The Synapse

Intercollegiate Science Magazine

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Staff

For years, *The Synapse* has provided a platform for creative scientific exploration, including articles on everything from the mechanics of equestrian riding to the importance of science writing. In the current climate of polarization and misinformation, it's critical to bridge the arts and sciences in pursuit of new understandings and greater truths. As the incoming Editors-in-Chief, we, Rachael Branscomb (OC '19) and Leah Treidler (OC '20), are excited to support writers, editors, and artists in examining the world in new ways and sharing their unique insights.

We're incredibly grateful to our predecessors, Tara Santora (OC '18) and Victoria Albacete (OC '18), for their hard work and high standards. And we're excited to welcome our new board, beginning with Yue Yu (OC '20) and Steven Mentzer (OC '20) who are taking over as Chief Layout Editor and Art Coordinator, respectively. Emma Larson (OC '20) will be our Web Manager, Tori Fisher (OC '21) will be taking over as Treasurer, and Jane Sedlak will be continuing on as our Outreach Coordinator.

As electric cars begin to line the streets and natural disasters ravage corners of the world, we at *The Synapse* are passionate about keeping up with the most recent scientific discoveries. In 2017, scientists created artificial wombs, growing lamb fetuses in a lab. For the first time, gravitational waves were detected from the merging of two neutron stars about 130 million years ago. CRISPR was successfully used to edit a human embryo. If you're hoping to learn more about advances in genetically modified organisms, read Joanna Zienkiewicz's article, *The Designer Plant Debate*. If you're fascinated by the idea of eventual human relocation, check out Kileigh Ford's article Exoplanets*: A Home Away From Home*, which analyzes exoplanets within and just beyond our solar system for their earth-like qualities and human-sustaining capabilities. And if you want to learn about a booming sector of cancer research, flip through Maureen Madar's article, *Genetics of Esophageal Cancer.*

To understand how the current political environment is affecting widespread change on scientific discovery, peruse Gailyn Gabriel's article, *Science Policy in the Trump Administration*. To explore the morally questionable and psychologically destitute side of space travel from a creative perspective, check out *Gravity Ridge* by Alexander Metz, the first ever fictional story published in *The Synapse*. And if you're afraid reliance on modern machinery is altering your intelligence, consider Tyler Duffrin's article, *Man's Best Friend*.

We thank you for picking up a copy of *The Synapse* — or checking us out online — and invite you to apply to write or edit for *The Synapse*. We hope that you continue to search for meaning in a rapidly developing world, research new discoveries for yourself instead of perpetuating misinformation, and advocate for an informed and generous scientific world, because it's only by the advocacy of people like you that scientific thought remains an integral and integrity-based part of the modern world.

Rachael Branscomb and Leah Treidler
Editors-in-Chief

Tara Santora graduated from Oberlin College in 2018 with a major in Biology. Tara began at *The Synapse* as a writer the first semester of their freshman year, eventually becoming Editor-in-Chief and forming the partnership between Oberlin College and Denison University. At Oberlin, they worked as a Quantitative Skills Center tutor, played on the quidditch team, and did research in the Bio and Environmental Studies departments. Drawing from the love of journalism they fostered at *The Synapse*, they're currently attending New York University's Science, Health & Environmental Reporting Program.

Victoria Albacete is a 2018 Oberlin College graduate from Pittsburgh with a double major in English and Biology and a minor in Hispanic Studies. In addition to serving as one of the previous Editors-in-Chief for *The Synapse*, Victoria spent her senior year as an Editor-in-Chief of the *Plum Creek Review*, Production Manager of the *Oberlin Review*, and a dancer with Movimiento. She has always had a passion for reading and hopes to join a children's and young adult literature-focused imprint of a major publishing company or to work abroad as an assistant editor.

A 2018 Oberlin College graduate, Elena Hartley double majored in Chemistry and Geology. She's worked with *The Synapse* for three years as an art contributor, art coordinator, and Chief Layout Editor. Outside of The Synapse, Elena has worked as a peer advisor at the Career Development Center, Layout Editor for *The Oberlin Review*, and a student representative for the Geology Department. A lover of drawing, she continues to use her art as a bridge to connect important topics in science to the public. She is currently attending the Science Illustration Certificate Program at California State University, Monterey Bay.

Rachel Dan is a 2018 Oberlin College graduate from Bethesda, Maryland with a double major in Neuroscience and Creative Writing. In her three years at *The Synapse*, she served as an artist, layout editor, writer, crossword maker, and Chief Layout Editor. A student in both humanities and sciences, *The Synapse* has afforded her the opportunity to explore scientific interests outside her academic life, writing about subjects such as the Juno spacecraft. She spends her free time reading, drawing, and practicing Aikido and she hopes to someday visit all seven continents.

Contents

Genetics of Esophageal Cancer

Exploring a Booming Sector of Cancer Research

Written by Maureen Madar

Illustrated by Parker Shatkin

How many people do you know that have or have had cancer? Everyone has been impacted by cancer at some point in their lives, but what actually is it? Cancer is a direct result of changes in our DNA, which is surprising to many people. An exciting field of research on this topic is the study of cancer genetics. Esophageal cancer can be used as a model to understand the basics of this field. Researchers want to understand how our DNA influences our likelihood to develop cancer.

Esophageal cancer is the eighth most common cancer in the world with a five-year survival rate of less than 20%. This cancer can be separated into two different classifications: squamous cell carcinomas (ESCCs) and adenocarcinomas (EACs). ESCCs develop from epithelial tissue that lines the esophagus, while EACs develop from glands that line the lower portion of the esophagus. Interestingly, ESCCs are more common in developing countries, while EACs are more common in developed countries. Esophageal cancer researchers have found several interesting genetic distinctions between ESCCs and EACs. These genetic differences have the potential to improve gene therapy as a cancer treatment option.

A few basic definitions are first required to understand the work of esophageal cancer geneticists. To begin with, a proto-oncogene is a gene that, when mutated, can become an oncogene. Oncogenes are pro-tumor genes that experience gain of function mutations, which result in hyperactive expression. Think of oncogenes like a car with a brick on the gas pedal. The oncogenes help to drive the progression of tumor development. In contrast to oncogenes, proto-oncogenes are tumor suppressor genes (TSGs). TSGs function to prevent tumor formation, but they fail to do their job when they experience a loss of function mutation. TSGs act like the brakes on a car to slow down and stop tumor development. A car stuck in acceleration mode combined with broken brakes will result in a vehicle that is driving out of control. Similarly, cancer progresses due to gain of function mutations in proto-oncogenes and loss of function mutations in TSGs.

One of the first critical findings in esophageal cancer genetics was understanding the differences between ESCCs and EACs. Researchers from The Cancer Research Genome Atlas (TCGA) questioned how there could be two different types of esophageal cancer. They sequenced DNA from samples of both ESCCs and EACs;the

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results shed light on the situation. Both types of esophageal cancer tumor tissues had acquired mutations in different proto-oncogenes, but both were mutated in the same TSG TP53. These results suggested that different proto-oncogenes contributed to the development of different tumor-types, but a universal loss of TSG function would also assist in ESCC and EAC development.

Another interesting discovery in esophageal cancer genetics is a connection between circadian rhythm proteins and cancer metastasis. Cancer metastasis occurs when cancer spreads to other parts of the body. Circadian rhythm is your body's natural 24 hour clock. It tells you when to wake up and when to rest. But what does it have to do with esophageal cancer metastasis? Researchers at the Second Hospital of Hebei in China have proposed a link between circadian rhythm proteins and esophageal cancer. They have found increased levels of the Per2 protein in metastatic EAC and ESCC tissues samples, but not in non-metastatic or in normal tissue samples. These results suggest that a potential gene therapy for metastatic EACs and ESCCs is inhibition of the Per2 protein.

While all of these research findings are interesting, what is the next step to actually improving cancer treatment based on these results? If changes in DNA sequences contribute to the development of tumors, then understanding the order of the mutations could give doctors a better screening window for esophageal cancer patients. Researchers at the University of Cambridge were able to order the predominant preinvasive mutations found in EAC patients. The results indicated that there were many mutated genes found in normal esophageal tissue. Two of the critical mutations, however, involved the TSG TP53 and the proto-oncogene SMAD4. Pre-cancerous changes were found in tissues that had TP53 mutated within the cells. Later in cancer development, early invasive tumors were found to also have mutated SMAD4 within the cells. The ordering of these two critical mutations provides an optimal screening window for doctors to intervene. Patients can potentially have DNA from their esophageal tissue sequenced to determine if they have these critical mutations prior to the development of an invasive tumor and can start treatment early.

> In addition to an improved screening window, gene therapy is the future of personalized cancer treatment. Targeted gene therapy is designed specifically for the mutations found in each patient.

In addition to an improved screening window, gene therapy is the future of personalized cancer treatment. Targeted gene therapy is designed specifically for the mutations found in each patient. One person may have an EAC due to mutations in TP53 and SMAD4, while another patient may have metastatic ESCC due to a mutation in TP53 and overexpression of the Per2 protein. Gene therapy is designed to introduce new copies of genes to make up for the genes that have been mutated. This is often done by injecting modified viruses carrying the desired DNA. If you are worried about effects the virus may have on the patient, do not fear because they have been modified so that no other infections can be introduced. This viral vector can be injected into the patient through an IV or by exposing a sample of the patient's' cells to the virus and later returning the cells to the patient. Gene therapy is still a relatively new treatment option and researchers continue to develop more efficient and safer ways to insert the new genes into patients.

Esophageal cancer genetic research continues to pave the way for improved classification and treatment options. EACs and ESCCs are good models for common tumor types, but the genetic mutation classification process can be applied to many other types of cancer. Gene therapy also has the potential to be a major player not only in esophageal cancer treatment, but in all types of cancer. Imagine genetic screens that are as easy, if not easier, as getting a blood work panel done. Everytime you go to the doctors office, they could sequence your entire genome in the time it takes to do a basic physical assessment. This information could give doctors improved predictive power and patient-specific gene therapy treatment options. Such a futuristic concept is the direction that cancer treatment is headed due to more efficient DNA sequencing technologies and gene therapy options.

Break Out The Soap

The Filthiest Objects You Touch Everyday

Written by Nathalie Weiss
Photographed by Diep Nguyen

When you think of dirty objects that you encounter every day, the first thing that comes to mind is probably along the lines of bathroom door knobs. The number of germs on unsuspecting items that you touch daily might come as a surprise to you. For example, kitchen sponges are often considered safe because we use them to clean things that we eat off of. However, these sponges carry 10 million bacteria per square inch on average. Some of this bacteria is pretty frightening, as it can contain salmonella, which causes diarrhea and vomiting in humans. Another surprisingly dirty household object is refrigerator handles, which are home to bacteria such as yeast and mold. Unfortunately for us, kitchen appliances aren't the only filthy objects that we touch every day.

> Cell phones have been found to be 10 times dirtier than toilet seats and could even have E. coli on their surfaces.

We often interact with public technology that can be responsible for making us sick, such as vending machines. Although this may come as a hard blow to snackers, vending machines are absolutely covered in germs. Kimberly Clark and a research team at the University of Arizona swabbed 5,000 different parts of the kitchens and break rooms in office buildings and found a large number of bacteria on the buttons of vending machines. These buttons pick up the germs that the people who used the machine were carrying on their hands. Most people eat their snack immediately after removing it from the machine, meaning that those germs go directly into their mouths. The contagion found most often on these machines is rhinovirus, which can give you the common cold. So, to avoid sneezing after your snack, make sure to wash your hands before eating out of a vending machine.

An interesting way to identify whether or not certain objects house unhealthy germs without going through a swabbing process is through analyzing their ATP levels. ATP, adenosine triphosphate, is a compound made of an adenosine molecule bound to three phosphate groups. ATP is present in all living tissue, and the breakage of a phosphate linkage forms adenosine diphosphate (ADP), which provides the energy needed to carry out the body's physiological processes. When the ATP levels of objects are 300 or higher, it means that the transmission of an illness is likely.

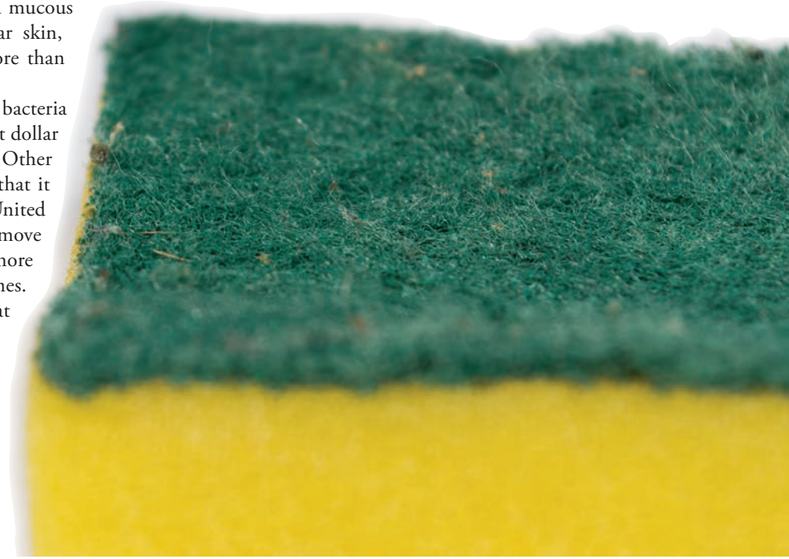
Parking meters are another commonly utilized piece of public technology that have high ATP levelS and 40% of them have been found to be contaminated on average with unhealthy bacteria. Who knew that parking your car could give you a cold? Going along the vein of public technology, crosswalk buttons have been found to be teeming with bacteria. It seems unfair that attempting to safely cross the road has the potential to make you sick, but 35% of crosswalk buttons were found to have ATP levels of 300 or higher. Common germs on crosswalk buttons include parainfluenza virus, which can cause the flu. Even if you aren't travelling by foot, you still need to be careful in public places. For example, the next time that you are on an escalator, don't grab the rails unless you absolutely need to! These rubbery safety nets have a 43% chance of having ATP levels of over 300. Germs on these rails that can negatively impact your health include multiple strains of the flu because these bacteria remain active on surfaces for several hours before dying.

When considering household germs, you should look directly at your cell phone to find where the most germs are housed. Cell phones have been found to be 10 times dirtier than toilet seats and could even have E. coli on their surfaces. E. coli are gram-negative bacteria that often live in the intestines of warm-blooded mammals and have the potential to cause the symptoms of the common stomach flu when ingested. Your remote control is also teeming with germs, having been touched by anyone that has ever used your television, as well as your carpet and couch. An easy fix to clean both your cell phone and remote are running antibacterial wipes over them once in a while to avoid coming down with severe flu symptoms. Moving away from household electronics and into self-care items, toothbrush holders have been found to be extremely dirty. Although toothpaste kills most of the germs left on the head of the toothbrush from its last use, the germs drip down the body of the brush as it dries and get caught in the holder. Toothbrushes can hold germs such as staphylococcus, which is a bacteria that causes pus formation in the skin and mucous membranes. Thus, weirdly enough, if you want clear skin, make sure you don't use the same toothbrush for more than three months.

> Kitchen sponges carry 10 million bacteria per square inch on average. Another surprisingly dirty household object is refrigerator handles, which are home to fungi such as yeast and mold.

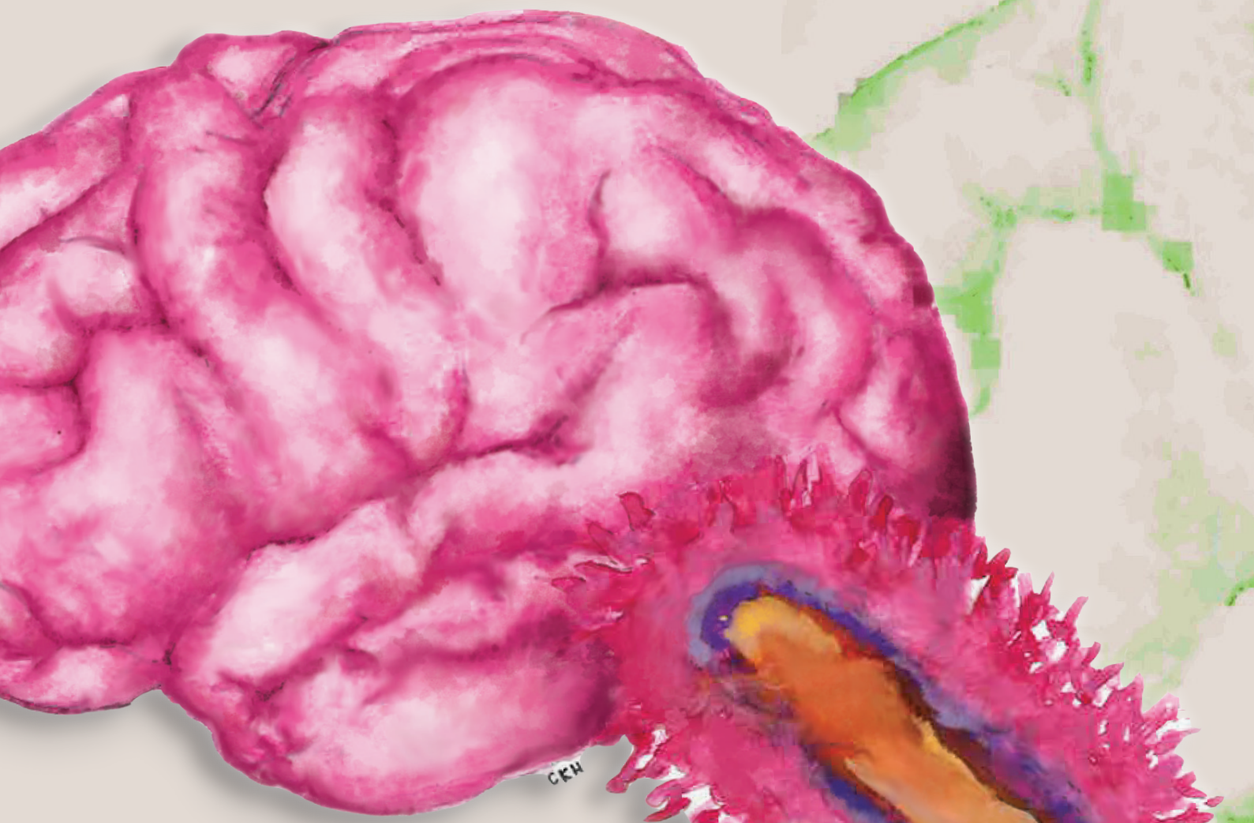
Money is, not surprisingly, heavy with bacteria because it gets passed from hand to hand so often. Most dollar bills are covered in 3,000 different types of bacteria. Other countries have plastic coatings over their currency so that it can be washed without disintegrating. Although the United States has yet to make this change, it would be a smart move health-wise. Another dirty household object that is more surprising than money is your washer and dryer machines. Viruses such as rotavirus, a group of RNA viruses that can cause acute enteritis in humans, are found in the metal drums. Enteritis is the inflammation of the intestines, which is usually accompanied by diarrhea and an especially strong pain in the small intestine. Ways to cut down on the germs that get transferred to your clothes include washing on hot whenever possible, using bleach, and drying for extra time.

We already discussed the 10 million bacteria per square inch on the average kitchen sponge but we ignored the other part of washing the dishes: drying them. Kitchen towels can hold salmonella and feces because bacteria like to grow in moist conditions, making towels a perfect environment for them. Both of these contaminants have the potential to make you vomit, so it is best to wash all of your towels after two days of use, as recommended by Charles Gerba, a professor of microbiology at the University of Arizona. So many everyday objects could be freed of germs if everyone practiced proper cleaning methods. There are a high number of items in households and in public that are never even thought about when it comes time for cleaning. Since we don't live in a world where every single object is properly cleaned at the correct time intervals, it is important to know which objects we touch everyday house the most germs in order to keep ourselves safe and informed.



You Can't Always Trust Your Gut

Written by Kallie Jiang
Illustrated by Claire Hoy



Parkinson's disease (PD) is a neurodegenerative disorder that affects around one million people each year. The disorder is characterized by severe motor impairment symptoms including tremor, rigidity, and abnormalities in posture. A key cellular feature that leads to these symptoms is the preferential degradation of dopamine-producing neurons, cells found in high concentration in areas of the brain such as the substantia nigra and the striatum. The loss of function of these dopaminergic neurons can be moderately rectified by dopamine replacement drugs; unfortunately, these therapies only superficially relieve symptoms and can, paradoxically, further impair motor skills.

The need for more effective therapies for Parkinson's disease is a call for a stronger understanding of what causes it. Choi et al., a group of researchers centered at Kyung Hee University in South Korea, suggest a seemingly unlikely culprit as a contributor to the development of motor impairment symptoms in Parkinson's patients: the gut bacteria Proteus mirabilis. This suggestion stems from the finding that some Parkinson's disease patients suffer from gastrointestinal and urological problems preceding the onset of motor symptoms, which indicates that PD might start in non-neurological tissue. Further, α-synuclein, a protein associated with Parkinson's disease development, has been found in the intestine of mice before the onset of motor impairment symptoms. There is direct evidence that α-synuclein spreads from the gastrointestinal tract to the brain via the vagal nerve in rats with PD. These discoveries, taken together, suggest that pathological changes in the intestines may induce Parkinson's disease. Analysis of the fecal microbiota of patients with severe PD showed increased amounts of bacteria from the family *Enterobacteriaceae*, suggesting that gut microbial changes may be partially responsible for Parkinson's disease progression. Since there is a dearth of more specific information behind this phenomenon, Choi et al. set out to determine which strain of gut bacteria can influence PD and a possible mechanism for doing so.

To determine which bacteria may be associated with Parkinson's disease, Choi et al., measured the number of bacterial colonies at the family level in animals with PD, then identified the bacteria that were high within specific families. The researchers orally administered these bacteria to the mice, then observed motor behaviors and relevant brain tissues. Finally, the researchers tracked direct damage of dopamine-producing neurons by analyzing change in α-synuclein, a hallmark of Parkinson's disease, levels in the brain. Choi et al. also measured amounts of α-synuclein in the colon to ensure that the protein was indeed coming from the gastrointestinal tract.

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By chemically inducing Parkinson's disease in mice three different ways, Choi et.al. confirmed that the number of *Enterobacteriaceae* was increased in mice with Parkinson's disease; they found that specifically *P. mirabilis* was increased. The researchers then treated mice in the premotor symptom stage (PS) of Parkinson's disease with *P. mirabilis* to see if the bacteria would exacerbate motor symptoms at this early stage of the disease. Treated mice showed severe motor impairment in addition to a significantly lower density of dopaminergic neurons in comparison to both mice in PS not treated with bacteria and control mice. This strongly suggests that *P. mirabilis* may contribute to the onset of motor symptoms in mice with PD. Interestingly, Choi et.al. also found that the increased presence of *P. mirabilis* in healthy mice could also induce motor deficits, further supporting the role of this bacteria in the development of Parkinson's disease.

The researchers connected *P. mirabilis* to Parkinson's disease by showing that the bacteria selectively damages dopamine-producing neurons. Choi et.al. suggest that a possible mechanism for this is that *P. mirabilis* increases α-synuclein production in neurons. Though more experiments are needed to determine the exact mechanism, Choi et.al. observed a significantly higher amount of α-synuclein filaments in the distal colon, substantia nigra, and striatum, which may mean that α-synuclein travels through the vagal nerve to the brain.

The researchers understand how to chemically induce PD in mice, but they are not clear on how the chemical inducers lead to downstream effects such as the increase of *P. mirabilis* in the gut. This raises the question: how do the researchers know that the treated mice actually have PD? Though the mouse models used by Choi et al. were useful for preliminary experiments, the research could benefit from using mice who have naturally developed PD so that the researchers could observe differences in results between mice with naturally occuring PD and chemically induced PD.

The research raises important questions. Is there a protein or other upstream factor that causes the changes seen in Parkinson's disease? Is PD entirely gastrointestinal in nature? The latter seems unlikely as some neurological symptoms of PD, such as memory loss, were not explained by the increase in gut bacteria. Regardless, recent research seems to suggest that the devastating motor effects of Parkinson's disease might simply be surface-level symptoms of pathogenesis that is not even occurring in the brain.

A possible way to determine how much gut bacteria controls PD and its symptoms would be to treat mice with the disease with antibiotics, which would significantly lower the amount of *P. mirabilis* in the gut. This would be accomplished by wiping out the PD gut bacteria and recolonizing the gut with gut bacteria typical of healthy mice. Not only would this experiment allow researchers to gauge the importance of *P. mirabilis*, but it would test the possibility of using antibiotics as a treatment for PD. Antibiotic treatment would likely only treat symptoms of the disease, as much is yet to discovered about the underlying causes of PD. However, antibiotics would not have as severe side effects as dopamine-replacing medications.

We must be cautious extrapolating what was found in chemically controlled mouse models to human patients. Though changes in gut microbiota have been observed in human PD patients, whether or not those changes reflect the extremely simple model shown in Choi et al. is yet to be seen. The chemical that the researchers used to induce Parkinson's disease in mice may have directly increased the amount of *P. mirabilis* in mice. It is possible that this same shift in the gut environment would not be seen in human patients. This question calls for a clinical trial that samples the gut bacteria of human Parkinson's disease patients and analyzes the microbiota to determine which species are being upregulated in the gut.

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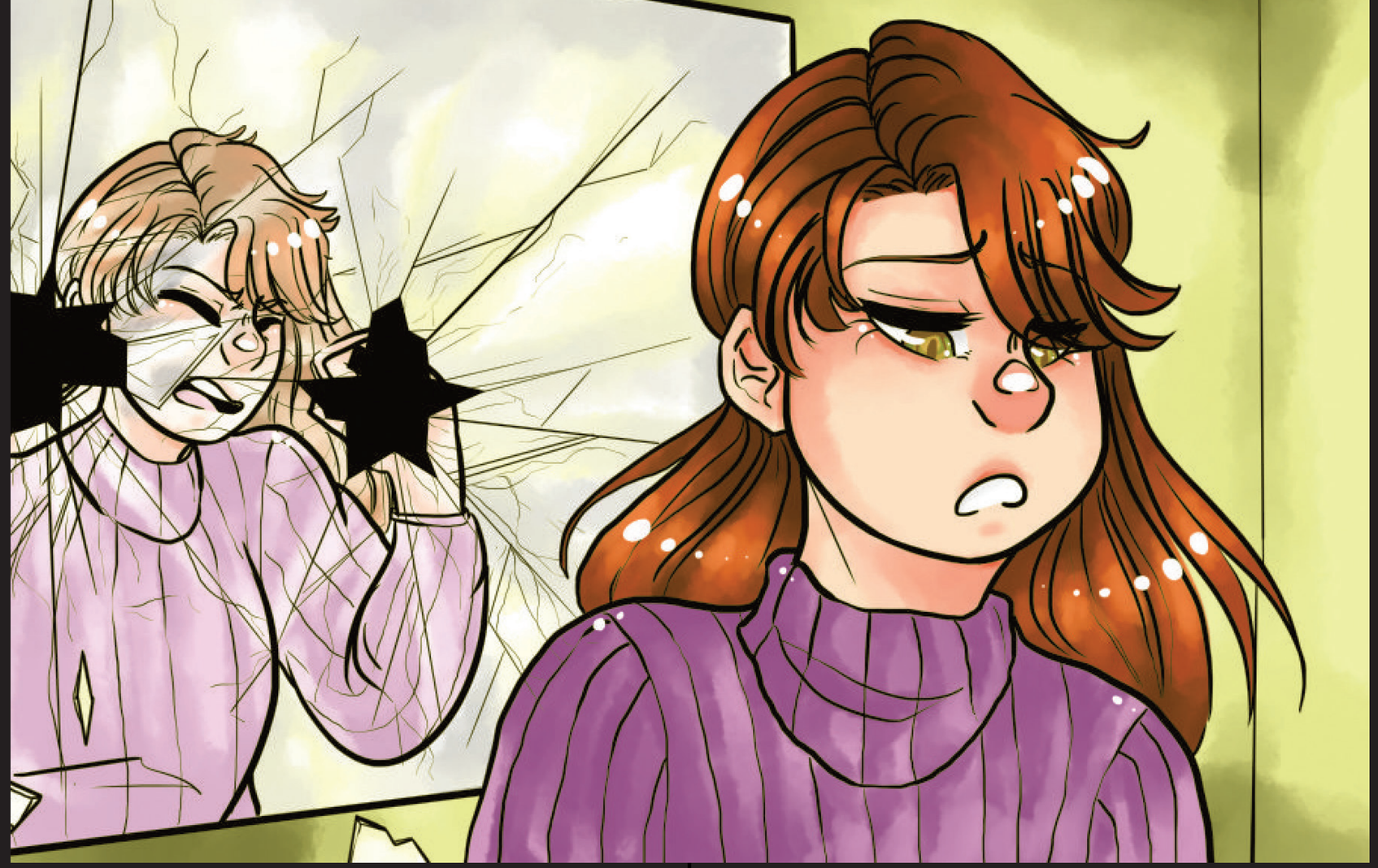
Parkinson's disease is most commonly seen as a neurological disease. People associate it with aging and brain deterioration, which is not necessarily incorrect. However, Choi et al. and other researchers have made it clear that this view is an oversimplification. With this knowledge that Parkinson's could be traced back to specific imbalances in the gut microbiota, researchers and physicians have a new basis for future experiments and therapies that could fight PD at the very core, reducing the need for superficial therapies with harmful side effects.

Impostor!

The Basics of Impostor Syndrome and How to Handle It



Written by Kirsten Heuring
Illustrated by Athina Apazidis

The other week, I was feeling rather troubled. I got a 98% on an exam for research methods. I was told by my editor at *The Oberlin Review* that I had written one of the best article openers she had ever seen. I was told that my screenplay for my cinematic storytelling workshop class was going pretty well. However, none of it felt that real to me, no matter how amazing my mom said it was. To me, it felt like anyone could have done what I did, and soon, everyone was going to realize how wrong they were. In my mind, what I had done was something anyone could have done, and everyone was going to realize sooner or later that was the truth. These people would know that I was not who they thought I was, and that I was a complete and utter fake. I was having a problem with impostor syndrome, and if what I described sounds familiar, you might have it too.

According to the American Psychological Association (APA), impostor syndrome, also referred to as the imposter phenomenon, is a mental condition that occurs when high-achieving people attribute their success to luck rather than their own hard work and talents. Psychologists Pauline Clance and Suzzane Imes first coined the term in 1978. According to Clance and Imes, people with the condition tend to fear of being exposed as impostors. As of the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), impostor syndrome is not a recognized diagnosis, but often coincides with anxiety and depressive disorders.

There are multiple risks that are said to contribute to the development of impostor syndrome. Originally, it was thought that impostor syndrome only occurred in high-achieving women. However, research has found that imposter syndrome can occur in people of any gender, but people from minority communities are more likely to develop the condition. Generally, people who are the only minority in their field are more likely to have impostor syndrome than people who are in fields full of their peers. According to a paper by researchers Kevin Cokley, Shannon McClain, Alicia Enciso, and Mercedes Martinez, Asian Americans reported higher impostor syndrome feelings than either Latinx Americans or African Americans. Also, impostor feelings predicted mental health better than minority stress status for all groups. Another risk factor for impostor syndrome is a high level of perfectionism. It can lead someone to either procrastinate on a project because they are not sure if they will reach their high goals for themselves, or someone may end up over-preparing because they feel like they do not know enough. Another factor is societal or parental expectations. In their original research, Clance and Imes noticed the study participants were expected to do well in school beginning at a young age. The higher the expectations of achievement, the more likely impostor feelings are to emerge. This is especially true in households that switch between giving extreme praise and giving extreme criticism. However, the cause of imposter syndrome is unknown, so there is still ongoing research to identify the sources.

> Impostor syndrome, also referred to as the imposter phenomenon, is a mental condition that occurs when high-achieving people attribute their success to luck rather than their own hard work and talents.

Feelings of impostor syndrome can also be triggered by certain events. For instance, if someone is attempting a new project, career, or other endeavor, they are more likely to experience impostor feelings because they feel unready for what comes next. Many people who have impostor syndrome are graduate students. According to psychiatrist Carole Lieberman, it is because grad students are in an "in-between" state of their professional lives; they are not quite out of school, but they are doing more than they did in undergrad.

Despite the problems that impostor syndrome causes, there are ways to combat it. First, one must recognize their impostor feelings. If you notice you are having impostor feelings, try writing them down or changing your thought process. For example, instead of thinking "I am not qualified at all for a lab position," a person can refuse the first statement and correct it by thinking "I might not be completely qualified, but that is okay since no one can be completely prepared for everything." This helps take the mental pressure off of a person's thoughts. If someone with the syndrome focuses on noticing their impostor thoughts and modifying them, eventually their feelings about themselves will change. However, this needs to be done gradually over a period of time since many of these thoughts tend to be ingrained into one's thought processes. Another way someone can battle impostor syndrome is by acknowledging compliments. Instead of brushing off praise, a person can accept it and attempt to see where the complimenter is coming from. For other people, starting to recognize when problems are not their fault could help with impostor feelings. Taking note of when things go wrong and figuring out which things can be attributed to chance or other causes besides human error may be a good step for that.

> One of the best ways to fight impostor syndrome is to talk to others about it.

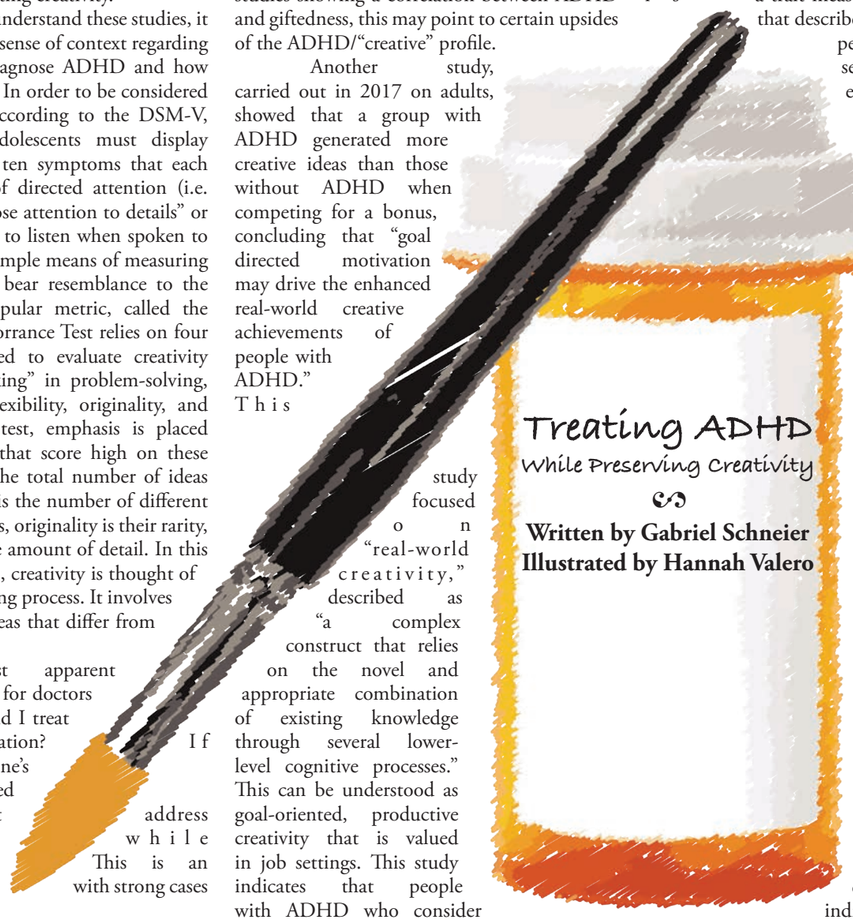
One of the best ways to fight impostor syndrome is to talk to others about it. Many people with the imposter phenomenon do not talk to others about their thoughts. However, if people discuss their performance with others, they can figure out if other people feel the same way they do. Maybe other people are just as confused or lost as they are, and knowing that can be reassuring. A person with impostor syndrome can talk to a group of friends or classmates or a single trusted person like an advisor, a professor, a best friend, or a psychologist. Any trusted person who knows your strengths and weaknesses can help to lessen the feelings. For people who are worried about talking to other people about their impostor feelings, there are relatively anonymous online communities where people can explain their impostor feelings and help each other sort through them.

For those who have impostor syndrome, know you are not alone. In an interview with The New York Times, Maya Angelou admitted that despite her success, she still worries that people will discover she has "run a game on everybody." Even Oberlin College's own Professor Rebecca Whelan, chair of the Chemistry and Biochemistry Department, admitted to her own problems. In her college education, she wanted to graduate summa cum laude. She worked her hardest, but as soon as she achieved her goal, she thought anyone could have done what she did, and it was not a big deal. Even the most amazing and accomplished people can have problems with impostor syndrome. Just because you have it does not mean it is a sign of failure.

For my own bouts of impostor syndrome, I tend to make jokes. When I texted my mom that I was getting to write this article on impostor syndrome, I joked that it was not a big deal and anyone could do it. (She did not get the joke until I explained it.) I have been trying to change my thoughts and be gentler on myself, correcting myself when I think I am not smart enough or I do not know enough to apply for research opportunities. Instead, I tell myself that I am still learning, and it is not bad for me to apply and learn more. It will take some work for me to ever be comfortable with myself and my abilities, but hopefully I can take the right steps from here to work on myself.

Treating ADHD While Preserving Creativity

Written by Gabriel Schneier
Illustrated by Hannah Valero



Many people with ADHD struggle with knowing how and when to treat it. Especially at a school like Oberlin where creativity is highly valued, it can be tricky for people to treat their ADHD with medication while holding on to the creativity and spontaneity that are vital to their personality. Fortunately, there has been extensive research done recently on this topic that can help us understand the complex relationship between ADHD treatment and facilitating creativity.

In order to understand these studies, it is necessary to have a sense of context regarding how psychologists diagnose ADHD and how they define creativity. In order to be considered as having ADHD, according to the DSM-V, older adults and adolescents must display five out of a list of ten symptoms that each characterize a lack of directed attention (i.e. "often fails to give close attention to details" or "often does not seem to listen when spoken to directly"). There are ample means of measuring creativity, but many bear resemblance to the oldest and most popular metric, called the Torrance Test. The Torrance Test relies on four scales which are used to evaluate creativity and "divergent thinking" in problem-solving, including fluency, flexibility, originality, and elaboration. In the test, emphasis is placed on generating ideas that score high on these scales — fluency is the total number of ideas generated, flexibility is the number of different categories of responses, originality is their rarity, and elaboration is the amount of detail. In this test, and many others, creativity is thought of as a non-linear thinking process. It involves novel, imaginative ideas that differ from the norm.

The most apparent question that follows for doctors and patients is: should I treat ADHD with medication? If these aspects of someone's personality are a mixed bag, can treatment address negative symptoms while preserving the good? This is an ongoing debate, with strong cases on both sides.

A few recent studies show interesting findings. One report from 2006 tested the performance of children with and without ADHD on measures of creativity. They used four groups: children with ADHD who are creative, children with ADHD who are not creative, those who are creative without ADHD, and one control. They found that 40% of creative children showed levels of ADHD symptomatology without classifying as ADHD. Furthermore, they found that the children with ADHD underperformed in certain cognitive measures, but those with ADHD and creativity outperformed the rest in all other measures. The symptoms of ADHD coincide with many typical traits of creative people, and this study further indicates this correlation. The most striking aspect of this study was the finding that children with ADHD and creativity outperformed all other categories on many tests. Taken in conjunction with other recent studies showing a correlation between ADHD and giftedness, this may point to certain upsides of the ADHD/"creative" profile.

Another study, carried out in 2017 on adults, showed that a group with ADHD generated more creative ideas than those without ADHD when competing for a bonus, concluding that "goal directed motivation may drive the enhanced real-world creative achievements of people with ADHD." This study focused on "real-world creativity," described as "a complex construct that relies on the novel and appropriate combination of existing knowledge through several lower-level cognitive processes." This can be understood as goal-oriented, productive creativity that is valued in job settings. This study indicates that people with ADHD who consider themselves creative can succeed especially in certain scenarios, namely those in which they are most driven. In these high-pressure situations, people with ADHD tend to outperform those without. In other tests, those without ADHD demonstrated similar levels of creativity, but ultimately did not report as many real-world creative achievements. This suggests that perhaps ADHD can define the settings in which creativity is expressed, and how it is expressed — an idea that could help doctors navigate the pitfalls of treatment.

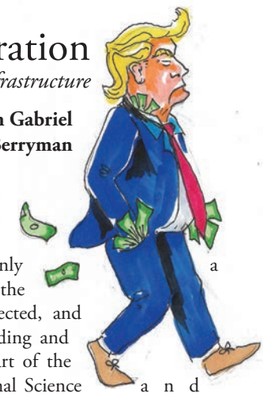
There are fewer studies that actually delve into the ways in which medications actually work, but there have been some that hold promise. One study at the University of Amsterdam in 2017 found that one ADHD medication known as Concerta increased creativity in people who rated low in measures of novelty-seeking, while it decreased creativity in those who measured high. Novelty-seeking is a trait measured by psychologists that describes how often and how persistently individuals seek out new experiences and risks. As is suggested by the study from the University of Amsterdam, and many others, people with ADHD tend to perform better in high-pressure or high-risk situations. In many cases, this leads people with ADHD to seek out those situations in which they know that they can unlock their creative potential. The researchers sum it up as, "These findings highlight the role of the dopaminergic system in creativity, and indicate that among healthy individuals NS [novelty seeking] can be seen as a predictor of the effect of MPH [active ingredient in Concerta] on creativity." This indicates that treatment must be tailored to the individual in order for it to effectively work without having a negative impact on creativity.

There is much more work to be done, but this study shows promise in that it provides concrete advice for doctors. With new medications constantly under development, it is an ongoing project to study each one and try to gauge the best practices for its use.

Science Policy in the Trump Administration

How the Trump Administration is Altering the Federal Science Policy Infrastructure

Written by Gailyn Gabriel
Illustrated by Aria Berryman



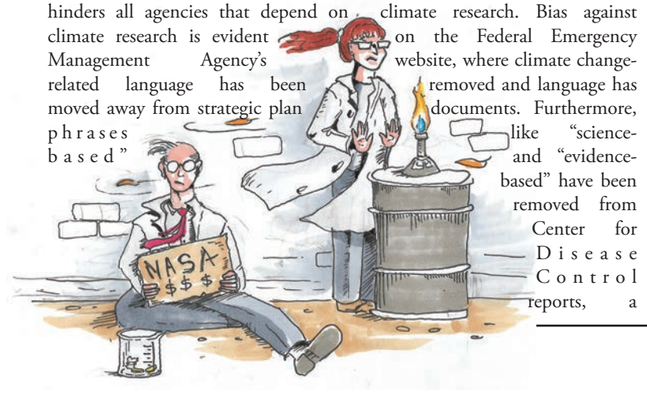
The Trump administration does not care about science, and it is apparent. On the heels of the second March for Science, the state of science policy in the U.S. has made more backslides than gains. The Trump administration's science policy is political and purposefully inefficient, and here I present several examples of its deliberate neglect of national scientific policy.

The reduction and neglect of the main vehicle for science policy, the Office of Science and Technology Policy (OSTP), can be observed in its new, yet vacant, website. Browsing whitehouse.gov is an experience unlike visiting any other presidential website up to this point in U.S. history. Trump's white house.gov is broken into a few strictly defined categories, and finding the pages for OSTP is a challenge. Compared to its precedent, the new website is desolate and offers only an email for outreach and more information about the actions of the agency. It offers shallow reports and describes the state of different areas of science like "energy dominance" and "innovation". OSTP generally plays a large role in STEM education, but this function of the agency is not prominent on the agency's site.

Despite the fact that the Trump administration has proposed massive budget cuts to most science agencies, it is a relief to say that most science-related government agencies—excluding the Environmental Protection Agency (EPA)—actually received budget increases for 2018-2019. The efforts of citizens and scientists pushing Congress to protect science are behind these budget increases. In the budget for the 2018 fiscal year, Congress allowed for a $5 billion increase across a number of different scientific agencies. While this is good news for most researchers, the existing guarantees only last until October 2019.

Funding for research institutions like NASA and the National Science Foundation (NSF) are the same as 2017 budget allotments and follow long-term funding trends. However, the National Institutes of Health (NIH) received a disproportionately large increase of $3 billion dollars—a budget jump that shocked researchers and slightly concerned scientist beyond the biosciences. The Trump administration's budget increases echo spending increases of the 1990s and early 2000s, in which federal spending prioritized biomedical research over other physical science research. In the late 20th and early 21st centuries, cancer research was under national scrutiny and science policy focused around "cancer moonshots"—the pouring of absurdly large amounts of money into a cure for cancer. These spending trends resulted in unintentional funding gaps between the NIH and other science groups, such as National Institute of Standards and Technology and NSF, that favored the NIH. These funding discrepancies became the standard in fiscal budgeting, and the Bush-era advisors that encouraged the changes could not mend them because of the difficulty of undoing mistakes in policy and budgeting.

While organizers in 2018 were able to protect funding for most science agencies, the Trump administration is most aggressive toward the EPA, which received significant budget cuts, and represents the Trump's administration's climate change denial. Cutting the budget of the EPA hinders all agencies that depend on climate research. Bias against climate research is evident on the Federal Emergency Management Agency's website, where climate change-related language has been removed and language has moved away from strategic plan documents. Furthermore, phrases like "science-based" and "evidence-based" have been removed from Center for Disease Control reports, a language change that calls into question the value of scientific research and the constant search for quantifiable evidence to support the creation of scientific policy.



Research funding is only a small aspect of science policy making, and the greater issue is how funding is granted, directed, and invested. Coordinating scientific research funding and policy advice is an involved task. Thus, as part of the science policy boom of the 1990s, the National Science and Technology Council (NSTC) was formed by executive order in 1993. Today, NSTC still functions at the cabinet level. As a sub council of the Office of Science and Technology Policy, the NSTC is an interagency body designed to ensure quality and consistency in science policy, as well as to integrate the federal agenda across industries. This body forms policies around science issues relevant to the president and Congress, like the Zika virus outbreaks, Ebola containment, and issues of clean water availability in the U.S. The NSTC also works internationally, forming science policy around global change and working with international research agencies. In moments of emergency, outbreak, and disaster, the NSTC serves as a resource for scientific expertise. The group contains a variety of high-ranking scientists throughout the federal government and is the active arm of U.S. science policy. Under the Trump administration, however, many positions in NSTC are vacant. In fact, a high number of science positions in the federal government are vacant.

Key positions that are vacant as of April 2018 are as prominent as the Science Advisor to the President and and chief science officers in the U.S. Department of Energy. Many Senate-confirmed positions still lack nominees, and some nominees have faced difficulties with Senate confirmation, resulting in an unprecedented number of long-term vacancies. In some cases, the vacancies are less a matter of neglect and instead are intentional. The Trump administration is intentionally making the federal science system inefficient, especially in areas of science that would counter their views. For example, Trump's choice for NASA Administrator, Jim Bridenstine, was recently approved by the Senate—though with a bitter party split on the floor. Bridenstine not only lacks a technical background in areas of scientific aerospace research, but will also be the first elected politician to lead NASA.

There are numerous cases of the Trump administration filling high-ranking science positions in the federal government with candidates that are ideologically charged or lacking basic qualifications. This raises the question of whether the Trump administration is practicing anti-intellectualism in its hiring choices or lack thereof. Anti-intellectualism presents itself as distrust in the intentions and ideology of "intellectuals" and the academic establishments that produce them. Anti-intellectualism is apparent throughout many federal departments, but is concentrated in the area of science policy. To this day, Trump has not appointed anyone to the position of Science Advisor to the President, and has only been rumored to be considering candidates with little scientific background, though with more political experience and ties within Trump's network. The de facto science advisor is the appointed deputy assistant in the OSTP, Michael Kratsios, a climate change-denying 30-year old with a degree in political science.

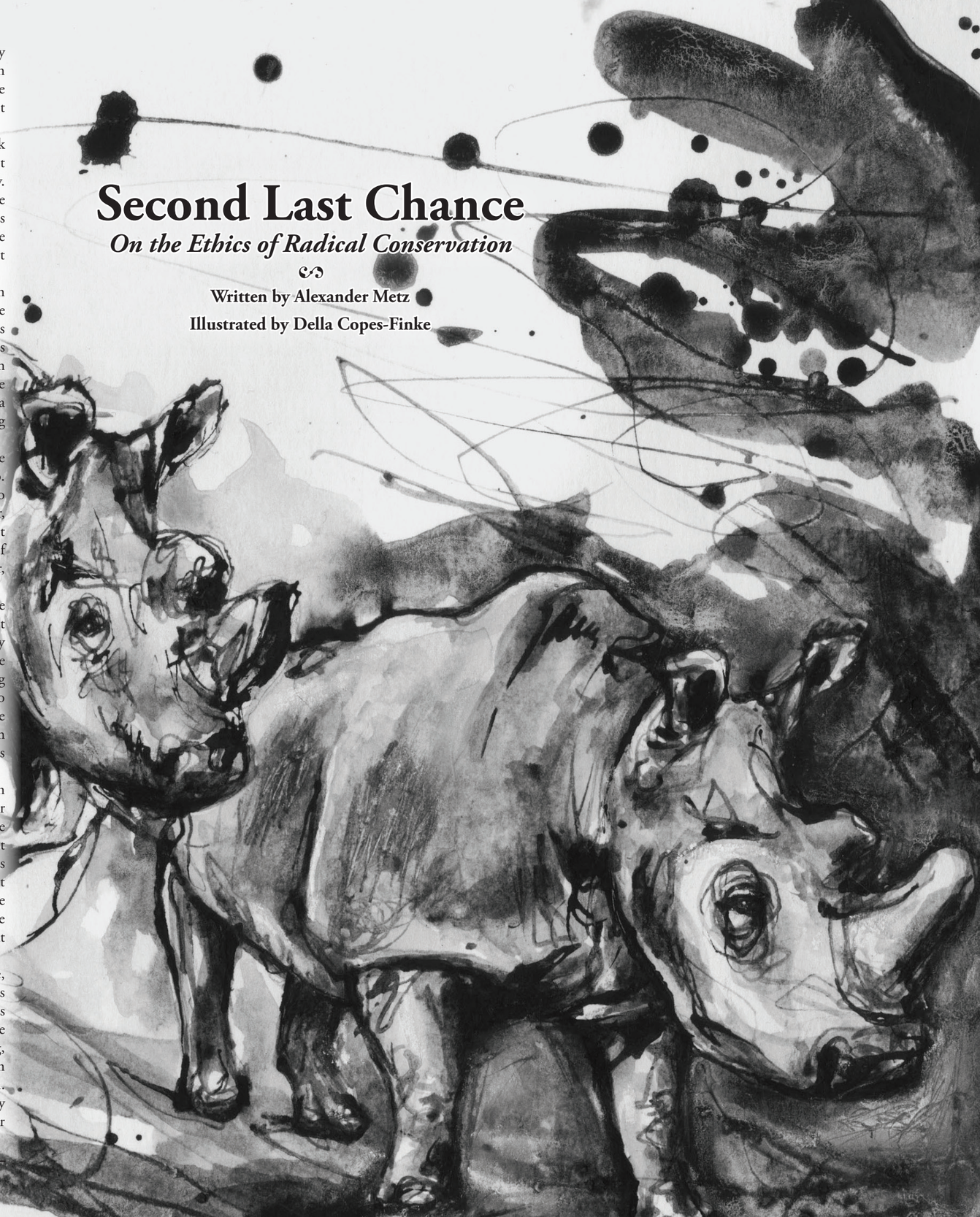
Federal science policy is being altered along these lines daily. All sciences will face censorship of keywords and phrases as well as a general inefficiency in the departments that represent them. While much is being done and undone in the world of science policy, many scientists are carefully watching Trump's political science. The collective action of scientists speaking out, organizing, and defending science has encouraged Congress to also defend science, as can be seen in the fiscal budget. By relaxing regulations, hiring inadequately, and controlling access to information, the Trump Administration is working to shape U.S. science along its political agendas.

Second Last Chance

On the Ethics of Radical Conservation

Written by Alexander Metz

Illustrated by Della Copes-Finke



As many might already be aware, the Northern White Rhino is now functionally extinct. The last male of the species died in March 2018, leaving only two related females, both too old to have any real chance of breeding successfully. This being the case, it seems that the species is doomed to oblivion; consigned, like many other species that have crossed paths with human beings, to the pages of books and to our memories and imaginations.

That being said, the White Rhino may yet have a chance at survival. Scientists around the globe have preserved sperm, egg, and tissue samples from many members of the species. These samples could theoretically be used resurrect the creature through either in vitro fertilization or some more fantastical technology (say, cloning). However, it does seem worth asking, now that the damage has been done, whether forcing the species back into existence would be in humans', the rhino's, or the planet's best interest. Given the high black market value of rhino horn, it seems that any new members of the species would either have to live in captivity, or run the risk of being poached, neither of which seems to be in the best interests of the animal.

Another reason we might think that reincarnating the White Rhino is ethically problematic is because of the immense costs and difficulty of doing so. The most commonly suggested, and most plausible, way of reviving the species is IVF (in vitro fertilization). In a nutshell, IVF involves taking eggs from one of the two females left alive (or from previously preserved samples), fertilizing them with harvested sperm, and implanting them in a Southern White Rhino (the species' closest relative) surrogate.

However, as is so often the case, this is easier said than done. In the past decade, IVF in rhinos has resulted in fewer than ten births. The process is extremely expensive and incredibly complex. It is, in fact, so complex that researchers do not, as of yet, have a means of implanting embryos with any surety of success. This process is not made easier by the fact that rhinos can weigh in the ballpark of two tons and are not known for being particularly cooperative.

As a further illustration of the difficulty of this procedure, let's look at human IVF. Though IVF is a relatively common in humans, it still has a less than 50 percent success rate even under perfect conditions where the surrogate is in perfect health and fairly young,is taking fertility drugs, and the embryos are in as good a condition as they can be. That means that when the IVF process has gone perfectly, the odds of this working correctly are no better than flipping a coin. Human IVF also costs roughly 20,000 dollars per attempt, which is not exactly cheap, but there is reason to believe (when you factor in the additional transportation costs and specialists that would be required for rhino IVF) that the figure could be multiplied by a factor of five or ten. National Geographic quotes a researcher saying the price tag could be as high as 9 million for the successful birth of a calf.

Even if we think the benefits outweigh the costs, there's also the hiccup that, in order for any population to be genetically stable, that is to avoid inbreeding, there needs to be a few dozen genetically unique members of the species. If you'll recall, there are currently only two related members. Although it's not impossible to overcome this bottleneck, (the 20,000 Southern White Rhinos that exist today are all the descendants of an original population of 30) it is also not easy. There's a big difference between a breeding herd of 30 and two aging females. Even if a population could be created it would require maintenance and protection.

Otherpossible routes to the creature's salvation are through cloning, hybridization (with the Southern White Rhino), and/or stem cells. This is a sort of kitchen sink approach intended not so much to save the rhino as to preserve some aspect of it. Indecently, these are also the techniques researchers say could be used to bring back the Woolly Mammoth, a species that has been extinct far longer than the Northern White Rhino. However, all these techniques are in their infancy, none have ever been used on a rhino, and they would likely be almost prohibitively expensive.

Therefore, the prospects for bringing the White Rhino back are slim. In the future, cloning technology might advance to an extent where producing full organisms from a small genetic sample is easy. However, as it currently stands, the difficulty of producing viable embryos is simply too high. All things considered, some conservationists argue that it would be better to devote the resources IVF would require to other causes, say preserving currently endangered species that might have a better chance of survival.

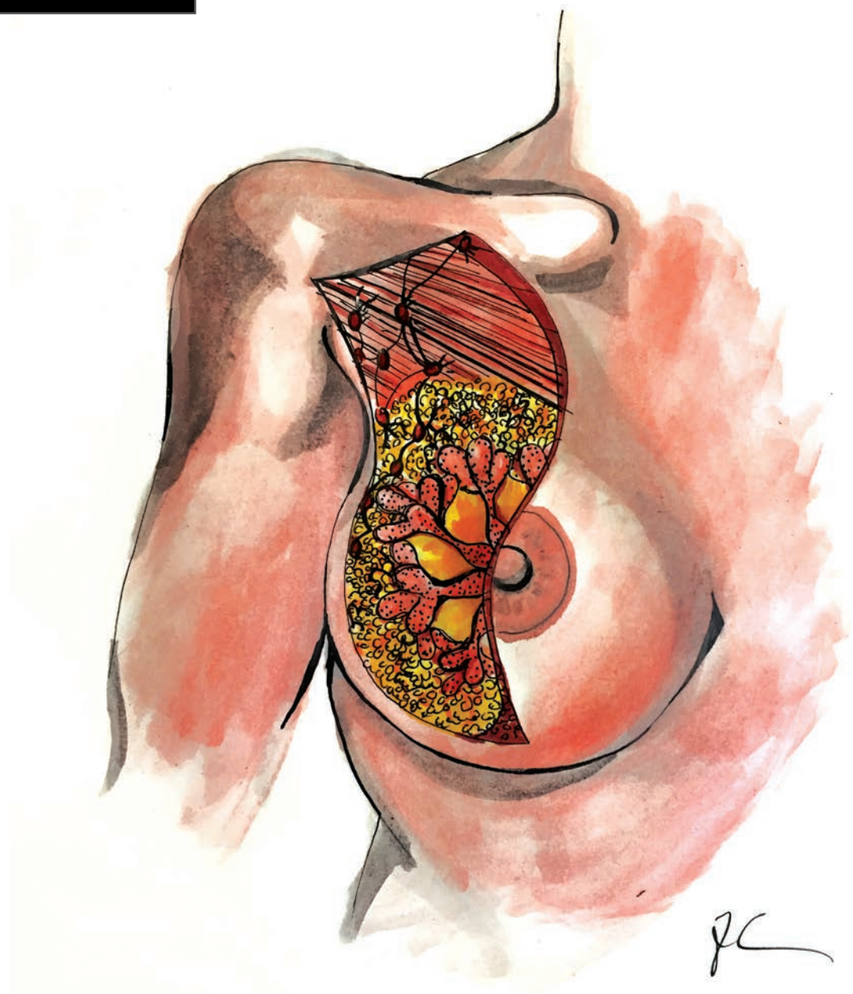
As a point of clarification, the above inquiry is distinct from the question of whether or not Northern White Rhinos ought to have become endangered/extinct in the first place. The answer to this is obviously no. However, this leads to another question. Whether it is ethical to bring a species back from extinction. If you've seen the film Jurassic Park you're familiar with the concern here. However, there seems to be a morally relevant difference between bringing back a species whose extinction was caused by natural selection, and bringing back a species that was hunted to extinction by humans.

Therefore, one may well think that preservation of the species rights some transgression humans have imposed on the rhino. This notion has a sort of intuitive appeal: since we caused them to go extinct, we ought to cause them to become un-extinct. However, there are several reasonable objections to this line of thinking, apart from the aforementioned financial concerns, that suggest the revival of the Northern White Rhino would be good neither for ecosystem nor, counter intuitively, for the rhinos themselves.

For one thing, insofar as poaching is still an extremely extensive problem for wildlife conservationists, any animals that were brought back to life would be targets for poachers. This seems a particular worry if the goal of conservation is to reintroduce a herd of rhinos into the wild. One might propose the counterpoint that stricter anti-poaching regulations, along with a potentially dwindling demand for rhino horn, might help keep new rhinos safe. However, even if this were the case and future rhinos truly would be able to live their lives free from human intervention, there's a subtler ecological concern that makes reintroducing the species seem less than ideal.

Namely, in that the White Rhino hasn't existed in the wild in any significant numbers for decades, there is some concern that either the habitat would no longer suit them, or they would no longer suit the habitat. If a sufficient amount of time is allowed to pass (say the amount of time required for scientists to produce a viable herd of rhinos) it is likely that the species' former habitat will have adapted to life without them. Therefore, the White Rhino could effectively become an invasive species in its own territory, causing a more ecological damage than the initial extinction. Possibly more likely is the converse, that the habitat would no longer be able to provide for a large number of rhinos.

In either case, it seems irresponsible to, in the current climate, bring back a creature only to see it suffer (whether that suffering comes from poaching or lack of resources). And, since breeding the creatures to exist solely in captivity seems cruel in its own sense, there seems to be moral reason to believe the species should, at least for the time being, remain extinct. Hopefully, in the near future, something will happen that will allow the White Rhino to return without fear of persecution. Until that time however, I suggest that we keep these creatures in only our thoughts, so that their non-existence may protect them from further pain.



RNA Interference for Therapeutic Treatment of Breast Cancer

How to Tackle the Issue of Multidrug Resistance

Written by Carson McCann
Illustrated by Zoe Cohen

Science fiction often projects ideas that seem absurd at the time of their release, but as time endures and scientific knowledge expands we find those otherworldly ideas become a typical part of life. Star Trek's Captain Kirk used the equivalent of a cell phone years before its invention. John Brunner's *Stand on Zanzibar* foretold of motor vehicles powered by rechargeable electric fuel cells. Car companies like Tesla, Porsche, and BMW are designing and selling electric sports cars. Further, Aldous Huxley's *Brave New World* depicted a future in which children are genetically modified by changing their developing environments. Despite the shocking thought of genetically-engineered children, modern society is taking steps toward the ability to selectively modify the human genome, and its potential is limitless.

Gene expression control has remained a heated topic of debate due to the ethical issues relating to its far-reaching potential. Research has demonstrated the ability to control gene expression by placing a blockage in the very central dogma of biology. The dogma states that our hereditary information passes from deoxyribonucleic acid (DNA) to ribonucleic acid (RNA) via the process of transcription. The RNA is then transcribed and protein expression leads to phenotypic observation. Therefore, researchers contemplated the idea of blocking the passage of information from RNA to protein expression. Studies have found that if you design a complementary sequence of RNA for a specific gene and inject it into a cell you can 'erase' its expression via a gene knockout. This process of gene expression control is termed RNA interference (RNAi). The ability to manipulate the expression of genes can reach as superficially as changing hair color or as impactful as treating and preventing deadly diseases. Breast cancer remains a disease of high morbidity and mortality due to the proximity of the targeted tissue to other vital organs. Cancerous cells in the breast can metastasize to regional lymph nodes, bone marrow, the lungs, and the liver. A metastasis in any of these areas is often fatal. RNAi's ability to 'knock down' the expression of an overexpressed gene has been shown to be applicable in combating the dilemma of multidrug resistance, when cancer cells evolve a resistance or immunity to drugs that were once successful. Although RNAi can be used to directly kill cancer cells, its ability to enhance the activities of other drugs is extremely valuable for combination drug therapy.

Before we can understand RNAi's ability to treat cancer patients, it is important to appreciate the pathway by which RNAi works. The mechanism for RNAi is a complex interplay of RNA modifications, enzyme guidance, and variable mRNA regulation. The mechanism starts when a double-stranded RNA (dsRNA) is injected into the cell. When dsRNAs are present in the cytoplasm of a eukaryotic cell, an enzyme called Dicer will recognize and cut the RNA into approximately 22 nucleotide-long strands. The processed product is termed small interfering RNA (siRNA). RNA-induced silencing complex (RISC) then recognizes the siRNA. RISC contains a protein called Argonaute, which binds to the RNA and has endonuclease activity. The RISC-Argonaute complex will splice the siRNA into a single strand, after which it will use the single-stranded siRNA sequence to cleave a specific complementary messenger RNA (mRNA) in the cell. If the siRNA sequence matches the targeted mRNA sequence exactly, RISC will cleave the strands for mRNA degradation. However, if there is only partial complementarity with the siRNA sequence, there will just be translational inhibition. In both scenarios the translation of proteins is blocked for the specific gene. The ability to knock down the expression of a gene has intrigued cancer researchers. Breast cancer is a disease characterized by mutations leading to the overexpression of oncogenes and a subsequent loss of function of tumor suppressor genes. In addition, cancer cells' constant aberrational mutations promote resistance to designed drugs. Researchers have found that RNAi techniques can knock down critical hyperactive oncogenes and induce sensitivity to cancer treatment drugs. Due to the prevalence, mortality, and morbidity of breast cancer in the human population, RNAi could serve as an essential therapy to save lives.

> The ability to manipulate the expression of genes can reach as superficially as changing hair color or as impactful as treating and preventing deadly diseases.

Resistance to chemotherapeutic drugs is a serious challenge faced in the clinical practice to induce apoptosis in tumor cells. Most anti-tumor drugs induce programmed cell destruction, but cancer cells can develop a resistance to the antineoplastic medicines. This resistance can extend to multiple substances in a process known as multidrug resistance (MDR), which ultimately hinders the effectiveness of chemotherapy. Many forms of MDR come from the overexpression of ATP-binding cassette transporters, which are transmembrane proteins that use ATP to move a substance from one side of the membrane to another. One example of a significant ATP-binding cassette transporter in cancer is the breast cancer resistance protein (BCRP).

BCRP facilitates MDR by pumping toxic substances out of tumor cells. Upon initial chemotherapy treatment, the cancer cells do not express BCRP at a sufficient level to adequately transport the apoptosis-inducing chemicals outside the cell. Most of the cancer cells will die; however, one of the key traits of these cells is their tendency to mutate at a rapid rate. Eventually, a cancer cell will likely adapt in such a way to survive the chemical treatment. Natural selection will isolate those adaptive cancer cells, and as a result, the cancer cells become resistant to the drug. Cancer cells adapted to survival often have increased production of BCRP. Overexpression of the transport protein reduces intracellular drug concentration and decreases cytotoxicity.

Ee et al. found success in diminishing MDR by downregulating BCRP expression using an siRNA specific to the gene. The group found that BCRP mRNA and protein levels significantly decrease twenty-four hours after siRNA transfection. They then performed cytotoxicity analyses on the siRNA-transfected cells to determine if there was an increase in sensitivity to chemotherapy drugs, specifically the antineoplastic agents mitoxantrone and topotecan. While mitoxantrone and topotecan have been found to be initially successful, their effectiveness decreases over time with MDR. The cancer cells were found to be sensitized to the two tested BCRP substrates. In addition, the cancer cells had enhanced intracellular accumulation of the chemotherapeutic drug. These results support siRNA deliveries as a potentially viable technique to combat MDR during chemotherapy.

Breast cancer is a significant and deadly disease in many modern societies. Breast cancer, like other cancers, is often initiated from an overexpressed gene leading to hypermorphic proteins and unregulated cell proliferation. Current chemotherapeutic substances can induce apoptosis and prevent cancer cells from proliferating and metastasizing. However, clinical practitioners using these strategies face difficulties with drug toxicity and cancer cells' ability to develop resistance to the drugs through increased expression of proteins that remove toxic compounds. RNAi appears to safely neutralize the proliferation, migration, and differentiation of cancer cells by selectively knocking down gene expression. RNAi can be exogenously transfected as dsRNA to be processed by Dicer into siRNA. The RISC-associated Argonaute will then bind to the siRNA, and the complex will facilitate endonuclease activity on a complementary mRNA strand to target specific gene expression for mRNA degradation or translational inhibition. Researchers have taken advantage of RNAi's knockdown capability to combat MDR and enhance the effectiveness of different chemotherapeutics.

The advancement of RNAi versatility could potentially be applied to combat all types of cancer. The ability to downregulate specific gene expression and enhance the performance of other drugs immensely increases the capacity of personalized drug design for cancer care. A system in which personalized drug design is commonplace would enable researchers to find the genotypic mutation specific to a tumor cell. Consequently, researchers could design an siRNA to target the exact mutation responsible for the cancer. It is likely that the world of oncology will revolve around genetic techniques, and RNAi has been the champion of the current era. ●

For more information about gene manipulation, check out the 2004 article "Unlocking the potential of the human genome with RNA interference" featured in volume 431 of *Nature*.

I remember reading a New York Times article a while back, entitled 'Prozac Nation is now the United States of Xanax'. It was about the explosion of anxiety disorders in not only the general population, but also in college students. The number of Google searches about anxiety has doubled in the last fifty years while the number of searches about depression has remained constant. According to the National Institute of Mental Health, 38% of girls and 26% of boys between the ages of 13 and 17 have an anxiety disorder. On college campuses, anxiety is the most common mental health concern.

Selective Serotonin Reuptake Inhibitors (SSRIs) are often the first line of defense against anxiety disorders, after therapy. This has lead to the general perception that the cause of anxiety disorders is a lack of serotonin in the brain. However, most recent studies have shown that this is not the case. And because SSRIs are so widely used, this misperception is problematic.

Serotonin is a neurotransmitter, which is one of the ways in which neurons communicate with each other. Neurons release neurotransmitters into synapses, which are the gaps in between neurons. The neuron that releases the neurotransmitter into the synapse is called the presynaptic neuron and the neuron that the neurotransmitter is "talking" to is called the postsynaptic neuron. Serotonin is commonly thought of as one of the "happy chemicals," but its effects are very complicated.

SSRIs increase the concentration of serotonin in synapses. Generally, after a presynaptic neuron releases a neurotransmitter, there needs to be a mechanism in place to "clean up" the synapse. Otherwise, synapses would be clogged up with neurotransmitters. One of the ways that neurons clear the synaptic cleft is by reabsorbing serotonin into the presynaptic neuron through a process is called reuptake. SSRIs increase concentration of serotonin in synapses by preventing the presynaptic neuron from reabsorbing the serotonin in the synapse. They block the serotonin reuptake transporter, so there will be more serotonin in synapses.

While SSRIs were originally intended to help with depression, they are now used to help with a host of conditions including anxiety disorders. Oftentimes, the general public takes this to mean that anxiety stems from a decreased concentration of serotonin in the brain. This, however, is an oversimplification which many recent studies have shown to be false. The latest research suggests that in the short term, increased concentrations of serotonin actually increase anxiety even though long term increases in levels of serotonin in the brain do help decrease anxiety.

> Selective Serotonin Reuptake Inhibitors (SSRIs) are often the first line of defense against anxiety disorders, after therapy.

> While SSRIs are effective in treating many anxiety disorders, we don't really have a clear understanding of how they work.

One explanation of why this may be the case can be explained by looking at how SSRIs affect people who take them. SSRIs generally take a few weeks to begin working. The lack of immediate effects indicates that there is not a direct correlation between higher levels of serotonin and decreased anxiety. Furthermore, the initial side effects of SSRIs look a lot like an an increase in anxiety levels! According to the UK's National Health Service (NHS), side effects of SSRIs include "feeling agitated, shaky or anxious; insomnia or drowsiness; suicidal thoughts; and a desire to self harm," and these side effects typically decrease over time.

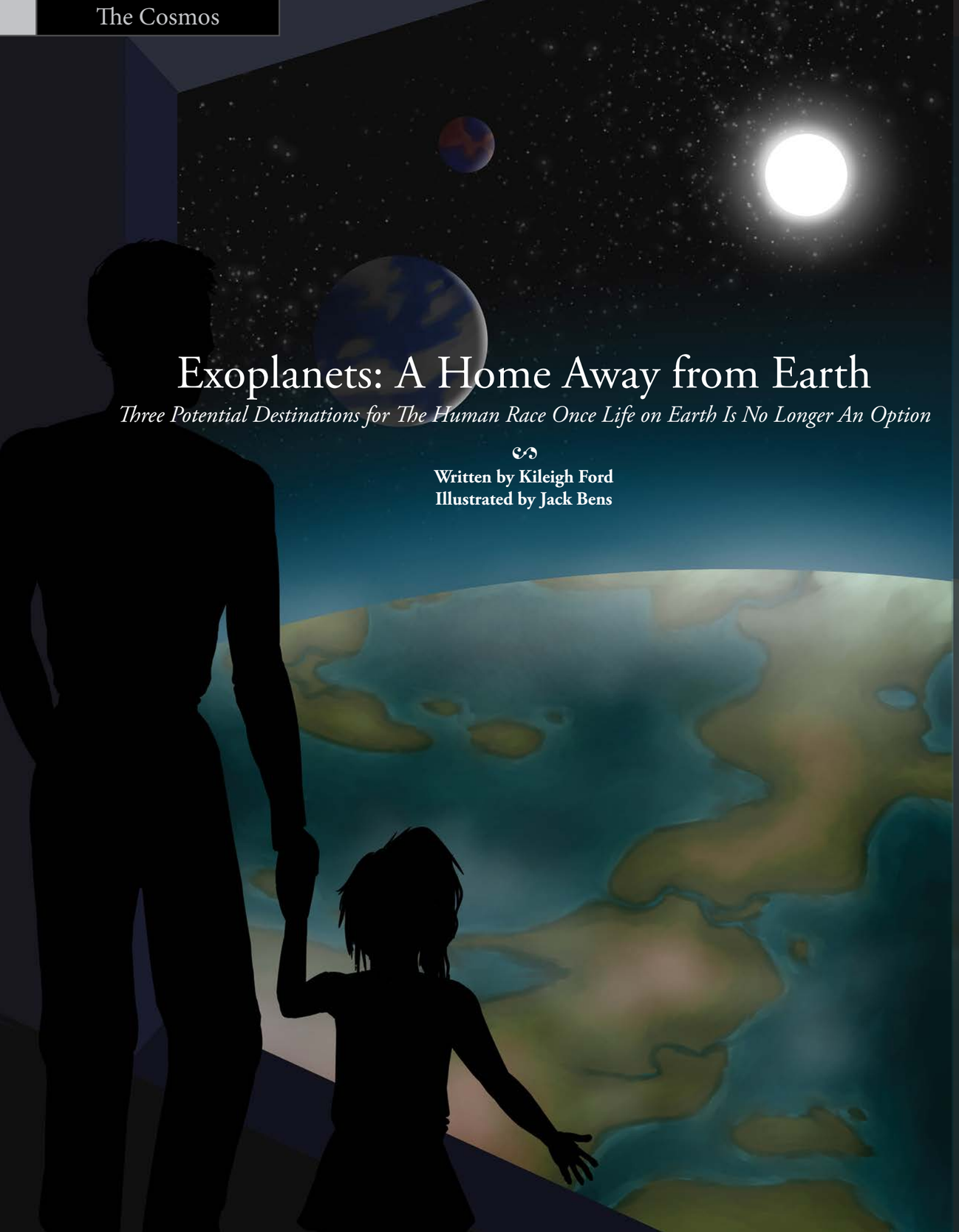
A recent study (Marcinkiewcz et al., Nature, 2016) looked at the neurocircuitry of serotonin in mice and also found results that align with this idea that serotonin initially increases anxiety level before mitigating anxiety. The researchers found that both SSRIs and paw-shocks to mice increase symptoms of anxiety with an increase in serotonin levels. Serotonin is produced in the dorsal raphe which projects into the Bed Nucleus of the Stria Terminalis (BNST). In rats, the increased serotonin interacts with and inhibits a different neural circuit in the BNST that silences anxiety decreasing outputs. The BNST projects to the ventral tegmental area (VTA) and lateral hypothalamus. These areas are associated with mood and relieving anxiety. When the BNST is inhibited, these areas are also inhibited. All of this together means that increases in serotonin increase anxiety. While we don't have concrete evidence that this pathway exists in humans, there are surprising similarities between rodent brains and human brains. Through further study, we may be able to better understand how this process works in humans.

Researchers have also found that people with anxiety disorders, specifically panic disorder, have a decreased density of 5-HT1A receptors, which inhibit serotonin release. Because of this, we understand that people with anxiety disorders likely have an increased level of serotonin in their brains. There is also an inverse relationship between the density of 5-HT1A receptors and amygdala activation. The amygdala is involved with the processing of emotions. This suggests that people with anxiety disorders not only have an increased concentration of serotonin, but that one of the causes of this increased concentration is correlated with an increase in emotional perception.

So, why do SSRIs work to decrease anxiety in the long term? The short answer is that we really don't know. One theory is that increases in serotonin lead to an increase in neurogenesis, or the making of new neurons. Until relatively recently, it's been thought that after childhood, it is impossible for human brains to make new neurons. However, more recently, scientists have found that this is not true. While adult humans have a very limited capacity for neurogenesis, it still does happen. There is some evidence that suggests that SSRIs and increases in serotonin lead to an increase in neurogenesis in the hippocampus. The hippocampus is involved in short term memory regulation and emotion processing, so it is possible that the increase in neurons in the brain can allow for improved emotional processing, decreasing anxiety symptoms.

While SSRIs are effective in treating many anxiety disorders, we don't really have a clear understanding of how they work. What we do know is that their effects are very complicated and that there are many common misperceptions of how serotonin interacts with anxiety.

The next step to fully understand the relationship between serotonin levels and anxiety is to test drugs to see if they can change the way that this circuit works. One possible option is to find a drug that targets proteins in the BNST. That way, we could directly target the part of the brain that the serotonin acts on to increase anxiety in the short term. By taking this drug with the SSRI for the first few weeks, we could combat the initial side effects. This is especially important since one of the big problems with SSRIs is noncompliance. One study determined that almost 50% who have been prescribed SSRIs stopped taking them within 60 days. By decreasing side effects, we can help decrease noncompliance rates and help the large number of people with mental illness feel better. ●



Exoplanets: A Home Away from Earth

Three Potential Destinations for The Human Race Once Life on Earth Is No Longer An Option

Written by Kileigh Ford
Illustrated by Jack Bens

If we were to pick up and move Earth's population today, where would we go? With the eventual death of our Sun in 5 billion years, there are a few options in our solar system for relocation—but the most viable choices are just outside. Exoplanets are planets beyond our solar system that resemble the Earth in size and lie in the habitable zone of the star they orbit. Exoplanets increase in number every year, each varying in size, resources, and makeup. Despite 3,708 confirmed exoplanets and another 4,496 candidates, astronomers are still on the hunt to find Earth's perfect twin.

In order to be habitable, an exoplanet must lie close enough to its star that liquid water can exist on the surface, which also depends on the temperature of the planet. Exoplanets may have a greenhouse effect, like we do on Earth, where greenhouse gases present in the atmosphere trap the heat radiating from planet within the atmosphere, heating it up. This can create a different temperature from what scientists calculate the expected temperature of a planet to be just based on the distance from the exoplanet to its star. Meanwhile, clouds reflect light, so cloud coverage contributes to cooling the planet from a high average temperature or

> Through a modeling study, astronomers discovered that Kepler-62f could be an entirely water-covered land mass.

can cool an environment too much to support human life. The proper environment for fostering human life is delicate, and while not all of these exoplanets may be able to meet these requirements, there are so many planets confirmed exoplanets that the probability of finding at least one that fits humanity's habitat needs as exactly as possible is very high.

Not all planets orbit a star like our Sun; the type of star a planet orbits is a big contributor to its habitability. A dim, cooler star—like red dwarf stars—will have a habitable zone in closer proximity than a huge, very hot star, which will host a habitable zone much further away. However, red dwarf stars shoot stellar blasts, bursts of magnetic energy, and x-rays—or electromagnetic waves of radiation—into space, potentially harming life on a planet orbiting too close to the star. These smaller stars tend to have longer lifetimes (from around 1 trillion to 100 billion years), whereas supermassive, hot stars burn up more quickly and, therefore, have a much shorter lifetime (around 100 million years). A habitability scale created by the authors of the paper "Comparative Habitability of Transiting Exoplanets" ranks confirmed exoplanets based on the planet's distance from its star, how rocky the surface is (rockier is better because it is easier to harvest metals and other resources, as well as electricity), the balance of light and heat the planet receives from its star, and its albedo (solar energy reflected off of its atmosphere). Earth itself is not a perfect 1, meaning most habitable, on this scale, but a 0.829. This may indicate that a perfect 1 is out there—we just have to look.

To get to these exoplanets, it will take some time and advancement in technology. Scientists chart the changing position of a planet over the course of six months against background stars to determine the angle at which Earth faces it, and use trigonometry to determine how far away the planet is. Measured in light years, the closest exoplanet viable for human life is about 4 light years away. A light year is a distance that refers to how far light travels in 365.25 days. Unfortunately, we cannot currently travel at the speed of light. If we could, it would take us 4 years to get to the closest exoplanet. To put things in perspective, 1 lightyear is approximately 5.9 trillion miles, or 1.2 billion hours! This means it would take a spaceship 137,000 years with current technology to make it to the exoplanet.

Let's take the first step outside of our solar system to the third-closest star to our Sun, Proxima Centauri. An almost Earth-sized planet exists in the habitable zone of this red dwarf star, which is located 4.22 light years away from Earth. This same planet is the closest exoplanet to Earth and the planet, named Proxima Centauri b, is a viable option for a new human domain. However, with a radius 1.3 times greater than Earth's, Proxima Centauri b is much closer to its star than we are to the Sun, which creates a set of circumstances very different from Earth. Proxima Centauri b receives x-rays that are 400 times stronger from Proxima Centauri than the x-rays we receive on Earth from the Sun. Proxima Centauri also often shoots out nuclear blasts.

Proxima Centauri b has a period of 11.2 days, which means it takes 11.2 days to orbit around its star. If the planet is tidally locked to its star, the orbital periods of the planet and star will be the same. If not tidally locked, they could have different periods (similar to Mercury and our Sun) in which Proxima Centauri b would orbit its star twice every three days. The differing periods would be ideal, as it would create a more even climate on the planet for humanity to dwell.

One major issue with Proxima Centauri b is that we don't know what it is composed of. Because we do not know the diameter of the planet, we cannot calculate its density and therefore, though it is likely that the planet has a rocky composition, it could also be a gas ball like Uranus. Evidently, Proxima Centauri b has several mysteries about its habitability that scientists have yet to figure out. While this could pan out extraordinarily well for humankind's sake, it could also turn out to be the opposite of what humans would need; this uncertainty is a problem we encounter with many exoplanets.

Moving on to the second area of space in the search for a new home, we find ourselves 1,200 light years away from Earth on the potentially Earth-like planet of Kepler-62f. Just 1.4 times bigger than Earth, this planet orbits a star that is smaller and dimmer than our Sun. Through a modeling study, astronomers discovered that Kepler-62f could be an entirely water-covered land mass. The conditions of a planet like this means that life may already exist there. According to the author of the model, Lisa Kaltenegger, "There may be life there, but could it be technology-based like ours? Life on these worlds would be under water with no easy access to metals, to electricity, or fire for metallurgy." This option would mean relearning how to live as a society and adapting to life in or on water, potentially with new species with which to coexist.

Perhaps Kepler-62f is not the best option, but its neighbor, Kepler-442b, is 5 light years closer to Earth, and Wired's K.G. Orphanides has dubbed it "more habitable than Earth." As previously mentioned, in a habitability ranking Earth earns a habitability rating of 0.829—but Kepler-442b receives a 0.836. Kepler-442b is 1.35 times the size of the Earth, has a period of 112.3 days, and lies well within the assumed habitable zone of the star it orbits, so it is more like Earth in these characteristics than other exoplanets. Would an expedited and expensive attempt to advance our space travel technology be worth it to live on a planet more habitable than Earth? That is the question we need to examine in finding our way to Kepler-442b.

If we were to pick up and move Earth's population today, where would we go? Three choices—each a new, unique world for humans to explore. These worlds vary from one another in immense ways, but demonstrate the variety of environments that potentially await human life. With many unknowns and a need for advancement in technology, there is still a ways to go in figuring out which planets could best suit human needs. For now, Earth suits us well, but in a few centuries humanity may find itself migrating to Proxima Centauri b, Kepler-62f, or Kepler-442b—bringing with it new ways of life and society. ●

The Anthropocene

How Modern Geologists are Creating a Paradigm Shift in Our Concept of Time

Written by Monica Dix
Illustrated by Steven Mentzer

As Western culture becomes increasingly aware of the impact humans have on our environment, a term has emerged into scientific and social consciousness that characterizes the intensity of our impact. Coined "The Anthropocene", geologists and climate scientists have proposed a new geologic epoch in which "Anthro", or man, is the driving force of planetary geologic change. Since its popularization by atmospheric chemist Paul Crutzen in 2000, the term has begun to center itself in not only geologic, but also political and social scientific discourse. Its implications are widespread in our societies and the way we think of environmental impact, social responsibility, and our actions on Earth.

The Anthropocene comes in an era of significant evidence of planetary climate change. Five years after atmospheric carbon dioxide levels hit record levels at the Mauna Loa volcano in Hawaii, large storms are becoming more and more frequent, and sea level is rising as glaciers and icecaps are melting at unprecedented rates. Yet these effects of global warming do not necessarily support the need for a new geologic area.

What defines a new geologic era is a phenomenon known as a "Golden Spike". This is a geological marker that transcends through millions and millions of years, a decisive transition that breaks units of geologic time into bite-sized pieces. These pieces all represent different atmospheric, oceanic, biological and geological conditions on our planet that help us as scientists trace the development of our planet to the world we know today. These spikes indicate a worldwide transition, and they have to be present at many locations globally, or oftentimes show a trend within the rock history in every region of the world.

One example of a Golden Spike occurred during the Cretaceous-Paleogene extinction event, known in popular culture as "the meteor that killed the dinosaurs". 66 million years ago, a meteor several kilometers wide hit the Earth in the southern part of the Gulf of Mexico. The impact itself and the effects it created were so disruptive that over

> If the entire history of earth was one hour, the first members of our species would come at 59 minutes, 59 seconds, and 0.9 tenths of a second.

75% of the species on Earth vanished, giving way to the Paleogene. In this time, adaptive radiation caused many new species to become present on Earth. These mass extinctions are one major geologic tracer in the fossil record, but the boundary is also shown globally by a thin layer of clay that shows a spike in the levels of iridium, a metal which is rare on Earth but common in asteroids. Called the K-Pg boundary, its highest levels found are across the Atlantic at Stvens Klint, a white chalk cliff off the coast of Denmark, but also in National Parks in the U.S. and Mexico.

When we think of The Anthropocene and what kind of tracer we can use to track it, it's difficult to conceptualize the longevity that such a marker needs to have. While plastics may take hundreds or thousands of years to decompose, metals like Iridium have been present and intact in the geologic record for 66 million years, which is already 6,600 times longer than the rate of plastic bag decomposition. Even the substances that we see in our lives as nearly impossible to decompose are specks compared to iridium on the scales of geologic time.

As explained by Jeremy Davies in his novel The Birth of the Anthropocene, a helpful way to frame this question is to think of ourselves as aliens visiting the earth millions of years in the future. Assuming humans are gone, our cities and structures will be long gone too, it would be up to the chemical and geological outcomes of our actions to cement our species as changemakers in the geologic record.

There are a variety of other examples that scientists have presented as potential Golden Spikes. One of these is the spread of agriculture to North America in 1492. While the agricultural revolution has long since passed worldwide, the colonization of Europeans in North America brought the same crops and techniques between two continental clusters. This connection of ecological change and agricultural boom at similar environments on both continents provides a strong worldwide commonality in ecology and human-altered landscapes.

The more concrete and widely accepted Golden Spike for the Anthropocene is the 1950s-1960s technology-focused transitions of Western culture on earth. In the global acceleration after the first and second world wars, the global population ballooned from 2.5 to 7 billion people, and GDP production increased from 1 to 3%. These signaled an acceleration and change of the way that humans interacted with Earth. Some of the markers that correlate to this shift include the fact that 98% of Aluminum has been produced since 1950, 1960s lead concentration in Greenland ice peaked from the leaded gas, and there's a unique black Carbon particulate that can be found geologically worldwide. The most compelling event however, is the Trinity Test. This was an atomic bomb test that created a mineral never before seen on our planet, now called Tritinite. These tests were accompanied by many different atomic bomb test events which released particulates that aren't otherwise naturally occurring, and provide additional geologic markers for this period in history.

Within this modern technology-centered transition, some scientists have also argued that simply all the plastics, concrete and structures that we've created as species are have spread around the world enough that they will be their own geologic marker. This is considered less legitimate than the chemical tracers, but builds on the idea that human technology is a turning point into the Anthropocene.

There are a variety of groups that are poised to make decisions on whether or not to officially declare the Anthropocene a new geologic epoch. Groups like the International Commission on Stratigraphy and International Union of Geological Sciences haven't made a ruling, but as of August 29th, 2016 the Working Group on the Anthropocene (WGA) voted to formally designate the epoch Anthropocene and presented the recommendation to the International Geological Congress. Despite this, the process for declaring the epoch and finding the perfect spike is still ongoing, though when it comes to the definition of the spike or boundary, the Trinity Test is one of the leading favorites.

While we may not know whether the geologists will find their Golden Spike, the significance of us as a species living through a transition in geologic era is enormously significant. We've only had seven epochs since the Cretaceous-Paleogene extinction event 66 million years ago, and we only entered into the most recent, Holocene, approximately 11,650 years ago. And all of this is literally the blink of an eye from the Earth's 4.5 billion year history. If the entire history of earth was one hour, the first members of our species would come at 59 minutes, 59 seconds and, 0.9 tenths of a second. This represents not only an incredibly rare and important transition on Earth, but an acceleration of the way we conceive deep time as a species.

From a non-scientific perspective, this also generates an enormous reframing through the context of our human impact. We've put ourselves front and center, and determined that our actions are significant enough on the planet that we need to rename the prominent forces shaping the Earth. This is even seen at Oberlin College, where entire seminar classes have been taught on the Anthropocene by Geology professor Zeb Page and Politics Professor Chase Hobbs-Morgan. Hobbs-Morgan's class is representative of the impact that science has had on political, social and feminist theorists, who are all grappling with the impact that our species has had to warrant this era, and the different perspectives through which to frame issues that the term raises.

An example of this literature is the anthology, Anthropocene Feminism, compiled by Richard Grusin. Its contributors delve into some of the most common frustrations of the Anthropocene from a social science perspective, which is that the name itself is too technology-focused and universalist in the way it gives responsibility to all Anthro- on planet Earth. Feminist Geologist Jill Schniderman stresses the importance of leaning into the significance of the name and what it meals for geologists and all of society. In her essay called The Anthropocene Controversy she says, "The multiple intersections make the recognition of a new epoch relevant beyond scientific enterprises. The Call of the Anthropocene pulls us to change our ways, to recognize the hundreds if not thousands of years of human dominance of earth as well as social and political struggles between oppressors and oppressed."

It is undeniable that this debate has captured the minds of humans across all disciplines, and presents a paradigm shift in our conceptualization of our actions as humans. As we embark into our futures, it's now up to us to decide if we will answer the call of the Anthropocene.

Man's Best Friend

The Evolution of Technology is a Double-Edged Sword

Written by Tyler Duffrin
Illustrated by Rin Liu

How many times a day do you scroll through your Instagram feed? Add photos to your Snapchat story? Tweet? Let your Facebook friends know what you are up to? Does most of your day-to-day interpersonal communication take place on your phone or a social media platform? If so, does it make you feel more or less connected to the rest of the world? Do you think about that? Or just interact with the people you are talking to?

On the one hand, when we use our phones and social media platforms to communicate, we become extremely connected to the rest of the world. Most of our friends use social media to communicate, so if we neglect to use it in the same way, we miss out on conversations, which we never want to happen; we want to be included all the time. On the other hand, when we use our devices to communicate, we become extremely disconnected from the physical world. Now that we are communicating in an entirely non-personable way, we miss out on the emotions, the empathy, the humanness that other people display, which is something we look forward to in engaging with other people. Being connected to the physical world, and deeply engaging with the people we communicate with in person, is crucial to our development through the lifespan. If you have ever taken a psychology class, one thing you should have taken away from that class is that humans are inherently social animals. We need and look forward to communicating all the time.

Ultimately, we choose to communicate with the technological devices that allow us to do so because they make our lives extremely efficient and easy. When we connect with others via our technological devices, we do not have to work as hard. We often take it for granted how easily we can interact with other people; nowadays, if we want to talk to someone, all we have to do is pull out our phones and send them a text, or a Snapchat, or a direct message. We can even convey meaning without opening our mouths or being in the same place as another person without the slightest movement. So why wouldn't we make use of the technology that allows for such easy communication?

We need very desperately to understand that every time we communicate through technology, slowly, deliberately, our individual cognition adjusts accordingly. And, as it follows, our customs and cultures adjust as a collective - our communicative methods change as a society. Then, nationally and globally, our distinctly human culture changes as we participate in this sort of engagement. For me, the profoundness in trying to understand such a dilemma is that this cognitive and cultural adjustment to the tools that we have made for ourselves is a natural phenomenon. When humans make a tool for themselves, they no longer need to have an understanding of how to participate in the activity that they made the tool for in the first place. Therein lies the very purpose of making a tool. A simple example of this phenomenon is the existence of a calculator. The development of the calculator brought about man's unnecessary understanding of how to manually compute basic mathematical procedures; it was no longer necessary for man to understand how to carry out this cognitive skill because his machine could take care of this problem for him. As a result of this newly-created technology, humans could rely on his tool to do the hard work for them, so they no longer needed to understand quite as deeply how to execute the task that the calculator replaced. So, it made their lives easier and simultaneously ate away at their cognitive abilities. This phenomenon follows for every invention. With innovation comes more ease, more comfort, more accessibility, and, depending on which psychologists' opinions you regard as being more accurate in defining the ways that humans learn, relatively less cognition or intelligence.

And that is not to say that humans become less intellectual, or, to put it crudely, more stupid, with the inventions of new things. Their thinking only adapts according to the tools they make for themselves. As a result, when we communicate via technology, our communication styles change. Our cognition adjusts because we create tools that make it easier for us to communicate. We do not become less able or intelligent, but our abilities take a different form, and adjust to the tools that are before us. In principle, this is not necessarily a bad thing. It is worth warning people about, though, in my opinion, because it is a natural occurrence. The question then becomes whether we can recognize how significant of a role technology plays in our communicative lives and whether we are too dependent on technology for our interpersonal communication. Will we ever be able to acknowledge how collectively addicted we are to our devices? Will we realize that our lives are not actually that difficult, and that we do not need to make our lives as easy as possible just because we know how to? Can we not see how reliant we have become on our technological advancements?

We need very desperately to understand that every time we communicate through technology, slowly, deliberately, our individual cognition adjusts accordingly.

The evolution of technology is inevitable and is a part of human nature, so it will never slow down, or work in the opposite direction. It can only speed up and move forward. Humans have always made tools for themselves, and it has always been a priority for humans to make their lives easier through the use of their own knowledge – their own ability to manipulate their environment and produce tools. But we do not need to let the devices we have created for ourselves take over our lives. We can be active participants in our own lives. We can refuse to obey social and technological norms. All it requires is conscious attention to exactly what we are doing when we are checking our Instagram, Snapchat, Twitter, or Facebook, several times a day. By asking ourselves what else we can be thinking about, what else we can devote time and energy to, we can root out our own laziness and become the best versions of ourselves. We can be productive, we can increase our humanness - we can tap into what lies beneath the surface. We can enrich our experience tenfold.

Ultimately, it is important for us to think about these things because they can be taken to dangerous extremes. If we let technology communicate for us–if we let technology creep its way too deeply into our everyday lives, the most human element of our human lives can be replaced by technology. To some extent, technology already plays too significant of a role in our everyday lives. I think it is our responsibility, our obligation to ourselves, to acknowledge which ways we want to use technology, and which ways we need to use technology, and to be able to differentiate our necessities and our desires.

Let's make an effort to remain human. Let's start catching ourselves in the act of resorting to technology for communication when we don't need to. We can always make our lives more significant and meaningful to ourselves. Let's be original. Let's be human.

The Designer Plant Debate

Why CRISPR Crops May Be in Your Crisper Drawers Sooner Than You Think

Written by Joanna Zienkiewicz
Illustrated by Claire Segura

For decades now, both the public and the government have debated the production and sale of genetically modified organisms, or GMOs. Traditionally created by inserting genes into one organism from another, they are developed for a number of different reasons such as improving nutrition and flavor. The first GMO to hit grocery stores was the Flavr Savr tomato in 1994, which was developed by adding a gene that interferes with a specific enzyme in order to increase shelf life. Although there is a lack of evidence supporting the claim that GMOs are dangerous or unsafe for consumption, some people are still considering GMOs to pose environmental threats, such as decreasing biodiversity. A new biotechnology, however, is potentially turning the GMO debate on its head.

Clustered regularly interspaced short palindromic repeats and associated protein 9, or CRISPR-Cas9, is currently the fastest, cheapest, most accurate, and most efficient genome editing method. This complex of enzymes and genetic guides was adapted from an ancient and naturally occuring genome editing system that evolved in bacteria to fight against viruses. In the late 2000s, scientists found a way to harness the power of this system to target and alter specific DNA sequences, by designing molecular guides that can sniff out a particular block of genetic code in any living cell. These guides are then injected into the desired cell along with Cas9, a DNA-cutting protein. Once in the cell's nucleus, the CRISPR-Cas9 complex works its way down the genome until it comes across a match to the guide sequence. When it does, Cas9 is activated and snips the DNA. By doing this, the complex can knock a gene out of commission, or even insert a replacement sequence if so desired. This technology has a wide variety of exciting applications, from curing complex human diseases, to creating alternative energy biofuel, to even reviving extinct animals.

The agricultural application of CRISPR technology is rewriting the GMO debate. Since 2016, the US Department of Agriculture has discreetly allowed at least a dozen crops to be genetically altered using CRISPR, ruling that gene-edited cultivar fall outside regulatory purview. Just this past September, for example, a version of the oilseed crop Cartelina sativa that had been engineered using CRISPR was approved by the USDA without having to go through the usual regulatory hurdles. The crop was developed by the company Yield 10 Bioscience to produce increased omega-3 oil content. The following month, the agency also ruled to exempt a drought-tolerant soybean variety developed using CRISPR from USDA regulation. In March, the agency issued a press release where they officially took the stance that gene-edited plants can be designed, cultivated, and sold without any regulation by the USDA as long as they don't include any genetic material from different species. They reasoned that gene-editing is an exceptionally fast form of breeding, so biotech crops created using CRISPR are not technically "modified." After all, humans have been altering the DNA of plants and animals through selective breeding practices for millenia. So, as long as genetic alteration could have been bred into a plant, such as through the insertion or deletion of base pairs into a DNA sequence, it will not be regulated.

Although the USDA's position does not necessarily come as a shock, given these recent regulatory exemptions, it is still greatly significant. The lack of regulatory hurdles could save an incredible amount of time and money for biotech companies that develop designer plants, allowing them to get their CRISPR modified products to market faster than ever thought possible. The loose regulation also makes it significantly easier for small startups and public institutions to enter the market. Genetic modification has traditionally been limited to commodity crops such as corn, soy, and wheat, but now genetically modified specialty crops, even ones with small markets, are suddenly worth developing.

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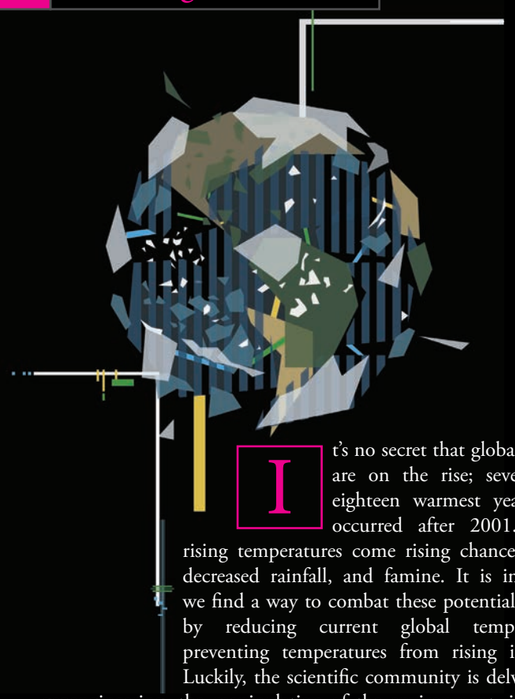
Although many companies are celebrating this news, the USDA's statement has put GMO giants on edge. In the past weeks, many have been moving to secure their supermarket relevance. At the end of March, American agrochemical and agricultural biotechnology company Monsanto announced it was investing $125 million in a startup called Pairwise, which focuses on using gene-editing to create better tasting and healthier produce.

CRISPR foods may show up in your shopping cart sooner than you think. Since the 1990s, the USDA has regulated which genetically modified crops go to market, not because of fear that they will harm human health, but because of potential environmental damage that crops with foreign DNA could cause. A plant with only a small amount of its DNA deleted or moved around, however, poses no such threat. Although neither the USDA nor the FDA have yet to issue any guidelines specific to the labeling of foods derived from CRISPR-edited plants, they have stated that CRISPR-edited products are practically indistinguishable from those developed through traditional breeding methods. So, the first time you pick up a pack of CRISPR-edited strawberries, you may not even realize it. ●



Fighting the Heat

Geoengineering Strategies and Potential Global Effects

Written by Rachael Branscomb
Illustrated by Zimeng Xiang

It's no secret that global temperatures are on the rise; seventeen of the eighteen warmest years on record occurred after 2001. With these rising temperatures come rising chances of flooding, decreased rainfall, and famine. It is imperative that we find a way to combat these potential consequences by reducing current global temperatures and preventing temperatures from rising in the future. Luckily, the scientific community is delving deep into geoengineering, the manipulation of the environment, in an effort to curb global warming.

Geoengineering strategies generally fall into one of two categories: carbon dioxide removal (CDR) or solar radiation management (SRM). CDR techniques remove carbon dioxide from the air, directly opposing the greenhouse gas effect. CDR technology is used today to remove carbon dioxide from small enclosed spaces, such as the International Space Station or submarines. Though effective on a small scale, applying carbon dioxide removal techniques to a degree that would make an impact on a global scale is hardly realistic. Thus, many scientists have turned toward developing methods to reduce the heat trapped within our atmosphere through SRM. The heat radiation released from the sun that enters the earth's atmosphere is absorbed by greenhouse gases and prevented from exiting back into space. SRM works to reflect some of this heat energy back into space, lowering the amount of heat trapped in the atmosphere.

One major SRM method involves albedo enhancement which increases the reflectiveness of clouds so more of the sun's heat radiation is reflected back into space. One particular method targets cirrus clouds, the thin wispy clouds that exist high in the atmosphere. Like other clouds, cirrus clouds absorb some heat from the sun as well as reflecting sunlight back into space. However, they differ from other clouds in that they tend to absorb more heat energy than they reflect, causing an overall increase in atmospheric temperatures. Cirrus clouds are made up of tiny particles of ice which absorb the sun's radiation. One theory proposes that cirrus clouds could be thinned or prevented entirely by injecting dust particles high up into the troposphere, the layer of the atmosphere where cirrus clouds are generally formed. The ice crystals that form cirrus clouds would then form around the dust particles, altering the way the clouds are formed and giving rise to thinner clouds. These thinner clouds would scatter less heat radiation onto the earth and also allow more heat to exit the atmosphere. Undertaking this technique would be incredibly costly in both time and money, but is one of the major innovations being considered to reduce global warming.

Another well-known method for blocking the entrance of heat into the atmosphere involves stratospheric aerosols. Sulfur dioxide projected into the air during volcanic eruptions causes temporary cooling effects. David Keith, a professor of applied physics at the Harvard John A. Paulson School of Engineering and Applied Sciences, devised a strategy in which jets fly through the atmosphere and spray sulfuric acid. The sulfuric acid would combine with the water droplets in the air to form sulfate aerosols, which are then dispersed around the globe by wind. The difficult part of implementing this technique again comes down to the scale at which sulfur atoms would have to be released. Thus, though more practical than trying to implant carbon scrubbing technology around the entire globe, this method of geoengineering is still far from practical.

Other SRM methods that have been considered include employing space reflectors, such as satellites, to reflect some of the sun's rays before they even reach earth. Other albedo enhancement techniques involve whitening clouds over the oceans to cause more reflection. Regardless of the selected technique, possible side effects of global heat reduction techniques must be considered. The sulfur injection technique might successfully cool the globe, but volcanic eruptions often lead to alterations in rain patterns, namely reductions in rainfall, so sulfur injection might cause similar negative consequences. Other unexpected effects of sulfur injection may include the depletion of the ozone layer due to the presence of particles high in the atmosphere, as well as the possibility of altered ocean currents, which could damage marine life.

> As the world grows progressively warmer, many scientists are pushing for action before the effects of global warming grow too extensive to combat.

Ultimately, geoengineering is a dynamic and risky field in which scientists have severe reservations when it comes to implementing the above proposed mechanisms. There are many unknowns involved with geoengineering, and it is hard to say if the scientific community will ever have enough of a understanding of the intricate balance of our global climate to predict how it will respond to human climate intervention. That being said, as the world grows progressively warmer, many scientists are pushing for action before the effects of global warming grow too extensive to combat. ●

Oh What A Tangled Web We Weave

Finding Prehistory

Written by Zoe Swann
Illustrated by Maria Altier

It turns out that linguists can reconstruct the prehistoric world, defined as before writing! Textiles are everywhere; weaving symbology appears in myths around the world; cloth can tell non-verbal stories, fashion clothing, and specify ancient gender roles. We often use the phrase "weaving stories"textile, technique and text all share a Greek root meaning "skill". In these stories we weave we can create worlds, as the Hopi Spider Grandmother spun a new world. By looking at archaeological evidence alongside language use and change, we can actually date and locate prehistoric cultures! The ancient population of interest in this article is probably the most famous: that of the Proto-Indo Europeans (PIE).

Woven woolen textiles are made from soft wool fibers, but wild sheep have not always been able to produce wool that was fit for spinning. In western Iran and today's Turkey, sheep were domesticated, likely for meat at first (8000 to 7500 BCE). They were blanketed primarily with long, scratchy hair known as kemp, only having a short undercoat of wool not suitable for spinning. Wool sheep as we know them likely appeared around 4000–3500 BCE, and because PIE (Proto-Indo European) contains so many words related to fabric and fabric making, we know that these words entered PIE after wool sheep appeared. The first suggestion of wooly sheep comes from a seventh-millennium BC Iranian figurine of a sheep with wooly clumps. The first proper evidence comes from 4000-3500 BC with the introduction of Mesopotamian and Egyptian descriptions of wool sheep being taller than their wild counterparts, and such. Therefore, in general, wool production does not seem to date before 4000 BC.

Wool thread only works when you spin "unnaturally" long wool strands together so that the fibers don't pull apart. Tools for spinning in this day and age consisted of a hand-held spinning needle, likely made of bone, and are just about the only part of the spinning process that survives in the archaeological record. It is important to note that before wool was used, linen (PIE *linom) made from flax thread was the dominant thread in the Neolithic era (ca. 7000-3500 BC), and tools for spinning flax and wool are difficult to differentiate. However, in the periphery of the PIE world, like India or Ireland, wool was predominant over flax, suggesting that when wool was introduced, it became very much a PIE staple.

> The first suggestion of wooly sheep comes from a seventh-millennium BC Iranian figurine of a sheep with wooly clumps.

Linguistically speaking (no pun intended), PIE language had several words and cognates indicative of close work with domesticated sheep, such as "ewe", "lamb" and 'ram". When this word evolved into daughter languages (as Latin evolved into Old-French, for instance), the result was often a word meaning "wool": *Hw(e/o)l). This further evolved in a wide variety of European language families such as Slavic, Greek, and Germanic into words meaning "felt," "roll," "beat," and "press." "Felt" is likely the unifying meaning among them, given the beating and pressing that goes into felt making. PIE also has words for belt, shoe, shroud, and blanket; and spin, weave, and even dye. This suggests that Proto-Indo-Europeans were wearing more than just animal skins!

The first western city-like civilizations appeared in Mesopotamia and Iran, where we see wool textiles woven and dyed with seeds, minerals, and berries. Wool absorbs a wide variety of colorful dyes better than linen fabrics, so woolen textiles became a way to produce art. Apparently these tapestries and cloths were produced by dyeing individual strands instead of stamping colors onto the already woven surface, which evolved later.

"But almost all the evidence (in the form of animal bones) for wool production appears in the Late Uruk period or later, after about 3350 BCE. When sheep are raised for their wool, the butchering pattern should show three features: Sheep or goats only differ in a few bones, but they should make up the majority of the herded animals; sheep, the wool producers, should greatly outnumber goats, the best milk producers; and the sheep should have been butchered at a very old age, after years of producing wool.

The evidence suggests that woven wool textiles appeared in Europe, as in the Near East, after about 3300 BCE, although wool sheep may have appeared earlier than this, about 4000 BCE, in the North Caucasus Mountains and perhaps even in the steppes. But if the root *HwlHn- referred to the short undercoat wool of "natural" sheep, it could have existed before 4000 BCE." ●

Doctor Ilene Wong

Urologist and author of YA Novel "None of the Above"

By Sulan Wu
Illustrated by Emily Herrold

Dr. Ilene Wong, under the pen name I. W. Gregorio, wrote her debut novel None of the Above, after being inspired by an intersex patient during her residency at Stanford. Dr. Wong is an intersex advocate, a member of interACT: Advocates for Intersex Youth, and a founding member of We Need Diverse Books™.

This interview has been edited for length and clarity.

Q: What is intersex and how have intersex people been affected by doctors and the rest of the medical community?

Intersex is an umbrella term that describes anyone who was born with sex characteristics that fall outside of the normal standard of male or female. This includes chromosomal anomalies or issues with external or internal genitalia. Unfortunately, the term intersex is problematic itself. Many people conflate intersex with gender, even though intersex has to do with biological conditions. Words are important. Being both a physician and a writer allows me to internalize how important language affects not only how we interact with people, but how we deliver care. 80% of intersex patients have changed care just because of the words that their provider uses.

I believe that the main thing that concerns me with how medicine has treated intersex is that medical professionals often pathologize this biological condition, deeming it as a disorder that needs to be fixed. Rather, it is a static identity that can be treated with psycho-social intervention or medical intervention when it is necessary. What concerns me is, why would a social emergency be treated with a surgical intervention?

When I speak to most intersex individuals, it is clear that many of them feel so much distrust towards the medical community because of how they have been stigmatized and shamed. Getting rid of the idea that they are anomalies can translate to better awareness in medical school, better training, and better care at all levels. Everyone needs to know that there is no normal—that the girl next door can be intersex and your chromosomes don't need to prevent who loves you and whom you love.

Q: There are many ways to advocate, support, and inspire change. As a surgeon, you have treated an intersex patient and are also a member of interACT. What prompted you to write this novel and how did it address the issues between the medical community and intersex people?

It's funny because many people ask me how a urologist became a writer, when I think the better question is how a writer became a urologist. I actually always identified as a writer. Growing up in the conservative part of central New York and being the only Asian person in my class, I grew up as an outsider. Books, as a result, have always my sanctuary—they were always my friends.

I could both write and be a doctor, and in many respects, being a doctor would give me the life experience and stories that I could shape what I wanted to tell. When I met my first intersex patient, however, I realized that there was a huge gap in our literature, particularly in young adult literature. When I think back on the books that I've read, it was really the children's and YA books that really changed me. Teenagers, right now, are the ones who change the world and I couldn't be prouder to be a YA writer.

Q: How did your intersex patient personally inspired you to write your novel? What other particular experiences influenced you to write None of the Above?

The main reason that my patient inspired [me] was because my medical education left me utterly unprepared to take care of her. I had to educate myself on how to care for intersex people. And they are often the educating doctors on what the unique aspects of their care are. The more I looked into the intersex support group pages, the more I became more aware of how great a disservice medicine has done to the intersex community.

After talking to my patient I realized that she was unaware that she was going to have hormones for the rest of her life after we removed her testes, and potentially also had to do vaginal dilations. Clearly, there had been a major lack of communication between her and my attending doctor, and it was frightening to me [to realize] how people can be coerced into undergoing life-changing surgeries without understanding what they'll be going through.

Q: What do you hope that people get out of reading your novel and learning about your efforts for change as an intersex advocate?

I hope that people start realizing that intersex exists and they can do their part to stop intersex shame and stigma. By doing that, they can help set the groundwork for the medical professionals to stop doing unnecessary surgeries. More often than not, the really problematic intersex surgeries happen because of parental anxiety—parents are afraid of how their kids will grow up, and if they will be bullied or treated differently. [If] parents can see their child and realize that they are healthy and not be so worried about these long-term consequences, then they might be less willing to consider surgery and be more willing to let their child be who they are.

Gravity Ridge

Written by Alexander Metz
Illustrated by Yue Yu

…miles and miles and miles."
-Alan Shepard playing golf on Earth's moon, February 6th, 1971.

Solaris V: January 20th, 2345.
Personal Log of Daniel Kirk:
Classified Top Secret: Do Not Read

To Whom it May Concern,

Space sucks. 300 some years of human space exploration have proven the cosmos to be an insufferable void. It pains me to say this, especially as the International Space Foundation has been so accommodating for the past decade of my career.

We've just returned from the Triton One colony with the news that they have discovered no new source of fuel, nor does there seem to be a significant chance they will do so. This was, in effect, the last nail in the coffin for the prospect of extra-solar missions. Humans simply die too quickly and too easily to leave the confines of our celestial cul-de-sac. Add to that the fact that a ship hoping to store enough fuel for such a journey would likely have to be the size of a small moon, and the prospects seem doubly grim.

The purpose of our mission was to survey the thirteen lunar colonies to see if any possessed anything close to a viable interstellar fuel source. It was thought with a compound dense enough, in large enough quantity there might be some chance of a generational embarking, or perhaps some cryogenic voodoo, that would put the stars in our grasp. But unless some such source is discovered, the volume of fuel required for such a mission is simply too vast. There is no way to traverse the light years from our sun to another.

For my part I don't really care. It's not terrible news. Not great but not apocalyptic either. In either case it doesn't affect me. I wouldn't have made it out there anyway. It's bad news for humanity as a whole: that we're stuck in our insignificant, overpopulated corner of space. If we can't spread out, we'll use up all our resources and starve.

Then again, some people think we're better off that way. Plenty said we shouldn't have left to begin with: politicians, social movements, religions. They all say we should come back to Earth. Back where it's safe. Back where we're from. Back where everything and everyone is known to us and we won't have to scream and claw for every molecule of air and ounce of liquid water. I won't say they're wrong. Sometimes it seems like hell out here: nightmare black, impossibly cold, a void.

Space. It's the space between, the space without. It's where nothing is. A colossal gaping mouth that wants to suck you in and make you part of it, make you nothing. And the only thing between you and it is a tiny metal skin, like the shell of an egg. So, whenever people say that we're safer on Earth. They're not wrong. Earth is safer, Earth is brighter, Earth is warmer. Earth is where I was born and where my father was born and my mother and brother. Earth is a friendly harbor in a raging storm. I can't blame people for wanting to stay there. Even for thinking it immoral to leave.

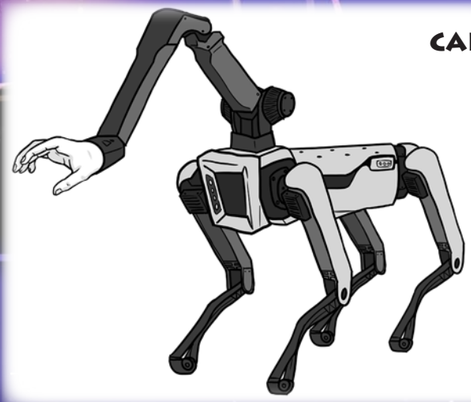
But of course, there's joy out here too. The joy of a sunrise over a planet with no atmosphere. The way the sun peeks over the horizon like a diamond. It makes you forget where you are, the blackness, the cold, the fact that you're living in what's basically a 48 million dollar tin can.

My favorite moment was the view from the top of Olympus Mons. It's the tallest mountain in the solar system: three times taller than Everest. A gigantic volcano. It was training, EVA suit stuff. They don't make you climb all the way, thank god. Just the last bit. They drop you off about ten miles from the top and you have to climb the rest. Since the gradient isn't actually all that steep it's not all that difficult of a hike, even with the gear you have to lug. A buddy of mine stashed a five iron in his bag with a couple of old Titleists.

When we got to the top he popped them out with this sort of weird grin on his face. He didn't say a word. Everyone else was taking in the view. Almost no atmosphere that high up so the horizon looks dusty red while the sky above you looks like just about the deepest night you can imagine. And you can see on forever. But, with all that this guy pulls out his five iron and this sack of balls and he finds a little spot of dirt near an overlook and starts whacking them.

You wouldn't believe the sound this club made. Beautiful and crisp and clear like a bell. The guy was good too. He was really clobbering them out beyond the horizon. After a while, everyone gathered to watch the balls sail off into the open sky. Miles and miles and miles. It was a moment of intangible strangeness capped with the beauty of white spheres hurled against the oblivion of a pale red sky.

And somewhere, billions of years from now when people are gone or have changed into something else, there'll be a little pile of red dirt. And on that pile will be a dented white-plastic orb. And on that orb will be a footnote in the ledger of the universe: human beings were here.



CARTOON CAPTION CONTEST

Thank you to everyone who submitted captions! We had many great submissions, but the winners are:

FIRST PLACE
"  "
-Cecilia Larson

SECOND PLACE
"Finally, a dog that is handy around the house."
-Nathan Daniel

THIRD PLACE
"Miyazaki lives!"
-Margo Bailey

/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.