human-readable. On the one hand, you have linear models which give highly-interpretable results at the cost of low predictability. On the other hand, you have neural networks and deep learning which have remarkable predictive power, but the results can be a bit of a black box. I needed to find a balance, and that's when I learned about the Generalized Additive Model (GAM). The GAM assumes an additive relationship between the independent variables and the dependent variable. The GAM fits so-called factor functions to each independent variable which allows us to analyze how that variable contributes to the dependent variable. Under the hood, GAMs work by fitting a finite sum of splines using a smoothing penalty. Although it may seem trivial, this approach allows us to fit factor functions that look nonlinear using linear methods. Essentially this means a GAM is just a fancy generalized linear model, and therefore we can use confidence intervals, feature selection with p values, fast cross-validation, and more! GAMs are great because they can be fit very quickly, and are very flexible being useful in many different applications.

Because PM2.5 is extremely complex and multivariate I began building a dataset of potentially significant variables. This included NOAA ground weather observations for factors like rainfall and wind speed, SafeGraph's human mobility metrics, and PurpleAir PM2.5 measurements as the dependent variable. We could keep adding variables to our dataset, however, obviously, not all variables are relevant in modeling PM2.5 variation. For this reason, I implemented a variable selection algorithm from Barmpadimos et al to detect variables of interest.

As a test, I compiled a dataset for the Grand Junction Colorado area from March 2019 to April 2020. Chosen for its dense arrangement of PurpleAir sensors near an airport (where NOAA weather observations are taken). All datasources were grouped on the county block group level (*see Figure 1*).

After running the variable selection algorithm with many different fitting parameters, what we found was that in our strict models, weather variables outshined the effect of reduced human mobility. With the more lax models, we found some evidence of statistical significance of human mobility, as the variable was deemed relevant for one county block group.

While working on this project, I watched PurpleAir's network grow substantially. Events such as the California wildfires have gotten everyday people interested in air quality, buying the low cost sensors for themselves and deploying them at their homes.

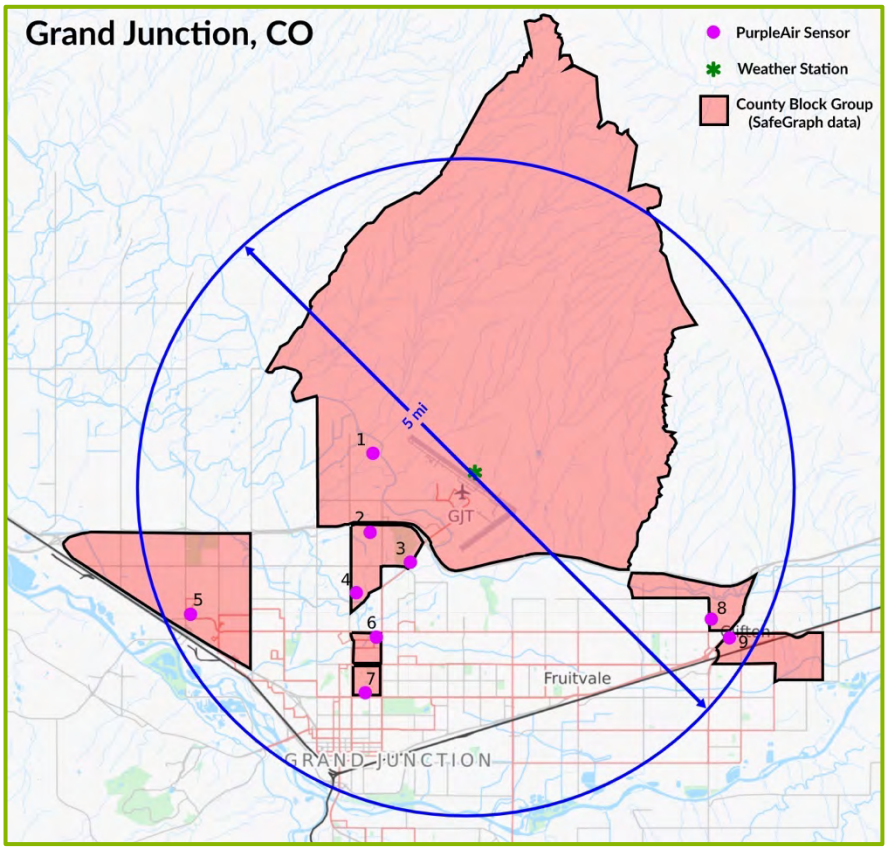


Figure 1: Sketch of Grand Junction, CO setup. PurpleAir sensors are represented by fuchsia dots, ground weather station is represented by a green asterisk, and the CBG corresponding to each PurpleAir sensor is shaded light red.

This constantly improving spatial density of the PurpleAir network is extremely exciting for my approach because it means that it may be applicable to more and more places over time. Another great benefit of my approach is that it can potentially be expanded by the internet-of-things. The internet of things is the concept that an ever-increasing amount of "things" are being embedded with sensors and connected online. As more and more everyday-devices come online, we can potentially get access to more data that could be useful in modeling PM2.5 variations. For instance imagine a future where cars themselves are connected to the internet, giving us data on carbon emissions of individual vehicles. Consider thermostats, grills, lawnmowers, any device that causes increased PM2.5. Because the GAM is an additive approach, the more relevant data sources we supply the model,

the better its overall fit. For this reason, we believe GAMs may be particularly useful in the future internet of things. I am still working on this project, trying to build GAMs which explain PM2.5 variation, especially ones which incorporate human mobility metrics.

In the future, I want to experiment with building GAMs with multivariate factor functions. My goal is to continue improving my dataset, learning how and why different variables relate to PM2.5. I hope that my work can serve as a reference to future researchers, wanting to model PM2.5.

I learned a lot about myself and what it means to be a researcher over the course of this project. I learned that fear of failure severely limits the ability to succeed. To be a successful researcher one must embrace failure with open arms. One must fail spectacularly and often. If your research question can be answered without any failures, it probably isn't a very interesting research question. Additionally, I learned that as counter-intuitive as it sounds, sometimes the most productive move is taking a step away from your project and getting some exercise. Maintaining a balanced lifestyle is key for productivity. Most of all, this project has hammered home the concept that doing good research isn't related to the accuracy or timeliness of a solution, rather it's about asking the right questions.

If you are interested in learning more about my methods and results you can read my capstone final report on my website: http://josephminnich.com/capstone

To view Joseph's presentation, visit: https://youtu.be/JjCYF1_kNMU

Joseph next to a PurpleAir sensor installed at American University

THIRD PLACE: Machine Learning to Map the U.S. Power Grid

Joey Lamborn, American University (Junior)

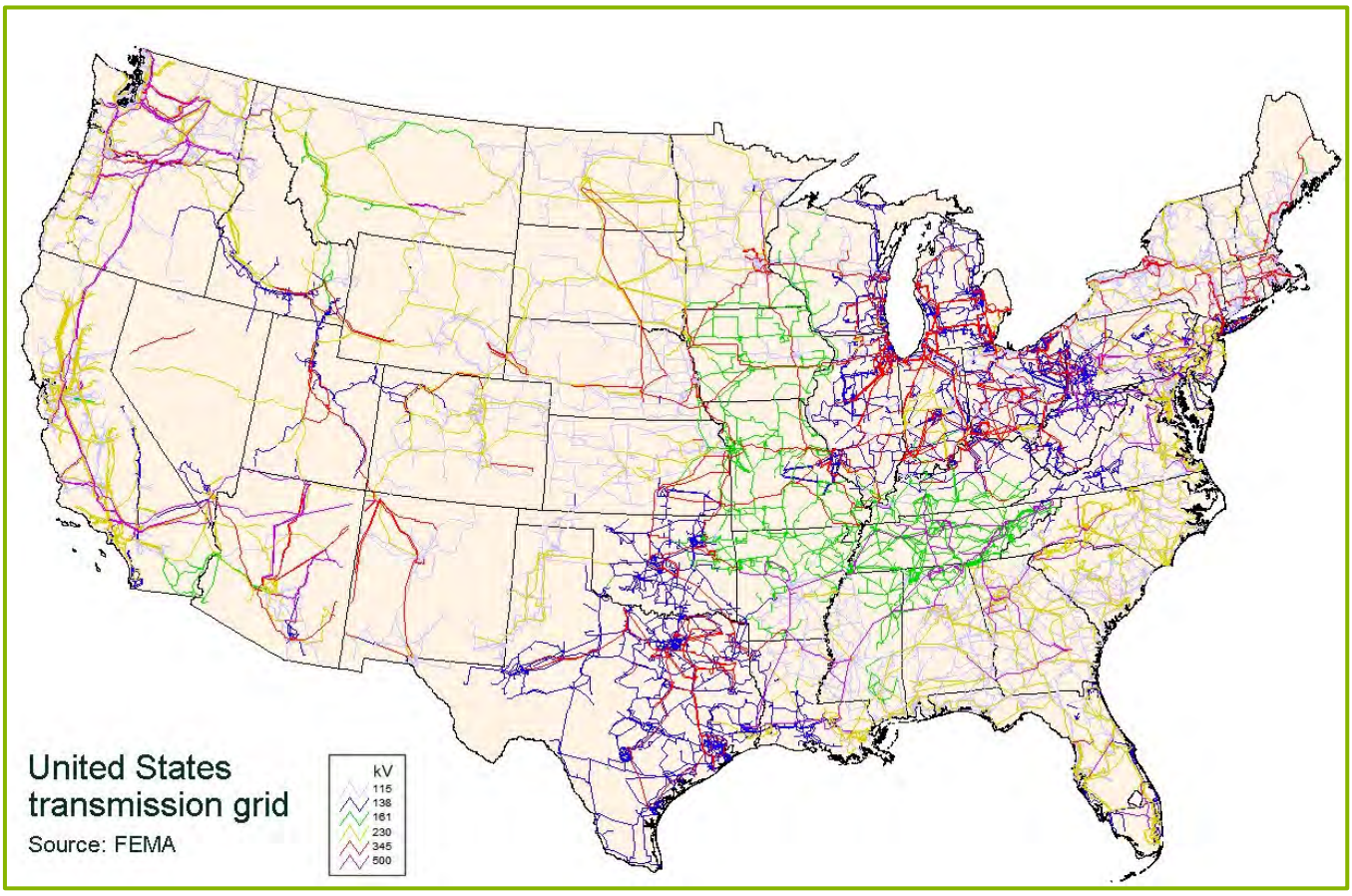


Figure 1: The U.S. power grid is made of 160,000 miles of high-voltage power lines and millions more miles of low-voltage distribution lines

If you asked me a couple years ago what I'd be doing, I would have never guessed interning at NASA! I came to American University studying political science, but once I took my first physics course, I was hooked. The semester after my introductory physics class, I switched my major and began looking for ways to get hands on experience. Thanks to the NASA DC Space Grant Consortium, I was able to work on a research project at the NASA Goddard Space Flight Center (GSFC), and thanks to my mentors and hard work, I was able to turn this opportunity into a full-time internship.

My research task was to develop machine learning tools to automate the mapping of the U.S. power grid. The power grid is vulnerable to large-scale solar events, and because the power grid is classified as critical infrastructure, it is key that these vulnerabilities are understood and explored. Unfortunately, solar physicists at NASA GSFC do not have access to a comprehensive map of the power grid, and therefore have limited ability to simulate the effects of solar events. Additionally, the U.S. power grid contains millions of miles of power lines, so mapping it by hand is by no means a feasible solution. Machine learning, on the other hand, has the power to automate tasks like this. Machine learning is a method of data analysis in which you use large amounts of data to build a model that can automate a task. For example, Netflix uses machine learning to recommend shows to you based on your viewing history. Machine learning is also particularly good at detecting objects in images, so I set out to build machine learning tools to automate the mapping of the U.S. power grid.

Due to COVID, Joey's team held virtual meetings this year

When I started my research, I had very limited experience with machine learning but a drive to learn more. I was lucky to have a team of wonderful mentors, Drs. Peter Schuck, Sean Blake, and Silvina Guidoni, who guided me through the learning process and helped me succeed. We started by building basic machine learning models to solve basic tasks, and our first accomplishment was building a machine learning model to detect Santa Claus in images. From there, we set out to build more complex models to do more advanced detection. Through this process, I learned the fundamentals of building machine learning solutions and became proficient in a range of data science techniques and tools.

While I gained valuable technical skills from my time at NASA, the most important skills I learned were from my mentors. They challenged me to never stop learning and to be creative in my problem-solving. There were many points where I thought I didn't have the skills or experience to continue my research, but my team was always there to remind me I could do it. My research experience at NASA Goddard Space Flight Center has inspired me to use machine learning technology to change the world. In an attempt to apply my experiences, a couple students and I have founded a company, 17minds, which uses data science to improve autism care. The technical skills I gained at NASA as well as the lessons I learned from my mentors have been invaluable in this endeavor, and I hope my research experience inspires others to pursue positions within NASA.

To view Joey's presentation, visit:
https://www.youtube.com/watch?v=KjIS6JJbm0Q

HONORABLE MENTION: Effect of Formaldehyde Based Embalming Fluids on the Chemical Composition of Drugs

Jaylan Pratt, Trinity Washington University (Graduate)

I am a proud graduate of Trinity Washington University. I graduated with a degree in Forensic Science with a minor in Forensic Psychology in 2020. I had the privilege of conducting research through the National Aeronautical and Space Administration (NASA) DC Space Grant Internship program from summer 2020 to spring 2021.

EFFECTS OF FORMALDEHYDE-BASED EMBALMING FLUIDS ON THE CHEMICAL COMPOSITION OF DRUGS

JAYLAN PRATT AND ANETTE CASIANO-NEGRONI
Trinity Washington University, Washington DC

RESEARCH QUESTION, HYPOTHESIS, GOAL

Formaldehyde is the primary preservative used in modern day embalming fluids. In some forensic cases where foul play is not considered, samples for toxicological analysis are not taken. However, if a later suspicion of foul play arises the corpse may be exhumed for toxicological tests. Our research aims to develop a method to study how the use of formalin affects the chemical composition of drugs post embalming. We hypothesized that all the drugs will react with the formalin, thus making detection more difficult. Our goal for this research is to characterize the structure of the drugs post-formaldehyde and formaldehyde-embalming fluid exposure.

BACKGROUND

Embalming is one of humankind's oldest techniques, which practices artificially preserving human or animal remains. Modern day embalming consists of various chemicals (preservatives, germicides, buffers, perfumes, dyes, etc) being injected into the deceased body for funeral proposes, transportations, and or further research. Formaldehyde, is one of the main components of modern embalming fluids acting as a preservative. In some cases where foul play is not considered, samples for toxicological analysis are not collected at the time of the autopsy (pre-embalming). However, if a later suspicion of foul play arises the corpse may be exhumed for toxicological tests. At this point, the body has been embalmed typically with a formaldehyde-based embalming fluid.

It has been shown that formaldehyde can affect different drugs structurally and cause chemical reactions, decreasing the concentration of the drug in the body preventing its detection. Such alterations can reduce the chances of drug detection post-embalming.

METHODOLOGY

- We reviewed literature to analyze 115 drugs to see if they have been studied in the presence of formalin following the chart below.

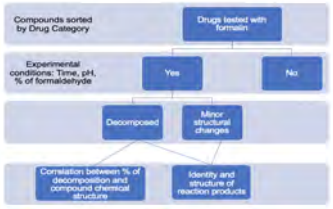


Table 1: List of the drugs studied in formalin solutions.

Alprazolam	Imipramine	Methamphetamine	Bupropion
Flunitrazepam	Nortriptyline	Fenfluramine	Olanzapine
Flurazepam	Cocaine	Benzoylecgonine	Chlorpromazine
Midazolam	Methamphetamine	Morphine (heroin)	Phenytoin
Oxazepam	MDMA	Fentanyl	Phenytoin
Triazolam	Amitriptyline	Tetramine	Paraquat
Chlordiazepoxide	Toluene	Pethidine or meperidine	Phenobarbital
Prazepam	Desipramine	Cyanide	
Lorazepam	Lidocaine	Sertraline	
Estazolam	Chloroform	Fluoxetine	

RESULTS

Figure 1: Drug Categories. The drugs analyzed in this study were categorized by drug type and if they were studied in formalin.

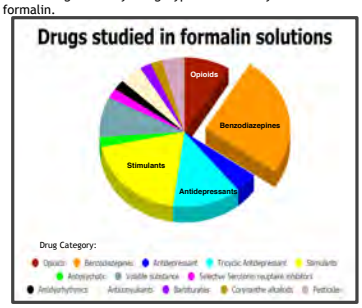


Figure 2: Drug Decomposition. Results for drugs in each category once in the presence of formalin at different experimental conditions.

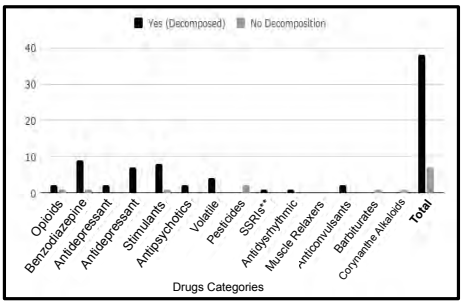


Figure 3: Percentage of decomposition of drugs in formalin solutions. Each drug category had drugs with varying decomposition percentages.

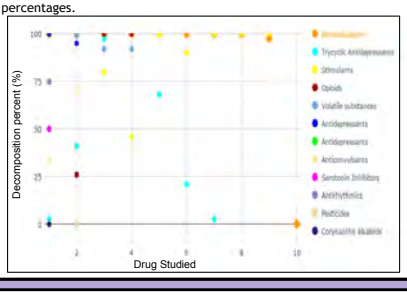
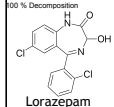
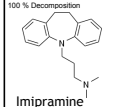
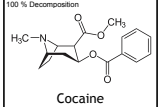
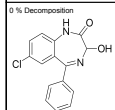
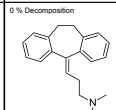
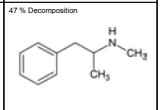


Table 2: Highlights of the chemical structure of some of the drugs. Correlation of structural features and percent of decomposition in formalin solutions

Benzodiazepine	Antidepressant	Stimulants
100 % Decomposition  Lorazepam	100 % Decomposition  Imipramine	100 % Decomposition  Cocaine
0 % Decomposition  Oxazepam	0 % Decomposition  Amitriptyline	47 % Decomposition  Methamphetamine

CONCLUSIONS

- Our results underscore that formaldehyde-embalming fluids affects the stability and chemical compositions of different substances making it difficult to be detected post-embalming.
- Only 37 of the 115 drugs have been studied in formalin and 78% of them have lost stability or decomposed at high pH (9.5) and high percentage (20%) of formalin. The identity of the decomposition products for most structures have not been determined.
- There is not a clear correlation between the drug structures and the percent of decomposition and its reaction with formaldehyde or other components in embalming fluids.

FUTURE DIRECTIONS

We are currently designing an experimental methodology to characterize the structure of the drugs pre- and post- formaldehyde exposure using a combination of Chromatography-Mass Spectrometry (GCMS) and Nuclear magnetic Resonance (NMR).

Lorazepam and Oxazepam will be study to gain insights on (1) structural changes, (2) type of chemical reactions taking place and (3) how functional groups in Benzodiazepines relate to the percentage of decomposition.

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ACKNOWLEDGEMENTS

I would like to thank the DC Space Grant for funding this summer internship opportunity along with my academic advisor Dr. Shizuka Hsieh. I would like to give a special thanks to my research mentor Dr. Anette Casiano-Negroni.

Jaylan Pratt's poster from the 2021 NASA Space Grant Competition

My research mentor Dr. Anette Casiano-Negroni and I began researching the effects of formaldehyde based embalming fluids on the chemical composition of drugs. Formaldehyde is the primary preservative used in modern day embalming fluids. Formaldehyde-based embalming fluids can affect different drugs and cause chemical reactions. Our research aims to develop a method to characterize the chemical composition and concentration of the parent drug and its metabolites in the presence of

formaldehyde. We conducted a literature data analysis of 122 drugs and other substances ranging from opioids, illicit drugs, antidepressants, pesticides, among others that have been shown to be involve in foul play. Our study revealed that 51 of these 122 substances have been studied in formaldehyde solutions at different pH and temperature conditions using High Performance Liquid Chromatography (HPLC) or Gas Chromatography-Mass Spectrometry (GCMS). Of these 51 drugs, 78% lost stability and the drugs within the same category had similar decomposition rates. Our preliminary results underscore that formaldehyde-embalming fluids affects the stability and chemical compositions of different drugs, making post-embalming identification difficult. We are currently moving towards finishing our experimental methodology to characterize the drugs and any metabolites resulting from the decomposition reactions.

Today, I am a thriving researcher in part due to my experience with this internship. I have gained a new appreciation for chemistry, along with an in-depth understanding of postmortem forensic toxicology. My sincere gratitude to the NASA DC Space Grant Consortium for the financial support and thanks to Trinity Washington University and my mentors Dr. Anette Casiano-Negroni, Dr. Shizuka Hsieh, and Dr. Patrice Moss for your guidance and leadership. Thank you, INSPIRE!
To view Jaylan's presentation, visit: https://youtu.be/UPeHE9ylUe4

Using Carbon Fiber Microelectrodes to Detect Dopamine

Michelle Hadad, American University (Junior)

I am a Health Promotion major from McLean, Virginia. This summer I received a scholarship from DC Space Grant Consortium and had the opportunity to continue research in the Zestos Lab in the Chemistry Department at AU. The goal of my project was to gain familiarity with Fast Scan Cyclic Voltammetry (FSCV), detect dopamine using Carbon Fiber Microelectrodes (CFMEs) and collect data using fast scan cyclic voltammogram (FSCV) through the High Definition Cyclic Voltammetry (HDCV) software.

Dopamine is an important neurotransmitter to study due its role in diseases such as Alzheimer's and Schizophrenia. FSCV is a popular tool to use because it can quickly detect changes of biomolecule concentration; therefore, it can quickly detect changes in neurotransmitters in the brain. By using CFMEs' (Figure 1), which are highly sensitive since they have surface oxide groups that absorb cations like dopamine, I was able to measure different concentrations of dopamine from 1μM to 100μM (Figure 2). Electrodes had to be cut under the microscope to a protruding length of approximately 100 microns before FSCV testing with dopamine (Figure 3). Different measurements of concentrations were collected on an analysis software where CV graphs, I vs T graphs and color plots were recorded and compared. It was concluded that due to an increase of concentration (ex. 1 μM → 5 μM), there is an increase in current, and this pattern is consistent for dopamine. During my 8 weeks, I attended weekly conference meetings which have furthered my curiosity in the STEM field. Overall, my summer has been impactful with the support of my lab group and the funding for my project. I wish to further my experience with FSCV this year with detection of cortisol. Cortisol is a major stress hormone and it has a lasting effect with the development of several chronic illnesses. I am very appreciative of the opportunity that I have been given to understand this aspect of research and to develop further interests with the detection neurochemicals. *To view Michelle's presentation, visit: https://www.youtube.com/watch?v=c7-XwRxHwU8*

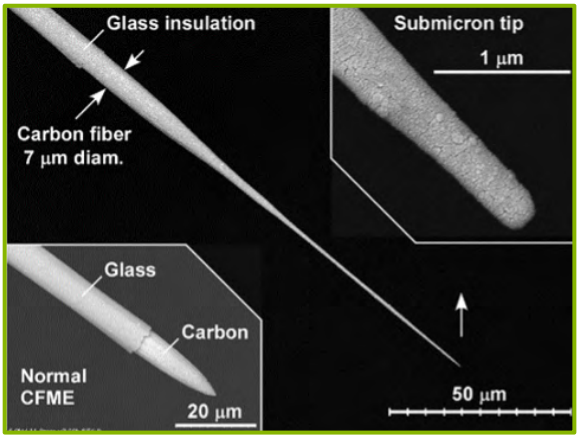


Figure 1: Scanning Electron Microscope (SEM) image of a carbon electrode under high magnification

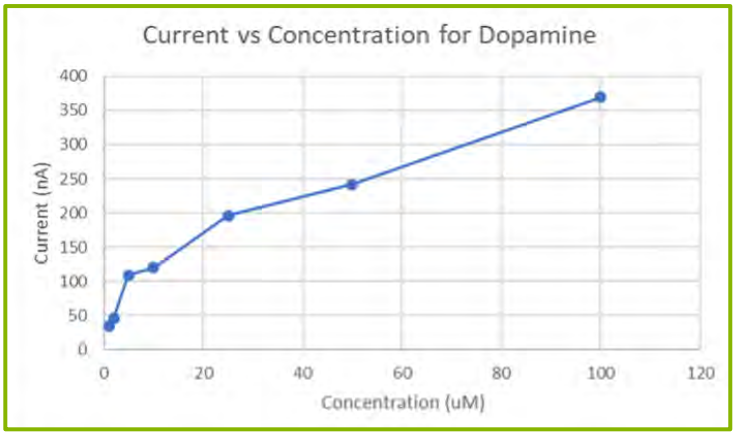
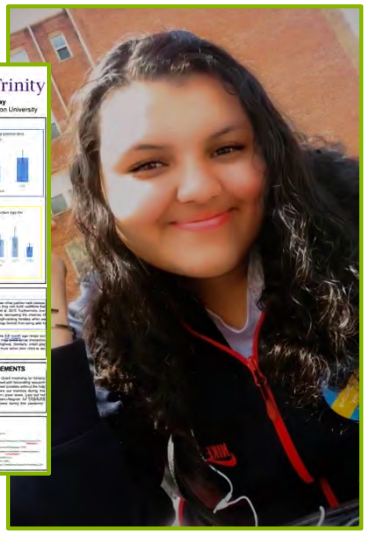
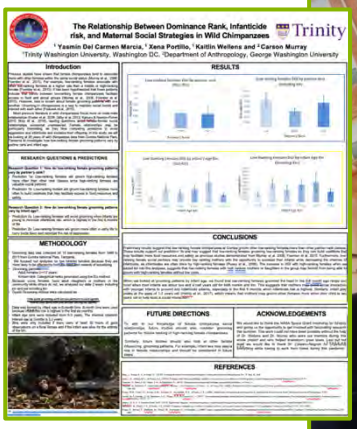


Figure 2: Current vs. Concentration Curve. Graph plotting concentration vs. peak oxidative current for the FSCV detection of dopamine


Figure 3: Electrode preparation – Michelle cutting carbon fiber microelectrode under the microscope

Wild Chimpanzees Correlations in Dominance Rank, Infanticide Risk, and Maternal Social Strategies





Yasmin Marcia, Trinity Washington University (Sophomore)

I am a sophomore at Trinity Washington University. For the summer of 2020, I had the amazing opportunity to do a 6-week paid internship funded by the NASA DC Space Grant. Working alongside my mentor Dr. Wellens and my partner Xena Portillo was such a great experience. We collaborated with researchers at The George Washington University to examine the female social relationships in wild chimpanzees. The data we worked with was collected from 25 years at Gombe National Park in Tanzania. Working with this data was especially enjoyable because Jane Goodall, a famous female STEM researcher, started and worked in-person at this same site. We even got to look at data from the same chimpanzees she knew and followed! Through this experience, I was able to get hands on practice working through the entire scientific process — we came up with a question, formed hypotheses and predictions, and used data analytic techniques to answer our questions. In the 6-weeks of trying to complete our research poster, I felt that I was improving my leadership and communication skills making my experience unforgettable. I got to share my ideas with other scientists and just being able to talk about our research gave me more insight into science research and also gave me new confidence. I always knew internship opportunities were a great opportunity to explore and discover new research and I am thankful I got to share it for the first time with the NASA DC Space Grant. Thank you INSPIRE, for sharing my 6-week internship journey which was incredible. *To view Yasmin's presentation, visit: https://youtu.be/jzzWYf8t7Ak*

CURE Plan – Study of Endocrine Disrupting and Asthma-Associated Chemicals Found in Natural Hair Care Products

Corryn Hicks, Trinity Washington University (Senior)

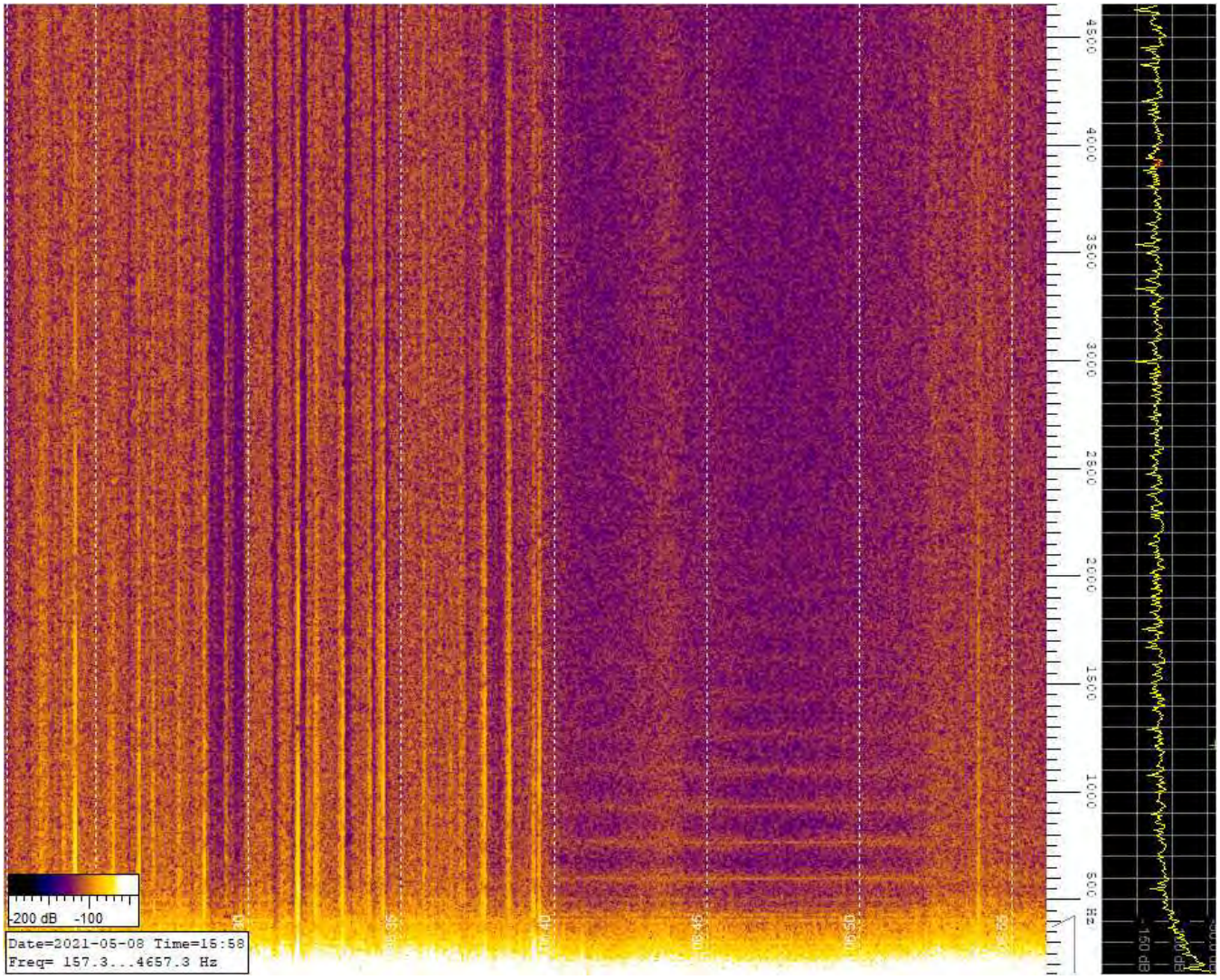
I am majoring in Biology as well as minoring in Chemistry. I am currently finishing up my senior year at Trinity Washington University. My research focused on endocrine disrupting and asthma-associated chemicals, often found in natural hair care products. My project was to begin designing a CURE (course-embedded undergraduate research experience) plan for organic chemistry, in which students will test hair care products specifically marketed towards women of color, in order to determine whether they contain endocrine disrupting chemicals and other harmful chemicals not listed on the ingredients list. I started my research by reviewing the literature and creating an annotated bibliography of previous studies that have detected chemicals in hair care products that are either endocrine-disrupting or associated with asthma. The CURE will enable undergraduate women to contribute additional knowledge about the chemical content of hair-care products, with a focus on those used specifically by Black and Latino women. We developed a CURE outline that incorporates activities to learn about the potential hazards in hair products and to practice experimental techniques traditionally taught in the first semester of organic chemistry, including spectroscopy and chemical separation methods. We decided to focus initially on one type of hair product, hair lotion, in which we selected four different brands. To prepare for initial experiments, I generated a list of chemicals that we would expect to find in the selected hair lotions. The plan also includes a student survey, before and after conducting the CURE in order to get a better understanding as to how they feel about Organic Chemistry and also in hopes to get them excited about this CURE. I would also like to shine light on the Annual Biomedical Research Conference for Minority Students (ABRCMS), which I had the pleasure in attending and presenting my research, I was awarded a Presentation Award in the Chemistry category.

This was a very meaningful experience within my six weeks of undergraduate research supported by the DC Space Grant Consortium. This experience has helped me to gain a better perspective about research. I am so thankful to be able to experience this amazing opportunity, in which has brought tremendous value to my life as a student in the STEM field. I also want to thank my mentors at Trinity for making this a great experience as well. Without their kindness, knowledge, and devotion this research would not had been as impactful as it is to me now. In the near future, I hope to conduct further research on natural hair care products. *To view Corryn's presentation, visit: https://youtu.be/SsVcpysB4CI*

Sounds of Mars Helicopter Captured During Fourth Flight on 30 April 2021

Dennis Gallagher, INSPIRE Chief Technical Advisor
(NASA Marshall Space Flight Center)

On April 30 NASA announced, “For the first time, a spacecraft on another planet has recorded the sounds of a separate spacecraft. NASA’s Perseverance Mars rover used one of its two microphones to listen as the Ingenuity helicopter flew for the fourth time. A new video combines footage of the solar-powered helicopter taken by Perseverance’s Mastcam-Z imager with audio from a microphone belonging to the rover’s SuperCam laser instrument.” Below is a screen capture of a portion of the audio from the Spectrum Lab software created by Wolfgang Buescher/DL4YHF:



The above display shows the audio power spectrum from the helicopter’s sound in a time-versus-frequency display; with blue, to orange, to yellow, and then white indicating increasing signal strength. At about 20 seconds into the video (near the middle of the horizontal axis) the helicopter takes off and the helicopter blades make a buzzing sound that is distinct from the noise that could be heard before it started flight. That buzz, faint orange horizontal lines, can be seen as a set of harmonic frequency components with roughly150Hz spacing starting at a fundamental frequency just below 600Hz. The frequency axis is shown running vertically on the right side of the spectrum. The buzz is acoustic rather than VLF radio noise, but if INSPIRE receiver experiences on Earth hold true on Mars, there seems little doubt the NASA Ingenuity helicopter rotating blades would produce a VLF signature that the INSPIRE receiver could pick up. Beam me up Scotty, I’d like to check that out!

The spectogram was created utilizing DL4YHF's Amateur Radio Software: Audio Spectrum Analyzer (Spectrum Lab) which is copyrighted by Wolfgang Buescher. To learn more about Spectrum Lab visit: http://www.qsl.net/dl4yhf/spectra1.html

Living in the “What Might Be”

Charles Richard Chappell (Rick.Chappell@Vanderbilt.Edu; ORCID: 0000-0002-1703-6769), Department of Physics and Astronomy, Vanderbilt University, Nashville, Tennessee, USA

Abstract

In a short period of time in the late 1950’s and early 1960’s two American presidents set forth challenges for our country to commit itself to space exploration, first with launching a satellite into orbit and then by putting American astronauts on the moon and returning them safely to Earth. This leadership of Presidents Eisenhower and Kennedy sent a clear message to all Americans, particularly young people, about the importance of committing their lives to becoming space explorers. It was a clarion call to thousands to begin their personal journeys of exploration by dedicating themselves to the study of science, mathematics and engineering. This is the story of one of these young people who in the face of early failure, responded to the nation’s call and found his self-esteem and ultimately his entire career living in the “what might be” of the explorer’s life.

The Uncertain Beginning

It had been a full day. High school graduation was less than a week away and there were many things to complete, not the least of which were my final exams. I turned into the driveway of my home on the Huntingdon College campus in Montgomery, Alabama. Entering my house, my dad called and asked me to come in and watch the evening news; he said that President Kennedy had made a speech to Congress that day proposing a new challenge for America. Sitting down, I heard the president say “this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth.” This was a defining moment and personal challenge for me, the possibility of responding to the president’s grand challenge for America and working to become a space explorer. This opportunity was the culmination of a childhood that had been characterized by both wrenching failure and initial successes that had been part of the journey to find what might make me special in life — the critical self-esteem on which young people and adults alike build their lives. This mysterious inner journey had brought me to this moment.

INSPIRE Board Member Rick Chappell was selected by the American Geophysical Union (AGU) to be featured in “Perspectives of Earth and Space Scientists”. This is a condensed version of the original article published. For the past decade, Rick has graciously shared his passion for space exploration with INSPIRE’s Space Camp for Educators and Students program participants by leading the post-graduation luncheon following their week at Space Camp in Huntsville, Alabama at the U.S. Space & Rocket Center. The interactive lunches with “Astronaut Rick” and his fellow NASA scientists have motivated dozens of INSPIRE students and teachers to pursue an education in STEM disciplines.

Rick (pictured center) with INSPIRE’s 2019 group and a model of the Saturn V rocket on von Braun’s walnut table

Both of my parents were professors at Huntingdon and both were excellent teachers. They had met as students at Vanderbilt University during the Depression, and I was excited about going there as a freshman that upcoming fall of 1961. My sister and I lived in a home that was a place where education and learning were valued, encouraged, and honored. That environment had been a foundational element of my search for self-worth, especially after my difficult and embarrassing failure at sports.

The America of the 1950s, as it is today, was captivated by sports of all sorts, and young people were continually reminded of the fame and fortune that can accompany their success on the athletic field and the entertainment stage. For me, Ted Williams of the Boston Red Sox was the hero. Baseball achievement became my goal, and once I got my first glove in the fourth grade, I began to play wherever I could to prepare for the Little League tryouts. In the fifth grade, at 11 years old, I joined the tryouts. I was an acceptable baseball player but not yet an exceptional one. To my great happiness, I was selected to be a member of a new team, and as the first game approached, the new team members were given their uniforms and their caps. This was a very big thing for all, and the ability to wear your baseball cap to school and brand yourself as a successful baseball player was of great significance. The day before the first game, my coach came to my house on the edge of the campus in the afternoon. He sat with me and my parents in our small living room and said calmly that even though the tryouts had been completed, another young man had come along later, and he was an excellent player. The coach told our shocked group that he had decided to put the other player on the team, and since there were only a limited number of spaces, he would need to take me off and would need to get my uniform and cap back. The success and self-esteem that I had felt in sports became an amplifier of the failure that I felt at that moment. It would be a long

time before I would understand the depth and significance of that event in my life. My one initial takeaway was that my life would not be built around a professional baseball career, which I knew Americans valued highly, but would, by necessity, have to be built around something else. I would have to find some other talent or ability to serve as the foundation of my self-worth in life. This complication seemed difficult to overcome, and what might happen was not at all clear.

It would be another president, Dwight Eisenhower, who would initially open the door for me to begin to find that other ability. When the Russians surprisingly launched the Sputnik satellite in 1957, President Eisenhower responded with a clear declaration to the American people that the country had been beaten and that Americans must respond with a focus on science and engineering that would allow them to compete with the Russians. At 14 years old in the 9th grade, I had found some success in my studies of science and math, and now my country was saying to me that these subjects were important in addition to baseball and football. This success became an encouragement to me to continue my newly found journey toward self-esteem. Empowered by America's push for science and technology, I increased my study of math and science. This study continued through my 3 years in high school, where I was very successful academically, although not at sports, and I began to be recognized by my fellow students as having some special ability. With President Kennedy's 25 May 1961 commitment to space exploration, my path was established, and my journey to the adventure of space exploration was confirmed. Young people listen to what their country tells them is important, and a nation's leaders must always be careful and thoughtful to encourage, feature, and support the things that they want their young people to decide to do. Ultimately, the total number of talented people who changed their lives and brought their abilities to the Apollo Moon program was in excess of 400,000.

Leaving Home to Follow the Journey of Exploration

My university years were meaningful and memorable, and the new colleagues, knowledge, and challenges combined to create a wonderful experience at Vanderbilt. In science and mathematics, I began to develop the fundamental tools to become a space explorer. Things were happening in America: Alan Shepard had flown into space in April, and John Glenn was just about to become the first American to orbit Earth. Learning to talk about complex science to friends who were not in science was an important talent that would serve me well in the future steps on my space journey. My self-esteem in physics and math continued to grow. One November morning in my junior year, I noticed groups of students standing together talking and listening to the radio. I went over and found shockingly that President Kennedy had been shot in Dallas. The American leader who had inspired so many in the country and who had started me on my personal exploration journey had been taken away. America had lost its leader and inspiration, but the things that President Kennedy had begun for the nation would continue to successful conclusions. I did well academically at Vanderbilt and, following graduation, worked for the summer in Huntsville, Alabama, for IBM, learning to write computer programs that simulated instruments on the Saturn V Moon rocket that was being built there. At the end of the summer of 1965, I drove west to Houston to pursue graduate studies at Rice University. Houston was just up the road from Clear Lake, the new home of the Manned Spacecraft Center, later to become the Johnson Space Center, where the Gemini flights were taking place in preparation for the Moon mission. At Rice the studies would become more focused on the space adventure as I joined the newly established Space Science Department and began my work with a brilliant Australian professor, Brian J. O'Brien, who was a most successful innovator and achiever in the early days of spaceflight. The classroom work was exciting, and it was combined with the opportunity to work in the laboratory developing instruments that would fly on rockets and satellites! My graduate work at Rice focused on understanding the processes that create the aurora borealis, or northern lights. Using data from rocket flights through the aurora and combining them with computer predictions, I was able to understand more clearly how the electrons and protons that rain down on the top of Earth's atmosphere from space cause the dancing curtains of auroral light. In doing this, I gained new knowledge about this space phenomenon and, for the first time, tasted the thrill of exploration and discovery.

Becoming a Space Explorer

While finishing my thesis, I spent a summer working at the Lockheed Palo Alto research laboratory. The computer programs that Lockheed had developed were ideal to help explain the rocket data. This position set the stage for my first real paying job in space exploration following the completion of my PhD. I was hired as a research scientist at Lockheed in Palo Alto, California, another step on the space exploration journey. I reported to work at Lockheed in June of 1968. This was a time when the newly developed NASA Saturn rockets were beginning to carry astronauts toward the Moon. Just over a year later on the evening of 20 July, 1969, my wife and I sat holding our young son, and watched Neil Armstrong and Buzz Aldrin step on the moon! The Lockheed research laboratory had many talented space explorers working in a variety of disciplines. The lifestyle was easy in Palo Alto, and I could ride my bike to work. After lunch each day my colleagues and I would walk on the shady streets in the research area around Lockheed, which was part of nearby Stanford University, and share our stories of the science research experience. Feeling the significance of this collaboration for the science combined with the interpersonal connection to fellow explorers was intensely rewarding. Exploration and life are full of surprise and serendipity. At work, the funding for my research on the aurora ended, and my boss asked me if I would like to work on a different type of data that was being measured by a satellite instrument that another group at Lockheed had built. I accepted and began to analyze measurements of the very low energy ions, electrically charged particles, that are found in Earth's upper atmosphere, called the ionosphere, as well as at much higher altitudes in the plasmasphere. These particles, it was thought, were very different from the more energetic particles that caused the aurora (Chappell, 1972). I would not know until later that this unplanned

change to study the low-energy particles would be the exploration challenge and quest that would occupy the remainder of my research career. I would find that these low-energy particles play an important role in creating the more energetic particles that fill Earth's magnetic envelope, the magnetosphere, and help create the aurora! This area of study revealed significant new things about Earth's space environment and allowed me to experience the true thrill of exploration in which curiosity, motivation, and determination lead to the discovery of new knowledge and a new sense of self-esteem for the explorer himself. Then one day after 6 years in California, NASA called from Alabama to see if I would consider coming home. The reason would be to work on identifying space science experiments that could be carried out on human spaceflight missions on the new space shuttle. To follow up the Apollo program and the Skylab space station, NASA was building Spacelab, which could transform a shuttle into an orbital laboratory, with scientists going along to do their research. It was an exciting opportunity to become a NASA scientist/explorer, and I could not turn it down. In February of 1974, I began work at the NASA Marshall Space Flight Center in Huntsville, Alabama. This historic rocket-building center had been started by the U.S. Army through the work of Dr. Wernher von Braun and his colleagues from Germany following the end of World War II. The center has an incredible history of rocketry and spaceflight, beginning with the launches of America's first satellite, first astronaut, first Saturn V rocket to the Moon, and the space shuttle. I had an extra feeling of belonging in Huntsville, where the cradle of space exploration in America was combined with the slower-paced and soft-spoken lifestyle of the South.

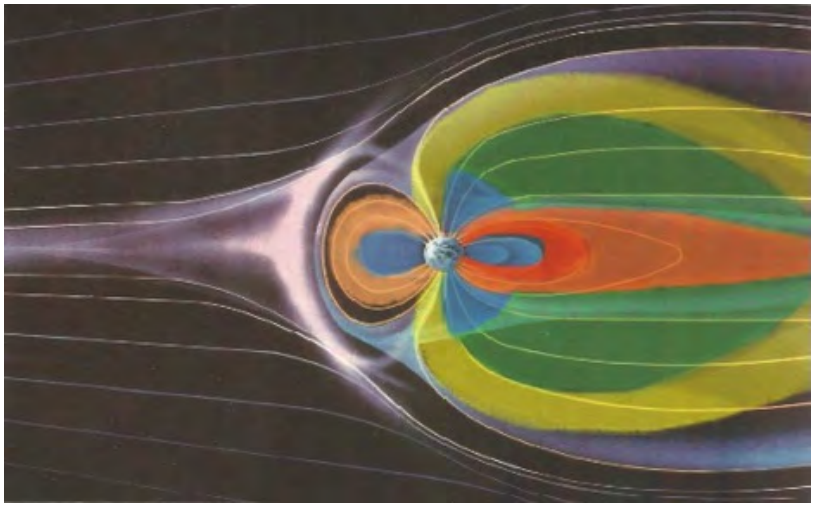


Figure 1 – A sketch of the Earth's magnetosphere as it is shaped by the solar wind flow and filled with up-flowing particles from the Earth's ionosphere

Joining that accomplished group of space explorers was a most special honor for me, and I immediately set about planning for space shuttle Spacelab missions of the future and starting my own research group studying the low-energy plasma of Earth's magnetosphere. The challenges of my life had broadened with the journey toward space exploration, now involving both my search to understand Earth's space environment and planning human spaceflight missions. Our research group grew, and the talent and teamwork of the group amplified the success and knowledge through their exciting interchange of ideas. Our group analyzed data from previous satellite missions and began to propose new instruments for future missions. Three were selected, built, and flown, and I experienced the role of becoming a NASA principal investigator and organization leader. During this same time period, I worked with special NASA mentors, Jack Waite and Bob Pace, to plan a future shuttle/Spacelab mission. Redstone Arsenal is a sprawling area on the west side of the town of Huntsville, and it contained laboratory and office buildings and large test stands for rocket engine testing. My space research group grew to include studying the Sun, a source of energy and particles for Earth's space environment and the upper atmosphere, where the solar and magnetospheric effects could be seen. One of the leading solar scientists, who came from Boulder, Colorado, to work with us, was Ernie Hildner. Ernie was tall and athletic and dedicated to personal fitness. He ran daily to stay fit and asked me if I would like to join him. Because of my childhood sports failure, I had been away from anything athletic in my life for 25 years, focusing on the intellectual and not the physical things. I hesitated to enter that realm of life again, but Ernie encouraged me to come along on a run and slowed his speed substantially so that I could keep up. Running at lunchtime around the historical open natural beauty of the Arsenal became a regular daily occurrence, and other scientists from the group joined in. After about 6 months, Ernie suggested that I should consider participating in a 10-km race. This seemed out of the question to me but with Ernie's training help, I finished respectably. Later, I trained and ran five marathons, including New York and Boston. This experience was a significant one. Psychologically, it allowed me to see that I did have athletic ability, and it brought the appreciation of physical fitness into my life, where it would stay.

This time period in the 1980s was to be a point of insight into life's journey for me. My quest to become a space explorer had taken shape, and my journey in life once again included exercise and fitness. Data from my first satellite instrument had shown something that was never expected when it was proposed: a large outflow of particles upward from Earth's ionosphere into its magnetosphere, challenging the long-held idea that the Sun was the sole supplier of the energetic particles (Chappell et al., 1987, 2008, 2017; Chappell, 2015) *(See Figure 1)*. It was clear evidence of the process of science in which explorers often find things that they are not looking for and these newly found things can be much more important than what was being sought originally. Serendipity often happens in exploration, and people and nations must choose to explore if they are ever to find the new treasures of discovery.

A second element of my space exploration had become the focus on human spaceflight for future shuttle science missions. Planning for the first Spacelab mission began at Marshall in partnership with the European Space Agency (ESA). I was appointed as the NASA mission scientist to coordinate the science activities. Together with the ESA project scientist, I led the working group of scientists who had been chosen to fly experiments on the first mission. Scientists from around the world came to Marshall, and the large meetings were held in the center conference room on the ninth floor of the main building,

the same room in which Dr. von Braun had held the defining meetings of the Apollo program. With its very large mahogany conference table and paneled walls, the room was a reminder of the many talented space explorers who had come together to create the technology to get Americans to the Moon. The Spacelab 1 mission was a new approach for human spaceflight in which the scientists on the ground would be able to interact directly with the flight crew members and would also be able to select two scientists who would fly as payload specialist science passengers on the space shuttle. The Spacelab 1 mission flew in 1983 and featured a crew of seven, which included the first two payload specialists who had been selected by the investigators. The very successful mission lasted 10 days, featured more than 70 different experiments and led to a series of more than 20 shuttle/Spacelab missions.

After Spacelab 1 was over, there was a desire to fly a second mission as a follow-up. The investigators on the first mission were asked to choose the two payload specialists and two backups to train for the follow-on mission, which became known as Atmospheric Laboratory for Applications and Science (ATLAS) 1. Because of my involvement in all of the activities in Spacelab 1, I was selected as an alternate payload specialist for the ATLAS 1 mission and began training to fly in space along with the other payload specialists. The seven years of training were an incomparable adventure, working with the other crew members, training in laboratories around the world, and spending more than a year at the astronaut office training at the Johnson Space Center. Charlie Bolden, the ATLAS/STS 45 commander, wanted me to do all of the same training that the primary crew did. This included the terminal countdown demonstration test, a dress rehearsal for the flight that took place at the Kennedy Space Center 1 month before the launch. At this point, the shuttle Atlantis was already on the launch pad with the ATLAS investigations in the payload bay. The crew stayed in the astronaut crew quarters about 15 km from the launch pad. On the morning of the test, the crew got up, had breakfast in the crew quarters, and then suited up for the ride to the launch pad, where they got onto the shuttle, which was being readied for launch. The crew wore their launch entry pressure suits, added the gloves and helmet, and climbed aboard the space shuttle, where they were strapped into the seats. The practice countdown to launch was started and then aborted so the crew could practice getting themselves out of Atlantis and escaping across the launch pad at the 60-m level to get into the large baskets that could carry them down the slide wire to get away from the launch pad to a nearby bunker for protection.

Point of Insight: The Figure in the Carpet

After all of the training was completed, the ATLAS mission lifted off on 24 March 1992. I watched while the shuttle Atlantis carried my friends into space. I then flew on the NASA plane to the payload operations control center in Huntsville, Alabama, where I was the communicator to the science crew members during the flight. This experience of spaceflight training followed by the all-encompassing involvement in the mission itself caused an emotional change in me. I had attained a role in space exploration at a level that I could never have anticipated when I began my journey as a failed athlete. As the process continued, my feelings and perspectives changed. The emotional movement toward space expanded my view, broadening the perspective from local to spaceship Earth, where the flyer sees no borders anymore, just continents and oceans that display Earth not as a collection of warring nations, but as a beautiful spaceship, the Blue Marble. I went back to the Kennedy Space Center when my crewmates returned and watched as Atlantis touched down at the shuttle landing strip. That journey was at the end, but it was a time of comprehending the full adventure of space exploration — exploring, discovering and learning. I came to realize that explorers have the great privilege of living an adventure in which they get to feel the personal self-esteem that comes from learning and doing new things and that the explorers themselves have left something new for posterity that was not known when they started their journey as a child. For the explorer, the resolution of the initial challenges in life's journey is to be able to give back to the world in appreciation of the adventure that the explorer has been given.

Rick in the White Room that connects to the Atlantis shuttle hatch (200 feet up) during launch practice preparation with NASA support crew

Living in the "What Might Be"

Explorers are curious, motivated, determined people who follow a journey to new discoveries, knowledge, understanding. Another element of their exploration journey is critical. Explorers need to be optimists. One cannot know the unknown without dedication and work in the face of difficulty. The discovery process involves looking for answers and staying with the work despite the hurdles and failures caused by unsuspected problems. I have always felt that there is a way to overcome a bump in the road and keep moving forward. This feeling was amplified as I worked with other explorers who had the same approach to life. To me, studying how the Sun-Earth space environment works was like putting together a 20,000-piece puzzle without any picture to go by! Each piece was found from the studies and experiments of all of the explorers in that field of work, and the pieces fit together through the interaction and teamwork of the scientists, engineers and computer specialists who worked to understand the newly explored space environment. The optimism of exploration, the ability to face the unknown with the conviction that an answer can be found, is a requirement for a successful explorer. This ability creates a very important

by-product for the explorer's personal life in a broader sense, the pervasive thought in the individual that there are new things that can be done to bring solutions and increased quality of life for all people, the "what might be." For me, this began with a desire to use my ability to explain science and exploration to the public that had first shown itself when I was a student at Vanderbilt. At NASA, I began to give talks to the public in a multitude of forums, ranging from civic clubs to high-tech companies and to school programs involving students of all ages. These talks were driven by my desire for as many people as possible to learn about the thrill of space exploration and its benefits for the country, especially for America's young people, who would be making their own personal decisions about their future life goals and journey.

In the early spring of 1994, the Marshall Space Flight Center director, Jack Lee, came by my office to ask if I would consider working in Washington for Vice President Al Gore as the special assistant to the NASA administrator, Dan Goldin. He said that Vice President Gore was visiting Huntsville later that week and wanted to talk with me about helping to lead the creation of the Global Learning and Observations to Benefit the Environment (GLOBE) program, a K–12 education program that Mr. Gore had written about in his book Earth in the Balance. The program would involve students around the world in exploring and measuring the environment around them. Later that week, I sat down with the vice president, who asked me to join with another scientist manager, Tom Pyke, from the National Oceanic and Atmospheric Administration (NOAA) to manage the GLOBE program. I was excited about this opportunity and a few weeks later found myself sitting in front of the very large picture of the whole Earth taken by the Apollo astronauts on their way to the moon that hung on the wall of Vice President Gore's West Wing office in the White House. Tom Pyke and I had been asked to come by to talk with the vice president about the progress of our plans to make the GLOBE program a reality. Mr. Gore had announced the program to the world on Earth Day 1994, the week before, and wanted Tom and me to bring together the team of people to make it a reality by Earth Day of the following year. With Vice President Gore's commitment, multiple agencies such as NASA, the National Science Foundation, NOAA, and the Environmental Protection Agency came together to support the program. Mr. Gore announced the launch of the program to the world on Earth Day 1995, and more than 20 years later GLOBE is very active and involves students and teachers from more than 100 countries around the world.

I returned home to NASA and in the fall of that year and received a call from Taylor Wang, a friend and payload specialist on one of the shuttle Spacelab flights. Taylor had become a professor at Vanderbilt and asked me if I would talk to his class about future space exploration which I accepted. After the class, Taylor and I went by to talk with Chancellor Wyatt about the need to improve the communication of science and technology through the media to the public and the Chancellor said that he wanted Vanderbilt to be involved. He asked if I would come back to Vanderbilt and lead a study and activity to improve science communication. I agreed and began to work at the First Amendment Center with Jim Hartz, a former NBC reporter on the space program and host of NBC's Today Show. This all came together in the beginning of 1996, and for 2 years Jim and I worked to understand how to strengthen the ties to and information flow about science through the media to the public. The resulting book, Worlds Apart: How the Distance Between Science and the Media Threatens America's Future, was published in 1998 (Hartz and Chappell, 1998). One of the key products was the creation of a new interdisciplinary major at Vanderbilt, the communication of science and technology, which has continued and has produced graduates who understand science and engineering and who can communicate it to the public. Students were challenged to understand the process of how exploration is actually done and about the nature of the explorers who do it, as well as the challenges of how to tell these fascinating stories of science through the media to the public. Following 15 years on the campus at Vanderbilt, I returned to live in Huntsville. The move back was very meaningful to me because it brought me back into contact with the many friends and colleagues whom I had worked with at NASA who had been the early heroes of space exploration.

I have felt the joy of exploring the space environment of our Earth and how it is continuously changed by our Sun. Being part of this exploration has brought inspiration, satisfaction, and pride to my life. As explorers, our commitment to the what might be of exploration, once ignited in youth, does not diminish. It is the same feeling that causes climate scientists around the world to build new satellite instruments and develop predictive computer codes. This new exploration is increasing the understanding needed by humankind to adjust our ways of living compatibly to protect our fragile planetary spaceship. It is also what makes today's rocket men and women continue to build the machines of space exploration like the Space Launch System, a rocket larger than the Saturn V, which will be the foundation for human travel to Mars, hopefully within the next decade. The what might be of exploration drives the what might be of life as the optimistic, motivated, determined curiosity about our possible future empowers all who want to understand why, and use that knowledge for the betterment of life on Earth. To be part of that experience drives the millions of scientists and engineers who live on this planet. It is the same drive that captured a young boy struggling to find his role in life and made it possible for him to live the wonderful exploration journey of adventure and contribution.

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INSPIRE's 2019 & 2020 William Taylor Memorial Scholarship Recipient Graduates and Launches STEM Career

Saleah McFadden

The INSPIRE Project's Dr. William W.L. "Bill" Taylor Memorial STEM Scholarship gave me the opportunity to attend school without any financial burden. This year, especially with a global pandemic, the world was in a constant spiral of uncertainty and fear. Many parents got laid off, many hospitals were out of capacity, and even many students could no longer attend school due to the lack of resources and finances. Thankfully, for me, the Dr. William W.L. "Bill" Taylor Memorial STEM Scholarship afforded me enough to cover my remaining balance for the academic year and allowed me to finish my matriculation at the illustrious Howard University.

One of the most difficult issues to handle on top of your academics, extracurriculars, and family is finances. The financial burdens placed on students to obtain higher education is one of the most detrimental issues that leads students to not completing their academic journey. I am so grateful for this scholarship assisting me in achieving my dreams and goals. Having this particular scholarship has allowed me to focus on my academic and professional career aspirations in engineering. I was able to learn more about myself mentally and spend more time with the important people in my life and explore the many opportunities presented to me.

Saleah taking the opportunity to pose on stage during the 2019 Forbes Under 30 Summit, where Serena Williams was the keynote speaker.

Over the past year, I have done a lot of self-reflection. Mechanical Engineering is an exciting field to be in because of the diverse opportunities and routes your career can take. It is also very frightful and stressful when you're nearing graduation and don't know what you desire to do, the pandemic threatens job security, and your classes are challenging you more than ever before. After lots of reflecting and exploring, it was apparent to me that engineering would be the foundation of my career and open doors into management, business, technology, aerospace and so many more areas I see myself in. I learned that majoring in a subject doesn't bind you to it, rather it allows you to use those skills in different settings and expand your potential exponentially. This past year I have accomplished so many things that I did not imagine doing. In addition to graduating with honors, I served as South Carolina Club President and Engineers without Borders Community Service Chair. I participated in the inaugural AT&T Historically Black Colleges and Universities (HBCUs) Innovation Challenge, where my team and I won first place along with a grand prize of $50,000. In addition, I was also a Venture Fellow at Squadra Ventures, Fannie Lou Hamer Fellow at Full Circle Strategies, and Social Media Strategy Fellow for Win with Black Women.

During my matriculation at Howard and as a Dr. William W.L. "Bill" Taylor Memorial STEM Scholar, I was named a 2019 Forbes Under 30 Scholar. As a Forbes Under 30 scholar, I travelled to Detroit, Michigan for a 3-day conference with some of the world's biggest game changers in every industry including Serena Williams, Kevin Durant, and so many more. I also became a HBCUvc Fellow in their 3rd cohort. The HBCUvc Fellowship program is an experience-based learning opportunity in venture capital and technology entrepreneurship, available to students attending select HBCUs and Hispanic-Serving Institutions (HSIs) to teach investment fundamentals and entrepreneurship.

I joined the Fiat Chrysler Automobiles Student Project Team, where I collaborated with other Howard students in STEM disciplines to aid in the construction of a street legal go-kart to submit in various competitions. My college experience awarded me opportunities like these and others that I am forever grateful to have experienced.

None of my experiences or accomplishments this school year, or the past two years, would have been possible without the William Taylor Memorial Scholarship. I am forever grateful to be a recipient of the award and will continue to uphold the legacy and standard of Dr. William Taylor.

To learn more about the William W.L. "Bill" Taylor Memorial College/University Scholarship or to apply online, visit:
http://theinspireproject.org/default.asp?contentID=5

About Saleah McFadden

Saleah McFadden is a recent graduate from Howard University, where she earned a Bachelor of Science in Mechanical Engineering with the distinction of Magna Cum Laude. Her next steps are moving to the Atlanta, Georgia area as a full-time employee with McMaster-Carr in their Management Trainee Program. Saleah's other accomplishments include being a 2019-2020 and 2020-2021 Thurgood Marshall College Fund Wells Fargo Scholar. She is involved in many organizations which include the American Society of Mechanical Engineers, Howard University Honor Society, National Society of Black Engineers, National Society of Collegiate Scholars, Engineers without Borders, Every Nation Campus, Fiat Chrysler Automobiles Student Project Team, Howard South Carolina Club, and Win With Black Women. Using her engineering background as the basis for her career, Saleah seeks to apply and merge her business experience to be able to create products and solutions from both an engineering and business perspective, producing invaluable results. Her passion for technology, management, space, engineering, mentoring, and much more make her easily adaptable, functional, and ready to take on the real world and make valuable change.

Saleah at the HBCUvc Fall 2019 Summit in San Francisco, California

INSPIRE Educational STEM Programs

College / University Scholarships

Dr. William W.L. "Bill" Taylor Memorial STEM Scholarship

Scholarship Awards: Up to $4,000 per recipient
Application Deadline: Ongoing

In honor of INSPIRE's co-founder Dr. Bill Taylor, The INSPIRE Project with its partners at the District of Columbia Space Grant Consortium and other science and technology organizations established this STEM (Science, Technology, Engineering, Mathematics) scholarship to help ensure our next generation of scientists and explorers. Undergraduate/ graduate and high school seniors who are majoring in a STEM discipline and are currently or will be attending a Washington, DC college or university are encouraged to apply.
Apply online at: http://theinspireproject.org/default.asp?contentID=5

Eligibility Requirements

All applicants must meet the following requirements and submit the required documents as outlined below:

- US citizenship
- Be registered as a full-time student in good standing at a Washington, DC college or university
- Must be majoring in a STEM (Science, Technology, Engineering, Mathematics) discipline
- Submit current transcript
- Submit two letters of recommendation with at least one from a teacher or faculty member
- Submit a 300 to 500 word essay discussing how this scholarship award will help you advance in STEM disciplines and the positive impact it will have on your future career plans

College / University Internships

NASA Goddard Space Flight Center Summer Internship Program

Summer Internship Awards: $7,300 Undergraduate Students / $9,000 Graduate Students
Internship Session: Early June – Early August (10 weeks, full-time)
Application Period: November – February (see NASA website for dates)
Fall and Spring semester internships also available

NASA Goddard Space Flight Center aerial photo courtesy of NASA

With support from the District of Columbia Space Grant Consortium and other partners, The INSPIRE Project offers paid full-time internships at NASA Goddard Space Flight Center. Fall and Spring semester internships also available

Internship Description

NASA summer internships are educational hands-on opportunities that provide unique NASA-related research and operational experiences for undergraduate and graduate students. The internships integrate participants with career professionals emphasizing mentor-directed, degree-related, real-work task completion. During the 10-week summer internship, participants engage in scientific or engineering research, development, and operations activities. Through these internships, participants engage in scientific or engineering research development, and participants leverage NASA's unique mission activities and mentorship to enhance and increase their professional capabilities and clarify their long-term career goals. Upon completion of internships, recipients are required to submit an article on his or her research project for inclusion in *The INSPIRE Journal*.

Eligibility Requirements

- US citizenship
- Minimum 3.0 GPA on a 4.0 grading scale
- Applicants must be enrolled full-time in a degree-granting course of study appropriate to NASA's long-term professional workforce needs
- INSPIRE summer internship applicants must be undergraduate or graduate students enrolled at a Washington, DC college or university

Applicants must complete the required NASA internship application which includes a letter of recommendation and current college/university transcript

For more information and to apply, visit the NASA internship website:
https://intern.nasa.gov/
Note: After completing online NASA internship application, please email: info@theINSPIREproject.org, so that INSPIRE can confirm receipt of your application with NASA GSFC.

Middle & High School STEM Educators

Kathleen Franzen Memorial Space Academy for Educators Scholarship Program*

Full Scholarships for Weeklong Summer STEM Program at the U.S. Space & Rocket Center in Huntsville, Alabama

The INSPIRE Project teamed up with the U.S. Space & Rocket Center, District of Columbia Space Grant Consortium, Washington Space Business Roundtable and other partners to offer Washington, DC middle and high school teachers and administrators full scholarships to attend Space Academy for Educators in Huntsville. The weeklong program during the summer includes authentic astronaut training simulators and activities developed to promote learning in a classroom setting. Curriculum includes NASA content and is correlated to the Next Generation Science Standards (NGSS). Trainees in Space Academy for Educators can earn 45 professional development hours and educators get access to a shared website with lesson plans, networking opportunities, and tips to adapt many of the workshop activities to individual class environments.

Workshop topics/activities include: Engineering Design Challenges, Rocket Construction, Math Workshops, Living and Working in Space, Orion Spacecraft, Space History and Mars & the Moon.

Teachers participate in Low Earth Orbit (LEO) and Mars Missions, simulate walking on the moon and working in the frictionless environment of space on astronaut simulators and weather permitting, spend an afternoon at Aviation Challenge simulating parachute landings and helicopter rescues in the water.

Space Academy for Educators full scholarships include:

- Round-trip airfare from Washington, DC to Huntsville, AL
- Six nights lodging and meals
- Program materials, flight suit, T-shirt and USSRC exhibit ticket
- Transportation to/from the airport in Huntsville

Apply online at: https://theinspireproject.org/default.asp?contentID=7

Middle & High School Students

Kathleen Franzen Memorial Space Academy for Students Scholarship Program*

Full Scholarship for Weeklong Summer STEM Program for Washington DC Area Middle & High School Students at the U.S. Space & Rocket Center in Huntsville, Alabama

The INSPIRE Project teamed up with the U.S. Space & Rocket Center, Washington Space Business Roundtable and other sponsors to offer full scholarships to Space Academy in Huntsville, Alabama for Washington, DC area high school and middle school students. Space Academy is an action packed 6-day program for students world-wide to participate in classroom, laboratory and training focused on space science and space exploration. Space Academy encourages teamwork, problem solving, communication skills and self-confidence. Students take part in astronaut-style training and simulations, as well as STEM activities to ensure our next generations of space science and technology explorers!

- Tumble and spin in the Multi-Axis Trainer
- Float on air in the 5-Degrees of Freedom Chair
- Walk like Apollo astronauts in the 1/6 Gravity Chair
- Experience a world without friction in the MMU
- Challenge yourself and support your Team at Area 51
- Pilots/Commanders land the Space Shuttle
- Mission Specialists walk "in space" on an EVA (Extra Vehicular Activity) to repair the Hubble Space Telescope
- Live and work in space operating the ISS life support
- Perform scientific experiments on soil samples from Mars

Space Academy for Students full scholarships include:

- Round-trip airfare from Washington, DC to Huntsville, AL *(INSPIRE chaperone accompanies students)*
- 5 Nights lodging and meals at the U.S. Space & Rocket Center
- Program materials, flight suit, team patch, T-shirt and photos
- Transportation to/from the airport in Huntsville

Apply online at: http://theinspireproject.org/default.asp?contentID=19

** NOTE: Due to the pandemic, the Space Academy for Educators and Students programs have been temporarily suspended for summer 2021. INSPIRE hopes to resume both programs in summer 2022.*

Special Thanks to The INSPIRE Project's Program Sponsors, Supporters and Volunteers

NASA | District of Columbia Space Grant Consortium | Washington Space Business Roundtable
U.S. Space & Rocket Center | International Launch Services | Space Ad Agency | Fisher Space Pen

The Transit of Mercury (November 11, 2019)

Dr. Gordon Telepun (foxwoodastronomy@gmail.com)

Introduction

When was the last time you stood outside and watched the Moon continuously for 30 or 40 minutes to see it move relative to a stationary foreground object? I'll bet most people have never done it! That is what I find amazing about total solar eclipses and inner planet transits across the Sun; they are events that allow me to watch the clockwork motion of the solar system in real-time. Articles about inner planet transits generally spend some time discussing the periodicity, meaning the predictions of the transit repeating through time. Due to our understanding of the orbital motions of the planets with respect to the Sun, the date and times of transits can be accurately calculated. So to observe a transit, the remaining variables are being located on the correct side of Earth during the transit, since it is a daytime event, and having clear skies. The ingress and egress of the planet on and off the Sun uses the nomenclature of four precise contact times just like we use for solar eclipses (first, second, third and fourth contact). But unlike total solar eclipses, most people do not find planet transits exciting enough to travel internationally to observe them.

Venus and Mercury Transits

If you missed the 2004 and the 2012 Venus transits, you can catch the next one; if you can live 96 more years! The next Venus transit occurs on December 11, 2117. The periodicity of Venus transits is interesting; they occur in pairs separated by 8 years, with a pair repeating in December and then a pair repeating in June. The 8-year pairs are separated by over 100 years. The southeastern United States was fortunate enough to have a chance to observe both of the recent Venus transits. In 2004 the transit was in progress, and nearing its completion at sunrise, so I traveled to the coast of South Carolina to observe that one. The 2012 transit began just before sunset and was in progress at sunset and I was able to observe that one in my hometown of Decatur, Alabama.

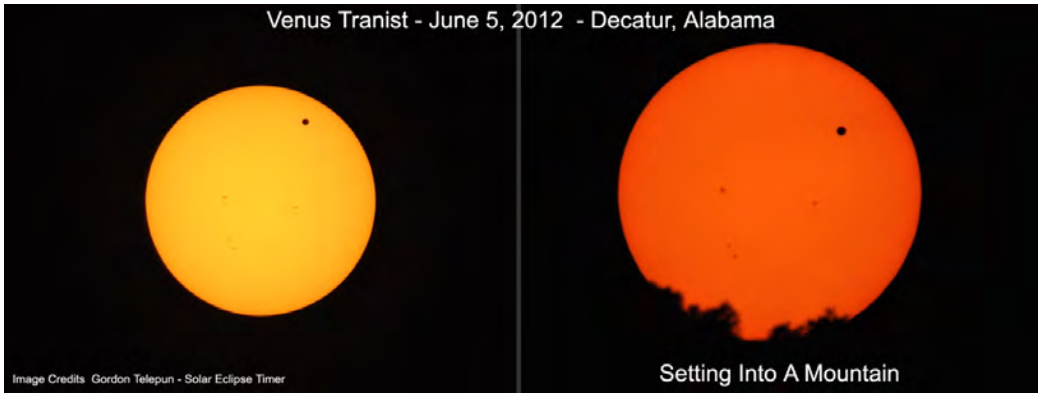


Figure 1 (above):
Venus transit in progress at sunrise on the east coast. Third contact image is in hydrogen-alpha

Figure 2 (left):
Eight years later the Venus transit begins just before sunset in the southeast. In Decatur, it sets behind the mountains while in progress.

Observing the two Venus transits helped put the 2019 Mercury transit into perspective for me. I observed the November 1999 Mercury transit but was not prepared for photography through the telescope. I missed observing the May 2016 Mercury transit either due to poor weather, my work schedule or both, I don't remember. But the 2019 Mercury transit was visible from my hometown and we had reasonably clear skies to observe it. What shocked me the most was how small Mercury appeared!

Mercury transits are more frequent than Venus transits, averaging about 13 each century. They occur in November or May and since the planet is closer to the Sun (perihelion) during the November transits (farther from Earth) its disk size is only 10 arc-seconds across. November transits repeat at intervals of 7, 13 or 33 years. During the May transits, the planet is further from the Sun (aphelion) so the disk size is 12 arc-seconds (closer to Earth) and the repeating interval is at 13 or 33 years.

Imaging the 2019 Mercury Transit

I imaged the Mercury transit with three different setups, at two different locations, over a range of time from just after sunrise with more atmospheric density and less clarity (remote location) to just before noon with the Sun much higher in the sky (my backyard observatory). The least effective setup, which was used early in the morning, was a 500mm Sigma zoom lens and a Sigma 2x teleconverter making the focal length 1000mm (f/13) using a full-frame Nikon D750 camera. The solar filter was a full aperture Seymour Solar Helios glass filter.

Figure 3 (left): This setup had too many surfaces of glass, along with imaging through the morning atmosphere and with light clouds, it was just not clear enough for good focus. The size of the solar disk image at 1000mm makes the planet size too small [f/13, 1/200s, ISO 320].

A reasonably effective set up in the early morning was a Meade 5" ETX Maksutov-Cassegrain telescope with a focal length of 1900mm (f/15) using a Nikon D5000 at prime focus with a 1.5 crop factor making the system work at 2850mm (f/22). The solar filter was a full aperture Thousand Oaks Optical SolarLite film.

Figure 4: At this focal length, the solar disk fills the frame and improves the visibility of the small planet [f/22, 1/60s, ISO 1600]. I also got lucky with this setup during the transit when a jet passed in front of the Sun leaving a contrail for just a few seconds [f/22, 1/320s, ISO 1600].

My best imaging occurred before noon with the Sun higher in the sky from my backyard observatory with a Meade 7" LX200 Maksutov-Cassegrain telescope with a focal length of 2670mm (f/15) using a Nikon full-frame D750 at prime focus. The solar filter was a 3-inch diameter off-axis Baader solar film filter (OD 5.0) which creates a bluish-white image.

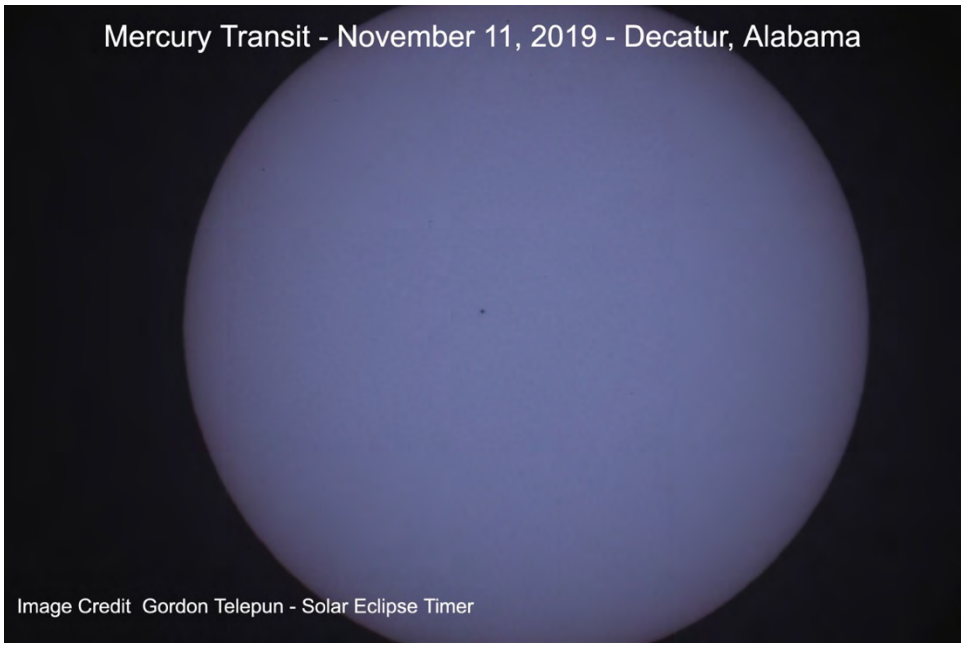


Figure 5: This filter passes a lot of light. After trying many different shutter speeds and having a few instances of stable atmospheric seeing, I was able to capture a few clear images [f/15, 1/320s, ISO 320].

Relative Scale

Because I had my own Venus transit images and my own Mercury transit images, I thought it would be interesting to match the sizes of the solar disk from the two transits and overlay the images to see the relative scale of the planets. You can see why a Venus transit can actually be seen with solar glasses without magnification and a November Mercury transit is challenging to see even with filtered binoculars.

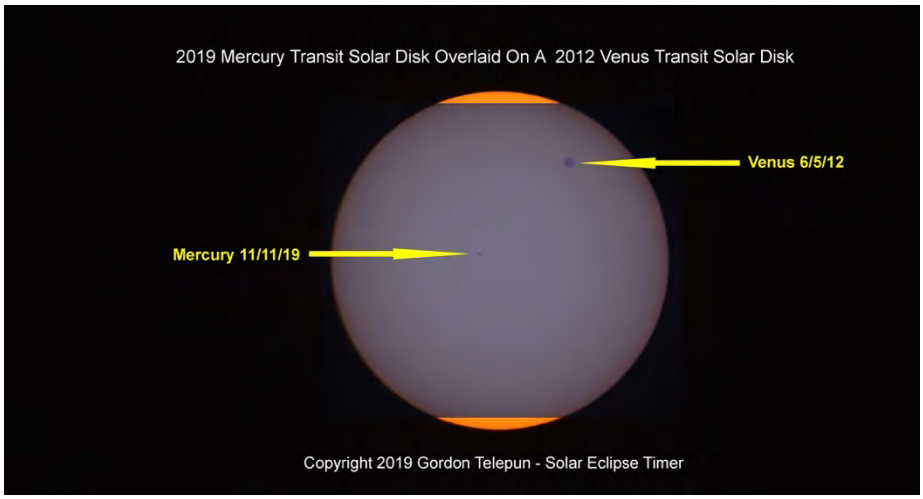


Figure 6: Matching the size of the solar disk from the two transit images allows a comparison of the size of Venus and Mercury on the face of the Sun.

When I look at my Baader filter image of Mercury, it makes me feel sorry for this tiny little planet! It's so small and so close to the Sun that its hottest regions can reach 427°C (800°F) while the dark side drops to -173°C (-280°F). Mercury whips around the Sun in 88 days but has a bizarre rotation that faces a side of the planet towards the Sun for 1,408 hours (58 Earth days). Photographing the transit made me think about how the Sun would appear in the sky of Mercury if I could stand on the surface and look up. The angular diameter of the Sun in our sky on Earth measures 31 arcminutes. On Mercury, with its eccentric orbit, its farthest distance from the Sun (Aphelion) is about 70 million kilometers away making the angular diameter of the Sun 67 arcminutes. During its closest approach to the Sun (Perihelion), it is about 46 million kilometers away making the angular diameter of the Sun 101 arcminutes.

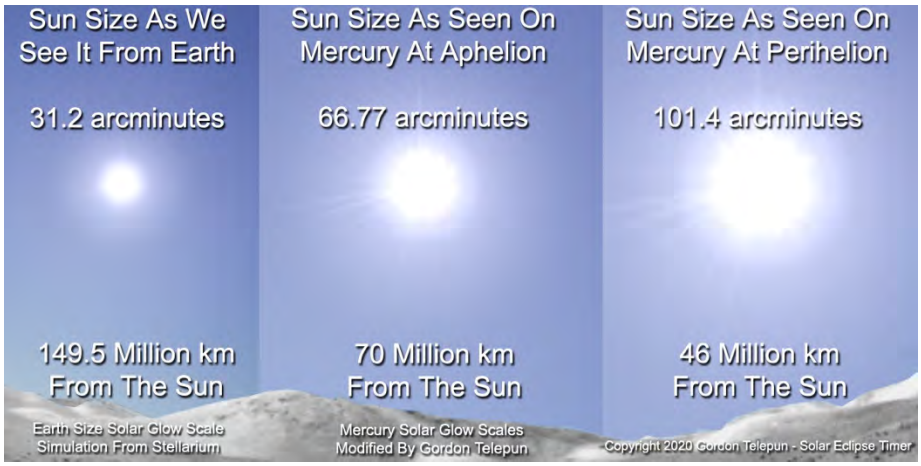


Figure 7: Simulation of the size of the Sun if standing on Mercury.

Summary

The next two transits of Mercury, November 13, 2032, and November 6, 2039, will not be visible from the United States. Both transits will be completely visible over the continent of Africa. On May 7, 2049, Mercury transit is again visible in the United States with ingress at sunrise on the east coast. But don't fret if you missed the 2019 Mercury transit. You have an opportunity to see the next United States total solar eclipse which will occur on April 8, 2024. This is the "ultimate transit" – the Moon across the Sun! You must prepare to get to the path of that eclipse!

Figure 8: Gordon in his observatory on the day of the Mercury transit with Destin Sandlin from the popular YouTube channel Smarter Every Day: https://www.youtube.com/user/destinws2

About Dr. Gordon Telepun and his Solar Eclipse Timer App

Dr. Gordon Telepun is a plastic surgeon who lives in Alabama. He is an expert eclipse photographer, eclipse educator and the developer of the mobile app Solar Eclipse Timer which is designed so he can be your personal guide and photography assistant through the stages of an eclipse. It was used with great success for the eclipses in 2017, 2019, 2020 and is ready for the next United States eclipse in 2024. The app geolocates, calculates the precise contact times and "talks" you through the eclipse. It's especially helpful for a total eclipse but it also has a partial eclipse timing mode. Detailed eclipse educational videos can be found on his YouTube channel – Solar Eclipse Timer: https://www.youtube.com/channel/UCn8hUby9U97J11hg27rdSNQ Other eclipse information, including details about the app, is available on his website: http://www.solareclipsetimer.com

Acknowledgements and References

1. Loren Ball, Emerald Lane Observatory. Assistance with orbital scale mathematics.
2. Maunder, Michael and Moore, Patrick. Transit, When Planets Cross the Sun. Great Britain. Springer, 2000.
3. NASA Eclipse Website. https://eclipse.gsfc.nasa.gov/transit/transit.html

INSPIRE's NASA Goddard Space Flight Center 2021 Spring Intern Reports on Research Project

Malaya Moon

Malaya visited the entrance of Goddard to take a photo for *The INSPIRE Journal*, as her internship was held virtually/online this semester due to the pandemic.

Astronomy Data Analysis: Estimating Galaxy Star Formation Histories

I am a first generation college student from Athens, Georgia. Stepping foot on Howard University campus for the first time was the moment I knew my life would be changing for the better.

As I am now officially a rising junior Computer Science major at Howard, I know the "freshman year me" is proud of the accomplishments I have achieved over the past two years. Coming out of my freshman year, I didn't think I was qualified enough for an internship but I took a leap of faith and landed my first NASA internship in the summer of 2020 at the Jet Propulsion Lab.

This spring I had the opportunity to take on my second NASA internship at Goddard Space Flight Center as an Astronomy Data Analysis Intern. Under the guidance of my mentor, Gregory Mosby, I was able to learn more about stellar populations and why it is important for us to study galaxies.

The purpose of this project was to create an analysis technique to more deeply understand and compare stellar histories. To conduct this study, we used a machine learning technique called diffusion mapping. With the use of an example library of simple stellar populations, 3D plots of diffusion maps of stellar populations at fixed age and multiple chemical abundances were developed to help explore how useful diffusion mapping might help in recovering both age and metallicity from a galaxy's total light output.

My time at NASA GSFC allowed me to grow as a computer scientist. My favorite thing during this internship is connecting with professionals in different departments and learning of the various career opportunities available to me. This experience has empowered and encouraged me to continue to reach for my aspirations in life. My overall experience with NASA is a dream come true. I've always looked up to Katherine Johnson as she was in the room where it all happened. One day I hope to be in that room too. Thank you INSPIRE for supporting me on this journey.

To learn more about INSPIRE sponsored NASA internships visit: https://theinspireproject.org/default.asp?contentID=6 or the official NASA internship website: https://intern.nasa.gov/

About Malaya Moon

Malaya Moon is a rising junior at Howard University majoring in Computer Science and minoring in Military Science. Malaya's accomplishments include being a Black Females Moving Forward (BFF) in Computing Scholar, Howard University Leadership Scholarship Recipient, Military Order of the Purple Heart Leadership Award Recipient and a member of the Upsilon Pi Epsilon International Honor Society for Computing and Information Disciplines. Malaya's involvement on campus include Co-Founder of the Google Developer Student Club Howard University Chapter, Association of Computer Machinery, National Society of Black Engineers, National Society of Collegiate Scholars, Howard's Army ROTC program, and Howard's Georgia Club.

This summer she will be a cybersecurity intern at F5 Networks. Her passion for STEAM is the foundation of the legacy she is creating as she takes on the world one step at a time.

INSPIRE VLF Receiver Incorporated in Artistic Exploration: *In Search of Aztlan...*

Martín Rodríguez

Photos by José Garcia-Lozano

As the child of Mexican and Polish-American parents, identity plays a central role in my artistic explorations. From 1983 to 1992 home was Rio Rico Arizona, a small town on the border of the USA and Mexico. I have vivid childhood memories of living in a working class barrio on the American side and crossing weekly to Nogales Sonora. As an adult, I now realize the profound influence this time spent along the frontier between two countries was for me. Those experiences continue to shape an understanding for who I am.

In Search of Aztlan… is a site specific transmission investigation exploring the territory around my childhood home, using experimental radio antennae to examine how borders, both physical and psychological, shape our individual and collective identities. While researching my Chicanx roots, I came across the essay *La Raza Cósmica* by Mexican philosopher José Vasconcelos. In this text Vasconcelos describes a "cosmic race" that is the mix of all races. This text resonated with parallel investigations into how radio is used by astronomers to understand our place in the universe.

With these concepts in mind, I fabricated a large 4'x 4' antenna of wood, yarn and copper magnet-wire. This experimental radio receiver fuses the *Ojo de Dios*, the *God's Eye* of Mexican folk-craft, with a traditional loop antenna. *Ojos de Dios* are believed to have the power to see things unknown to the human eye, resembling the way in which an antenna captures radio from the ether. This antenna manifests the fusing of traditions, connecting of borders, and mixed identity. It is designed to listen for distant transmissions from the mythical homeland of the Aztec's, Aztlan. This first iteration monitors the ionosphere with the INSPIRE VLF receiver as well as a handmade cassette-sized crystal radio. This project is ongoing as I continue to improve the antenna design to scout radio signals across the Sonoran Desert exploring radio's ability to break down human-made borders, and embody the identities of those who exist along their margins.

About Martín Rodríguez (Artist Bio)

*As a multidisciplinary Chicanx artist and independent curator, Martín Rodríguez's work emerges from personal experiences. By engaging the present, his practice mixes performance with interventional happenings and installations. After surgery to remove a brain tumor which left him temporarily paralyzed, Rodríguez searched for new meaning. When radio signals trapped in his guitar began to sing, he seized on the phenomena, and began exploring the cracks of the radio spectrum as a material for making art. Notably, his work has been presented by the Musée d'art contemporain Montréal (CA), MUAC (MX), Darling Foundry (CA), Spektrum (DE), as well as various festivals and performance venues across Canada, and the US. In addition to producing his own work, he organizes and curates various events, happenings, and festivals including: Acoustic Mirror – a live streaming radio concert and experimental broadcast series, Bodies in Resonance (2021), the international digital art festival Sight and Sound Festival (2019), Ibrida*Pluri A/V Festival (2019), Amplified (2018) and PirateBlocRadio In-Situ (2017). From 2014 to 2018, he worked as Technical Director, Lab Director, and Co-Director of Eastern Bloc, an artist-run center dedicated to presenting emerging media artists in Montréal, Canada. To learn more visit: http://rdzmartin.com/*

“Natural Radio” as a Didactic Alternative in Waves Physics

Audemário Prazeres, Founding President of Astronomical Association of Pernambuco (State of Pernambuco in Brazil)

Audemário Prazeres, Teacher / Founding President of AAP in Brazil

The great challenge of carrying out a project related to radio astronomy is to raise people's awareness to understand the importance of electromagnetic waves that are present in our daily lives in different artificial forms and of natural cosmic origin. Radio astronomy is a science capable of congregating and uniting people in all places where curiosity prevails. Listening to natural radio waves will help us better understand our place in the universe and its influence on our daily lives. Radio astronomy awakens fascination in people's imagination that is independent of age and gender – men, women, young people, old people and children, who all are captivated by its enigmatic beauty in its hidden mysteries. Unfortunately, media reporting about radio astronomy often confuses its basic concepts and context of study. The result of poor reporting tends to lead to the unfortunate expectation that it is all about contacting aliens. As a result, the impression is left that the vast field of research that radio astronomy offers is, in a way, unmotivated for its development. Therefore, it is not surprising that school teachers are often afraid to explore radio astronomy in their classrooms beyond simple Internet content.

I was thinking about these and other difficulties that the Astronomical Association of Pernambuco (AAP), a nonprofit entity founded in 1985 located in the state of Pernambuco in Brazil, has in its mission of developing the social project entitled “Solidarity Astronomy”, and started its educational work related to radio astronomy in order to awaken scientific initiation and stimulate the didactic side among fans of wave physics.

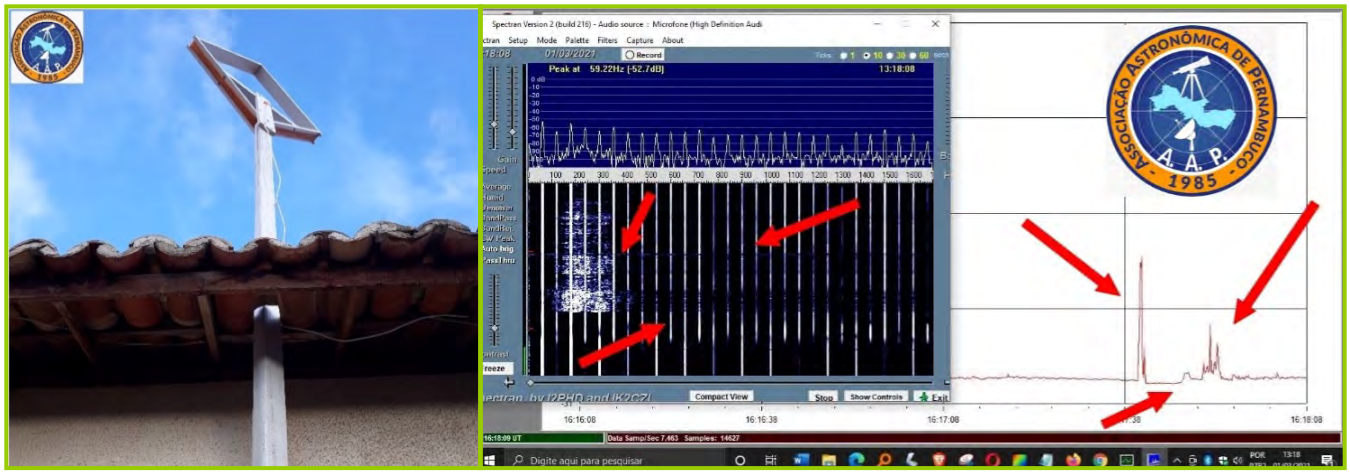
Thus when we became aware of The INSPIRE Project, we immediately identified the noble objectives of the educational initiative, which are very similar to what we have been practicing at the AAP in its 36 years of existence, which is to enable the strengthening of the sciences within everyone's reach. In this way, we carried out our “Solidarity Astronomy” project in communities with difficulties in accessing scientific practices, especially those located in rural areas peripheral to city centers.

INSPIRE, is an acronym for "Interactive NASA Space Physics Ionosphere Radio Experiments”. It is the assembly of a receiver kit that operates in the very low frequency (VLF) range. This receiver was designed to receive radio waves in the frequency range from 0 to 15 kHz in which they capture the natural VLF emissions generated mainly by lightning strikes where lightning generates broadband electromagnetic waves ranging from a few Hz to reaching MHz.

Brazil is one of the countries in the world with the highest incidence of lightning. According to the National Institute for Space Research, there are more than 78 million a year! From 2000 to 2014, there were 1,792 deaths from electrical discharges recorded, which is an average of 120 per year.

The institute also concluded that two-thirds of these deaths occurred in open environments, such as beaches, fields and plantations. Under these conditions, the chances of death from electric shock are 1 to 1,000. In our country, for every 50 deaths from lightning strikes that occur on Earth, one happens in Brazil. Even here, there are several fires in the biomes due to the incidence of lightning, as well as problems in telecommunications, signals from Internet operators, and damage to the power distribution towers.

Pre-pandemic activities with children at AAP



Fixed loop antenna to be used with the INSPIRE receiver. Lightning recorded by AAP on another VLF receiver that it owns.

We intend to create a database based on investigations on the increase or decrease in the number of electrical discharges generated by lightning in the central region of the State of Pernambuco, where the headquarters of the AAP is located, so that we can present a report of the flow of these electromagnetic discharges. As well as, in parallel, initiate a pedagogical action with aficionados on the risks of lightning and the concept of the importance of studying natural radio emissions and their dynamics. As part of our research, our intent is to use the INSPIRE kit to capture “natural radio” emissions and electromagnetic discharges generated by the incidence of lightning. Each lightning bolt creates a radio pulse that can travel thousands of kilometers, bouncing between the Earth's surface and the ionosphere. Of particular interest is that ionospheric irregularity is important in causing VLF attenuation as it propagates.

Editor’s Note: We look forward to sharing with our readers future INSPIRE receiver VLF observations by AAP.

Kathleen Franzen Memorial Space Academy Scholarship Program

INSPIRE Space Academy Alumni – Our Next Generation of Scientists and Explorers

During the past 13 years, 39 educators and 70 students have been awarded full scholarships to participate in this week-long educational STEM program for middle and high school educators and students held at U.S. Space & Rocket Center (USSRC), NASA’s official Visitor Information Center for Marshall Space Flight Center, in Huntsville, Alabama. The action-packed week includes 50+ hands-on STEM activities and experiments. Aside from astronaut training, the Space Academy for Educators program includes intensive classroom, laboratory and training focusing on space science and exploration activities developed to promote learning in a classroom setting and equips teachers with knowledge, activities and materials to excite, engage and attract students to STEM disciplines. Year after year in INSPIRE’s annual educator surveys, 100% of Space Academy for Educators STEM scholarship recipients still teaching in the Washington, DC area, utilize materials and knowledge acquired via the Space Academy program directly impacting approximately 2,800 students in 32 schools each year. Special thanks to INSPIRE’s sponsors including the Washington Space Business Roundtable, District of Columbia Space Grant Consortium, Patriots Technology Training Center and private donors for their support and inspiring our next generation of space scientists and explorers.

INSPIRE Program Manager Eva Kloostra with Nile Brown at Space Camp in 2012. Nile just completed her sophomore year at Indiana State University where she is majoring in Biology and is on the Track & Field Team.

Due to the pandemic the Space Academy program is suspended until summer 2022. Past space camp student alumni, who were also members of the INSPIRE NASA 2017 Solar Eclipse Team, shared some of their many recent successes…

Isadora Germain (Junior, United States Air Force Academy) – 2014 & 2017 NASA Solar Eclipse

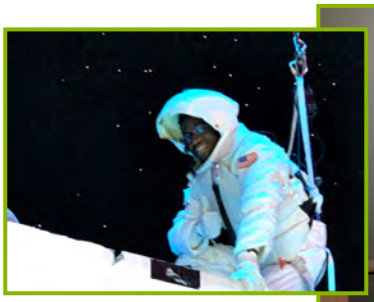
I was provided with two amazing opportunities from The INSPIRE Project in high school. They gave me the opportunity to go to Space Camp and also to travel to watch the solar eclipse as part of the NASA team. These amazing experiences not only allowed me to learn about the space-related things I was passionate about but also gave me greater confidence in my abilities. I accepted my appointment to the United States Air Force Academy after high school and was luckily able to continue following my passion for space that Space Camp had instilled in me. I decided to pursue a major in Astronautical Engineering and just finished my third year of school. In my classes, I learn about everything from orbits, to satellites, to planning space missions. My classes make me nostalgic for the days I spent at Space Camp! The U.S. Air Force Academy has also allowed me to take flying lessons in both powered aircraft and gliders, and next year I am scheduled to learn how to skydive! I am also a member of the Air Force Academy Marathon Team, and I placed first in my age group in the Marine Corps Marathon in 2019. I am so grateful for the experiences and confidence in myself that The INSPIRE Project gave me and where it brought me today. Thank you INSPIRE!

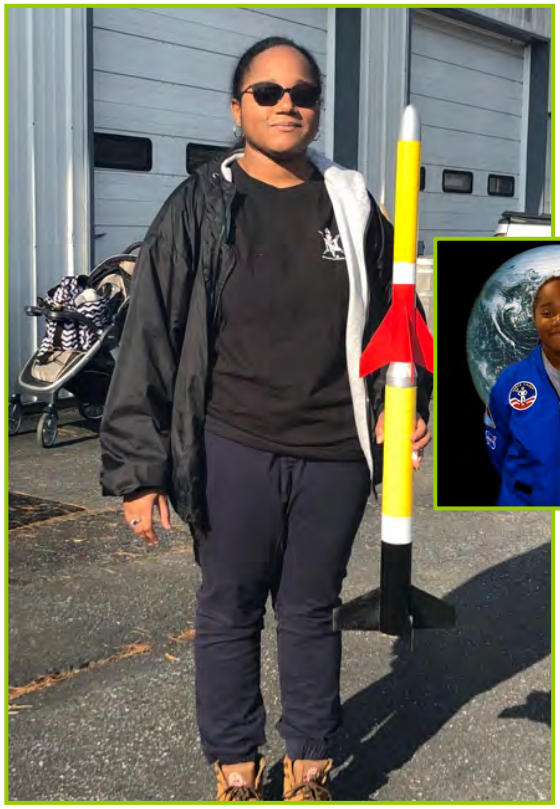
Bryce Stephens (12th Grade) – 2015 & 2017 NASA Solar Eclipse

I am a current high school senior, getting ready to graduate in the next few weeks. Over the past year, I have become a student advisor on the student board of my National Society of Black Engineers Jr. Chapter, NSBE FIRE Jr. During my time as a student advisor, I have taught high school and middle school students the basics of Computer-Aided Design (CAD) and guiding them through different CAD challenges. In addition, I also taught those students about engineering concepts and helped them complete projects geared towards reinforcing those engineering concepts. In the spring, I took part in the TEN80 Racing competition as part of the Design team, where I created 3D models and 3D printed those models of different parts needed for our team's radio control race car. I took part in the Junior Achievement Company Program, taking the role of Supply Chain Director. Throughout this program, I worked with my fellow students to start up our own company, which is geared towards wellness and overall comfort, called Complete Comfort. As a result of my efforts throughout the season and performance at pitches and competitions, I was awarded the title of Supply Chain Director of the year for 2021, which is a repeat of my award from 2020. I have continued to play travel soccer at a high level, competing in the EDP Division 1 and ECNL leagues. This summer, I will be taking part in an internship at NASA focused on designing the ground vehicles for the OSAM-1 robotic servicing mission. I will be graduating from CMIT North High School in Laurel, Maryland and receiving my associate's degree in Information Technology from Prince George's Community College, as part of my high school's early college program. I have decided to attend Tuskegee University in Tuskegee, Alabama on the school's full-ride Distinguished Presidential Scholarship and will be majoring in Aerospace Engeering. I am very excited to attend Tuskegee in the fall and I am prepared to see what the future holds.

Clark Gray (Sophomore, Syracuse University) – 2015, 2017 NASA Solar Eclipse & 2019 Advanced Space Academy

I am currently a sophomore at Syracuse University majoring in International Relations and minoring in Mandarin Chinese. I most recently served as a peer leader of several freshmen in the WellsLink Leadership Program which is a nationally recognized academic excellence and leadership program for first-year students. I serve as the vice president of Glorify God, an organization run by students seeking to glorify Jesus by representing the ideas of faith, love, and hope as mentioned in the Bible. I am also a member of an intramural kickball team. I am currently enrolled in the Syracuse University Army Reserve Officer Training Corps (ROTC) and plan on commissioning as an Army Officer upon graduation. I'm on the Dean's list and am the # 1 cadet in my sophomore class. I was selected for the ROTC Project Global Officer (Project GO) study abroad scholarship to study Chinese in Taiwan this summer. While the current COVID-19 spike in Taiwan threw a wrench in my study abroad plans, I am still very grateful for the opportunity to attend an eight-week intensive Chinese language program at the Military College of South Carolina, also known as the Citadel. My experience attending Space Academy during the International Space Academy program taught me a lot about communication, leadership and cooperation. Almost everyone on my team was from a different country so it was both interesting and challenging. I feel that our conversations and experiences were similar to those between scientists on the International Space Station (ISS) and that experience helped to prepare me for college. I am looking at possible careers in international space, intelligence and/or security in the future.





Charis Houston (Sophomore, Capitol Technology University) – 2015 & 2017 NASA Solar Eclipse

My trajectory since attending Space Academy in 2015 has gone to new heights. As a rising junior at Capitol Technology University, I have had the opportunity to participate in different projects and opportunities related to Astronautical Engineering. Since January 2020, I have been a part of my university CACTUS-1 CubeSat ground team, which launched in January 2021. This summer, I will participate with my school team in the RockOn workshop by the Colorado Space Grant Consortium and NASA Wallops Flight Facility. The workshop focuses on an introduction to building and launching a sounding rocket payload experiment. Outside of school, I volunteer with a local organization focused on teaching middle and high school students skills needed to succeed in STEM. I believe it is essential to pay it forward and help kids explore their interests in STEM, just as the Space Academy did for me. With eyes set on my career after graduation, I hope to work in mission operations. My coursework and project opportunities in school follow largely around mission operations. The excitement and interest in mission operations stem from attending Space Academy and working alongside other students who are passionate about space.

Julian Thomas (12th Grade) – 2016 & 2017 NASA Solar Eclipse

I am currently a senior in high school on my way to graduation. My high school bears the name of a Tuskegee Airman responsible for training pilots during World War II. After high school, I plan to study Aviation Management at University of Maryland Eastern Shore as my career goal is to become an air traffic controller. From a young age, I have been passionate about aviation. In 2015, I participated in a robotics competition with two of my friends at NASA Goddard Space Flight Center. We were blessed to win the first-place prize which was an all-expense-paid trip to the NASA Space Camp in Huntsville, Alabama which was sponsored by INSPIRE. During this influential week, I received an autographed book from the astronaut Buzz Aldrin, talked to people aboard the International Space Station (ISS), and made friends with students from across the world. The best part of the experience is that it became clear to me that I wanted a career involving aviation and aeronautics because of the many activities we participated in. This experience led me to be chosen to be a part of the NASA-INSPIRE research team at Austin Peay State University in Tennessee for the Solar Eclipse in 2017. Without the influence and impact that INSPIRE had on allowing me to come to this camp, I would not be where I am today. In addition to allowing me to attend Space Camp, it also gave me the passion to be an influence to others. Whether that was through humanitarianism, community service, outreach, the tutoring and upbringing of children, or missionary work, I knew that I wanted to make an impact in the lives of others. I believe I accomplished this goal because during my duration in high school I completed over 300 hours of community service. As I end my time in high school I want to serve as an ambassador and mentor to other kids. For anyone going into aviation or anything STEM-related, The INSPIRE Project along with Patriots Technology are great places to get started. I can serve as a prime example of what can occur when you put resources in place to allow kids to broaden their experiences and allowing them to have opportunities that would otherwise not be there. I will speak not only on my behalf but also on the behalf of my family in stating, invest your time and energy in organizations like INSPIRE because the results are there and I am a prime example of the investment.

Justice Flora (12th Grade) – 2016 & 2017 NASA Solar Eclipse

The INSPIRE Project has been an awesome experience and has truly changed my life. Before INSPIRE, I wasn't sure if I really wanted to pursue a STEM career. However, after the Space Camp and NASA Solar Eclipse experiences I knew STEM is where I belonged. After learning with Ms. Eva, Ms. Karin, Mr. Dennis, Ms. Mitzi and Astronaut Rick during my INSPIRE experiences, I was able to get involved with many different opportunities which have significantly impacted the course of my high school experience. Going into Charles Herbert Flowers High School I was accepted into the Project Lead the Way Engineering Program which focuses on 5 different aspects of engineering throughout my time in high school. Project Lead the Way covers the introduction to engineering, the principles of engineering, civil engineering and architecture, digital electronics and lastly engineering design and development. My senior capstone project group received the highest grade in Prince Georges County this year, which all started from my experience with INSPIRE. I recently committed to Penn State University studying Civil Engineering under the Schreyers Honors College and Millennium Scholars Program. I can surely say without INSPIRE it would be very hard to visualize what my high school experience and interest in STEM would have looked like. Thank you INSPIRE for placing me on the track to study STEM in high school and college.

Justice with INSPIRE Advisors Dennis Gallagher and Mitzi Adams of NASA Marshall Space Flight Center at Space Camp in 2016

Colby Gray (Freshman, Gordon College) – 2016, 2017 NASA Solar Eclipse & 2019 Advanced Space Academy

I graduated from McKinley Technology High School in June 2020. I just finished my freshman year at Gordon College. While at college this year, I was selected as a James Higginbotham Legacy Fellow, where my cohort worked diligently to become young Christian professionals. I also served on the Lewis Hall Events Council, where I helped plan fun activities for students to help them connect and not feel so isolated during this pandemic. Additionally, I was a member of Afro-Hamwe (the black student union), where we organized many informational seminars and events on campus that centered around topics that deeply affected our student body. I also was a trumpet player in the Symphonic Band, where we performed many musical pieces outdoors including “The Invincible Eagle”, “Toccata”, “Swing Low Sweet Chariot”, “March, Opus 99” and many more. I was also honored to have one of my poems featured in the spring edition of “The Idiom," the college’s student arts publication. Lastly, I had the wonderful experience of being a Prep Chef at my campus' dining hall, where I was able to express my great interest of cooking. At Space Academy, I enjoyed getting to experience different leadership positions such as being in the mission control and on the ISS. During my freshman year, I also got to experience different leadership roles and positions which I also really enjoyed. As a result of my experiences, I have decided to change my major from Music to Business Administration & Management and would like to start a business analysis company.

Robert Allsbrooks IV (Sophomore, Morgan State University) – 2015 & 2017 NASA Solar Eclipse

I went to Space Academy in 2015 and worked with NASA in 2017 to study the effects of the Solar Eclipse with the help of INSPIRE. In the summer of 2018, I was able to get an Internship at NASA working in the Thermal Studies Department with an Infrared Detector that will be going on a telescope in 2024. At the end of my internship I was offered an extension to continue my work for a few more weeks. During my senior year of high school, the college application process was tough, but after a long process I was accepted into 19 colleges. Although it was a tough decision, I decided to attend Morgan State University to study Electrical Engineering on a full ride scholarship. All Electrical Engineering students at Morgan State have to attend a summer program, so I decided to do the Pre-Freshman Accelerated Curriculum in Engineering (PACE) Program. PACE focuses on making sure students are ready for freshman year courses and to make sure they are well adjusted to college life. They also prepare students to take placement exams for Calculus and English. During PACE, I was able to meet professors, develop my skills in math and science, find my roommate, and most importantly rediscover myself. This program pushed me to my limits, allowing me to really think about my future as an engineer and maybe even more. For my future goals, I am going to keep them in the air. This year my goal is to secure an internship for next summer that provides me more experience in the engineering field.

Editor’s Note: Robert submitted the above article for the 2020 volume of the Journal, which did not publish due to the pandemic, just before heading off to college. I spoke with Robert on Saturday, May 23, 2021 just as he was getting off an airplane in California. Robert is excelling in college and just completed his sophomore year at Morgan State University. He was chosen for a summer engineering internship at Northrop Grumman Space Systems in Redondo Beach, California which he started on the following Monday. Congrats to Robert and all of INSPIRE Space Camp alumni students! Eva

Joshua and his son, Alexander, at Goosepond Fish and Wildlife Area south of Linton, Indiana

INSPIRE VLF-3 Receiver Notes

Dennis Gallagher, VLF Receiver Chief Technical Advisor

I wanted to send you a note to tell you that I really enjoyed building the VLF-3 receiver. As an amateur radio operator, I've had some experience with soldering and constructing experimental projects, but I think this kit could be assembled with little experience. The unit was well engineered and the instructions were easy to follow. I took the unit out to a remote area for testing with my son, Alexander, who is a third year electrical engineer student studying at the Rose-Hulman Institute of Technology. We were excited to hear that the receiver worked better than expected and listened for quite a while under the stars. I fabricated an antenna from a 1.5 meter collapsible whip attached to a tripod. We drove a stainless steel rod down about 3 feet into the soil for a ground connection. Thanks again for providing the kit. It has given me this great memory with my son, as well as given him another layer to his studies! – Joshua Wolfe

VLF Online Resources

NATURAL RADIO & VLF DISCUSSION GROUP (Formerly Yahoo Discussion Group)
https://groups.io/g/VLF

VLF GRAPH CONVERSION SOFTWARE
Spectrum Lab: http://www.qsl.net/dl4yhf/spectra1.html

VLFrxTools: http://abelian.org/vlfrx-tools

LOCAL TIME TO UTC CONVERSION
http://www.worldtimeserver.com/current_time_in_UTC.aspx

To Purchase an INSPIRE VLF-3 Receiver Kit and Download Assembly Instructions & Observation Forms
http://theinspireproject.org/default.asp?contentID=3

INSPIRE VLF-3 Kit Questions
CustomerService@TheINSPIREProject.org

INSPIRE Journal VLF Observations/Article Submissions:
Editor@TheINSPIREProject.org

For 32 years, the INSPIRE Very Low Frequency (VLF) radio receiver kit has been designed with one underlying goal – to educate students of all ages about the sounds of space through hands-on experience. Building one's own electronic device is a step forward to opening the world of scientific exploration and showing that this complex world is made up of many simple components working together. (Did you know the VLF-3 receiver kit has 114 parts?) The receiver's features include an internal battery / external battery connection and stereo audio plugs for listening to the VLF signals between 300 Hz up to 15 kHz – antenna not included.

VLF Questions from INSPIRE VLF-3 Receiver Users

What type of antenna do you recommend using with the VLF receiver? (*INSPIRE's Most Frequently Asked Question)*
Any fixed or telescoping whip antenna with an integrated BNC connection will work. There are several viable options available online *(see INSPIRE website for suggestions)*. A simple wire can be attached to the screw terminal on the receiver to serve as the antenna; remove the insulation from the ½ inch or so that connects to the screw terminal. Six foot long wire and held up by something, but electrically insulated from that support, would totally substitute and be long enough. The wire antenna can be longer but start with the frontend gain turned down to start with. A good ground wire still needs to be connected to the other screw terminal on the receiver. No inductive load coil is needed, nor would it matter if the whip antenna you use has a coil. The operating frequency range is too low for the coil to make any difference.

Over what range can the VLF receiver detect lightning?
In general, the receiver can pick up lightning generated anywhere on Earth. There are limits of course. The further away, the more the ionosphere-ground wave guide will influence the signal, both attenuation and dispersion. Within a few kilometers the lightning would be expected to be received as an impulsive spheric across most of the originating frequency range. Beyond that distance some portions of the spectrum will be more absorbed than others and dispersion will become more evident, sounding more like a tweek. Whistlers will have traveled at least once far from the surface Earth to follow the local magnetic field as it travels out into space to the opposite hemisphere.

Share Your VLF Observations in *The INSPIRE Journal*

The INSPIRE team invites you to share your VLF observations with our readers. Describe your experience, including any comments that relate to carrying out your field observations. Field photographs and spectrograms are welcome components along with a short bio and photo to accompany your submission. All submissions are reviewed prior to publication.

About Dennis Gallagher

Dr. Dennis Gallagher is a Senior Researcher in the Heliophysics and Planetary Science Branch at NASA Marshall Space Flight Center and serves as INSPIRE's Chief Technical Advisor. Dennis answers VLF kit users' technical questions. He has been actively involved with the organization since it was founded in 1989.


Photo courtesy of
Tony Bateman (Finland)

INSPIRE VLF-3 Radio Receiver Kit Ordering Information

INSPIRE VLF-3 Radio Receiver Kits can be ordered online at:
www.TheINSPIREProject.org

INSPIRE accepts purchase orders for multiple kit orders. Discounts are available for non-profit organizations utilizing kits STEM curriculums.

For more information email: CustomerService@TheINSPIREProject.org

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In 2009, The INSPIRE Project expanded its STEM educational programs to provide scholarships and internships to educators, middle/high school students, and university students to ensure the next generation of space science and technology explorers. INSPIRE's team is comprised of dedicated board members and advisors who volunteer his/her time to make it possible for INSPIRE to continue fulfilling its expanded mission of providing students the resources to pursue study in STEM disciplines. If you would like to make a life-changing gift, please visit: www.TheINSPIREProject.org.
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