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NU SCI

SPACE

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LETTER FROM THE PRESIDENT

For many, space is a source of curiosity and wonder, leading to both awe-inspiring research and captivating film and TV franchises. Whether you are a Jedi or Starfleet captain, you have probably spent at least one night staring at the stars in awe.

For the second time in NU Sci's history, we dedicate an issue to the state of wonder and plethora of research being conducted in and about space. These bodies of research range in size from long-term, multi-nation collaborative works to groups right here on Northeastern's campus. We revisit the year one of the Kelly twins spent in space and report on the recently published research on how space affects the human body. In addition, we explore why it is so important for society that we explore space. Lucas Cohen and Matt Kalpin describe our search for extraterrestrial life here on Earth and beyond. NU Sci also takes a look at how NASA's funding has changed over the years.

As always, this magazine would not be possible without the hard work and dedication of our writers, editors, and designers, in addition to our marketing team who helped get this magazine into your hands today. I am, and always will be, extremely grateful for their hard work and commitment to NU Sci.

As with every spring issue, we also dedicate a page to our graduating seniors, a group of which I am a part. It is hard to believe that this is my final issue of NU Sci. When I joined NU Sci – completely on a whim in my freshman year – I had no idea what the magazine would become or how it would impact me personally and professionally. Working for this magazine has changed my perspective on the importance of science journalism and I will carry my time here with me for the rest of my scientific career. Back in my day, the magazine was in black and white – I remember very vividly when it was announced that we had been given the budget for a color magazine – and our team was a third of what it is now. None of this progress would have been possible without the amazing team of students that I have been given an opportunity to work with over the past five years. More importantly, none of this would be possible without you, our readers. You, more than anyone, have played a pivotal role in what NU Sci is today and for that I cannot thank you enough. It has been an honor to write and work for this magazine during my undergraduate career.

Live long and prosper and may the force be with you,

Katie Hudson

President of NU Sci

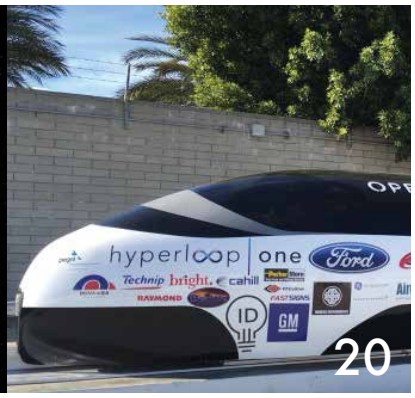


TABLE OF CONTENTS

Not Just for Space 4
Research to improve astronaut health has universal applications

Mapping the Depths 6
Using spatial analysis technology to map the world around us

NASA Tackles Climate 8
Climate change, meet outer space!

Light Pollution 10
Or why you can't see your favorite constellations from your dorm room

Earthly Extraterrestrials 14
Exploring how different organisms could exist in outer space

TRAPPIST-1 18
How do you sustain life in a system far, far away?

The Human Mission to Mars 19
Where do we stand?

A New Mode of Transport 20
NU Hyperloop Club looks toward their next steps

Nature vs. NASA 28
What scientists learned from the Kelly twins about humans in space

A Tribute to Our Seniors 31
We'll miss you!

NOT JUST FOR SPACE

Research to improve astronaut health has universal applications

Imagine being isolated in a spaceship, hundreds of thousands of miles away from a hospital, when a minor health complication occurs. Something that people would go to the doctor for on Earth- like an obstructing kidney stone- but in space it becomes a mission and potentially life-threatening event. Although these acute events are marked by their potential severity, they aren't the only health risk astronauts face during their travels. Research has demonstrated multiple long-term effects to an astronaut's body following space missions. To combat these effects, as well as manage acute health events in-flight, the National Space Biomedical Research Institute (NSBRI) was created. The NSBRI is an institute that helps develop collaborations between universities, NASA, and industry that conduct related research in different regions. Currently, it is a consortium of 12 institutions from across the United States, including Harvard Medical School, Baylor College of Medicine in Texas, and the University of Washington, among others. This multidisciplinary approach has brought new investigators into the playing field- as about fifty percent of investigators in the NSBRI were not previously associated with NASA.

The NSBRI is split into seven teams that focus on specific overarching health problems that astronauts face both in space and after they return. Each team primarily focuses on promoting astronaut health to support the overall success of the mission, and is led by two investigations from different institutions. This research, while meant for applications in space, also has another effect- it has already created and will continue to create improved medical care on Earth.

CARDIOVASCULAR ALTERATIONS

The Cardiovascular Alterations team works to determine the effect of long-duration missions on the heart and blood vessels. It also tries to find a way to improve pre-flight management and detection of cardiovascular disease for asymptomatic astronauts. One project the team is currently working on is the ability quantify the risk of cardiac events by looking at coronary calcium scores of an individual. They are hoping that these scores can be used as a determining factor that could be used mitigate the risk of an in-flight event. This team has also developed novel ultrasound techniques to assess cardiac changes in size, shape, and function during space missions. This research will help create a more comprehensive criteria for astronaut selection to minimize the risk for cardiac events. These results don't just impact space flight- they can also improve the ability to detect asymptomatic patients on Earth who have a high risk for cardiac events, and help develop strategies to minimize their risks.

HUMAN FACTORS AND PERFORMANCE

There are a variety of factors that influence an astronaut's ability to work in space and it is the job of the Human Factors and Performance Team to make sure these factors don't impact the mission. They study ways to improve daily living for crewmembers and other personnel so that they are healthy, productive, and safe in-flight. By focusing specifically on sleep and work schedules, as well as environment lighting, the team hopes to limit on-the-job errors that can be easily prevented. Aspects of the environment such as light wavelength and intensity are simple changes that can greatly impact an astronaut's performance. They are also developing a human-system model to test perception and decision-making in order to quantify and better understand the effects of both human and automation errors as they propagate through a control system. On Earth, this research is applicable in fields where individuals are in high-pressure situations and exposed to long hours of work, like in the military or civilian aviation.

RADIATION EFFECTS

The Radiation Effects Team works actively to reduce the impact of radiation exposure that occurs in missions that are beyond low Earth orbit. Radiation exposure can greatly impair an astronaut's ability to perform on a mission due to acute health problems like nausea, vomiting, fatigue, and changes to the immune system. Long-term effects of radiation exposure can include damage to the cardiovascular system, eyes, and central nervous system, as well as an increased cancer risk. Because of these serious mission-threatening effects, and the impact they have have on astronauts later life, the Radiation Effects Team is working to understand the mechanism of radiation effects on tissues, cells, and complex biological systems within the human body. They are also hoping to gain a greater understanding of specific health risks from acute radiation exposures. This research will not only benefit the astronauts, but also people exposed to unusually high levels of radiation on Earth, such as those undergoing radiation therapy.

SENSORIMOTOR ADAPTATION

Although astronauts have undergone rigorous training prior to their mission, they still may experience sensorimotor deficits. Disorientation, as well as cognition, balance, and motor control problems have all been documented while in space. This team's research aims to understand the physiological processes that lead to these deficits, as well as develop personalized countermeasures to address risk areas within operational needs. This research includes developing ways in induce vertigo, to be used for simulations of landing and extravehicular activity during training back on Earth. They are also developing strength and balance training methods to improve movement following return from space, as well as more efficient drugs for space motion sickness. Balance training programs developed by this team can also be used within the aging population to help aid in the prevention of falls.

NEUROBEHAVIORAL AND PSYCHOSOCIAL FACTORS

In space, astronauts experience long periods of isolation, which has the potential to create greater stress within individual astronauts, as well as challenges within the group. The aim of this team is to improve mental health during flight, detecting behavioral problems as early as possible and applying effective interventions during and after. They are currently working on developing a computer system for self-diagnosis and managing interpersonal conflicts throughout the missions. Although many aspects of the NSBRI's research focuses on maintaining astronaut health within space missions, this team also focuses on the astronauts transition back to life on Earth. The Neurobehavioral and Psychosocial Factors Team works on techniques to facilitate the assimilation between the crew and their families following their return. This not only helps astronauts, but can help other teams in high stress situations like surgical teams or military personnel.

MUSCULOSKELETAL ALTERATIONS

Astronauts quickly lose bone and muscle from their lower body while in space for extended periods of time because they aren't bearing the same amount of weight in space as they would in earth, causing their muscles and bones to degenerate. Astronauts can lose between 1 to 1.5 percent of their bone mass in their hip in one month of microgravity. During long space missions, bone loss can cause multiple problems, including reduction of physical performance and increased risk for fall-related injuries and fractures. To limit these risks, the Musculoskeletal Alterations team is identifying ways to help reduce loss through exercise and pharmacologic and nutritional interventions. They are hoping to create exercise regimens tailored to specific astronauts as well as designing improved exercise devices. These improvements seek to help combat muscle atrophy and bone loss in space where there is reduced gravity, also could be used to prevent and reduce bone loss for treatment of osteoporosis and for other patient, such as paraplegics, who experience musculoskeletal weakening. New therapies can also prevent and treat muscle atrophy in bedridden patients and those with systemic diseases like cancer, sepsis, or AIDS.

SMART MEDICAL SYSTEMS AND TECHNOLOGY

During long-duration space missions, emergency situations can occur far from hospitals or even a trained physician. It is possible that because of this, medical procedures may have to be performed by non-physician astronauts. To facilitate these procedures medical care systems that are highly automated, small, low power, and noninvasive are being developed. These medical care systems would also assist in diagnosis and treatment for major illnesses and trauma as well as early detection of medical problems during flight. Most recently, they have developed a therapeutic ultrasound device used to treat a variety of conditions, such as kidney-stone-induced obstruction, which requires surgery on Earth and can create major complications light-years away from a hospital. This noninvasive measure has now entered the first in human trials and, if successful, can be applied in hospitals on earth as well.

BY CICELY KREBILL, BIOLOGY, 2019

DESIGN BY ANNA LI, BEHAVIORAL NEUROSCIENCE, 2019

MAPPING THE DEPTHS:

Using spatial analysis technology to map the world around us

BY ERICA YEE, INFORMATION SCIENCE & JOURNALISM, 2020

DESIGN BY CIARA SELDERS, BEHAVIORAL NEUROSCIENCE, 2020

Humans have used maps since ancient times, from hand-drawn atlases to foldable pamphlets to mobile apps. Today's technological developments have allowed mapping to go far beyond what the original cartographers could have imagined. Beyond the day-to-day convenience of using Google Maps for directions, researchers can use Geographic Information Systems (GIS) to explore layers of mapped data.

GIS is used to manage and visualize any plottable geospatial data, such as postal codes, city boundaries or elevations. Analysis of the processed and mapped data can reveal relationships and patterns to problem-solve and impact policy. These capabilities have a lot of potential for revolutionizing research in a variety of fields.

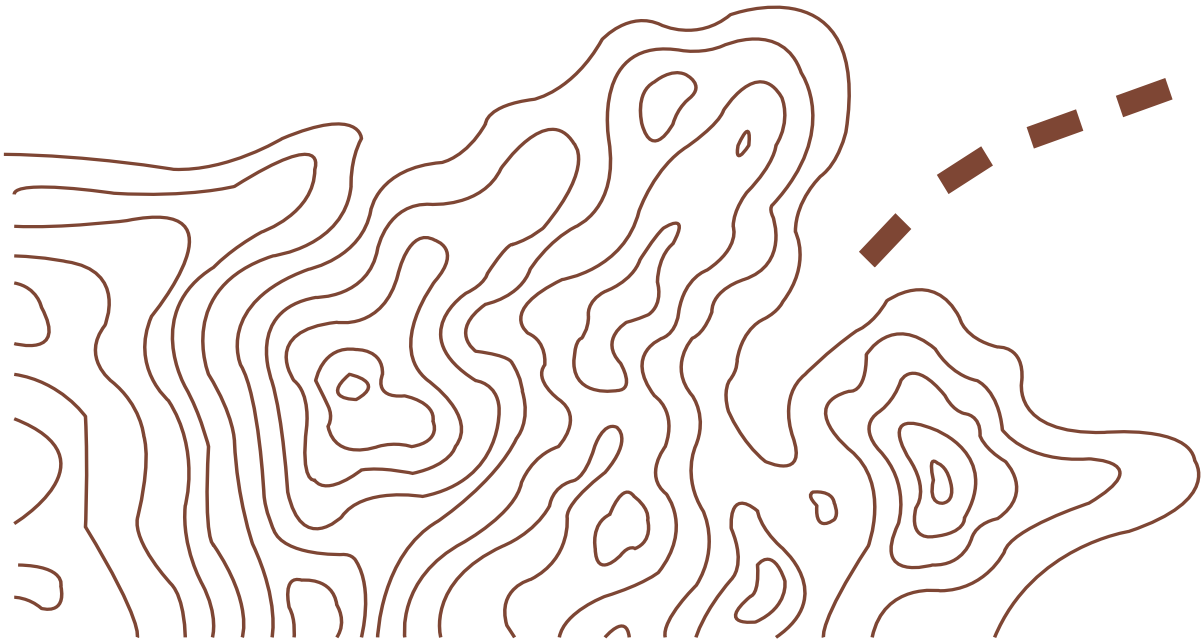
> "On a computer, you can put multiple layers of information on top of each other and find relations and hidden patterns within the data."

"Traditional cartographic maps are about one layer of information. But on a computer, you can put multiple layers of information on top of each other and find relations and hidden patterns or a story with the data," explained Bahare Sanaie-Movahed, Northeastern's GIS specialist based in Snell Library.

GIS was initially used mainly for engineering and natural resources fields, according to Sanaie-Movahed, who has master's degrees in GIS and environmental engineering. Now, other fields, such as history and political science departments, are also taking advantage of the technology. Maps of election results, for example, can now compare all types of demographics with voting patterns. The New York Times correlated political and cultural bubbles by mapping the popularity of different TV shows throughout the US with how those areas voted in the 2016 presidential election: Duck Dynasty correlated most with support for Trump and Family Guy for Clinton.

Businesses, too, see the benefit. "Say I want to build a business selling pet food," Sanaie-Movahed proposed. "I can use GIS to select my location, check how many people around Massachusetts [have] pets, where are other stores that would be my competition. I put this information together and come up with the location where I want to build my own company."

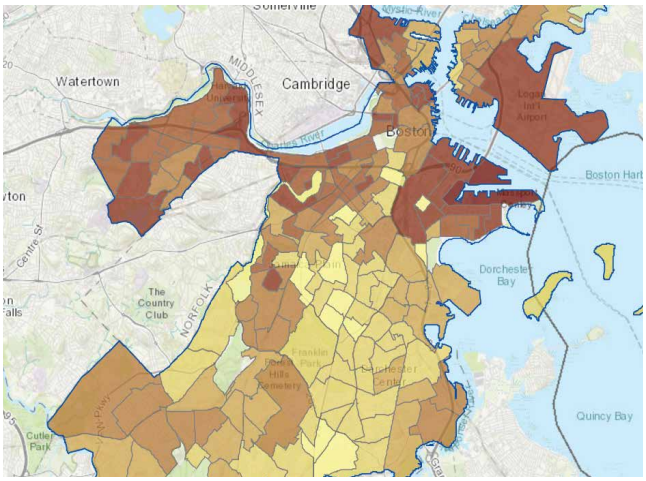
A new interactive web tool from the CDC, called the 500 Cities Project, allows users to explore health data estimates at city and neighborhood levels for the largest cities in the U.S. Mapping the data can help government and health workers visually identify patterns of health issues facing specific locations and develop targeted prevention campaigns.



GIS technology makes it possible to map data in great detail, but there are also key challenges: Maps need to be updated with current data and geography. It can be difficult to consolidate data from different sources for the same map. Different audiences require different types of user interfaces. There are so many tools, and each have slightly different features.

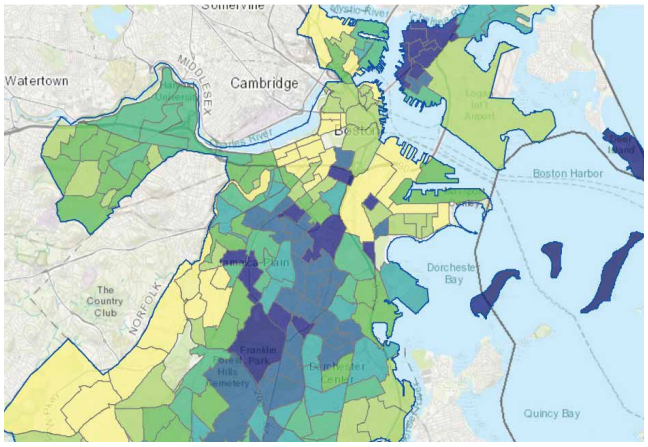
Sanaie-Movahed added, "Every day you're waking up, a new program, a new platform is out there. It's a big data day.

"We are trying to visualize data, make it easy to digest and easy to understand," she concluded. "But we have to be careful. You can tell lies with statistics -- same issue with maps."

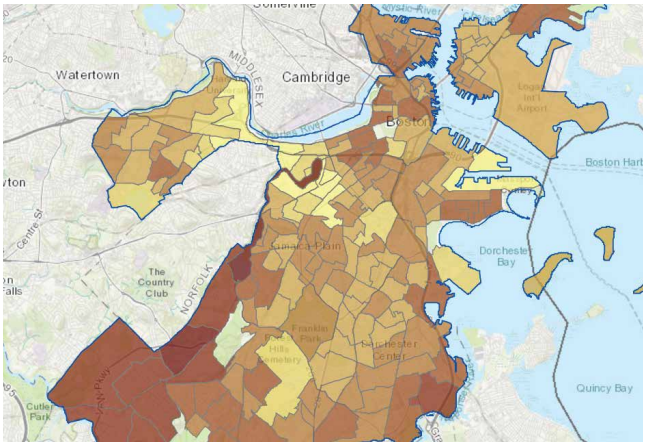


This data shows that South Boston and East Boston have the highest rates of binge drinking among adults over 18 (2014).

The 500 Cities Project: A Few Examples*



This information in this map suggests that Franklin Park and Roxbury have the highest rates of residents aged 18-64 without health insurance (2014).



According to these estimates, West Roxbury has the highest rate of cancer (except skin) among adults over 18 (2014).

*Go to https://www.cdc.gov/500cities/ to learn more.

NASA Tackles Climate

Climate change, meet outer space!

BY SAGE WESENBERG, BIOCHEMISTRY AND JOURNALISM, 2019

DESIGN BY:, ANNIE LEE, DESIGN, 2019

If it weren't for NASA's ability to tell us what Earth looks like from an extraterrestrial bird's eye view, climate science today might be drastically different.

The National Aeronautics and Space Administration (NASA) was created in 1958 through the National Aeronautics and Space Act for the purpose of creating technology to observe the unknown realm of space. Soon after NASA's creation, an Earth observations program was started, working with the National Oceanic and Atmospheric Administration (NOAA) and the United States Geological Survey (USGS) who carried out Earth Observations research using observational technology developed by NASA. This program formed the Nimbus and Landsat series of satellites but failed overall in the 1970s due to budget cuts and a governmental need for NASA to conduct research on other national needs including pollution and climate change.

The Space Act was revised in 1976, giving NASA the ability to study the stratospheric ozone, which was the beginning of formal research on earth sciences. Through this, NASA learned about greenhouse effects, carbon dioxide levels, water vapor, and temperatures on nearby planets; questions arose as to how Venus and Mars could be so environmentally different to Earth, despite having originated from the same place. At the same time as this research was taking place, climate research on Earth was developing rapidly, leading to the important discovery that climate change occurs rapidly, not on a several thousand year timescale like previously thought.

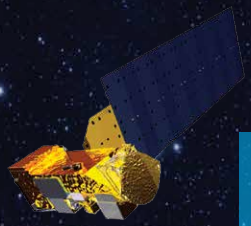
In 1984, as the political interest in climate change rose, the Space Act was revised yet again to research "the expansion of human knowledge of the Earth." The Mission to Planet Earth and the multi-agency Global Climate Research Program enabled NASA to run many space missions and develop many technologies and satellites to provide and analyze global data obtained from space.

Through many satellite programs in orbit around Earth, NASA and the world now have a vast collection of measurements on factors that impact climate change. These include measurements of aerosols in the atmosphere from natural events like volcanoes and dust storms, as well as the burning of fossil fuels. Rising sea levels globally have also been extensively recorded since 1992, averaging three inches since then. Other satellites look at changes in global ice sheets and atmospheric ozone abundances.

With NASA's efforts tracking such widespread data over several decades, the Intergovernmental Panel on Climate Change was able to conclude in 2007 that "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."

But now, a decade since that declaration, politics has taken the wheel in climate change with the Trump administration and other Republicans denying climate change, and there is uncertainty for the future of NASA's Earth Science Division, a $2 billion industry. NASA may shift away from climate research to focus on deep-space missions, while their ever important climate studies could move to another agency or be cut altogether. In a world where climate change impacts are clearer than ever, we must rely on organizations like NASA to continue in their endeavors to understand how to protect our planet.

AQUA



Using water vapor in the atmosphere, clouds, precipitation, snow coverage and sea/land mass coverage, the Aqua cycle helps scientists understand Earth's water cycles. This data can help to predict future storms, weather patterns and water level changes as ice melts.

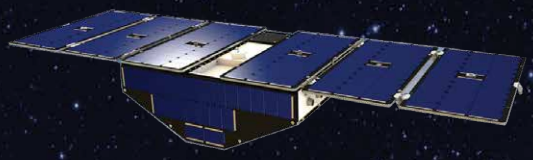
AURA

Four satellites work together to measure ozone, trace gases, and aerosol levels in order to study atmospheric chemistry and ozone trends; this data is important for studying greenhouse gas data.

CALIPSO

The CALIPSO satellite, launched in 2006, gives a 3D perspective of cloud and aerosol formation and their impact on weather and air quality.

CYGNSS

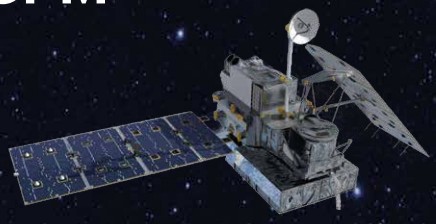


This system of eight satellites uses GPS signals that are reflected by the ocean during a hurricane, and their distortions during a storm can help predict wind and ocean surges once the hurricane reaches land.

EO-1

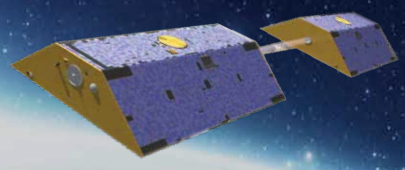
EO-1 is a satellite that utilizes antenna technologies to capture enhanced imaging of natural events such as wildfires and volcanic eruptions.

GPM



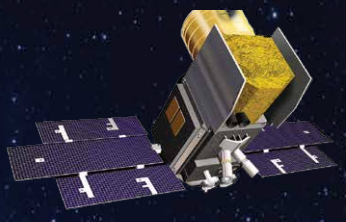
The Global Precipitation Measurement satellite network involves global collaboration to measure precipitation worldwide to understand water and energy cycles with the hopes to help predict future destructive storms.

GRACE



These paired satellites calculate changes in gravity distribution by measuring the varying distance between the twin satellites as they follow each other around in orbit. This data can help to understand the movement of bodies of water and large ice masses.

ICESat



This updated satellite, in its second version, takes laser altimeter measurements of ice sheet elevation and thickness to track changes around the world, especially in at-risk locations of ice-sheet melting such as Greenland and Antarctica.

PHOTOS BY NASA EARTH OBSERVATORY

LIGHT POLLUTION

Or why you can't see your favorite constellations from your dorm room

BY LUCAS PRINCIPE, ENVIRONMENTAL SCIENCE, 2019

DESIGN BY ANNA LI, BEHAVIORAL NEUROSCIENCE, 2019

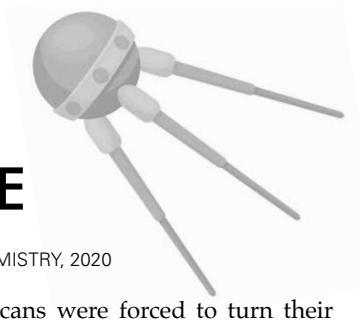
If you're one who regularly appreciates looking up at the constellated night sky, you know how frustrating it is to stargaze in Boston. Quite often, the grandiose views we are used to seeing in the countryside seem to be drowned out by the metropolitan skyline. We call this effect light pollution, which is simply an umbrella term used to describe any adverse effect of artificial light, specifically light that is not being efficiently utilized. Light pollution occurs in many numerous forms, though we will only discuss a few. Uplight is the term we use for light being ineffectively directed into the sky instead of the ground below. Uplighting is the main source of light pollution to astronomers and stargazers; you can thank obnoxiously bright streetlights and flashing signs shooting rays into the air above for not being able to see the Milky Way. Clutter is the term used to describe excessive groupings of light sources that are clumped together inefficiently. If we work off the idea that the goal of night lighting is to "see what's lit, not the light," then a clear example of clutter would be the Las Vegas strip. Thinking about that strip, each casino, hotel and attraction is vying for your attention, packed together in such a small area, so each sign will try to be brighter than all the rest. This lighting competition sends massive amounts of light into the night sky and totally obscures any celestial views you might have. Light pollution also affects more than just our view of the cosmos; light pollution can harm the environment by interfering with the biological activities of nocturnal species, and inefficient lighting wastes roughly two billion dollars and 8.2 million tons of coal per year in the United States.

While the light pollution in the dense city center of Boston is not as severe as that of Las Vegas or New York City, our city still has some of the worst light pollution in the country. An observer on the darkest Boston night will still have trouble identifying key stars in constellations and will experience a drastic reduction in the overall number of stars visible. However, right here on campus one of our very own student run organizations is aiming to fix that. Northeastern SEDS club (Students for the Exploration and Development of Space) is working to build an on-campus observatory that would allow the community better access to stargazing and researching. Justin Metz, last semester's President and Founder of Northeastern's SEDS chapter, says the organization's goal is to garner support from faculty in order to make this observatory dream a reality. Metz also discussed how the observatory would "aim to run experiments on how to combat light pollution is dense urban areas." SEDS, Northeastern's only astronomy club, needs more support in order to build this observatory; if you're a fan of stargazing, this might be the club for you.

While SEDS is making progress on their observatory project, many stargazers in Boston are still wondering where to plan their next outing. One organization that aims to help the astronomy junkie is The Internation Dark-Sky Association (IDA). The IDA is "the recognized authority on light pollution and is the leading organization combating light pollution worldwide." They actively combat light pollution and also provide guidance to amateur stargazers looking to plan an astronomical vacation through their certified dark sky parks. Many of these parks such as Grand Canyon National Park in Arizona, and Black Canyon of the Gunnison National Park in Colorado, are housed out west, where population density and light pollution are significantly lower. However, it's wrong to assume there's nowhere in the northeast to stargaze without significant light pollution. To start, numerous remote locations of New Hampshire and Vermont are home to some of the lowest populated areas in the country. And at only a few hours' drive away, these various locations are easily accessible. Moreover, if you're looking for a designated campground, Maine's Acadia National park and the Adirondack Park in Northern New York are both home to beautiful campsites and tremendous views of the cosmos. Plus, they're only four hours away, significantly shorter than the 40 to 50 hours it can take to drive to the West Coast.

FEAR THE SPHERE:

HOW SPUTNIK SHOCKED THE WORLD AND REVITALIZED AMERICAN SCIENCE



BY MATTHEW DEL MASTRO, BIOLOGY, 2017

DESIGN BY KYRA PERZ, CHEMISTRY, 2020

When President Obama announced his intention to expand government funding for scientific research and education, he needed to draw on imagery that would convince even Republican skeptics that investment in American science was vital. He began by hearkening back to great American inventors such as Thomas Edison and the Wright Brothers, and finished not with an American innovation, but a foreign one. He told the crowd: "This is our generation's Sputnik moment." Why would Obama close his vision of America's scientific glory days with a Soviet space satellite? This was no mistake by the well-read president. When the Russians became the first nation to launch a satellite into space, the shockwaves reverberated throughout the U.S., transforming the concept of science as Americans knew it and positioning the country as the world's scientific superpower.

In the 1950s, Americans had an ambivalent relationship with science and technology. On the one hand, new innovations such as dishwashers, synthetic fabrics, and television were making life more comfortable and opening up more leisure time. A booming economy meant that many Americans had the means to bring technology into their homes. Yet all the while, a specter loomed over this domestic bliss in the form of a very different kind of technological development: the nuclear bomb. The United States and Soviet Russia were locked into a global ideological and military struggle, and the threat of a nuclear attack was in the back of every American's mind. Still, the sentiment was that in the event of conflict the progressive United States was sure to prevail over the supposedly ignorant peasants of the backward Soviet Union. On October 4, 1957, a small shining metal orb would shatter this illusion.

> "Shaping a country into a scientific superpower requires a nation working and investing together in pursuit of a shared goal."

While today's advanced satellites monitor the weather and coordinate GPS, comparatively Sputnik did little. The small reflective sphere, approximately the size of a classroom globe, orbited the Earth while emitting a constant beeping sound. Yet there was a deeper symbolism in Sputnik's flight; as Americans across the country picked up the ominous beeping of the passing Sputnik on their radios, it would have been inescapably obvious that if the Russians could bring a satellite over America, bringing a nuclear bomb might soon be within their capabilities.

Americans were shocked, fearful, and angry. But who was to blame? The Soviets had stunned the world with a feat of intellectual prowess, but there had been no foul play or communist outrages. Americans were forced to turn their gaze inward and examine their own society. In the wake of Sputnik, producing gleaming kitchen appliances and extravagantly designed automobiles suddenly seemed like a pathetic way to squander the country's scientific talent. It quickly became clear that the new age ushered in by Sputnik called for an entirely new type of scientist, trained from childhood onwards to tackle the greatest challenges of the time. Federally directed reforms in education removed traditional coursework in subjects such as Greek and Latin in favor of math and science. Drilling on verb conjugations and rote memorization were dispensed in favor of creative problem solving exercises meant to encourage ingenuity.

Equipping schools and training teachers to run the new programs called for a substantial government investment, but Americans didn't mind. Lyndon B. Johnson spoke for many when he said, "he who controls space controls the world." With so much seemingly available to win or lose, Americans supported whatever government spending was necessary to get the job done. This mindset was extended to the operations of the newly established NASA. When President Kennedy pledged to put a man on the moon, he warned that it would "carry very heavy costs." But he made the admission knowing that an American populace still haunted by the memory of Sputnik would back him all the way.

President Obama must have been hoping to generate a similar groundswell of support in his call to reinvigorate American science. But in retrospect, there was no "Sputnik moment" in 2011. Americans still rank in 24th place globally – considered "below average" - in academic achievement in science, and the disparity doesn't seem to be a top priority for the American public. The recent election has exposed that Americans still have many fears ranging from terrorism and immigration to economic woes. But unlike Sputnik, these perceived threats won't rally Americans around a common purpose such as scientific advancement. If anything, they seem to promote further division. The original Sputnik moment powerfully demonstrated that shaping a country into a scientific superpower requires a nation working and investing together in pursuit of a shared goal. Whether there is such a moment in store for our generation is far less clear.

Dickson, P. Sputnik: *The Shock of the Century.*
Mieczkowski, Y. Eisenhower's Sputnik Moment : *The Race for Space and World Prestige.*

ALL SPACED OUT

Why bother exploring space?

BY KATIE HUDSON, MARINE BIOLOGY, 2017

DESIGN BY MEGAN MCGUIRE, DESIGN, 2020

"Space: the final frontier. These are the voyages of the starship Enterprise. Its five-year mission: to explore strange new worlds, to seek out new life and new civilizations, to boldly go where no man has gone before." – Star Trek

The Star Trek series premiered in 1966, during the height of the space race between the U.S.S.R and the United States. During this decade, and in the years after 1969, space exploration was at the forefront of many political and scientific agendas. During this time, public interest in space exploration was high, as exemplified by the opening monologue to the Star Trek series quoted above. In a 2009 survey conducted by the National Aeronautics and Space Administration (NASA), researchers found that half of scientists who had their work published in Nature in the past three years were inspired to become scientists by the Apollo lunar missions in which humans set foot on the moon for the first, and last, time.

Today, however, public interest in space exploration is a fraction of what it was between 1961 and 1972. This decline in public, government, and even scientific interest can be correlated with the significant decline in manned space missions. Man has been replaced by machine in space, especially in planetary missions such as missions to the Moon, Mars, and beyond our solar system with satellites like New Horizons, which flew past Pluto in the summer of 2015 after being launched in early 2006. Humans still make frequent trips into space, but most of these are confined to the International Space Station (ISS). Whether exploration occurs by man or machine, space exploration still occurs nevertheless and the benefits of this exploration remain.

In the absence of direct competition with the U.S.S.R, the direct benefits of space exploration have become ambiguous. Nevertheless, the technological advancements that have been made since the space race and space exploration programs are still extremely relevant today. Early developments in space exploration technology not only made today's space program possible, they provided the innovation necessary for the development of technologies such as solar panels, heart monitors, and jet turbines. For example, NASA has been developing uses for solar energy since 1976, when they began reporting the amount of solar energy available in Cleveland, Ohio. Since then, they have reported on first the development of solar water heating systems, then the development of solar panels from technologies that originated in NASA research programs.

> "Stephen Hawking once said that 'to confine our attention to terrestrial matters would be to limit the human spirit.'"

The list of technology and research that is born from space exploration is expansive – so expansive that NASA publishes an annual report on the research and technologies that have originated in NASA space missions and research. These reports, called Spinoff, date back to 1976 and profile research and innovations in the fields of health and medicine, transportation, public safety, consumer goods, energy and environment, information technology, and industrial productivity nationwide. Spinoff stems from NASA's Technology Transfer Program, which was established in 1964 to bring NASA research and technology to the private sector for commercialization and private use.

Some of the technologies featured in Spinoff through the years are now common used for household products, medical practices, or to design new products. The blankets that marathoners are given at the conclusion of a race, for example, originated from NASA research and development of a material to protect spacecraft and astronauts from temperature fluctuations in space. Memory foam mattresses were originally developed to increase safety and comfort in NASA vehicle seats. Heart disease can now be detected without the need for invasive surgery thanks to a NASA-developed imaging technology that was originally designed for space probe imaging. Long-term experiments with algae in space led to the discovery of a nutrient used to supplement infant formula. These examples are only the tip of the iceberg – with an average of 50 profiles per issue of Spinoff and a total of 41 issues, there are at least 2,050 commercial products that have been the direct result of NASA missions and research. As NASA continues to send both people and machines into space to conduct unique and valuable research, this number will only continue to grow, improving the quality of human life on earth while expanding into space.

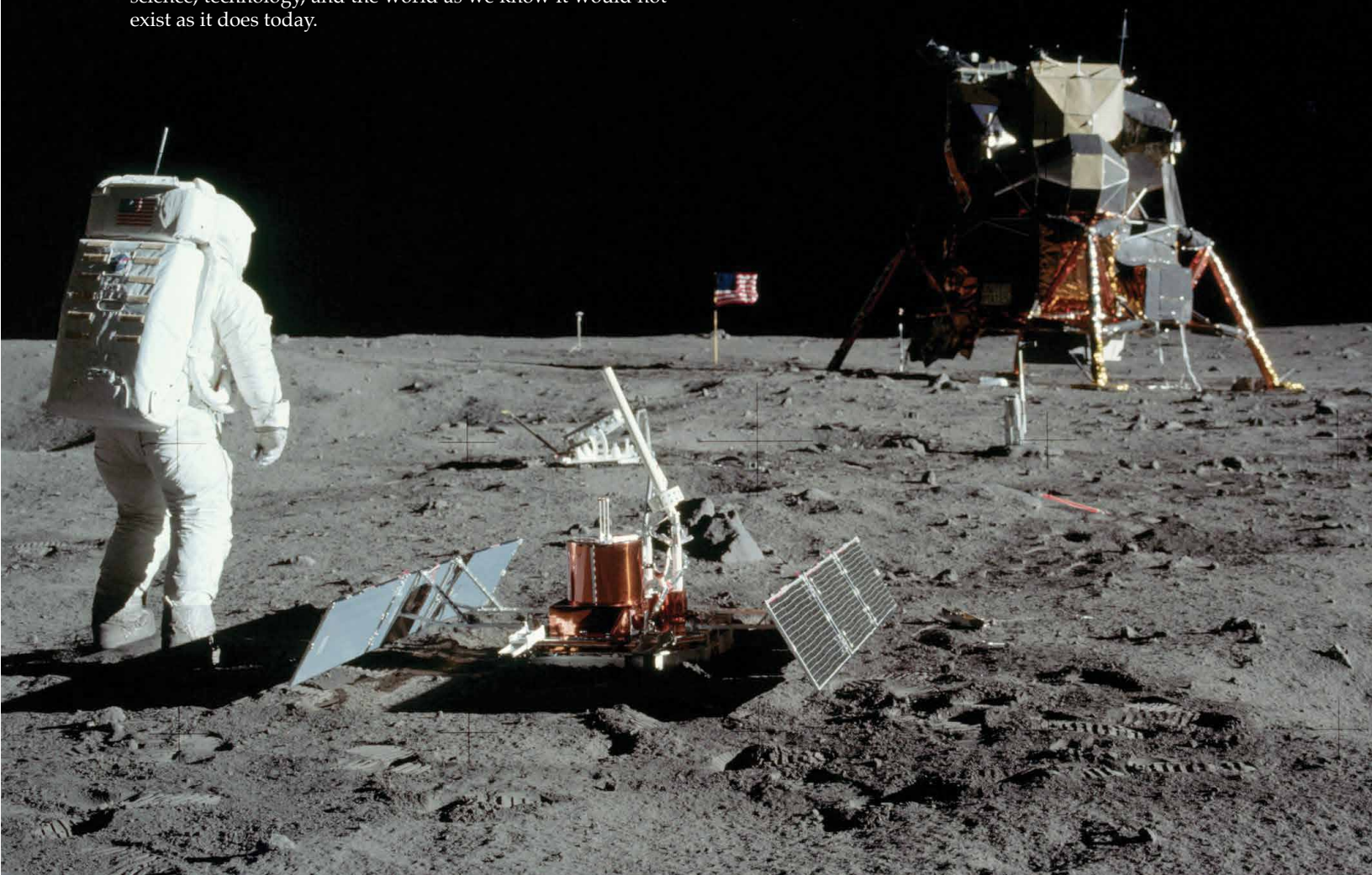
The impact of space exploration goes beyond the commercial products that have been developed due to its research and innovation. NASA missions like the lunar landings not only physically expanded human curiosity, but also were a catalyst for the expansion of human views on where we as a species could eventually go. This curiosity has offered and

continues to offer inspiration for generations of scientists. Space challenges the boundaries of possibility and of the human life, in both extremes. Stephen Hawking once said that "to confine our attention to terrestrial matters would be to limit the human spirit."

Recently, NASA announced the discovery of seven exoplanets, or planets outside of our solar system orbiting a single sun, known as TRAPPIST-1. Three of these rocky exoplanets are being located in the "habitable" zone, which is defined by NASA as "the area around the parent star where a rocky planet is most likely to have liquid water." TRAPPIST-1 is located approximately 40 light-years or 235 trillion miles from Earth, making it one of the closer stars with associated exoplanets. Although it would take approximately 40 years to reach this system, the distance has not stopped people from asking about the possibility of life within this solar system. It is discoveries such as this one that are one of the major drivers of the human spirit and overall curiosity about the world around us.

The inspiration provided by space exploration will drive the next generation of scientists for decades to come. The inspiration that space exploration provides, one could argue, has more value than the commercial products the research produces. This is especially true today, when exploratory research is rarely encouraged and funding for these types of programs is extremely limited. Without this inspiration, science, technology, and the world as we know it would not exist as it does today.

> "The technological advancements that have been made since the space race and space exploration programs are still extremely relevant today."



Earthly Extraterrestrials: Life in the Vacuum of Space

Exploring how different organisms could exist in outer space

BY LUCAS COHEN, MARINE BIOLOGY, 2019

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2020

When we look up at the stars, most of what we see is the empty black void that so tightly envelops our planet – a void that stands defiantly between us and our nearest planetary neighbors, faraway suns, and distant galaxies. We picture the cruelly cold, vast expanse of space bombarded with powerful beams of cosmic radiation and think: *surely no creature on earth can – or would, for that matter – survive out there.*

Of course, our intuitions are, as with many other assumptions, wildly off-track. The fact is that life can survive exposure to the vacuum of space – and, as to whether non-human organisms *would*, of their own design, exit the atmosphere, we determined long ago that the decision isn't theirs to make. Naturally, the first organisms sent into space weren't exposed to the vacuum, but instead kept inside pressurized cabins. The first of these organisms was the model fruit fly, *Drosophila melanogaster*, in 1947 – launched on the tip of a V-2 rocket. Perhaps one of the most famous animals to leave the Earth's atmosphere was Laika, the Soviet dog who made her final journey aboard the spacecraft Sputnik 2 in 1957.

We still send animals to space to test the effects of zero-gravity on various physiological processes, but in the 21st century we've begun to use partial or unfettered exposure of organisms to the vacuum of space as a means of examining the very limits of survival.

Recently, researchers aboard the International Space Station (ISS) conducted a long-term study on algae survivability in space, exposing two species – *Sphaerocystis* sp., a green algae, and *Nostoc* sp., a cyanobacteria or blue-green algae – to unimaginably harsh temperatures and unrelenting UV and cosmic radiation. The project was part of a wider initiative dubbed the Biology and Mars Experiment (BIOMEX), spearheaded by scientists at the German Aerospace Center in Berlin. The primary goal of this particular experiment was to determine if the algae might be used as food sources in a future Mars mission. The two species are extremophiles, chosen based on their abilities to resist extreme cold and desiccation.

The algae were desiccated slightly prior to experimentation and kept in specialized trays equipped with sensors that could record fluctuations temperature and radiation. These trays mounted on the exterior of the ISS for 16 months, after which the algae were collected and inspected. Researchers were surprised to find that the algae thrived not only within a temperature range of -20°C to 50°C amidst inundation with two damaging UV wavelength ranges (UVA and UVB), but also responded well to extreme dryness and some harmful UVC.

The researchers, in the process of examining damage to algal DNA and changes in carotenoid biomarkers, hope to expand our understanding of how exposure to these conditions affect non-human DNA and key biochemical functions. As with other studies of microbes in space, the algae experiment also explores the prospect that life from another planet might've seeded Earth long ago – a theory known as panspermia.

> "We've begun to use partial or unfettered exposure of organisms to the vacuum of space as a means of examining the very limits of survival."

This interest in the ability of organisms to survive these extreme conditions emerged with studies of lichens, aggregates of algal cells and fungi that exhibit remarkable survival abilities under great degrees of stress. An experiment conducted aboard the European Space Agency's BIOPAN facility during the Foton-M2 mission of the mid-2000s showed that the lichen *Rhizocarpon geographicum* could, in fact, survive exposure to space. This same facility later housed the tardigrades – tiny arthropods known colloquially as "water bears" – that became famous as the first true animals to survive in the vacuum of space. While tardigrades pervade popular culture, they're also the subject of widespread research on the mechanisms behind their unprecedented survival abilities. One study published in late 2016 demonstrated that a tardigrade-specific protein could enhance the tolerance of cultured human cells to X-ray-induced DNA damage, suggesting that specific chemical machinery underlies these organisms' incredible aversion to death, and that this machinery could eventually apply in therapeutics or other medical fields.

So the next time you look up at the stars and see a lifeless void, imagine, instead, that somewhere a tiny microbe might be hurtling happily towards an unsuspecting planet.

PHOTO BY PAUL HUDSON

The Paradox of Life: Where is E.T.?

BY MATT KALPIN, BIOENGINEERING, 2021

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2020

In 1977, a 72-second signal was recorded at an Ohio State University radio observatory that, to this day, remains one of the strongest forms of evidence of intelligent, extraterrestrial life. The astronomer, Jerry Ehman, who recorded this six-character sequence wrote one simple word in the margins of the observation: "Wow!" Astronomers have been unsuccessful in finding the signal for the past twenty years, however that does not discourage modern NASA astronomers and the Hubble Space Telescope from searching for the origins of life.

The evolution of life in any given solar system supposedly depends on whether or not a planet lies within the habitable zone surrounding the central star, known as the Goldilocks Zone. This is not a set radius away from the star, but rather the most hospitable region, in which temperatures are mild enough to allow for the formation of water. In Alpha Centauri, the solar system nearest our own, the exoplanet Proxima B – one and half times the mass of earth – orbits around the dwarf star Proxima Centauri within the habitable zone. Only 4.25 light years away from us, Proxima B maintains temperatures moderate enough to allow for the formation of water, even though it's closer to its star than Mercury is to the Sun. Although this discovery seems promising, Proxima B also lies close enough to the star to be influenced by solar flares and other eruptions. Planets such as Proxima B are often the centers of research on the origins of life; however, their usual proximity to red dwarf stars means that solar radiation can erode the planets' atmospheres, and leave them unfit for life to form.

In our own solar system, new technological advancements are being utilized in the search for extraterrestrial life. NASA has proposed to develop a submersible vehicle capable of exploration within the methane oceans of Titan. Titan is the second largest moon in our solar system, trailing behind Jupiter's Ganymede, and is also the only other location in the solar system that contains an open body of liquid like Earth. The submarine will be sent to the largest sea on Titan with the hope of uncovering rudimentary formations of life.

On the more philosophical side of science, astronomers continue to ponder the origins of life. 16 years before the discovery of the "Wow!" signal, Frank Drake, another radio astronomer, formulated an equation that can be used to hypothesize the number of interstellar civilizations. Drake came to the conclusion that N, the number of intelligent civilizations, can be expressed by the product of seven variables: the rate of star formation (R), the fraction of stars that form planets (Fp), the number of hospitable planets (Ne), the fraction of planets on which life forms (Fl), the fraction of planets where intelligent life forms (Fi) and are capable of communication with us (Fc), and the estimated amount of time that the civilization has existed (L) – the actual equation is: $N=R \bullet Fp \bullet Ne \bullet Fl \bullet Fi \bullet Fc \bullet L$. Drake originally estimated that 10,000 civilizations should exist in our galaxy alone. However, the value of N has dramatically decreased over the years as the value of L has changed based on the duration of human civilization here on Earth.

PHOTO BY SERGEY NIVENS

So, where is everybody? The Fermi Paradox exists to answer this question.

If there are over 1021 stars in the observable universe, why are humans the only form of intelligent life to exist? Fermi, a physicist who questioned the estimates of N from the Drake equation, proposed two explanations for this conundrum: either aliens do not exist, or aliens exist but have not communicated with us. Arthur C. Clarke, science fiction writer and author of 2001: A Space Odyssey, drew a similar conclusion, "Two possibilities exist: either we are alone in the Universe or we are not. Both are equally terrifying." An in-depth analysis of these propositions actually shows that Fermi hypothesized that the formation of life is much more complicated and rare than expected. We might suppose that great filters, or extinction events, have thus far wiped out all intelligent life in the universe except for us. In other words, humans are the first civilization to arise and expand out of these filters. However, a more dismal explanation is that humans are the last species to exist. Fermi's other hypothesis was that extraterrestrial species do exist, but due to the expansion of the universe, it is nearly impossible to communicate with us.

> "Two possibilities exist: either we are alone in the Universe or we are not. Both are equally terrifying."- Arthur C. Clarke

The universe is expanding nine percent faster than previously expected: 67 kilometers per second per mega-parsec (3.26 million light years). In simpler terms, the further out into space we observe the universe, the faster it recedes away from the viewer. This means that besides the Andromeda Galaxy, which is heading towards our Milky Way at approximately 250,000 mph, our galaxy will be confined to the Local Group (a collection of over 30 galaxies including the Milky Way and Andromeda) and space exploration outside of this region will be nearly impossible unless an unprecedented technological breakthrough is achieved. Traveling at 20% the speed of light, it would still take nearly 20 years to reach Alpha Centauri, and although this seems reasonable, current technology is still in the process of reaching these speeds.

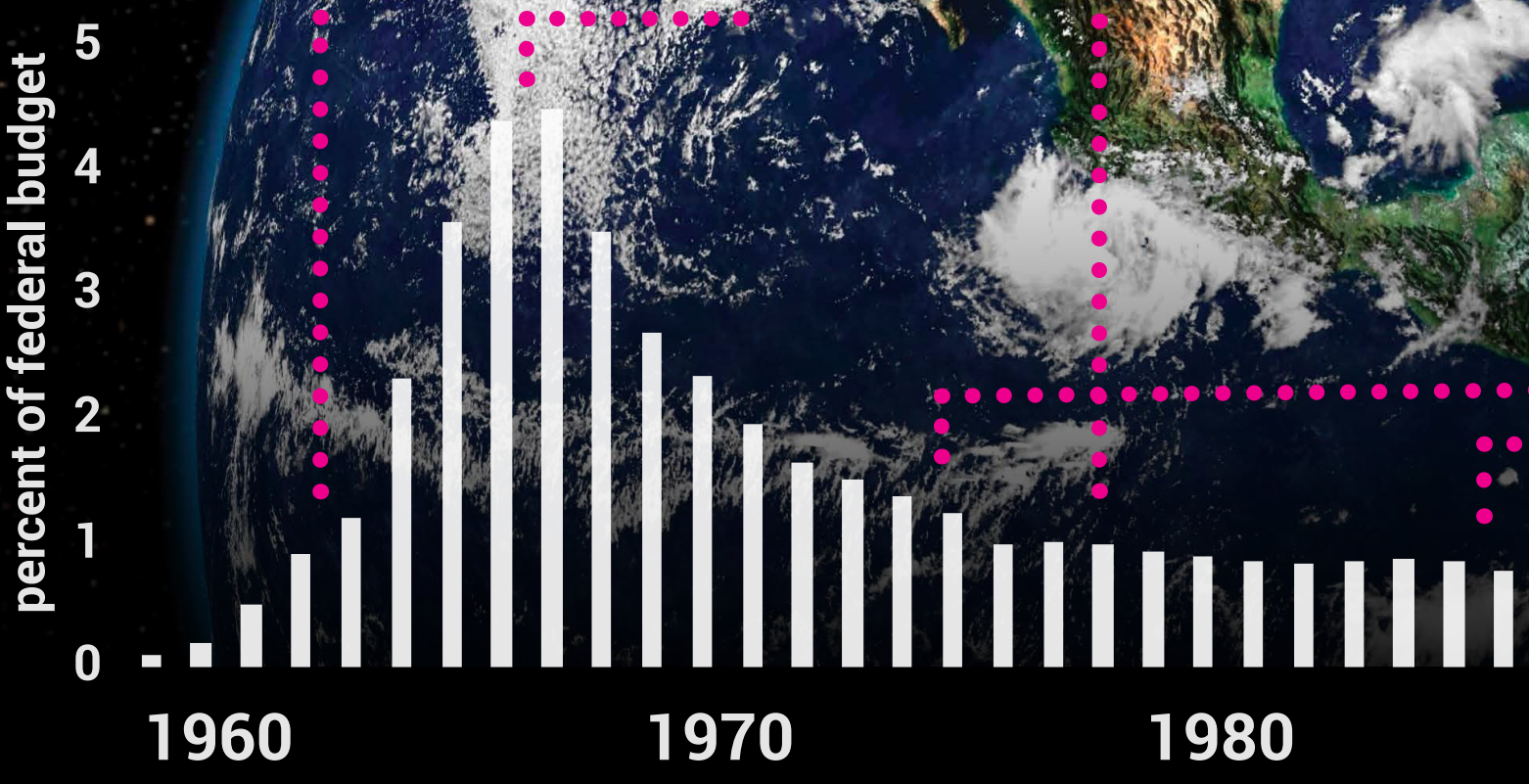
The search for the origins of life has led to innovations in space exploration. Since its completion in 1990, the Hubble Space Telescope has recorded over 1.3 million observations of the observable universe. It is promising that at least out of all the recordings, one exoplanet could house life. However, to put the formation of life into perspective, the Earth formed over 4.5 billion years ago, and the Big Bang occurred 13.7 billion years ago; humans have existed for roughly 200,000 years, which means our existence has filled only 0.000146% of our universe's timeline. As insignificant as this number appears, astronomers and scientists alike continue to turn their research to the distant past of the universe in hopes of one day finding a simple single-celled organism, which could explain the entire existence of humanity as we know it.

NASA

Project Apollo (1961-1972)
Landing the first humans onto the moon — accomplished on Apollo 11 by Neil Armstrong, Buzz Aldrin and Michael Collins.
$109 billion in 2010 U.S. dollars

Project Mercury (1959 - 1963)
First U.S. crewed program — safely put a man into Earth's orbit before the USSR did.
$1.6 billion in 2010 U.S. dollars

Skylab (1973-1979)
The first U.S. space station — a solar observatory onboard provided unprecedented data about the sun.
$10 billion in 2010 U.S. dollars



NUSci takes a look at the federal funding NASA has received over the years and the projects it has undertaken to deepen our understanding of the universe.

Apollo-Soyuz Test Project (1975)
The first joint U.S.-Soviet space flight — symbol of the end of the space race.
$1 billion in 2010 dollars

Space Shuttle Challenger (1972-1986)
One of two failed manned missions — after the Challenger disaster, President Reagan formed the Rogers Commission to investigate the incident.
$27 billion in 2010 dollars

Hubble Space Telescope (1990-now)
A vital research tool for astronomy — the telescope remains in orbit, and is estimated to remain functional until 2040.
$10 billion in 2010 dollars

New Horizons (2006-now)
An interplanetary space probe — New Horizons flew 7,800 miles above the surface of Pluto on July 14, 2015.
$700 million

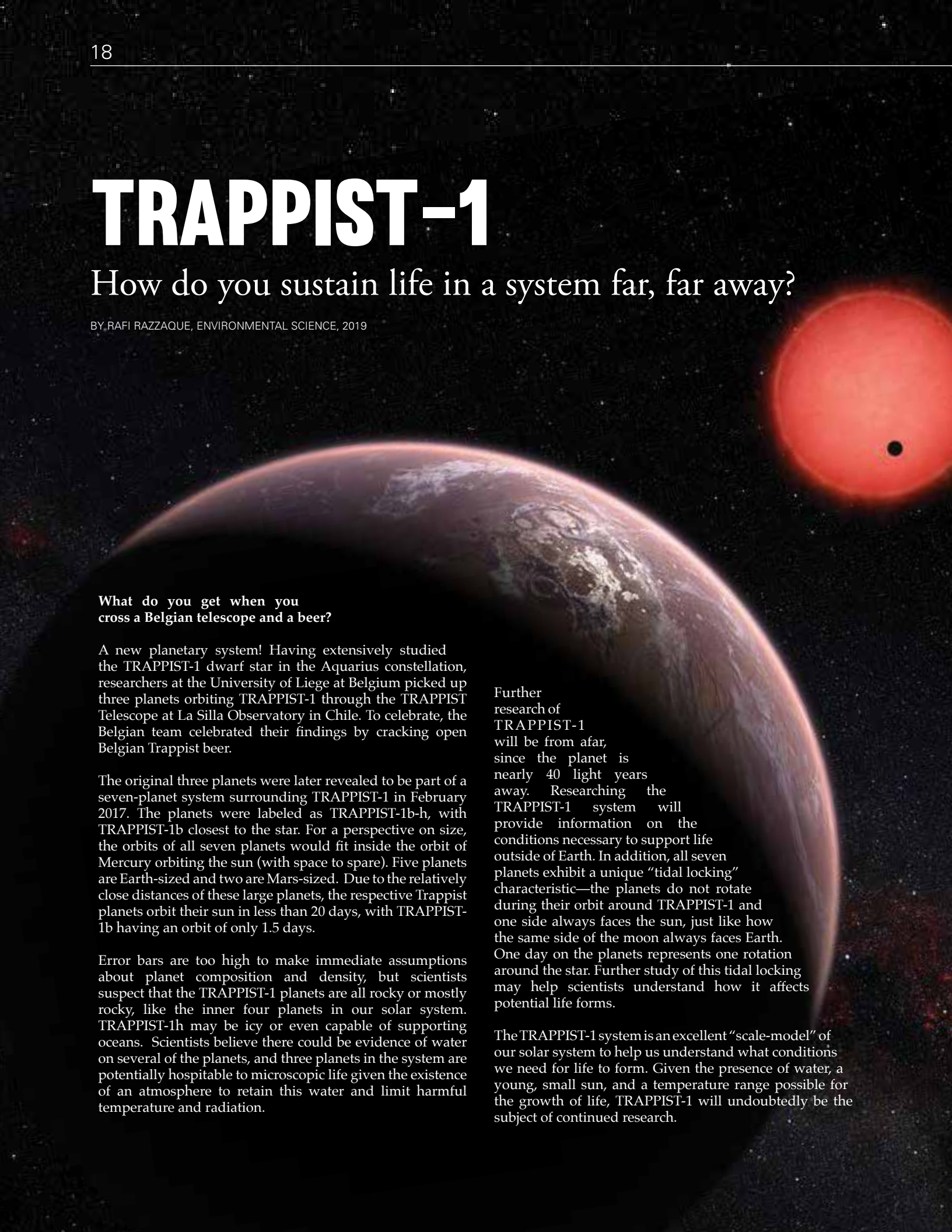
Curiosity rover (2011-now)
A car-sized robot navigating the surface of Mars — Curiosity's primary job is to investigate Martian climate and geology, including the role of water.
$2.5 billion

BY ANNA LI, BEHAVIORAL NEUROSCIENCE, 2019
INFORMATION PROVIDED BY NASA

TRAPPIST-1

How do you sustain life in a system far, far away?

BY RAFI RAZZAQUE, ENVIRONMENTAL SCIENCE, 2019



What do you get when you cross a Belgian telescope and a beer?

A new planetary system! Having extensively studied the TRAPPIST-1 dwarf star in the Aquarius constellation, researchers at the University of Liege at Belgium picked up three planets orbiting TRAPPIST-1 through the TRAPPIST Telescope at La Silla Observatory in Chile. To celebrate, the Belgian team celebrated their findings by cracking open Belgian Trappist beer.

The original three planets were later revealed to be part of a seven-planet system surrounding TRAPPIST-1 in February 2017. The planets were labeled as TRAPPIST-1b-h, with TRAPPIST-1b closest to the star. For a perspective on size, the orbits of all seven planets would fit inside the orbit of Mercury orbiting the sun (with space to spare). Five planets are Earth-sized and two are Mars-sized. Due to the relatively close distances of these large planets, the respective Trappist planets orbit their sun in less than 20 days, with TRAPPIST-1b having an orbit of only 1.5 days.

Error bars are too high to make immediate assumptions about planet composition and density, but scientists suspect that the TRAPPIST-1 planets are all rocky or mostly rocky, like the inner four planets in our solar system. TRAPPIST-1h may be icy or even capable of supporting oceans. Scientists believe there could be evidence of water on several of the planets, and three planets in the system are potentially hospitable to microscopic life given the existence of an atmosphere to retain this water and limit harmful temperature and radiation.

Further research of TRAPPIST-1 will be from afar, since the planet is nearly 40 light years away. Researching the TRAPPIST-1 system will provide information on the conditions necessary to support life outside of Earth. In addition, all seven planets exhibit a unique "tidal locking" characteristic—the planets do not rotate during their orbit around TRAPPIST-1 and one side always faces the sun, just like how the same side of the moon always faces Earth. One day on the planets represents one rotation around the star. Further study of this tidal locking may help scientists understand how it affects potential life forms.

The TRAPPIST-1 system is an excellent "scale-model" of our solar system to help us understand what conditions we need for life to form. Given the presence of water, a young, small sun, and a temperature range possible for the growth of life, TRAPPIST-1 will undoubtedly be the subject of continued research.

THE HUMAN MISSION TO MARS: WHERE DO WE STAND?

BY MEREDITH CRAIG, PHYSICAL THERAPY, 2021

DESIGN BY ARCHANA APTE, UNDECLARED, 2021

NASA has been setting the bar for space exploration since the program's foundation in 1958. From orbiting a man around the Earth to sending one to the moon, their work has always been groundbreaking. Most recently, NASA has set their eye not on the moon, but on the planet Mars.

Scientists are hoping to discover evidence for sustainable life on Mars. To do so, their Mars Exploration Program is focusing on a strategy known as "Seek Signs of Life." Past missions reveal that at one time (between 3.8-3.5 billion years ago), Mars was very similar to Earth, especially its climate. Scientists want to know whether microbial life existed on Mars as it did on Earth then. This could potentially indicate current microbial existence and the possibility of sustaining humans in the future.

Before humans can be sent to the Red Planet, scientists need to understand the interaction between all geologic and climatic processes and how this has affected Mars over centuries. NASA has set four goals that need to be met in order to determine if life can be sustained:

1. Determine if life ever arose on Mars.

Although recent explorations have shown that liquid water was once present on the Mars, "Seek Signs of Life" will need to confirm the presence of organic molecules essential for life (carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur) before humans can be sent. They also need to confirm that there are no excessive environmental hazards like UV radiation.

2. Characterize the climate of Mars.

Although Mars' climate was once very similar to Earth's, it now has a thin, cold atmosphere that may not be capable of sustaining life. Scientists will need to analyze rocks, soils, landforms, and weather patterns before confirming that the climate is suitable for human life.

3. Characterize the geology of Mars.

In order to meet this third goal, scientists will perform the same tasks necessary to complete the second: analyzing rock and soil patterns in order to better understand Mars' history and entertain its future possibility of sustaining life.

4. Prepare for human exploration of Mars.

As one would expect, it is extremely difficult to send a human into space and land them on an unknown surface, so it will take extraordinary practice and experience with precision landing. Scientists also need to understand the health hazards these astronauts may face and what precautions can be taken to protect their health.

These are all long-term goals, building up to the ultimate goal of landing humans on Mars by the 2030s. NASA has also set three thresholds to prepare themselves for the challenge of sending a human further than ever before. The above goals are a part of a threshold known as "Earth Independent," work on which will continue into the 2030s and beyond. The second threshold is known as "Earth Reliant," which focuses on sending astronauts to its new International Space Station in order to develop deep space systems and study life support and human health in space. This work will continue until about 2024, and also overlaps with the third threshold, "Proving Ground," which will begin in 2018 and continue to 2030. These missions will take place near the moon in an area referred to as "cislunar space" by NASA. A yearlong mission will be launched in order to determine if humans can handle the long journey to Mars. Astronauts will collect asteroid samples to return to Earth in order to test spacewalking and sampling techniques, a necessary part of the human journey to Mars.

This may seem like an impossible mission, and it is certainly not without its challenges. However, that was also true of NASA's previous missions. Ultimately, our progress on the mission to Mars can be summed up with one quote from NASA: "…It's an achievable goal. There are challenges to pioneering Mars, but we know they are solvable. We are well on our way to getting there, landing there, and living there."

PHOTO BY NASA

NU HYPERLOOP CLUB LOOKS TOWARD THEIR NEXT STEPS

BY GWENDOLYN SCHANKER, JOURNALISM AND BIOLOGY, 2018

What do you get when you cross a group of motivated students with an innovative idea from Elon Musk?

A revolutionary new mode of transportation.

Manny Barros, Ted Rausch, and Ben Lippolis, along with the other members of Northeastern's Hyperloop Club, have spent much of the past year designing and constructing an 18-foot pod that, once completed, will be able to travel effortlessly through a depressurized tube. Hyperloop is the brainchild of well-known businessman and inventor Elon Musk, who in 2013 published a paper called "Hyperloop Alpha" outlining a futuristic commuter transport system that would allow people to travel between cities at 700-plus miles an hour, much faster than they could in a car, train, or even a plane.

"The Hyperloop has the potential to drastically improve way of life," said Lippolis, a senior business major who serves as the business development lead on the project. "I'm a big Elon Musk fan so this is something I instantly wanted to be involved in."

Northeastern's team is part of "Paradigm Hyperloop," which is a collaboration with Harvey Mudd College and Memorial University. Paradigm was originally a team of six schools – then known as OpenLoop – but has since evolved so that all operations are concentrated in Boston and at Northeastern. The NU students primarily communicate with their non-East Coast colleagues via instant messaging on Slack.

"I've probably sent thousands more Slack messages than text messages over the last 10 months," said Rausch, a third-year mechanical engineering major.

Their pod design accounts for air supply, levitation, brakes, and landing gear. All of the different parts depend heavily on one another, so the pod requires a lot of physicality testing as well as weekly design meetings, which are held in Hastings Hall. "It's definitely a full-time job," Lippolis said.

OpenLoop was one of 27 teams selected to participate in the Hyperloop Pod Competition at the SpaceX headquarters in Hawthorne, California in January 2016. It was the team's first opportunity to troubleshoot and also gave them a chance to observe the progress of their national and international competitors, all of whom are working to make Musk's vision a reality.

"There were teams with pods they checked on the plane and teams with 3,000-pound pods," Rausch said. "We had the second-largest one." The Boston-based pod was driven cross-country by an auto transport company called Reliable Carriers.

Barros, a sophomore mechanical engineering major, added that the custom-designed air levitation system of the Paradigm pod made their design stand out at the competition. "SpaceX was excited to work with us," he said.

Although the team did not get an opportunity to test the efficacy of their pod in the SpaceX Hyperloop tube, they did run a number of useful safety tests. "We were able to learn a tremendous amount, and I think that's going to help us a lot going forward," Lippolis said.

The next step for the team will be Summer 2017's "Competition II," where they'll hopefully get the chance to make a full-speed run on the Hyperloop track, which is approximately one mile long and six feet in diameter. They've got a lot of work they do before they're ready for the summer, but Barros is optimistic.

"We have a lot to do in four months, but we have a record," he said.

"We don't quit – for better or for worse," chimed in Lippolis, who is currently working with the team to put together a short video about Paradigm Hyperloop to attract more sponsors. "We want to make it easier to understand for people and make them want to be involved," he said.

Regardless of the project's outcome, the experience that comes with designing something completely new is unmatched.

"It's like two co-ops worth of real-world experience," Rausch said. "[SpaceX] is very open about how it's new for them too. There's a growing energy coming to the transportation area, and to be putting energy towards an outdated area that needs innovation is very motivating."

Lippolis hopes to continue working with the Hyperloop team after he graduates in May. He says that despite the late nights he's put into planning, design, and discussion, he never gets tired of working alongside his friends.

"These relationships are bonds that will last a lifetime," he said. "We're all a specific flavor of dedicated. These are my favorite people, simple as that."

The Day the Earth Stopped Spinning

BY RAFI RAZZAQUE, ENVIRONMENTAL SCIENCE, 2019

What would happen if the Earth stopped spinning?

In a word, chaos! We would be at risk of everything from coastal flooding to death rays, and mankind would eventually meet its demise.

Let's back up a second. If Earth were to stop spinning, there are two possible scenarios. Earth would either seize up mid-rotation, or would slow down to an eventual standstill. Regardless of the scenario, the end result would be just as dire. Should the Earth freeze immediately, the effects would be far more dramatic considering inertia.

In the event of a sudden stop to the Earth's rotation, inertia would ensure that everything not bolted down properly would hurtle forwards at over 1,000 miles an hour, be it humans, infrastructure or nature. The atmosphere would propel everything forward, with winds of speeds of up to 10,000 miles an hour. The atomic bomb-force windstorms would cause massive erosions to cities and landscapes. Oceans would flood coastlines and areas farther inland in minutes. The equator and areas near it would be disproportionately affected relative to the polar areas, as the Earth moves the fastest at the equator and the slowest near the poles. Should the Earth slow to a crawl before stopping, the Earth and its inhabitants would still face massive consequences.

Although the chances of survival are thin due to lack of preparation for such an event, life could theoretically continue. As long as the Earth's slowdown takes more than five seconds, the human body can biologically sustain the slowdown forces. Nothing on Earth will fly into space regardless of how quick the slowdown is.

Regardless of how the Earth actually stopped, some fascinating and difficult events would take place, challenging our likelihood of survival. On the benign side of things, the lack of rotation will impact the gravitational force on the oceans, meaning our oceans will move away from the equator and migrate towards the poles. Eventually Earth will eventually feature a supercontinent near the equator and two oceans near the poles. Earthquakes could be a potential threat to this redesigned Earth. In addition, the Earth as we know it is not a sphere due to rotational deformities. Earth would become a true sphere from the lack of rotation.

With no rotation, the Earth would only rotate once for every rotation around the sun; as such, one 'day' on earth would be approximately one year as we know it. Our 'day' would consist of six months of extreme heat and potential drought, and then six months of dark, winter night.

Eventually, the scorching heat and extreme cold would severely affect the few remaining organisms on earth; we would lose water, which is necessary for life, at a huge rate. If that did not bring about the end of the human race, the magnetic field caused by Earth's rotation would eventually die out, leaving us vulnerable to solar flares and extreme radiation.

An event that causes the Earth to stop spinning is extremely unlikely or far in the future: the Sun will most likely burn out first, some 5 billion years in the future! Nonetheless, exploring the possibility is a lesson in the many ways that our planet and solar system look after us every day without us even noticing! Be kind to the Earth for being as hospitable and safe as it is.

Would You Fight for a Country that Won't Fight for You?

A review of *Hidden Figures*

BY VIVIAN LEE, COMPUTER SCIENCE AND BUSINESS ADMINISTRATION, 2020
AND MELISSA MICHELS, COMPUTER SCIENCE AND BUSINESS ADMINISTRATION, 2020

DESIGN BY KYRA PERZ, CHEMISTRY, 2020

You arrive home after a strenuous day of work to greet your children. They inform you that earlier that day they performed emergency drills at school. Their professor instructed them to hide under their desks and cover their heads in the event of a surprise attack from the Russians. The only thing you can be certain about is that it's a time of uncertainty. The next day at work you enter a board meeting with the nation's most honored officials. You are not only the first women to sit in on such a briefing, but the first African-American women in a period of segregation and social injustice. The lead pilot for the upcoming mission asks, "How can we calculate the go no-go point of entry for my mission?" Silence fills the room. Then seconds later without hesitation you state the coordinates. You don't know how these officials will react but you are confident in your mental calculations. The pilot smiles and asks how the team will be able to ensure his safe return to earth. Eyes shift. Every person in the boardroom and young eyes across the nation are awaiting America's next attempt to rival the Soviet Union. Your boss turns his head to face you and hands you the chalk. "Take a crack at it…"

> "How can we win a race to the future when we're still struggling with issues from the past?"

How can we win a race to the future when we're still struggling with issues from the past? That's the question Katherine G. Johnson, Dorothy Vaughan and Mary Jackson asked themselves as they drove to work at NASA Langley Research Center each day, working to help the United States advance in the Space Race during a time of uncertainty against the Russians. As three African-American women, they had to continually demonstrate not only their competence but also their brilliant wit and determination simply to be considered equals to their white male counterparts.

As Mary Jackson stressed to the judge who would be the deciding vote on her admission to attend night classes at an all-white high school, there is an importance in being first. We as human beings like being first. First place often conjures images of fame, glory, or a large trophy. Many firsts in America have become common knowledge among us: George Washington was the first president of the United States, Neil Armstrong was the first man to walk on the moon, Barack Obama was the first African-American president of our country. We're told to remember these firsts because they're important. They're groundbreaking. They made history. *Hidden Figures* is the story of many firsts, but they were not firsts that became common knowledge in our country's history. No less important, no less revolutionary, they were buried away and almost forgotten. The entire nation cheered as they watched former astronaut John Glenn became the first American to orbit the Earth in the Friendship 7 mission. Who they didn't see was the hard-working Katherine G. Johnson behind the scenes; she was the one who diligently performed the calculations that would ensure his safe journey and return.

No one can question the bravery Glenn had in voluntarily boarding a chunk of metal that would later become a flaming fireball falling out of the sky. But there's something to say about the bravery exhibited by Johnson in walking into work each and every day, with all eyes staring at her. Eyes telling her she didn't belong, not on an intellectual level, but because of the color of her skin. Working amongst colleagues who wouldn't dare share a coffee pot with a colored woman, running half a mile across NASA's campus every day simply to use the nearest colored restroom, Johnson continually displayed bravery and tenacity, showing that under no circumstances would she quit.

Hidden Figures received a score of 93 percent from Rotten Tomatoes and 7.3/10 stars on IMDb. We wholeheartedly agree with these high ratings and would take it further by giving this movie an A! As women in the growing, yet still male-dominated, field of computer science we found this movie truly inspirational and uplifting. The weight of the daily struggles each of these women endured is inconceivable and learning about their individual stories and how they paved their own roads to success gives us hope that with dedication and perseverance, the sky's the limit.

STAR WOBBLING AND BILL NYE

How our favorite science guy continues to impact space exploration

BY PAULA HORNSTEIN, BIOLOGY, 2020

DESIGN BY CATU BERRETTA, COMP SCI, 2020

The brightest star in the galaxy has recently announced his return: Bill Nye the Science Guy is coming back to the small screen, with his new show, Bill Nye Saves the World.

Nye has certainly not been in hiding since his days on the Disney Channel. He has worked on numerous projects over the past two decades, all of which focus on educating the public on the truths of science and rebutting all the scientific myths that currently plague the western world. In 2015, Nye spoke with President Obama about the effects of climate change and potential means of healing the ozone layer. He has also been vocal about current hot topics, including women's reproductive rights and the importance of vaccinations for children. All in all, Nye continues to fulfill his role as "The Science Guy," impacting us both on and off screen.

> "Nye's intention, as an advocate for science, is to eradicate ignorance regarding the scientific realms that affect us, both as a nation and as individuals."

In addition to the persona he acquired from TV, Nye is also CEO of The Planetary Society, a non-profit organization which seeks to educate the public on space, encourage scientific literacy, and raise funds for innovative and potentially groundbreaking projects involving galaxy exploration. The Planetary Society, founded by Carl Sagan, Bruce Murray, and Louis D. Friedman in 1980, focuses on projects impacted by NASA budget cuts, creating awareness and hopefully promoting funding for these ventures.

One of these projects is improving exoplanet imaging. Exoplanets exist outside of our solar system and revolve around their own stars. Astronomers are interested in exoplanets because of their potential to support life. Little is known about them, but The Planetary Society is taking steps to learn more about these planets and their sustainability.

One way of determining whether an exoplanet is viable is by a method called "star wobbling" that occurs as a planet tugs on the orbit of the star, causing the star to shake a slight amount. The amount of wobble can be monitored by the use of a spectrograph, which, according to Nye, "splits starlight into its component wavelengths. As a star wobbles, its spectrum shifts. By recording these shifts over time, astronomers can infer that a planet is present."

If an exoplanet's wobble is remotely close to that of Earth—about ten centimeters per second—it is possible that it has Earth-like properties and could have the potential to support life. However, because the planet-to-earth wobble margin is very thin, spectrometers must be precise.

To increase the accuracy of spectrometers, The Planetary Society is sponsoring a project called the Exoplanet Laser. Headed by Dr. Debra Fischer of Yale University, the Exoplanet Laser involves using "a system of lasers to generate an artificial spectrum that is imprinted alongside the star spectrum" which, in turn, calibrates the star spectra. This gives astronomers a more accurate depiction of the size, weight, and pull of an exoplanet that is otherwise unobservable.

Over the past decade, The Planetary Society has raised funds for more accurate spectrometers and data analysis on exoplanets, as well as stronger and more reliable telescopes for Fischer and company. In addition to the data accumulated by these resources, the Exoplanet Laser would allow for deeper exploration into the existence of exoplanets and their potential to support life.

The vision of both Nye and The Planetary Society is to encourage us to "know the cosmos and our place within it." This ranges from becoming more informed about our own planet and what we can do to help it, to designing and creating a planetary defense system that would destroy Near Earth Objects (meteors, comets, and the like) before they hit Earth, saving our world from mass destruction.

Nye's intention, as an advocate for science, is to eradicate ignorance regarding the scientific realms that affect us, both as a nation and as individuals. Under Nye's direction, The Planetary Society reflects that same goal: that we must work to better understand our relationship with the universe—our place within it, what we can do to learn more about it, and how that knowledge can be applied to improve the state of our Earth.

Check out planetary.org to learn more about Bill Nye's perspective on space and the organization's projects!

AIR BUDS | THE ANIMALS PIONEERING SPACE TRAVEL AND RESEARCH

BY EMILY ASHBOLT, BIOMEDICAL PHYSICS, 2017

DESIGN BY YU CHENG, DESIGN, 2018

PHOTO BY NASA/MARSHALL SPACE FLIGHT CENTER

Early on in their careers, many scientists have to become accepting of the number of animals that are sacrificed in the name of scientific progress. It is not an easy concept to accept, and there are multiple regulatory programs to ease both the end of life of the animal and the consciences of those who are responsible. For those not within the scientific realm, the concept can seem even more abhorrent than it does to the indoctrinated.

NASA has a unique take on this challenge. Unlike the scores of rodents and primates that take one for the team in our cosmetic and pharmaceutical industries and stay out of the public eye, space program animals have the tendency to become famous. When your lab animals have a press corps, it becomes harder - but is often all the more necessary - to explain the reasoning behind Russia and the U.S. strapping their bodies into capsules not knowing what will happen to them.

> "Most animals sent up for tests, particularly in the early years of the space race, met grisly ends."

Most animals sent up for tests, particularly in the early years of the space race, met grisly ends. Those who survived were VIPs till their end of their days, but their ranks are few and the price they paid is hard to measure.
Even today, small animals and bacteria are still routinely rocketed into the outer atmosphere, usually for observations on the effects of zero-gravity on growth and behavior. And these animals still have the tendency to become stars - how could anyone forget the infamous Russian sex geckos of 2014? They also have the unfortunate tendency of still meeting sticky ends- RIP frozen Russian sex geckos- to say nothing of the actual experience of space travel for already skittish prey animals.

The first animals launched into orbit were monkeys and mice, sent up by Americans starting in 1948 to test the effect of weightlessness on mammals. The Russians followed soon after in the early 1950s with small dogs, chosen because they believed they'd be more obedient than monkeys. Few of these animals survived. Most notable at this time period was Laika, a stray dog and the first animal to orbit the earth (in Sputnik II). Laika died of overheating and stress a few hours into her journey. She was never intended to come home anyway- the spacecraft had no re-entry plan.

Mice and monkeys continued to be the animals of choice for Americans, and dogs for the Russians, throughout the 1950s. The late 1960s also saw animals being sent to space purely for scientific curiosity and less to judge human survival likelihood. Soviet flights took rabbits, turtles, fish, insects and frogs into space throughout this period. Mechanical failure doomed most of them.

The Soviets continued curiosity experiments in the 1980s and early 1990s to look at the genetic changes brought about by space travel. Temperature failure ended the lives of many creatures en route. The tragic destruction of the American Space Shuttle Columbia in 2003 saw the demise of not just the entire human crew, but also the onboard spiders, ants, bees, and fish. And that leads us to the Russian geckos of 2014, which were sent on a mission to understand zero-gravity mating and embryonic development, but were frozen in space after their craft lost contact with the motherland.

Going to space is risky business, and many animals have lost their lives in the push for exploration. Some of them live on, famous, but many are forgotten, even while their bodies, entombed in retro spacecraft, still orbit the earth today. There is no denying that the space race would not have been possible without the sacrifices of these creatures. The ethics of animals being used in human research has many grey areas. But the next time you see a shooting star passing overhead, take a second and think of a dog, hurtling through the atmosphere, not sure of her mission, or location, or purpose; just a small tail wag for her, and a great leap for mankind.

Somebody's Always Watching Us

(From the International Space Station)

BY JORDYN HANOVER, BEHAVIORAL NEUROSCIENCE, 2017

DESIGN BY YU CHENG, DESIGN, 2018

Since 2000, the International Space Station has housed astronauts from around the globe. The station was launched through the international cooperation of over 20 countries, and each of the expeditions since has focused on research that could impact the entire world. More recently, the station has been expanded to prepare for future operations. The station currently has living space for the astronauts (which is equivalent to a five-bedroom house), where the travelers spend the duration of their expeditions. In this space there is a large exercise room, as astronauts need to exercise frequently to help counteract the effects of space, which have been shown to cause about 2% bone mass loss every month. The typical crew size is six people, and there are currently six astronauts (a full crew) on the station. The crews typically rotate 2-3 times per year. The six astronauts there today are part of the 50th expedition to the ISS.

The astronauts on Expedition 50 are due to return home in April 2017, having spent the past six months studying lighting and microgravity. According to the NASA expedition summary, the crew is researching "how lighting can change the overall health and well-being of crewmembers, how microgravity can affect the genetic properties of space-grown plants, and how microgravity impacts tissue regeneration in humans." The International Space Station orbits the earth approximately every 90 minutes, so the crew sees multiple sunrises in a typical day. This makes the lighting onboard the station crucial to the space travelers' ability to maintain a typical sleep schedule. The expedition is also looking into the tissue and bone loss common in crewmembers. Research that emerges from this expedition could lead to regeneration that could be applied to the greater population. The final goal of these astronauts is to measure the layers of stratospheric gases in order to help shape climate policy.

In November 2016, three new astronauts arrived at the space station on Expedition 51, and they are expected to return approximately 7 weeks after the astronauts from Expedition 50 return home. Astronauts typically arrive and depart from the station in groups of three, though there have been expeditions where the crew was larger or smaller than six. The astronauts currently on the space station are Commander Robert Kimbrough and his Flight Engineers, Peggy Whitson, Andrey Borisenko, Thomas Pesquet, Sergey Ryzhikov, and Oleg Novitskiy. All of the astronauts currently at the station are American, Russian or French, but astronauts have traditionally come from five different international space agencies: NASA out of the United States, Roscosmos State Corporation for Space Activity from Russia, the European Space Agency, the Canadian Space Agency, and the Japan Aerospace Exploration Agency. That said, the majority of crew members at the station have been Russian and American.

Want to learn a little more about the crew? Commander Kimbrough is a 49-year-old former Army colonel and is currently on his second space mission. He performed two spacewalks on his first mission, and has trained at NASA since 2004. Andrey Borisenko, 52, is a Russian astronaut who has been working in the Roscosmos space program for almost 30 years. Sergey Ryzhikov, 42 began working at the Gagarin Cosmonaut Training Center in 2006, and finished his space training three years later. Thomas Pesquet, the youngest on the expedition at age 39, completed his training at the European Space Agency in 2010, and completed further training in preparation for Expedition 50. Peggy Whitson is the oldest astronaut currently spending time at the ISS, and at 57, is perhaps the most experienced astronaut currently on the station. Whitson was also a member of Expeditions 5 and 22 and so is now embarking on her third ISS expedition. She has also performed multiple spacewalks during her previous missions, and has worked at NASA since 1989. Oleg Novitskiy, age 45, worked as a pilot in the Russian Air Force before completing his spaceflight training in 2009.

The International Space Station is the effort of international cooperation from multiple countries through several different agencies. The station is visible from Earth without a telescope, and has online trackers available to anyone who wants to know where the station is in orbit at any moment in time. This collaboration has led to years of important international research and will likely continue into the next decade as the station continues to circle the earth, and as astronauts continue to be launched into space.

Shane Kimbrough and Peggy Whiteson

PHOTO BY NASA JOHNSON

Packing for Mars, Packed with Fun

BY ADANYA LUSTIG, LINGUISTICS, 2018

DESIGN BY GATES SCHNEIDER, BEHAVIORAL NEUROSCIENCE, 2021

Mary Roach's *Packing for Mars***:** The Curious Science of Life in the Void, may be about living in outer space, but she maintains the down-to-earth sensibility she cultivated with her first best-seller, Stiff. Roach's classic style of nonfiction delves into a different aspect of what it's like for humans to live in space in each chapter, ranging from interstellar hygiene, to living without gravity, to the psychology of isolation. For each facet, she discusses a landmark study, a historical event, and often either consults a researcher or experiences a phenomenon for herself.

Roach writes for the layman, yet her enthusiast tones do not mask her extensive experience in science journalism for decades. Her approachability is Roach's greatest success; you get the feeling of familiarity chatting with a friend insistent on sharing an incredible new story.

Enthralled by the idea of humans in space, Roach illustrates the fascinating, bizarre and entertaining side to interstellar exploration and colorfully shares how fascinating, bizarre, and funny that world can be. For example, in her section on hygiene, Roach described how the Gemini VII long johns were starting to deteriorate by the end of the mission, especially because the new urine management system leaked considerably. "For instance, on the second day of the flight, when [Pilot] Lovell, reporting to Mission Control that he was ejecting urine from the spacecraft, noted, "Not too much of it; most of it's in my underwear."

> "I see a back-handed nobility in excessive, impractical outlays of cash prompted by nothing loftier than a species joining hands and saying, 'I bet we can do this.'"

Roach's work is not limited to storytelling; she does her best to experience what she can of living in space for her readers: she drinks treated urine, and she manages not to throw up while experiencing low gravity on the downswing of a C-9 airliner.

Though her personal asides and sense of humor seem to mock our wild pursuit of space travel, she also notes the beauty of the distinctly human endeavor. Her reflection holding onto a Martian meteorite does just that: "I stood there taking in its hardness and its heft, its realness, making an expression that I'm sure I'd never before had call to make. The meteorite wasn't beautiful or exotic-looking. Give me a chunk of asphalt and some shoe polish and I can make you a simulated Mars meteorite. What I can't possibly simulate for you is the feeling of holding a 20-pound divot of Mars in your hands."

Packing for Mars is fascinating, but you'll be able to pick it up and put it down when you like; it isn't gripping. This is both a flaw and a success—it's almost like a coffee table book. It's best enjoyed a couple chapters at a time when you're in the mood for something a little gross and entertaining.

It's not all bowel movements, though. Roach answers the question that space enthusiasts have been fending off for years: What's the point? "The nobility of the human spirit grows harder for me to believe in. War, zealotry, greed, malls, narcissism. I see a back-handed nobility in excessive, impractical outlays of cash prompted by nothing loftier than a species joining hands and saying, 'I bet we can do this.'"

Packing for Mars will leave you laughing, chock-full of bizarre factoids to tell your friends, and inspired by the immense work of getting humans into space. Maybe it will just make you appreciate your shower.

PHOTO BY WIKIMEDIA COMMONS

The Space Station Blues

BY DAVID LU, PHARMACY, 2021

DESIGN BY GATES SCHNEIDER, BEHAVIORAL NEUROSCIENCE, 2021

From freeze dried mashed potatoes to unequilibrated sleep, the small nuances of everyday life for the six astronauts living on the International Space Station make the other seven billion people living over 400 kilometers away appreciate life on Planet Earth that much more. Living in space is no joke; though most people would surely jump at the opportunity to be launched into the exosphere, only the best and brightest are put through years of intensive physical and psychological training to don that itchy, bulky orange jumpsuit. However, according to recent news, getting launched into space just got way more comfortable. A new 21st century Boeing Blue spacesuit onesie featuring touch screen gloves, comfortable Reebok boots, and zip-on hood helmet will clothe International Space Station bound astronauts aboard the Boeing Starling next year.

“A new 21st century Boeing Blue spacesuit onesie featuring touch screen gloves, comfortable Reebok boots, and zip-on hood helmet will clothe International Space Station bound astronauts aboard the Boeing Starling next year.”

The Boeing Blue is designed to be worn inside the spacecraft. It protects against sudden depressurization or fire during dangerous launches and re-entries but can’t shield astronauts from space debris or solar radiation. Nickednamed the ‘get me down quick suit,’ the design was inspired by the pressurized suits worn by World War II pilots. Sleek, lightweight, and comfortable, it is 10 pounds lighter than the original orange “pumpkin” suit. With fewer bells and whistles, the suit is much easier to take on and off and is made of a material similar to David Clark’s breatheable knitted nylon material called link-net that helps the suit maintain its shape and allows for greater range of motion. The suit also helps astronauts connect to ground and space crews through the communications headset within the hood-like fabric that nests the helmet and a wide polycarbonate visor to improve peripheral vision. To represent their respective organizations, astronauts will wear either a Boeing logo or a NASA insignia patch on the right shoulder, an American flag on the left, and the Starliner patch and their name tag across the front.

“Spacesuits have come in different sizes and shapes and designs, and I think this fits the Boeing model [and]...the Boeing vehicle,” stated Chris Ferguson, Boeing’s director of the CST-100 Starliner crew and mission systems who played an integral role in the design of the suit. Although silver, white and orange are usually thought of as the traditional spacesuit colors, David Clark and other companies behind the Starliner outfits have worked with other blue spacesuits before.

Boeing did consider other color combinations before settling on “Boeing Blue,” which is one of Boeing’s trademark colors that matches aspects of the Starliner’s interior.

“The final Boeing spacesuit design required a significant amount of give and take from those who provided input,” stated Boeing in a company publication. “A blue and white suit was considered but it wasn’t as cost-effective as one that was all blue.”

However, no matter the material, comfort, or technology, the suit must make sure that the astronauts get to space and return home safely.

PHOTO BY FLICKR AND EURPOEAN SPACE AGENCY

Nature vs. NASA

What scientists learned from the Kelly twins about humans in space

BY STEPHANIE WASIUK, BIOLOGY, 2017

DESIGN BY KRITHI NATHAN, BIOLOGY, 2019

With settlements on Mars on the horizon, a lot of questions are emerging about the effects of long-term space travel on the human body. Not only has man never set physical foot on Mars, but the amount of time required to make the journey has only been completed by a few astronauts. How plausible is transporting humans to Mars without facing adverse health effects? NASA developed their Twins Study program to answer that exact question.

Twin brothers Scott and Mark Kelly were the subjects of this experiment launched by NASA in November of 2012. Because the twins have almost identical genomes and have had similar histories of traveling through space, they were a near perfect pair for this research. The study involved a one year stay by Scott on the International Space Station (ISS), while brother Mark remained on Earth, as a control. Samples from the twins were collected before, during, and after Scott's mission for analysis.

Scott's 340 day-long space stay began in 2015 and ended with the landing of the Soyuz TMA-18M shuttle on March 1st, 2016. Results of the studies were highly anticipated and the preliminary findings were released on January 26th, 2017.

This study was done in conjunction with 10 institutions outside of NASA, each of which evaluated a different system within the human body to see if and how it changed on Earth or in space. Aspects that were examined included the physiology of various organs, the microbiome, behavioral health, and molecular changes or genetic modifications.

After spending nearly a year in space, Scott's body went through a number of changes. While in space, he grew 2 inches in height, but returned to his original Earth height after landing. Cognitive functions, such as speed and accuracy, decreased during his time on the ISS. Interestingly however, his cognitive function declined over time for the first six months, but got no worse from that point on. Other abilities that also declined were his motor skills and nearsighted vision. His bones did not grow as rapidly as they did when he was on Earth, yet his repair mechanism efficiency increased. It is speculated that this was the result of increased exercise while in space. Not everything was affected, however – his immune system remained just as responsive throughout the entire mission.

Arguably the most interesting data point involved Scott's telomeres, which are the protective caps on the ends of replicating chromosomes. The shortening of telomeres leads to aging and can be involved in cancer. During the space mission, they actually increased in length, which was the opposite of what was expected. Once Scott returned to Earth, his telomeres returned to their original lengths. In addition, Scott's DNA methylation levels increased in space while brother Mark's levels decreased back on Earth. DNA methylation is a type of modification that can effectively turns genes off - this can be a part of regular development or disease if the patterns are abnormal. Levels in both brothers ultimately returned to pre-flight measurements after Scott returned. It is still unclear why Mark's levels were affected in this way and the implications are currently being studied.

> "The length of Scott's telomeres…actually increased. This was the opposite of what was expected."

The implications of many of these studies are yet to be discovered as more data on the Kelly twins will be released later in the year. The Kelly twins are not the only astronauts involved in these kinds of studies, however. Russian cosmonaut Mikhail Kornienko accompanied Scott Kelly on the One-Year Mission from 2015-2016. Another NASA study involving subjects unrelated to the Kelly twins, is also promising additional results on the impact of space travel on telomere length in 2018.

Not only does this research have significance in the realm of space travel, but here on Earth it is a development of the general use of humans as research subjects. Concerns have been raised over the publication of the Kelly twins' genetic information. This study will continue to add to the debate about what information can and should be made public in the case of human subjects.

As more and more data makes its way back to Earth, humankind may gain a greater sense of what is possible in regards to long-term space travel and even living on another planet. This data is thought-provoking on the state of our own planet and how we are - or aren't - taking care of it. Hopefully, this kind of travel will be by choice and not by necessity.

Through the Looking Glass: My Sensory Gating Disorder

BY CHRISTINA MIYABE, PhD CANDIDATE PHARMACEUTICAL SCIENCES, 2017

DESIGN BY KRITHI NATHAN, BIOLOGY, 2019

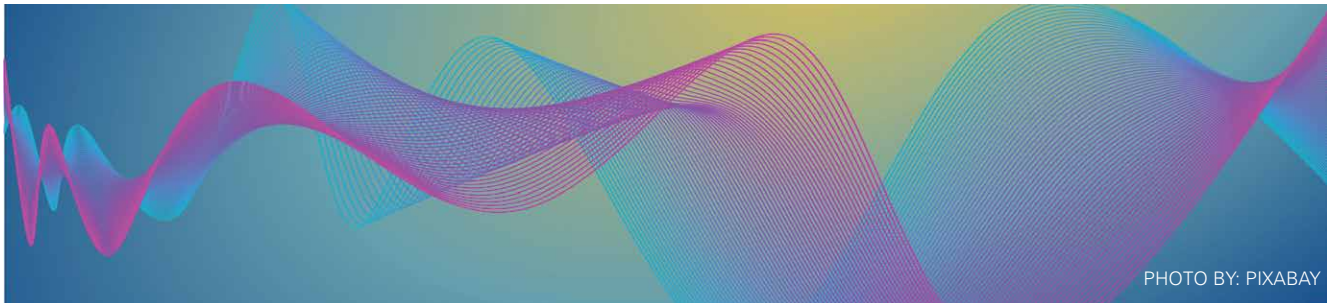


PHOTO BY: PIXABAY

It used to confuse me when anyone said they'd lost their "train of thought," because my brain has never had just one train. I process the world differently than the typical person, and as I've journeyed to become a scientist studying the brain, I've discovered something about myself that has been a lifelong struggle. I have an auditory sensory gating disorder that fits no current psychiatric diagnostic criteria.

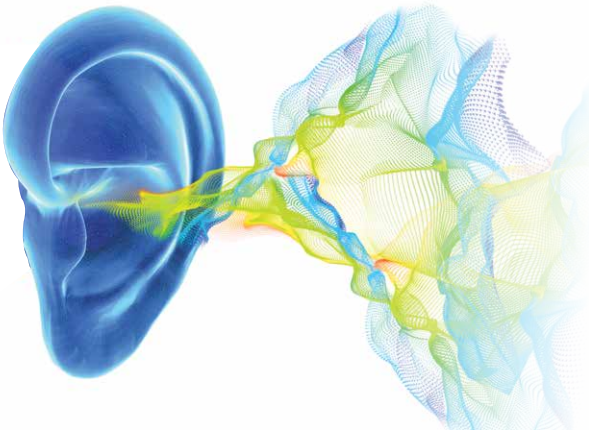
There is a clear difference in the way I process the sensory input from the world around me than the way that others do. The symptoms this causes have exhibited many different mental illnesses over the years. This has led me to many different specialists, each of whom treated me to their best ability, but none of whom truly understood me. Whether my brain's chemical imbalance is a product of genetic predisposition or environmental factors does not matter, although it is certainly a unique combination of both for each individual. What does matter is what my symptoms are and what I can do to mediate them as best as I can so I can still function in society.

My brain does not filter out ambient noise. While a typical brain will be able to focus on one type of sound and disregard other background noises, mine will have at least one train of thought per individual noise it is processing - there is no such thing as a background noise for me. This makes me prone to overstimulation when I'm in an environment with many distinct sounds, like on the MBTA. But it's not all bad: this also allows me to excel at lecture-based theoretical courses. I am predisposed to paying attention to everything I hear, so zoning out isn't an option.

There are other little "tells" here or there - hypersensitivity to light touch, hyposensitivity to pain, poor spatial awareness, compulsive self-stimulatory behavior (I constantly touch my hair), etc. But I will never fit the criteria for the disorder that most accurately describes me, because my diagnosis only fits pieces of criteria in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), the set of guidelines

> "...we cannot categorize that which does not have clear boundaries."

used to categorize mental disorders for healthcare purposes. This brings forward a problem within the stigma of mental disorders and mental illnesses: we cannot possibly categorize that which does not have clear boundaries. There is a real danger in prescribing incorrect psychiatric medications based on clean, neat little boxes of mental disorders. There are no boxes and we are all on the spectrum of typical to atypical. We must start approaching mental health issues with more self-awareness, flexibility, and empathy.



A LAUNCH INTO THE FUTURE OF SPACE TOURISM

PHOTO BY WIKIMEDIA COMMONS

BY ADRIANNA GRAZIANO, BIOLOGY, 2019

DESIGN BY SHRADDHA KAKADE, JOURNALISM, 2018

The exclusive feeling of launching out of our planet and into space is no longer an experience only limited to trained astronauts. Beginning in 2001, seven pioneers have successfully engaged in orbital and suborbital space flights. They're known as space tourists, and they may be at the beginning of a very profitable and exciting market appealing to adventurers who want to explore the wonders of space.

Reasons for personal space travel vary. For example, engineer and first female space tourist Anousheh Ansari conducted anemia and back pain research and also investigated the different microbes that inhabit the International Space Station (ISS). On the other hand, Richard Garriot de Cayeux used his opportunity for educational outreach to London students via amateur radio and created "space's first newspaper" for London's Metro News. Whatever the reason, space tourists, who sometimes prefer to refer to themselves as citizen space explorers, are passionate enough to endure medical screenings and months of training before launch. Most of the training entails experiencing high g-force (acceleration), high altitudes, and motion control. This is incredibly important for safety so members aboard spacecrafts don't experience G-LOC (g-induced loss of consciousness) from the incredibly high acceleration that moves blood away from the brain.

Unfortunately, the expenses for space training and the travel makes the space tourism industry restricted to the incredibly wealthy, with the Russian Space Agency setting the price for missions between 20-40 million US dollars for 8-15 day flights. Still, the idea of commercial space travel and more so the experience it provides has become increasingly popular over the years with the general public. Companies such as Zero Gravity offer weightless and Lunar/Martian gravity plane experiences for around $5,000/person.

Even Walt Disney World is appealing to riders seeking this thrill with their ride Mission: Space, exposing riders to a Mars expedition simulation at 2.5g using large spinning centrifuges. This begs the question – if space tourism became an accessible market, could we see an age where average citizens can and, more importantly, would want to pay considerable sums to experience space travel?

In a 2016 Telegraph article, experienced NASA astronaut Don Thomas gives a confident answer: yes, and it's coming soon. Private companies like Virgin Galactic are beginning to capitalize on this market, reducing ticket costs to around $250,000, though no missions have been confirmed or launched despite the $80 million they've collected in deposits. The cheaper flights will be suborbital, lasting roughly five minutes and showing the black curvature of the Earth, though not making a full revolution around the Earth.

> "The exclusive feeling of launching out of our planet and into space is no longer an experience only limited to trained astronauts."

Other companies are venturing even further, considering the possibility of "vacations in space." Russian company Orbital Technologies have plans for a small, orbiting space hotel where up to seven guests will go on a 300 km journey around Earth. The stay is expected to cost around $1 million, and the idea falls along with the futuristic plans for "Lunar Colonies" and longer, leisurely stays in space. Most recently, SpaceX announced that it's aiming to send two space tourists around the moon in 2018 – the farthest that mankind has traveled in 40 years! The creation of their space crafts has been directed by NASA, and, despite this company's difficulty meeting deadlines, their technology is ready to go. Hopefully, their passengers are prepared as well with the undoubtedly heavy price tag and potentially risky trip.

With private companies investing in commercial space travel and activities, the future looks bright for thrill seekers and researchers searching to expand their world, or rather universal, view. Perhaps soon the journey to space will be accessible and within your reach for the taking.

SENIOR TRIBUTE

BY GWENDOLYN SCHANKER, JOURNALISM AND BIOLOGY, 2018

Another year, another graduating class. Here's to these Northeastern seniors who've found time to set aside for NU Sci. We'll miss you!

KATIE HUDSON

Current President Katie Hudson, marine biology major, has been a part of NU Sci since Fall 2012. Her first issue was Issue 13, making her final issue – Issue 32 – the 20th magazine she's contributed to! During her time with NUSci, Katie has worn many hats, including writer, editor, editor-in-chief, and president. Her favorite articles have included "Oreos: Not Milk's Favorite Cookie" from Issue 17 and "Great Scott! How Back to the Future II Predicted the World We Live In" from Issue 26. After graduation, Katie will be pursuing a PhD in Oceanography from the University of Delaware. Her favorite part of NU Sci has been the people she's met as well as the opportunity to learn more about science communication. "Because of the magazine, I feel that I am better prepared to communicate my science in a more effective way," she said.

EMILY ASHBOLT

Emily Ashbolt, biomedical physics major, has been a part of NU Sci since 2013, and has been an editor since her sophomore year at Northeastern. Her favorite articles include "Would You Like a Side of GMOs With Your Burger?" from Issue 16 and her Issue 31 article on cancer physics, "Viva La Newton." She has loved being part of NU Sci because it has given her the opportunity to research cool stories and "continue writing even as my academic career seemed intent on never letting me write again." After graduation, Emily will be doing Teach for America in South Dakota, where she will be teaching high school math.

MATT DEL MASTRO

Matt Del Mastro, biology major, has been a part of NU Sci for four years, throughout which he has played concurrent roles as writer editor, treasurer, and Webmaster. Matt specializes in feature-length articles on the history of science, his favorite of which was "Discovery & Division: Scientific Controversy Through the Ages" from Issue 22. His favorite part of NU Sci was learning about new aspects of science from writers representing a variety of fields, something he hopes to continue exploring in his post-Northeastern career.

JORDYN HANOVER

Jordyn Hanover, behavioral neuroscience major, has been writing for NU Sci since Spring 2013 and has been an editor since Spring 2015. Her favorite part of working for NU Sci has been getting to know all of her great writers and editors, and of course, learning cool new things about science. Her favorite article was Issue 25's "Mad Genius: The Brilliant and Troubled Mind of John Nash." After graduation, Jordyn hopes to explore a career in managing clinical trials.

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