THE SYNAPSE

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Editor-in-Chief
Emma Larson (OC '21)

With the intention of capturing a broad audience, contributors at *The Synapse* characterize the scientific progression of the past, present, and future. As the Editor-in-Chief, Emma Larson (OC '21) works alongside writers, editors, and artists to make this magazine possible. We always welcome new and consistent contributors and appreciate our loyal readers. Thank you for supporting *The Synapse*!

synapse@oberlin.edu
@thesynapsemagazine
@thesynapsemagazine
synapsemagazine.org

Featured Contributer
Emma Keppler (OC '21)

Originally from Portland, Emma Keppler is a third-year Neuroscience and Psychology double major at Oberlin College. She has worked for *The Synapse* as a content and layout editor for the last five semesters. You can see her beautiful layout on pg. 20 for the article "Bitcoin." Outside of her work with *The Synapse*, Emma is also the treasurer and secretary for Oberlin's chapter of Nu Rho Psi (the National Neuroscience Honor Society). She is also a student research assistant in Professor Tracie Paine's lab, which studies the neurobiology of dysfunctions in attention and impulse control in rats. When she's not spending time in class or working for her lab, Emma enjoys running, watching Netflix, and looking at her adorable dog Henry. Emma appreciates *The Synapse's* commitment to increasing the accessibility of science to the general public.

Featured Contributer
Rebecca Fenselau (OC '22)

Originally from Sunnyvale, California, Rebecca Fenselau is a second-year student majoring in Chemistry and Biochemistry at Oberlin College. She has been an editor for *The Synapse* since the beginning of her freshman year, and became the treasurer during her second semester. Becca is transitioning from her responsibilities as treasurer to a new role as editor-in-chief. Interested in climate change and the intersection of social justice and research, Becca plans to pursue a PhD in chemistry after spending some time working in industry or volunteering. Her other activities on campus include facilitating Oberlin Workshop and Learning Sessions, lifeguarding, and researching in Professor Belitsky's lab. She appreciates *The Synapse* for making science more accessible to everyone, for getting people excited about science, and for helping people to develop good communication and writing skills. In her free time, Becca likes swimming, horseback riding, and skiing.

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The Crazy Cat Lady Disease

Toxoplasmosis Gondii and Its Effects on Human and Animal Behavior

Written by Kirsten Heuring
Illustrated by Emma Larson

Everyone knows the stereotypical, lazy jokes about crazy cat ladies. They collect too many cats, enough to fill up a home. They focus on their precious pets day and night with little care for anything else. Some people even tease that these women have a disease. How else could they love cats so much? However, these jokes are not as misguided as people think. There is a parasite known as Toxoplasmosis gondii which has its sexual reproductive cycle in cats. It spreads through cat feces into humans, rats, mice, and other cats. It can cause behavioral changes in mice, rats, and humans, including an increased affinity for cats.

T. gondii is able to affect animal behavior by infiltrating the brains of its hosts. A study showed that in mice, these parasites are able to enter the brain by using microglia, an immune cell found in the brain. Microglia have the ability to cross the blood brain barrier, a semipermeable layer of cells which prevents unwanted and unneeded cells and substances from crossing from the blood into the brain tissue. *T. gondii* uses this to its advantage; it infiltrates the cell then increases the cell's ability to cross the blood brain barrier. Once inside the mouse—or human—brain, the parasite starts to affect behavioral changes.

T. gondii can only sexually reproduce in the intestines of cats, while in other animals, it reproduces asexually. Because of this, the only way the parasite will be able to reproduce with any

> In most people, the disease is latent; with the exception of immunocompromised individuals, there are no major pathological effects that occur from contracting the disease.

genetic variation is if it comes into contact with cats. Due to their reproductive cycles, the majority of the behavioral effect caused by *T. gondii* have effects on relationships with cats.

In rodents, *T. gondii* causes self-destructive behaviors for their hosts in ways that makes them more likely to be caught and killed by cats. In wild rats, which are wary of new experiences, the parasite causes them to become more open to unfamiliar objects and situations. Rats and mice become less scared of cats and their smells, even preferring the smell of cats to the smell of their own species. Because of this, they are more likely to enter areas where cats are present or even just general mouse traps. Infected mice even have learning deficits, and they are less likely to understand a maze when they are infected. Rodents tend to also be more active and excitable while carrying this parasite, making them more likely to attract cats with their movements.

Despite not being within the cat's food chain, humans also have behavior affected by *T. gondii*. In most people, the disease is latent; with the exception of immunocompromised individuals, there are no major pathological effects that occur from contracting the disease. About a third of the human population is infected, and most of them have no idea. The main behavioral sign is an increased affection towards cats. This can lead to more cat ownership or just a greater fondness for felines.

In humans, *T. gondii* has more effects than the increased desire to pet cats. People with the parasite have no increased risk of psychiatric conditions, major cognitive impairment, or poor impulse control. However, humans with *T. gondii* have subtly different cognitive processes than those without. In some tests, men infected with the parasite have been shown to score lower on IQ tests while infected women tend to score higher than their uninfected peers. Women with the parasite tended to be more outgoing and easygoing than their uninfected peers while infected men were more on edge. Researchers have also noticed a decrease in the ability of affected people in long-term concentration and psychomotor performance. In a simple reaction task where participants were instructed to press a button, the people infected with the parasite showed deficits in button pressing earlier than their uninfected counterparts. However, the parasite can affect more than just individual people.

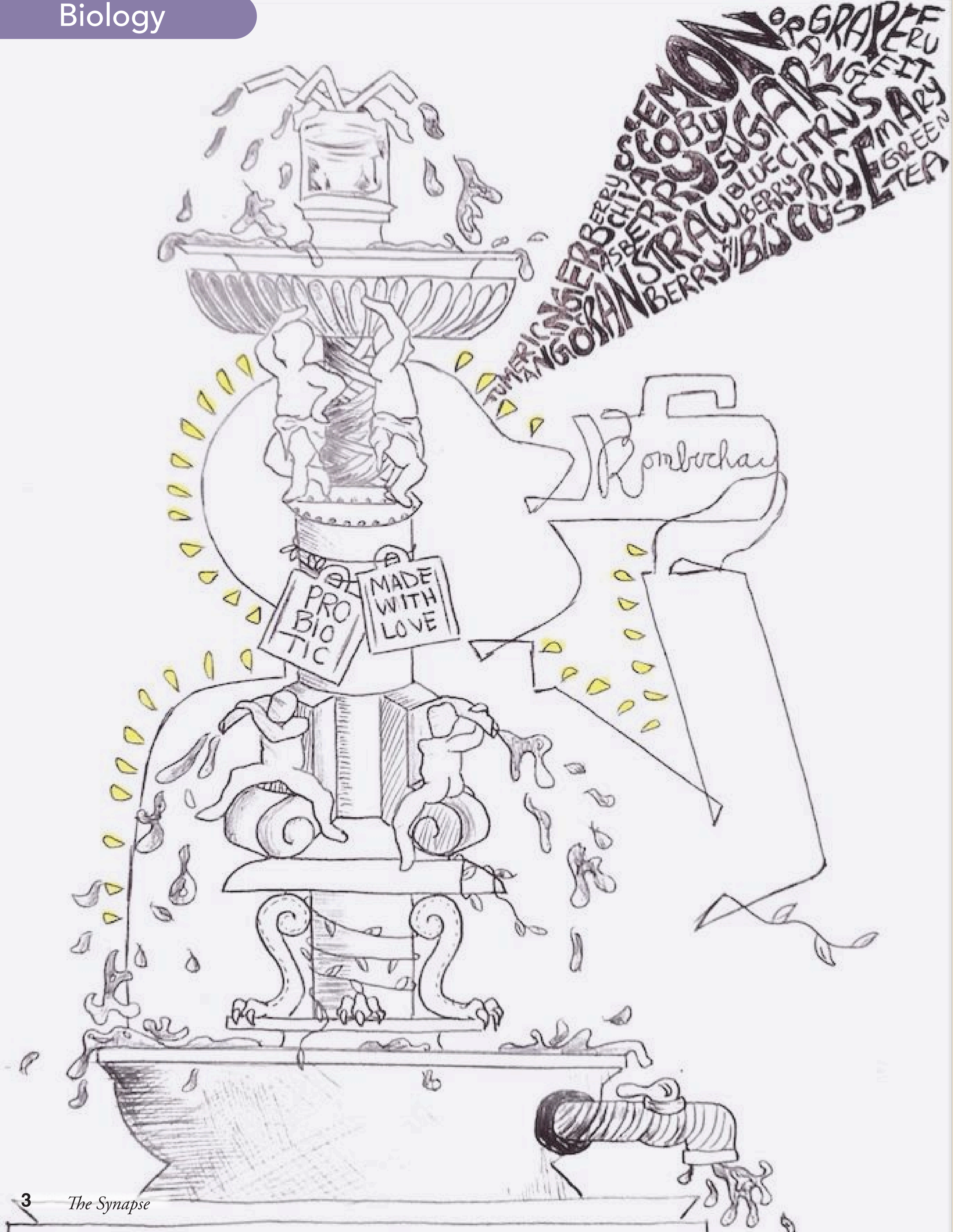
Depending on one's location, the population of people infected with *T. gondii* can range between 0% and 100%. Based on the fact that *T. gondii* can affect individual personalities, if a population has enough members affected, these changes can result in changes to the culture, itself. Researcher Kevin Lafferty decided to investigate this link. He found that in Western nations, a greater percentage of people infected with *T. gondii* is correlated with both greater avoidance of uncertainty and a greater emphasis on traditional gender roles. However, the same correlations were not found when the study focused on African or Asian nations. That means though the amount of people affected with *T. gondii* can affect the culture of a nation, it cannot completely change the inherent values of the people.

Most of the effects of *T. gondii* that have been discussed so far have been fairly benign. However, lifelong, latent infection can lead to some troubling effects. A European study found that in women over 45, infection with *T. gondii* is correlated with an increased risk of suicide when data is adjusted for economic status. *T. gondii* also has links with mood disorders. People who have

> In humans, *T. gondii* has more effects than the increased desire to pet cats... Humans with T. gondii have subtly different cognitive processes than those without.

depression with suicidal symptoms have higher levels of *T. gondii* antibodies than nonsuicidal patients or healthy controls, meaning that the patients with depression most likely had higher amounts of *T. gondii*. However, there was no link between the amount of *T. gondii* and the number of suicide attempts. This leads to the conclusion that though *T. gondii* can exacerbate existing conditions, it does not seem to directly cause any condition.

The crazy cat lady disease, *T. gondii*, can worm its way into the brains of mice, rats, and humans, changing behaviors along the way. In rodents, it causes them to seek more risks and participate in more self-destructive behaviors. In humans, the disease generally remains latent, but it can cause mild behavioral changes or affect preexisting risk factors. Though the vast majority of people will not be bodily be harmed by it, perhaps it would be best to avoid. Perhaps the next time you're about to clean a cat's litter box, maybe consider putting on some rubber gloves. • • •



Kombucha

Modern-day Snake Oil or the Future of Health and Fitness?

Written by Leo Hidy
Illustrated by Anna Francis

Growing up, the cold glow of my refrigerator always seemed to reflect off the multiple shining bottles of kombucha that my mom would neatly place on the bottom rack. My mom always made sure to drink at least once a day, but I could never understand her affinity for these colorfully labeled vinegar drinks. Each bottle advertises weight loss and a cure-all for the body's woes, marketing itself as a type of modern-day snake-oil to; but, according to a study by Jeffery Gordon, my mom's belief in the curative powers of kombucha has more legitimacy than I once thought.

Kombucha gets its uniquely pungent flavor and proposed health benefits from the careful mix of yeast and bacteria that form its characteristic brown membrane called a Symbiotic Culture of Bacteria and Yeast, or SCOBY. The blend of yeast and bacteria, specifically lactobacillus, acetobacter, and gluconacetobacter, convert the tea's natural sugars into lactic acid. The company Health-Ade, a Kombucha giant, advertises these "positive bacteria" as key to their drink's overall fat-burning abilities. While bacteria tend to get a bad rap in the world of health, they are what give Kombucha its legitimacy within the world of health and fitness. It turns out that these little single-celled organisms keep our bodies healthy by aiding in digestion and regulating our immune system. Microbiologists have found that the 10-100 trillion microbes living inside of our gut can help us digest food and communicate with immune cells.

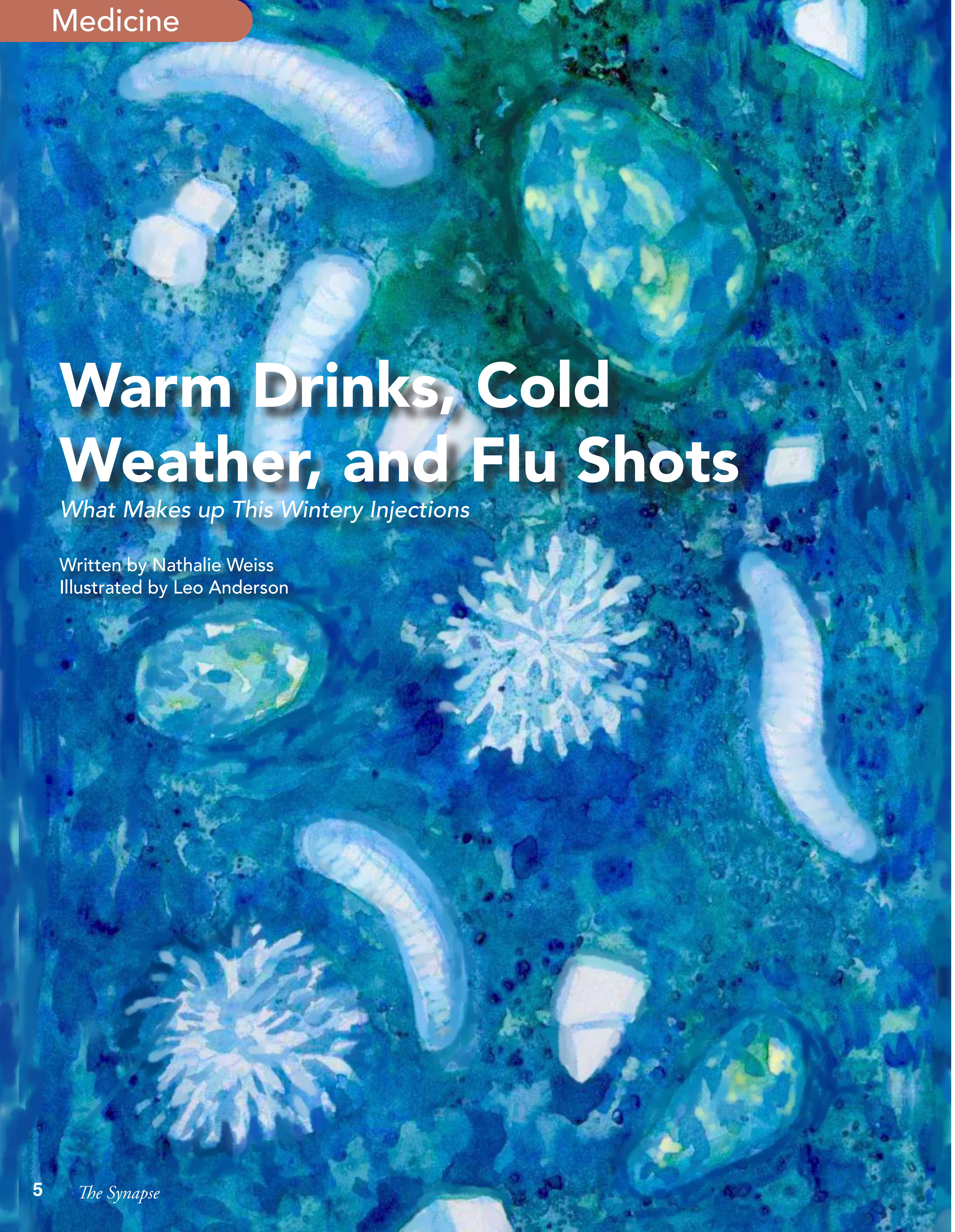
Most recently, scientists have discovered the game-changing way that these microbes impact weight loss. Knowing that bacteria directly impacts digestion, Jeffery Gordon sought to explore bacteria's ability to alter one's metabolism. To do so, Gordon experimented on two mice that exhibited wildly different metabolic features. The first mouse was obese, while the other was lean. However, both mice shared the exact same DNA, thus, Gordon was able to rule out any genetic factors such as hormone production that could have impacted each mouse's metabolism. Gordon then implanted the gut bacteria of both twins into two separate communities of lean mice. The results found that the lean mice who had received the gut bacteria from the obese mouse began to gain weight and exhibit obese metabolic features.

> What exactly is this fat-blasting 'lean bacteria,' and is that the bacteria that makes Kombucha seemingly healthy?

To see if he could reverse the effects of obesity, Gordon co-housed mice that had received the obese twins' bacteria with mice that had received the lean twins' gut microbiota. Gordon found that the presence of the lean microbiota caused the obese mice to lose wheight and develop the metabolic features of the lean mouse. To make the experiment more applicable for humans, Gordon fed the obese mice two very different mainstream diets. Diet A was strictly fruits and vegetables, while diet B was high in saturated fat and low in nutrients. When the obese mice were fed the diet A, the lean microbiota had no problem invading their guts. However, when fed diet B, the lean bacteria had a signifincalty harder time colonizing the guts of the obese mice. Gordon's experiment shows that bacteria can affect a person's metabolic features, but only when a high fiber diet is in place.

That brings us to the question: what exactly is this fat-blasting 'lean bacteria,' and is that the bacteria that makes Kombucha seemingly healthy? Unfortunately, Gordon found that there is no one specific species of bacteria that can increase a person's metabolism. Insteaded, he concluded that the marker of a 'lean' gut community is one that has a high diversification of bacteria. The type of bacteria that colonize our gut is contingent on the foods that we eat. If we eat a low fiber and unwholesome diet, then our guts end up fostering a homogeneous gut community that is without key bacteria need to carry out vital functions in our bodies. Conversely, if we eat a high fiber and nutrient dense diet, we create a diverse community of bacteria in our gut that insures that every niche type of bacteria is present.

The concept of Kombucha is not necessarily false. Gordon's study proved that a highly diverse gut community directly correlates to an increase in positive metabolic features. However, Kombucha only offers consumers a very small boost of lactobacillus, acetobacter, and gluconacetobacter, bacteria that is naturally found in western staples like yogurt, fruits, and coffee. Eating a nutritious, or even a relatively well-rounded diet insures these three species of bacteria naturally thrive in abundance inside of one's gut, rendering the health benefits of Kombucha moot. These fizzy drinks will most definitely not lead to a significant alteration of ones microbiome, and in excese, the average two-eight grams of sugar per bottle can actually lead to weight gain. While the science behind Kombucha's marketing remains accurate, this journalist will just stick to water. • • •



Warm Drinks, Cold Weather, and Flu Shots

What Makes up This Wintery Injections

Written by Nathalie Weiss
Illustrated by Leo Anderson

Winter: a time of warm drinks, spending time with loved ones, and getting your flu shot. We are urged by everyone, from our doctors to parents, to get the flu shot. But what exactly is a flu shot and how does it work? Flu shots are composed of a mixture of small amounts of different strains of influenza, formaldehyde, thimerosal, polysorbate 80, chicken egg proteins, sugars, gelatin, antibiotics, and aluminum salts. These ingredients may sound random and even a little gross, but they all play an important role in protecting you against the flu. Within your flu shot is common influenza viruses mixed together: Influenza A virus H1N1 (the Michigan strain), Influenza A virus H3N2 (the Hong Kong strain), and one or two Influenza B viruses (the Brisbane and Phuket strains). Influenza A can be carried and spread by different animals, while Influenza B can only be contracted by humans. Both of these viruses are spread in the same way- through droplets formed when someone sneezes, talks, coughs, etc. The presence of these viruses in the flu shot prompts the body to produce antibodies, which streamlines the process of a future encounter with the flu as the body can recognize and fight it off more effectively.

Formaldehyde is an ingredient whose presence seems a bit more complicated than the presence of A and B viruses. Formaldehyde is a colorless yet pungent gas in solution that is made through the oxidation of methanol, which is a liquid alcohol. Although it is toxic and even lethal in high doses, formaldehyde serves an important role in the flu shot's ability to protect us from the flu. Formaldehyde inactivates toxins from the viruses and bacteria that may have been present in the flu vaccine during production. Like formaldehyde, thimerosal also serves a similar purpose. Thimerosal is a preservative that can be used as a local

> The sugars and gelatin prevent the vaccine from losing potency when exposed to environmental factors such as light and heat.

antiseptic for minor cuts and specifically protects against the growth of unwanted fungi and bacteria in syringes when they are in multi-dose vials. To make thimerosal, scientists use a special type of mercury called ethylmercury. Regular mercury can cause illnesses when delivered to the body in large doses and can also remain in the blood for years. Ethylmercury, however, only stays in the blood for a few days, making it a safer alternative.

Another ingredient that promotes the vaccine's effectiveness and safety for bodily consumption is polysorbate 80. Polysorbate 80 keeps the other ingredients in the flu shot evenly distributed, like how additives prevent the separation of ingredients in food products such as salad dressings and sauces. Chicken egg proteins are also crucial to creating a flu shot. Many flu vaccines are produced through growing the viruses present in the shot within a fertilized chicken egg. Once inside the chicken egg, the virus makes copies of itself before it is then taken out of the egg and put into the vaccine. Sugars and gelatin are other food products that appear in the flu vaccine. The most common sugars present in the shot are sucrose (table sugar) and sorbitol (an artificial sweetener), and the gelatin is usually pork-based. The sugars and gelatin prevent the vaccine from losing potency when exposed to environmental factors such as light and heat.

Common antibiotics such as neomycin and gentamicin play a pivotal role in your flu shot. Neomycin can treat swimmer's ear and hepatic encephalopathy, which is the loss of brain function that results when the liver is damaged and cannot remove toxins from the blood. Gentamicin treats urinary tract infections, swimmer's ear,

> Formaldehyde purifies the flu shot by inactivating toxins in viruses and bacteria that may have been present in the flu vaccine during production.

the bubonic plague, pelvic inflammatory disease, and brucellosis (an infection caused by the consumption of unpasteurized dairy products). These antibiotics protect the vaccine from bacteria that could grow during production and storage. Although antibiotics enhance the vaccine itself, aluminum salts enhance the body's response to flu viruses. Aluminum salt, also known as aluminum sulfate, has the chemical formula $Al_2(SO_4)_3$. These salts are adjuvants, which improve the body's immune response to an antigen.

The flu vaccine contains many ingredients, some of which are recognizable from their presence in common food products, while others seem completely out of place, such as formaldehyde. However, all of these ingredients work together to improve both the purity of the vaccine itself as well as the body's response to future influenza viruses. Although it is not 100 percent effective, the Centers for Disease Control and Prevention (CDC) suggests that once a person is 6-months-old, they should begin getting their yearly vaccinations. This is due to the fact that the viruses present in the vaccine change every year as flu viruses adapt. So next winter, remember to get your gifts and your flu shot early! • • •

An Invisible Epidemic

The Significance, Challenges, and Science of Autoimmune Neuropathy

Written by Anna Harrison
Illustrated by Yue Yu

Autoimmune neuropathies are a class of disorders that encompass a variety of conditions where an individual's immune system attacks the peripheral nervous system. Often responsible for the propagation of chronic symptoms including fatigue, nausea, and chronic pain, autoimmune neuropathy is an increasingly important area of research. Despite the pressing need for further research on this topic, scientific knowledge on this class of disorders remains largely unknown. A few disorders have known initial triggers and modes of pathogenesis that have been well-defined but most remain a mystery. As a result of this void in autoimmune neuropathy research, public awareness is lacking, pharmaceutical development is stunted, and patients are left in vulnerable positions with few treatment options and very little information about their conditions or, for that matter, validation of their pain.

It is extremely common for neuropathy to occur on small nerve fibers, part of the sensory and autonomic nervous system. In fact, a recent meta-analysis study concluded that small-fiber neuropathy underlies about half of the illnesses labeled as fibromyalgia, which affects 2-5% of the global population. While certain large-fiber neuropathies such as chronic inflammatory demyelinating polyneuropathy can cause permanent damage, small-nerve fibers regenerate throughout life, so patients who receive proper care have a high likelihood of recovering completely. Symptoms can include reduced tactile sensation, hypersensitivity to tactile stimuli, poor balance (sensory ataxia), burning sensations, abnormal blood pressure and heart rate, and gastrointestinal dysfunction. In fact, neuropathy is the underlying cause of many cases of irritable bowel syndrome.

This article will review the current research methods utilized in studying autoimmune neuropathy and the barriers that researchers face in understanding the pathology of this class of disorders and creating safer treatment alternatives.

Neuropathy is the damage or death of nerves in the peripheral nervous system which includes nerves outside of the brain and spinal cord. Two main types of peripheral neurons include motor neurons that are in charge of movement and sensory neurons which sense and communicate stimuli and regulate bodily functions. Autoimmune neuropathy begins with a number of different initial inflammatory triggers such as diabetes, injury, infection, toxin exposure, or molecular mimicry. Molecular mimicry, or the overlap in reactivity between a foreign epitope and self-tissue, has been implicated in some autoimmune neuropathies, particularly from human papillomavirus. Regardless of the trigger, an unknown neuroinflammatory mechanism is activated where the immune cells mount an attack on part of the nerve fibers. Researchers are interested in understanding this unknown mechanism since it is a crucial piece needed to develop better diagnostics and treatments for autoimmune neuropathies.

One way in which scientists examine this unknown mechanism is through the use of model organisms. Rodent models are often used to study immune modulated pain or neuropathic conditions because of the ability to transfer disease through passive transfer, a technique in which a patient's immune components are transferred to a rodent in order to further study the specific disease. For example, researchers like Anne Louise Oaklander at Massachusetts General Hospital are able to study suspected autoimmune small-fiber neuropathy in rodent models. A sample containing a small-fiber neuropathy patient's immune components is passively transferred to mice or rats through a series of intraperitoneal injections. The goal of this passive transfer is to give healthy mice the autoreactive cells or other components that propagate the disease. Some researchers use serum, which includes all immune cells, proteins, hormones, and other non-red blood cell blood components while others use plasma, which is serum with the addition of an anticoagulant. Most commonly, however, immunoglobulin G antibodies are extracted from the serum and used for passive transfer to demonstrate the role of autoantibodies in pathogenesis.

Antibodies are proteins secreted by B-lymphocytes that bind to foreign targets and mark them for degradation by the immune system. When antibodies become autoreactive, they bind to our tissue and mark them for destruction by the immune system. Immunoglobulin G antibodies account for about 75% of all circulating antibodies. While there are a number of differences between human and mouse immune systems and care must be taken in performing these procedures, successful transfer of immunoglobulin G has been demonstrated.

A number of different assays are used to detect the sensitive changes that occur in small fiber neuropathy. The most common of which are behavioral tests that measure responses to physical stimuli to determine the threshold at which the rodents feel pain. When neuropathy is present, this threshold will either significantly increase (hypersensitive) or decrease (hyposensitive). The Hargreaves test and cold-water tail-flick are common methods to assess thermal pain. The Von Frey test is a classic measure of tactile stimuli used to calculate the mechanical withdrawal threshold via a range of blunt forces applied to the rodent's paw.

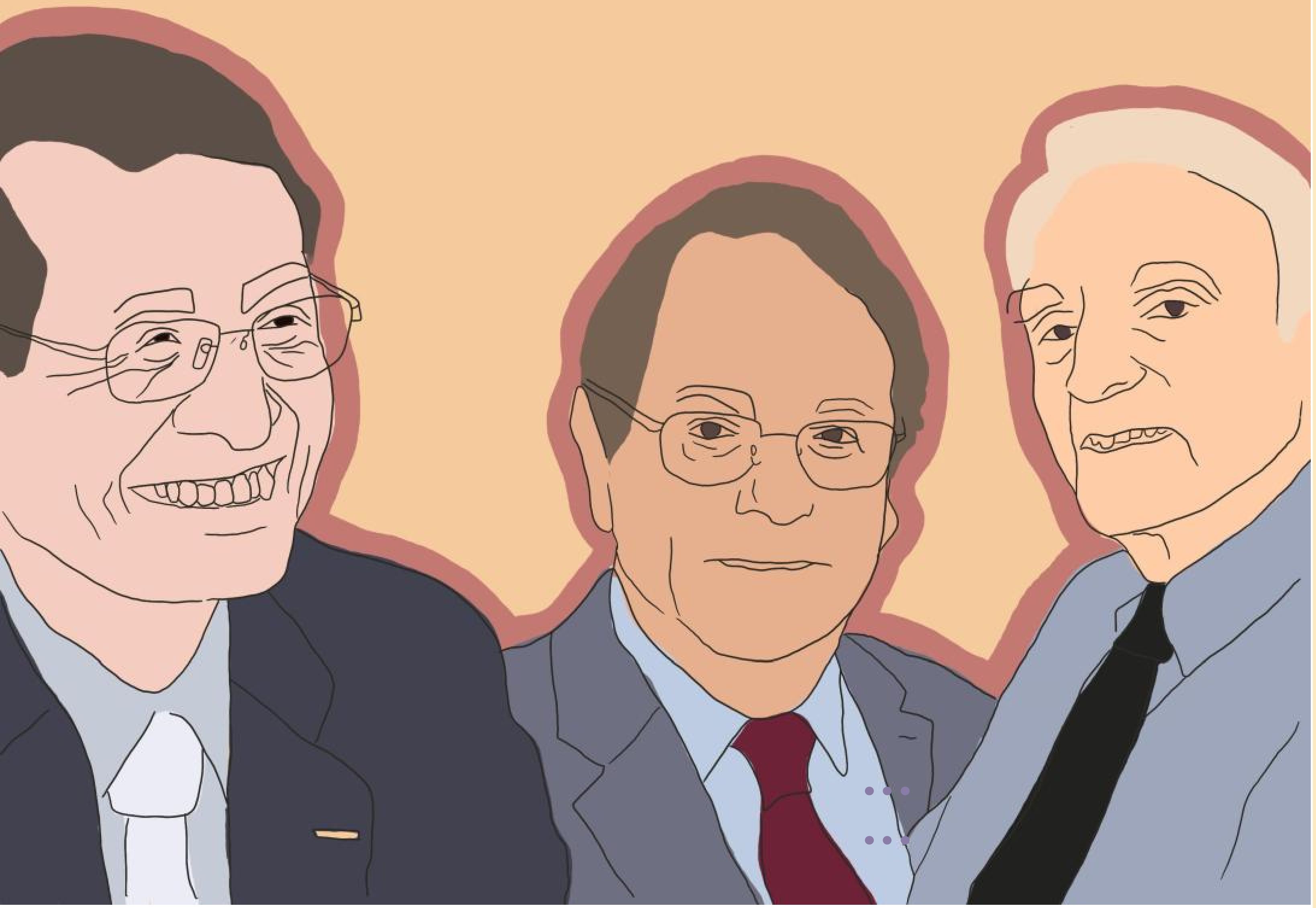
While these behavioral tests have been performed successfully hundreds of times and provide valuable insights in many painful conditions, as biotechnology advances the utility and robustness of the assays are called into question. A closer look at the literature shows a significant amount of variability in the data. Furthermore, assays often fail to reach statistical significance even when post-mortem pathological studies prove the presence of disease. For example, Dawes et. al demonstrate the presence of autoantibodies in a hypersensitive neuropathic pain model through immunohistochemistry, yet many of their behavioral pain assays lack statistically significant results. Several studies have been published demonstrating the vulnerability of mice to changes in their pain thresholds from a number of variables including things as simple as the color of the researcher's shirt.

Alternatives to behavioral assessments for pain or sensory neuropathy include electrocardiograms and electrophysiology studies to quantify changes in heart rate as well as transit studies to assess GI motility (both commonly affected by an autonomic neuropathy). Rodent plasma can also be analyzed for the levels of various inflammatory markers, and immunohistochemistry can be conducted to stain tissues with nerve damage. Recently, a study on acute painful neuropathy labeled patients' own antibodies and used them to immunostain small and larger fiber tissue to see if there was a response. Nerve density readings can also be done and are currently the standard objective clinical diagnostic measure of small fiber neuropathy.

While researchers are working diligently to create new methods to assess pain, challenges arise due to the high number of sub-categories and variable clinical presentations of autoimmune neuropathies. While they have clear pathologic distinctions, it becomes difficult to talk about these conditions when few doctors and researchers are familiar with the different variations of autoimmune neuropathy and the symptoms it can cause beyond the classic distal nerve pain and erythromelalgia.

Another barrier to studying autoimmune neuropathy is the specific population impacted. Individuals experiencing chronic pain, fatigue, and fibromyalgia are more likely to be female and/or reliant on pain medications like opioids. While searching for a solution to an unrelenting pain, far too often patients are denounced and labeled as hysterical or chronic complainers. Without the proper scientific evidence and the gender and social hierarchy present in medicine, the medical community has failed to acknowledge or provide for these patients, which perpetuates the challenge of research funding. Empowering this population of patients, bringing this issue to the attention of doctors, and changing the chronic-condition dialogue could be the first step towards forging change in this field.

Despite the tremendous national burden of chronic pain, fatigue, and fibromyalgia, funding for these autoimmune neuropathy disorders still remains low, and research for a new-generation global problem appears to be stuck in past generations. Increasing public awareness about autoimmune neuropathies and challenging the misogynistic dialogue about "chronic complainers" could be the first step in forging the way for advancements in autoimmune neuropathy research. • • •



The Battery Revolution

From an Electrifying Pile to Civilization as We Know It

Written by Ethan Pochna
Illustrated by Leina Fieleke

The internet revolution has irrevocably changed society, increasing our connectedness like never before. However, an under-appreciated revolution allowed this connectivity to go mobile: The Battery Revolution. Between the late 18th century and today, experimentation with electrochemical reactions (turning chemical energy into electricity) has changed the role electricity plays in our lives. The synthesis of the lithium-ion battery was a quantum leap forward, and the Nobel Prize Committee awarded the 2019 Nobel Prize in Chemistry to the three men behind it: John B. Goodenough, M. Stanley Wittingham, and Akira Yoshino. The committee credits them with "laying the foundation of a wireless, fossil-fuel free society," and when you look at what powers our phones, laptops, and electric cars, it's easy to see how. Despite the centuries of innovation, though, all batteries work in the same fundamental way: Electrochemical generation of energy within a closed cell.

This requires a chemistry review. Molecules are formed out of atoms sharing electrons (negatively charged subatomic particles), and when molecules split, the electrons aren't evenly distributed between the resulting particles. Thus, these particles, called ions, have charge imbalances that manifest as either positive or negative. Ignoring a lot of complex science, ions form bonds following two criteria: One, create the strongest bond possible given the circumstances. Two, bond with complimentary particles to re-balance charge. Thus, opposites attract.

In a battery, there are two metal electrodes-- an anode and a cathode-- in a solution full of ions called electrolytes, which result from a molecule dissolving in water. Each electrode competes with electrolytes to offer a more appealing bond, and in the ensuing interaction, the electrolyte uses the electrode's electron pool to balance itself. The anode gives to the electrolyte an ion that takes with it more than its share of electrons, so the anode is left electron-deficient. On the other hand, the cathode receives electrons from the electrolyte, resulting in an electron surplus. Once connected, electrons flow between the imbalanced electrodes, resulting in electricity.

Alessandro Volta, an Italian scientist working over 200 years ago, was the first to discover a reliable electrochemical system. He created a pile of zinc and silver disks separated by cloths soaked in a sodium chloride solution. Zinc and silver are dissimilar enough that they react inversely with sodium chloride to create an electron flow, but Volta's arrangement and materials were inefficient, bulky, and resulted in a tiny output. Nevertheless, his research laid the groundwork for electrochemical innovation, and, over the next 60 years, scientists investigated different electrode and electrolyte materials and arrangements to create more practical cells.

The next big breakthrough came in 1859, when Gaston Plante created a battery that could be recharged. Batteries "die" when their electrodes run out of ions to give or space to receive, but rechargeable "secondary" batteries are setup so that by applying a charge, the "primary" reaction is reversed and the electrodes are either re-plated (rebuilt) or deionized. Plante discovered such a reaction that used lead and lead oxide electrodes and a sulfuric acid electrolyte.

Lead and lead dioxide both react inversely with sulfuric acid to produce lead sulfate, creating an electron flow, while the break down of lead sulfate via electrical charge re-plates both electrodes. This meant that Plante's battery could "store" electricity, and then discharge it. However, the liquid acid was bulky, dangerous, and barely conductive, so the battery's energy density was miniscule and cost enormous.

The next phase of the battery's evolution came in 1866, when George-Lionel Leclanche used Volta's basic concept to create a closed, portable, and powerful "primary" (not rechargeable) battery. His manganese-oxide and zinc electrodes created a more energetic reaction than Volta's zinc and silver, and he used a "dry" electrolyte paste. Leclanche then created a sealing method that used a cylindrical frame, optimizing size, output, and accessibility leagues ahead of the competition. His design later became the first consumer battery in the 1890s and led to the Duracell "alkaline" battery in the 1950's.

In 1899, Waldemar Junger provided the next leap forward by revisiting the "secondary" battery with Leclanche's cylindrical concept and new advancements in materials science. Unlike Plante, he separated the two electrodes so their electrolyte solutions wouldn't interact. This allowed for higher-energy materials, and Junger chose manganese oxide and cadmium, which were the best non-explosive electrode options that successfully interacted with "wet" solutions at the time. Compared to Plante's battery, this nickel-cadmium battery had higher output, smaller size, and greater durability, but less charge capacity. Additionally, it was expensive, and didn't become commercially viable until the 1930s. Nevertheless, it provided, alongside lead-acid and carbon-zinc, a template for battery technology up through most of the 20th century. Each type served its purpose and satisfied technology's demands. Then, an arms race, developments in medical tech, and the explosion of consumer electronics changed those demands, and a new type of battery was needed. The search for materials was on.

Lithium was an obvious choice. Of all the metals, Lithium's ions are the most attractive to electrolytes, essentially providing the most incentive for a reaction. Unfortunately, Lithium loves to

"...all batteries work in the same fundamental way: Electrochemical generation of energy within a closed cell."

explode, and traditional electrolytes were too reactive. In 1972, an organic electrolyte solution was used in a lithium-manganese primary battery, the first "coin" battery. The output, size, and capacity ratios blew past competition, and eyes turned towards rechargeability.

As an anode, lithium easily replates. However, finding a replating cathode with ions compatible to organic electrolytes was difficult. While researching superconductors for renewable energy in response to the Oil Crisis, Stanley Wittingham discovered one. This energy-rich material was titanium disulfide, which can intercalate, or store in its open structure, lithium ions. Essentially, Wittingham discovered a stable material that, as a cathode, harnessed the power of lithium ions, and he created the first rechargeable lithium-ion battery. Then, the lithium anode exploded.

John Goodenough didn't fix that problem, but he did discover an even more productive cathode, intercalated cobalt oxide, which created a far more powerful battery in 1980. This set Akira Yoshino up for the finishing touch. The advancement meant that, provided an anode could intercalate a reasonable amount of lithium ions as well, a fully lithium anode wasn't necessary. The ions, not the molecules, drive the reaction. Yoshino found the material he was looking for, and in 1985, he created the first commercially viable, rechargeable lithium-ion battery. Due to the nature of the electrodes, this charged faster, stored more, and lasted longer than any of its predecessors-- by a wide margin on all fronts. Lithium-ion batteries were commercially released in 1992, and technology was never the same.

This meant complex, energy-intensive technology like computers and phones could go mobile, and the tech could be upgraded to energy-consuming levels previously impossible. It made smartphones, laptops, 4k and 4G feasible. It largely eliminated the problems that come with the unpredictability of renewable energy production by allowing for industrial-scale energy storage. The power of lithium-ion batteries has even made electric cars possible. Indeed, by forever changing how we power our lives, Goodenough, Wittingham, and Yoshino have changed our civilization.

Are We Corrupting Outer Space?

Independent Astronomers Violate International Space Accords

Written by Serena Dunlap
Illustrated by Aria Berryman

When Europeans began exploring the globe, it brought a plethora of discovery and innovation. However, with the migration of Europeans also came the disease-causing bacteria and viruses that congregated their homeland. When the natives of these new lands encountered these foreign species, it led to a great devastation to their population - millions of natives lost their lives to these new diseases. Earth still faces these issues today as non-native animals and plants dumped into new environments, subsequently eliminating local wild and plant life. While the problem of non-native species may have been limited to Earth for the past several hundred years, the irresponsible actions of private individuals may have expanded this issue to space.

Take, for instance, the dumping of Tardigrades on the moon. Tardigrades, a phylum of water-residing micro-animals, are incredibly resistant because of their ability to undergo cryptobiosis. This process puts them in a "tun" state wherein their metabolism is slowed dramatically, limiting their need for oxygen. These tardigrades can remain in this near-death state for extended periods of time, during which they are seemingly indestructible. Their resilient nature has led to a long history in the scientific community of testing tardigrades' limitations. Scientists have even gone so far as seeing if these creatures can exist in space. They can!

Then came scientist Nova Spivack and his Beresheet Lunar Lander, which was intended to be the first privately-owned spacecraft sent to the moon. The Beresheet Lunar Lander was created for Spivack's "Arch Mission": to bring a repository of Earth's history to space for any future beings to find. What he did instead violated international space agreements by contaminating lunar environments. After Spivack's cargo was approved, he snuck in two unchecked items: a sample of human DNA and a hunk of epoxy encased tardigrades. So, when the Beresheet Lander crashed, it very well may have left both biohazardous samples to interact with the moon's environment as they pleased. Given the tardigrades' resilience, the organisms are capable of staying on the moon for a lengthy period of time.

Another example of private scientists causing potential deep space contamination is Elon Musk's Tesla Roadster launch. Infamously, the private company SpaceX and its founder Elon Musk sent Elon's personal car, equipped with a dummy driver jamming along to "Life on Mars" by David Bowie on the radio, into the vacuum of space. This made for an admittedly great meme and a good advertisement for Musk, but it was also pretty negligent towards space travel protocols. The original plan was for the car to orbit the sun until it eventually fell into the star. However, the orbit of Musk's car as it passed Mars' orbit was wider than predicted due to an overestimate of the payload weight. The unpredictability of its current orbit is of concern to some scientists. As the car approaches the asteroid belt, it could then connect with other moving objects, leading to the dispersal of bacteria and other matter anywhere into the galaxy.

This perceived danger is in part due to the assumption that the car did not go through a decontamination process before entering space. This process is called baking and consists of cooking a vessel and its cargo at very high temperatures. If the Tesla had undergone this process, there would have been significant scorching on the seats, which was not apparent on images of it. Musk has neither confirmed nor denied this. This mission was government approved, but the payload was not closely monitored, and NASA refused to let a scientific payload be brought up by the Falcon Heavy rocket. Not properly decontaminating space is problematic, because we really don't know what life or environments we may disturb. For example, if we accidentally bring microbes to Mars we may inadvertently infect existing life, or spawn new life before having thoroughly studied the uncontaminated area.

Both Musk's car and Spivack's samples left unknown variables to interact with biohazardous materials, making a strong case for encompassing private companies into pre-existing international space accords. Moreover, with the rising number of billionaires, it is more and more possible for private companies with these means and abilities to exist. In response, many scientists suggest making strict rules about decontamination that are specific to each individual mission based on the likelihood of life being impacted. For example, a mission to Neptune would be relatively lax, as the planet isn't likely to host life. However, a trip to Europa or Mars would have a very comprehensive decontamination process. As far as the spoken agreements that exist between several nations, some have voiced interest in putting rules into law, though little has been done thus far to make this a reality. However, many citizens and scientists alike are pushing for a change to be made sooner rather than later.

NASA is now saying that alien life will probably be found by 2025, and many other respected astronomers strongly believe in extraterrestrial life. With this in mind, how cautious should we be? Have we already unknowingly impacted deep space and alien life? • • •

How Long is a Coast?

A Seemingly Trivial Question Leads to Fascinating Results

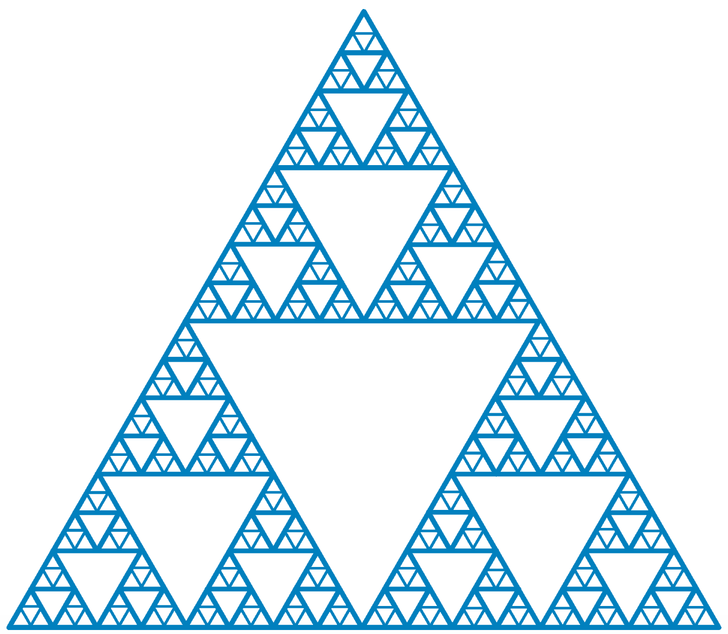
Written by Ruma Arabatti
Illustrated by Victoria Fisher & Emma Larson

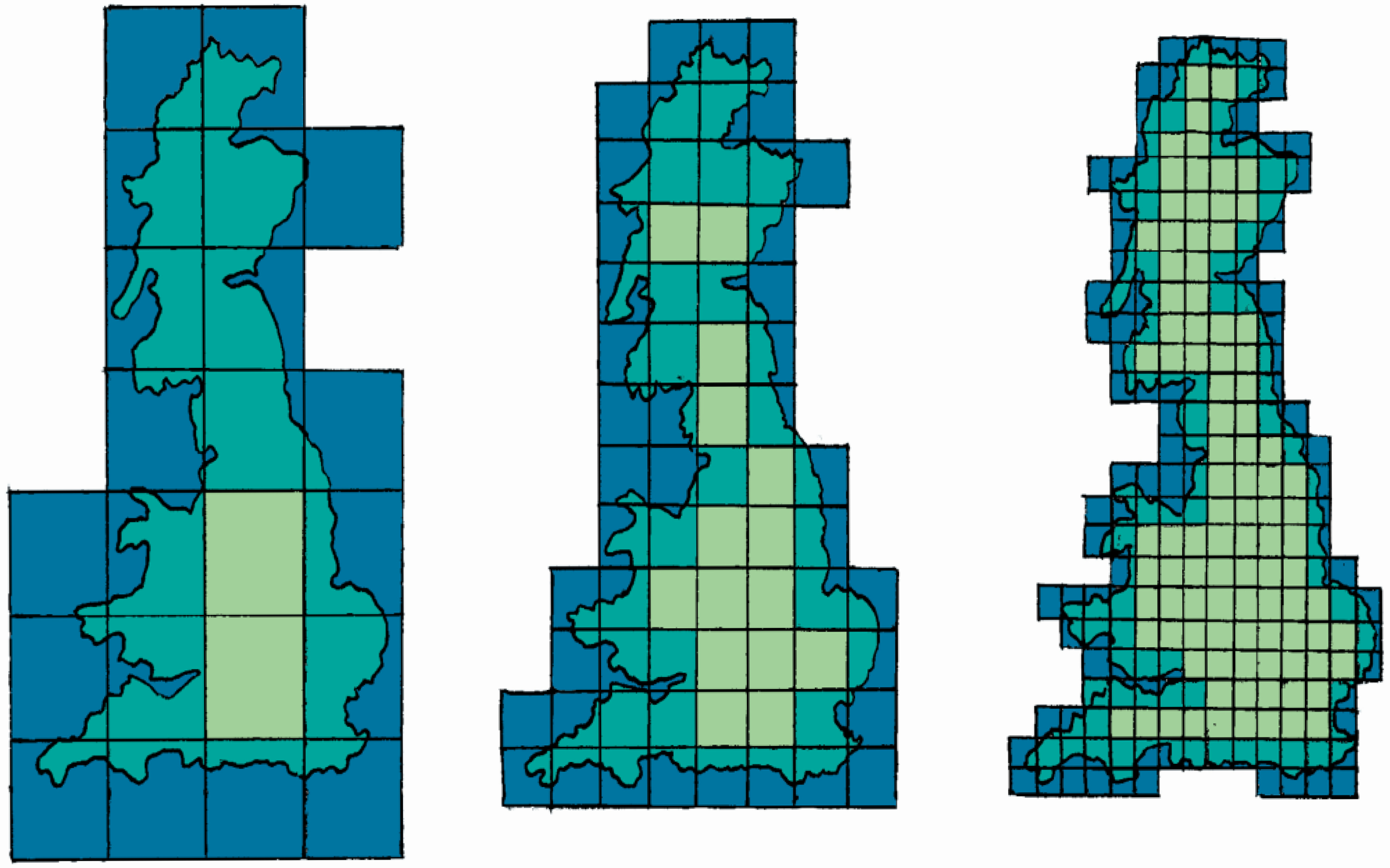
Say on one lazy summer day, you pull up Google Earth and decided to measure the coastline of the United States. After multiple measurements, you come up with a number close to 45,000 km. How close were you compared to official figures? To your surprise, you're nowhere close. The World Factbook puts the number at 19,924 km. Skeptically, you search for another source and fall into another surprise. The World Resources Institute estimates the U.S. coastline to be nearly seven times as much, at 133,312 km. What is the reason for this discrepancy? It certainly couldn't be a rounding error. Soon enough, you see why. The Alexander Archipelago in southeast Alaska reveals kilometers upon kilometers of mountains, like the jagged edges of a piece of foil. The Puget Sound near Seattle forces itself into Washington State, engraving friezes into the rock. With these intricate details, it is absolutely crucial to take into account the length of the ruler you use to measure with.

The conflict of ruler size with coastline length is nothing new. In 1951, Lewis Fry Richardson, a mathematician investigating the causes of war, believed that factors leading to disputes could be modelled mathematically. As a result, the chances of war could be predicted based on quantitative factors, much like the weather. One question he explored is how much more likely neighboring countries are to end up fighting one another, and it was here he engaged in a fascinating digression. It began with strange numbers: for the length of the Spain-Portugal border, Spain gave a figure of 987 km, while Portugal gave a figure of 1,214 km. To measure the length himself, Richardson studied from maps of various scales and counted off the number of "rulers" (of a fixed length) it took to cover the border. He discovered that as the size of the ruler decreases, the resulting border length increases like we have discussed before, because tinier rulers account for extra nooks and crannies hiding within the border. So, we should expect that as the ruler size gets smaller, the resulting border length should approach a specific value, right? Not quite. For reasons we shall see in a bit, as the ruler size decreases to infinitesimal lengths, the total length increases without bound. In other words, it's meaningless to ascribe an exact length to a border or coastline.

Mandelbrot sought to find a value that existed independently of the ruler size. He began by introducing the concept of a fractal, a shape with an infinite perimeter but a finite area.

At first, you must think that there must be some kind of mistake. After all, the entire branch of calculus was developed on the idea that anything could be represented as a sum of infinitesimal building blocks.There must be a way to rectify the situation, literally and figuratively. Answers came nearly twenty years later, when Benoit B. Mandelbrot happened to stumble upon Richardson's results. In his seminal paper, "How Long is the Coastline of Britain? Statistical Self-Similarity and Fractional Dimension,", Mandelbrot sought to find a value that existed independently of the ruler size. He began by introducing the concept of a fractal, a shape with an infinite perimeter but a finite area. He proposed that the degree of roughness could be described by a number D, which possesses properties similar to a dimension. In our intuitive perspective of a dimension, we usually say that one-dimensional entities are lines, two-dimensional objects are squares, and three-dimensional objects are cubes. However, unlike the idea of whole number dimensions with which we usually associate objects, Mandelbrot said that the dimension can be fractional. To understand how objects could possess non-integer dimensions, we must define what a dimension means in fractal geometry.





Take a line, for example, characterized by only one "spatial descriptor" (corresponding to a dimension of one): length. Let's scale it by a factor of one-half. Notice how two of these scaled lines can fit inside the original line, a property known as self-similarity. Next, let's look at a square, characterized by two spatial descriptors, and also scale it by one-half. We are now able to fit four scaled pieces into the original, i.e. we have four self-similar pieces. When generalized to an object with D many spatial descriptors, the number of self-similar pieces will be

$$N = \frac{1}{x^D}$$

where x is the scaling factor. Now that we have a general definition, we can then attain a value for the dimension of a fractal. Take, for example, the Sierpinski triangle, a nested set of equilateral triangles in the shape of another equilateral triangle.a

Using the general rule we established, we end up with a number of about 1.58, a little more than halfway between a line and a plane. It seems strange to think of a shape that way, but it's a good example to start thinking about what a dimension really means.

Now that we know how to calculate the dimension of a self-similar object, you must be thinking: how are we supposed to find the dimension of something as complicated as a coastline? Fortunately, there is a way, and the method is simpler than you may think. To put it simply, we can place a country like Great Britain over a grid and count the number of squares the coastline touches, scaling the squares on the grid, and counting the boxes again. A square on the grid possesses a side length 1/x, where x is the factor we scale the original object with. After that, we can scale the squares down some more and recount the touched boxes. The rate of change between the touched boxes and side lengths is the dimension. Richardson and Mandelbrot estimated the dimension of Great Britain to be around 1.25.

The dimension here also represents the degree of roughness, or how much an object varies in a given space. If you look at Norway, a country riddled with fjords and islands, it's no surprise knowing that it possesses the greatest dimension of all, at 1.52. Though this number serves no apparent practical purpose, it eliminates the nonsensical result of infinite coastline length. This makes it possible to reasonably compare the nature of coastlines independent of ruler size.

There is no perfectly accurate method to measure the true length of a coastline. In fact, it's meaningless to even embark on such a task. However, one can hardly call the attempts to do so a failure. Mandelbrot's invention of fractal geometry transformed this apparent impossibility into a powerful mathematical concept, and its applications arise across disciplines, anywhere from chaos theory to seismology. The creation of such a branch of mathematics refines our intricate language of the universe, a place inhabited by uncertainty and complication, and brings us a little closer to understanding reality. • • •

A Synapse Series: History of Science

The History of Biology

A Peek at The History of Oberlin Biology Department

Written by Yue Yu
Illustrated by Norah Han

In 1834, when Oberlin College first established its science curriculum, there was only a limited number of classes due to the lack of faculty members and science facilities. In the past century, the significant development of the college and the impact of the general biology society have influenced the department's curriculum structure. Analyzing the course catalogs from the different periods will allow us to look at the stepwise growth of the Department of Biology in Oberlin.

The earliest biology classes offered in Oberlin included Botany, Anatomy, Physiology, and Zoology. These courses were taught by James Dascomb, who was the only instructor for science classes until 1850. Unlike the current science departments, which occupy the whole four-floor Science Center building, the early science classes were taught in a corner on the first floor of Oberlin Hall, a building located where the Aladdin restaurant is now. In 1850, an entirely new curriculum structure was designed to organize the increasing number of natural science classes. From 1860 to 1870, during the Civil War, the number of natural science classes offered in Oberlin shrunk, possibly due to the limited resources at that special period. Some courses such as zoology were no longer offered, while other courses like botany were reduced. After this tough period, in the late 1870s, the number of classes in natural science boost more than in any other subject area. The effort of the Oberlin faculty contributed directly to this rapid expansion. For instance, Professor Albert A. Wright, who joined the science faculties in 1874, designed the first experimental exercises for the laboratory sessions and gathered plentiful natural science specimens for the Oberlin College Museum.

In the 1890s and early 1900s, the curriculum became more flexible as students could choose classes depending on whether they wanted to further their study in Botany or Zoology. New courses including Elementary Botany, Systematic Zoology, and advanced classes in Vertebrate Anatomy were provided to students. This change in the course catalog may be due to the significant reformation of departments that took place in 1892. A new department called the College Department was formed. Within this department, the first biological science divisions, the Department of Zoology and the Department of Botany, were created. The natural science courses offered in the Department of Philosophy and the Arts before 1892 were moved to the new departments, increasing the number of natural science classes. In addition, various new laboratories became available to students and faculty in the early 1890s, which triggered the long-term increase in number of the laboratory courses. In 1892, the botany facilities and resources transferred to the Finney House, which was built on where the Finney Chapel is now. In the Finney House, two new laboratories were built in connection with the herbarium. In 1904, the Spear Laboratory, which located in the Lincoln House, was built for the sole use of the Department of Botany. It was a more convenient place for various botany works as the whole building was equipped with water and electricity.

Finally, with the effort of the college administration, the Department of Botany and the Department of Zoology were merged into the Department of Biology in 1962 following the construction of the the Kettering Hall of Science in 1960. Kettering hall had two wings, one harbored the biology department and the other the chemistry department. The new spaces allowed a significant increase in the number of biology laboratory sessions in the 1960s.

Another noticeable change is that the Graduate science program(AM), which had been offered since 1890, was no longer given after 1962. This means all faculty and facilities were devoted to undergraduate education and research. The reallocation of resources may be one of the reasons why numerous new biology classes appeared on the course catalog list while only a few new faculty members were hired in this period.

The curriculum became more flexible in this period as classes were arranged into 100, 200 and 300 levels, just like the current courses. The General Botany and Animal Zoology were replaced by a 100-level introductory class, which covered extensive topics of both Botany and Zoology. However, some of the higher-level courses listed in the catalog were only offered to students who earned a grade better than B in the specific introductory-level courses. The department might have needed this rule to limit the number of students in higher-level classes due to the limited resources. For instance, in the course catalog of 1964 and 1965, one of the courses that required a grade better than B is microbiology, which required optical microscopes for the lab session. Due to the limited number of optical microscopes available at that time, the school had to consider students who are likely to put more efforts into the course as the priority.

In the late 1970s and 1980s, the department put more effort into the development of cross-department courses to satisfy students' interdisciplinary interests. Students in these classes could earn credits toward both biology and psychology major. Given faculty and students' rising interest in neuroscience, a program in Psychobiology was created in the college catalog in 1975. The program kept expanding as more faculty joined the program, and more neurosciences classes such as Fundamentals of Neuroscience were added to the course catalog. Five years later, in 1987, the Department of Neuroscience was established. Consequently, some interdisciplinary classes were isolated from the Department of Biology, although the credit of most neuroscience classes can still be counted toward the biology major.

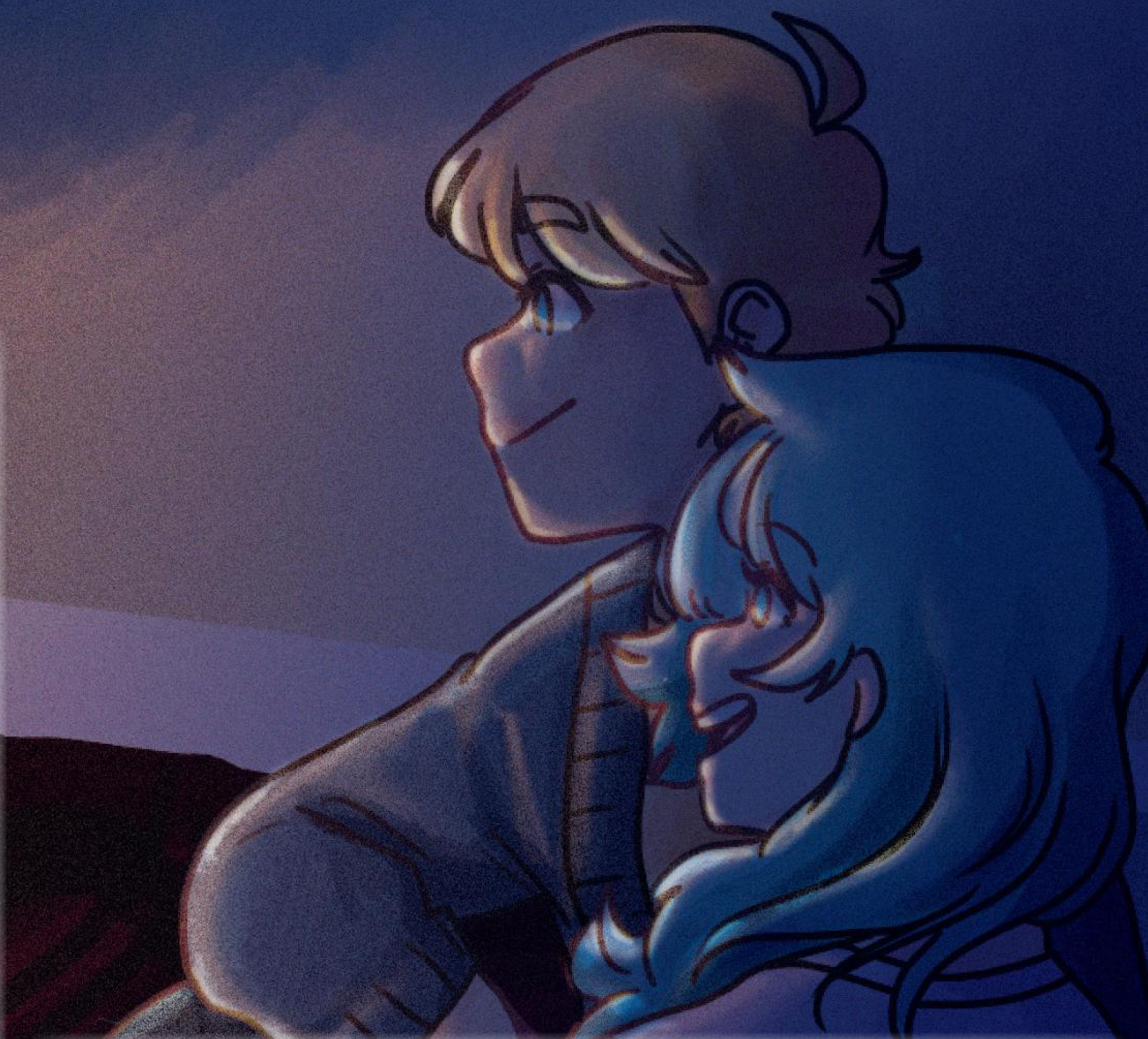
In the 2000s, the lab sessions were redesigned, and more interdisciplinary classes with innovative course structure are added to the course list. The construction of the new Science Center in 2002 plays a critical role in the development of this period. The current Science Center resolved the overcrowding problems and safety issues in Kettering. It has several big lecture halls and many multimedia classrooms, which allows more classes to be offered at the same time. Also, the various laboratories in the Science Center satisfy the need for experimental exercises, and the installation of the frontier scientific instruments, such as the supercomputer and the confocal microscope, supports research.

The course catalogs that are kept in reserve in the archive today are snapshots of the department in different developmental periods. Underlying is the effort of the college and the faculty to provide students with better science education: more hands-on experience, more diverse fields, and more cutting-edge topics. Next time the course catalog comes out, one may read not only the courses offered in the following semester but the century-long history behind it.

Finding Emotions

Using Finding Nemo to Analyze Emotionality Based on Gender

Written by Elizabeth Toigo
Illustrated by Athina Apazidis



According to gender and emotion stereotypes, women are more emotional than seemingly unfeeling men. When does this assumption hold true? Based on recent literature, this statement becomes more complicated than a single straightforward stereotype. Different contexts, parental roles, and personal beliefs connect gender and emotion. Finding Nemo demonstrates that the emotions of Marlin, Nemo's dad, reflect gender-emotion stereotypes, but he ultimately opposes them during his journey of finding his son. In turn, Marlin's portrayal of different emotions can be a symbol of both his external and internal journey throughout the movie.

In Finding Nemo, Marlin endures not only a physical journey, but also an emotional one. From raising Nemo as a single father to losing Nemo and swimming across the ocean to find him, Marlin transforms from merely a fish who internally contains his emotions, to an externally expressive dad who opposes gender-emotion stereotypes. Throughout this emotional transformation, Marlin grapples with the consequences of either remaining consistent with gender-emotion stereotypes or opposing them. Gender and emotion literature can shed some light on the emotional complexity of this character.

After the tragic death of Nemo's mom, Marlin finds himself in a single-parent home with his biological son– a situation that no fish wants to find themselves in. It is, however, a factor discussed in gender-emotion literature. Single-parent advice literature assumes that single fathers have a strong bond with their children. In the context of this bond, society encourages them to be emotionally expressive, yet warns single mothers that their emotional expression is harmful to children. Some of the first words Marlin says to Nemo are, "Daddy's here. Daddy's got you. I promise, I will never let anything happen to you." This phrase illustrates the bond between Marlin and Nemo, which began even before Nemo was fully developed. In this bond, consistent with single father advice, Marlin is able to express his emotional worries, protectiveness, and love for his son. When Nemo is headed to school, Marlin warns, "So, first we check to see that the coast is clear. We go out [of the house] and back in. We go out, and back in. And then one more time--out and back in." Marlin is protective of his only son and wants to ensure that nothing will happen to him. After Nemo's mother is killed, Marlin says, "And my son was mad at me. And maybe he wouldn't have [swam away] if I hadn't been so tough on him, I don't know." Guilt is a common emotion among parents, but research indicates that single fathers feel guilt more intensely than married fathers. When Marlin loses his son, he is still dealing with the guilt of his wife's death.

Towards the beginning of Marlin's journey, his emotional expressions are mostly stereotypical. For instance, adults associate angry expressions more with males than females, and Marlin shows anger from the outset of the movie. As Nemo threatens to touch the boat, he demands, "Nemo! What do you think you're doing? Get back here! I said get back here, now! Stop! You take one move, mister. Don't you dare!" Another emotion, pride, is commonly associated more with men than women, and is also consistently exemplified by Marlin. For instance, he uses a phrase of endearment, "That's my boy," throughout the movie. Marlin expresses both masculine anger and pride in his relationship with Nemo.

Marlin's emotional masculinity becomes intensified by his circumstances; he has lost not only his wife but also his son. Throughout his journey, Marlin's emotions are accepted by other underwater creatures due to the correspondence bias. This bias states that internal attributions are made for women's emotional expressions whereas situational attributions are made for men's emotional expressions. This is particularly evident with emotions such as sadness, fear, and anger, which Marlin routinely exhibits on the journey to find his son. When Nemo is first taken and Marlin responds with, "Oh no. No, no. [The boat's] gone, it's gone. No, no, it can't be gone. Nemo! Nemo," it is perceived as an acceptable emotional expression given the context of the situation. His overly emotional reaction is not attributed to his personality or seen as overreacting because, as a man, his emotions are perceived as due to external factors. Later, Marlin meets the sharks and Bruce, noticing Marlin's terror, comments, "Now there is a father looking for his little boy." Marlin's emotions, from anger to fear to sadness, are consistently attributed to the tragic situation of the loss of his son rather than his innate disposition. This evaluation of his emotions based on the situation becomes a pivotal turning point in Marlin's internal journey, as his sadness and fear develop into newfound emotions that he expresses, rather than keeping them internal.

As the journey continues, Marlin expresses emotions that are not consistent with gender-emotion stereotypes, as he shows unrequited love, happiness, and excitement towards his son. Research has found that women seemingly express love, sadness, fear, and sometimes happiness more than men. Marlin, however, expresses these emotions more than the females in Finding Nemo, such as Dory. These emotions are not natural for him; he expresses them only as he learns more about his relationship with Nemo. Towards the end of the movie, he says, "I'm feeling...happy. Which is a big deal for me." Marlin demonstrates that emotions not stereotypically associated with males, such as happiness, are difficult for men to externally express. After this pivotal moment, he then opens up even more after riding with the sea turtles through the ocean currents,exclaiming, "Ha ha ha ha! That was..fun! I actually enjoyed that!" He expresses his excitement and happiness with less hesitation than before.

Many people believe that men express more anger and pride while women express more happiness, sadness, love, and fear. Marlin expresses mostly anger and pride in the beginning of the movie, but as the journey progresses, he also shows considerably more happiness, sadness, love, and fear compared to his women counterparts. Once Marlin finds Nemo, his outward journey ends, while his inward journey ends with him whispering, "I love you too, son." He does not shy away from expressing this. Instead, he is peaceful. Marlin no longer succumbs to gender-emotion stereotypes, unconsciously opposing them after he reunites with his son.

Marlin in Finding Nemo exemplifies the complexity of gender and emotion stereotypes, specifically how one may unconsciously both conform to them and oppose them. Marlin's external journey to find his son is symbolic of his internal journey, where he must decide what type of emotional fish he will be. This is analogous to the journey that men in our society must endure. How will men choose to act with their knowledge of stereotypes? What journey of emotional self-discovery do people undergo in our society? Opposing gender-emotion stereotypes is an obstacle that everyone must overcome. When will your journey start? • • •

Bitcoin...

Is Not Really A Coin

Written by Haley Giang
Illustrated by Alex Tash

As technology advances in this highly developed scientific era, computer science has a greater impact on our daily life. We gradually replace physical objects with online presence. For example, now we can pay with our credit cards instead of paying with cash in person. Currency is no exception. Currency that exists in intangible, virtual, or digital form came to be known as "cryptocurrency." In this article, I will introduce a type of cryptocurrency called Bitcoin. I will discuss Bitcoin's characteristics, and the public ledger on which Bitcoin runs, and its value as well as what you can do with it.

The largest and most well-known cryptocurrency right now is Bitcoin. Three important characteristics of Bitcoin include: being the first decentralized cryptocurrency, running on a ledger called "blockchain," and having a value that fluctuates constantly.

So, what does "decentralized" mean? Most current forms of money, whether that be in cash or stored in debit/credit cards, are controlled by the government, banks, or payment networks like Visa, Mastercard, etc. Unlike these kinds of money, Bitcoin is not run by a single company or person; rather, it is maintained by a group of volunteer coders and is connected to a network

Bitcoin's price is always fluctuating; one week a single bitcoin can be worth $10,000, the next week it can be worth $17,000, and the week after that it can be worth only $2,000.

of hundreds of thousands of computers all around the world. This computer system keeps track of all Bitcoin transactions. This system can be thought of like a group project on Google Slide where everyone can contribute from their local computers through a decentralized system.

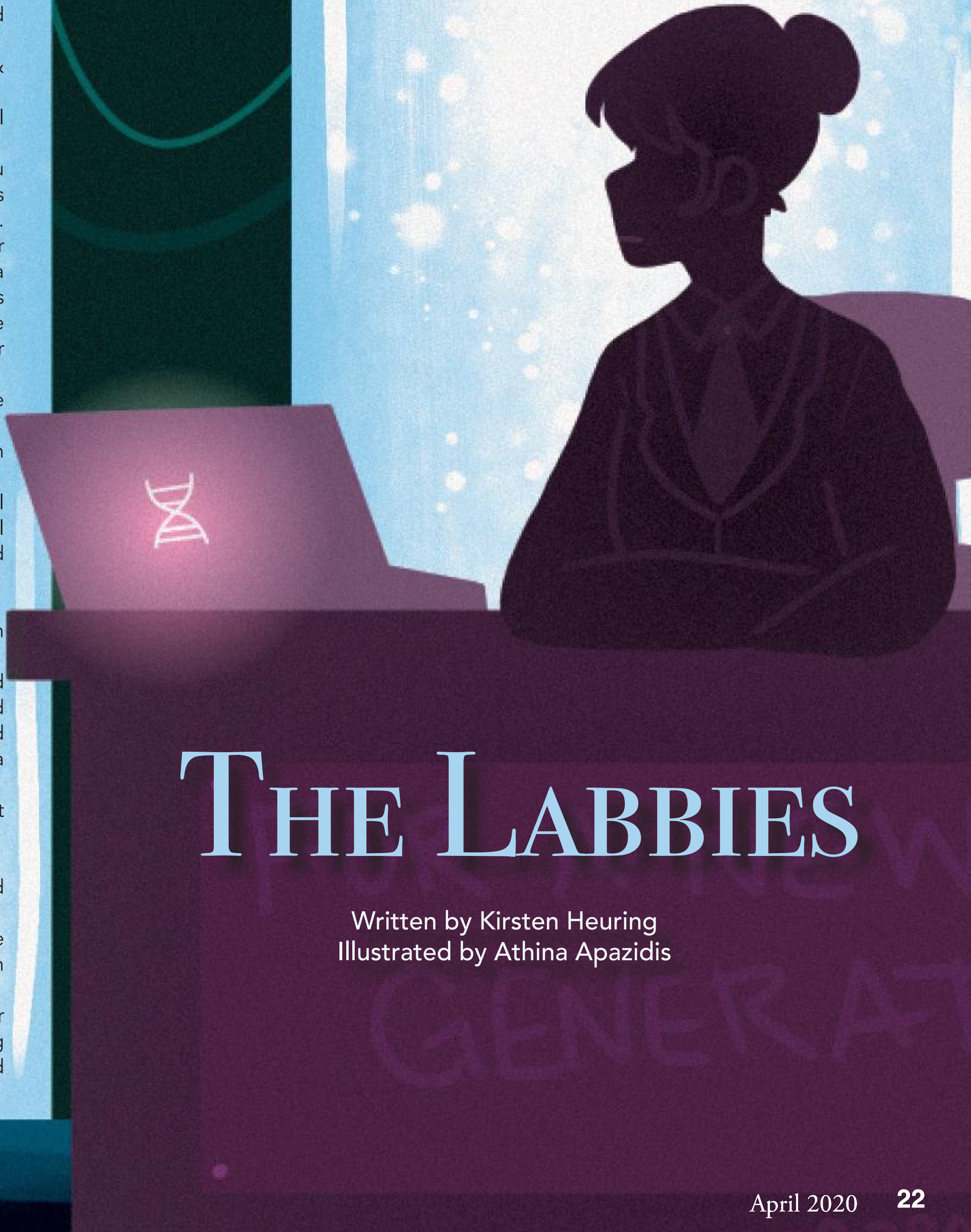
The decentralized system on which Bitcoin runs is a ledger called "blockchain." The blockchain records all transactions that happen and gets updated every hour in computers worldwide. Blockchain, like its name suggests, consists of multiple blocks of transaction. A block is a form of information storage that records a transaction's date, time, and amount of money purchased. In order for a block to be added to the blockchain, the transaction must occur, must be verified, and must be stored in a block. It also must be given a hash, which is a unique code for each block that ensures the transaction is not duplicated or counterfeited. When that new block is added to the blockchain, the block becomes visible everywhere because blockchain is public, which prevents fraud and theft because people cannot hide the number of bitcoins they have in their wallets.

As of right now, a single Bitcoin is worth more than US$ 7,000. However, this value is not constant. Bitcoin's price is always fluctuating; one week a single bitcoin can be worth $10,000, the next week it can be worth $17,000, and the week after that it can be worth only $2,000. There's no way of predicting Bitcoin's value from one week to the next.

You can store your bitcoins in a bitcoin wallet. Like a normal wallet, if someone steals it, they will be able to steal all your bitcoins. But unlike cash that can keep being printed out, there's a limit to how many bitcoins can circulate—21 million. So far, about 18 million bitcoins have been distributed. This fixed supply of currency guarantees that banks are under control.

Suppose you have a certain amount of bitcoins in your wallet. What can you do with it? There are stores that allow you to purchase with bitcoins, but generally, people consider it an investment, albeit a risky one, which they call "mining." An advantage of Bitcoin is that because it is decentralized, it is really easy to transfer money from place to place. Consider transferring from a traditional money system (USD, CAD, GBP, MXN, etc.) to a cryptocurrency system, called the Fiat, the transaction is easier and faster. For example, if I want to send money from the US to Vietnam to my family, it would take a few days for the money to wire transfer. It would have to go through a local bank to the US National Bank to the Vietnam National Bank to another local bank. But with Bitcoin, the money will be transferred immediately with concrete receipt and evidence.

The concept of cryptocurrency, although not new, is still under construction and assessment, meaning coders and computer scientists are still trying to perfect the system. There are still questions relating to its privacy and security that remain unanswered. For now, scientists are still trying to make Bitcoin, as well as other cryptocurrencies, more accessible to the public. And in the near future, we might be able to replace cash and other kinds of money with cryptocurrencies. • • •



THE LABBIES

Written by Kirsten Heuring
Illustrated by Athina Apazidis

Content Warning: The following story contains implication of non-consensual sexual interactions and slavery

"Excuse me?"

Carlotta heard a smart, high-heeled shoe tapping on the marble floors in front of her. She looked up from her computer screens, forcing a smile. In front of her was a statuesque woman in a fur coat. The woman's arms were crossed, and she glared at Carlotta haughtily.

"I'm here to see Dr. Lu about my labby. I am his 11:15."

Carlotta glanced at her computer clock. It was 11:00. She pulled up the doctor's schedule and tried not to groan when she saw that, yes, the impatient woman was scheduled. Now, Carlotta would be stuck in the lobby with her for the next quarter of an hour. Perfect. Just what she wanted. She managed to keep her plastic smile as she looked up at the woman.

"Dr. Lu is with another client right now, Miss Harrison. He will be with you in about 15 minutes. If you could please have a seat? I'll bring you a coffee or tea if you'd like."

Miss Harrison huffed and reluctantly clacked off to one of the waiting tables.

Carlotta rolled her eyes once she was sure the fur-coated woman could not see her. She had been working for Lu, Matthers, & Klein for a little over a year, and ever since she had started, she had been dealing with men and women, like the charming Miss Harrison, daily. After all labbies, lab-grown humans, were all the rage, and the doctors at Lu, Matthers, & Klein were the best in the business.

Carlotta frowned as she heard dress shoes walking across the marble floors. Male this time, and there was the slap of bare feet right behind. Carlotta glanced up. An older man in a bespoke suit was walking with a dazed young man beside him. The younger man was only in a hospital gown, and he kept blinking, unused to the light. The older man smiled a bit.

"Don't worry, Louis. You'll be out of the sunlight soon."

The younger man nodded tentatively and tripped over one of the rugs at the entrance of the building. The older man caught him and smiled, caressing his face.

"It's alright. I have you. Let's go home."

Carlotta looked back at her screens as the pair left and shifted uncomfortably in her seat. Then again for someone like that, time was money. What was the point of searching for someone compatible when you could just pay and make them?

Carlotta heard the doors open again. She frowned slightly when she did not hear the usual clack of dress shoes or heels made against marble.

"What are riff-raff like you doing here?" Miss Harrison asked. Carlotta looked up to see a couple who had never come in before. Two men were standing next to each other. One was tall and lanky while the other was shorter and more compact. They did not look like the sort of rich people that usually came in. They looked more like middle-class professionals, the type that usually couldn't afford the costs of a labby. The shorter man glared at her.

"Like you should talk! You're probably just here to get some sort of glorified--"

"Love, please," the tall man said, gently taking his partner's hand and squeezing it. The shorter man grew quiet but continued to glare at Miss Harrison.

"How dare you!" She snapped. "I should call security--"

"Miss Harrison? I think Dr. Lu just got done. You can go back and see him now," Carlotta said. The last thing she wanted was a fight in the lobby.

The woman huffed. "Finally!" she snapped before storming back.

Carlotta breathed a short sigh of relief and turned to the couple. The tall man was holding his partner's hand and trying to comfort him, even though he, himself, was shaking. His partner huffed and looked annoyed, but he was gently rubbing the back of the tall man's hand to comfort him.

"I'm really sorry about that. Welcome to Lu, Matthers, & Klein. My name is Carlotta. How may I help you?"

"Um… Hi… Uh… Can you explain how this works?" the tall man asked. It sounded like he was trying not to stutter.

"Of course! So after you decide what kind of human you would like, skin tone, intelligence, sex, eye color, etc., the doctors here used that information to pick out just the right genes to use. Those genes are implanted into stem cells that have had their previous DNA extracted. From there, we put the stem cells in a special, patented incubator. After a month, the fully-grown human is ready to come out of the incubator. For the next two weeks, you are welcome to come visit them as they learn about the world, and after they understand the basics, you're welcome to take them home!"

Carlotta had her spiel memorized. Honestly, it was the closest she got to using her biology degree in this job.

"Has anyone here ever asked for a baby?" the shorter man asked.

Carlotta blinked. That was a new one. She usually got all sorts of requests: servants, romantic partners, the occasional parental figure, the occasional super anthropomorphic animal, or some weird combination of the other stuff. But no one ever wanted a baby.

"No," she replied honestly.

"Can you guys do that? Make a baby?" the shorter man asked again.

The taller man looked nervous but hopeful. Carlotta looked between the two of them. She walked back to her desk and checked her computer, pulling up different techniques. The men followed her, each squeezing the other's hand. After a few minutes, Carlotta looked up at them.

"I think it could be possible. I can schedule you both an appointment with Dr. Matthers? She likes a challenge."

"That would be great!" the taller man said excitedly.

The shorter man smiled up at his partner and gently rubbed his back. "See? I told you we could be parents…"

For one of the first times at her job, Carlotta felt a genuine smile tugging at her mouth. She looked up at them both. "So when would you like to schedule your appointment?"

The shorter man took care of the paperwork as his partner held his other hand. The tall man was grinning ear to ear, nuzzling his partner's hair. The shorter man gently waved him off so he could finish the forms. Carlotta looked them over when he was done.

"Looks like everything has been sorted. We'll see you next week," she said.

The tall man hugged his partner tightly as the shorter one smiled slightly and rubbed his back. They left together, holding hands. For once, Carlotta couldn't help but smile. Perhaps this job was not as horrible as she'd thought—

"I'm here to see Dr. Matthers about my servant."

Carlotta sighed and looked back at her keyboard. She put on a cheery smile and looked up to greet the next rich customer. • • •

Neuroscience Themed WORD SEARCH

J	A	X	J	U	Q	Q	Z	A	C	B	N	D	G	I
E	T	I	R	D	N	E	D	E	J	I	Y	W	M	W
Q	K	A	Y	Q	C	J	R	C	C	Z	X	M	E	T
D	A	T	W	H	U	E	A	O	O	D	T	V	F	V
S	F	L	V	D	B	P	T	G	E	S	S	O	I	K
M	Y	O	A	E	R	Y	S	Y	N	A	P	S	E	V
N	O	Z	L	D	X	G	B	C	I	C	I	M	I	M
M	E	L	A	O	G	R	D	B	M	C	N	J	J	O
F	U	R	K	R	A	Y	W	U	A	G	E	N	K	G
M	D	H	V	I	V	Y	M	H	P	O	H	F	W	R
K	Q	P	N	E	R	Y	J	A	O	H	H	R	Y	Q
F	D	E	P	V	S	B	H	P	D	X	Y	P	E	T
P	Z	A	O	M	Y	Y	W	P	S	J	N	H	Y	X
Q	Z	C	I	B	Y	A	I	L	G	P	P	V	X	B
K	B	I	O	S	A	H	N	P	K	L	O	L	Z	F

AMYGDALA BRAIN CEREBELLUM DENDRITE DOPAMINE

GLIA NERVES OXYTOCIN SPINE SYNAPSE

Meet *The Synapse*...

...at Oberlin

Pictured from left to right, back to front: Zoë Martin del Campo, Steven Mentzer, Athina Apazidis, Rebecca Fenselau, Emma Larson, Yue Yu, Evelyn Morrison, Miranda Marnik-Said, Victoria Fisher

...at Denison

Pictured from left to right: Casey Pearce, Kileigh Ford, Elizabeth Toigo, Delaney McRitchie

/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.