The Synapse: Intercollegiate science magazine

Volume 28 | Issue 1 Article 3

2021

The Synapse 28

THE SYNAPSE

INTERCOLLEGIATE SCIENCE MAGAZINE

ISSUE 28 | APRIL 2021

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Editor-in-Chief

Rebecca Fenselau (OC '22)

Rebecca Fenselau is thrilled to present the 28th issue of *The Synapse*. Covering topics ranging from medically induced comas to how COVID-19 has catalyzed the increase in hate crimes towards Asain Americans, *The Synapse* aims to make scientific information interesting and accessible to all, regardless of their background. As Editor-in-Chief, Rebecca Fenselau (OC '22) works to plan new initiatives to expand the magazine's impact and to make *The Synapse* a sustainable, impactful organization. She hopes you enjoy the final issue of this academic year and continue supporting *The Synapse* through your readership and contributions!

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Institutions of *The Synapse* Magazine

OC - Oberlin College and Conservatory
DU - Denison University
CoW - College of Wooster
CWRU - Case Western Reserve University

Featured Contributer

Holly Yelton (OC '24)

Holly is a first-year Oberlin College student from Louisville, KY. Holly loves how *The Synapse* seamlessly blends her two favorite subjects: science and art! Holly appreciates that *The Synapse* takes time to recognize the importance of art, and not just that of science. She has contributed art pieces for Issues 26-28. While her major is still undecided, Holly is considering an East Asian Studies minor. Outside of her academic life, Holly enjoys drawing, playing guitar, and baking. You can check out her art for "Dancing to Unleash Creativity" for this issue on page 26.

Featured Contributer

Sydney Rosensaft (OC '24)

Sydney is a first-year Environmental Studies major at Oberlin College. Sydney loves *The Synapse* because it is a venue for undergraduates to write about their passions in science. She has contributed to *The Synapse* as a writer and content editor since the Fall of 2020. In addition to her role as an avid contributor to *The Synapse*, she is part of Oberlin's Students for Energy Justice group, which raises awareness of environmental issues primarily in Ohio. In her free time, Sydney loves going on hikes and playing with dogs. She currently does not have plans for after college and is enjoying this time of uncertainty. The pandemic has helped her adopt a lifestyle living day-by-day. Be sure to check out her fascinating article "How Much DNA Do Identical Twins Really Share" on page 10 of this issue.

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Fireworks from Outer Space, A Gift from Betelgeuse

Understanding the Life of an Iconic Star From Astronomers' Recent Observations

Written by Sabrina Helck
Illustrated by Mahamad Salah

Have you ever looked up on a clear night and been curious about the thousands of stars twinkling in the sky? Well, maybe you do not think about it too much, but all of those stars go through life cycles, and they are each at different stages in their life. Sadly, an iconic star named Betelgeuse seems to near the end of its life after astronomers noticed it dimming.

First, let us get to know Betelgeuse. Betelgeuse, pronounced like the 1988 film, *Beetlejuice*, is the tenth brightest star in our night sky. It sits on the top left shoulder of the winter constellation, Orion. Although we can see Betelgeuse shining brightly in the sky, it is actually 642.5 light-years away, so about 385 million miles. If you were to look for it in the Orion constellation, you might notice it looks orange, unlike some other stars around it. This is because Betelgeuse belongs to the red supergiant category. Stars fit into different categories as they go through different stages during their lifetime, and supergiants are the largest stars among any of the categories. Betelgeuse itself is almost 1,000 times larger than our sun. Red supergiants also typically mark the beginning of the end of a star's life, which is the case for ten million-year-old Betelgeuse.

With the death of Betelgeuse comes an incredible celestial performance, which is why the recent observations of Betelgeuse dimming are so exciting. It raises the possibility that the star may die soon and result in a supernova!

In late 2019, astronomers noticed Betelgeuse beginning to drastically dim. This created a lot of buzz among the scientific community in hopes that we could possibly observe the death of this famous star in our lifetime. But why would seeing it die be so exciting? For most of a red supergiant's life, it uses a process called nuclear fusion to convert hydrogen to helium providing the source for the star's brightness. Nuclear fusion is the process of two nuclei from two different atoms sticking together to form a heavier element. However, once the hydrogen runs out, the countdown begins for the inevitable explosion. With a giant star, like Betelgeuse, the force of gravity is massive. This inward pull from gravity causes nuclear fusion to occur more rapidly. Helium fuses to carbon, carbon fuses to neon, and then neon to silicon. Finally, silicon fuses to iron. Once iron begins to form in that final step, the star's days are numbered. As fusion occurs, the center of the star gets denser and denser. At this point, gravity takes over, and the star collapses in on itself. When this happens, it sets off an explosion known as a supernova, and it looks spectacular.

With the death of Betelgeuse comes an incredible celestial performance, which is why the recent observations of Betelgeuse dimming are so exciting. It raises the possibility that the star may die soon and result in a supernova! Other astronomers speculate that the reason for its dimming was just a giant dust cloud, but let us stick to the more exciting hypothesis.

Some astronomers wonder whether or not it will die in our lifetime. Many believe it may take up to 100 thousand years before we see Betelgeuse go supernova, but I like to be optimistic. Let us say the star dies and explodes in our lifetime. What would this mean for us on Earth? We can compare Betelgeuse to a very large nuclear power plant; when it explodes, nearly everything within 50 light-years will be destroyed or engulfed by radiation. Do not worry, though — we will be just fine. Being almost 650 light-years away, we would just see a really cool light show. You may be thinking, "What would it look like?" and astronomers have the same question. In fact, no one really knows. This would be the first known time a star this close would go supernova in human history. Astronomers believe that when it happens, the star's brightness will increase rapidly and tremendously. At first, it would appear as bright as a thin crescent moon, then gradually get brighter and brighter to eventually appear brighter than a full moon! It would stay like this for a while and gradually dissipate, leaving an empty spot on the shoulder of Orion.

One last thing I will leave you with is that it might have already happened. But how? Did we miss it? This entire time we have been discussing "what if's," so how could it be possible that it already happened? I mentioned earlier that Betelgeuse is 642.5 light-years away. Light only travels so fast, so this means that it takes 642.5 years for Betelgeuse's light to reach Earth. When we look at the stars, we are looking into the past at events that have already happened because it takes such a long time for that information to reach us. So, when we observe the star eventually exploding, the event actually happened almost 650 years ago. The supernova may have already occurred, and now we are just waiting around to see it from Earth. So, the next time you look up at the stars, make sure to take a look at Betelgeuse, and think about the potential it has to pull off one of the most remarkable cosmic light shows that any human has seen. • • •

Where the Moon Came From

The Giant Impact Hypothesis and Other Big Ideas

Written by Eleda Fernald
Illustrated by Minh Phan

The Apollo missions are often referenced in pop culture, from movies to song lyrics (see: Denzel Curry's "Ultimate"). Famous as they are, the actual scientific goals for these missions are less commonly known - was it all about politics and ego, or was there significant scientific motivation? In fact, while many scientific objectives were overshadowed in the politics of the Space Race, the trip to the moon provided immense information to scientists investigating all sorts of questions, including how the moon was formed.

As Denzel tells us (through subtext), one of the objectives of the 1960s Apollo missions was discovering the moon's origin. The Apollo missions retrieved moon rocks that scientists studied to figure out what the moon is made of, which then gave us a clue as to how it was formed. Several hypotheses have been proposed over the years, but the giant impact hypothesis has gained the most traction over the last few decades. Some researchers have challenged this model in recent years, and scientific debate on the validity of the giant impact hypothesis is ongoing.

The giant impact hypothesis was first presented in August 1974 by Donald R. Davis and William K. Hartmann. This version of the model proposes that as Earth was growing, other smaller objects that ranged from the size of our moon to the size of Mars were also gradually forming. These objects would have crashed into the still-growing Earth, or proto-Earth. Researchers realized that a large enough object might be able to blast part of the Earth's outer layer, called the mantle, out of the Earth and into its atmosphere. That material, combined with the shattered remnants of the colliding object, would then form rings around the Earth in its orbit, and eventually aggregate to form a moon. Since the Earth's iron was all safely kept in its core, the collision would leave the iron untouched, explaining the moon's lack of the metal. When the giant impact hypothesis was first presented, however, scientists had not agreed that the Earth's iron core would have finished forming in the core by the time of the collision. Simultaneously, researchers Cameron and Ward were exploring the same question using a different approach, investigating angular momentum constraints. Their findings supported this model, specifying that the original colliding body could have been as large as Mars. Ten years later, at a conference in Hawaii, several lunar origin hypotheses were presented, and the giant impact hypothesis secured its place as the strongest proposal, spurring further research.

That material, combined with the shattered remnants of the colliding object, could then form rings around the Earth in its orbit, and eventually collect together to form a moon.

New proposals have challenged this hypothesis, claiming that if the moon was composed of material from the proto-Earth and this large outside body, then the moon's composition should differ more significantly from that of the Earth. Objects from different parts of the solar system have different ratios of oxygen isotopes — oxygen molecules with differing numbers of neutrons. Since the impacting object came from a different part of the solar system, researchers suggest that it should have a different oxygen isotope ratio from that of the Earth's material. It follows that the moon, which the giant impact hypothesis predicts is composed of both material from the impacting object and the Earth, should contain some 'alien' isotopes not found on Earth. However, the moon and the Earth have extremely similar oxygen isotope ratios. This similar composition, which was originally used as evidence that the moon was partly composed of Earth material, is now used as an argument against the giant impact hypothesis.

This proposal is based on theoretical modeling, but not experimental observations. In 2014, for instance, researchers observed small differences in oxygen isotopes between the Earth, moon, and some meteorites, and claimed that this discovery supported the giant impact hypothesis. They suggested that the impactor may have formed in the same area as the Earth and Mars, which would explain the similar compositions.

Before the giant impact model entered the scene, there were a few leading hypotheses that have some weaknesses. The co-accretion hypothesis suggests that the moon and the Earth grew at the same time, in the same place. However, this seems unlikely, as the moon does not have an iron core like the Earth does. If the moon and Earth really grew together, one would expect their composition to be very similar. The moon's lack of an iron core represents a big enough difference in composition to undermine this hypothesis. Likewise, the capture hypothesis suggests that the moon was passing by the Earth, fully formed, when it got caught in Earth's orbit. This also looks improbable, considering the moon contains so many isotopes similar to those found on Earth.

Researchers continue to develop their understanding of how giant impactors evolve and how celestial objects develop. That's why it is so important to continue investigating what this new understanding means for claims that objects that collided with the proto-Earth must have come from regions with completely different isotopes. With this progress, we can continue on with our ultimate purpose of enjoying astronomically-referential song lyrics.


CRASH
LANDING
ON YOU

Perseverance Rover's Goals:

1. Determine whether life on Mars ever existed by searching for indicators of ancient microbial life.

2. Characterize Mars's current and past climate, and discover what caused its climate to change over time.

3. Characterize Mars's geology, including collecting and documenting samples to be returned to Earth in a future mission.

4. Gather knowledge about the viability of human expeditions to Mars, primarily through experimenting with the instruments on Perseverance.

The Power of Perseverance

Mars's Newest Resident Has Arrived

Written by Megan McLaughlin
Illustrated by Averly Sheltraw

February 18, 2021 was a big day. At 3:55 p.m. EST, NASA mission control confirmed that the Perseverance rover had safely touched down on Mars, becoming the planet's newest resident. Perseverance is a part of NASA's Mars Exploration Program, a long-term mission to explore its climate, geology, signs of ancient microbial life, as well as to test the technology in preparation for human exploration.

Perseverance was built at the NASA Jet Propulsion Laboratory in California, the United States (U.S.). It is the largest Mars rover NASA has ever built, weighing 2,260 pounds (1,025 kilograms). The path to constructing and launching Perseverance was a long one. The Perseverance mission was first announced in December 2012, just a few months after the Curiosity rover's successful landing on Mars. After the announcement, NASA scientists thoroughly considered variables such as mission priorities, landing sites, and which instruments would be critical to the achievement of the mission objectives. These decisions were part of the pre-launch phase, as well as were assembling the rover in a contaminant-free environment, transporting the rover from California to Florida, and performing tests before the launch.

After the pre-launch phase came the launch, cruise, arrival, and surface operations. Perseverance launched at 7:50 a.m. EDT on July 30 from the Cape Canaveral Air Force Station in Florida and traveled 309 million miles (497 million kilometers) over the course of 213 days to reach its final destination, the Jezero Crater on Mars.

Perseverance's primary objective is to find signs of microbial life. Scientists believe that 3.5 million years ago, Jezero Crater was a lake that spanned 28 miles (45 kilometers). The crater is home to one of the best-preserved delta deposits on Mars. These deposits have clear inflow and outflow channels, which indicate that the crater undoubtedly held water a long time ago. Therefore, NASA Scientists anticipated that the Jezero Crater — especially the river delta area — had a high potential for containing ancient microbial life.

While Perseverance's landing in the Jezero Crater facilitates scientists' search for ancient microbial life, the scientific aspirations do not stop there. Perseverance is equipped with seven instruments, twenty-three cameras, and two microphones that all serve different purposes in helping the rover pursue her goals. Some of these instruments include Mars Environmental Dynamics Analyzer (MEDA), which monitors the weather and dust level on the surface of Mars, and Radar Imager for Mars's Subsurface Experiment (RIMFAX), which uses radar to see geologic features under the surface of Mars. Further, it contains Planetary Instrument for X-ray Lithochemistry (PIXL), which has a tiny X-ray tool that can identify the chemical makeup of rocks, and Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE), which produces oxygen from Mars's carbon dioxide-rich atmosphere.

MOXIE is a particularly trailblazing instrument that has significant implications for the future of Mars missions. MOXIE converts carbon dioxide, a resource that makes up about 96 percent of Mars's atmosphere, into oxygen, which is required to launch rockets. MOXIE will demonstrate whether or not rockets can be launched from Mars in the future. If successful, MOXIE would return caches of rocks and deposits that Perseverance will harvest to Earth for future study. Future reworking of MOXIE could also be used to launch astronauts back to Earth from Mars and help with breathing technology. Right now, MOXIE can produce only 0.022 pounds (10 grams) of oxygen per hour — nowhere near close to the tens of metric tons it would take to launch rockets off of Mars. Future MOXIE revisions would need to be built at least 100 times bigger.

Also aboard Perseverance is Ingenuity, a four-pound (1.8 kilograms) helicopter that will make history as the first attempt at powered flight on another planet. Unlike the many instruments that make up Perseverance, Ingenuity is an autonomous aircraft that is not designed to aid Perseverance with its goals for the Mars 2020 missions. Instead, Ingenuity is a project focused on technological innovation; how Ingenuity performs on Mars will determine if robotic scouts are a promising option for future Mars missions. Ingenuity is merely a technological demonstration to see if a powered flight on another planet is viable, but if Ingenuity is successful, future helicopters might offer scientists a new perspective that rovers and orbiters are unable to provide.

Perseverance's anticipated mission duration is at least one Earth year. In that time, Perseverance will collect samples of rocks, specially selected by the rover's instruments, to store in caches in the hopes that they may be returned to Earth in a later mission. Perseverance makes history by being the first rover to collect samples that are intended to be brought back to Earth.

Perseverance builds on the legacy of her predecessors. Spacecrafts have increasingly become more technologically advanced and increasingly more capable of making discoveries—especially ones that point to possibilities of microbial life on Mars. For now, Perseverance's primary objective is to find out whether or not there truly is life on Mars. As @NASAPersevere posted on Twitter on February 18, "Perseverance will get you anywhere."

How Much DNA Do Identical Twins Really Share?

Effects on the Study of Psychiatric Disorders

Written by Sydney Rosensaft
Illustrated by Charlie Maddox

Did you know that identical twins are not actually identical? In a study of 381 sets of identical twins, only 38 had the exact same genes. There were more than 23 thousand possible postzygotic mutations discovered that can exist in identical twins, with a median of 14 per pair. Sure, identical twins are more similar than fraternal twins, but they differ greatly from each other. Differences in twin interests and identity are often attributed to environmental influences, but underlying genetic variations suggest that genes play a big role as well. Recent studies have found that identical twins' deoxyribonucleic acid (DNA) are very different, even from birth. These variations lead to significant life distinctions, including serious psychotic illnesses, and impact the reliability of twin studies.

For a long time, it was widely assumed that identical twins share the exact same DNA because they originate from the same fertilized egg. Once an egg is fertilized, it grows to a zygote. The zygote then enters the embryo stage, which is when it splits and develops two organisms, two twins. Since these twins are from the same zygote, they are known as monozygotic twins. On the other hand, fraternal twins originate from two separate fertilized eggs and are known as dizygotic twins. Dizygotic twins share no more DNA than regular siblings.

However, monozygotic twins' shared egg does not mean they have identical genetic information. The differences between monozygotic twins are apparent as soon as the splitting of the embryo begins. If the embryo does not split evenly, one twin may end up with more genetic material than the other. The more uneven the split, the greater the difference in genes, leading to more developmental differences in the twins. In a study of monozygotic triplets, gene mutations were generally only shared between two of the triplets, showing that those two individuals developed from slightly different cells than the third triplet. Once the twin's separate egg begins dividing and developing, genes mutate and lead to physical discrepancies. Sometimes the mutations lead to minor differences like differing eye or hair colors. Yet, depending on how many genes mutate, identical twins sometimes develop different skin tones, which can be shocking for parents who are told their children are supposed to look alike.

If the embryo does not split evenly, one twin may end up with more genetic material than the other.

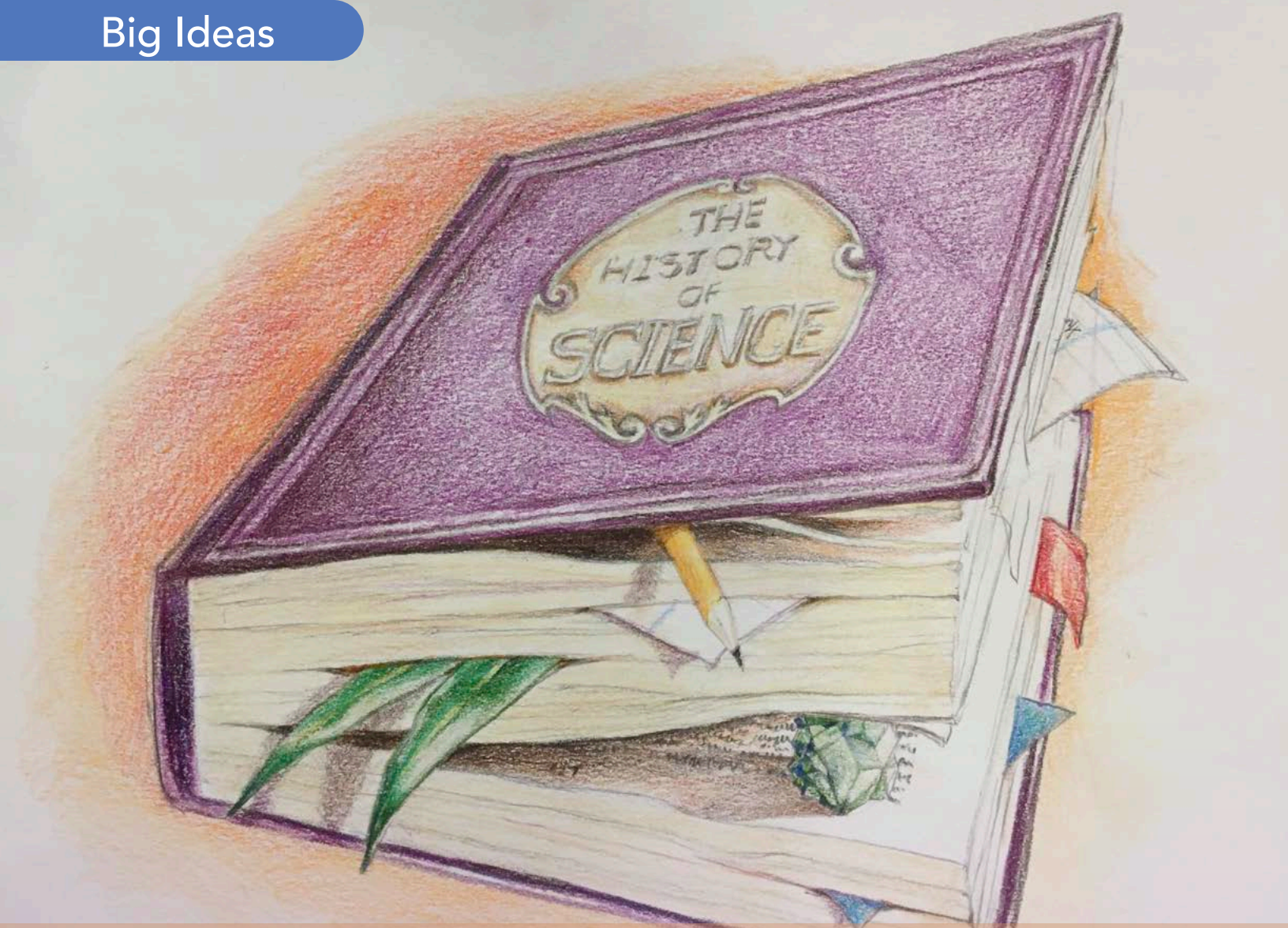
One of the most significant twin discrepancies that can come from mutations is the varying risk levels of developing psychological disorders. While environmental factors do affect the development of psychiatric disorders in twins, scientists are realizing that genes play a bigger role in developing neurological disorders than previously believed. Identical twins live in similar environments and are often treated the same, so their differences are strongly attributed to genes. Genes influence how people interact with and shape their environment, which, in turn, can change how likely someone will develop a disorder. Two common disorders that develop in only one twin are schizophrenia and autism spectrum disorder (ASD).

When it comes to schizophrenia, only 48 percent of identical twins share a diagnosis. If one identical twin is diagnosed with schizophrenia, the other twin has only a 30 to 50 percent chance of developing the same disorder. Interestingly, when twins do both have a schizophrenia diagnosis, they have very similar symptom profiles.

In the case of ASD, the disorder is further complicated because there is not just one type of symptom, cause, or gene. Until recently, these differences in twin disorder diagnoses were thought to be due entirely to the environment. Typically, environmental factors have a huge influence on the development of ASD. However, research in twins shows that a shared environment had little impact on twins' likelihood of developing severe autism. Instead, it was mainly their genes. Therefore, twin DNA differences are more evident in severe cases of ASD, where the relevant genes can be more easily identified. These findings have both negative and positive implications.

On the negative side, acknowledging that twins are not truly identical means that twin studies are less reliable than previously thought. The basis of twin studies is the belief that, since twins have identical DNA, environmental effects can be isolated and studied. However, if twins do not truly share DNA, the basis of these studies is disproved, thereby creating questions about findings from past twin studies. Twin studies have been the gold standard in psychiatric disorder research, so this revelation poses a significant scientific challenge.

Luckily, there is an upside to discovering that different twin diagnoses are due to genetic variations: scientists can learn more about the genetic origins of psychiatric disorders. Many disorders originate in regions of genes called "copy number variants" (CNVs) Whereas most genes in a person exist only in two copies, CNVs can have zero to 14 possible copies. In identical twins, it is easier to trace the differing regions because there is less variance in overall genetic information than there would be in dizygotic twins or regular siblings. This understanding opens up a new pathway for research: using slight genetic differences in twins to learn more about psychiatric disorders. Although traditional twin studies that are thought to isolate environmental effects may not be reliable anymore, new studies that uncover the origins of psychiatric disorders now have the opportunity to flourish. • • •



The Case for Learning History in Science Class

How Historical Context Shapes Scientific Discovery

Written by Mia Formato
Illustrated by Josephine Brane-Wright

Every science, technology, engineering, and math (STEM) student has a unique reason for studying science. An environmental engineering student may feel they need to help stop climate change. A nursing student may have a strong desire to help people. An astronomy major could have a lifelong passion for studying space and sci-fi. In college, many of us discover what we are most passionate about, what causes we want to fight for, or what problems we want to solve. Our undergraduate education sharpens our original reasons for going into STEM and into a purposeful future career.

This happens in college STEM courses which heavily emphasize the role of the individual in science. They bombard us with names of historical heavyweights: we all know Isaac Newton, for example. Chemistry majors will recognize the name Willard Gibbs. And any biology student could tell you who Reiji Okazaki was. Yet, rarely are we taught any scientific history beyond these names. Our classes stress the importance of these individual contributions to science, so as students learn the material, we also learn how to lead scientific investigations. We are taught that our own motivations for becoming scientists are paramount, second only to the discoveries we will one day make, the Nobel prizes we will win, the lives we will save, or the technology we will invent.

However, there is more to scientific history than just the scientists themselves. For example, consider penicillin, the first antibiotic. It is often remembered in tandem with the names of the men who discovered it: Alexander Fleming, Howard Florey, and

Ernst Boris Chain, among others. Fleming first identified penicillin in 1928 and Florey, Chain, and their team purified it in 1940. In 1945, these men collectively won a Nobel Prize for their work. By March of that same year, penicillin became available to the general public in the United States, and the rest of the world followed. This marked a monumental turning point in human history. The age of antibiotics had begun.

So why did the antibiotic age begin in 1945 when penicillin was discovered in 1928? One answer is that research takes time. Fleming was interested in studying the Penicillium molds that produced penicillin, which was how he made his discovery. Florey's team tackled the difficult task of purifying and testing its therapeutic capabilities. By 1940, their hard work paid off, and two years later, they cured streptococcal meningitis with an antibiotic for the very first time. The years spent developing penicillin is not unusual. Science is a waiting game. Experiments take time to devise, set up, and perfect.

But science is also a money game. Research of any kind requires funding. Florey's lab at the University of Oxford was only able to produce small amounts of pure penicillin. They could not mass-produce it on their own. Initially, the British government was uninterested in funding the project, so Florey's team turned to the United States. Through cooperation with the United States Department of Agriculture (USDA) and multiple American pharmaceutical companies, penicillin was finally mass-produced.

Yet truly understanding why events unfolded this way needs even more context, specifically World War II. If soldiers had not been dying in droves from battle wound infections, there would not have been the same urgency surrounding penicillin's mass production. Without the war, the American military-industrial complex that made such an effort possible so quickly would not have existed either. Penicillin still would have been discovered, purified, and shown to be effective, but without World War II, the arrival of the antibiotic age could have been delayed by decades.

Science doesn't depend on our personal contributions alone, or possibly at all, in the grand scheme of things. How it's perceived by societal institutions is much more important to determining what discoveries are made, make a difference, and make history.

It feels bizarre to associate war with science. Ask someone why we have antibiotics, and they might say, "because Alexander Fleming discovered penicillin in 1928," "penicillin was invented in 1945," or something along those lines. A less likely but arguably more well-rounded answer is because penicillin's discovery coincided with a world war, meaning governments and corporations around the world took special interest in making it widely available. Of course, penicillin's success still required the hard work and brilliance of Fleming, Florey, Chain, and the other Oxford scientists. Their dedication to their work and personal motivations are part of the story. But, like penicillin's origin is more than just the names on its Nobel prize, science in general is much bigger than just scientists.

Social circumstance continues to influence science. Take, for instance, the coronavirus disease 2019 (COVID-19) vaccine. Research into novel vaccines, coronaviruses, infectious disease spread, and other similar topics are now at the forefront of everyone's mind. Funding is also more accessible than ever. For example, Dr. Angelica Campos, a virologist at the University of São Paulo, studies how viruses like the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) emerge from bats in the Amazon rainforest. "It's extremely difficult to get funding for our kind of research," she said in an interview, "now during the pandemic, it has been a little easier. But as soon as the virus crisis is over, our financial worries will return." Like with the Oxford scientists, these researchers and their expertise are very important. However, superseding them are the institutions that determine science's role in society. It is these government agencies, corporations, and people leading them that ultimately decide what science is important and what research should get funded.

To prevent another pandemic, research like that of the University of São Paulo must continue to be supported after this temporary surge in interest. Unfortunately, that is not really under the control of the scientists. They also cannot control how their research is used once published, should it be used or even funded at all. These decisions are made by companies, politicians, and everyday people.

Scientists across all disciplines understand this aspect of their work, as it is a constant reality for them. They know it is important to understand the role their work plays in the bigger picture. For example, academic researchers must be able to articulate the precise argument needed to write successful grant proposals in order to get funding. But writing a stellar proposal does not guarantee a grant. Scientists cannot always rely on others to understand the importance of their work and support it like they do, not even those researching viral transmission in the middle of a viral pandemic. Unfortunately, too much depends on factors beyond their control.

Despite the instrumental role all of these factors play in scientific research, they are rarely discussed in undergraduate classes. Our undergraduate courses provide us with the knowledge we will tap for later discoveries to learn how to become scientists. However, they do not prepare us for what it is like to be a scientist. This may send us into our futures with a misunderstanding of what is important. Science does not depend on our personal contributions alone. How the research is perceived by societal institutions and the general public is much more important in determining what discoveries are made.

In order to understand who and what will shape our future as researchers, academics, engineers, doctors, technicians, pharmacologists, and more, we need to understand the importance of the science we do beyond ourselves. This knowledge comes with experience and time. But the seed can be planted by teaching students more about science's role in society. Learning scientific history along with scientific knowledge will raise a new generation of scientists who not only have talent, skills, and purpose, but thoughtfulness and perspective. As we amass centuries of knowledge of the natural world through our classes and professors, we can amass centuries of life experience by studying a bit of history too. • • •

CONTENT WARNING: Non-graphic discussion of violence, racism, suicide, depression, and anxiety

Perpetual Foreigners in America

COVID-19 and the Rise of Hate Crimes and Racism Toward Asian Americans

Written by Eunice Kim
Illustrated by Joana Kyle

Since the beginning of the coronavirus disease 2019 (COVID-19) pandemic, hate crimes against Asian Americans have been steadily on the rise. Over a three-month timespan between March and June 2020, more than 2,100 anti-Asian hate incidents related to COVID-19 were reported across the country. Within the past couple of months, there has been a sharp increase in attacks that threaten the safety and mental health of Asian Americans. These hate crimes range from verbal assaults to physical acts of violence. In San Francisco, an 84-year-old Thai man died after being violently shoved to the ground during his morning walk. These cases of forcefully shoving Asian seniors to pavements have become increasingly common, causing seniors to fear for their lives. Another incident under investigation is an attempted murder of a Burmese American family at a Sam's Club in Texas. The suspect who stabbed the family stated he "thought the family was Chinese, and infecting people with coronavirus." These hate crimes are indicative of long-standing negative perceptions of Asian Americans that are prevalent in American society. Now, Asian Americans are not only burdened by the risk of COVID-19, but they are also vulnerable to stigmatization and victimization of hate crimes occurring regularly. This article will provide a brief overview of the foreigner label placed on Asian Americans as well as the impacts that racial discrimination and hate crimes have on their physical and mental health.

Asian Americans and COVID-19: Both Viewed as Foreigners in America

As COVID-19 spread around the globe and throughout the United States, the virus was coupled with xenophobic labels such as "China Virus," "Kung Flu," paired with other racist remarks from politicians and other influential figures. These factors led to the large surge of hate crimes against Asian Americans. Through this type of rhetoric and violence, the perception that COVID-19 is bound to Asian bodies regardless of national origin, race, or ethnicity became normalized. Through the portrayal of news media and politicians, COVID-19 is viewed as foreign and "other." Similarly, Asian Americans are viewed as "other" and as perpetual foreigners, a stereotype where individuals with Asian ethnic appearances are directly associated with foreignness regardless of generational status. This racial categorization that any Asian-looking individual is perceived as Chinese, Asian, and foreign puts all Asian Americans at risk. These hate crimes and anti-Asian rhetoric also have deep historical roots. In the late 19th to mid-20th century, the portrayal of Asian Americans as the "Yellow Peril" was heavily popularized through news media and pop culture. The "Yellow Peril" represented the fear of uncivilized Asian invasion and domination. These long-standing discriminatory views are resurfacing in the time of the pandemic as many non-Asian Americans are looking for someone or something to blame for the current fear, anger, illness, and economic hardships.

Hate Crimes and Racism Toward Asian Americans Significantly Impact Physical and Mental Health

Recently, Asian Americans have been experiencing increased levels of stress and anxiety from not only these uncertain times but also from racial discrimination as well as fear for their safety. Under stress, the body works to adjust to these stressors and maintain homeostasis through a process known as allostasis. Allostasis activates a fight-or-flight response as a means to respond to the perceived threat. When the fight-or-flight response is activated, the sympathetic nervous system is also activated. As a result, blood pressure and heart rate increase, and hormones like adrenaline and norepinephrine flood into the bloodstream to provide quick energy. Typically, this hypervigilant mode is only active for a few minutes, but under chronic, prolonged stress that comes from racial discrimination and anxiety, the sympathetic nervous system is continually active. Studies have shown that racial discrimination and anxiety increase inflammation and decrease the body's immune response. Under prolonged stress, the sympathetic nervous system activates pro-inflammatory processes resulting in a high allostatic load. Allostatic load describes the damage and overtaxation of the body's regulatory system due to persistent stress. These race-based traumatic stresses can result in acute stress disorder and post-traumatic stress disorder, which are disorders that arise from real or perceived racial discrimination. As minority groups regularly experience racial biases, they can go into a chronic state of "racial battle fatigue."

Not only does stress impact the physical body, but it also heavily impacts an individual's mental health. Even before the pandemic, research has shown that Asian Americans are the least likely to seek mental health services due to factors ranging from cultural beliefs to social stigma. Dangerous and misleading racial stereotypes such as the model minority further exacerbate the situation. The model minority is a term often applied to Asian Americans who are praised for their successes across economic, academic, and various other sectors. However, when the group's successes cross the acceptable threshold, Asian Americans are met with hate crimes and racism. The term is often used to contrast the achievements of other racial groups and pit Asian Americans against other people of color. With increasing anti-Asian sentiments due to COVID-19, Asian Americans are alienated through the politicization of the pandemic. The impacts of this scapegoating can have long-lasting and severe consequences such as heightening suicidal thoughts, depression, and anxiety.

Conclusion

Disease does not differentiate between citizenship, race, or ethnicity. Yet, Asian Americans have suffered discrimination, prejudice, and disease scapegoating during the COVID-19 pandemic. The rise in Asian American hate crimes due to COVID-19 and the recent Black Lives Matter movement draws attention to ongoing racial issues and provides a means in which to challenge the notion of America as a post-racial society. During this time, close introspection and reflection on our biases and beliefs are necessary steps to combat racism and create a safer society for all people. • • •

Big Red's Feathered Friends

On the Delicate Ecosystem Hidden Right Above Our Heads

Written by Marco Balic
Illustrated by Mia Formato

Denison University is teeming with life. Even during the pandemic, the majority of students can be found on campus, power-walking from building to building. As humans go about their businesses during the day, the "Denison Venison" frolics across roads at dusk and maybe a skunk or racoon rummages through toppled trash at night. However, there is a particular group of animals that are in attendance all day and night, facing dangers that many of us humans do not even think about.

Birds are majestic — but ultimately delicate — creatures. Careful observations can reveal the diversity of Denison's bird population to even the most amateur of birdwatchers in Granville Ohio. Such observations can unearth how fragile the relationship between humans and birds can really be, with the former often causing immense harm to the latter.

In 2018, an article was released by The Denisonian, Denison University's student-led newspaper, describing a noticeable decline in the presence of previously-common vultures. The turkey vulture, in particular, holds great significance as the unofficial mascot of Denison University, nicknamed "Big Red.". The turkey vulture is known for having an incredibly strong sense of smell, used to help locate rotting corpses. It is a scavenger at heart, like the lesser-known black vulture, which tends to follow the turkey vulture in search of food. The easiest way to distinguish between the two species lies in the underside of their wings: turkey vultures display mostly pale feathers, while black vultures are pitch-black with white wingtips. At Denison, both species are ubiquitous — at least, until now.

Before the vultures' disappearance, the immense flocks of corpse-eating birds were causing major damage to the roofs and heating, ventilation, and air conditioning (HVAC) systems of the buildings they roosted upon. Fixing the repeating damage was not cheap, so Denison administrators partnered with the United States Department of Agriculture (USDA) to disperse the vultures from the village of Granville altogether. All of the tactics used were harmless to the birds. One such method was pyrotechnics — repeated use of noisemakers at sunset. Pyrotechnics intended to get vultures to leave the treetops behind Swasey Chapel before they could fall asleep. This program has proven safe and effective, with the firework-like noises becoming a familiar sound for students attending in the Fall. However, what if there are collateral effects to scaring Big Red's mascots away?

Despite their bad public image, vultures are vital to ecosystems across the world. Their unique adaptations make them incredibly effective at their job as nature's janitor. For example, their stomach acid has a pH of one to two. The acidity annihilates much of the microbes in the carcasses they consume, thereby reducing the chances of diseases spreading in their local environment. Unfortunately, about 60% of vulture species across the globe face the threat of extinction. A study from 2011 covered the topic of massive population declines in vultures found in Asia and Africa — primarily due to poison entering the environment or due to poaching. This trend correlated with an increase in decay time of carcasses and a growing number of feral dogs and rats acting as disease-carrying scavengers. Thus, leaving vultures unprotected can lead to serious health and economic issues. So, what about the ecosystem in and around Denison? While the USDA-approved deterrence methods have had a visible effect in the Granville area, they simply keep vultures from making the place their permanent residence. They can still be seen flying overhead, searching for food. Thanks to the legal protections surrounding vultures (as well as many of the birds of North America), these unsung heroes are here to stay.

> Birds fly head-first into window-covered buildings for multiple reasons, such as mistaking their own reflection for a competitor invading their territory or being attracted to the light emitted from indoor lamps just beyond the transparent panes.

Vultures are not the only birds frightened by the USDA's noise-making fireworks. In the fall, hawks also flee due to the noise. Subsequently, the prey of these majestic birds visits campus more often than Denisonians expected. The red-tailed hawk, one of the largest and most common hawks in the United States (U.S.), is one notable example. Red-tailed hawks are found perched by themselves — perhaps on a tree by the steps that lead up from downtown Granville, or on top of a lamppost behind the athletic center. They swivel their heads like a gimbal, their piercing gaze searching for small mammals to consume. The most perceptive observers may get a chance to see a red-tailed hawk settle in for the night on campus. However, Denison's campus is just an occasional hunting ground for them. The lofty perches are great vantage points for hawks who are hungry enough to ignore the presence of humans. Thus, even with occasional evening noisemakers in the Fall semester, it is safe to say that these pest-controlling birds of prey are unlikely to permanently leave campus.

If vultures feel like an eyesore, Denison University still offers plenty of beauty to behold. Swasey Chapel, for instance, serves as the school's primary landmark. The towering steeple watches over Granville and draws the attention of campus visitors. Pigeons are also attracted to the building, roosting together below the spire. There are other buildings on campus, though, that pose

a much more fatal attraction for birds. The end of summer spells the beginning of countless birds' migration to the south of the United States. Among them are Ruby-Throated Hummingbirds and American Goldfinches; the former journeys across the southern U.S. and over the Gulf of Mexico, while the latter rarely ventures south of the U.S. border. Unfortunately, the dead bodies of these species can be seen on the academic quad of campus, particularly during September when their migrations are just starting. Whether on a set of stairs by the Talbot Hall of Biological Sciences, or under the bridge between Burton-Morgan and Knapp Hall, corpses have appeared near immense arrays of windows. This is unlikely to be a coincidence. A study from 2014 set the upper bound for annual bird fatalities due to building collisions at nearly one billion. Birds fly head-first into window-covered buildings for multiple reasons, such as mistaking their own reflection for a competitor invading their territory or being attracted to the light emitted from indoor lamps just beyond the transparent panes. Window collisions can instantly render a bird dead, or induce long-term brain damage. Either way, these accidents are more often fatal than not.

These are not the only major killers of birds. Free-roaming domestic cats — introduced into the environment by humans — prey upon as many as four billion birds every year. An additional 64 million birds die due to power lines, whether by collision or electrocution. In fact, a relatively recent report shared a terrifying result: the avian population of North America is at about two-thirds of the abundance it had in 1970. This steep decline will not stop unless humans do something. From adding decals to sunroom windows to reduce collisions, or keeping pets indoors when young fledglings in the backyard have just left their nest, there are many small-scale ways for people to help the U.S.'s avian population stay strong. Even if birds cause problems for humans sometimes, there are safe and legal solutions that keep their well-being in mind. For example, Denison University deterred the vultures that were damaging its buildings with the help of a government agency.

The balance in any given ecosystem is fragile. Denison University is no exception. Birds are delicate and majestic creatures, and they are an integral part of the gorgeous campus. From Ohio's handsome state bird, the Northern Cardinal, to Big Red's bald-headed mascots, to rare birds passing by during migration — opportunities to appreciate birds are abundant at Denison. This makes it a great place for students to try out birding. Students at Denison University are truly lucky to have such a rich avian population — but it is up to each individual to see this for themselves, and realize just how delicate the balance between humans and nature can be. • • •

More Attractive Than You Think:

The Discovery of Magnetic Fields Generated by Venus Fly Traps

Written by Isabelle Small
Illustrated by Olivia O'Brien

Venus flytraps have captivated children, fans of science fiction, and plant enthusiasts for decades. These tropical plants subvert our ideas about vegetative characteristics with their carnivorous diets and movable "jaws." In January 2021, researchers at Johannes Gutenberg University Mainz in Berlin discovered that Venus flytraps produce a detectable magnetic field. The generation of a magnetic field by electrical signals, also called biomagnetism, has been studied widely in humans and animals but, until now, had only been identified in two other plants. Anne Fabricant, the lead researcher, explains that "wherever there is electrical activity, there should also be magnetic activity." However, Fabricant reports "that the magnetic signals in plants are very weak, which explains why it was extremely difficult to measure them with the help of older technologies." So, while the discovery of the magnetic field itself was relatively expected, actually being able to measure the field was momentous.

The Venus flytrap is able to sense the presence of its prey in its trap through mechanical receptors in the form of small hairs on the inside surfaces of their lobed leaves. These receptors are activated once touched by prey. While plants lack a nervous system, they can send signals from one part of the plant to the other. These signals travel in the form of an action potential, a rapid change in charge across a membrane, creating an electric shock that propagates from one cell to another. The change in charge occurs when positive ions accumulate on the outside of a membrane and quickly cross over through a protein channel, rapidly making the negative internal charge more positive. Through action potentials, plants and animals are able to rapidly send messages to other parts of the organism when a stimulus (either good or bad), has been detected. These electric shocks become a flow of electricity that moves throughout the organism, albeit a very small one. Like electric forces, magnetic forces are reliant on charged molecules interacting with one another with attractive and repelling forces. Due to this relationship, they are very interconnected. A magnet in motion can generate electricity, and conversely, an electrical flow can create a magnetic field. In animals and plants, their action potentials create small magnetic fields.

> In January 2021, researchers at Johannes Gutenberg University Mainz in Berlin discovered that Venus flytraps produce a detectable magnetic field.

The researchers at Johannes Gutenberg University Mainz were able to trigger action potentials in the Venus flytraps with heat transmitted through surface-voltage electrodes. These electrodes were clamped to one of the flytraps' lobes, and the temperature was increased from 20° to 45°. As the electric action potential flowed through the Venus flytraps, the researchers were able to detect the magnetic field using glass sensors filled with a vapor of atoms whose electron energy levels are modified by magnetic fields. The development of these sensors, called atomic magnetometers, was historic. While magnetic fields have been detected in plants before, they were measured by superconducting-quantum-interference-device (SQUID) magnetometers, which are incredibly hard to use given that they are large and require extremely low temperatures. The atomic magnetometers are a lot more convenient than SQUID magnetometers because they are able to work at room temperature and can be miniaturized for easy portability. Additionally, the techniques developed by the Johannes Gutenberg University Mainz researchers are non-invasive and therefore can detect these changes in the plant without piercing the leaf and triggering other action potentials.

The researchers are currently focused on using their technique to measure smaller magnetic fields in other plants. However, their findings "give some hints about how electric currents are distributed in the trap" says Fabricant, and could be applied to discovering more about intercellular communication in plants. Without a central nervous system or "brain" headquarters, many aspects of these signals in plants remain a mystery. Tracking these signals with the help of atomic magnetometers can help start to answer some of these questions. Additionally, their findings can be used in non-scientific industries. We know that when plants sense a threat, they relay this information through signals that are picked up by cells, which generate a response. This knowledge that plants generate electromagnetic signals in times of stress can be used to track the health of crops. Measuring these fields and the changes in them in an easy and non-invasive fashion could be incredibly helpful in monitoring the crops' response to temperature changes, pests, or chemicals. In industrial agriculture, being able to detect that a section of your crops is being harmed through changes in its electromagnetic fields has the potential to save immense amounts of food and water waste.

Venus flytraps have defied our expectations for years with their simultaneous animal-like and plant-like characteristics. But their importance in connecting our knowledge of intercellular communication between the animal and plant kingdoms is even greater than we thought. The researchers from Johannes Gutenberg University Mainz developed a technique to accurately and easily measure the mechanical fields of plants in a non-invasive way. Investigating life at the cellular level not only contributes to the collective scientific knowledge, but also provides information that may alter policies to improve well-being on a larger scale. The detection of magnetic fields in Venus flytraps is only the first step towards learning more about the microscopic systems that regulate our everyday life, and is a springboard for that insight to inform our actions in the future.


ANIMAL
(PROTEIN)
VS
PLANT
(PROTEIN)

Battle for "Healthiest Protein"

Animal versus Plant Protein

Written by Anna Slebonick
Illustrated by Danny Valero

Everyone gushes over the alleged powers of protein: doctors, athletic trainers, and even scientists. They say, "it's good for you" and that "it will make you stronger." However, different sources of protein and their respective nutritional values are discussed less frequently. Perhaps animal protein is the best source, since animal meat is more likely than plant-based protein to contain all nine essential amino acids. However, not all proteins affect our bodies in the same way. Researchers have discovered stark differences between animal protein and plant protein. While vegetarians and vegans deal with common misconceptions about their plant-based diet, they may be avoiding certain health outcomes that meat-eaters could be subject to. At the same time, animal protein may have more nutritional value than plant protein.

The nutritional content of protein can be dissected into various components. The Protein Digestibility Corrected Amino Acid Score (PDCAAS) assesses the quality of a protein source based on its digestibility and essential amino acid composition. A protein receives a higher score when it is highly digestible and contains all the essential amino acids. Animal proteins have a high PDCAAS, typically between 90 and 100, due to their high digestibility and amino acid content. Some plant proteins score just as highly as animal proteins, but as a whole category, plant proteins tend to have lower digestibility and fewer amino acid types. For example, whey protein, which is derived from cheese, has a PDCAAS score of 100, while peanuts have a score of just 52. Thus, in terms of digestibility and amino acid content, animal protein beats plant protein.

> Researchers have discovered that animal protein can impact our bodies differently than plant protein.

In addition to digestibility, the specific amino acids in the protein determine the beneficial properties of protein. For instance, the essential amino acid leucine may play a significant role in promoting muscle gain and during the post-exercise recovery period. In a study by Banzenek and collegues, participants performed resistance training for eight weeks and consumed either pea or whey protein. At the end of the eight weeks, the muscle composition did not vary between the pea or whey protein-consuming groups. The researchers noted that pea and whey protein have similar leucine contents. In comparison, a study by Volek et al. "demonstrated that the lean body mass gain in young men was 45% lower after consumption of 20 g of soy protein isolate compared to whey protein concentrate during a 36 week period of resistance exercise training." Interestingly, soy protein isolate and whey protein both score 100 on the PDCAAS. Volek and collegues did note that whey protein is higher in leucine content. Banzenek et al.'s study showed that two proteins with similar leucine content had similar effects on muscle synthesis, while the study by Volek showed two proteins with different leucine contents have significantly different effects on muscle synthesis. These two studies suggest leucine content may serve as a better indicator than solely the PDCAAS in choosing the "best" protein specific to muscle synthesis. Since whey has the highest leucine content and builds and repairs muscle tissue in the most efficient manner, animal protein wins again.

While animal protein's nutritional value has a good reputation, its health outcomes do not. A study by Chavarro and collegues investigated the effects of animal and plant protein intake on ovulatory infertility in women. The study found that switching five percent of carbohydrate intake to animal protein increased the risk for ovulatory infertility by 19 percent. Conversely, women who switched five percent of their carbohydrate intake to plant protein had a 43 percent lower risk of ovulatory infertility. These results suggest that consuming animal protein could harm a woman's reproductive future. It is still unknown why animal protein negatively affects a woman's fertility, yet plant protein has the opposite effect. Since animal protein negatively affects fertility, plant protein wins this round.

Animal protein's reputation worsens when looking at its overall impact on health. Two cohort studies by Dr. Song and collegues examined the relationship between type of protein intake and mortality using thousands of participants over 20 years. The studies found that animal protein was associated with a higher mortality rate, and plant protein with lower mortality rates. Upon closer examination, the studies found that "processed red meat was strongly associated with mortality, whereas no association was found for protein from fish or poultry." Red meat is known to contain higher levels of cholesterol and saturated fat than other types of animal protein. On the other hand, the researchers noted that plant protein is associated with lower blood pressure, as well as lower risks of cardiovascular disease and Type 2 diabetes. The macronutrient composition of the protein of interest likely contributes to the correlation with mortality and overall health found in the Song et al. studies. In consideration of overall health and risk of mortality, plant protein comes out as the healthier protein.

So, which protein is the healthiest protein? The answer depends on the definition of "healthy." Plant protein is the better option for maintaining overall health, but animal protein delivers the most nutritional content. Women who intend on becoming mothers and individuals with or at risk for cardiovascular disease or Type 2 diabetes may want to choose plant protein over animal protein. Those concerned with building muscle may want to pick whey protein as their post-exercise snack. Ultimately, the choice comes down to individual lifestyle goals and preferences.

Sustainable Agriculture Through Ancient Technology

The Endurance of Rice Paddies Through Time

Written by Melita Wiles
Illustrated by Claire Li

When we hear the word technology, we often think of cell phones and computers, futuristic toys and electronics, but there was a time when technology meant something different. We rarely think about it, but the items we utilize in our everyday life were cutting-edge technologies when they were first invented. Some have been improved with new innovations, while others have not changed much because their efficiency and necessary function were already created almost perfectly ages ago. An important ancient technology that we still use today is the rice paddy. Rice feeds over half of the world and has helped build multiple cultures throughout history. This type of agriculture is sustainable and ingrained in the culture and traditions of these communities.

Rice paddies were created by the Neolithic cultures around 10,000 to 4,500 BCE in southern China. The engineering techniques they developed spread rapidly throughout China. These "paddies" are flooded fields of plowable land used for growing crops, such as rice. The best place to start these rice paddies are on a slightly sloped hill, where there is a constant water source. These paddies also need gravel, topsoil, and stones nearby. At the bottom of the paddy, rocks are built up to create a wall, and gravel is placed on the adjacent sides. The water transports and distributes the gravel to the correct place, and gravel is covered by eight to 12 inches of dirt and topsoil to create a bed for the rice to grow. The final step in creating the paddy is inundating it with water. The depth of the water can be controlled in various ways using multiple outlets.

Over 100 million people in Southeast Asia rely on deep-water rice for sustenance, and more than half of the world's people rely on rice to live.

The rice is planted from seeds, and when it is ready to be harvested, the water is simply drained from the top paddy to the next paddy on the slope. While the top bed is harvested, the next bed along the slope is planted and grown. A key theme throughout rice fields is the importance of irrigation. Fast-flowing streams irrigate the fields in the form of channels descending from the top of the slopes. If the area is less than ideal for rice growth, animals like water buffalo can be used to transport additional water and other necessary materials for the fields. The only changes to this ancient technology have been the introduction of different tools, such as cast-iron tools and different plows. Other than those subtle changes, the technology and engineering behind rice fields or paddies remains the same.

One concern with this type of farming is that these paddies emit methane. Rice paddies account for 20 percent of human-related emissions of methane. The water in the flooded field blocks oxygen from the soil, creating perfect conditions for microscopic organisms to emit methane. This is harmful to the environment and specifically contributes to climate change, but also makes the rice grow faster, which is beneficial to farmers. In 1980, a team found that draining these paddies in the middle of the season increases rice yield and decreases methane emissions, a technique that many farmers have adopted since then. Because of this change, China has seen a 70 percent reduction in methane levels. This mid-season drainage does create other issues, though; the process causes another harmful greenhouse gas, nitrous oxide, to be released.

While the science and engineering behind these fields are ingenious and truly effective for production, there are cultural and traditional aspects associated with this development that are equally important to the farms' durability. Some countries identify the cultivation of rice as a huge contributor to the development of their culture. Usually, the whole community stationed around the rice paddies will work together to grow the rice. Schedules are created to alert people when it is their turn to plant or harvest the rice. In order to harvest the rice, the highest paddy must be drained into the paddy directly below it, and this step requires careful planning and teamwork among community members.
Not only do communities work together, but these techniques have been passed down from generation to generation through families. This type of communal farming has taught cultures how to work together better and support others outside of their direct family, deepening community bonds. Through the dependency developed by these practices, countries that take part in rice farming are better at collectivist thinking. In recent studies, psychologists found that they could identify where Chinese people grew up in the country based on whether they had individualistic or communal outlooks. Other studies found that people from areas with more rice paddies thought more holistically.

While this is not a perfect science, these paddies have been feeding humanity for years. Exactly 11 percent of the world's plowable land is used for rice cultivation. Over 100 million people in Southeast Asia rely on deep-water rice for sustenance, and more than half of the world's people rely on rice to live. The creation of these paddies is important for sustaining human life, as well as to culture, communities, and generational traditions. While we may take ancient technologies for granted, they continue to shape our world in unseen and impactful ways.

Medically Induced Comas

An Exploration Into Head Trauma Recovery and a Possible Alternative

Written by Isabella Bacon
Illustrated by Eileen Faulk

A nasty car crash. Repeated blunt-weapon trauma to the face. A bullet wound in the forehead. With extreme traumas to the brain like these, one of the only sources of hope is through medically induced comas. A medically induced coma, or the intentional shutdown of brain function, is used as a last resort when the brain cannot get enough blood to specific regions due to injury or illness. Blood carries oxygen and glucose to the brain, providing it with energy. If the cells are not getting enough energy, they can die off, resulting in even more damage than the initial incident. Thus, if you can reduce the brain's overall energy needs, such as through the induction of a coma, the remaining energy can be focused on healing. Essentially, by preventing the brain from carrying out its normal functions of thinking, feeling, controlling movement, and more, doctors can influence more of the energy available to the brain to be used for recovery.

An additional benefit of comas is that they can help reduce swelling in the brain. The brain often swells after injury due to ruptured blood vessels and the innate immune response that follows. An innate immune response is a nonspecific reaction that occurs when the body has been injured, for example, sending lymph (a defense cell-containing fluid) to the injury site. The additional fluids increase pressure inside the head, which can lead to regions of the soft brain being squeezed against the hard bone of the skull, causing secondary damage. Comas can reduce blood vessels' size by reducing blood flow, leading to an overall decrease in the brain's size, thus, reducing the squeezing effects. By reducing swelling and energy demands, comas are sometimes able to assist in recovery.

In addition to those that are medically induced, comas can occur naturally when the brain experiences extreme trauma, which is where the idea of medically induced comas came from. However, when comas are medically induced, they occur through the careful administration of medications. Typically, pentobarbital, a sedative derived from barbituric acid, is used. Pentobarbital is given to the patient while they are being observed via an electroencephalogram, a machine that allows the visualization of the brain's electrical activity. The electroencephalogram is used to detect when the patient's brain starts to display a specific electrical activity pattern that indicates they have entered a coma and that the pentobarbital dosage is correct. Once in the coma, the medication will be continually administered and the patient's vitals, including their brain waves, will be closely monitored.

When monitoring the brain waves of a patient, doctors look for a particular wave pattern called 'burst suppression,' which is when short bursts of complete inactivity follow short bursts of activity. The periods of activity allow the brain to maintain its function at a level that allows for continued survival, but the rapidly following periods of inactivity allow for recovery to occur. These patterns roughly match the patterns of naturally occurring comas, but what happens during each burst of activity may look different. The bursts tend to be fairly regular and consistent in medically induced comas, but are quite variable when naturally induced These differences can help doctors diagnose the cause of a coma, be it a traumatic injury, renal failure, illicit drug usage, anoxia (a lack of oxygen), tumor, stroke, or infection.

The critical distinction between the two types of comas is that drug-induced comas are reversible as soon as pentobarbital is no longer being administered. In contrast, naturally occurring comas may or may not end, and the end date is neither known nor controllable. Although this means that medically induced comas are generally safer than naturally occurring ones, there are still risks involved with any type of coma. No matter the type, comas affect the entire body. This occurs through an increase in gamma aminobutyric acid (GABA), a neurotransmitter or signaling molecule, that signals cells around the body to decrease their activity. This reduction of activity can be harmful to many areas, but is particularly dangerous when it affects the heart. Specifically, pentobarbital reduces blood pressure, which can lead to reduced heart functioning, severe blood clots, and even heart failure. Additionally, this reduction of activity suppresses a patient's ability to cough, which typically helps prevent viruses and bacteria from entering the lungs. When combined with a potential decrease in immune function, patients have an increased risk of infection. As a result of these side effects, there are many risks associated with any type of coma.

Data has shown that medically induced comas do not actually increase recovery rates in patients, or that if they do, the

costs of being under barbiturates for so long may outweigh the slightly increased recovery time. The question of the costs versus the benefits is one doctors have to ask themselves every time they are thinking of placing a patient into a coma. In some cases, it is likely the patient will die without a medically induced coma, so the decision is rather simple. In other cases, the recovery of the patient with or without the coma is unknown.

Since many of the complications come from both the medication used and the comatose state, reducing either would lead to an increased likelihood for recovery. So how could this be accomplished? As of right now, there is not any other well-studied method, hence why medically induced comas are still common practice in extreme trauma cases. One hypothesis for how patients could avoid some of the risks of medically induced comas is to put only the harmed portion of the brain into the shutdown state rather than the entire brain. This would need to be accomplished using a methodology different from pentobarbital administration, since pentobarbital acts on the patient's whole body and cannot be administered to only one region of the brain. To shut down one brain region, scientists looked to nature for inspiration and found a possibility in a process that commonly happens in healthy brains: long-term depression.

> The critical distinction between the two types of comas is that drug-induced comas are reversible as soon as pentobarbital is no longer being administered.

Long term depression (LTD) is the reduced efficacy in the connection between two brain cells. In a healthy brain, one cell can readily communicate with the next cell. This process is accomplished via chemical messengers that increase or decrease the likelihood of the signal being passed on. When a region of the brain is in a state of LTD, the number of chemical signals needed to pass a message is drastically increased, resulting in a considerable decrease in the number of signals that can be passed on. If the signal cannot make it past the connection, the next cell will never even know that a signal occurred and will continue to exist in its resting state, essentially as if the cell was 'off.' This could potentially be used to create a barrier around the injured part of the brain, preventing signals from reaching the site of injury. Because no signals would be reaching that area of the brain, the energy costs in that region would be reduced, and all the blood flowing to the site would go towards recovery rather than function.

One of the primary differences between the shutdown state induced using this method and the drug-induced coma is the lack of the characteristic 'burst suppression' when manipulating the brain via LTD. By creating a barrier of cells around the injured area, local brain activity would not be occurring for short bursts laced with inactivity but would be almost entirely nonexistent. Whether or not this would allow for the same recovery benefits as the 'burst suppression' patterns is unknown.

The second question with this methodology is if the decrease in energy costs would be drastic enough to allow for enough energy for recovery. One solution to reduce the demands further is placing the patient into a reduced state of activity that is not quite as drastic as a medically induced coma but still reduces the brain's demands. This could possibly be accomplished with general anesthesia, which is given to patients prior to surgery. Anesthesia causes brain wave patterns that are somewhere between the patterns present in sleep and the 'burst suppression' patterns characteristic of comas. Anesthesia is much more widely used and has significantly fewer associated risks, indicating that it may allow for recovery from traumatic brain injuries in a much safer way than medically induced comas.

Overall, medically induced comas can be very dangerous, despite being a common technique used to aid recovery from traumatic brain injuries. However, new avenues of research are exploring using localized techniques that could have similar benefits while minimizing the risks. These techniques hope to harness the power of LTD and will hopefully lead to a higher recovery rate for traumatic brain injuries. • • •

Dancing to Unleash Creativity

The Science Behind Improvisational Dance's Impact on Creativity

Written by Kailey Zaronias
Illustrated by Holly Yelton

Imagine a setting in which creativity roams free, an environment in which any story can be told, and the only limitation is the physical existence of the human body. This creative experience is the foundation of improvisational dance. Enriching creative thinking, dance improvisation tests both the brain's ability to cultivate abstract thoughts, and the body's ability to physically portray a symbolic message.

Creativity is crucial to problem-solving and innovation throughout life. It begins to develop in early childhood with convergent thinking skills, which evaluate possibilities to make decisions, and divergent thinking skills, which generate new problem-solving connections. In the first several years of life, creative experiences quickly accumulate to build one's cognitive foundation. As cognitive science researchers uncover new information about the brain, working memory, creativity, symbolism, and more, it becomes exceedingly clear that strategies for enhancing neural foundations are best implemented in early childhood, when cognitive abilities are especially impressionable. The Dana Project by Laura-Ann Petitto clearly illustrates this fact. A study from the project compared the creative experiences of non-dancers and dancers who had trained since before age seven. Researchers found that dancers had significantly increased accuracy on attentional tasks, selective attention, and improvement in rapid short-term memory stimuli by analyzing behavioral tasks, participant surveys, and functional near infrared spectroscopy imaging (fNIRS) processing, and performance on other creative thinking tasks. Essentially, dancers had stronger creative and critical thinking skills than many non-dancers their age. These early creative experiences that build a child's neural foundation hold immense potential for their lifelong cognitive abilities.

Given that creativity is so crucial to human development, and dance is an inherently creative field, one would imagine that dancing and dance education are used to enrich childhood creativity. Unfortunately, this is not usually the case. Dance education today often involves a teacher-student imitative style of instruction where the students are expected to follow the teacher's exact instruction and are rewarded for correctness, not creativity. This teaching tradition misses out on the opportunity to attend to children's creative instincts. In a 2020 study by Dr. Luca Oppici and colleagues, children's working memory (short-term memory used for cognitive tasks) and motor skills were significantly improved when their dance instruction incorporated a high-cognitive teaching style. This teaching style encouraged dancers to be more mentally active, creative, and adaptable during dance practice than with the more passive, imitation-based teaching style. If dance schools can adopt a high-cognitive teaching style, they can better nurture early childhood creative development. While styles such as ballet and jazz traditionally rely on low-cognitive imitation-based teaching, dance improvisation does the opposite.

Improvisation is the ideal type of dance for teachers to encourage creative cognitive engagement in their students. As a free-form type of dance, improvisation allows the dancer to portray any symbolic message with their choice of movement vocabulary. This style of dance is unique and important because students must think quickly, trust their technique, and rely on their creativity to generate expressive movement. In a 2017 study, Hansen and Oxoby found that improvisational dance training improved both the nonverbal creativity and the cognitive flexibility of the dancers' creative design fluency. In much of today's dance education, it is uncommon to encourage the exploration of creativity through improvisation. Thus, a dance curriculum incorporating improvisational movement has great potential to enrich childhood development with creative thinking.

While the format of improvisation is ambiguous by nature, many noteworthy figures throughout history have created structures that can guide modern improvisational dance. Isadora Duncan and Florence Fleming Noyes stand among the remarkable dancers who have structured natural, creative, and independent movement learning. Duncan's modern dance technique focuses on children's natural movement pathways, including flowing, oppositional walking, running, and expressive gesturing. Her pedagogy makes movement natural and creative, rather than a perfectionist style of movement. Noyes' development of improvisational dance training builds on Duncan's movement style, while also encouraging dancers to explore the meaning behind their movements. Dancers are guided through exercises in which they draw inspiration from emotions, personal stories, and aspects of nature as metaphors for self-choreographed movement. While these techniques are not necessary for the creative cognitive benefits of improvisation, Duncan and Noyes' teachings can be used to guide dancers through a more effective and explorative improvisational practice.

Research in early childhood dance education and improvisation is still relatively unexplored. Many questions regarding the science and applications of improvisational dance's cognitive benefits are left to be explored. For example, what neurological connections are involved? Are the creative benefits of dance transferable to other learning domains? How do different movements affect creativity? Cognitive science researchers are still contributing to this fertile area of study. For example, a 2012 study by Slepian and Ambady found that fluid arm movement, as opposed to rigidity, enhanced creativity in the domains of idea generation, cognitive flexibility, and remote associations. Further research will be valuable for greater inclusion of dance and creative movement in early education, more diligent accountability for dance educators' teaching methods, and increased awareness for policymakers to understand how and why to support the dance community.

Until then, dance can continue to inspire creative exploration for people of all ages and abilities. An abstract and creative approach to movement makes dance accessible to everyone, even those with no formal dance training. Improvisational dance is non-judgemental, open to interpretation, and an incredibly freeing experience. I hope that as we go on with our daily routines, we can make a little time to turn on our favorite songs, close our eyes, and let our creativity run wild. • • •

The Great Firewall of China

The Implementations and Impact of Internet Censorship

Written by Nathan Englehart
Illustrated by Evelyn Lazen

Currently, China has 751,886,119 internet users, the greatest number of users of any country in the world. As the internet becomes increasingly integral to modern life, internet traffic control has major national security and economic implications for modern China. China's solution to these issues is its nationwide firewall, colloquially referred to as the "Great Firewall of China," which is a combination of various technological implementations responsible for the censorship and content filtering of internet traffic.

In most countries, including the United States, internet content deemed harmful to society is censored (for example, the sale of illegal drugs and child pornography). Much of this censoring takes place using a network security system called a firewall, which monitors and controls incoming and outgoing network traffic. China takes its firewall a step further by screening for sensitive information and political content. China also uses its firewall to block foreign social media websites as a form of domestic trade protection. The Chinese firewall implements various solutions for censorship and content filtering, including network blackholing, quality of service filtering, Domain Name System hijacking, and URL filtering to prevent unwanted internet communications.

The Chinese firewall's most basic censorship implementation is the network blackholing of banned connections. Internet protocol (IP) addresses are numerical names assigned to each computer connected to a computer network. Using IP addresses, computers can be identified and physically located.

Therefore, the Chinese firewall is capable of combating the primary method Chinese internet users utilize to avoid censorship.

Network blackholing is a basic process: the firewall keeps a list of banned IP addresses, and if the firewall detects that a user is attempting to communicate with a banned address, the connection is automatically dropped. Maintaining an updated list of flagged IP addresses is very difficult, so this method is generally a last resort.

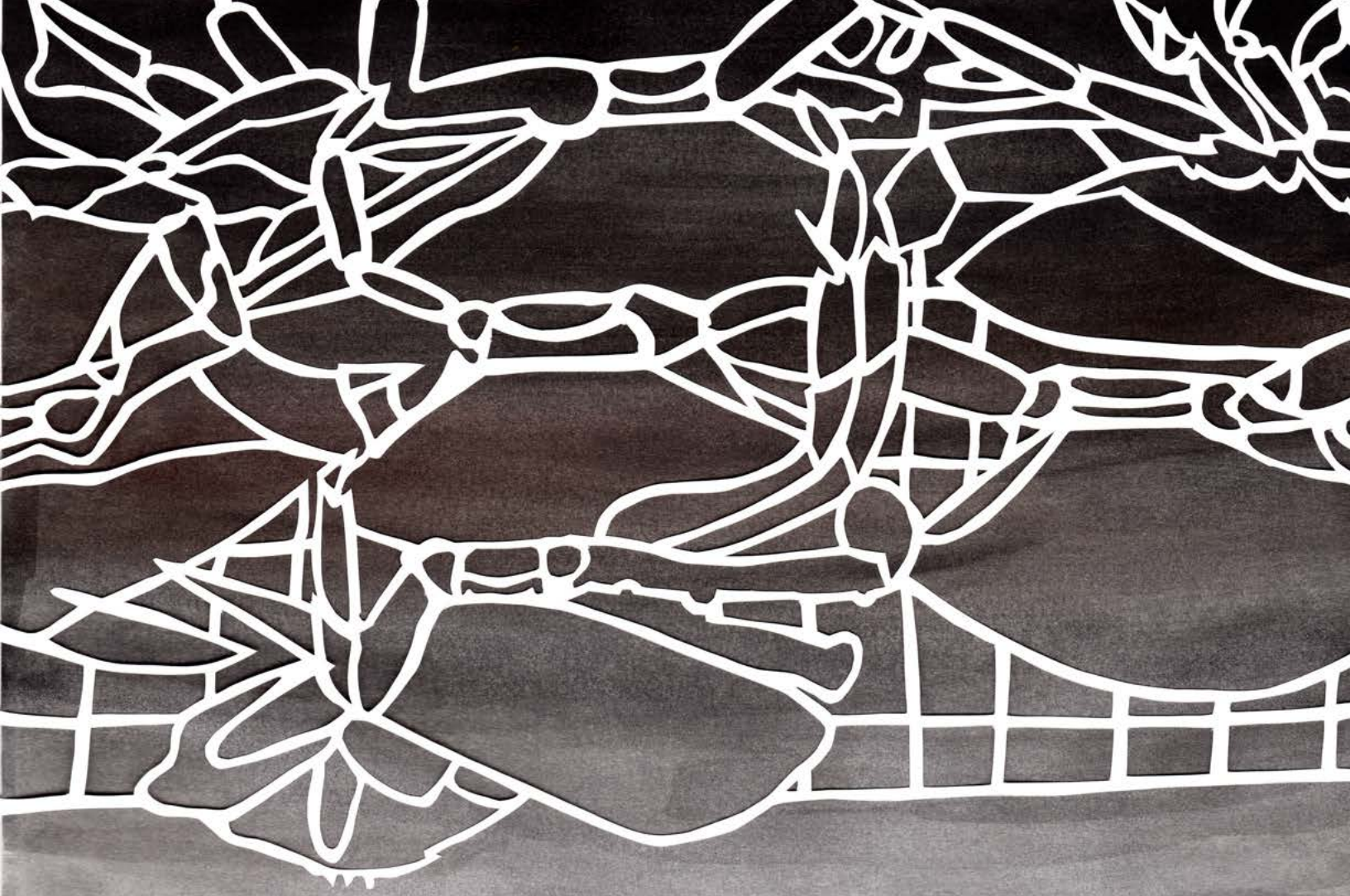
Quality of service (QoS) filtering is a more common implementation of censorship used by the Chinese firewall. QoS filtering uses deep packet inspection identification, a data inspection technique that analyzes data being sent over a computer network, according to a survey conducted by Joseph Lorenzo Hall and colleagues in 2018. The Chinese firewall monitors data being sent by users and echos the collected information to a system that then analyzes the data, and scores user requests based on how suspicious it determines the connection to be. The more suspicious the system determines the connection to be, the more it slows down the connection to the request on the client side. If the connection is very suspicious, the client's request will time out, effectively banning the user from the connection.

QoS filtering is commonly utilized to prevent users from employing a Virtual Private Network (VPN) to circumvent the Chinese firewall. A VPN allows for users to theoretically bypass the firewall by sending requests to a VPN server, which then relays the search to the host. This potentially keeps outside parties (such as the government) from being able to access data such as your search history, or where certain searches originate from. Users connect to VPN points outside the local network when sending requests to internet servers. At these VPN points, information is generally encrypted and decrypted. The encryption tunnels implemented by VPNs make it difficult for user information to be intercepted by actors interested in the user's requests. However, QoS filtering catches VPN connections with deep packet inspection before requests can reach VPN points. Therefore, the Chinese firewall is capable of combating the primary method Chinese internet users utilize to avoid censorship.

The Chinese firewall also uses Domain Name System (DNS) hijacking to prevent user connection to a few sites, including Twitter and Facebook. DNS servers match IP addresses with human-recognizable website names. The firewall determines whether users are trying to engage in unwanted connections through flagged domain names and keywords. When users try to engage in unwanted communications through a domestic DNS server, the server will have the user look for the website at the wrong location causing a connection timeout. If a user tries to use a foreign DNS resolver such as Google Public DNS, the firewall mismatches the user-input human-recognizable name with a random blocked IP address.

Similar to DNS hijacking, another method of censorship that China's firewall implements is URL filtering. This implementation of censorship involves proxies. Proxies are intermediaries between connection requests and the connection destinations. Using transparent proxies, the Chinese firewall performs keyword-based scans on requested URLs. Thus, the firewall is able to block web pages based on keywords it finds associated with them. This can lead to interesting cases of web accessibility. For example, "http://en.wikipedia.org" is accessible from within China, but "https://en.wikipedia.org/wiki/Internet_censorship_in_China" is not accessible.

China's firewall filters internet traffic in and out of the country. The firewall uses QoS filtering to prevent users from using VPNs to avoid the firewall. By blocking websites based on target keywords using URL filtering, China can sensor sensitive political material. Using DNS hijacking to prevent users from connecting to foreign social media platforms, China can also promote domestic tech companies (e.g. Twitter vs. Sina Weibo). Thus, the varying methods through which China's firewall implements censorship significantly influences the online habits of Chinese citizens today.



Hey, Your Body is Calling

The Fitbit's Evolution

Written by Kayri Craig
Illustrated by Kailey Zaronias

Many people have to monitor their blood pressure, heart rate, or oxygen saturation on a daily basis to track their health and plan their day. In the early 2000s, the devices that checked these vital-signs were found in doctors' offices and hospitals. They eventually made their way into drug stores like CVS or Walmart, where they were made more accessible to the public. Then made easily purchasable from a website or at a supermarket. Capitalizing on the desirability of health tracking, the company Fitbit began creating wearable technology. Fitbit's first device — created in 2008 — "Fitbit," was a device meant to be attached to one's clothing and would track calories burned, sleep, and movement. To access the results, the user connected the device to their computer, which reported a breakdown of its analysis of the data. The Fitbit has since gained many updates and new features. Specifically, the heart rate and heart rate variability monitor, the blood oxygen saturation level sensor, and electrocardiogram function have made Fitbit a worthy health tracker.

Two basic features Fitbits have always had are the step tracker and sleeping patterns tracker. A Fitbit step tracker diverges from a traditional step counter, especially the ones you can shake in order to add false steps, by using a three-axis accelerometer to determine if you are moving up/down, left/right, and forward/backward. It takes this information and feeds it into an algorithm that checks to see if the data matches how a person takes a step.

Now Fitbit's parent company, Google, is taking health tracking to a new realm where a cellphone is the health-tracking device

Fitbits are also designed to give the user information about their sleeping patterns. Fitbits without heart rate trackers do this by detecting movement, according to the patent authors, Venkatraman and Gee. They record that one is sleeping when they are at rest and have not moved for around an hour. The device can determine that the user is sleeping restlessly if there is a lot of movement, like tossing and turning. Sometimes Fitbits consider excessive movement as time spent awake. Most of the devices that do track heart rate monitor sleeping patterns similarly, but use the heart rate sensor to determine the user's sleep stages. This information can reveal important patterns that can be addressed and lead to better sleep.

The first update added as a standard feature on Fitbits was the heart rate monitor. The heart rate monitor tracks your heart rate at all hours, and within the past year, Fitbit has developed software that can determine heart rate variability, which tells the user how the change in time differs between their heartbeats. Heart rate variability is becoming a mainstream marker of health, according to research done by Dr. Tiwari and colleagues, so the Fitbit may become an even more powerful health indicator. The patent for "wearable heart monitor" details that the smartwatches and trackers with the capability to determine heart rate have a sensor on the underside of the watch or bracelet, and infrared and red LEDs shine into the skin in order to determine blood volume changes in the tissue. The determination of the change of blood volume is obtained by measuring changes in light absorption from the skin. The Fitbit then takes this data and compares it to movement data at the time. The device can remove waves caused by extraneous movement (not from the heart wave sensor), which then shows an accurate heart rate.

Following the addition of the heart rate monitor, Fitbit installed the saturated oxygen (SpO2) content sensor. Saturated oxygen content tells us how much oxygen is in a person's blood. If a person's saturated oxygen content falls below 90%, they typically develop hypoxia, which can alter a person's heart and brain functioning. Consequently, knowing that your oxygen saturation content is becoming low can be life-saving. The Fitbit SpO2 user manual says Fitbit's intention for this feature is to track the average of a person's blood oxygen content, particularly measured during the user's sleep. This feature uses the same infrared and red LEDs to shine into the skin, determine the change in blood volume, and use that information to calculate the expected oxygen saturation rate.

Now Fitbit's parent company, Google, is taking health tracking to a new realm, where a cellphone is the health-tracking device, and touch is minimal. Most health trackers or devices require skin contact in order to offer any sort of reading or analysis. However, Google has recently developed technology which is said to read pulse and breathing rate by only using a cellphone camera. An article written by France-Presse reports that the camera will capture the movement of a person's chest and use that information to calculate respiration rate. The camera will also be used in a similar way to the LEDs of the Fitbit. The user will place their finger on the camera lens and the phone will be able to detect changes in blood volume and light absorption in order to determine heart rate. This is one of the first instances of being able to capture respiration rate and heart rate using only a cellphone, with nothing connected and limited contact. Soon, our vital-signs will be in our own hands. • • •

A Synapse Series: Green Energy

America's New Energy Resource

How the Earth's Heat Sources Could Reduce the Nation's Growing Carbon Footprint

Written by Sara Khorshidi
Illustrated by Adriana Baker

Our country's ever-growing rate of energy consumption is a major contributor to global warming and cannot be slowed by individual efforts. Commercial industry, government, and military contribute to at least 70% of all energy consumption in the United States (U.S.) every year, most of which is fueled by petroleum and natural gas.

Over the past 50 years, all end-use energy sectors have been replacing their coal sources with electricity sources. On the surface, it appears to be the greener option, but many do not think about how this electricity is generated. The majority is done through mechanical energy produced by steam turbines, typically using non-renewable sources to generate the steam. In 2019, nearly 63% of domestic electricity generation came from steam turbines powered by fossil fuels, with coal being one of the top two contributors. The time has come for a renewable, versatile, low-emission energy source for the U.S. to rely on.

A resource that has been largely overlooked by the U.S. is geothermal energy, which utilizes the Earth's natural heat to provide heat or electricity. For economic viability, geothermal plants must be constructed in naturally occurring tectonic hotspots, which are limited in the United States. Our few conventional geothermal plants reside in Nevada and California, which produce the world's largest geothermal-installed power generation capacity. However, they only account for 0.5% of our net electricity generation. Because of this, geothermal plants have developed a reputation for being weak and unreliable.

In 2005, a panel from the Massachusetts Institute of Technology evaluated the potential of Enhanced Geothermal Systems (EGS) to become a primary electricity resource for the U.S. EGS is a man-made underground reservoir constructed in high-temperature rock with low natural permeability and fluid saturation. While conventional geothermal energy is limited by location, EGS can be installed almost anywhere, and the benefits it offers are exactly what we are looking for in achieving a future with sustainable energy.

To create an EGS, fluid is drilled into pre-existing cracks of the rock deep underground, causing them to further fracture and increase permeability. The fluid gathers heat from earth, circulating it through the fractured rock, and returning it to the surface through a production well, generating electricity upon reaching the power plant. Since the electricity is produced by heat, EGS operates continuously at a minimum level of power demand, thus needing no means of power storage. Once produced, electricity is sent straight to the consumer.

After analyzing decades of research, the panel found that there are very few physical barriers or limitations in using EGS. Initial concerns about EGS, such as water loss, geochemical impact, and inducing earthquakes, are now solved or manageable through proper operation and care. However, these risks have not yet been reduced to a point where investors feel comfortable funding installations.

The largest setbacks of EGS are the cost and lack of drilling and piping technology, both of which are directly correlated to the lack of data and physical research on the subject. An estimated $800 million to $1 billion is needed to produce EGS power plants at a rate to be viable candidates in domestic electricity supply by 2050. Though this may seem like a massive amount, it is lower than the cost of installing and maintaining a coal power plant. In addition to the cost, installation requires advanced engineering and technical knowledge that many engineers have not mastered yet. Without proper research and development, projects will remain expensive and will not yield enough power to be profitable. With funding and technological improvements, EGS sites could increase their amount of economically extractable energy from 0.5% to over 10% of U.S. electricity generation.

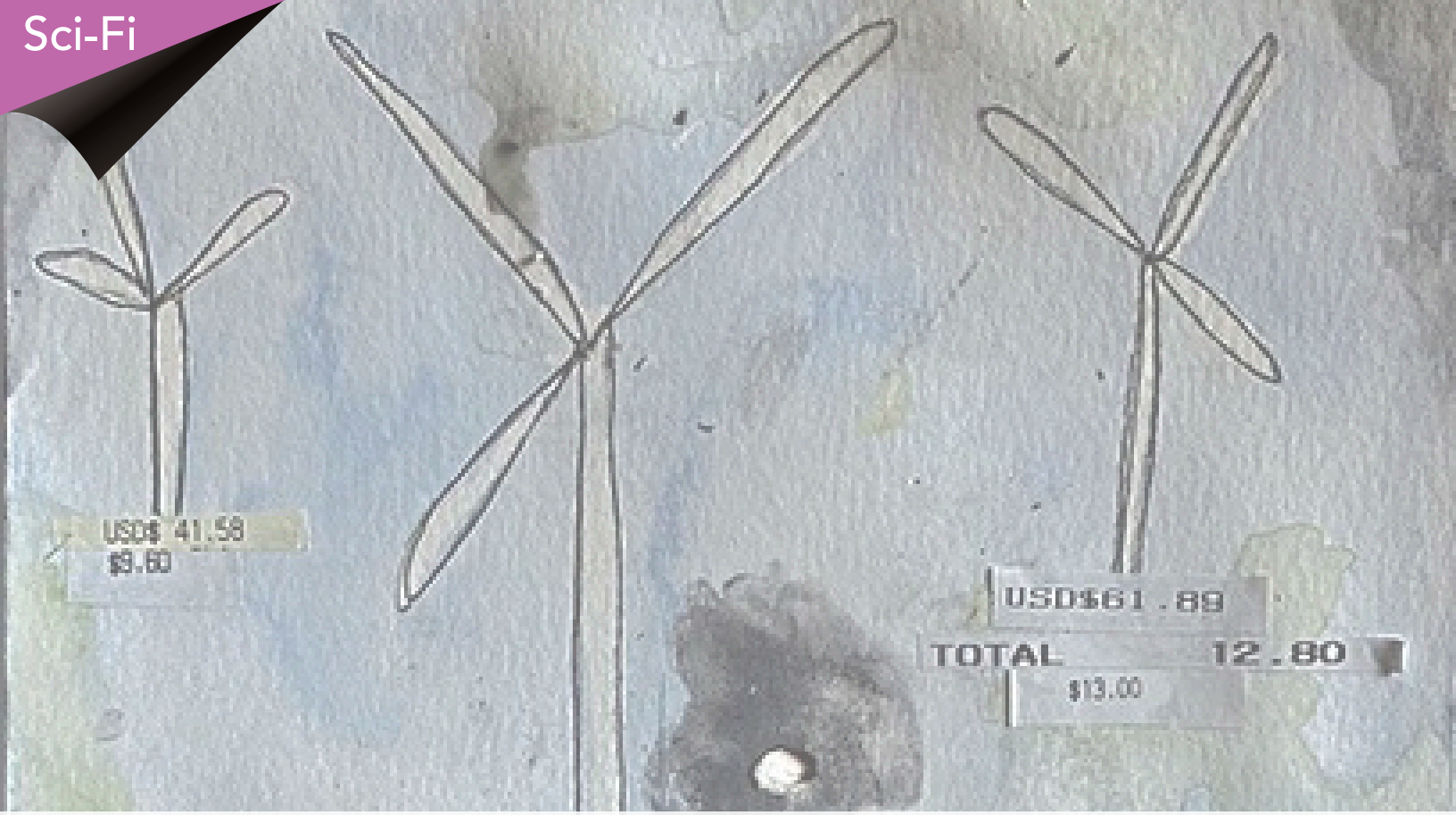
While private investors are not ready to fund EGS, energy markets and future government policies could influence investors' interest in developing the technology. To accomplish this, the government will have to fully support EGS development and implementation; only then will the private sector take over.

For EGS to succeed in the competitive electricity sector, positive policies must be granted on the state and federal level, similar to those of oil and gas reserves. Several high-grade EGS resources should also be under development within the first 15 years of approval. We must also continue to actively participate in international EGS studies.

> Technologies developed and researched by public research organizations are fundamental in moving towards a low-carbon society.

The Department of Energy (DoE) sees a lot of potential in geothermal energy and has been aware of it for years. In 2016, DoE funded a $29 million geothermal energy research grant to the Frontier Observatory for Research in Geothermal Energy (FORGE) in Utah. DoE also has been discussing EGS with other countries who have begun research and development on the topic.

Recently, the potential for EGS usage in the U.S. has grown. President Joe Biden is expected to take action in energy management by decarbonizing the energy sector. Biden is not the only one interested in renewable energy: it is estimated that the largest area of energy industry spending this year will be in renewable power projects, surpassing the spending for oil and gas for the first time. Additionally, FORGE began drilling their first experimental EGS resource in October, 2020. Even with all these elements, it is unlikely that we will see EGS as a major contender in electricity generation anytime soon. The government needs to see at least another decade of development before they will feel confident supporting it. Because of Biden's decarbonization initiative, EGS research may get funded, and geothermal energy might get the attention it deserves.



Grand Opening

Written by Claire Parker
Illustrated by Susan Robinson-Cloete

Appalachia was lush in the summer. The cicadas sang at sunrise, bears rambled freely in the foliage, and flaming azaleas prospered. The grassy meadow in front of Henry Burrows seemed to whisper to him; an imperceptible beat that sent shivers down his back even though the midday heat was almost unbearable. Henry wiped the uncomfortable thought and sweat away from his brow and turned to his associate.

"This seems like as good a place as any."

"Of course, sir," William said as he jotted down notes. "Should we get the photos for the press?"

Henry looked back at the meadow opening. A gleaming white building. Massive glass windows to let in the sunlight. The roof would have a garden. The Burrows & Co. marketing team would advertise this location as a special green store, the cooled shelves lined with their new 100% Pure Lab™ meat series, crops from the roof at premium prices, and some locally sourced farm produce. Henry could taste the success in the humid air.

He posed for the shot, anticipating the photographer's instructions after so many years. He needed to be seen as approachable to the public. Back in his father's day as the head of the company, the marketing team had devised a way to make the CEO seem involved in every decision. So here Henry stood, his smiling face the seal of approval for the newest location of the next Burrows & Co. branch. With the new regulations from the Green Shift laws over the past decades, companies were responsible for their own image. Many of their reputations had been damaged by the media spin of "the real truths" about the pollution crisis, so they had to fight back tooth and nail in order to preserve their power. The companies made deals and came up with campaigns announcing their transition to clean energy while still maintaining their economic power. Henry's father had personally championed the switch from coal power in his factories to photovoltaics, and was hailed as an environmental hero. What a legacy to live up to. And here Henry was standing in front of a field for a publicity shot.

The photographer signaled that he was done and Henry let the forced smile drop from his face.

"Do you know when we can break ground, William?" he asked.

"They say they can start as soon as tomorrow. But…" he trailed off, looking away from Henry.

"But what?" he replied irritably.

"There are rumors that a protest against the construction of our new location is planned for whenever the builders arrive."

Henry sighed and rubbed his eyes. This had been happening more and more lately. "Send an authorization to the environmental enforcement squad to come out and guard the grounds. The land has already been purchased, so there is no contest."

"Of course, sir." William paused, as if to add something. Henry looked at him expectantly. William cleared his throat. "It's the old mining coalition. The Black Lungs."

Ah. There were still small pockets of people who were still serving their sustainability sentences in Appalachia. Generations of men and women who had worked in the mines, emerging covered in soot, crimes against the earth mingling with the grime under their nails. Most of them understood they had to serve their time as environmental rehabilitators, but some of them, like the Black Lungs, weren't as understanding. The leader of the old mining coalition, an old man whose voice sounded like the gritty coal dust he had corrupted the air with, claimed that companies like Burrows & Co. had taken their livelihoods away when the mines shut down, and that they deserved reparations for the harm the coal caused their bodies. One day, he thought icily, they'll get what they deserve.

"I'll be there personally tomorrow, William. We cannot afford to lose profits because of some group of radicals."

***

Henry wanted to make an entrance. Appearances were everything, and arriving as the peacemaker to an ugly brawl between a group of radicals and a company trying to provide resources to a dwindling community would only boost Burrows and Co.'s public image. Lost in thought, he pulled over to the construction site. He snapped back to reality, and he fumbled with his seatbelt as he flung open the door.

No equipment was in place, no environmental enforcement officers, no sign of any movement anywhere. Silence. He checked his GPS to make sure he was in the right location. He was. He clenched his jaw. He needed an explanation. William. He thrust his hand in his pocket to grab his phone when he felt a tap on his shoulder.

"Sir."

"William," he said as he turned, his voice rising. "Where the hell—"

He cut off when he saw the man who stood by William's side. The man had to be at least seventy, but his smoldering eyes beneath his hardened brow sent a jolt of recognition through Henry. Those eyes stared out from wanted posters, from every hijacked mandatory sustainability sentencing update broadcast the government televised. But there was more. Side by side, Henry connected the physical similarities, for this man's eyes hadn't just stared out at him from a wanted poster. He met William's piercing gaze.

"Mr. Burrows," William said casually, "allow me to introduce you to my father, Gilbert Carson."

"Ye can call me Gil, Henry." The man stuck out his hand and Henry recoiled. Gil's arm glinted in the morning light, metal from the shoulder down. He saw Henry's stricken expression and gave a gravelly chuckle. "An old mining accident from my youth. My wife, Hilly, fixed it up for me after we got sentenced. Ain't she a beaut?"

Henry regained his composure. "So, what is going on here?" he said diplomatically.

William exchanged a glance with Gil. The laughter left Gil's eyes, the burning embers returning.

"Well, son, it seems like there's been a misunderstanding between us Black Lungs and the Burrows family."

"A misunderstanding," Henry scoffed.

"You see," Gil began walking and motioned for his son and Henry to follow, "us coal miners got the short end of the stick when people like your father came on the scene during the Green Shift. We got slapped with these sustainability sentences while all we were trying to do was make a living wage. Now you green financiers think you can put all the blame on us."

Gil stopped abruptly and turned to face Henry. "Surely, you can see why we're upset."

"Yet, you didn't find a different job. No one was forcing you and your family to stay, Gil."

"And no one was forcing you into your father's throne, yet here you sit, all golden and tarnished."

Henry opened his mouth to retort, but William interrupted him. "I've worked for you for years, Burrows, and I've yet to see any meaningful action on your part. You use clean energy for your stores, spew nonsense about how everyone deserves healthy, sustainable food and clean water, yet you hike up the prices of the locally sourced produce people could sell to each other. You rerouted the streams we depend on for fresh water to your stores and sell it by tap there. You have a damn monopoly on our necessities, Burrows."

"The economy needs people like me. If it weren't for Burrows & Co., the whole country would be stuck in a rut, no money flowing in or out. We helped build the world back up better than it was before. Fossil fuels are a thing of the past, no thanks to people like you."

"We had to work for our own demise, while you profited off of it." William's face hardened. "The time has come to make a larger statement. People need to know who you really are, Henry Burrows."

Gil stomped his foot against the dirt of the field twice, and Henry heard a distant rumbling. A beat. A shiver went down his spine. A nearby tree gave a sudden burst of light as a long antenna extended from the top of its canopy.

"What's happening?" Henry stuttered out.

"We have all the documents. Every transaction, every conversation, every decision from the past 40 years that shows all the ways you have blamed people like us coal miners for your misdeeds." William took a small, black box out of his pocket and flipped it open. Henry watched with a morbid curiosity as William's thumb hovered over the singular green button.

"And we are sending it out around the globe. People deserve to know. People deserve to live freely, without judgement for a fault that isn't theirs. We aren't the problem."

"I trusted you, William."

"And we all put our trust in you."

Then William pressed the button.

Congratulations, Class of 2021!

● Artist ● Writer ● Content Editor ● Copy Editor ● Layout Editor ● Board Member

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Roger Ort ●

Val (Xingzi) Zhang ●

Emma Larson

Claire Nave ●

Marco Balic ●

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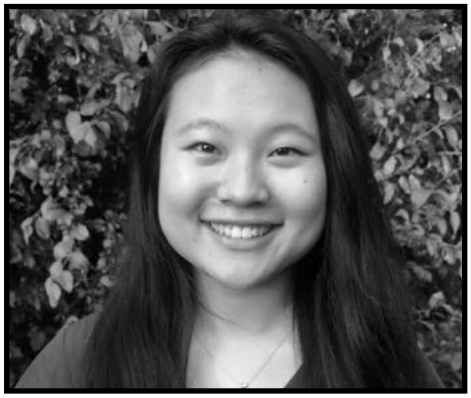
Casey Pearce ● ●

Kayri Craig ● ●



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Maeve Greising ●

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Elaine Wu

Allison Schmitt

Athina Apizidis

Evelyn Morrison

Rochelle van der Merwe

Victoria (Tori) Fisher
Editor-in-Chief

A Tale of Three Dots

Letter from the (Graduating) Editor

I learned about The Synapse during my first semester at Oberlin. Tara Santora, then Editor-in-Chief, stood in front of my introductory biology class explaining the magazine with a poster projected behind them. The magazine's old logo comprised of "THE SYNAPSE," written out, with three red dots connecting the Y to the P. Those tiny red dots hung mysteriously from the logo. I wondered: what do those dots mean? Why are they there? Of course, I never had the forethought to actually ask the Editors-in-Chief to explain the meaning underlying them. I figured I could always ask later. Then, suddenly, in my second year of college, I became the Editor-in-Chief without a clue as to what those dots meant.

That year, we completely redesigned the magazine. During that period of change, I discovered I was not the only one who found the dots intriguing; the whole board leaned into our dot theme. Pull quotes were adorned with dots instead of lines. Our discipline headings were rounded instead of boxes. We even adjusted our logo so that three giant red dots prominently sat in the middle of the A. Yet, the board never discussed their significance. It was from our smallest and most controversial change that I determined the meaning of the dots.

During a cold evening in February 2019, the members of the board sat in a heated debate: should each article end with one dot or three? Historically, a single dot indicated the end of an article, as is customary in magazines. With the new aesthetic, though, the board decided that the single dot felt out of place. We swapped in the new-end-of-article signifier, which you can see closing every article in this issue. I did not initially agree with the change, firmly residing in the pro-single-dot camp. The dots reminded me of the ominous "To be continued…" at the end of shows and movies. However, I realized that was precisely the point.

Science is continuous. While the writer may have finished their thoughts, there is always more that will be discovered. Each article is embedded in an ever-growing web of information. The dots represent the connection to the current literature and to the research that is to come. In many ways, The Synapse holds this place for me. While my time as Editor-in-Chief of this incredible magazine is coming to an end, the stories, friends, and lessons I have learned will stick with me for many years.

Meet the Denison Staff!

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Managing Editor-in-Chief

Barlow Wagner
Art Coordinator

Daisy Aviles
Outreach Coordinator

Casey Pearce
Treasurer

Meet the Oberlin Staff!

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Co-Graphic Designer

Rochelle van der Merwe
Treasurer

Drew Dansby
Oberlin Community Liason

Evelyn Morrison
Intercollegiate Coordinator

/syn . apse/ noun : the point at which a nervous impulse passes from one neuron to another.
The Synapse is an undergraduate science magazine that serves as a relay point for science-related information with a threefold objective. First, we aim to stimulate interest in the sciences by exposing students to its global relevance and contributions. Second, we work to bridge the gap between the scientific and artistic disciplines by offering students a medium through which to share their passions, creativity, and ideas. Third, we strive to facilitate collaboration between undergraduate institutions across the country, especially within the natural science departments.