The Synapse

Intercollegiate Science Magazine

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At the end of

September, Oberlin College had the unique opportunity of hosting a Translating Science Symposium. The symposium was created in reaction to the March for Science and the problems that it revealed about the general public's perception of science research, as well as how science affects humanity at basic and more complex levels. Various college departments and groups collaborated to bring together five science communicators—four of them Oberlin College alumni—to talk to students, faculty, and community members alike about their work in science outreach.

This was really exciting for us at *The Synapse*—this is what we're all about!—and we were thrilled to be able to participate in this opportunity to look at scientific inquiry from a communications angle with Oberlin alumni who have actually gone on to work in science journalism and science history. If you'd like to read more about the symposium and the alumni featured therein, check out the interview of Bijal Trivedi '92 and Dyani Sabin '14 by Tara S. and the career panel review by Victoria A. in the latter pages of this issue.

The Translating Science Symposium caused both of us to think deeply about how science and science communication has impacted our lives, and how what we do with science can impact the lives of others. In this issue of *The Synapse*, you can find Oluwadamilare Ogunjimi's article *Tragic Science*, which traces several historical case studies focused on the misuse of science and pseudoscience. If politics is close to your heart, you may be interested in Joanna Zienkiewicz's article *Why Liberals and Conservatives are More Different than You Think*. And if you're interested in a topic that's both terrifying and captivating, take a look at Eleda Fernald's article *The Curious Case of the Reindeer in the Tundra*, which is about how climate change is melting permafrost and revealing virulent strains of bacteria that have been hidden for years.

To science majors and nonmajors alike—there is more than scientific research available to you as you go through Oberlin. As you spend your years here experimenting and learning and changing your mind again and again, know that there is more to science than diving into a lab and coming out every once in awhile for food and maybe some sunshine.

On that note, we're both excited and a little sad to announce that the majority of *The Synapse*'s Oberlin editorial board will be graduating in spring 2018. Therefore, we would like to invite anyone who has interest in the Editors-in-Chief, Art Coordinator, and Chief Layout Editor positions at Oberlin to contact us for more information. As has been proven over and over in the past year, especially through the Translating Science Symposium, science communication is essential for science to stay relevant to greater global communities. *The Synapse* is proud to be a part of that effort, and we'd love to have you join us.

Victoria Albacete and Tara Santora
Editors-in-Chief

Carson McCann is a junior Biochemistry major with a concentration in Neuroscience at Denison University. From Las Vegas, NV, Carson is the Treasurer of *The Synapse* at Denison. Carson joined the magazine because he loves that he can write about whatever interests him and apply things he learns in the classroom to current topics of interests. This is his second year as a writer for the magazine. Outside of *The Synapse*, Carson is the Vice President of the Denison chapter of Habitat for Humanity, Treasurer of Alpha Epsilon Delta (Denison's pre-med honors society), and Outreach Coordinator for the Denison Chemical Society. Be sure to check out his article *Falling into a State Deeper than Sleep*.

Leah Treidler is a second year from Berkeley, CA who intends to major in Cinema Studies and/or Creative Writing with a minor in Physics at Oberlin College. Leah became involved with *The Synapse* last semester when she edited and wrote for the magazine. Leah was an editor for this issue and also recently joined *The Synapse* board as an Intercollegiate Coordinator. Leah took an interest in The Synapse because of their belief in the importance of making science accessible by combining science with creativity, such as through the artwork that makes this magazine so unique. Outside of science writing, Leah also enjoys writing short stories, drawing, and listening to podcasts. She also works for Live from Studio B as a video producer.

Claire Segura is a second year Physics major at Oberlin College from Greenville, SC hoping to double major in Mathematics and minor in Studio Art. She has contributed art to the past four issues of *The Synapse* and created the striking art featured on the cover of Issue 13 (previous issue). In her free time, Claire likes to draw for fun and go for long walks around campus to stretch her legs and think. She believes the magazine is an important venue for students to choose and share what excites them about science; personally, Claire finds learning about an interesting scientific topic and using it to inform her artistic decisions particularly satisfying.

A second year from our very own Oberlin, OH, Steven Mentzer is a Studio Art major and Gender, Sexuality and Feminist Studies (GSFS) minor at Oberlin College. He's contributed art to several past issues of the magazine and joined the admin board this fall as Treasurer and Intercollegiate Coordinator. After completing his undergraduate degree, Steven plans to study architecture in graduate school, but while he's here, he spends his free time fencing on the club team and keeping busy with artistic projects. Steven believes that by integrating art with scientific inquiry, *The Synapse* contributes to making science engaging and accessible to those who are not professionally involved in the sciences.

Contents

The Curious Case of the Reindeer in the Tundra

"The anthrax is coming, the anthrax is coming!" –Paul Reindeer

Written by Eleda Fernald
Illustrated by Zoe Cohen

The setting: a very remote, (supposedly) very cold corner of Siberia. The summer of 2016. The cast: several families evacuated via airlift; 2,300 sickly reindeer; and an infectious brigade of bacteria, reawakened after a long and chilly slumber, called Bacillus anthracis—also known as anthrax. The suspect: a 75+-year-old reindeer carcass. The true culprit, the master villain for whom the septuagenarian reindeer is but a pawn in a more complicated and devious game: global warming. It is the stuff of the Twilight Zone, and it is the stuff of our reality.

When a wild animal dies of disease, it does not get cremated. Usually its body remains wherever it died, it is picked over, and it decays, eventually becoming covered in an accumulation of sediment. Sometimes, if people have identified that animal as a carrier for a disease that threatens humans, the animal's body will be buried. Either way, the remains get trapped in sediment, and buried with those remains is the disease that killed the animal. If the carcass is buried in normal soil, it will continue to break down. If it is trapped in frozen soil, the body will be preserved. Permafrost is permanently frozen soil. To be more specific, the International Permafrost Association defines permafrost as ground that remains frozen for at least two consecutive years. It is mostly found in polar regions, like the Arctic. However, much of the permafrost is now unfreezing as a result of climate change. As it thaws, so do all of the viruses and bacteria that lie dormant within frozen carcasses buried in the soil. As the temperature of the Arctic rises, it is possible that more frozen carcasses will thaw and release viruses and bacteria. This means that more outbreaks could occur near the Arctic with every heatwave.

One may think, "But wait! How could anything survive 75+ years as an ice cube and then just wake up and go about infecting people again?" or perhaps, "How many infected, frozen carcasses could possibly be stuck in there anyway?" The short answers: 1) bacteria and viruses are resilient buggers, and 2) there are many carcasses in the permafrost—seriously, a great number of animals have gotten sick and died over the course of Earth's history.

Let us now examine the long answers. According to the BBC, some bacteria and viruses are excellent at withstanding extreme cold and can survive for long periods of time. Permafrost is dark, cold, and oxygen-poor, which make for excellent microbe-preserving circumstances. Sporulating bacteria can survive for more than a century, and some viruses can live for thousands of years. Therefore, some kinds of bacteria and viruses could still be viable after being frozen in permafrost. So, when the permafrost melts, those viruses and bacteria could be freed and able to wreak havoc upon the planet once more.

Such was the case in Siberia. During the summer of 2016, the Yamalo-Nenets region of Siberia experienced a heatwave, which promptly kicked off an outbreak of anthrax. The heatwave thawed the permafrost. The frozen soil had preserved a buried reindeer carcass that had been infected with anthrax decades ago. When the soil thawed, the carcass did as well, and the previously immobile spores of *Bacillus anthracis* were released into nearby soil and water. These anthrax spores made their way into the food supply and led to the region's first anthrax outbreak in 75 years. More than 2,300 reindeer grazing in the area became infected, leading to the hospitalization of at least 20 infected people. The Center for Disease Control (CDC) states that anthrax spores are transferred from organism to organism via contact with an open wound, which puts anybody who handles infected animals at risk. Reindeer-herding families were evacuated, with the help of Russian troops that were specially trained for biological warfare.

> It follows that some kinds of bacteria and viruses could have been frozen in permafrost, but still viable.

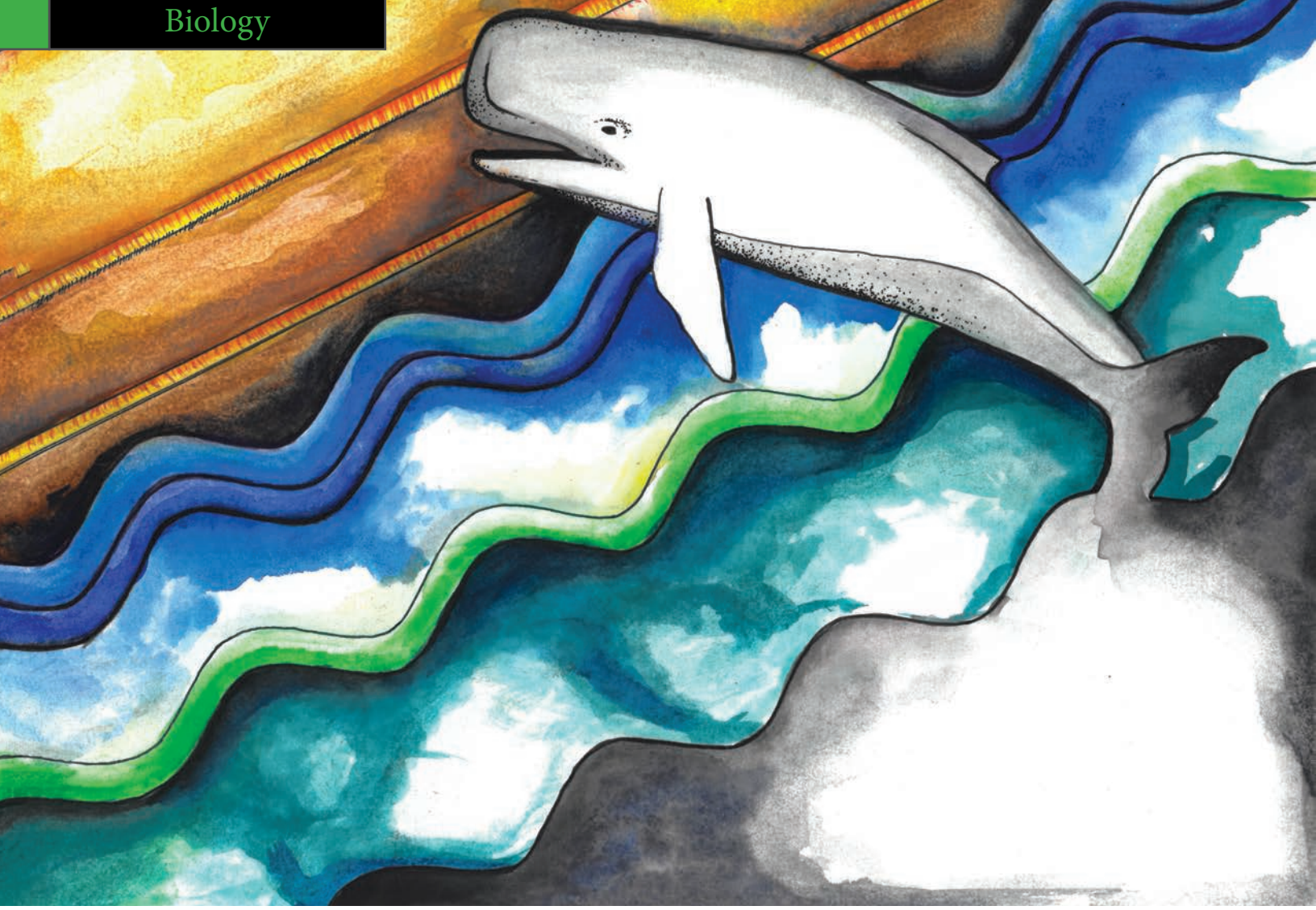
This anthrax-carrying reindeer may not be the only example of an outbreak originating from permafrost. More than 1 million reindeer died of anthrax in the early twentieth century. While these carcasses were buried, they were not buried deeply—frozen soil is hard to dig into. The result: 7,000 shallow burial grounds sprinkled across northern Russia. As more permafrost thaws, deeper layers of soil and their contents will be freed. The deeper the layer, the older it is. The older the layer, the older the viruses contained within its frozen carcasses. The older the virus, the less likely it is for modern humans to have resistance to said virus or to have appropriate vaccinations stored up. Jean-Michel Claverie at Aix-Marseille University in France says that this possibility is why it is important for us to hang on to the vaccines for diseases that we claim to have been "eradicated." No diseases are truly eradicated. Some are just

buried in the Arctic, and sometimes they come back.

Other potentially dangerous pathogens include the 1918 Spanish influenza, smallpox, and the bubonic plague. If they followed the pattern of outbreak seen in the anthrax case, these hypothetical outbreaks would likely show up around the cemeteries of infected victims. Siberia is a potential site for another such outbreak. In the 1890s, there was an intense smallpox epidemic. One town buried its deceased under the upper layer of permafrost on the banks of the Kolyma River. Today, the combination of the river flooding and melting permafrost has eroded the banks. As the banks deteriorate and the soil thaws, the International Permafrost Association warns it is possible that the bodies of the smallpox epidemic's victims could thaw as well, and release infectious agents.

As if the thawing permafrost was not dastardly enough, global warming has another angle to bring these frozen viruses into daylight. As Arctic sea ice melts, Siberia's north shore has become easier to access. This increased accessibility is of great interest to gold mining, oil drilling, and natural gas drilling operations, which are now able to dig deep into permafrost layers that were previously inaccessible. Digging up these layers will expedite the permafrost thawing and the potential release of viruses. According to the BBC, if industrial operations were to dredge up some virus that led to an outbreak, the virus in question would likely be of the giant virus class. These viruses are so named because they are physically large, even huge enough to see with a regular microscope! Giant viruses are tough and are less likely to be genetically damaged after long periods of time stuck in frozen soil.

How does one approach these fascinating yet bleak prospects? There is good news! Researchers are currently investigating various viruses recovered from permafrost to determine how many could pose a threat to humans. Already evidence of several kinds of bacteria that are dangerous to humans have been discovered. The good news here is that they have not yet attempted to revive any of these pathogens. So, there's that.



Whale You At?

The Influence of Solar Storms on Frequency of Whale Strandings in the North Sea

Written by Gaby Sarri-Tobar
Illustrated by Steven Mentzer

You are driving down a road when you hear "Turn left in 500 feet" come from your GPS. This small device directs your every turn and should ultimately get you to your desired destination. Suddenly, that great new song comes on the radio, you start jamming away, and you miss the left turn. What you should do now? You think about turning around at the next opportunity, but then the GPS tells you to "Continue for 1 mile and turn left at the next road." You are lost no more. We are lucky to have such remarkable forms of technology that at the touch of a button will take us from Point A to Point B, and even redirect us when we happen to get lost.

Animals like whales don't necessarily have a GPS for guidance, yet they manage to migrate immense distances while rarely getting lost. Migrating species have a remarkable ability to follow specific routes during migration season despite the long periods of time that pass between seasons. However, what happens when whales get lost and, rather than enjoying a burgeoning supply of kelp, end up stranded on beaches miles from their desired destination? Whale beachings, or strandings, are a mysterious phenomenon that has puzzled whale lovers and scientists alike. In trying to understand incidents of whale beachings, there is definitely a biological and an environmental aspect to explore.

In February of this year, New Zealand faced one of its worst whale beachings in history, which resulted in the deaths of 250 pilot whales. According to a piece in The New York Times, 50 whales did eventually swim back out to sea, but 90 whales re-beached themselves that same afternoon. As the article mentions, a consistent factor that researchers believe contributes to whale beachings is navigational mistakes, which can occur when the whales are escaping predators or chasing prey. The severity of these events lies in the fact that whales have immense social bonds and swim in packs. When the leader of a pack happens to go off-course, everyone following is in jeopardy of getting stranded.

Navigational mistakes can be quite problematic for whales. A recent report in *BBC News* extrapolates on this phenomenon to examine what could be causing whale beachings hundreds of miles away in the North Sea. Researchers believe large solar storms play a role in whale beachings, specifically those of 29 sperm whales in the North Sea in early 2016.

In response to the sperm whale stranding in the North Sea, researchers published a study in the *International Journal of Astrobiology* to examine the influence of solar storms on sperm whale strandings. They explain that there is a connection between migrating species and astronomical interrelations that exist between magnetic fields, particle flows, and radiation. In essence, species like whales that migrate into northern regions rely on magnetism for orientation.

Through mechanisms of echolocation and magnetism, whales are able to communicate with one another and navigate along their migratory routes. It can be said that whales are equipped with their own biological GPS system. Earth has superimposed magnetic fields which whales learn to use to determine where they are and where they need to go. But, similar to the case of an electric GPS, these systems can become uncalibrated, sending the driver or whale onto an unmarked path.

Geomagnetic anomalies, like solar storms, can potentially cause these biological GPS systems to become uncalibrated. A mixture of changes in ocean depth and geomagnetic anomalies, such as an unexpected major solar storm, can cause an overabundance of information that interferes with whales' internal magnetic senses. As a result, whales can become disoriented and accidentally take a wrong turn that leads them into shallow waters.

Through mechanisms of echolocation and magnetism, whales are able to communicate with one another and navigate along their migratory routes.

The scientists who published the study in the *International Journal of Astrobiology* hypothesize that the sperm whales were thrown off-course because of interferences within geomagnetic fields which consequently disrupted their internal magnetic 'compass'. They predict that an increase in solar storms at the end of 2015 led to such shifts in geomagnetic fields. Moreover, given that this is an unfamiliar route, sperm whales may have experienced greater difficulty with advancing through more treacherous waters. Some of the added difficulty lies in the fact that many of the packs of whales who travel along this route are composed of young whales, otherwise known as "bachelor groups". Thus, inexperience with shifts in geomagnetic fields characteristic of the North Sea is another contributing factor. Sperm whales spend much of their early life in lower latitudes, where magnetic disruptions such as solar storms are not as easily felt. Young whales are unaccustomed to dealing with shifts in geomagnetic fields and may be more easily disoriented by shifts in magnetic fields in the North and Norwegian Seas. They are unable to adopt "alternative navigation systems" and thus the consequence is an increase in the frequency of whale strandings.

Given that whales already rely on geomagnetism to navigate along migration routes, the problem arises when there is an excess of geomagnetic information. Whales, like the sperm whales in the North Sea, may not be capable of discerning this additional and often faulty information. What results is confusion, and the whales inevitably follow a path that does not really exist and end up stranded on beaches. Some whales, typically older and more experienced, are capable of reorienting themselves, or as a GPS would tell you when you get off-course: "Recalculating...recalculating". However, "bachelor groups" have not reached this point of experience and so recalculation is not an option. In addition, one must consider how solar storms impact a whale's ability to potentially recalculate.

One way in which species can "reset" their internal magnetic system is by using the sun. However, as noted in the study, the two solar storms that aligned with the sperm whale strandings were so strong that disruption of the geomagnetic field made it harder for such whales to re-calibrate. The study adds that the "disruption of the geomagnetic field by a solar storm at the crucial time of magnetic adjustment at the sea surface could result in the whales following a wrong course for a whole day."

During solar storms, there is a major flux of charged particles and radiation coming from the sun and reaching Earth's surface. With such a flux of high-energy particles, Earth's magnetic field can shift, causing inclination. Inclination is an important navigational parameter used by other migrating species, and so there is a possibility that it is also used by whales. Essentially, solar storms can alter geomagnetic field lines in relation to their geographic conditions. Inclination is characterized by the angle formed by a compass needle when it is held vertically. So, it is essentially an angle of intersection with the reference point being Earth's geomagnetic fields. In the case of the solar storms that occurred in December 2015, the inclination fell in the North Sea during the first storm and then rose during the second. These changes in the angles of inclination cause deviations in latitude and, depending on how long these effects last, can have monumental consequences on migrating species that may be in the area.

As sperm whales migrate north, they are met by magnetic field lines that have a higher vertical component. That is, the angle between a vertically held compass and the presupposed geomagnetic field lines is large—in the range of 70 degrees. Older whales are more likely to have experienced the effects of solar storms and thus are more knowledgeable about how to deal with shifts in their magnetic sense. Young whales migrating on their own, however, are more prone to disorientation because they are not able to rely on a second navigational system nor do they understand the geomagnetic shifts they encounter. They then end up stranded in shallow waters as they veer off-course.

Results from the study in the *International Journal of Astrobiology* show that there is no definitive causal relationship between shifts in solar activity in and around the North Sea on whale strandings. However, the study did conclude that the 29 sperm whale beachings could have been triggered by strong solar storms that took place in December of 2015. As the researchers note, there are a number of issues that contribute to positive correlations between environmental changes and the frequency of whale strandings, so further study of this phenomenon is necessary.

Whale beachings have become an ever-pressing phenomenon to understand, especially in the realm of conservation. And, as the study mentions, shifts in Earth's magnetic field because of geomagnetic anomalies have an impact on many migrating species, whether they be honey bees or homing pigeons. Animals are not afforded the great privilege of having GPS systems that are safe from the effects of solar storms. While we may be able to "recalculate," whales and other migrating species could face more catastrophic consequences than just simply making a wrong turn; they may never end up at their destinations and instead be stranded on a beach, unable to get back to their native habitats. There is still a lot left to study concerning the phenomena of whale beachings, like the effect of climate change and variations in solar activity on the warming of ocean waters, and the effect this may have on frequency of whale strandings.

If you'd like to learn more about whale strandings and solar storms, see Matt McGrath's article "Northern Lights linked to North Sea whale strandings" from the September 2017 issue of *BBC News*.

Categorizing Sexual Experience

Sensory Modalities and Orgasms

Written and illustrated by
Lameya Aamir

In all of biology and neurology, there are few concepts as intriguing as the human orgasm. A phenomenon that's been described as everything from "indescribable" to "pure bliss", vaginal and clitoral orgasms in particular has provoked many different investigations over the past 130 years. From the use of vibrators to relieve women of hysteria in the 19th century to recent research focused on the neurochemistry of cisgender women's brains while they are sexually aroused, cisgender female sexuality has been a topic of immense interest and value for a very long time, and orgasm has been an essential part of this. In the context of sensory behaviors, I believe that orgasm, or sexual pleasure itself, is a sensory modality and the various sexual organs could be considered sensory organs with sensory capacities, including the clitoris.

To preface, I believe that there are more sensory modalities than Aristotle's five, which are vision, hearing, taste, smell, and touch. A sensory modality is an aspect of a stimulus that can be discerned after the stimulus occurs. Sexual pleasure could be categorized as a sensory modality because it is an aspect perceived after interaction with sexual stimuli, like erotica or pornography. Currently sexual pleasure is often associated with one of Aristotle's five sensory modalities, usually touch. However, scientific literature about sensory modalities includes several criteria for individuating the senses, which I argue are appropriately met in the case of sexual pleasure. I will use these criteria for establishing sexual pleasure as a sense while comparing it to other senses. The four criterion that I will use were established in 2002 by Brian L. Keeley, a Philosophy Professor at Pitzer College.

The first condition of a sensory modality is physical: "the external physical conditions upon which the senses depend." We know that there are different physical stimuli for each sense—the aroma of coffee in Slow Train can positively stimulate your sense of smell, while a cat's soft fur stimulates your sense of touch when you pet it. The stimuli for sexual pleasure—otherwise known as the sexual stimuli—can not only initiate, sustain, and enhance sexual arousal, but may also lead to orgasm. You might be familiar with various different types of sexual stimuli, as they can be visual, auditory, and tactile. The most effective sexual stimulation of the clitoris is usually manual or oral, and is, therefore, often referred to as direct clitoral stimulation. There are two main factors that separate sexual stimulation from tactile stimulation: first, the output of each type, and second, the target area of the stimulation. Sexual stimulation affects specific nerve endings in sexual

organs that produce excitement and pleasure during sexual activity, whereas pure tactile stimulation allows the effects of other sensations such as pressure and temperature to be felt.

The second condition of a sensory modality is neurobiological: "the character of the putative sense organs and their modes of connection with the brain." In other words, the sensory organ has to respond physiologically to the sensory stimulation. In the case of the clitoris, it responds to a sexual stimulus. Tactile manipulation of the clitoris invokes a physiological response in not only the clitoris but the whole body—there is a head-to-toe kind of experience: the clitoris enlarges, the heart beats more quickly, breathing becomes faster, various muscles tighten

> I believe that there are more sensory modalities than Aristotle's five: vision, hearing, taste, smell, and touch. There are several potentially novel modalities that have been added to this list.

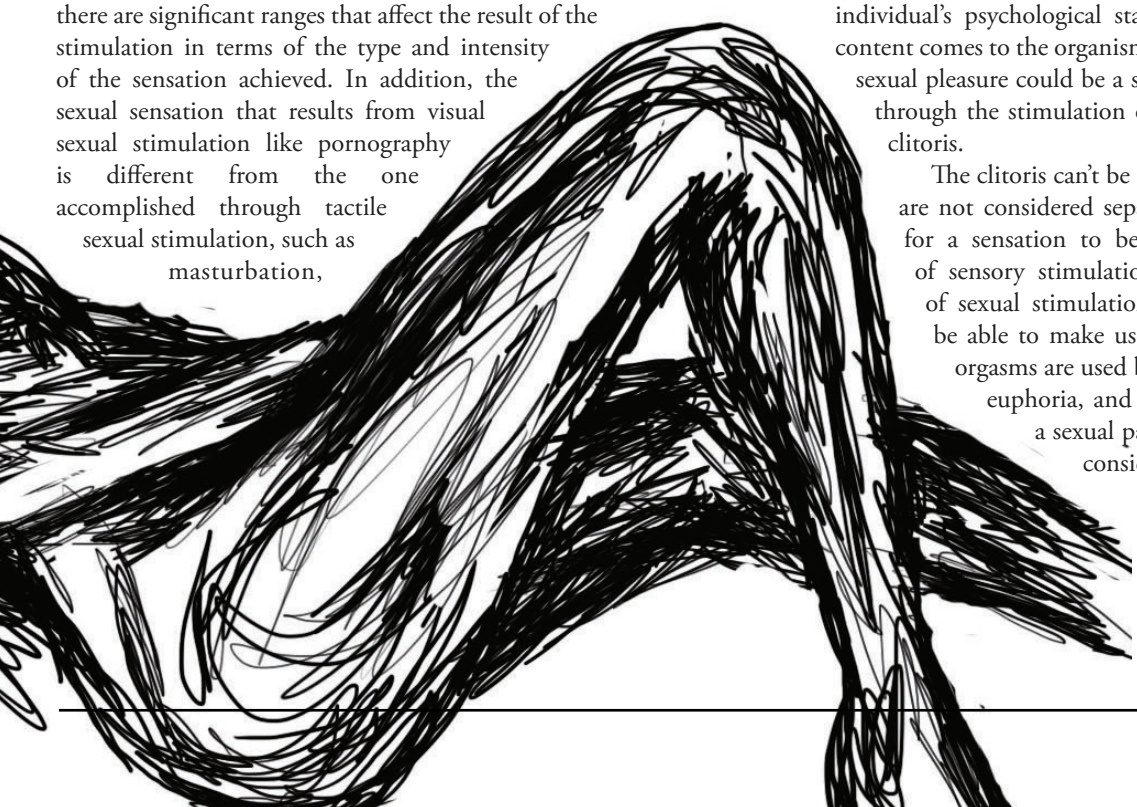
all over the person's body, breasts swell slightly, nipples stiffen, and the vagina both creates a natural lubricant and stretches slightly wider. Tactile stimulation alone of any other nerve ending, even relatively close to the clitoris, doesn't create the same bodily response as stimulation to the clitoris itself may cause. Any sense organ needs to have receptors or nerve endings to pick up stimuli, and in this case, the clitoris has a spectacular number of nerve endings; the tip of the clitoris alone has more than 8,000!

The third condition for individuating the senses is behavioral: "the ability to discriminate behaviorally between stimuli that differ only in terms of a particular physical energy type." Sexual stimuli are particularly varied in this way, as the combination of stimuli can provoke unique sexual responses in different individuals. In his literature about sensory modalities, Keeley rejects that "from any sensation in a given modality, it is possible to reach any other by a sufficiently long series of matching steps." This supports the idea of sexual pleasure as a sensory modality because there are many different types of stimulation and within those types there are significant ranges that affect the result of the stimulation in terms of the type and intensity of the sensation achieved. In addition, the sexual sensation that results from visual sexual stimulation like pornography is different from the one accomplished through tactile sexual stimulation, such as masturbation, or auditory sexual stimulation, such as hearing arousing sounds. The localization of a sexual stimulus is also an important factor in these combinations, as the resulting sensation from clitoral stimulation is different from the sensation achieved through vaginal stimulation. Within each stimulus category, different levels of the same stimulation and thus different levels of its respective sensation can be achieved progressively as well. For instance, different kinds of tactile stimulation can result in different kinds of orgasms. Have you ever experienced a different kind of sexual pleasure when you changed the way you were masturbating?

The final condition is dedication: "the evolutionary or developmental importance of the putative sense to an organism." The clitoris is believed to have evolved specifically for the purpose of sexual pleasure; it usually induces sexual arousal when it is stimulated. Therefore, the clitoris is capable of sexual reception—it detects sexual stimulation with the receptors present in it and responds accordingly to the stimulation.

Keeley has said that "sensory modality is not simply an issue of what things in the external world can become the content of an individual's psychological states, but rather the mode by which that content comes to the organism." According to his definitions and criteria, sexual pleasure could be a sensory modality that organisms experience through the stimulation of sexual organs, which would include the clitoris.

The clitoris can't be considered a sensory organ if sexual stimuli are not considered separate from other sensory stimuli. In order for a sensation to be considered a sensory modality, a range of sensory stimulation should exist—which does in the case of sexual stimulation. The organism in question should also be able to make use of the alleged sense; sexual pleasure and orgasms are used by some people to relieve sexual energy, feel euphoria, and create physical and emotional bonds with a sexual partner. Therefore, sexual pleasure should be considered a sensory modality and the clitoris, along with the other sexual organs, can be considered a sensory organ.



Get Your Head in The Game

A Call to Action for Proper Treatment of Traumatic Brain Injury

Written by Zoe Swann
Illustrated by Lydia Newman-Heggie

How many people do you know with chronic fatigue? How many people do you know who have been in a car crash, or have had a concussion?

There is no debate. Traumatic Brain Injury (TBI) results in endocrine dysfunction far more than previously realized and has life threatening effects that often go unseen.

Brain injury is caused by acceleration and deceleration of brain tissue from motor vehicle, assault, athletic collision, or veteran blast injuries. All of these forms of TBI cause shear strain (where your cells break open), resulting in possible hemorrhage, neural necrosis, network disruptions, and cell death. Injury to the axons of individual neural cells also easily occurs after shear strain.

So how do these injuries occur? If the front of my skull were to hit the dashboard of a car, my brain would hit the back of my skull and then bounce forward due to inertia. This causes the acceleration and deceleration of brain tissue, thus leading to shear strain injuries. After

forming a lesion in the front and back of the brain, hemorrhage and edema occur, which mean blood and water on the brain respectively. This pressure causes cells to rupture and the immune system must come to the rescue, filling the brain and skull with even more fluid. Because pressure means more cell death, more network disconnection occurs, often leading to drastic changes in behavior as parts of the brain can no longer communicate effectively. And all of this can happen easily, even under the mildest of circumstances.

Depending the injury mechanism, a particularly vulnerable area of the brain is the hypothalamic-pituitary-axis. Part of the endocrine system, it communicates via the pituitary with glands all over the body by way of hormones. These hormones are produced and secreted by several glands in the body and are extremely susceptible to disruption of the system. Each hormone contributes to a myriad of disorders after TBI, such as growth, stress, sex dysfunction, and even diabetes insipidus.

The hypothalamus in the forebrain is responsible for sending neural input to the pituitary gland below it, which is encased in the bony sella turcica. For spatial reference, a pituitary tumor can be surgically accessed by going directly up the nose by drilling through the sella bone. After TBI, the bony sella may fracture, injuring the pituitary gland. If the pituitary, "the master gland," is injured, dysfunction occurs. A study

> 1.5 million people sustain a TBI each year, and only 230,000 patients, or approximately a sixth, survive.

published 2015 in the *Indian Journal of Endocrinology and Metabolism* found that 80 percent of TBI patients had sella abnormalities. The number of people diagnosed with endocrine dysfunction is nowhere near that, meaning that a significant portion of the TBI population is going without proper diagnosis of any endocrine dysfunction and subsequent treatment.

Often, endocrine dysfunction is missed entirely or misdiagnosed as PTSD or post-concussive disorder. This misdiagnosis can result in life threatening or quality-of-life threatening conditions. For example, hypogonadism—or sex hormone dysfunction—may not be apparent in a pre-pubescent injured child, who then by puberty will be very difficult to treat. Children also produce more growth hormones than adults, so they are prone to experience undiagnosed stunted growth after TBI.

It is estimated by the CDC that 1.5 million people sustain a TBI each year, and only 230,000 patients, or approximately one-sixth, survive. The prevalence of pituitary dysfunction is diagnosed at the rate of about 27 to 47 percent regardless of injury severity. However, it likely occurs at a much higher rate of 70 percent in TBI patients. This means that millions of people each year are living without a proper diagnosis.

A high population of people who experience traumatic brain injuries are athletes. Athletic institutions, such as the NFL, have been subject to concern and scrutiny after the discovery of CTE (chronic traumatic encephalopathy), which occurs after several mild, repeated injuries and is related to Alzheimer's Disease. Many athletes, veterans, and victims of assault who have sustained concussions have later developed symptoms of Alzheimer's. These symptoms often include memory loss, behavior changes, aggression, and substance abuse.

There have been over 200 post-mortem confirmed cases of CTE in professional athletes. Football players are particularly susceptible. Although symptoms begin in a person's 40s or 50s, if this person experienced a head impact before the age of 12, they are much more likely to have severe symptoms and a severe prognosis. These athletes also face an increased risk of suicide and substance abuse. For these reasons, research into this disorder should be recognized by organizations like the NFL as worthy of funding. This is an essential step in ensuring the safety of their players.

Interestingly, sex hormones, like progesterone and estrogen, might have neuroprotective effects by regulating fluid balance,

> If this person experienced a head impact before the age of 12, they are more likely to have severe symptoms and a severe prognosis

inflammation, stroke, and edema. One solution to improve the prognosis of many athletes may be to consider hormone therapy. However, professional athletes may be reluctant to take sexy hormones typically associated with femaleness.

People serving in the military are also highly susceptible to TBI; in fact, it is these days considered "the injury" of the military. Veterans most often suffer blast injuries from explosions, either due to the initial pressure wave or flying bodies and shrapnel. Opioids are often used for pain management, which has led to the rising opioid epidemic. This epidemic has major implications for endocrine dysfunction after TBI.

Following primary mechanical and secondary injury, stress and medication can be a major factor in endocrine dysfunction post-injury. Opioids are relevant to several models, as civilians are often bedridden or hospitalized after a moderate to severe injury, and veterans suffering a blast injury are often in stress-inducing situations both prior to and directly following the injury event. Additionally, overuse of opioids or phenobarbital in the ICU may aggravate secondary injury to the pituitary and cause adrenal insufficiency, resulting in low cortisol levels. Without cortisol, the body cannot respond normally to stress, such as common infections that occur during hospitalization.

What are we doing about the misdiagnoses and treatment in all of these various populations who experience TBI? Unfortunately, pituitary dysfunction is still not on the radar of many health care professionals. But, by understanding how endocrine dysfunction manifests in different age groups and different models of injury, we may be able to produce an acute treatment and help those with immediate injuries and chronic symptoms.

If you're interested in learning more about the basics of traumatic injuries, see "Explosions and Blast Injuries: A Primer for Clinicians" from the Department of Health and Human Services, available on the CDC Injury Prevention website. If you'd like to read more about problems with the pituitary gland as a consequence of brain injuries, see Eva Fernandez-Rodriguez's July 2017 article "Hypopituitarism Following Traumatic Brain Injury: Determining Factors for Diagnosis" in *Frontiers in Endocrinology.*

The Neuroscience of Demonic Possession

Explaining a Seemingly Supernatural Phenomena

Written by James Cato
Illustrated by Della Copes-Finke

Imagine this: your friend Damien catches a common respiratory disease. He sniffles at his desk, honks his nose, and coughs every so often. A few weeks later, Damien becomes fatigued, then bedridden. His face begins writhing, his legs are pedaling, and his fingers are rolling as if playing the piano. "Babies screaming in the walls," Damien mutters incessantly, "in the walls!" Damien shrieks at shadows and howls at the sight of another human being. His mood and personality shift, his limbs seize, his mind sees things that aren't there. What would you think? Would it not seem like a hair-raising onslaught of misery from hell?

Think how petrifying these events must have been to people long ago who knew nothing about the brain! All of these details, other than Damien's name, are real, documented recently by scientists—even the content of his vivid hallucination. It turns out that the terrifying portrayals of possession seen in *The Exorcist*, *The Conjuring*, and many more films are far from complete fabrications. Haven't you always wondered if there might be some kernel of truth to all those reports?

Humans have recorded incidents of demonic possession across continents and throughout human history. The possessed exhibit extreme strength, inhuman movements, and make utterances in foreign voices. Accounts also include self-mutilation, uncharacteristic lewd behavior, and aversion to religious stimuli. These reports have baffled and disturbed Buddhists, Jews, Muslims, and Christians alike. Many believe to this day that these behaviors are spawned by a spirit or demon taking control of the mind and body of the afflicted. But the recent discovery of the rare autoimmune disease dubbed anti-N-methyl-D-aspartate antibody receptor (anti-NMDAR) encephalitis, offers an alternative explanation for such eerie circumstances.

This possible neurological mechanism for purported demonic possession follows an autoimmune attack on a distinct receptor in the brain—specifically, an important ligand-gated glutamate receptor. Glutamate is the primary excitatory neurotransmitter in the brain.

These receptors, called NMDA receptors (NMDAR), are famous to neuroscientists for their role in synaptic plasticity, which is a cellular mechanism that aids in memory and learning. But NMDARs are found in many brain regions unrelated to learning and memory, including those involved in motor behavior and breathing. A link between NMDARs and psychosis is suggested by the fact that two psychoactive drugs, PCP and ketamine, cause hallucinations and exert their neurological effects primarily through their effects on the NMDARs. Thus, it is plausible that an autoimmune attack on NMDAR could lead to symptoms similar to those seen in cases of purported demonic possession.

Anti-NMDAR encephalitis—an inflammation in the brain due to the autoimmune attack on NMDAR—was only first described in 2005, so our understanding of the disorder is still incomplete. However,

> Humans have recorded incidents of demonic possession across the continents and throughout human history.

many notable correlations exist between this disease and the purported supernatural soul-takeovers depicted throughout history. In particular, the common arc of the disease matches the typical story of an evil spirit's ethereal assault. First, victims experience nonspecific symptoms of a flu-like illness. They act lethargic, weak, and depleted. Usually, this wouldn't concern a caregiver much. Likely, friends and family would consider the patients to be simply under the weather—but the following symptoms are far more worrisome.

Weeks after the initial symptoms, the patients—or victims—begin to exhibit fluctuating psychosis. This might include, to varying degrees and intensities, agitation, delusional outbursts, catatonia, and more. Previously, the patients had been considered mentally and emotionally normal, so such a sudden and dramatic change in behavior shocked and confused the patients' loved ones. The patients appeared to have descended from healthy, consistent normalcy to an otherworldly insanity. It is understandable that one might suspect a new entity had taken over their bodies.

The characteristics of anti-NMDAR encephalitis correspond convincingly with accounts of possession. For example, anti-NMDAR is correlated with ovarian teratomas, a type of tumor found primarily in young adult female-bodied individuals. Similarly, young women

> The patients have appeared to descend from healthy, consistent normalcy to otherworldly insanity. It is understandable that one might suspect a new entity has taken over their bodies.

are disproportionately represented in accounts of demonic possession throughout history, so the trope of young women suffering as the victims of possession corresponds to the fact that women are more susceptible to the disease. Additionally, the effects of anti-NMDAR encephalitis can account for perceived personality changes, as the fluctuations of agitation and catatonia could lead to crude mood swings or unprompted violent behavior. Similarly, many descriptions of possessions portray the victim with incredible strength, becoming completely stiff and difficult to move, and it turns out that a recorded symptom of anti-NMDAR often leads to extreme muscle rigidity.

One of the most frightening facets of sensationalized possession is voice-changing. Often, media depicts this in film and fiction as the demon itself speaking through the victim in a malevolent, despotic baritone. This interpretation might stem from the autoimmune disorder's tendency to produce perseveration, which is the stubborn repetition of a word or phrase. This, paired with sudden tonal shifts associated with mood, may completely change the the patient's voice.

Even 'unexplainable' symptoms thought to flow from the spiritual dimension could be clarified by anti-NMDAR symptoms. For instance, the disorder incurs facial dyskinesia, which are involuntary, atypical muscle movements. This might explain how some possession accounts note that the victim's face was changing. Most sources list violent outbursts and paranoia as potential sequela, so the 'evil' actions of attacks towards household pets and livid tantrums might be linked. 'Non-human movements' are most likely manifested descriptions of choreoathetosis (involuntary writhing) and seizures. Psychosis could account for growling, self-injury, and changes in dress and diet.

Of course, anti-NMDAR encephalitis does not fit every description of demonic possession. Not everything is known about the autoimmune disorder, but it's unlikely it could be linked to levitation or telekinesis. It does not cause the temperature of the room to undulate,

> We did not always categorize medical abnormalities consistently, especially when the supernatural forces were thought to reign supreme in the brain.

nor change the color of the patient's eyes. There are no reports of the disorder allowing patients to exhibit telepathy or clairvoyance, either. So some mysteries of demonic possession stories remain unsolved. However, it is reasonable to assume that spectators have reported exaggerations and inaccuracies about the bizarre disease during its stressful and sudden onset.

It is also quite possible that other disorders, such as Dissociative Identity Disorder (DID) or other forms of psychosis, might have been labeled as possession throughout history too. We did not always categorize medical abnormalities consistently, especially when supernatural forces were thought to reign supreme in the brain. Yet anti-NMDAR encephalopathy does accurately describe many chronicled behaviors during so-called infernal infection—perhaps, in its own small way, working towards absolving a great, mysterious superstition.

Luckily for Damien, modern medicine allows us to treat anti-NMDAR encephalitis. Especially if the disorder is diagnosed early on, patients tend to respond favorably to treatment. Although cognitive deficits persist if anti-NMDAR goes undiagnosed for too long, increased awareness will help more patients receive the care they need. Perhaps soon, the notion of a hellish occupancy can be cured with a simple procedure.

If you'd like to learn more about anti-NMDAR encephalitis, see Joseph Fisher's article "Psychosis in the ED: A case of NMDA receptor antibody encephalitis" from July 2017 issue of *The American Journal of Emergency Medicine*.

Painting the Inner Landscape of the Mind

Exploring the Mental Maps of Memory and Imagination Through Science and Literature

Written by Ally Fulton
Illustrated by Claire Segura

In the early spring of 1985, Clive Wearing, an accomplished British musician and musicologist, was at the height of his career when he contracted a herpes encephalitis virus. Within days, the virus had attacked Wearing's central nervous system, leaving him with one of the most severe cases of amnesia ever recorded. Wearing could no longer store memories; he could only remember his past in thirty-second increments. Encouraged by his doctors and his wife Deborah, Wearing kept a diary for years by his bed. Its contents illuminate his experience of constantly reawakening into a new consciousness. An entry from January 13, 1990 reads: "9:06 am Now I am awake (1st Time), 9:34 am Now I am awake (1st Time), 9:40 am Now I am AWAKE (1st Time), 9:54 am I am awake with cup of coffee." This journal entry illustrates the extent to which Wearing fully lost his sense of time, place, and self in his loss of memory.

Astonishingly, Wearing was able to hold on to two things despite being unable to store any memories. He never lost the love for his wife, Deborah, and he also retained his ability to sing and conduct in certain settings. Wearing was always calling for Deborah, wanting her to be by his side at all times. If she left the room for a split second, he would begin calling for her if his memory restarted. Wearing's preserved musical abilities emerged when Deborah brought Wearing to church one day, where he began to sing a hymn. Even more astounding, when she brought him to see his old choral group, he was able to conduct an old piece of music exactly as he had before the virus damaged his nervous system.

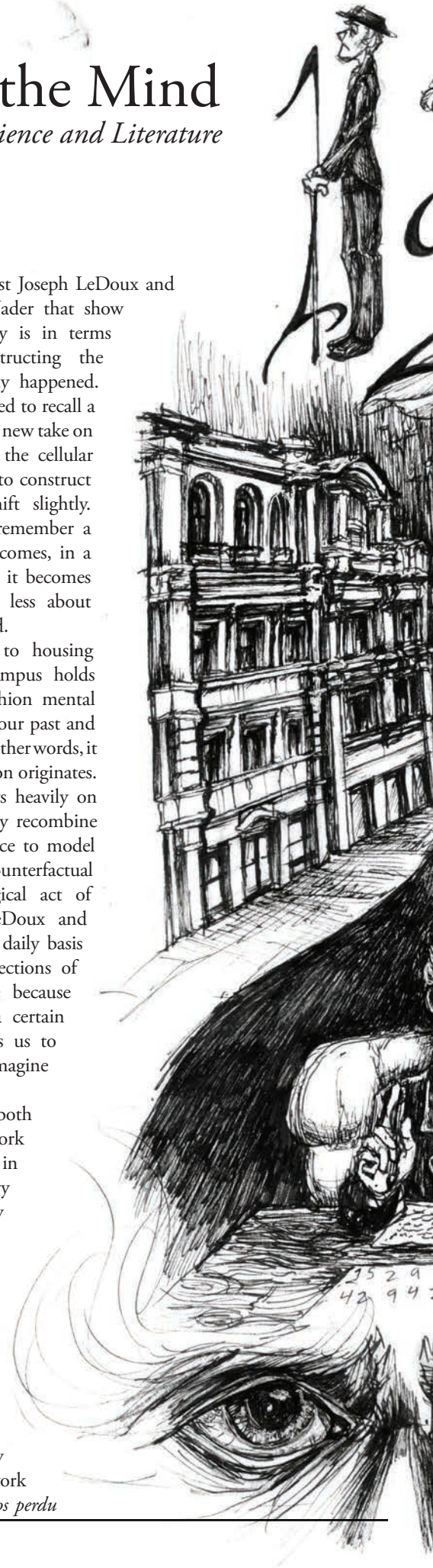
Love and music. Both are entrenched in sensory stimuli, which call to mind Marcel Proust's treatises on memory. Memory, for Proust (one of the founders of our contemporary knowledge on memory), was of greatest interest in its episodic, or autobiographical, form, rather than in its semantic form. Semantic memory is long-term memory that processes ideas and concepts that aren't drawn from personal experience, such as names of colors and capitals of countries. The term was born from collaboration between Endel Tulving at the University of Toronto and Wayne Donaldson at the University of New Brunswick in 1972. In contrast, episodic or autobiographical memory is specific to you—even your earliest recollections have an auto or self-quality to them. Autobiographical memory is your personal past, your lived experience, a recollection of biographical experience and specific events in time in serial form.

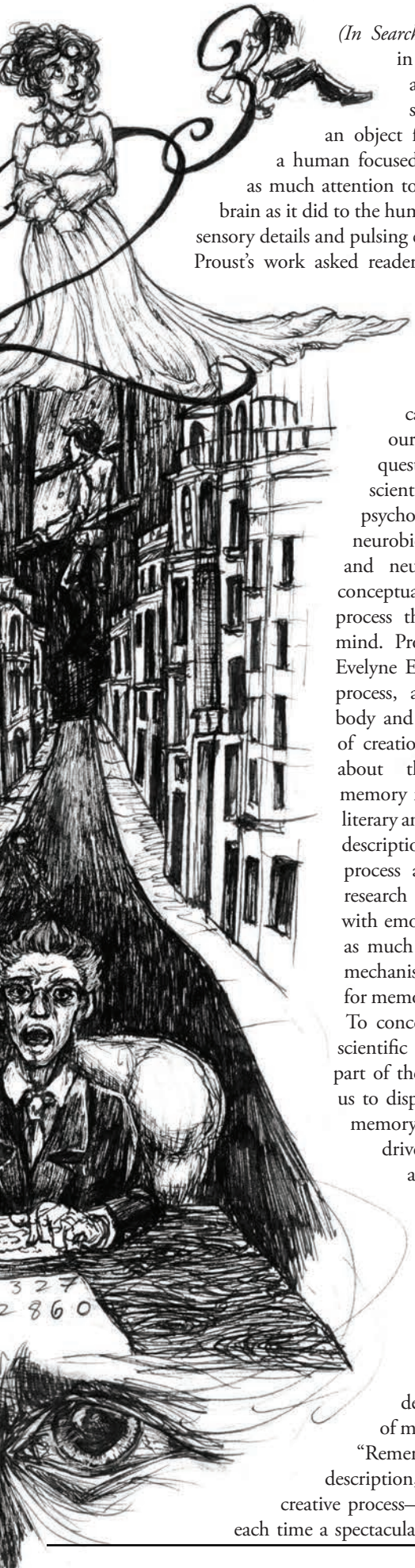
> A single memory is an active net of cellular constructions that connect one brain cell to another.

Semantic and episodic memory, on a neural level, are physical traces largely built of proteins. A single memory is an active net of cellular constructions that connect one brain cell to another. All memory reconstructions take place in the hippocampus. Dr. Julia Shaw, a psychology researcher at the University College London, aptly describes these pathways in a visual metaphor: "The brain as a galaxy and the memory network is made up of stars that are constantly moving." The constant motion described by Shaw suggests memory is malleable. This is supported by the studies of neuroscientist Joseph LeDoux and psychologist Karim Nader that show how unstable memory is in terms of accurately reconstructing the truth, or what actually happened. Every time you are asked to recall a memory, you develop a new take on that memory because the cellular constructions you use to construct that memory will shift slightly. Thus each time you remember a specific memory, it becomes, in a sense, a new memory; it becomes more about you and less about what actually happened.

In addition to housing memory, the hippocampus holds the site where we fashion mental maps to both recreate our past and envision our future. In other words, it is where our imagination originates. The imagination draws heavily on memory; we constantly recombine bits of actual experience to model hypotheticals and counterfactual scenarios. The biological act of remembering that LeDoux and Nader deal with on a daily basis shows that our recollections of the past are adaptive because it provides us with a certain flexibility that permits us to alter our memory to imagine the future.

While both LeDoux and Nader's work have been formative in the field of memory studies, the ways they conceive of memory and approach it scientifically arose out of a paradigm shift in memory studies in the early twentieth century. Marcel Proust provoked this paradigm shift, largely through his seminal work *A la Recherche du temps perdu*





(In Search of Lost Time), published in seven parts between 1913 and 1927. Proust sought to situate memory as not just an object for scientific study, but as a human focused subject that required just as much attention to the inner workings of the brain as it did to the human experience, replete with sensory details and pulsing emotions.

Proust's work asked readers to consider what might be lacking in a solely scientific approach to memory. How does integrating the humanities—in this case, literature—enhance our study of memory? These questions prompted influential scientists such as experimental psychologist Marigold Linton, neurobiologist Antonio Damasio, and neurologist Oliver Sacks to conceptualize memory as a lively process that is not isolated in the mind. Professor of French Studies, Evelyne Ender, calls this a "*dynamic* process, a process that enlists the body and the mind in a unique act of creation." Ender thinks critically about the interdisciplinarity of memory research and its reliance on literary and scientific knowledge. Her descriptions of memory as a dynamic process asks the field of memory research to always concern itself with emotion, narrative, and image, as much as it's concerned with the mechanistic and biochemical basis for memory and memory formation.

To conceive of memory as both a scientific process and an essential part of the human experience allows us to dispel common metaphors for memory as file cabinets or disc drives and establish memory as something akin to a painting or sculpture, a freer form that embraces the voluntary and involuntary choices of the individual. Ender, while a literary scholar and not a psychologist, provides structure and depth to Proust's metaphor of memory as an artistic process. "Remembrance in [Proust's] description," she writes, "is an active, creative process—each time a performance, each time a spectacular and unique mental event that affects a miraculous match between sensations, emotions, and images." Ender asserts that memories do not give us direct, unfettered access to lived past experience. Instead, we use the emotional and sensory details that dominate our memories to imaginatively construct past experience.

Ender, Shaw, LeDoux, and Nader all provide crucial perspectives to consider when formulating an understanding of how memory functions. And while they all tangentially touch on the relationship between memory and imagination, it is useful to turn to the case of a famous mnemonist to delve into questions that arise when memory mixes with imagination. What happens when you are unable to distinguish between imagination and memory? When you are unable to separate the lived past from the evolving present and the imagined future? Does an endless memory coincide, then, with an endless imagination? This was the case with Solomon Sherevsky, or S., the man with an impossible memory. Documented by the well-known neuropsychologist Alexander Luria in his 1968 work *The Mind of Mnemonist*, S. is labeled as a man with memory that had "no distinct limits". However, on further investigation into S.'s journals, Reed Johnson of *The New Yorker* finds that S. did not have as perfect a memory as Luria claimed. While S.'s autobiographical memory did indeed flourish, it was often fully occupied by the literal details of experience, such as place, taste, and smell, to the point where he could not grasp abstract concepts.

> Every time you are asked to recall a memory, you develop a new take on that memory because the cellular constructions you use to construct that memory will shift slightly.

"The strength and durability of his memories seemed to be tied up in his ability to create elaborate multisensory mental representations and insert them in imagined story scenes or places; the more vivid this imagery and story, the more deeply rooted it would become in his memory," writes Reed, describing S.'s strong sense of synesthesia, where one sense strongly recalls other senses. S. would avoid doing activities such as reading the newspaper at breakfast because the taste of the printed words would mix and clash with the taste of his meal. So, while S. may have had a particularly strong memory, he also inadvertently absorbed sensory details without the actual sensory impressions hitting his body. As Luria notices, "One would be hard put to say which was more real for him: the world of imagination in which he lived, or the world of reality in which he was but a temporary guest." S., then, demonstrates that it is possible to lose some grip on reality because of his inability to distinguish imagination from reality.

S.'s experience, brought to light by Luria and again by Johnson, begs the question: If Luria had conceived of S. beyond a scientific subject with an endless memory, would he have enriched the scientific study of S.'s mind and memory? If we take into account Proust, and the work of scientists that followed him, the answer seems to be yes. As scientists whose work is concerned with the mind and memory formation continue to progress in their research, it is imperative that they continue to follow in the footsteps of those like Sacks, Linton, LeDoux, and Nader, who find worth in conceiving of memory in both scientific and literary fashions. If we are to better understand the intricacies involved in memory and the imagination, we must remember that memory enables consciousness, which is just as much a study of the mind as it is a question of what it means to be human.●

If you'd like to learn more about memory and imagination, see Evelyne Ender's book *Architexts of Memory: Literature, Science, and Autobiography*, published in 2005.

More Than J

Understanding the Mechanics an

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Written by Ja
Illustrated by

Christopher Nolan's *Inception* (2010), a film focused on dreaming and manipulating dreams for personal use, leaves its viewers questioning the fine line between science and science fiction. The film follows "dream thief" Dominick Cobb, who enters other people's dreams and creates specific scenarios in order to "steal," or extract, information from his subjects. With the help of his team, he plots their riskiest heist yet, which involves dreams within dreams. The concept of dreaming continues to remain a perplexing and intriguing aspect of the human experience, and *Inception* only further prods at its ambiguity. This leaves the viewer asking just how much science, if any, really exists in this film. Are the dream sequences in *Inception* possible? Or are they simply good filmmaking, compelling storytelling, and figments of the imagination? Studying the mechanics of dreaming and the neuroscience behind it can offer answers.

Both dreaming and waking up from dreams are central to the film. The characters' discussion of "kicks" as a way to jolt the dreamers awake is an essential feature of the film, one that a character describes as "that feeling of falling which snaps you awake." In science, this "kick" is called a hypnic jerk and it is a motion usually correlated with a sense of falling that a vast majority of individuals have experienced either while dreaming or at the very moment of falling asleep. Hypnic jerks are myoclonus jerks or twitches, which are the sudden, involuntary jerking of a muscle. Numerous classifications of myoclonus exist; however, hypnic jerks are specifically benign and harmless myoclonus that occur during the initial phases of sleep. Hypnic jerks mirror the same twitches that individuals experiencing myoclonic seizures undergo, yet are a non-epileptic occurrence. Hypnic jerks have been tracked and monitored using electroencephalography and it has been recorded that these myoclonus twitches generally occur in the wake to Stage 1 sleep phase. The stages of sleep have been categorized into four stages, with Stages 1–3 as non-Rapid Eye Movement sleep and Stage 4 as Rapid Eye Movement (REM) sleep. During Stage 1 sleep, or somnolence sleep, unsynchronized beta and gamma brain waves are transitioning to a further synchronized state, shifting from beta and gamma waves to slower alpha waves and then to theta waves. Hypnic jerks are so common in this stage of sleep because muscle movement and eye movement are still semi-active, and bodily movement hasn't significantly decreased yet, as it will in the later phases of sleep. These jerks could be spontaneous or induced by stimuli, as the "kicks" in *Inception* are. The film's portrayal of the "kicks" in the characters' dreams—different impressions of falling, including an avalanche—that jolted them out of said dreams, align with the way hypnic jerks occur and are perceived in real life.

The gravity-defying dream sequences in the film are, in fact, completely possible occurrences when dreaming in real life. Despite being grounded by Newton's law of universal gravitation when awake, while asleep, our minds have the ability to imagine endless possibilities outside of the laws of physics due to the lack of proprioception in REM sleep. Proprioception is the perception of self and of the body, a sense of position that is caused by the two-way nerve pathway traveling from the muscles to the brain and back. Information travels from one set of nerves and proprioception travels along the other. In REM sleep, the body doesn't use its sense of position, and thus, one's dreams are not limited by the brain's proprioception ability. Special effects may have been responsible for creating the gravity-altering fight scene in *Inception*, but it is also entirely possible for such a scene to occur subconsciously as well. Just as flying is a major recurring theme in many individuals' dreams, our dreams are not weighed down by our awareness of natural

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laws, thanks to the lack of proprioception in REM sleep.

A dream thief in *Inception* proclaimed, "Our dreams feel real while we're in them." But what if it's possible to bypass being unaware of dreaming and become completely conscious of it? The ability of the characters to manipulate their dreams is a major premise of the story throughout the entire film. Without this caveat, the plot of the movie would cease to function. This ability for a person to control their own dream is called lucid dreaming, and it is not entirely fictional. The most common definition of lucid dreams is that they are dreams in which the person is aware they are dreaming. This awareness of the dream allows the dreamer to control it, rather than simply just going along with the dream. The director of the sleep laboratory at the University of California Berkeley, Dr. Matthew Walker, researches cognitive elements of the brain using neurophysiological and functional MRI mechanisms and has found that the area of the brain responsible for lucid dreaming is the lateral prefrontal cortex. This cortex is involved with a variety of complex behaviors, including logic, self-consciousness, and planning. While a person is in REM sleep, the lateral prefrontal cortex should be inactive; however, Dr. Walker suggests that this cortex might possibly "activate" during a person's REM cycle, thus allowing logic and planning to function simultaneously while dreaming. This would permit the person dreaming to recognize that they are dreaming and thus grant them the power to control certain aspects of the dream. Researchers at the Creative Center in Industrial Technology Research Institute in Taiwan used an analytical process of examining the complexity of a brain's signals, Multiple Scale Entropy, to mark the varying levels of complexity of a person's brain signals. The research exhibited through the Multiple Scale Entropy (MSE) analysis showed that a lucid-dreaming brain had a higher score of complexity and that the same brain had a lower score when there was no indication of lucid dreaming. A high MSE score indicates that certain regions of the brain are activated and/or engaged with other cortices and regions of the brain, whereas a low score implies that the regions and cortices of the brain are inactive and/or disengaged with other regions and cortexes. Given that brains that were lucid dreaming had higher scores than brains in regular REM sleep, the analysis suggests that it is possible that the brain's regions are disengaged with another during regular sleep, and are "activated" and connected with other regions during lucid dreaming.

Even though a vast expanse of knowledge about dreams has been gained within the past hundred years, they continue to remain a mysterious part of human life, and are, perhaps, what also make films like *Inception* so compelling. The different aspects of dreaming in the film translate to real, explainable neural mechanisms. However, while some dream phenomena are partially understood, such as hypnic jerks and lucid dreams, why hypnic jerks occur and how some individuals are able to, in some way, control their dreams, has not yet been completely explained. Perhaps that is why dreams persist as a thought-provoking subject and area of research. They are something most humans experience, yet, even in the twenty-first century, are not wholly explainable or controllable.

So thus far, despite what the film may lead us to believe, it is not yet possible to hire a dream thief or for people to dream the same dream together. Some things will just have to remain purely science fiction—for now.

To discover more about this topic, check out Ira Hyman's article, "Inception: The Science of Creating Dreams," from the July 2010 issue of *Psychology Today*.

Love on the Brain

How Neuropeptides Are Shaping Our Love Lives

Written by Kate Hull
Illustrated by Parker Shatkin

One of Oberlin's most surprising (although heavily rumored) statistics is the remarkable number of Obie-to-Obie marriages—I've heard anywhere from 50 to an eyebrow-raising 80 percent. If this is the case, Oberlin seems to be an excellent place to find love. So, what exactly is stirring inside all of these Obies? Why do we feel love at all, and how is it maintained?

William Shakespeare once wrote, "Love looks not with the eyes, but with the mind, and is therefore winged Cupid painted blind." Although Shakespeare lived and wrote well before the dawn of modern neuroscience, his writing encapsulates the sentiment of what it means to be in love. Namely, the experience of love emanates not from a higher power, but from the all-powerful organ that is your brain.

Psychologists traditionally differentiate love into two categories: romantic love and companionate love. Romantic love is most associated with the first stage of love and involves strong feelings of desire for a specific person (also known as the "honeymoon phase"). This form of love is strongly tied in a physiological way to the release of the neurotransmitter dopamine. Companionate love generally follows after romantic love, and revolves around a mutual care and understanding of each other. The switch from romantic love to companionate love is typically thought to facilitate long-term relationships and involves another set of neuropeptides: oxytocin and vasopressin.

Ever feel a rush of excitement when you spot your crush at one of the infamous Oberlin house parties? Well, that surge of emotion—sometimes referred to as "butterflies"—is frequently attributed to the release of dopamine, a neurotransmitter that activates reward circuits in your brain. Neurotransmitters are tiny chemical messengers that, when released from the tip of a neuron, can affect another neuron by binding to its receptor. In this case of dopamine, its release triggers feelings of pleasure and reward that help explain the excitement we experience when we're around people that we like!

To better understand how romantic love manifests in the brain, fMRI brain scans of Rutgers and Stony Brook University college students were taken as they looked either at pictures of people they were romantically in love with, or similar photographs taken of people they were acquainted with. The results of this experiment found that early stage romantic love was heavily attributed to subcortical reward regions of the brain that are dopamine-rich. Additionally, the study found that looking at pictures of romantic partners engages neural systems that deal with motivation to acquire a reward. Thus, early-on romantic love can be characterized as a motivational state that can lead to euphoria, describing why we might go out of our way to be around that special someone.

While it makes sense that the dopamine-induced desire propels us to begin dating and fall in love, it seems many Obies are in it for the long haul. So what keeps us together as we sober up from the excitement of new love? On top of the connection between dopamine activation and feelings of romantic love, fMRI research has demonstrated that levels of activation in specific brain regions may be correlated with amount of time spent in love. In particular, it was found that those who had been in love for a longer time showed a reduction of dopamine activity in their posterior cingulate, an area associated with obsession, but significantly higher activation in the ventral pallidum, an area linked to attachment. These findings are consistent with self-reports which suggest that partner-based obsession subsides early on in the relationship, but feelings of attachment, commitment, and intimacy—hallmarks of companionate love—grow as the relationship persists. Although dopamine continues to be important throughout your relationship, the transition from romantic love to companion love is attributed to two famous pair-bonding neuropeptides: oxytocin and vasopressin. It is the activities of this dynamic duo that are responsible for feelings of attachment (seen in areas like the ventral pallidum) that enable you to put up with (and even still like!) your partner after the obsession of early love passes.

Oxytocin and vasopressin are dual hormones and neuropeptides that are produced in the paraventricular nucleus of the hypothalamus (found at the base of your brain) and subsequently released by the posterior pituitary. Oxytocin is most typically associated with female reproduction: specifically, it plays a pivotal role in childbirth and child-rearing by helping to expel the baby from the uterus, signaling for milk ejection, and creating a loving and nurturing bond between mother and infant. Oxytocin is also heavily involved in relationships, however, and is released during skin-to-skin contact in both males and females and fosters feelings of contentment and closeness after sex (hence its nickname: "the cuddle hormone"). Vasopressin, on the other hand, is more often associated with social behavior in males (specifically aggression toward other males). To better understand how the two hormones relate to companionate love, neuroscientists have turned toward an unassuming subject: the vole.

Voles, a small type of rodent, appear all over studies of love. Of particular interest to researchers are the prairie vole, the montane vole, and the meadow vole. Despite the fact that these types of voles share over 99% of their genetic material, they differ from each other in mating behavior: while the prairie vole forms monogamous relationships (one of only 3% of mammals to do so), the montane and meadow voles are only ever interested in a one-night stand. Differences in mating patterns are thought to arise due to subtle variations in neuroendocrine function between the species. By uncovering the mechanisms that account for these differences, neuroscientists hope better understand why it is that humans often form and maintain long-term relationships. So what do the voles reveal?

It turns out, when prairie voles have sex, oxytocin and vasopressin are released. Once released, these hormones are able to activate receptors in brain regions associated with reward and reinforcement—namely, the ventral pallidum and the nucleus accumbens—suggesting a reason why prairie voles maintain a single relationship for life. If oxytocin and vasopressin are blocked, however, prairie voles' relationship becomes a short-lived fling (similar to the montane vole). Conversely, if given an injection of hormone but kept from mating, prairie voles still prefer their partner over another. On the other hand, if given an injection of hormones, montane voles do not act differently. This is due to the fact that reward regions in their brain do not contain receptors for oxytocin and vasopressin, so long-term relationships are not associated with pleasure for them.

Extrapolating from this, in another vole-related experiment, researchers implanted a vasopressin receptor gene from the monogamous male prairie vole into a meadow vole. As a result of this genetic transfer, originally polygamous meadow voles began exhibiting coupling behavior, like prairie voles. Translating this research to humans, it is postulated that people, like monogamous prairie voles, have oxytocin and vasopressin receptors in areas of the brain that deal with reward. Thus, continuous activation of receptors within these pathways overtime is thought to create memories of a partner that are rewarding, thereby reinforcing the relationship.

A common perspective—and fear—surrounding relationships is that romance fades with time. Although some early aspects of love may dissipate (such as obsession with a romantic partner), research suggests that even couples who have been together for years can still experience the intensity, engagement, and sexual interest of romantic love. Thus, transition from romantic to companionate love doesn't mean a loss in passion; rather, it creates a relationship in which passion exists in tandem to attachment. In other words, Oberlin students have got it pretty good.

Why are there Black Streaks on My Scantron?

And Other Eraser Questions

Written by Nathalie Weiss
Illustrated by Jack Bens

Picture this familiar scene—you are sitting in class taking a Scantron exam, where you fill in bubbles for a machine to read later. Your palms are sweaty and your heart is racing. You are probably frantically attempting to remember all the information you crammed into your brain the night before. Struggling, you are rushing to beat the clock when you realize you've filled in the wrong bubble on your Scantron exam. It was supposed to be B, not C!

Panic flashes before your eyes and you reach for your eraser. But when you press it to the paper, a black smear is created—your eraser just stabbed you in the back when you needed it most. Now, the Scantron will mis-mark your answer! Why didn't your eraser work? It was created for the sole purpose of removing graphite from paper. It may seem that bad luck is to blame when your eraser fails you, but it actually has to do with the chemical composition of the eraser itself. This leads us to an important question: Why do some erasers create an even larger mess when you try to erase with them, while others completely remove the graphite marks?

Before we dive into the differences between multiple types of erasers and their erasing properties, let's take a look at how erasers work. When you use a pencil, you are actually rubbing graphite particles off of the tip of your pencil and onto the paper, where they stick. This is why your pencil point dulls when you write and why pencils get shorter over time. However, luckily for the case of the mis-marked Scantron exam, these particles of graphite are not permanently stuck to your paper—because you have an eraser! When it comes time to remove these particles, like when you've filled in the wrong answer bubble on your Scantron exam, an eraser works by scratching the surface fibers of paper to loosen the graphite particles on the page. Each eraser has an abrasive surface usually made of pumice, a very light and porous volcanic rock formed when a gas-rich froth of glassy lava solidifies rapidly. Pumice is harvested through surface mining and is then dried for refining. It allows the eraser to scratch the paper and pick the graphite up off of the page. Pumice is an ingredient that is found in almost every eraser because it provides natural abrasiveness that does not need to be man-made. Even though all erasers have the same function, not all erasers are as good as removing graphite as others because they don't all include the same quality of ingredients.

> The reason that natural rubber makes for a better eraser than synthetic rubber is because natural rubber contains an innate abrasiveness where synthetic rubber does not.

The difference between an eraser that clears the paper of pencil marks and one that smears the graphite is the type of rubber used in the eraser. The ingredient to blame for those pesky dark smears on your paper is synthetic rubber, which is much easier and cheaper to process than natural rubbers and is thus more prevalent in pencils today. Natural rubber and synthetic rubber are made using different processes, which

accounts for the variety in their abilities to erase.

Erasers, much like many other mass-produced items, are often made as cheaply as possible. When producing mass volumes of goods, synthetic ingredients—ingredients made by chemical synthesis to imitate a natural product—are cheaper to produce than harvesting natural ingredients. Harvesting materials by hand takes much more time and manpower than creating materials in a test tube. Thus, unless you happen to be a person who spends a large portion of your budget on the best quality erasers around, the eraser on the end of your pencil right now is most likely made from pumice, vegetable oils, and synthetic rubber. When making an eraser, this entire mixture is then heated to produce a solid that will wear down with use.

Natural rubber, or caoutchouc, coming from the obsolete 18th-century Spanish word cauchuc, is an elastomer—an elastic hydrocarbon chain—derived from latex, a milky fluid harvested from plants such as milkweeds, chicory, and dogbanes. The structure of latex is 65-70%

A way that you can both effectively remove graphite from your paper and help the environment is by purchasing erasers that are all-natural.

water, 25-30% natural rubber, 1-2% protein, and 1% mineral. One way that latex is harvested is by cutting out a v-shaped wedge in a tree trunk like a Hevea tree. Hevea trees are a species of rubberwood that is native to rainforests in the Amazon region of South America. After a wedge is cut in the Hevea tree, the latex drips out from under the bark. This is not a completely environmentally-friendly process, however, because a chemical may be applied to the cuts in the bark to stop the latex from coagulating, which can disturb the tree's natural growth. The latex then is mixed with sulfur and lead oxide to change it into a strong, viscous rubber mass. When latex is collected from herbaceous plants like milkweeds, latex must be cut from highly specialized latex-rich tissues. After the latex is removed from the herbaceous plant or tree, diluted acetic acid is added to make rubber coagulate into slabs on the partitions. The slabs are then packed into bales, coated with clay to stop them from sticking to each other, then shipped out to manufacturers.

Synthetic rubber, however, is made from petroleum-based monomers. Monomers are the building blocks of polymers and are bonded to identical forms of themselves in a chain. Petroleum is a liquid mixture of hydrocarbons from oceanic organisms that died a really long time ago and were put under extreme pressure and heat by layers of rock. Petroleum can be refined for human use and is defined as either naturally occurring, unprocessed crude oil or petroleum products made of refined crude oil. In this case, we are talking about petroleum products made of refined crude oil. The process of creating synthetic rubber from petroleum requires oil drilling. This causes the release of toxins into the air, contributing to the number of greenhouse gases in the atmosphere, and, even more disturbingly, when oil spills occur, causes the suffering and death of birds, mammals, and fish in local environments.

The switch from natural to synthetic rubber usage in erasers occurred in the middle of the 20th century. However, not everything new is better. The reason that natural rubber makes for a better eraser than synthetic rubber is because natural rubber contains an innate abrasiveness whereas synthetic rubber does not. Furthermore, natural rubber has higher levels of elasticity, air-tightness, and oil-resistance than synthetic rubber. This allows it to be less susceptible to exposure to air and light, which can cause synthetic rubber erasers to lose some of their rubber qualities due to oxidation and chemical degradation. Thus, erasers that are made with synthetic rubbers are the erasers that cause the graphite to smear across your Scantron exam.

So now that we know the culprit behind that smear, what do we do to avoid it? One way to avoid a smear is to use an eraser from a

hundred years ago that has been hermetically sealed to avoid exposure to air and light. Assuming that you don't have both an ancient eraser and access to a strong enough Tupperware to hermetically seal said eraser, a way that you can both effectively remove graphite from your paper and help the environment is by purchasing erasers that are all-natural. All-natural erasers are better for the environment because the process to create them does not result in the release of foreign chemicals into the ecosystem. However, many Hevea trees are harmed when all-natural erasers are made because their bark is removed to harvest the latex underneath, which can lead to the tree becoming open to infection. When the trees are cut in a way that only strips away a small portion of the tree's bark, the tree will survive in most cases. The issue occurs when a large portion of the bark is stripped away or the tree is particularly susceptible to disease. With this information in mind, buy all-natural erasers to do the best thing for your Scantron exams, and encourage companies to carefully harvest latex using all-natural processes.

Falling into a State Deeper Than Sleep

How Melatonin Affects the Body

Written by Carson McCann
Illustrated by Sulan Wu

Why can't it happen already?! My imagination clutters with a thousand issues all focusing on the most pertinent at hand: sleep. I understand the consequences of an occupied mind late at night, but I can't help but count every lost second of sleep. Anxiety courses through me as I anticipate the fatigue I will feel during the quickly approaching exam in the morning. The test I have spent all week preparing for is conquering me, and I have yet to step into the classroom.

My eyes throw a tantrum and shut themselves as if they are a vault door in a desperate attempt to ensure they will not have to open until the sun rises. In the midst of my frustration, it happens. I finally feel my eyes weigh heavy. My thoughts funnel into one semi-coherent stream of consciousness. Eventually, the weight of my eyes grows to be too much. All the stress I felt less than a minute ago seems so insignificant in comparison to the exhaustion I now feel. I gradually feel my mind slip into much-needed slumber. I try to recall the source of this sudden tidal wave of fatigue inundating my mind. Just before my mind fades into rest I remember: the melatonin pill I took earlier has come through to rescue me from my insomnia.

Although I was able to finally sleep, chronically relying on sleeping pills to snooze can cause significant harm to the body. Sleeping pills, such as Ambien, Restoril, or Lunesta, are widely used in modern society due to the struggle many people face with sleeping. However, these synthetic substances can lead to a dangerous dependence with adverse side effects. For this reason, many people are hesitant to use sleeping pills for chronic sleeping issues. Melatonin, on the other hand, is claimed by its supporters to ostensibly be the end-all, cure-all drug for sleeping perils. Since melatonin is a hormone naturally produced in the body, melatonin pills are considered a supplement. The endogenous origin of the sleeping aid turns the substance into an attractive option for many people.

Melatonin does not appear to have dangerous side effects for regular users. Although advocates for the drug argue that their sleeping problems are fixed and they can focus better during the day, some have complained of drowsiness. How exactly does the supplement induce drowsiness? Every day our bodies follow a sleep-wake cycle known as the circadian rhythm. The circadian rhythm is regulated by the hormone melatonin. During the day, melatonin levels are low. In contrast, once the sun sets the pineal gland in the brain secretes melatonin. Our body tells us that it is time to sleep when it produces melatonin, the hormone that induces the unmistakable feeling of drowsiness. After taking melatonin, our eyes soon begin to feel heavy. Every blink feels so satisfying.

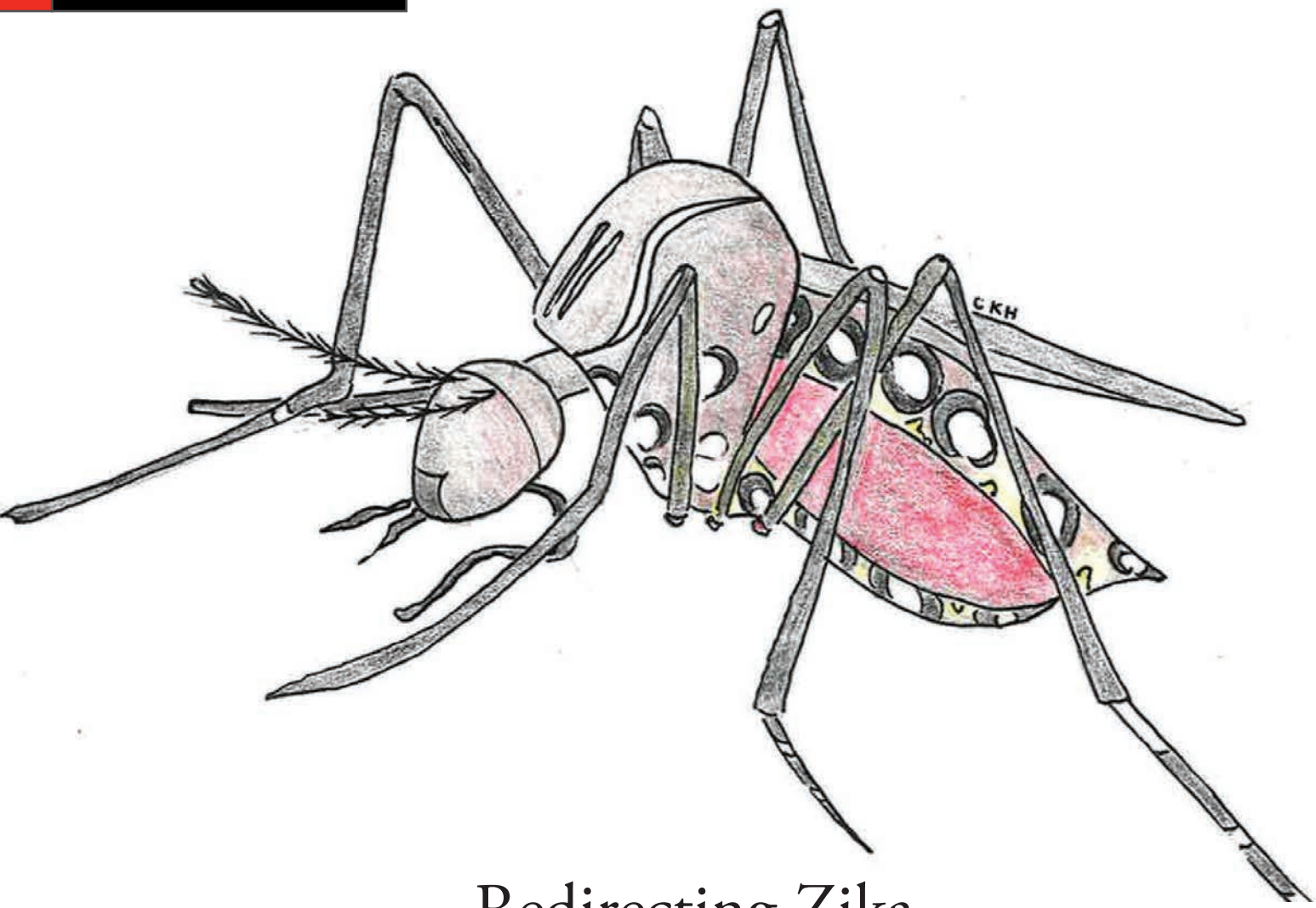
Melatonin contains a significant amount of the amino acid tryptophan. Tryptophan helps to increase the body's levels of serotonin, the neurotransmitter associated with relaxation and wakefulness. Melatonin and serotonin have a push-and-pull relationship. A moderate increase in serotonin production helps to regulate the production of melatonin. The small amounts of tryptophan found in certain foods, like turkey, can also feed the production of melatonin. This is why we tend to require a nap after the ritual feast every November.

Many mental disorders can occur due to an imbalance of melatonin and serotonin levels. Melatonin and serotonin act as antagonistic chemicals in the body. Melatonin is produced when a person is in darkness. Therefore, a deficiency in melatonin often leads to insomnia or Seasonal Affective Disorder (SAD). Insomnia is an illness characterized by difficulty falling asleep, and it can be acute or chronic. Seasonal Affective Disorder is due to the body's difficulty adjusting its circadian rhythm to the changes in the yearly sunrise-sunset cycle. People who live in areas with extremely long days or nights are more susceptible to SAD. Our bodies will also not produce the ideal amount of melatonin when we expose our eyes to bright screens. Watching television or reading tweets from our phones will make it more difficult to fall asleep. On the other hand, serotonin helps the body to stay awake during the day. Accordingly, serotonin deficiencies can lead to a feeling of lethargy or depression. Depression is often treated with Selective Serotonin Reuptake Inhibitors (SSRIs), which cause the dendrite of the postsynaptic neuron to take in more serotonin. In order to achieve an optimal and healthy balance of hormones, melatonin levels should be high at night while serotonin levels should be high during the day.

To its advocates, melatonin pills are ostensibly a harmless sleeping aid, but is that entirely true? Regardless of the objectively impressive benefits many people receive from consuming the supplement, there are side effects. Common side effects include daytime sleepiness, headaches, dizziness, and discomfort in the abdominal area. The daytime grogginess is due to overproduction of melatonin, which can throw off the melatonin-serotonin balance in the body. A higher melatonin level in the body can act like a serotonin deficiency. People with depression can experience worsened symptoms by taking melatonin. Additionally, pregnant and breastfeeding people should avoid using melatonin pills as increasing melatonin levels can affect other hormones. Due to the rapidly changing hormonal levels during development, the supplement can also have deleterious effects on children and adolescents. Children should avoid using melatonin pills to resolve sleeping disorders because the induced imbalance of hormones can disrupt development in adolescence. In addition, the effects of chronic consumption of melatonin are largely unknown. Studies have shown that the benefits of melatonin tend to disappear after six months to a year of consistent use. On top of the unknowns about the long-term use of melatonin, the acclaimed "wonder drug" carries its own set of dangers.

Above all, melatonin's innocence comes into question due to its classification as a supplement. Since the drug is labeled a dietary supplement, the U.S. Food and Drug Administration (FDA) is not as strict on what melatonin pills need to state on each bottle. The FDA does not require overdose dangers to be posted on the packaging or dosages to be regulated for melatonin. Melatonin should be dosed somewhere between 1-3 mg. However, the supplement can be bought off the shelf at any given drug store for 5-10 mg doses. Just because melatonin is a natural hormone does not mean that melatonin pills are completely safe. Users should consult a healthcare provider before taking the supplement. Just as any other medical aid, melatonin has a certain time, place, and duration recommended for its use. Its users should be aware of the correct dosage they are taking and commit to taking it for a short amount of time. Despite the possibly detrimental side effects, melatonin's dangers are relatively tame. Especially compared to some of the medications available for people struggling to fall asleep, melatonin appears to be a reasonable choice. As long as the supplement is dosed at an appropriate level, the benefits of the supplement are maximized and the risks are minimized. A person who is adapting to a new time zone or is experiencing acute insomnia could consider taking a melatonin pill and feel safe in their decision. Achieving the optimal amount of sleep using a small melatonin supplement can be much more beneficial than falling asleep late and waking up late, which is known as Delayed Sleep Phase Disorder. The supplement can be a safe alternative to rebalancing the circadian rhythm in the body. Just as I, the anxious student in the beginning of the article, found sleep, you, too, could consider taking a melatonin supplement in a pinch. However, you should talk to your doctor first to see if a melatonin supplement is safe for your consumption.●

**Note: do not take any dosage of melatonin without first contacting a specialist.*



Redirecting Zika

A Treatment for Brain Cancer?

Written by Rachael Branscomb
Illustrated by Claire Hoy

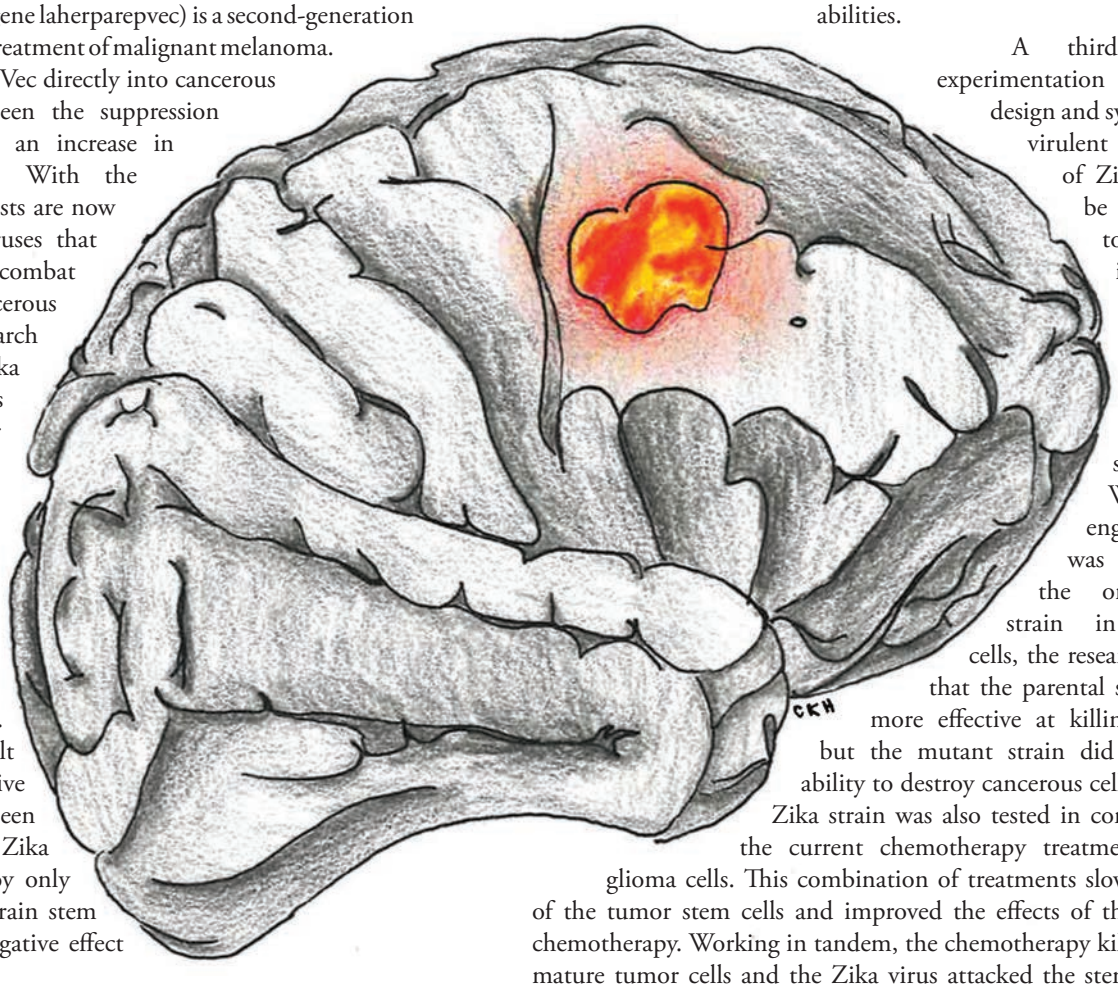
Though originally discovered in 1947, it was not until the 2016 epidemics that swept through South and Central America that the Zika virus really caught the public's attention. Spread by mosquitoes and sex, a Zika infection normally brings with it about a week's worth of low fever, rash, swollen joints, and muscle pain. However, for expectant mothers who become infected while pregnant, the virus can lead to serious neural complications for the developing fetus, including microcephaly, a birth condition where the baby's head and brain are much smaller than expected. Despite its current negative status as a global health threat, Zika's destructive neurological effects may someday be redirected to treat brain cancers.

Of the many types of brain cancers, glioblastomas, a type of brain tumor, are the most common in adults and one of the hardest to treat. Because a person diagnosed with a glioblastoma has only a 30 percent two-year survival rate, scientists are working hard to research treatments that can kill the tumors or at least slow their progression. Like normal body cells, the growth and development of glioblastoma tissue originates in stem cells, which are able to self-renew and proliferate without limit. However, unlike healthy cells, glioblastoma stem cells are resistant to radiation and chemotherapy and are able to avoid the body's immune system. The stem cells may continue to grow and divide even after the more mature tumor cells have been removed through surgery or killed by chemotherapy.

An oncolytic virus is defined as a naturally-occurring or genetically-engineered virus that selectively replicates inside cancer cells to kill them without harming normal body cells. The idea to use viruses for such purposes has actually existed for quite some time, originating with observations of tumor regression in patients who contracted systemic viral infections. It was in the 1960s and 1970s that scientists first attempted to wield naturally-occurring viruses as cancer treatments. However, the idea was almost abandoned because there was an inability to control the pathogenicity of the viral cells within the body. Viruses have little problem proliferating within cancer cells due to the cells' impaired ability to protect against them. Scientists' dilemma then became allowing this replication of viruses within tumor cells while simultaneously preventing the viral cell replication within normal, healthy cells. Due to the technological limitations of the time, the trials in the '60s and '70s ultimately failed. It was only through the development of modern

techniques and an improved understanding of the viral genome that the desire to tackle oncolytic viral treatments was revived. In fact, the first oncolytic virus drug used to treat cancer in the United States, T-Vec, was approved in 2015.

T-Vec (talimogene laherparepvec) is a second-generation herpes virus used in the treatment of malignant melanoma. With the injection of T-Vec directly into cancerous tissue, patients have seen the suppression of tumor growth and an increase in overall survival rates. With the success of T-Vec, scientists are now searching for other viruses that have the potential to combat the growth of cancerous cells and tumors. Research indicates that the Zika virus specifically targets both neural progenitor cells and stem cells. Naturally, stem cells are abundant in the brains of developing fetuses and babies, and the effects of a Zika infection can cause major consequences in fetal brain development. However, because adult brains have few active stem cells, it has been hypothesized that Zika treatment would destroy only the tumor-producing brain stem cells and cause little negative effect on the rest of the brain.



Researchers from the University of California, Washington University School of Medicine, Cleveland Clinic, and the University of Texas Medical Branch have recently begun to experiment with the possible positive effects of Zika in mice that have aggressive glioma, a broad category for brain and spinal cord tumors that originate from glial cells, which are cells that help neurons function. To test the effects of Zika on the tumors, mice were injected with a specially designed mouse-adapted strain of the virus. The group of mice treated with Zika demonstrated significantly smaller tumors when measurements were taken two weeks post-injection as well as a longer lifespan than the control group who had only been injected with saline. This is the first of a series of data that strongly supports that the destructive powers of Zika can be redirected to combat gliomas and possibly glioblastomas.

> One major concern that research teams now face is how to develop this virus into a human treatment.

With these highly promising results in mind, the research team took to the lab again, this time testing the effects of the virus on human cells. Glioma tumor cells and stem cells were removed from patients and grown in petri dishes in the lab, as well as were tissue specimens of glioma cells that had grown into brain tumors. The Zika virus was shown to preferentially infect and kill glioma stem cells over other types of cells within the brain, even over mature glioma cancer cells, which divide uncontrollably. Once infected by Zika, the glioma stem cells were rendered unable to reproduce and were more likely to die. These results again support the supposition that Zika has cancer-preventing abilities.

A third round of experimentation involved the design and synthesis of a less virulent mutant strain of Zika designed to be more sensitive to the body's immune system while still retaining the ability to target and kill glioblastoma stem cells. When this engineered strain was tested against the original parent strain in glioblastoma cells, the research team found that the parental strain remained more effective at killing tumor cells, but the mutant strain did still retain its ability to destroy cancerous cells. The mutated Zika strain was also tested in combination with the current chemotherapy treatment for mature glioma cells. This combination of treatments slowed the growth of the tumor stem cells and improved the effects of the conventional chemotherapy. Working in tandem, the chemotherapy killed most of the mature tumor cells and the Zika virus attacked the stem cells that the chemotherapy had missed.

Although these results sound positive, the integration of Zika virus therapy into the world of brain cancer treatments is still a long way off. There are many health concerns that scientists and doctors will have to overcome before Zika is inducted into mainstream treatments. One major concern that research teams now face is how to develop this virus into a human treatment. It is a long jump from the laboratory petri dish or mouse model to a human trial. It takes a large amount of virus to effectively shrink a tumor, and it is potentially very dangerous to inject large amounts of Zika anywhere, especially directly into the brain where it is known to cause severe neural deficits. More experimentation is also required to address concerns about the strains' potential abilities to disseminate throughout the brain or revert or evolve into a more virulent form. Scientists are already working on ways to enhance the safety profile of the virus by introducing more mutations.

Though virotherapy is still not entirely understood, the field of oncolytic virus treatments is currently evolving as scientists begin to understand more of the mechanisms behind cancer and the viral genome. Research is now working to identify anticancer mechanisms through animal tumor models with oncolytic viruses that may one day be transferred to a human model. With the recent breakthrough of T-Vec, we will hopefully soon see the introduction of similar viral therapies as cancer treatments in the near future.

ICYMI

There's a New Way to Kill Cancer Cells

Written by Caila Glickman
Illustrated by Valentina Zhang

In case you missed it—research oncologists around the world are treating cancer using the immune system. You, like many others not participating in oncology research, may have missed the news, but immunotherapy drugs are leading to the most recent breakthroughs in cancer history. Researchers are only now opening up this treasure chest of life-saving medicine, so things are moving quickly. No advancement of this magnitude has happened since the 1960s, when chemotherapy drugs were finally curing diseases like childhood leukemia and lymphomas. Now, cancer immunotherapy is becoming an entire field rich in revolutionary medicine and treatment of disease.

Chemotherapy and radiation are no longer the only options; treatment is becoming more targeted to focus on cancer cells and leave healthy cells to live out their days. Oncological research is now moving away from toxic drugs and focusing on exploiting the tremendous power of none other than the immune system. I spoke with Dr. Ron Peck, a medical oncologist who worked on a clinical research trial for ipilimumab, a cancer-erasing drug, so he could spell it out for us. Here's the science behind how and why these drugs are working:

Typically, the immune system uses its T-cells, a type of white blood cell, to find and destroy mutated and/or harmful cells in the body. These T-cells are the cells that your body would use to kill viruses and bacteria that are making you sick. When T-cells destroy these invader cells and fight the good fight, your body once again gets healthy and the immune system is typically turned off by a marker known as CTLA4 on the T-cell. Cancer cells, however, can hide their 'chemical ID' from the immune system, allowing the cells to divide and grow at rapid speeds without being detected. This is why they are almost impossible to stop and destroy; because the immune system fails to recognize cancer as an invader, it 'turns off' without ever targeting cancer cells. Drugs like ipilimumab are flipping that CTLA4 switch back to 'on', pushing the immune system to eliminate tumors as a result.

Research in cancer immunotherapy focuses on turning the immune system back on to target specific cancer cells. This is done by reversing those signals that would turn the immune system off. These drugs are actually called checkpoint inhibitors because they turn checkpoints (like CTLA4) back on when they would normally turn off. Since this is an atypical process for your body to go through, these 'switch-flipping' drugs need to be prepared in a lab. Biotech companies first manufacture specific antibodies, or virus neutralizers, that are extremely sensitive to the exact type of cancer marker researchers are looking to destroy. This antibody will then mark the cancer cell as an invader, revving up the immune system so the T-cell is able to detect and kill it.

This technique, however, is not novel. Over 100 years ago, it was found that patients with visually-detectable cancer who happened to also have severe infections were being cured of both issues. We know now that when the immune system is in overdrive (like when it's targeting a virus), T-cells will also target and kill cancer cells. In the 1980s, research oncologists began developing and genetically engineering proteins in an effort to target cancer cells through immunotherapy. These drugs, however, were incredibly toxic and failed horrifically. That is not to say that ipilimumab and drugs like it are perfect; there are side effects. For example, since the immune system is now working on overdrive, some patients have developed autoimmune-like diseases in which their immune system begins to attack healthy cells instead of harmful ones. This issue disappears once medication is stopped and patients are typically willing to take that risk since the drugs are essentially ridding their bodies of terminal cancer.

> It's been found that about 20 percent of patients who previously had terminal cancer and less than a year to live are now cancer-free.

Dr. Peck worked specifically with patients dealing with metastatic melanoma, a type of skin cancer which has metastasized, or

spread, throughout the body. This type of cancer, one of the fastest growing, has an average survival rate of six to nine months after diagnosis. No treatment has ever successfully prolonged survival until now.

Ipilimumab, an antibody that targets a specific receptor on T-cells to find and destroy metastatic melanoma cells, began undergoing clinical studies in 2000. In 2010, the first positive phase three study of metastatic melanoma treatment came out. This means that researchers tested the drug on patients to assess efficacy, effectiveness, and safety, and each category checked out. The study showed a prolonged survival for patients, an unprecedented result in treatments for this cancer, and led to the drug's approval in 2011. Now, seventeen years after the study first began, it's been found that about 20 percent of patients who previously had terminal cancer and less than a year to live are now cancer-free. Doctors are calling it 'long-term survival'; the word 'cured', as you may imagine, is a little taboo in the field.

While 20 percent may seem low, it's an incredible accomplishment at combating terminal cancer. Still, the question haunts research oncologists: why only 20 percent? No one knows yet. The study is only about 10 years out for data collection, and clinical researchers are hoping to find markers which can predict whether or not these types of drugs will work for certain patients over others.

More research is being done in this field than ever before. Ipilimumab has acted as the 'shoulders' for similar drugs to stand on that are a lot more effective and have a lower risk for autoimmune-like symptoms. Many oncologists who used to view immunotherapy drugs as incredibly dangerous are now hopping on the bandwagon to research more checkpoint-inhibitor drugs. The biggest advancements since ipilimumab are anti-PD1 drugs. Like CTLA4, PD1 is also a checkpoint for the immune system to be turned off. There are now five anti-PD1 drugs that have been approved in the last three to four years for seven different types of cancer.

This research is unbelievably recent and growing at rapid speeds. Recently, there was a groundbreaking approval for a new type of immunotherapy technique to treat childhood leukemia; in short, T-cells from the body are extracted and genetically engineered to hone in on leukemia cells, induce an immune response, and kill the diseased cells. This technique has been termed 'CAR-T cell therapy' and it uses genetics as a way to train the immune system.

It is obvious that the clinical research field in oncology is expeditiously improving. It is bringing in techniques and approaches from the untapped field of immuno-science. It is finally getting a grip on how to destroy metastasized malignancies. It looks like we have finally reached the breaking point and the age in which we may have a viable new avenue for curing cancer.

If you'd like to learn more about cancer immunotherapy, see the National Cancer Institute's regularly updated "Immunotherapy" page on their website.

The Illegal Parrot Trade: The Caged Birds Sing of Freedom

"The caged bird sings with a fearful trill, of things unknown, but longed for still, and his tune is heard on the distant hill, for the caged bird sings of freedom." –Maya Angelou

Written by Casey Pearce
Illustrated by Emily Herrold

Birds are revered in nearly every culture across the globe as a symbol of freedom. Consider the bald eagle, the symbol of freedom in American culture. Birds are truly the most free of all the animals and can fly anywhere in the world they desire. But if birds are so highly exalted for their freedom, why are they so often found in cages?

Every year, thousands of parrots are smuggled into the United States from places all over the world to feed the growing pet trade. After capture, parrots are kept in small cages as they await their fates. Parrots are usually taken through one of two routes. In places like South America, Australia, and Africa, smuggling parrots takes increased effort and usually involves an elevated mortality rate. In these cases, the parrots are captured and then have to be smuggled by plane or ship into other countries. This means that the parrots have to illicitly make it through customs. Large, beautiful parrots are therefore stuffed into small cages, boxes, or bags. They are kept with their beaks taped shut, often sedated by drugs or alcohol in order to keep them still and quiet. According to the Animal Law Coalition, some parrots have even been found with their eyes gouged out to ensure that they will not move if there is sudden light. Some parrots are even taped onto the bodies of their captors.

In other places, like Mexico, the parrots are sold to people on the streets from cages. Tourists and wealthier locals will buy a parrot for the novelty and the status symbol that comes from owning one of these rare birds. Selling the birds like this is still highly illegal, but it is difficult to stop the trade. People who sell these birds know that it is illegal and will be ready to pack up at a moment's notice. While this is a much less harmful route, it still often results in a high mortality rate among the parrots due to abuse and neglect. It is no surprise that the second leading cause of death for parrots is the illegal pet trade. For all birds to survive capture and smuggling is very rare. The Animal Law Coalition states that generally 60 percent of birds die sometime between their capture and their arrival in a designated country. To compensate for these deaths, captors will seize more birds than they intend to sell. By capturing so many birds, the captors are detrimentally impacting the populations of parrots in the wild.

After the birds that have survived arrive in their designated country, usually in Europe or North America, they are sent to breeding facilities. Parrot breeding facilities are similar to puppy mills; the birds are kept in poor conditions and are forced to have clutch after clutch of eggs until they die or are sold. Parrots in the wild usually only have one clutch every year and spend time caring for and raising their young. In these breeding facilities, the birds are forced to lay eggs over and over again. This can cause female birds to die from calcium deficiency because so much of the calcium in their bodies is used to make eggs. The eggs are then taken from the parents and hatched artificially, and the chicks must be hand-fed by people. Hand feeding is a complex process, as it is not easy to hand-feed lots of birds at a time. The food cannot be too warm or too cool, because extreme temperatures can cause crop burns or crop stasis. The crop is an enlarged area of the esophagus in the digestive tract where food is initially held. Crop burns occur when a parrot's crop is damaged by food that is too hot. The burns can be extensive and cause holes in the crop and even death to the parrot. Crop stasis occurs when food stays inside the crop for too long, which can cause deadly fungal or bacterial infections to arise. Additionally, chicks can aspirate and die if they are fed too quickly. Many people believe that hand-feeding parrots will make them better pets, but in reality, when parrots are not raised by other parrots, they can have social and behavioral issues such as screaming, sexual behavior towards humans and inanimate objects, and aggression towards other birds.

> Parrots, whether captured from the wild or bred in public, do not make good pets. They are not domesticated; many companion parrots are direct descendents of wild parrots.

While the behavioral issues parrots face are well-documented, they have not been well researched. There are many accounts of hand-fed parrots behaving very differently from wild parrots, but current research is focused on how to end the illegal pet trade and restore wild parrot populations. Currently, the closest studies we have are those done to judge if human-raised parrots can be released back into the wild. The debate on the issue is heated and difficult to quantify. In some cases, parrots have had high survival rates when released into the wild, but companion parrots that rely largely on humans for survival have very low survival rates and will starve to death or succumb to predators very quickly. There is a clear difference in the behavior and socialization of companion parrots and parrots raised to be released.

Parrots, whether captured in the wild or bred in captivity, do not make good pets. They are not domesticated; many companion parrots are direct descendents of wild parrots. It takes many years for a species of animal to truly become domesticated, and due to their high intelligence, it is suspected that parrots will never be domesticated. They are like needy toddlers: they poop and they eat and they scream for what they want. The Moluccan Cockatoo is the loudest bird on earth, clocking in at 135 decibels as recorded by the San Diego Zoo. Standing next to a cockatoo

while it screams causes a great deal of discomfort. Most larger parrots can also bite with great force; their beaks are designed to easily crack open even the toughest of nuts. When parrots get upset or territorial, they will bite. Many parrot owners know very little about the birds, keeping them in cages that are too small with the wrong diet. This can exacerbate the screaming, biting, and behavioral issues seen in parrots. People who keep parrots must understand all of the difficulties that come with them. Those who do not will end up with a pet they do not want; it is estimated by the Humane Society that 75 percent of birds kept as pets are abused or neglected.

If parrots do not make good pets, why are they smuggled in such high numbers? The illegal pet trade is considered one of the most profitable trades after drugs, weapons, and humans. The pet trade is inherently different from these other trades. While drug, weapon, and human trafficking often rely on organized crime to smuggle illegal items, the pet trade relies on locals. Most of the illegal pet trade occurs in developing nations within Africa and South America. The people who traffic birds are not monsters, and most of them do not want to see the birds hurt. For the most part, bird traffickers are just people trying to survive and support their families. The illegal bird trade cannot be justified, but it can be understood. If the choice came down to feeding your family or capturing birds, most know exactly what they would do. The illegal pet trade is one fragment of the complex socioeconomic issues found within developing nations.

The parrot trade and illegal pet trade is a far-reaching issue. There is no easy solution. There are laws currently in place, such as the Wild Bird Conservation Act passed in 1992, which protect many species of parrot from illegal trade, as well as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). While these laws help discourage the parrot trade, it continues to flourish and is estimated by the U.S. Fish and Wildlife Service to be a multibillion dollar global industry. To truly attack the root of the problem, we must educate and advocate for these parrots. People must understand where the birds they are buying come from. The biggest threat to the illegal parrot trade is lower sales due to people refusing to be complicit in a system that abuses and kills parrots. There are many parrots that can be found in foster homes and sanctuaries, and these are often the best places to get a bird to assure that one is not being complicit in the illegal parrot trade. If the illegal parrot trade can be ended, parrot populations will face significantly fewer threats and may be able to better face habitat loss and fragmentation. Parrots may be able to speak, but it is up to us to speak up for their safety.

Tragic Science

Case Studies of Misuse of Knowledge

Written by Oluwadamilare Ogunjimi
Illustrated by Roger Ort

On TV, science is quick and clean. Scientists are swift, efficient, and can do almost anything, given the resources. However, anyone who has done research or spent sufficient time in a lab can testify that science rarely goes as planned. Rather, science is riddled with failures that ultimately tumble into each other in such a way that human knowledge about the natural world is propelled, whether by leaps or baby steps. Some of these failures are laughable, while others are tragic and end with someone getting hurt. Some of science's greatest tragedies include the willful overlooking of a brilliant, trailblazing femme scientist, despite her central role in one of humanity's significant discoveries; the development, by unknowing researchers, of a weapon that would impact billions of lives; and the introduction of a dangerous, world-changing ideology as a result of entitlement and irresponsible theory.

In 1951, Rosalind Franklin, already known for her study of coal crystals in Paris, arrived at the King's College Biophysics unit in London, unsure of what her next project would be. J.T. Randall, King College's head of Biophysics, recommended she join physicist Maurice Wilkins in his work, using X-ray diffraction to deduce the shape of DNA. Wilkins, who was on vacation during this settling of affairs, returned to his lab, expecting to greet a docile woman ready to act as a Junior Lab Assistant and do whatever he said. Instead, he found Franklin running the lab as if it were her own—let's be real, it practically was.

Science is riddled with failures that ultimately tumble into each other in such a way that human knowledge about the natural world is propelled, whether by leaps or baby steps.

Wilkins and Franklin's pairing was an ordeal in and of itself. Wilkins didn't enjoy having his authority in the lab challenged by a woman, and Franklin was not the kind of person to step down for his ego's sake. They were constantly at each other's throats, to an eventual point when the lab had to be split in half, each of the scientists sticking to their own side. In a near boating accident, Franklin even came close to accidentally killing Wilkins. When a friend later joked about her having tried to kill him, everyone laughed rather uncomfortably, unsure whether there could be any element of truth in this suggestion. Apparently, they wouldn't put it past her.

The match-up turned out to be even more problematic when Wilkins, without permission, shared Franklin's data and calculations with a couple of clever boys desperate to make a name for themselves from a nearby university. These boys were James Watson and Francis Crick, and Franklin's data was the missing piece they needed in their research. At first, Watson and Crick were completely unaware that they were working with stolen data. Franklin was furious when she found out, but, seeing how close they were to their goal, eventually helped Watson and Crick make sense of her data. This unorthodox collaboration amounted to the discovery of DNA's three-dimensional structure. Watson and Crick, who unknowingly stole Franklin's data, and Wilkins, who didn't contribute much besides being a terrible lab mate, were awarded a Nobel Prize. Franklin had died four years before the occasion, and the Nobel Prize isn't awarded posthumously. Over the years, Franklin was slighted from recognition in far too many ways.

Another of Maurice Wilkins' contributions to science was his work on the Manhattan Project, a top-secret U.S. government operation that oversaw the development of the atomic bomb. As a response to the Japanese attack on Pearl Harbor in 1941, the first two targets of the atomic bomb were the cities of Hiroshima and Nagasaki, which were devastated by the nuclear blasts. At about 37 sites around the country, including the Los Alamos National Laboratory and the University of Chicago, up to 130,000 researchers had worked on the Manhattan Project. However, most of these researchers were unaware of what their work was being used for—or its implications—until hearing J. Robert Oppenheimer's chilling quote at the project's completion: "Now I am become Death, the destroyer of worlds." Without knowing the full scope of their project, thousands of workers and researchers contributed to the deaths of about 225,000 people.

Sadly, the atomic bomb does not stand alone in its devastating results of scientific endeavors; plenty more scientific failures and successes have resulted in mass death and destruction. For example, prior to and during World War II, the ideology of eugenics spread throughout the U.S. and Europe. This ideology, built on the belief that human evolution should be human-guided, was used to justify the oppression of millions. "Human-guided" eventually took on the meaning of ridding the world of people with traits deemed less than desirable. It started in the U.S. where sterilizations were forced on institutionalized patients, many of whom were women and people of color—society's scapegoats. This ideology, which set the groundwork for fascism and Nazism, was initially supported by many U.S. scientists, and popularly circulated through the media—that is, until the movement grew into the Holocaust, and the inhumane horrors masked behind the ideology could no longer be denied. Even after the Holocaust, the field of eugenics left a legacy of pseudoscience that would be employed to dehumanize Blacks and other people of color.

The damaging theory behind the eugenics movement was originally developed in 1883 by Francis Galton. *In Inquiries into Human Faculty and Its Development*, Galton laid down a general plan to mimic natural selection in order to rid humanity of its "inadequacies". During the development of his theory, Galton designed and honed measuring devices for "favorable" and "unfavorable" characteristics in humans. These devices included the bell-curve, used to determine which groups lacked "favorable" traits, and the concept of "Nature Versus Nurture", which he coined to distinguish between hereditary and environmental traits. Galton proposed that society keep a record of the best families with the best traits and ban "unsuitable marriages."

Ironically, Galton's own feelings of inadequacy seem to have influenced his work. Galton saw himself as a brilliant scientist, with the best education that an upper-class upbringing could afford, yet he felt he never received the recognition he deserved. He felt both inspired and robbed by the success of his cousin Charles Darwin. Galton's theory of eugenics, his claim to prominence, allowed him to divert attention from these feelings of shortcoming and redirect disdain toward targeted demographics while elevating his own social worth. The theory took the world by storm, providing dominating social groups with the means to lash out at oppressed groups, arguably to cover up their own inadequacies or emphasize their power in an already existing social hierarchy. Galton's lust for fame contributed to decades of pseudoscience, oppression, and pain.

As we've seen, science can have very damaging social implications. The realm of science is not as removed from social dynamics and power systems as one may think. Science is often messy, but sometimes it can be *catastrophically* messy, resulting in anything from a researcher's contributions being ignored due to their identity to the unjust deaths and oppression of millions. Knowledge can be an amazing thing. It can be exciting. It can be collaborative and awe-inspiring. But sometimes, knowledge, whether accurate or misguided, can be dangerous.

Big Ideas

Why Liberals and Conservatives are More Different than You Think

The Science Behind Political Opinions

Written by Joanna Zienkiewicz
Illustrated by Mikaila Hoffman

From increasing education spending to increasing military spending, stricter gun laws to stricter immigration laws, environmental protection to fetal protection, there are many issues that showcase the ideological differences that separate liberals and conservatives. The disagreements that stem from these differences have long left the realm of polite debate and become hostile and, in some situations, even violent. Both sides express prejudice and intolerance toward each other, which often manifests in the form of negative stereotypes (e.g., liberals are naïve, entitled millennials who overspend on coffee and avocados, while conservatives are ignorant, wealthy, NASCAR-loving religious fanatics). Many view an individual's political ideology as stemming from personal values and moral character. Recent research, however, has shown that the differences in worldview between liberals and conservatives are significantly related to an individual's biology and psychology.

For over half a century, psychologists and sociologists have speculated on the psychological motives and tendencies that influence ideological differences between the left and the right. Investigations on this subject have shown that differences between the two groups are not superficial, but occur on a psychological level. Liberals and conservatives exhibit different personality traits and even different unconscious reactions. For example, one study found that conservatives are more sensitive to threatening facial features than liberals, while another study found that conservatives' eyes tend to linger for a longer period on disturbing images in a collage of photographs. In examining the bedrooms of college students, a team of psychologists found that liberals own more travel memorabilia and books, suggesting that they are more adventurous than conservatives, while conservatives possess more organizational and cleaning items, suggesting they are more self-disciplined than liberals.

In addition to the research psychologists and sociologists have produced on the psychological and environmental influences on political orientation, recent studies have begun to identify biological factors. It is difficult to imagine that people could be born with predispositions to certain opinions, and for a long time researchers considered this not to be a possibility. Research has shown, however, that social attitudes cannot be attributed exclusively to psychological or environmental factors, prompting further investigation into how an individual's biology may influence their political orientation. Several studies, for example, have begun examining the relationship between neuroscience and political attitudes.

A study conducted by neuroscientists at University College London found evidence that political opinions of young adults can be related to physical differences in brain structure, specifically in the volume of grey matter in different brain regions. Grey matter is a type of brain tissue that is made up of the cell bodies of neurons, which chemically communicate with one another to stimulate or inhibit brain activity. The variation in amount of grey matter can largely be attributed to genetic factors, though environmental influences have also been found to play a role. For example, some experienced taxi drivers have developed an increased volume of gray matter in a brain region associated with spatial navigation.

The University College London study utilized structural MRI scans of young adults who had confidentially self-reported their political attitudes on a five-point scale ranging from "very liberal" to "very conservative". The group found a correlation between the political orientation of these young adults and the volume of grey matter in different areas of the brain. The study concluded that greater conservatism is associated with greater grey matter volume in the amygdala, while greater liberalism is associated with greater grey matter volume in the anterior cingulate cortex.

The amygdala has many functions related to emotional processing, but it is most active in situations that induce fear or anxiety. The fact that conservatives were found to have more grey matter in their amygdala, and therefore have greater sensitivity to fear, supports the conclusion that they are generally more anxious than liberals. The discovery that liberals tend to have more grey matter in their anterior cingulate cortex supports the idea that they are more tolerant of discord, as the anterior cingulate cortex is involved in decision making and activates in moments of conflict or uncertainty. This study therefore supports psychologists' findings that liberals tend to display a preferred mode of thinking, remembering, or problem-solving that reacts well to ambiguity and novelty. However, it is important to note that correlation is not the same as causation.

In addition to neurological differences, genetics have also been found to affect political ideology. Studying twins is a popular method among scientists in determining the heritability of psychological traits.

Essentially what this research shows is that an individual's political opinions are deeply ingrained within them, and that they are least partially the result of genetic factors outside of their control.

Because identical twins share 100% of their genes while fraternal twins share 50% of their genes, a scientist comparing the similarities between sets of identical twins and sets of fraternal twins can attribute any excess likeness between the identical twins to genetics. This ultimately allows researchers to isolate the environmental and genetic influences on a specific trait and determine the heritability of traits.

Twin studies have demonstrated a connection between social beliefs and genetics. A group from the University of Nebraska—Lincoln expanded on this method to specifically examine the genetic heritability of political ideology. The researchers collected data on the responses of twins on a questionnaire that asked politically relevant questions and analyzed them to determine correlations and heritability. Their data showed that identical twin correlations were higher than their corresponding fraternal twin correlations. The data also showed that that political beliefs had high heritability estimates, suggesting that genes do play a role in explaining political opinions.

What benefits arise from the knowledge these studies provide? The hope is that by understanding how political opinions are influenced by psychological and biological factors, opposing sides will become more empathetic towards one another. Essentially what this research shows is that an individual's political opinions are ingrained deep within them, and that they are at least partially the result of genetic factors outside of their control. By comprehending this, people could potentially decrease the hostility between members of opposing political parties. This knowledge could also make discourse more effective because liberals could appeal to certain traits of conservatives and vice versa. Ultimately, these studies could conceivably lead to more effective discourse between conservatives and liberals and bridge the gap between opposing ideological viewpoints.●

Translating Science Symposium

Career and Networking Panel Discussion

Written by Victoria Albacete
Illustrated by Elena Hartley

On Friday, September 29, various Oberlin College academic departments—including Biology, Chemistry, and Rhetoric and Composition—in conjunction with the Career Development Center and the Science Library hosted the Translating Science Symposium in Craig Lecture Hall. The Translating Science Symposium was created with the intention of connecting Oberlin students with experienced and accomplished alumni working in science communication, and featured four Oberlin alumni and a guest from the city of Oberlin. An all-day event, the symposium consisted of three parts: 10-minute TED talk-style presentations from each guest speaker, drop-in hours at the Career Center for students who elected to chat with the speakers one-on-one, and finally a science communication career panel discussion and networking event.

After a TED talk session that was overflowing with students, faculty, and community members, it was a little bit of a relief to walk into Craig Lecture Hall and find an auditorium comfortably full of people genuinely interested in asking questions about the panelists' careers and goals in science communication. The Career Panel Discussion was moderated by Patrick Keebler, Associate Director of Career Education at the Career Development Center, who, after short introductions from each of the panelists (which consisted of Bijal Trivedi (OC '92), Brianna Rego Lind (OC '06), Dyani Sabin (OC '14), Nancy Fliesler (OC '82), and Karen Schaefer; a brief description of whom can be found in the sidebar at right), dove right into audience questions.

Over the next hour and a half, questions for the panel ranged from those specific to certain panelists' work to broad queries applicable to all of the women's experience in the field of science communication. Throughout the panel, all five women responded engagingly, unafraid to poke some self-deprecating fun at themselves on occasion, but always answering with genuine feeling about their experiences and the work they've produced.

One of the first questions of the night came from Chair of Chemistry and Biochemistry Rebecca Whalen. After a quick aside directed to Schaefer about vocal fry, Whelan prefaced her question: "One really interesting way to frame the science journalist's goal is to make their own job obsolete by enabling scientists themselves to be able to communicate. … Ought it to be an aspiration that scientists have to be effective communicators of their own work, and if so, do you have advice for us on how to be effective communicators?"

While all five panelists had their own helpful responses to the query, Fliesler gave the most audience-friendly reply: "I would just suggest to scientists: Spend more time with non-scientists. Try to explain to people who hate science or think they're not smart enough to understand science, explain to them what you do, and if you can get them to understand, then you're probably speaking at the right level. Try explaining it to a kid. It's really good practice." Sabin chimed in with some nonchalant humor: "Tell your research in a tweet. Can you tweet it? You can explain it."

To complement the panelists' answers, an interjection from a representative from the Science Library encouraged audience members to come by the library and join the American Association for the Advancement of Science, recommending their workshops and interactive social media to scientists to help teach media outreach and communicating with the general public.

The next question came from an audience member, ruefully admitting to their own struggle with perfectionism in writing and asking about the panelists' writing processes for developing different stories. All five women admitted to their own struggles in writing, with Sabin talking about her own "zero draft" that "is zero, it is nothing" and Schaefer advising "Get yourself a first draft—don't care whether the writing is good yet, you can always go back and fix it." Rego Lind pensively offered the thought that "… you never finish writing, you just stop writing. And that can be a very difficult thing to get comfortable with. And you get better at it. You get better at writing better. You get better at writing better earlier in the process, and you have to move on, because if you don't you never end and you never get to move on to the next story."

When asked about talking about climate science in the face of well-funded political opposition, the panelists who responded shared similar interviewing and writing techniques: Avoid controversial phrases and vocabulary—like 'climate change'—and think about your audience. Talking about her experience with writing for a blue-collar demographic about climate science, Sabin recalled, "The idea was that we took this part of climate science and went, 'What is it that would appeal to the audience that we are trying to reach in order to talk about climate science and technology for that audience?'" When she interviewed a person for an article about solar panel installation being blue collar work for the future, Sabin humorously noted, " [He] didn't believe in climate science, but did believe in the independence that solar panels provided from the government, from the grid—and he was all for installing those solar panels."

Later on in the panel discussion, a female member of the audience asked about the demographics of the field of science communication—are women still a minority? When the question was received with head shakes, she was cautiously optimistic: "Are you in a field where there's no sexism?"

In response, Trivedi let out a disbelieving laugh, replying, "No. Look at the editors of all those magazines—don't even get me started on that—it's all white males up top, for a lot of those publications. It is heavily male up top." Sabin confirmed Trivedi's conclusion, adding, "The editors, but also longform features—very, very male. And those are the things that pay well, so if you look at the pay discrepancy, it's sort of the 80-20 thing? Like 20% of the field is male, and they're all the ones with the editor and feature writing positions."

The last question of the night, however, was an encouraging one, asked by a College fourth year: "What is it that you've learned about discovery and where ideas come from?"

A diverse array of enthusiastic answers came back from the five panelists; Trivedi was wholly impressed by scientists' dedication to their craft, enthusing, "They are so committed. They have this seed of an idea and then they just pursue it doggedly, with such intense concentration and intense passion." Schaefer's take was a little different: "What impressed me mostly—they're all sorts of different people—is their simplicity. They have such breadth of vision, such creativity, they're willing to take such risks—they can ask the simplest questions: What if? That nobody else has asked. And then they take that risk, and they maybe step out on a limb, and get laughed at or risk losing funding or something, but by golly they follow through, and they find that their risk was worthwhile."

Panelists

Bijal Trivedi, OC '92
Washington, D.C.
• Majored in Biochemistry at Oberlin. Graduated NYU's SHERP program for science journalism.
• Has written for *Scientific American*, *National Geographic, Science*, and *Nature*, among others, and has worked as the Editor for the NIH Director's blog.
• Won the 2012 Best American Science and Nature Writing for "The Wipeout Gene", published in *Scientific American*.
• Freelance journalist for the past 12 years; currently writing a book.

Brianna Rego Lind, OC '06
Oakland, CA
• Majored in History and minored in Geology at Oberlin.
• Graduated with a PhD in History of Science from Stanford University; completed a postdoc with original research in tobacco control and the tobacco industry from UC San Francisco.
• Currently writing a book about the history of the department of tobacco research at Philip Morris.

Dyani Sabin, OC '14
Chicago, IL
• Majored in Biology at Oberlin.
• Graduated NYU's SHERP program for science journalism in 2016.
• Has written and produced videos for *Scientific American* and *Inverse*.
• Worked at the Science Library during her undergraduate years.
• Currently a freelance journalist.

Nancy Fliesler, OC '82
Boston, MA
• Majored in Environmental Studies at Oberlin.
• Has written for ABC News medical unit and for the past 15 years, Boston Children's Hospital's *Vector* blog.
• Currently the senior science writer and editor for *Vector* blog.

Karen Schaefer
Oberlin, OH
• Worked for 12 years in public radio stations in northern OH.
• Has written, produced, and read for NPR, Marketplace, and PRI's The World.
• Freelance journalist and independent radio producer.
• Currently completing grant work funded by Ohio Sea Grant College Program.

Bijal Trivedi

OC '92 Translating Science Panelist

By Tara Santora

Bijal Trivedi is a freelance science writer who focuses on medical research, biology, and biotechnology. She graduated from Oberlin College in '92 with a Biochemistry major before working as a lab technician at the Whitehead Institute of MIT for two years. Following this, Bijal attended UCLA in pursuit of a PhD in Drosophila genetics. However, after reading Gina Kolata's article in The New York Times about the cloning of Dolly the sheep, Bijal decided to finish with a Master's degree in genetics, then switch her focus by earning a Master's in Science Journalism at NYU.

At The Synapse we publish two issues of our magazine per semester, but you cover articles over a period of months or years. What is that like?

Well, I started doing daily news stories and evolved into doing longform journalism. Originally when I was working for, say, the National Geographic News Service, I would either write a story a day or every couple of days. They were about 750 words, and you could complete all the reporting in a day or so. But with longform, you do get to delve. I started out obsessed with covering the science and thinking that the people angle was very flimsy and whimpy. Since then I have evolved, and longform has with me. I include a lot more of the human angle in stories now.

Could you give an example of that?

I'm working on a book about cystic fibrosis. Ten years ago I would have focused on the science: the biology of the disease and the drug development. But really what's interesting and what led me to do a book was meeting a family whose son died from cystic fibrosis and following their journey and their mission to cure this disease. Everything they've done to fight this disease and to encourage research —that's what was really inspiring. While the science is fascinating the genetics is amazing, it's really the human story that ties all those disparate elements together.

Can you tell me more about your book?

I wrote a story for Discover magazine about the development of Kalydeco. Kalydeco is a drug for cystic fibrosis, but only for cystic fibrosis patients that have one particular mutation. It was the beginning of personalized medicine. Learning about how the drugs were developed—the people behind it, the foundations behind it —I discovered that the story was so much bigger than this ten-page article. But I quickly realized that each of these characters, each of these personalities had their own story. I've never felt like that before. I stayed up for three nights; I couldn't think of anything else. I wrote to the main character. I said, "I have to tell your story. Will you work with me on this?" They said yes, and here I am two years later.

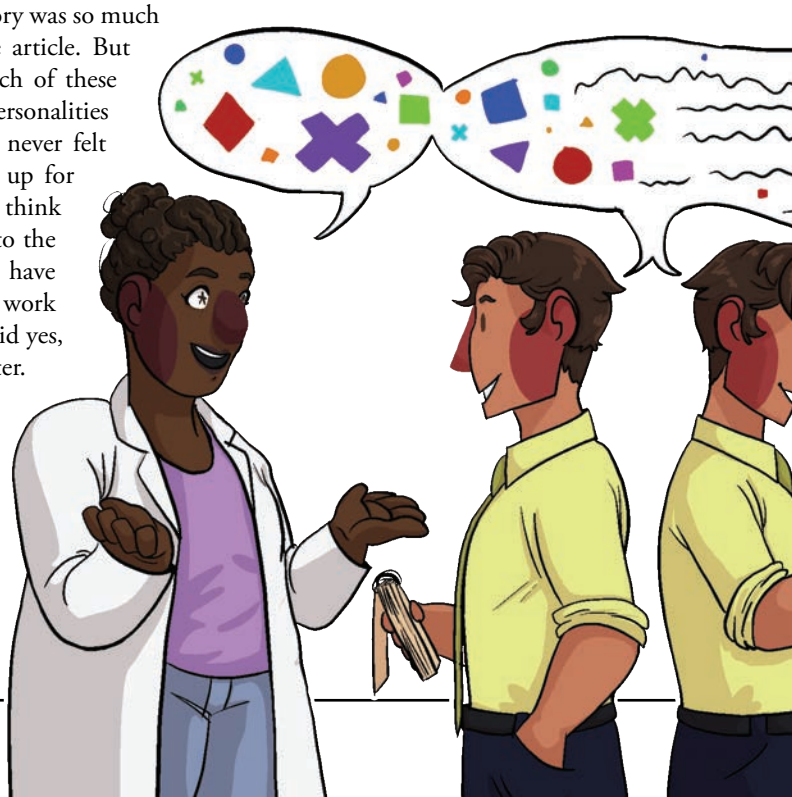
It was exhilarating when I realized that I would be writing my first book on this. Because every story you write, you think that could be a book or this could be a book. But with this cystic fibrosis story I was up for three days straight, probably completely delirious. And I knew. I knew then that this the story. This is what I have the passion to do. You have to trust your gut on some things. If you're passionate about it, if you think's it's a story, it probably is. And you have to chase it.

That is so inspiring. I have to ask, maybe for my own selfishness, what advice would you give to a student interested in pursuing science writing?

Do an internship. Journalism school is great, but it's expensive. If you can intern at a good publication, that's the best way to start doing this. Read a lot; know what sort of journalism interests you; be able to distinguish why one publication is more your cup of tea than another. But I think you can get so much great experience for free as an intern. Find somebody who's work you admire, and get an interview, and get an internship. You might skip over journalism school.

How do you feel about going to school for science journalism versus starting out on your own?

I think it depends. I had been doing biochemistry and then molecular genetics. I was all science. I had not the faintest idea how to switch tracks. So for me going to school for journalism was great. I had no clue about how to be a journalist, so it was wonderful. But I think if you started as a writer, or if you are an English major or Composition major, I think it's a much easier switch.



Dyani Sabin

OC '14 Translating Science Panelist

By Tara Santora

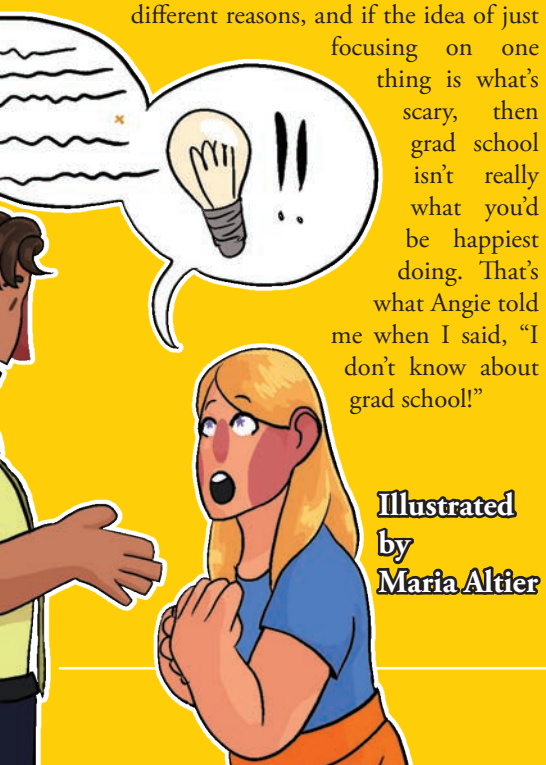
Dyani Sabin is a freelance science journalist who recently graduated from the Science, Health and Environmental Reporting (SHERP) program at NYU. Before this, Dyani graduated from Oberlin College in 2014 with a major in Biology. She has written for publications including Scientific American and Inverse.

What was your experience with science like while you were a student at Oberlin College?
I got to do research in two labs while I was in Oberlin. The first was Marta Laskowski's plant lab—I was there for my first two summers at Oberlin. Then I went to Angie Roles's crayfish lab for my last two years, and it was amazing. I had a great time! I particularly liked going outdoors. I didn't get to do that a lot in Marta's lab, which is why I moved to Angie's lab at first. Research is really an experience that is not like anything else.

Did you do anything while you were at Oberlin that specifically related to science communication?
I was an OWL [leader for Oberlin Workshop and Learning Sessions], for BIOL 102: Genetics, Ecology, and Evolution, which is BIOL 200 now. It was my first experience in learning how to present science in a different way. I often had to target different learning styles and turn science into a game.

How did you decide to go into science communication?
I was doing research and I got to the point where I was thinking about what happened next. When I thought about going to grad school and studying one thing and doing such depth of work, I panicked. I didn't want to focus on just one subject. I ended up floundering and discovering that science journalism was a career. I thought, Cool, I could do that. And here I am.

That's extremely similar to how I feel at the moment in regard to grad school.
Everything is scary as a senior. You don't want to choose badly. But things can be scary for different reasons, and if the idea of just focusing on one thing is what's scary, then grad school isn't really what you'd be happiest doing. That's what Angie told me when I said, "I don't know about grad school!"



Illustrated by Maria Altier

Why do you think science writing is important to the world?
Science affects everything that we do, and scientists are not trained to communicate what they do. This makes sense; they have a lot of other things that they have to do.

So someone has to do it, right?
Right. Also, most people are either afraid or don't realize how much science impacts them. One of the stories that I worked on relatively recently was about how the FBI's facial recognition database is prejudiced against women and African Americans. It has a much higher rate of false positives in these populations. I managed to talk to one of the scientists who worked on analyzing the FBI database, and he told me that as a community of facial recognition researchers, they're not entirely sure why this happens, and that it's a failure of their community that they haven't fixed the problem and really studied it. The FBI is using it, and most people don't know that even the scientists who do it think this is a problem. They know it's a problem and they're trying to fix it, but don't know what to do yet.

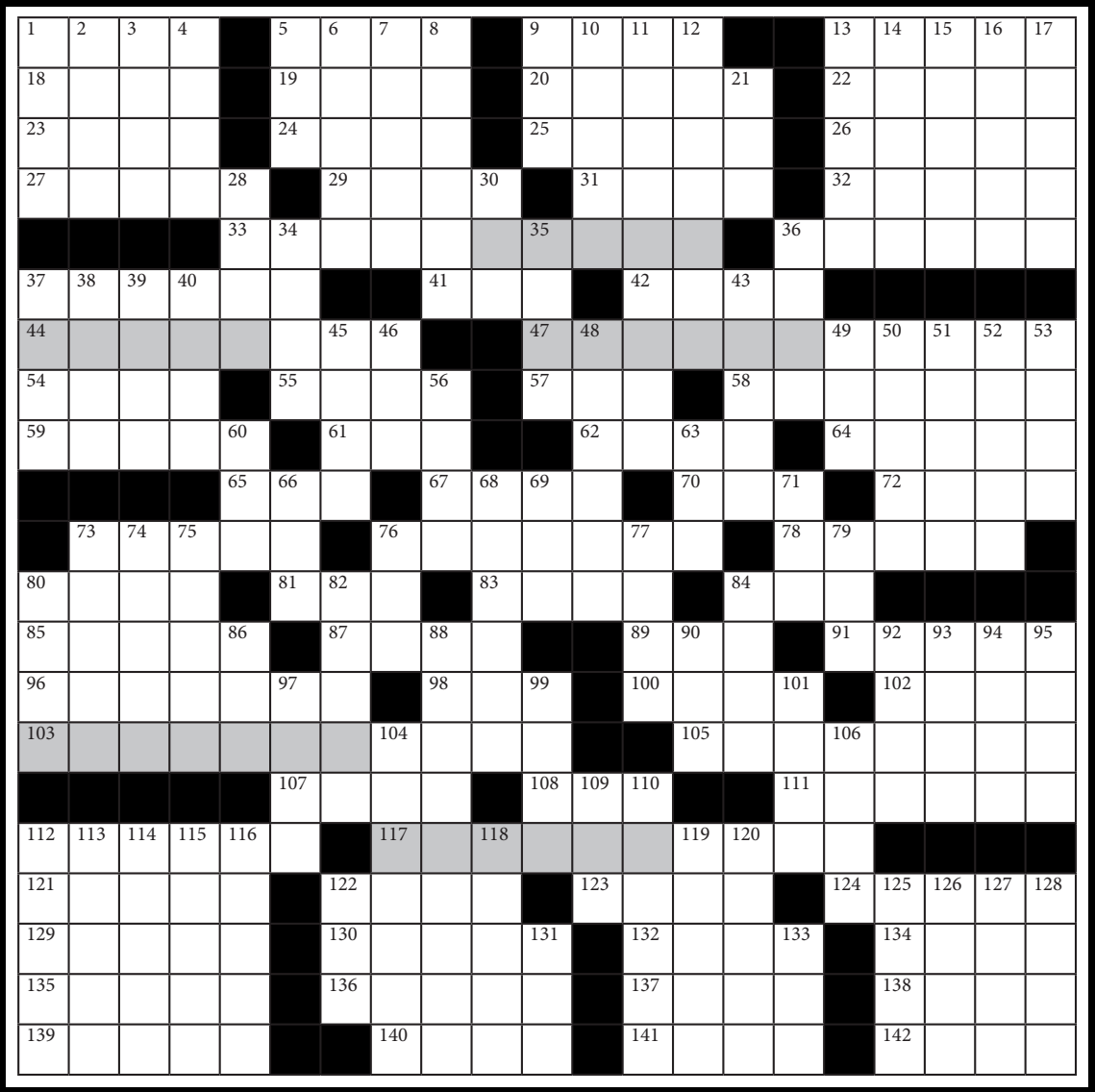
This was six months ago, so things may have progressed, and I don't want to misrepresent what they're doing—but with those sorts of things, the impact is immediate. But even for something like crayfish research in evolution, the research can tell a story about how we are here, and what the world is like, and why. And there's a value to that, even if the research doesn't impact the average person's life.

Well put. So, what exactly is your job at the moment? What do you do?
D: I am a freelance science journalist. I'm not tied to any one publication, but I pitch stories about anything. On an average day I get up, I shower, I eat breakfast. Then I sit down at my desk in my apartment and open the research journals. Then I go from there, sending ideas to editors and asking researchers for interviews. That's first thing in the morning. Then I try to write for a while, then make some phone calls.

What's the best moment that you've had as a science writer so far?
When I was doing research with Angie we went to The Evolution Conference. I got to listen to a researcher who was doing work on rats. He was using rat mitochondrial DNA to trace the travel of the Vikings because the rats travelled with the ships, and when the ships got to land the rats would stay even if the Vikings left. Rats tend to survive, so if any rats survive, they can look at the mitochondrial DNA and say: These are Viking rats. I was able to write a story about that when I was in school—I got to call a researcher in Madeira, Spain, who was so excited because no one had ever called him about his research before. And it was the moment when I realized [that] this is what I want to do for the rest of my life.

ACROSS

1. 1984 Van Halen hit
5. Go for a strike
9. Minus
13. How to track planes
18. Russia's home
19. Londoners don't use it
20. Like some brews
22. "_____, Jamaica, oh I want to take you"
23. Complain
24. How to refer to co-authors
25. Two U.S. Presidents
26. Someone really skilled
27. Bye!
29. Awesome
31. Old school cosmetics case
32. Feedback
33. Like some chemical reactions
36. Toots one's own horn
37. It's used in dot- and cross-product
41. Rapper Brother _____
42. Heroic tale
44. An exemplary person
47. Where to find lineages
54. Hindu deity
55. Chinese dynasty
57. Medicine regulatory org.
58. At one's disposal
59. Night noise
61. Home to the Hawks, abbr.
62. "_____ upon a time"
64. Above the _____
65. 2016 Olympics host
67. Never have I _____
70. Mule's father
72. Showed one's cards
73. Skewer
76. Closest
78. Pseudonym
80. Son of 138. Across
81. Makes things tasty
83. Disney dog
84. Pigment
85. Band of brothers
87. Indigenous tribe native to Arizona
89. Governors' org.
91. Eat (with down)
96. WWII battle site
98. Rib seasoning
100. Adorable
102. Islamic ruler
103. The next world, so to speak
105. What's in a name, or including the terms in the puzzle's shaded squares
107. Protein common in Italian cuisine
108. Pcs. of intellectual property
111. Resistant
112. _____ of Legends
117. www.synapsemagazine.org, for example
121. Consumed
122. "I shot a man in _____, just to watch him die."
123. Hit the _____ on the head
124. Romulus' twin
129. Points you in the right direction?
130. Beef designation
132. Held on to
134. "Chilled to the _____"
135. Electric _____
136. Odor
137. Cave retort
138. Father of 80. Across
139. As opposed to written
140. Whirlpool
141. Political position
142. Subsequent



Crossword Corner

By Daniel Markus

DOWN

1. Coffee tree locale
2. Pre-owned
3. Car brand
4. French Delicacy
5. 2007 Seinfeld character
6. Exterior
7. Bundles up
8. 1955 novel by Vladimir Nabokov
9. Mauna ____
10. Ceased
11. Elder _____
12. Katana wielder
13. 2003 film starring Cuba Gooding Jr.
14. U.S. men's soccer coach Bruce
15. Trash heaps
16. "Much Ado _____ Nothing"
17. Diatribes
21. Unit of pressure
28. What the U.S. government is hiding, supposedly
30. Field officer's rank, for short
34. Bush's blunder
35. Zeppelin's "Black Dog" has a memorable one
36. Chesapeake and Biscay
37. Tape machines
38. Enthusiasm
39. Army garb
40. Russian ruler
43. Adhesives
45. Bye!
46. TV home to *Bones*
48. Beloved
49. What to sip when bitter
50. Jewish spiritual leader
51. Virus that caused 2014 outbreak
52. Little laborers
53. Inception
56. Mirth
60. Epoch
63. Construction machinery company, for short
66. Watson maker
68. Also known as Diazepam
69. Epoch
71. For example, in crossword lingo
73. Olive drab alternative
74. Histology stain
75. Cause to happen (with about)
76. The WHO or HRC, for example
77. iPhone process
79. Guitar inventor Paul
80. Hobbit Peregrin
82. "Have you no _____?"
84. Plural word frequently treated as singular
86. Blue
88. Lengthy
90. Instrument string material
92. Sen. Brooks' weapon
93. Romance word?
94. Tricked out car part
95. Oldest continuously operated shoe company in the United States, supposedly
97. Knitted
99. Software stage
101. Test
104. V to I
106. Above
109. Time amt.
110. They have forked tongues
112. Smallest
113. _____ bird
114. Bizarre experience, in slang
115. Natural History Museum souvenir, perhaps
116. Eligible
118. Pile
119. Brother's daughter
120. Software stage
122. Student supervisors
125. Deep black
126. Value occurring most frequently
127. Operating system type
128. Banished (with away)
131. Eye sore?
133. Lil tater?

Want to see YOUR CROSSWORD featured in *The Synapse*?

Email: synapse@oberlin.edu

Answers to Previous Puzzle

/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.