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THE SYNAPSE

INTERCOLLEGIATE SCIENCE MAGAZINE

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Victoria Fisher (OC '21)

Victoria Fisher (OC '21) is very excited to present the 20th issue of *The Synapse*, her first issue as one of the editors-in-chief. In this issue, we explore components of our world as small as amphetamine molecules traveling through our brain and as large as cosmic events like eclipses. She is very proud of the hardwork and dedication from everyone our contributors - especially those who may have stepped out of their comfort zone by taking on another role. She hopes you enjoy the final issue of this academic year and continue supporting *The Synapse* through your readership and contributions!

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Maria Altier
OC '19
Featured Contributor

After growing up in a little town of central New York called Freeville, Maria Altier came to Oberlin College. Having contributed to a grand total of eight issues, Maria has been an artist for *The Synapse* since 2017. You can find her illustration for the article, *"The Pill" Problem*, on page 20 of this issue. One of the reasons she loves the magazine is that it doesn't place art and science in opposition. Drawing and adventuring through Dungeons and Dragons are some of Maria's favorite pastimes (she particularly appreciates acting as Dungeon Master). If you see someone that looks like her on campus, then you've probably found her twin sister who also goes to Oberlin! With a major in Art History and an intended minor in Chemistry, she hopes to one day become an art conservator.

Elizabeth Toigo
DU '21
Featured Contributor

A native Ohioan, Elizabeth Toigo is a psychology major with a neuroscience concentration at Denison University. She has worked as a writer and as the Denison Outreach Coordinator for about a year. In addition to her contributions for The Synapse, Elizabeth serves as the president of the volleyball club, a peer mentor, a tour guide, and an active member of Sigma Xi, Psi Chi, and the Phi Society. She appreciates The Synapse for giving students a platform to explore their interests within the science community, so that we can stay aware in spite of jargon commonly found in most scientific literature. She is also a huge fan of Disney movies because they inspire people of all ages. After graduation, Elizabeth wants to go into the medical field and potentially become a physician assistant in neurology.

Contents

Time Behind a Shadow

The What, Where and When of Lunar and Solar Eclipses

Written by Kileigh Ford
Illustrated by Annie Karasarides

On Earth, we're constantly orbiting the Sun as the moon circles around us: three bodies, two moving at different rates. When all three line up, there are two different reactions, dependent on whether the Earth is between the Sun and the moon, or the moon is between the Sun and the Earth. These cosmic events are not totally out of the ordinary, but they are spectacular every time and leave us awestruck nonetheless. These bodies entering into one another's shadows are known as lunar and solar eclipses.

There are actually a few things that cause eclipses. Firstly, we can only see a lunar eclipse during a full moon and a solar eclipse during a new moon. This is due to the moon's location in proximity to the Earth; only at these times during the lunar cycle do the three heavenly bodies have the opportunity to perfectly line up. However, due to the 5 degree tip of the Earth's orbit, they do not always line up exactly. Secondly, it is important to understand the role of the penumbra and umbra. The penumbra is the lighter, outer shadow cast by the moon in partial solar eclipses, and by the Earth in penumbral lunar eclipses. The umbra is the very dark center of the shadow. The moon's shadow causes total solar eclipses, while the Earth's shadow causes both partial and total lunar eclipses. What is seen during an eclipse on Earth depends on the exact placement of the Sun, Earth, and moon. The lining up of these celestial spheres and casting of their shadows are key aspects in creating the various types of eclipses.

We may see a lunar eclipse during a full moon when the Earth moves between the Sun and the moon. As the moon orbits the Earth and the Earth orbits the Sun, the Earth may fall perfectly between the two. Access to sunlight is what allows the moon to shine, and as the Earth moves between the Sun and moon, sunlight is blocked from reaching the moon. We may see a total, partial or penumbral lunar eclipse lasting for only a few hours from any spot on Earth where the moon is visible.

Access to sunlight is what allows the moon to shine, and as the Earth moves between the Sun and moon, sunlight is blocked from reaching the moon.

Total lunar eclipses are much rarer, as they only occur when the Earth is exactly between the Sun and the moon. Here, the Earth blocks all of the Sun's light from reaching the moon, preventing its shine. Despite this, some of the light passes through the Earth's atmosphere and onto the moon. Through this, the blue light is filtered out, leaving only red light to shine onto the moon's surface. Alternately, a partial lunar eclipse occurs at least twice a year, when only part of the moon is behind Earth's shadow. The last form of a lunar eclipse, penumbral eclipses, is very hard to observe. Here, the outer shadow of the Earth falls onto the moon, producing a very slight dark shading on the face of the moon.

On the opposite side of the lunar cycle, a solar eclipse occurs when the moon is in between the Earth and the Sun. With the Sun shining directly on the moon, a shadow is produced from the moon onto the Earth, blocking the light from the Sun onto the Earth. Solar eclipses only occur during a new moon and, during one of these eclipses, special safety glasses are required to view it, as looking directly at the Sun is incredibly dangerous due to its immense brightness. Similar to lunar eclipses, there are total and partial solar eclipses, but there is also an annular solar eclipse.

Total solar eclipses are only visible to the small section of Earth that is in the center of the moon's shadow on the Earth when the Sun, the moon, and the Earth are in a direct line. From Earth, we see the sky darken and a ring of light surround a very dark circle, which is the moon. A partial solar eclipse occurs when the three bodies aren't perfectly lined up, so only part of the sun appears dark. Finally, an annular solar eclipse can be seen when the Earth is at its farthest point from the moon. The moon does not fully block the Sun, as it appears smaller due to its distance from Earth. Here, we see the moon as a dark circle in front of the Sun.

Luckily, we can look forward to some more eclipses this year. On July 2, a total solar eclipse will be most visible to people in the middle of the Southern Pacific Ocean, north of Easter Island. However, it will also be visible to people in central Chile and Argentina in the late afternoon. July 16 will have a partial lunar eclipse that is best visible to those in Europe, Africa, and before dawn in southern Asia and Australia. South America will be able to catch the tail end of the eclipse whereas North America is out of luck due to the timing. Finally, on December 26, an annular solar eclipse will grace the Eastern Hemisphere with its presence, beginning in Saudi Arabia and ending in Guam.

With some new eclipses on the horizon for 2019, and six waiting to dazzle in 2020, eclipses may seem like a once in a lifetime view, but they certainly are not. While lunar eclipses are much easier to see, solar eclipses look much more spectacular. Get yourself a nice chair to sit back, and grab a pair of solar eclipse-safe glasses or prepare to watch the moon turn red, because if you're lucky enough to see an eclipse, it will not disappoint. • • •

The Biochemistry of Luster Dust

To Eat or Not to Eat

Written by Emma Larson
Illustrated by Jack Bens

Of course on the day after Valentine's Day, I found myself eating chocolate. But not just any chocolate—a golden-glazed chocolate bar. As I gnawed on this "Golden Ticket," I wondered, "What exactly was I ingesting? Was the gold coating really edible? What was used to make it?"

Apparently, bakers have a variety of luminous products to create food art and shiny treats: luster dust, petal dust, pearl dust, sparkle dust, disco dust, twinkle dust, shimmer powder, and highlighter dust. All of these dusts have the same purpose but slightly different properties: some have more or less pigmentation, are matte or metallic, or have finer or bigger grains. Luster dust is an all-encompassing term for all of these products. Usually people add either dry, solid dusts onto food or dissolve their luster powder to make edible paint. For example, someone might throw dry luster dust onto a cupcake or into a glass of champagne to jazz things up. On the other hand, if someone was decorating an extra-special dessert for a wedding, they might prefer mixing luster dust with vodka or liqueurs to make gleaming paint for a silver-swirl design. Despite how widely used these glittery things are, we don't know much about the toxicity of their ingredients.

Saying that many inedible glitter and dust products—often labeled as "non-toxic" or "for decorative purposes only"—are advertised and marketed on the Internet, the Food and Drug Administration recently issued a warning about luster dust. The FDA cites the main ingredients of luster dust, which often include the color additive mica-based pearlescent pigment. This pigment puts the luster in luster dust.

Digging deeper into the regulations of the FDA and the biological effects of these "edible" compounds, we uncover some interesting information, or lack thereof. The FDA defines mica pearlescent pigments as compounds made from titanium dioxide, iron oxide, or a mixture of oxides deposited onto the mineral, mica. It clarifies that these pigments are developed by depositing titanium or iron salts from basic solutions onto mica, and then using calcination to form the titanium dioxides and iron oxides on the compound.

> Consider the mysterious side effects of biting into that golden chocolate bar or that cupcake with white frosting.

Titanium and iron salts, however, can be quite harmful to human health. For example, during the creation of titanium dioxide, titanium tetrachloride is combined with water to create the intended oxide as well as a powerful acid, hydrochloric acid. Though titanium tetrachloride and other salts break down very quickly and are unlikely to be dangerous to consumers, they may pose health risks to workers involved in pigment manufacturing. In a manufacturing setting, the most likely paths of exposure to titanium tetrachloride are respiration or physical contact with airborne particles. Because humans are essentially made up of water, titanium tetrachloride can react on our moist tissues or in our lungs. If we breathe or touch this compound, then we are effectively touching or inhaling hydrochloric acid. According to the Agency for Toxic Substances and Disease Registry, breathing in a large amount of titanium tetrachloride might be fatal, but even less severe exposure might lead to coughing, congestion, blindness, chemical bronchitis, or pneumonia. These symptoms are ultimately caused by chemical burns. While titanium and iron salts are more concerning to the health of manufacturers, if they were to sneak their way into luster dust products, then they may cause some negative health effects in consumers, depending on the amount of golden chocolate that we decide to eat.

Hopefully, pigment producers efficiently produce titanium dioxide and iron oxide without any remaining salts, though there is always human error. Even if effective production is the case, titanium dioxide and iron oxide may also be problematic for exposure or consumption. For example, titanium dioxide dust is also carcinogenic if inhaled, but again, this is more likely to be an occupational hazard. For oral ingestion, the size of the titanium dioxide particle is important; smaller particles cause more damage, while larger particles cause less damage. Research on animals reveals that the oral ingestion of titanium dioxide nanoparticles damages or inflames the liver and the kidneys. On a molecular level, titanium dioxide particles can disrupt the functions of proteins and enzymes which are essential to healthy cells. Depending on the type of cell, a titanium dioxide particle can even lead to cell death.

After considering the role of oxides and salts, we come to understand mica pearlescent pigments. Multiple layers of titanium dioxide, iron oxide, or both titanium and iron oxides are deposited onto mica to finally form the pigments. Different combinations and numbers of layers and various particle sizes produce the vast array of mica pearlescent pigments, which are used to color many things other than foods. The FDA approves the use of mica pearlescent pigments in cereals, confections and frostings, gelatin desserts, hard and soft candies, nutritional supplement tablets, gelatin capsules, chewing gum, cordials, liqueurs, malt beverages, wine coolers, and cocktail mixers. In addition, mica pearlescent pigments are found in contact lenses, paints, colored plastics, and mineral makeup. The sanctioned use of mica pearlescent pigments in so many materials shows how important it is to further investigate these particles.

Unfortunately, considering the pervasive consumption of these colorants, there is relatively little research about how the body metabolizes them. If a compound isn't stable or can be absorbed through the digestive system, then it might cause problems to an unknown extent. Mica pearlescent pigments are rather stable, but major questions remain: Can we absorb these chemicals through our digestive tracts? If so, how does our metabolism process them? Is it possible that small particles of the pigments can be absorbed, and that titanium oxides or iron oxides can slough off of the mica and into our systems? With so many questions left unanswered, consider the mysterious side effects of biting into that golden chocolate bar or that cupcake with the white frosting.

Lucid Dreaming

The Science of Achieving Awareness in Dreams

Written by Claire Sullivan Nave
Illustrated by Roger Ort

There is a 1 in 10 chance that you're in a dream right now. Let that sink in. Dreams can be bizarre and fantastic, but they can also be strikingly similar to reality. Telling the difference between the two is crucial to having one particular type of dream: lucid dreams in which the dreamer is aware that they're dreaming. Lucid dreams allow the dreamer to experience heightened vividness and reality, remember dreams better upon awakening, and even control them. According to researchers Schadlich and Erlacker, people use lucid dreaming for things as varied as changing a bad dream into a pleasant one, solving problems, getting creative insight, practicing skills, or simply having fun.

On average people spend about 7-9 hours sleeping, and 20–25 percent of that time is spent during rapid eye movement sleep in which dreams generally occur. Dreaming takes up around 10 percent of time outside of non-dreaming sleep—so there really is a 10 percent chance you're dreaming right now. Because of their potential for creativity, introspection, and exploration, lucid dreams are a great way to make use of your time.

Several studies have verified lucid dreaming as distinct from REM sleep. In a 2009 study, Voss and colleagues trained participants to become lucid and signal with eye movements in their sleep when lucidity occurred. The researchers compared brain activity of the participants while they were awake, in REM sleep, and experiencing lucidity, finding greater activity in the lucid state than the REM state for high frequency brain waves. High frequency brain waves are associated with learning, memory, and concentration. Interestingly, the differences in brain activity between REM and lucidity were particularly pronounced in the frontal and frontolateral areas of the brain, which control skills like problem solving and executive functioning. In another study examined in a 2017 review by Klara Ertl, researchers gave brain stimulation of high frequencies to frontotemporal areas. Participants then scored higher on a measure of lucidity than with other frequencies or placebo stimulation. This research indicates that lucidity is a real phenomenon—so how can people actually achieve lucid dreams?

Two habits fundamental to all lucid dreaming techniques are reality checks and dream journaling. Reality checks test if one is dreaming or awake by exploiting weaknesses in how the brain forms the dream environment. Good reality checks aren't prone to false positives or negatives, can be carried out before the dreamer loses focus, and are unobtrusive when performed in waking life. Jumping up to see if you float rather than fall may be reliable and fast, but it's far from inconspicuous! Common reality checks include reading text and glancing back to see if it's changed—oftentimes dreamed text will seem scrambled upon a second glance. Another method is counting fingers, as dream hands often have strange numbers of fingers. Reality checks must occur in the dream to actually induce lucidity, and performing them consistently in waking life will ensure they eventually occur in dreams. Another essential habit is keeping a dream journal. A common claim for people struggling to start lucid dreaming is that they simply don't dream much, but this is just a lack of recall. People generally dream several times a night, but according to one study by Nielsen in 2012, people only remember around a single dream per month. Though it's difficult to start a dream journal without remembering any dreams to begin with, just intending to write down dreams will help in remembering them. Good habits of reality checks and dream journaling are the foundation for more complex techniques.

There are many lucid dreaming techniques that have been verified by scientific research or published in guidebooks. A good place to start is Mnemonic Induction of Lucid Dreaming, which relies on prospective memory—the dreamer focuses on their intention to become lucid and repeats an affirmation like "I'm aware I'm dreaming," as they're falling asleep. Another option is WBTB, or Wake-Back-to-Bed, in which the dreamer gets up briefly in the middle of the night before returning to sleep. The theory is that activation of the frontal cortex is important in lucidity, so waking will activate that area and make lucidity easier. WBTB can be very reliable, but may cause problems for those who have trouble returning to sleep. Another method, Wake-Initiated Lucid Dream, is somewhat different—instead of facilitating awareness during the dream, WILD has the dreamer retain consciousness while falling asleep until entering a conscious dream.

There are many other methods, such as cycle adjustment, waking up later than usual to increase consciousness during that last part of sleep; hypnagogic imagery, paying attention to imagery experienced just before falling asleep; or even the eyelid method, focusing on little dots swirling on the eyelids and trying to make them form patterns or change color. It is unlikely that any of them will work on the first few nights though, so persistence is essential to growing a lucid dreaming ability.

Tibetan Buddhists have used dream yoga for centuries in the pursuit of self-transcendence. In the Tibetan yoga teachings of dreaming, lucidity is a powerful way to dispel the notion of reality being real. Lucid dreaming is inherently about testing the boundaries of what we really know—and as with all exploration, a mindset of patience, openness, and persistence is invaluable in moving toward new discoveries.

A College Student's Life Living From Nap to Nap

Sleep and the Formulation of Interfering Memories

Written by Elizabeth Toigo
Illustrated by Claire Kaliski

As college students, we specialize in a lot of areas: maintaining a social life, aiming high in academics, working, taking on leadership roles, and finding the best free food available on campus, to name a few. But sleep? I don't know her. Trying to balance all of my pressing priorities with sleep seems impossible. I constantly find myself living from nap to nap, always itching to get my next fix. When I return from a long day of classes, I look at my desk, I look at my bed, then back at my desk, then back at my bed, and I cave—every time. Usually, we students believe that we just need another cup of coffee, a quick power nap, or an AWAKE bar to get us right again after a long night in the stacks, no doubt working on a paper due for an 8 a.m., but might the long term effects of these habits affect us beyond the memes of college life? Can consistent nightly sleep rather than sleep deprivation actually improve our wellbeing as students? Well, research shows that sleep deprivation can indeed affect our memory, resulting in more inaccuracies, distortions and, potentially, false memories.

As many of us have probably experienced while trying to remember an answer on our physics finals, memories are not perfect replicas of past experiences, which means that remembering is prone to inaccuracies and distortions. These

> Although memory processing is important while awake, sleep has also proven to be critical in how memories are formed during off-line memory reprocessing

inaccuracies and distortions that lead to memory failure not only occur in the short-term, but also can be retained or enhanced over time. Although memory processing is important while awake, sleep has also proven to be critical in how memories form during off-line memory reprocessing, the default memory system that filters out unnecessary information and retains what is important.

Sleep plays an important role in consolidating memories, which could help to uncover how the memory system reshapes. In 2004, Wagner demonstrated that, when performing cognitive tasks, having eight hours of sleep provided greater comprehension of the task at hand compared to nocturnal wakefulness, or daytime wakefulness. Sleep seemingly restructured the memories of the cognitive tasks so that the most important information was retained, providing insight about how to perform those tasks. Next time you contemplate pulling an all-nighter for an upcoming biology exam, just remember that a full night's rest could actually provide key insights during the test! Don't believe me? Try it!

Furthermore, sleep may play a critical role in consolidating emotional memories. For instance, it was found in 2008 that in a sleep condition memories about important negative objects were preserved without the unnecessary background information, whereas time spent awake throughout the night led to forgetting of the entire negative memory. This

> Sleep deprivation is more than just the funny memes that you see on twitter

demonstrates that sleep consolidates memories by retaining the most critical information and disregarding the unnecessary noise, while nocturnal wakefulness results in less processing, and ultimately, random and unnecessary thoughts being remembered at the cost of important information.

According to Payne, in 2004 studies of episodic word-memory association, sleep (compared to nocturnal wakefulness) improved performance by increasing resistance to interfering information. Additionally, sleep contributed to the reorganization of episodic memories through off-line processes that stabilize memories by eliminating the unimportant information. Have you ever endured a restless night where you woke up from a total of 30 minutes of sleep before a big exam, only to take the test and feel bogged down by unhelpful facts? That may be due to your brain being susceptible to interfering information.

If you are sleep deprived as you are reading this, then I hope the one piece of information that actually remains accurate in your memory is this: Sleep deprivation is more than just the funny memes that you see on Twitter. While I used to be of the belief that naps can cure all ills, I have learned that maybe, just maybe, my mom might have been right about the importance of getting more than five hours of sleep each night. So the next time you find yourself procrastinating at 2 a.m. in the library, staying up late because you are just so close to beating your high score in 2048, or trying to decide whether or not to let Netflix autoplay that next episode of Breaking Bad, just remember how the lack of sleep could be affecting you in the long run. • • •

Dance and the Empathetic Mind

Written by Evelyn Morrison
Illustrated by Claire Hoy

If you look around a room of people, then it takes little time to identify those who are uncomfortable in the space and those who are at ease. Without speaking or engaging directly, these states are almost immediately identifiable based on the minute cues of facial expression and body language. Dance, the elevated form of everyday movement operates in much the same way—communicating moods and ideas through highly intentional movement and generating intense and visceral reactions to its content. Dance as a means of communicating, socializing, processing, and exploring has been persistent in civilization across time and space because it provokes in the observer the emotional narrative of the performer. By nature, dance requires close attention to bodies in space and a comprehension of their intention and meaning. What in the brain allows for this connection and understanding and what does it mean for the role of movement in the provocation of empathy?

A possible explanation of the neural underpinnings of empathy lies in mirror neurons. First discovered in Macaque monkeys, and later in humans, these cells comprise a network of neurons that activate in premotor and parietal areas when observing movement, emotion and sensation. Somatotopically organized, the system contains distinct regions corresponding to various body parts like the mouth, feet, and hands and is shown to play a role both in the imitation of simple movement and in learning complex movement without practice.

Research shows that watching someone move or be touched activates the same somatosensory areas in the observer as if the action had been executed on them thus unconsciously simulating the movement for the observer. In fact, the experience of observing and partaking is primarily differentiated only by the degree of activation. This phenomenon is seen in movement the observer can comprehend within the context of their own body; observing the path of a point on a screen, for example, does not elicit the same potentials because it does not closely resemble human movement and thus cannot be mapped onto somatosensory areas. This presents compelling evidence for a neurological base that allows individuals to live the experience of others through their own body.

Another interesting facet of mirror neurons is their role in understanding movement intention—determining the goal of an action and predicting subsequent actions. Compared to the observation of a movement or the movement's context in isolation, the pairing of these two increases premotor activation. This indicates an ability to recognize basic movement and understand the intention behind it—a process that is not facilitated by conscious intent but rather occurs by default. While further research is necessary, it can be theorized that, for basic movements, action prediction and understanding of intention are related processes underpinned by mirror neurons and embodied simulation of observed movement. This embodied simulation, however, is not limited to the internalization and comprehension of exterior movement, it is also key in interpreting and even adopting emotion. In actively watching an individual experience pain, the observer maps it somatotopically onto their own sensorimotor system and when observing a face expressing strong emotions like fear and joy, a rapid electromyographic response is propagated in corresponding facial muscles of the observer. In this way, the emotion state of the observed can be actively reconstructed in the observer.

The question then becomes, if the mirror neuron system is hardwired, what factors account for variation in the ability to empathize. Research done in individuals with autism, who struggle with understanding action intention and emotional expression presents a neurological difference. In some cases, there is a thinning of the gray matter in areas of the mirror neuron network, specifically the ventral premotor, posterior parietal, and superior temporal sulcus cortices. Furthermore, the degree of thinning corresponds with the autism spectrum disorder severity. While the application of the variation question in individuals without autism requires more research, developing theories suggest that factors such as environment influences during development, pre-existing schemas, mental attitudes, and conflicts can influence the ability to empathize with and understand others.

If mirror neurons are as important to the process of understanding through embodied simulation as this research suggests, then dance and movement are intimately related to the foundations of human empathy. As an art form centered on the creation of feeling both in participants and the observer, dance utilizes the ability to communicate nonverbally, to express and to understand emotion and intention, based on a system of neurons that allow for the sensory internalization of external movement. This ability, however, is as much innate as it is learned; which begs the question of how it can be developed through dance and utilized beyond it. This is a question that demands further research and a deeper understanding of mirror neurons. However, methods like Dance Movement Therapy which employ physical mirroring and movement have been successful at fostering empathy and communication. This offers the exciting possibility of applying neuroscience to dance in an attempt to better understand and improve the capacity for human empathy. • • •

Insect Allies

Genetically Modified Insects Could Be Farmers' New Best Friends

Written by Anthony Gao
Illustrated by Georgie Tisdale Steding

A vast expanse of corn slowly wilts in the intense summer heat. The area has been facing record temperatures for over a week, and the forecast shows no signs of it letting up. As the sun simmers on, a swarm of hungry insects suddenly descends upon the field. But these insects aren't there to finish off the corn. On the contrary, they were sent to save the crop by spreading specifically designed viruses with the ability to genetically modify the plants. While this may seem like science fiction, it may soon become a reality, depending on the success of a current research project funded by the Defense Advanced Research Projects Agency.

However, this "new reality" is not readily achievable due to the lack of acceptance and intense controversy currently surrounding genetically modified crops. Supporters argue that genetically modified organisms are the only way we can feed the world's fast-growing population: Genetic modification allows scientists to create crops that are both more nutritious and more efficient, producing higher yields while requiring fewer resources. Opponents claim GMO consumption could potentially cause unknown long-term health effects and that genes granting durability could transfer from these crops to less desirable plants. With the development of new GMO technologies and increasing amount of evidence that they are safe for consumption, society has slowly started to embrace GMOs as a safe and efficient alternative to traditionally grown crops, but many have not yet come to accept the technology.

GMO seeds do have one major weakness: they cannot adapt to new dangers after a crop has already been planted. Say a new infection suddenly spreads through a population of plants or drought suddenly hits an area where the crops haven't been modified for drought tolerance. Most of the season's harvest would quickly be wiped out, devastating the livelihoods of farmers, and there isn't much that could be done to save the crop. To solve this problem, scientists from the Defense Advanced Research Projects Agency proposed a project involving the development of insects carrying genetically modified viruses.

The project, officially named Insect Allies, was announced in late 2016 and is expected to be finished by 2021. Insect Allies takes advantage of the natural ability of insects to transfer viruses into plant tissue, which in turn are able to quickly alter the plant's genotype. As an added benefit, insects are usually confined to a specific target plant, preventing undesired modification of other plants. While it may seem like a troubling and unsafe proposition (since the viruses or insects could mutate), the project requires several safeguards to be built in before being considered successful. The viruses, for example, must be edited for stability, showing no significant genetic loss after two weeks. In addition, the insects are required to contain three kill-switches (such as sensitivity to time, light, heat, or diet) so that none of a test group survives after a period of time where at least 50 percent of unmodified insects would still be alive. The research groups have also considered genetically modifying crops such that only targeted plants can receive the virus, reducing the impact if the virus is found to adversely affect the plant.

Despite the safeguards put in place, there are still concerns about the safety of Insect Allies. A group of European scientists and lawyers published an article in Science from October of 2018 criticizing the lack of foresight and public discussion about the project. Firstly, they argue that the project is futile: no one can predict the problems that will arise, and during an actual crisis it would take too long to develop an effective virus. Also, insects could easily travel to nearby farms and potentially violate another farmer's choice to grow organic crops. Most importantly, however, the project's techniques could be used to develop bioweapons in the form of insects carrying harmful viruses meant to damage another country's agriculture. In fact, it's significantly easier for the system to harm plants than it is to save them—a plant could be killed by simply knocking out any vital gene, whereas a productive change would require inserting specially tailored genes at specific locations. As a result, the researchers would develop the technology to create bioweapons well before being able to use it for protection, raising concerns in the international community.

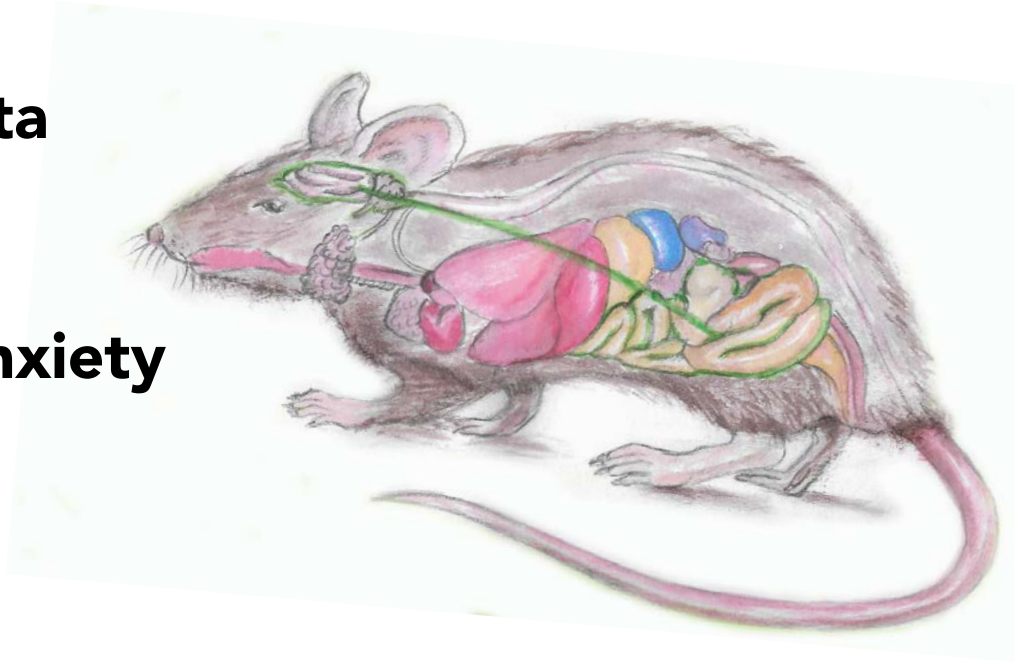
The agency defends the project on the basis of its immense potential: If Insect Allies is successful, then the technology behind it would result in a massive leap forward in food security. The critics offer a less risky alternative of spreading viruses through aerosol, but that would require significant infrastructure and wouldn't infect plants as efficiently as insects with the natural ability to carry the virus to its target tissue. As an example of a potential application for the project, communities around Africa are currently experiencing infestations of fall armyworm that quickly spread across the continent months after being accidentally introduced in 2016. If Insect Allies had already existed, the agency asserts that it could've efficiently and inexpensively conferred resistance to crops, saving thousands of farmers from crisis.

But is it really worth the risk of insects or viruses going rogue? Should we really be using armies of insects to modify crops in a world that still hasn't come to accept gene editing? Is it worth developing this beneficial program if the methods could easily be taken and used by other groups for nefarious purposes? Only time will tell, and the time is coming soon. • • •

Low Gut Microbiota Levels Affect the Development of Depression and Anxiety

Lactobacillus Levels Connect to Improvements in Mental Health

Written by Cameron Moss
Illustrated by Emma Larson



Depression affects about 7 percent of the population, and several hypotheses have been proposed to explain what may cause it. Depression has been directly connected to genetic polymorphisms, monoamine deficiency, stress response dysregulation, neuronal plasticity deficits, and inflammation, but none of those can account for all cases of depression. In order to further explore the possible link between gut microbiota and depression, one research team decided to see if people living in a "shared environment," or having a shared microbiota composition, also had similar vulnerability to developing depression and other mental illnesses. The team discovered a new factor that might be involved in the development of health problems and how those issues could improve or worsen with certain types of medicines.

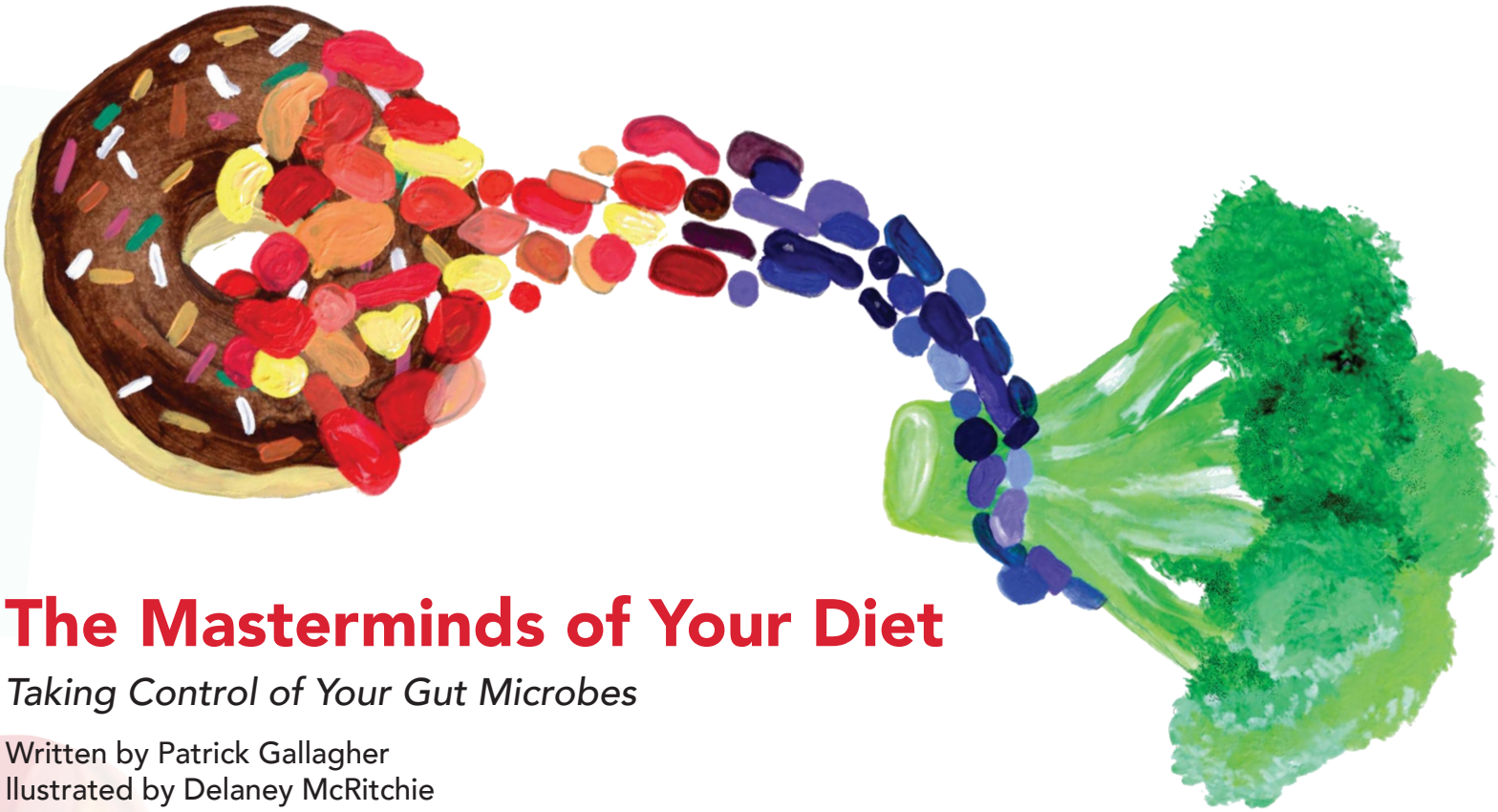
The gut microbiome is known to affect many aspects of health, but its connection to mental health has never been established empirically. In 2017, Marin and colleagues invented a system to model how gut bacteria in mice play a role in causing anxiety and depression-like behaviors. The team discovered that a lower presence of two different types of bacteria influences the development of certain behaviors. More specifically, Lactobacillus levels in mice influence the behavioral abnormalities and despair behavior that the mice demonstrate. However, when the level of Lactobacillus was restored, the mice's metabolic alterations and behavioral abnormalities showed significant improvement.

Marin and others combined behavioral, molecular, and computational techniques to test the role of the microbiota in mediating despair behavior. The mice displaying despair behavior had an altered microbiota composition, specifically carrying less Lactobacillus in the gut. Scientists also found an increase in circulating kynurenine, a metabolite that is often measured as higher in patients with depression, in the stressed mice relative to the control group. They then identified a Lactobacillus-derived, reactive oxygen species that may suppress host kynurenine metabolism by inhibiting the IDO1-enzyme expression in the intestine. Results showed that the administration of Lactobacillus to stressed mice led to improved metabolic homeostasis and stopped the demonstrated despair behavior. The gut-microbiome environment is likely to play an important role in the development of depression and anxiety for some species, even though they have varied microbiota environments.

> The mice displaying despair behavior had an altered microbiota composition, specifically carrying less Lactobacillus in the gut.

The research on the gut microbiome did not stop in 2017. A study published in 2019 highlighted an unusual increase in the stress hormone corticosterone in young mice with normal gut microbiomes that had previously been subjected to early-in-life stressors. The results of this study indicated that the bacteria in the environment are contributing to behaviors associated with anxiety and depression. However, both of the studies involved only mice; researchers did not perform any further tests to compare the microbiota levels in people who suffer from depression and anxiety versus those who do not. Therefore, much more work has to be done before we can draw the parallel conclusion between depression development in mice and in humans.

The 2017 research team's data provides a mechanistic scenario of how a microbiota player (specifically Lactobacillus in their research) may contribute to regulating metabolism and resilience during stress. These results inspired a new and more effective pharmacology approach for people struggling with depression and anxiety. Instead of relying on drugs that may be too strong, may not work for everyone, or could have negative side effects on the patient, a new method focusing on patient's gut microbiota composition could be more beneficial and less costly. Most Americans believe that prescription drug prices are unreasonable and can contribute to a lot of financial stress on families. It would be a relief for patients who struggle to afford their medicine to have another option which is likely much more affordable and could target one's diet rather than manipulating the process of signal transduction in the central nervous system. Given that a lot of frequently prescribed drugs are still mysterious to medical professionals, it might be wise for patients suffering from depression to consider other treatment options, once they become available. The research done in 2017 and 2019 not only laid the foundation for scientists to further explore the connection between gut microbiota and depression but potentially opened up a whole new branch of medicine. • • •



The Masterminds of Your Diet

Taking Control of Your Gut Microbes

Written by Patrick Gallagher
Illustrated by Delaney McRitchie

Your gut bacteria may be craving chocolate—not your brain! A compilation of recent scientific studies suggests that the bacteria living inside your gastrointestinal tract communicate with your brain, influencing when, what, and how much you eat. We've known for many years that the microbes in your digestive track play an important role in breaking down the foods you eat, ensuring the body can absorb the nutrients necessary for life. Now we are learning they do much, much more.

Fruit flies placed on a special diet lacking a single, essential amino acid will eat food containing the missing amino acid when given the choice between a variety of foods. How does this happen? Gut microbes synthesize many important compounds such as vitamin K, B vitamins, short-chain fatty acids, and a number of proteins. These compounds have a number of different effects, acting on the many cell types present in your gut. For example, some compounds act on neurons in the gut that then send signals to the brain. These signals then influence your behavior. This is known as the microbiome-gut-brain axis. In this axis, your gut bacteria release signals, similar to hormones, that travel to your brain via the long vagus nerve to tell your brain when to start or stop eating or what foods to eat.

In the fruit flies on the special diet lacking an essential amino acid, removal of specific gut bacteria eliminated the preference for the diet containing the critical amino acid, showing the importance of the microbiome in the axis. In a separate study, when a specific bacteria was present in the gut of mice, they exhibited fewer symptoms of anxiety and depression compared to control mice. These behaviors were dependent on an intact vagus nerve, demonstrating the microbiome-gut-brain axis was responsible for the "mellow" behaviors.

Sometimes gut microbes don't always send the healthiest signals to our brains. Mice fed a high sugar, high fat diet developed obesity, prediabetes, and heart disease. Gut bacteria from these obese mice were transplanted into germ free, lean mice. These mice developed obesity, prediabetes and heart disease just like the obese mice, clearly demonstrating the importance of gut microbes. Thus some microbes may even signal you to eat more chocolate or foods high in sugar and animal fat! Different things we do, like eating specific diets or taking antibiotics or other medicines can lead to selection for some types of gut bacteria. When you eat chocolate cake and other foods high in sugar and fat, specific populations of gut microbes thrive, growing out of proportion to other gut microbes. Then, these selected populations of gut microbes send signals to the brain that get translated as "happy feelings." This causes you to crave more unhealthy food.

Several studies in humans have shown healthy diets encourage growth of populations of "good" microbes in your gut.

Your diet strongly influences your gut microbes. Several studies in humans have shown healthy diets encourage growth of populations of "good" microbes in your gut. Can we make ourselves more healthy by controlling our gut microbiomes? Scientists are working to determine what are the best foods you should eat to encourage a "good" microbiome. They are also studying to see if swallowing supplements containing gut bacteria, called probiotics, will be beneficial for our health. So, while we wait for the scientists to give us the answers, what can we do to rule over the microbes in our gut and control unwanted microbial-driven cravings for sweet, fatty unhealthy foods? One, eat a healthy diet. Two, avoid high sugar, high fat foods that encourage the growth of "offending" populations of microbes. Three, consider taking a probiotic every day. Your gut will thank you for it. • • •

Unwinding the Web

The Mathematical Basis of the Spider Web

Written by Victoria Fisher
Illustrated by Delaney McRitchie *(Top)* and Claire Segura *(Right)*

Imagine you are walking through a dewy forest one morning. As you pass below the trees you suddenly crash into a spider web, which is perched between two branches. Many of us would scream for fear that one of those small, scary arachnids would end up in our hair, on our clothes, or elsewhere on our bodies. For us, this may be a frightening experience, but for the spider, they may have just lost their home or hunting grounds, an integral component to their existence. While most spiders build webs, the styles and structures of the webs are as diverse as spiders themselves. There are over 45 thousand different species!

The many unique web types are all developed with specific uses in mind. Take, for instance, the "triangle web," which is created by spiders who do not release venom. This web is a horizontal triangle made with fuzzy silk, that spiders can catch and smother their prey on. Another type of web that you may have found in your home is the "tangled web." This is a three dimensional and messy web used to trap the spider's prey. While the webs typically found in homes are created by only one or a few spiders, up to thousands of spiders will work together to create a massive multilayered net—like we see in the scene with Aragog from Harry Potter and the Chamber of Secrets. However, some webs are not used for catching prey at all. Consider the "funnel web," which, as the name describes, is a large funnel of different silk threads. These can be used to store

eggs, to hide from predators, or as homes for males as they wait to mate with a female.

The "orb-style" web is the most familiar structure, as it is one of the most common types of webs for spiders in North America. The orb-style web is a flat, two-dimensional net that has been the focus of computational and mathematical research in webs. They are made out of very strong silk produced by glands in spiders' abdomens. While spiders vary in the exact types of silk they make, the proteins that make up the silk contain three different substances: pyrolidin, potassium hydrogen phosphate, and potassium nitrate. These strengthen the silk against environmental stressors such as changes in pH, bacteria and fungal growth, and changes in humidity. They help create a very strong and elastic material that maintains the structure and formation of the web, even when it is stretched by 30–40 percent.

When a spider begins creating an orb web, it will place itself on a secure surface, such as a tree branch or beam. The spider will place what is called attachment silk, which is made in the pyriform glands, on this surface. The spider will then wait for a gust of wind to blow it across to another secure platform where it will attach this first strand. However, before the flight, it must first calculate precisely how far it will have to move so that it can create the appropriate amount of silk. Assuming the strand it has produced is satisfactory, the spider will then carefully walk back and forth along this tightrope-like line, adding more silk to strengthen the thread. The spider creates an additional strand that is centered on and perpendicular to the initial threads, making a Y formation. The spider produces seventeen more radii, which connect to the center of Y, but it will only use seven to create the final structure.

The next step for the spider is to create a logarithmic spiral, which is defined by the following equation:

$$r = ab^{e\theta}$$

A and b are arbitrary variables and theta is the angle from the origin or center. A logarithmic spiral is sometimes referred to as the golden spiral, given its relationship to Fibonacci numbers and the golden ratio. A logarithmic spiral is formed by drawing segments between equally spaced rays, where the segment is perpendicular to the ray to which it is connected. The logarithmic spiral is created by the spider starting from the center of all the radii and then proceeding outward. With only seven different strands, the spiral will grow rapidly, forming large gaps in the web, making it very ineffective at catching prey. Thus, the spider uses a non-sticky kind of silk called "walking thread," which is produced by the major and minor ampulleceae glands; the minor type produces silk that is only half as thick and strong as the major gland. Since the silk used is not sticky and the spiral creates large gaps in the web, this spiral will not be present in the final shape. However, the logarithmic spiral provides a baseline shape for the spider to follow to complete its web.

The next (and final) step for the development of the orb-style web is the creation of an arithmetic spiral. The arithmetic spiral is defined by the equation:

$$r = a\theta^{1/n}$$

A is an arbitrary variable, theta is the angle from the origin or center, and n is the factor that determines how tightly the spiral (or web) is bound. The arithmetic spiral is much tighter than the previous logarithmic structure, and it forms the shape typically seen in a spider's web. In order to help form this spiral, the spider follows the line of the logarithmic spiral, eating the walking thread as it goes along. However, the spider must also calculate precise curvature needed for the new spiral, which requires a much more complicated formula:

$$\text{arc curvature} = \frac{|n|\theta^{1-1/n}(1+n+n^2\theta^2)}{a(1+n^2+\theta^2)^{3/2}}$$

This process is entirely automatic in the spider, demonstrating just how impressive their innate skills are.

As the spider makes the new spiral, it deposits adhesive droplets along the silk. The adhesive proteins are created by the aggregate gland, while the silk itself is made by the flagelliform glands. These droplets are necessary to give the silk its sticky texture so that unsuspecting insects are trapped when they come into contact with the web. The web is also very difficult to see. The silk is very thin with a diameter of around 0.15 millimeters, further, the precision with which the spider creates the arithmetic spiral causes the web to be near invisible. In fact, in its initial state, the web is imperceivable to the human eye. However, if light is reflected off the web at a specific angle or water droplets fall on the strands, altering their orientation and shape, the web may become visible.

The creation of a web is a very intricate and resource heavy process for these tiny creatures. Even after the spider has created one web, it will begin this sequence all over again the following day or night, as the web is rendered unusable within a day of its creation. While some spiders will recycle the proteins needed for the web by consuming the old one, you can imagine much of the spider's energy goes into creating all the materials for these massive and sticky nets. The spider must also take into account different environmental factors such as weather and prey type. This results in each spider having a highly specialized method for creating their webs and capturing their prey. So, next time we take a walk through the woods, we should be careful where we step—we might save one of these mathematical wonders. • • •

"The Pill" Problem

Unspoken Dangers of Hormonal Birth Control

Written by Anna Harrison
Illustrated by Maria Altier

"The pill," or female hormonal birth control, has had tremendous socio-economic benefits. It drove the women's rights movement forward and stimulated conversations about the role of women in society. However, very little attention has been given to the shortcomings of this miracle pill, the dangers of how it is prescribed and its harmful side effects. Nor are patients fully informed about the mechanisms by which the pill functions.

In the United States, 100 million women take oral hormonal birth control. However, in 60 percent of cases, the pill is prescribed for non-contraceptive reasons. While the pill does alleviate symptoms for a variety of health conditions caused by hormones, it does not actually address the cause of these symptoms and treat the underlying condition.

As women's health specialist Dr. Jolene Brighton asks, "Would you take Advil every day for a splinter, or remove it?" Women are often prescribed this pill as a quick and convenient solution to their health concerns. They receive little explanation on what it is, how it works, or how it will fail to treat their underlying condition. This blatant neglect of a woman's health often leads to more serious medical issues, especially when she stops taking the pill.

The pill itself has dangerous side effects. These include headaches, fatigue, thyroid complications, and adrenal dysfunction, digestive issues, hair loss, depression, and even low libido. The list of risks also encompasses increased rates of infertility, stroke, breast, cervical and liver cancer, diabetes, heart attack, and autoimmune diseases. But even once the pill is stopped, women are often left with terrible mood swings, adult acne, fatigue, abnormal periods, and headaches.

Should a pill with such serious side effects really be prescribed as a quick fix for something like migraines, cramps, or acne? No. Especially not when these symptoms arise from other treatable conditions.

Women have complained about such issues since hormonal birth control was introduced in the 1960s. Yet, almost sixty years later, it is still the most commonly used form of contraception. Little research has been done to understand and reduce side effects. Nor have convenient alternatives been readily discussed with patients.
To understand how hormonal oral contraceptives cause these issues, we'll have to explain something that few doctors do: how birth control actually works.

The most common form of "the pill" contains two hormones: progestin (lab-synthesized progesterone) and estrogen. These two chemicals have profound impacts on the intricate feedback loops throughout the entire endocrine system.

The two phases of the menstrual cycle naturally include fourteen days of elevated levels of estrogen and fourteen days of elevated progesterone levels. The window of fertility occurs when sperm and egg can meet in the uterus for just five days in the middle of the cycle. This is because sperm can survive for three to five days in the uterus, although during ovulation the egg survives for only 24 hours after its release into the endometrium, or the lining of the uterus. Rising levels of estrogen and dropping levels of progesterone cause two other hormone levels to increase: luteinizing hormone and follicle stimulating hormone. These hormones cause ovulation.

Delivering high levels of estrogen and progestin via the pill for the entire month, except for a week in which a harmless placebo pill is administered, suppresses the pituitary gland from releasing follicle stimulating hormone and luteinizing hormone. Without those increased doses, ovulation doesn't occur. Periods continue with increased regularity because of "placebo pill" that doesn't contain any hormones. Hormone levels drop dramatically and induce the shedding of the endometrium. Essentially, the pill facilitates the suppression and replacement of the entire normal hormonal cycle.

In the US, 100 million women take oral hormonal birth control In 60 percent of cases, the pill is prescribed for non-contraceptive reasons.

Through mechanisms that remain poorly understood, the pill has been shown to trigger inflammation. One hypothesis is that the continuous delivery of abnormally high levels of hormones disrupts the endocrine-immune interaction and causes inflammation. Another suggested mechanism is that the alternation of intestinal microflora is caused by taking the pill and gastrointestinal diseases.

C-reactive proteins are made by the liver in response to acute inflammation, specifically macrophage and T-cell activation. Elevated CRP is directly linked to increased risk for cardiovascular disease, thyroid disease, and autoimmune disease. The pill, which 98 percent of sexually active women in the United States have taken, directly causes CRP levels to increase, according to studies published in Mediators of Inflammation, Obstetrics and Gynecology, and Human Reproduction. It is no wonder that women are at such a great risk for these diseases.

Ultimately, birth control is a tremendously important feature of health care. But as the sixtieth anniversary of "the pill" approaches, we must take a hard look at the issues that arise from hormonal birth control. It is time to educate young female patients and their doctors about what birth control really does to a female body. It is time to expand hormonal birth control research and availability of its alternative methods, and address the underlying causes of symptoms that the pill is prescribed to mask. • • •

Adderall

Use and Abuse of Study Drugs on College Campuses

Written by Angel Ehrenschwender
Illustrated by Barlow Wagner

Since the popularization of amphetamines as weight loss pills, nasal decongestants, and depression medications between 1930 and 1970, amphetamines have taken a hold of our society and have not loosened their grip. In the Netflix documentary Take Your Pills, researchers investigate how these same chemical compounds are being prescribed to the next generation ready to get its fix. Adderall, Ritalin, and other prescription stimulants are prescribed to individuals who suffer from Attention Deficit Disorder or Attention Deficit Hyperactivity Disorder, often at a young age, but use of this drug has moved beyond treatment of this disorder. Despite the classification of amphetamines as a Schedule II stimulant, their consumption in America today has surpassed that of the 1960s.

Becoming increasingly recognized as "study drugs," prescriptions such as Adderall or Ritalin increase attention and allow users to focus in on a single task by eliminating distractions and encouraging efficient and productive brain functioning. They also cause alertness, often keeping users awake by increasing heart rate and blood pressure. While these drugs are often helpful and effective in treating ADD, their use has taken a recent turn. Used more and more commonly among college students without a prescription to stay up all night and cram for a test or to finish an assignment, their abuse in higher education has run rampant and has become a focal point of stimulant drug use. Recognized for their ability to induce cognitive enhancement, these drugs, obtained illegally and often mixed with other drugs to produce dangerous effects, have become all too prevalent on college campuses. Having grown accustomed to this culture, one student from the documentary remarked that she "forgets that it is illegal" to sell her prescription pills to others, though it is considered a felony in the United States. Another student equated amphetamine consumption to eating a good breakfast or drinking a cup of coffee in the morning, not recognizing that the potential health and criminal consequences could be detrimental.

In addition to use in the classroom, these same study drugs have permeated into sports culture as well as the workforce after graduation. Although most widely recognized for their effects on attention, they also boast the ability to reduce pain and speed up reaction time, which could give athletes an advantage in competitions. Used by athletes such as Olympic gold medalists Michael Phelps and Simone Biles, as well as CEOs and white-collar workers trying to get ahead, the abuse of stimulant drugs has no clear end. In our hypercompetitive world, individuals are turning to a bottle of pills to supply the edge necessary to succeed.

The culture of study drug usage and cognitive enhancement centers around widespread disillusion in the higher education system. In Take Your Pills, several students and athletes comment on the developing obsession to get ahead, setting the curve. The pressure to perform in the classroom and on the field has driven many to great lengths and in this case, beyond legal limits. However, when a student is conditioned to find their value and worth in the letter written on the top of a test, they will do almost anything. This unhealthy cycle of competition and drug abuse ultimately spurs increasing and overt drug abuse among college students.

In a generation of instantaneous information coming from every direction, we are willing to do anything for a quick fix. If a student needs to study all night, then they just "pop an addy." But, at what cost? Chronic users in the documentary commented on anxiety, nausea, headaches and a general feeling of "not being yourself." Are we willing to sacrifice who we are for a grade? These drugs are being prescribed at earlier and earlier ages despite minimal studies concerning the long-term neurological and physiological effects of chronic use. When prescribing any drug prior to complete brain development, we must recognize this potential risk. This uncertainty is disregarded, however, as Adderall and Ritalin are still prescribed at an astonishingly high rate in the United States. The drug companies, working to make millions off of the American consumer, have created a culture of prescribing to "cure" in doctors' offices. The result is over prescribing to an already overmedicated generation of young people.

While the medical system is partially at fault, responsibility also falls on the culture surrounding higher education. Colleges broadcast lower and lower acceptance rates, and then push students to perform well in and out of the classroom once they step on campus. All of this, however, is necessary to get the best job with the highest pay, or move on to the most prestigious graduate school programs. But how many could credit a portion of their success to a small blue or orange pill? And at what cost? Is this pill enhancing who we are, or forcing us to be something we are not?

Something has to interrupt this never-ending cycle. Medically, prescription of these drugs has to be regarded as a possible remedy rather than the "cure all" that it has become. In addition, leaders in higher education have to recognize the consequences of the culture they have cultivated on college campuses and work toward healthy change. And finally, students have to understand the incredible risk and responsibility associated with every pill that they take. Ultimately, the decision to take these drugs is ours. In breaking the addiction, whether it be to the pill itself or the grade associated with it, we gain freedom to be ourselves. • • •


G453

Foldascope

Written by Ashley Xu
Illustrated by Aria Berryman

When you think of a microscope, do you think of a bulky, fragile piece of equipment worth hundreds, maybe even thousands of dollars? I bet you're definitely not imagining an item you would purchase for casual everyday use, let alone imagining a paper-thin, bookmark-sized object you could fit in your pocket. Well, you thought wrong! The Foldscope is a portable microscope that can be assembled simply by folding a standard-sized sheet of plastic-coated paper with a lens printed directly into it. Now, what if I told you that this über-portable microscope is also ultra-affordable, costing almost nothing to create? What if I also told you this microscope could withstand being stomped on, doused in water, and dropped from a five-story building, and still come out unscathed and completely functional?

The scientific microscope dates back to the seventeenth century, when Antonie van Leeuwenhoek (1632-1723) invented the first microscope, a small handheld device held close to the eye, created using two pieces of metal and a small spherical lens. Leeuwenhoek was no scientist—he was a Dutch textile merchant—but he had an insatiable curiosity and desire to learn about the world around him. As a result of his own experimentation, he created a microscope and was the first person to view single-celled organisms, opening up a whole new world of knowledge and leaving an indelible mark on modern science. His microscope eventually evolved into the large clunky microscopes typically used in U.S. schools, but the Foldscope is probably more similar to the first microscope.

The Foldscope, an optical microscope costing less than $1

USD to manufacture, is assembled from one standard sheet of paper and a 2.38 millimeter glass lens that is printed into the paper. With an imaging resolution of two microns and a magnification range of 140-2000 times, the Foldscope allows users to view microscopic specimens like red blood cells and live bacteria. The Foldscope accommodates a standard-sized glass microscope slide and requires only natural light to operate, but a light source can easily be attached using a simple LED light and watch battery. Findings can even be projected onto a screen or wall using a light source. The parts of the Foldscope are color-coded, to be punched out of paper and folded, assembled like origami in just several minutes. The origami assembly allows for precise alignment of each part, and the instructions are text-free and diagram-based, allowing anyone, anywhere in the world to put it together easily. A fully-assembled Foldscope is about the size of a bookmark and weighs under 10 grams, which is about the weight of two nickels!

To use a Foldscope, one simply places a sample on a microscope slide, inserts the slide in front of the lens, and then raises the Foldscope to one eye so that it almost touches the eyebrow. To adjust the viewing field, users pull tabs on the side of the Foldscope to slide the lens to different locations over the microscope slide. To focus an image, users flex and bend the paper Foldscope to adjust the distance between the slide and the lens, until the image becomes clear. The fantastic optical physics of small spherical lenses allow for the high resolution and magnification exhibited by the Foldscope.

The Foldscope was developed by Manu Prakash, an assistant professor of bioengineering at the Stanford School of Medicine, and co-inventor Jim Cybulski, a Ph.D. student in Prakash's lab at the time. Prakash was first inspired to create the Foldscope in 2011 when he was traveling in Thailand. He noticed that many field stations and remote clinics had state-of-the-art microscopes on hand. However, most people were too afraid to use these microscopes because they were anxious about possibly breaking such expensive pieces of equipment, so the microscopes often ended up under lock-and-key, almost never to be used. Prakash's observation of these clinics in Thailand was in no way unique.

Around the world, millions of people living in parts of Africa, Asia, and Latin America are plagued by infectious diseases and a lack of resources to identify and treat them. Doctors require microscopes to diagnose their patients, and most of these poor, remote regions do not have access to the necessary technology, leading to people being misdiagnosed or left untreated. Even in places that do have microscopes, parts often break or have mold grow over the lenses in humid climates, rendering the machines unusable. Without the money and knowledge to properly maintain microscopes, clinics are left powerless and ineffective.

After his trip to Thailand, Prakash was determined to find a way to develop a cheap and durable alternative to the traditional microscope that could easily be carried and used in field conditions. In 2012, the first prototypes of the Foldscope were developed and refined by Prakash and his team of researchers at Stanford. In 2012, Manu Prakash gave a presentation at TEDGlobal, bringing the Foldscope to the world's attention, and that same year, the Bill and Melinda Gates Foundation provided them with a $100,000 grant to field test the Foldscope in India, Thailand, and Uganda. In 2014, Prakash and Cybulski published a paper detailing how to build and assemble a Foldscope as well as the Foldscope's full range of capabilities.

The Gordon and Betty Moore Foundation supported Prakash and his team in distributing upwards of 60,000 Foldscopes in over 135 countries in 2014. These Foldscopes were distributed by volunteers at no cost to the recipients. All that was asked of recipients was that they share the findings made with their Foldscopes to on an online community called the Microcosmos, aptly named for the infinitesimal world, or micro cosmos, that microscopes open up to the human eye. Camera phones are compatible with Foldscopes by holding the camera up to the microscope's lens to easily record videos or take photos. Users were encouraged to document their findings on the Microcosmos website, where anyone can see Foldscope pictures from users all around the world. The site features everything from a 5-year-old's look at E. coli in a household kitchen in the U.S. to a doctor's view of a patient's malaria-infected red blood cells in Africa to a teenager's observation of tardigrades in a backyard in India. In December 2015, Manu Prakash and Jim Cybulski founded Foldscope Instruments, Inc., a for-profit business, with a nonprofit subsidiary dedicated to subsidizing costs for sending Foldscopes to resource-

> It is up to artists, archaeologists, and preservationists not only to uncover and guard artistic heritage but also to shed light on and be conscious of art's environmental issues.

poor communities all around the world. Today, Foldscopes are widely available online.

The Foldscope has revolutionized the approach to treating diseases in poor countries. It currently comes in twelve medical diagnostic variants, each designed to identify a specific disease-causing organism. Using this small microscope, scientists and health workers can identify the parasites that cause malaria, African sleeping sickness, black fever, and various other tropical diseases. Foldscopes are extraordinarily versatile and can be adapted for various different uses, such as bright-field, dark-field, fluorescence, and projection microscopy. Special LED lights, multiple lenses, and filters can all be added to the Foldscope to aid in the identification of specific organisms.

Prakash aims to put microscopes in the hands of everyday people with no extensive backgrounds in science—people like Leeuwenhoek—from young children to adults, to see what curious minds can discover about the natural world. Prakash is interested in biomimicry, which is the design and modeling of technological systems based off of natural biological processes in the world around us. Through encouraging all Foldscope users to post their discoveries on the Microcosmos online community, Prakash has made the entire world his laboratory, with everyday laymen as his researchers, in the hopes that new discoveries will be made toward better understanding how and why certain organisms behave the way they do and leveraging this knowledge to potentially create more efficient and effective tools. Foldscopes have left their mark on science education in developing countries. Their inexpensive nature allows them to be widely distributed to everyone from young children to university students in countries that would otherwise never have the financial resources to provide expensive traditional microscopes to every school, let alone every student. Prakash's biggest goal in making the Foldscope is to make people curious, with the hope that one day, every child can carry a microscope in their pocket.

As of October 2018, there are now over half a million Foldscopes distributed all around the world, and they are in use in over 140 countries.

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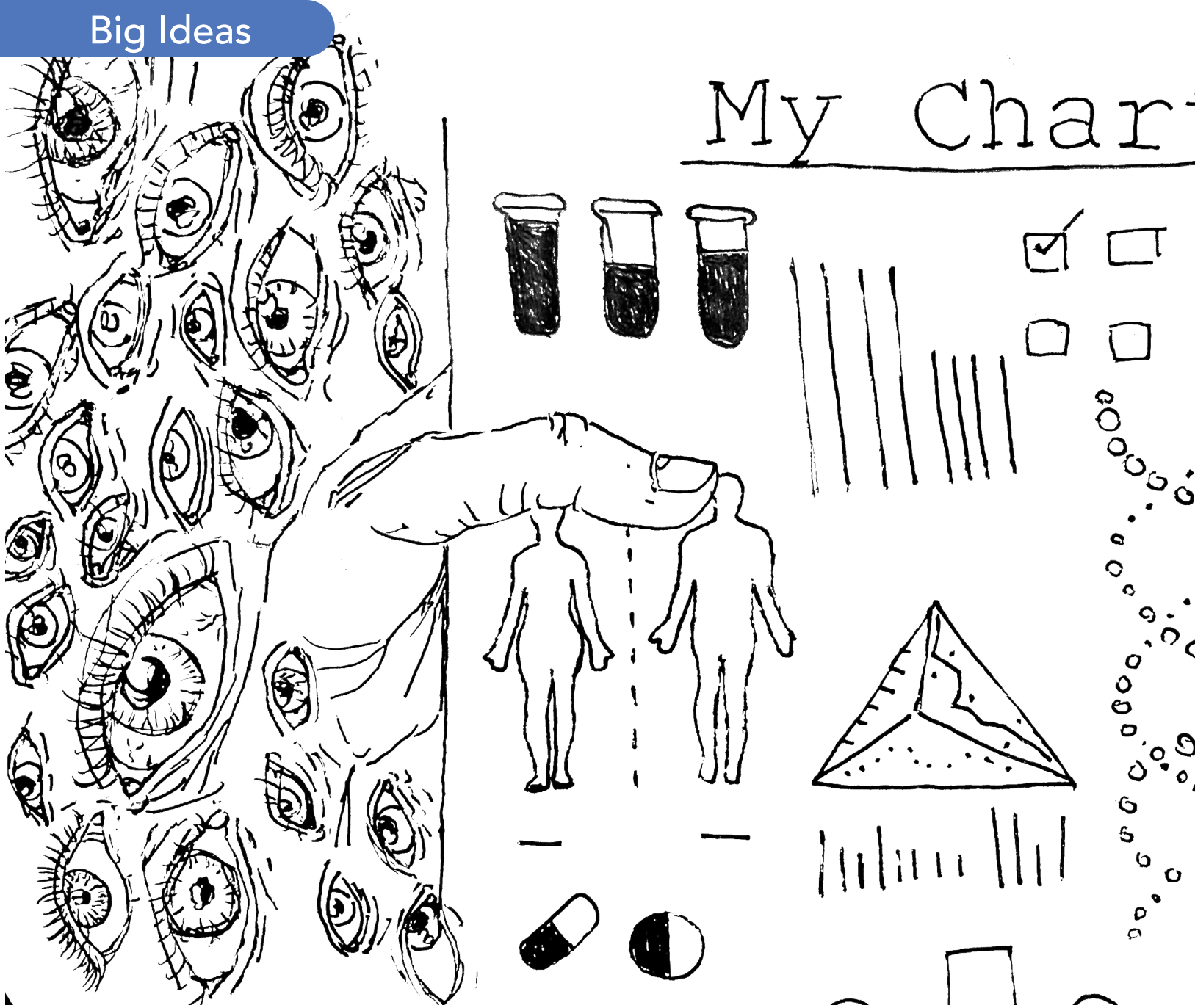


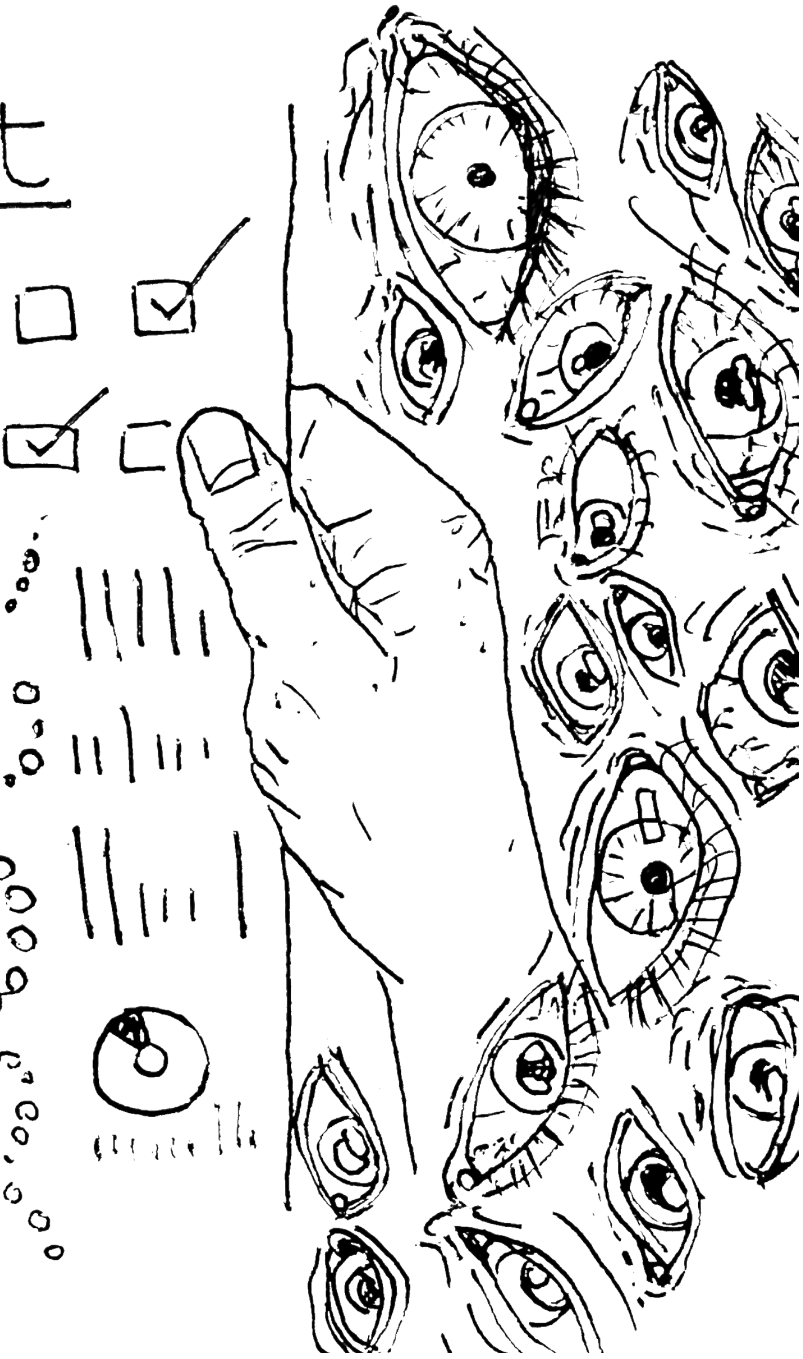
Electronic Health Records

Improved Healthcare is in Our Hands

Written by Veronika Danchine
Illustrated by Katherine Lindsay

Today, 96 percent of hospitals are using electronic health records. These health records provide a clear platform for important information to be relayed to patients from practitioners. For example, patients can review personal medical information, request medication refills, receive and review lab results, make payments, and schedule appointments. An electronic patient portal is a secure gateway that gives patients convenient, 24-hour access to their personal health information from anywhere with an internet connection. Patients can interact with their doctors through their portal by sending messages and asking follow-up questions without having to schedule another appointment. A recent focus on this new system has led to research towards making electronic health records even more accessible and understandable for patients of all ages. Implications of the improved electronic availability of health records could include improved patient health, as patients would be more informed about their conditions and be better suited to take control of their health care.

Different incentives have caused the jump in implementation of Electronic Health Records portals for the majority of hospitals in the United States. Government subsidization is the primary incentive for EHR use. The Center for Medicare & Medicaid Services requires eligible professionals and healthcare facilities that take part in



Medicare and Medicaid need to use EHR. Hospitals and facilities that participate in this program must provide patients with secure online access to their health information. The present requirement proves to the government that patients are receiving and using health records effectively and makes it easier for medical facilities to send their reports to the government since all patient files are electronic. Most countries in the European Union have also adopted EHR with the same government incentives. Standardizing health records to be electronic in hospitals facilitates keeping records all in one place and also allows patient information to be sent to other physicians if the patient goes to a different facility.

Medical professionals that work in facilities using EHR also receive benefits. The system is not perfect yet so many practitioners have noted trouble clicking through the system to input information that answers so many questions. The main concern is that using a computer to input notes during a visit creates a barrier for the physician to personably communicate with the patient during an appointment. Additionally, there are 700 different EHR vendors that do not talk to each other, so transferring data to other facilities is still done through CD-ROM or fax. Despite these kinks, practitioners actually have more time to attend to other patients and administrative tasks since they can respond to patient questions through the portal rather than on the phone or with an additional appointment. And of course with this improved communication, not only are records now legible no matter what, patients and doctors can continue their conversation outside the office visit through the portal. This can lead to a more solid relationship with the healthcare provider. Small concerns emailed or messaged through the portal help avoid costly visits for patients and let practitioners have more time for other tasks.

Patients also benefit from the implemented EHR portal use. Most of the benefits are from patients' increased interactions with their health records. As a patient, you are less likely to miss any appointments as most portals come equipped with the ability to send email reminders. Secondly, since each patient has access to their prescriptions, lab results and other information, portals enhance the extent to which patients are actively involved in their healthcare. Third, it saves time! You no longer have to come in or wait for the mail to receive your test results, and appointment scheduling and medication refill requests can be done online.

Even with all of these benefits, it is still important to analyze how patients are actually reacting to these portals. It turns out patient demographics, such as age, affect frequency of electronic portal use. One increased field of clinical research is focusing on teen patients. It is necessary for teens to be comfortable with their electronic health records so that they can manage their health care more effectively in the future. A 2016 study by Thompson and colleagues found that teens value their privacy and utilize the confidential messages feature more than reviewing appointments or laboratory tests. Additionally, a 2015 study by Wartella and others, looked at how teens use technology for health information, and found that teens primarily use the internet and social media networking sites for health information rather than their healthcare portals. Finally, teens are unlikely to read or respond to messages regarding medical care that are sent via email. Since the implementation of EHR is relatively recent, there are still some kinks to smooth out. Research on patients' use of EHR is just beginning to reveal some valuable results that will help to improve the portals for patients and practitioners.

With respect to the general population's use and access to EHR, the Office of the National Coordinator for Health Information Technology conducted a data study on the National Cancer Institute's 2017 Health Information Trends Survey. The results revealed that there has been a 42 percent increase in patients that were provided with portal access since 2014. The encouragement of the patients' healthcare providers largely influenced this increase. Nevertheless, only around half of the patients provided with healthcare portal access viewed their medical records. Using this information is crucial for further research on patient satisfaction and motivation to view health records. So far research is limited on this subject but improved portal layout and encouragement from physicians should continue to increase patient participation.

Electronic health records have many benefits, most notably their accessibility for patients and health care providers. The next step is getting healthcare providers to be more adamant about patients taking health care into their own hands. They can help by teaching patients about their healthcare portal and helping them to sign up for the platform in the office itself. Another idea is having a specific person in the office who is able to field all questions about the portal and teach people how to effectively use its key features. Patients and practitioners should use the portal to continue communicating, which will keep both updated on the well being of the patient.

How to Fake a Face

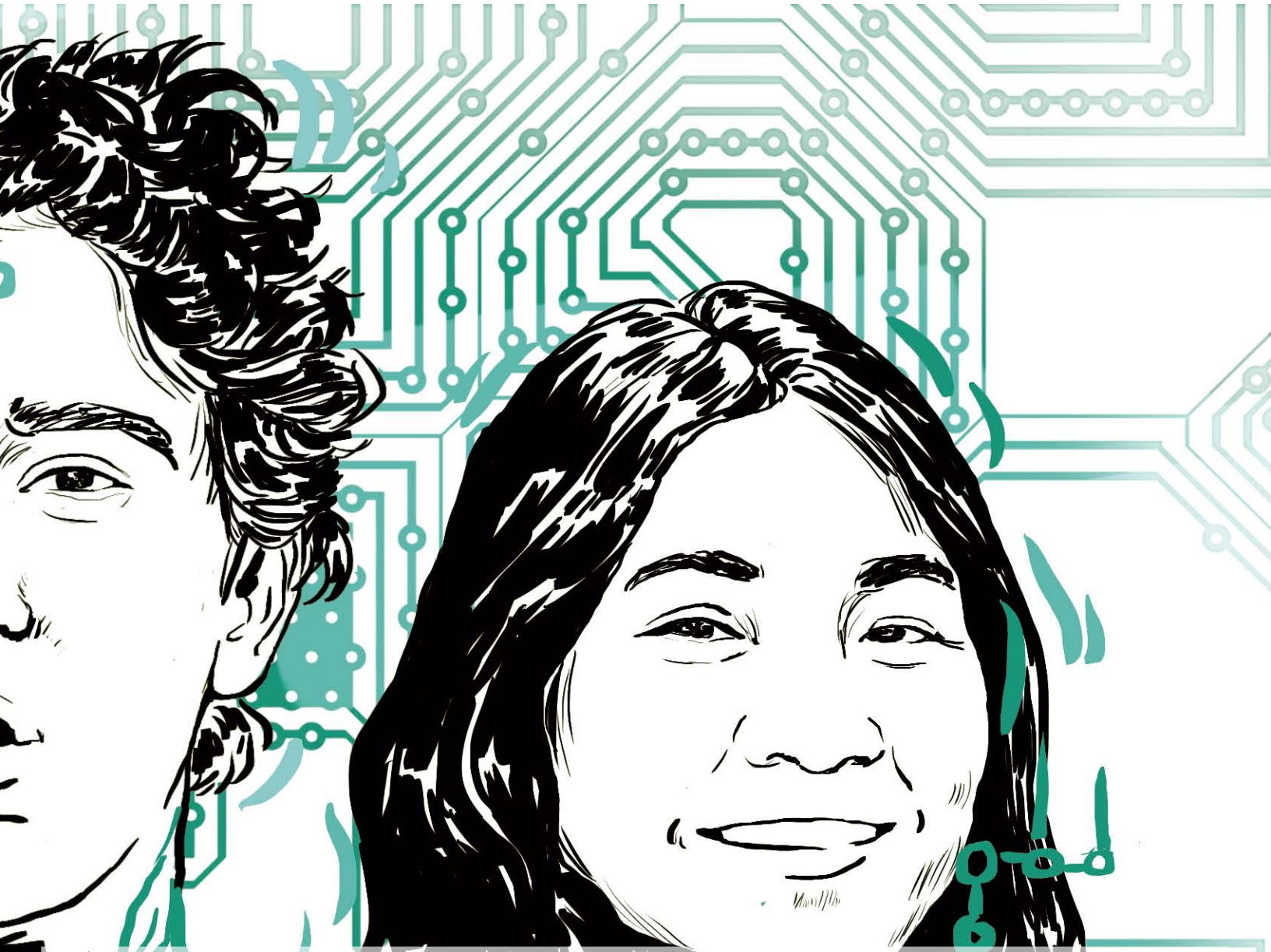
AI Systems Create Realistic Faces From Scratch

Written by Reuben Duebester
Illustrated by Cecilia Larson

How do you know what you see, when you see it? This seemingly simple question has been a significant problem in computer science for almost 50 years. Image recognition, also referred to as computer vision, is the task of extracting high-level information from an image or video. Humans are very talented at performing this task, capable of recognizing objects in images even when they have been distorted or partially obscured. Developing an algorithm that matches this competence has proven surprisingly difficult. Attempts at creating image processing algorithms began in the late 1960s alongside the emergence of artificial intelligence as a field, but many of the current algorithms and methods were not developed until the late 1980s and early 1990s. Even the best algorithms in use today don't match human perception.

One particular area of success in image processing technology has been facial recognition. If you have ever used FaceID on a smartphone, you have taken advantage of this success. According to National Public Radio, the facial recognition algorithms developed at Facebook and Google have recognition rates of 98 percent and 94 percent respectively, while the current algorithm used by the Federal Bureau of Investigation only scores an 85 percent success rate. Artificial intelligence systems are now very good at recognizing faces, and this progress has led researchers to ask a new question: If computers can recognize a face, can they generate their own pictures of faces that are indistinguishable from the real thing? In the last few years, Generative Adversarial Networks have emerged as a promising tool for creating highly convincing faces entirely from scratch. In April 2018, a remarkably powerful new algorithm developed at a large American technology company, NVIDIA, led to a flurry of activity in the field. These algorithms are already impacting society in subtle ways, and raise serious questions in digital ethics that we will soon need to address.

The best way to understand Generative Adversarial Networks is to break the phrase down into its parts. First of all, what is a network? Networks, commonly referred to as neural networks, are modeled on how neurons work in nature. In the human brain, thousands of neurons are wired together. When a neuron receives a stimulus in the form of an electric charge, it distributes that stimulus to neighboring neurons. These complex sequences of neuron activation form the basis for cognition and sensory processing. At a basic level, an artificial neural network works in a similar way. First, simulated "neurons" are arranged into layers. Each neuron in a layer receives a stimulus value from neurons in the layer above, it then combines these inputs, and processes them using some variable weight, before feeding the result to the neurons in the layer below until it reaches the final layer. The final layer of the network produces a numeric output that a human can interpret. These networks can be trained to do a specific task—such as return a "yes" value if an image contains a cat—by changing the weights of each neuron. A common strategy is to feed the network a dataset with known values —such as pictures prelabeled "cat" or "not cat"—and then modifying the network until



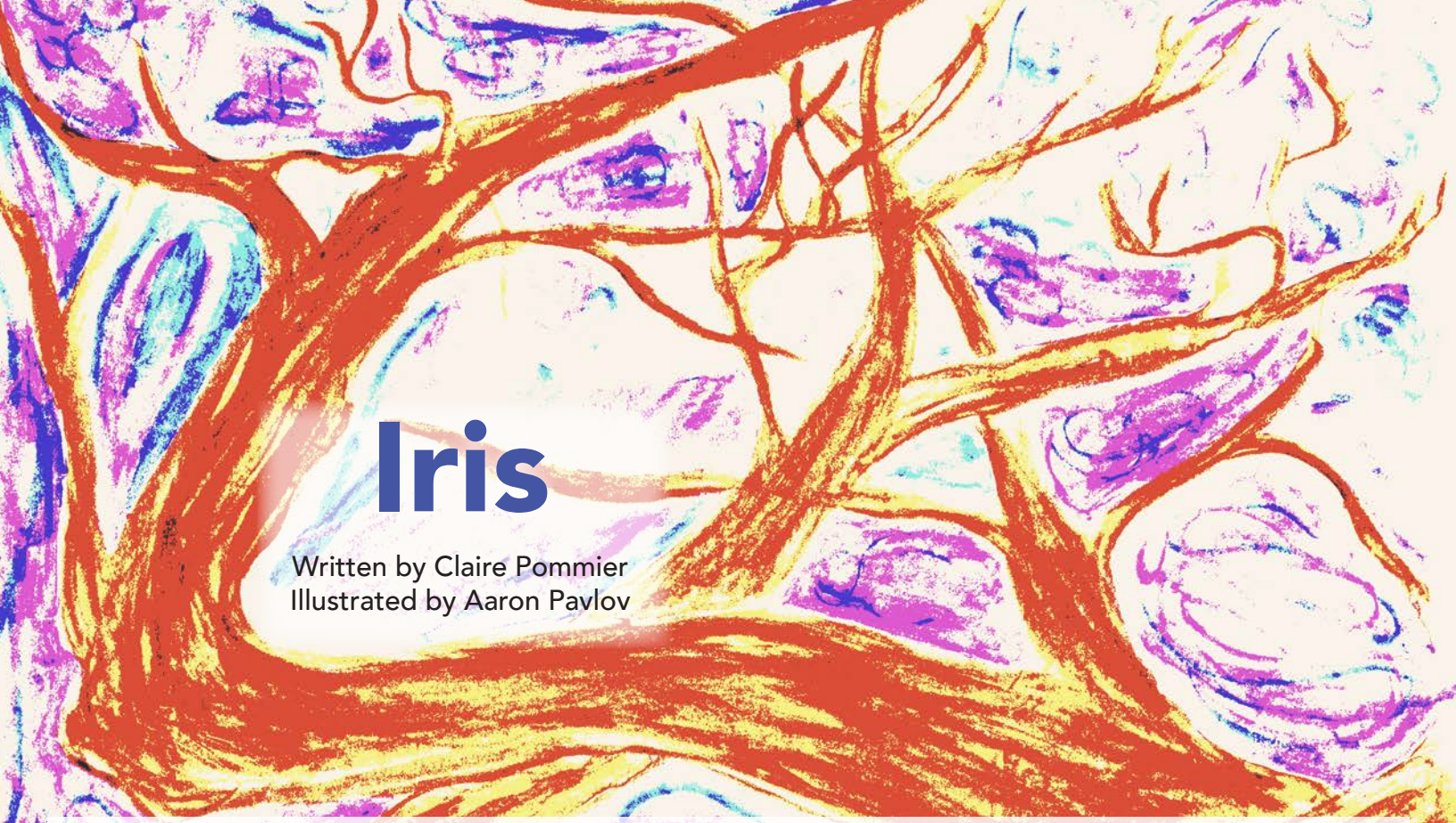
it makes correct guesses.

Next, we need to understand what it means for a network to be adversarial. Adversarial learning is a different strategy for teaching a neural network to perform a task. Two neural networks are created and pitted against each other in competition. One neural network—the discriminator—is trained in advance to perform a specific task, such as recognizing photos containing cats. A second network—the generator—is then given the following challenge: produce output that will fool the discriminator! A fierce competition ensues. In our example, the discriminator will constantly improve at distinguishing cats from non-cats, but the generator will also constantly improve at producing cat-like images. This naturally brings us to the final part of the definition. The system is referred to as generative because the end result is a neural network that has been trained to create original images that are—hopefully—indistinguishable from the ones originally used to train the discriminator.

Generative Adversarial Networks still have a lot of room for improvement. They can produce novel static images quickly and reliably but are incapable of producing completely original and believable video footage. GANs have also been used successfully to transfer facial data from one video source onto another. This technology broke into mainstream news in early 2018, when users on Reddit created a community dedicated to sharing fake pornographic content featuring celebrities. Although this content was quickly banned, the tools remain freely available for anyone to experiment with them.

Fake video clips produced by these tools are currently limited to just a few seconds and contain glitches and artifacts that make them easy to spot. Additionally, producing these false videos is a very difficult computational task, requiring hours of processing time on dedicated cloud-computing systems. Unfortunately, the technology doesn't need to be perfect to be dangerous. Security experts and lawmakers are becoming increasingly concerned that video faking technology could be used in online disinformation campaigns as soon as the 2020 elections. The best GANs may never replicate the subtle nuances of human behavior, like blink frequency and microexpressions, but that probably won't matter if the content is politically charged and disseminated over social media.

Along with its potential as a powerful weapon for disinformation and smear campaigns, GANs could also create an environment where the authenticity of any legitimate photo or video could be called into question. Over time, this technology will only get more convincing and more user-friendly. Soon anyone with a basic technological understanding might be able to fabricate convincing video footage on their personal computers. It will take increasing vigilance to sort real footage from fake, especially video content shared on social networks with the intent to shape political opinion. Which brings us back to the same question with which we began: How do you know what you see, when you see it? • • •



Iris

Written by Claire Pommier
Illustrated by Aaron Pavlov

Content Warning: This story contains non graphic depictions of suicide

Wormholes—too small to pass through, in the end. A groan of disappointment from the general population at the fading of its hopes and dreams of time travel. But the energy they emitted! The untold new particles and gravitational phenomena to be studied! Enough to cut the effects of the energy crisis by two-thirds and catapult science a century ahead overnight. And it was said they were maddeningly beautiful to behold…

Anya inched along the exterior of the energy harvester and research facility NIWR 26, her breathing loud in her ears, rivet gun in hand. The edge of a metal panel curled up in front of her, its edges glinting in the light of the superheated gas surrounding the wormhole.

"A real pain, this spot is," came the staticky voice of her work partner, Cindy, in her ears. "Didn't it come undone last week as well?"

Anya placed her hand on the plate, holding it flat, and pressed the rivet gun to one of the empty holes. There was a distant whirr and snap, the sound only audible where it traveled up her arm—no noise in space.

"It's right next to the thrusters," said Cindy. "So it gets a lot of stress, I expect. We should put in a request for stronger material, if they make us go at it with just these standard rivets we'll be out here every week…"

She floated idly into view, barely recognizable as human under the many layers of her spacesuit. Protection against types of radiation they hadn't even known about a decade before. "You're good with tools. I've still got a couple to go, but it looks like you're almost done."

"I was a farmer," replied Anya, lining up the next hole. "I've learned to adjust quickly to new equipment."

"A farmer…" Cindy's sigh floated over the radio. The nebula colors of gas stretching all around them reflected off her visor, turning her face rainbow. "That sounds nice."

"It… was," said Anya slowly. "Far harder than people imagine, but… I wouldn't have chosen any other life. Until the exodus started."

Cindy sucked in a breath. "That must have been rough."

"It was." Another rivet—snap, whirr, the vibration numbing her arm. "Whole ghost towns of people gone offworld. No one to sell to… no income. No one to talk to, even. I toughed it out for five years before I caved and got an offworld job."

"Fixing rivets," said Cindy.

"Fixing rivets."

The demand for people to fill the jobs opening up offworld had been enormous. She'd known all along she could find financial security ten times more easily in space than on an Earth that was rapidly becoming deserted, but she hadn't wanted to leave the ground under her feet, the smell of grass in the spring, the richness of the soil. Sunlight. So she'd stayed, as long as she could, until she couldn't anymore.

"You used to be a painter, didn't you?" she asked, to take her mind off the memories. At least the buzz of machinery was familiar to her.

"I was," said Cindy, floating upside-down—at least from Anya's perspective—her legs crossed as best as she could with the bulk of the suit. "That was why I got a job here. I thought the wormhole would give me enough visual inspiration to last a lifetime."

Anya gave a half-laugh, moving on to the next hole. A couple more and this panel would be done. "Too bad we can't even look at it."

"Yeah," said Cindy wistfully. "We can't even look at it."

That had been one of the first and most unforgettable discoveries about the wormholes: that everything about them—the energies surrounding them, clouds of time-reversed particles, a hole punched through the four-dimensional curvature of the universe—was fundamentally incompatible with human eyes. It was not a sight the brain was ever, after millions of years of evolution, designed to process. Scores of researchers had been sent back home catatonic from a single glimpse, staring blankly from hospital beds, and the budding wormhole research industry had been frantically halted for the time it took to develop protective visors. Protestors had filled the streets, or the halls of their space stations, an outcry about things man was not meant to meddle with. There had been murmurs of trespassing in God's domain, of the angels who would burn your face off when you looked at them. And yet science had rolled on.

Cindy rolled over meditatively, turning her face past Anya, towards the wormhole; the visor on her helmet snapped into black opacity at the first sign of higher-than-normal tachyon levels in its cameras. "Bleh. See? There you go. It only makes you even more curious."

"Are there people who look on purpose?"

"Hmm? Oh, sometimes, if you disable the blackout. It's basically suicide, if you ask me. I don't think anyone's ever recovered. So my common sense says no, of course... But God, is it tempting sometimes." The blacked-out helmet was completely nonreflective; no one was going to catch a second hand glimpse from its surface. "Like standing on a fifth-floor balcony and getting the urge to jump."

Anya thought about that sensation, the rivet gun whirring in her hand again. "Are you going to finish your spot?"

"What? Oh, sorry." Cindy turned back to the wall of the facility, away from the wormhole; her visor cleared, showing her face again. "I got distracted."

"I'll do your portion," said Anya. "It'll go faster."

• • •

When they were inside and peeling off the layers and layers of protective gear, Cindy said, "Oh, I forgot to tell you." There was a seriousness in her tone that made Anya look up. Her lower half was still encased in shiny foil. "Hmm?"

"I'm leaving tomorrow," said Cindy, undoing the Velcro straps on her arms. "I'm getting transferred to the xenobiology station on Braxus 9. They want me to do illustrations of their projected anatomical models." Now the Velcro straps on her legs, lifting each foot in succession. "It's a step up from rivets, don't you think?"

"Yes," said Anya. "That sounds very nice. I'm happy for you."

"I'm sorry I didn't tell you sooner," said Cindy, pulling the last layer off, and reaching for the labelled hanger. "It slipped my mind… I had a busy morning, I nearly forgot." She ducked her head in an embarrassed smile. "It still hasn't sunk in, to be honest."

"I'm sure you'll do great," said Anya.

The smile grew wider, happier. "Thank you so much." She slipped the hanger over the rack and turned to Anya, sticking out a hand. "It's been a pleasure working with you."

"Likewise," said Anya, and shook her hand with the loud rustle of the insulating layer. Her hand felt thick and clumsy. It was hard to move.

"See you," said Cindy, disappearing down the hallway in her undersuit, and Anya was left standing there, her torso sticking out of the protective foil like a worm from an apple, like a clown in clown pants, like something very big and shiny and stupid.

• • •

The next day dragged itself along slow and empty, slug-like and vacuous. Anya was assigned, alone, to oil the joints around the thrusters that turned them in the opposite direction the facility needed to go, when it moved at all. Right now the thrusters were cold and still and Anya carefully moved each component, felt for resistance, applied lubricant where it was needed. Around her was the blaze of color from the wormhole, silent and vast, and silently, vastly generating enough energy every second to kill her in a heartbeat if she was unprotected.

An angel of yore, and she could only see its halo.

Cindy must already have left. There wasn't anyone else to pass tools to, and she'd leave them floating in the vacuum beside her before remembering there was no one else to grab them.

A xenobiology illustrator, huh? Good for her. A painter, just like she used to be, just like she always wanted to be.

Cornfields green and lush in the bright Earth sun…

Cindy had come here for the ultimate visual inspiration, hadn't she? And she'd never even gotten to look at it. Maybe the colors painting the sky around them had been enough. Maybe not. Fields lying fallow, the desiccated harvest slowly rotting into dirt, not enough people to work the land.

Like standing on a fifth-floor balcony and getting an urge to jump…

What had Cindy's paintings been like? Anya had never thought to ask. She'd never even seen one of them. Did she paint people? Did she paint the wormhole around them? Did she paint fresh soil?

Again Anya let go of a tool and no one was there to pick it up. No one was going to be there, really. No one was left. Not on Earth, not here on the outer wall of NIWR 26, clinging to the panels like an insect.

But God, is it tempting sometimes.

Anya wished she'd gotten to see Cindy's paintings. Maybe she could still see one. Maybe she could still see what Cindy's paintings could have been, the ultimate masterpiece, right there behind them all along—

She turned to face the wormhole. Her vision immediately went black; she jammed her finger on the override button and held it down. Fifteen seconds, the requisite length of time…

The world blazed into color before her, like a miniature sun, a hole punched through the four-dimensional curvature of the universe. There it was.

It was beautiful. It was— • • •

Chemical Compound Words

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

ACID
ALCOHOL
ALKENE
ANALYTICAL
AVOGADRO
BASE
BEAKER
BOHR
CARBON
CHEMISTRY
COMPOUND
DIFFRACTION
ELECTRON
ELEMENT
EQUILIBRIUM
FLASK
HYDROGEN
INORGANIC
ISOTOPE
KINETICS
LIGAND
LITHIUM
MOLE
MOLECULE
NEUTRON
NUCLEUS
OCTET
ORGANIC
OXIDATION
PARAMAGNETIC
PAULI
PIPETTE
PROTON
QUANTUM
REACTION
REDUCTION
SOLUTE
SOLVENT
SPECTROSCOPY
STEREOISOMER
STOICHIOMETRY
VALENCY
WATER


NOTICE
NOTE

/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.