Edition 3
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EQUILIBRIUM

CONNECTIONS

Science & Art Magazine

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Letter from the Editors

Kate Giffin and Kristen Schuh

Dear Readers,

In this edition of *EquilibriUM*, we delve into the intricate ways that science and art connect and enhance each other.

In a world that often compartmentalizes disciplines, it is necessary to bridge these gaps to discover fresh perspectives, foster innovation, and enrich our collective knowledge. Both of us work in interdisciplinary fields studying how the brain and body interact in sometimes strange and nonsensical ways – connections are one of our favorite parts about research.

The natural world consists of an interweaving web of processes and systems. Understanding these connections can propel scientific discovery and lead to breakthroughs in how we understand the world around us. Beyond the research topics themselves, the work of research is driven by connections between people: within individual labs, between labs, even across fields, institutions, and continents. Research simply cannot happen without connections.

Similarly, good art is often all about connections. The connection between artist and audience, between colors and textures, between artistic styles and genres, between seemingly unrelated ideas, images, or emotions. This is why we chose the theme "Connections": we wanted people's imaginations to run wild. We wanted to highlight the ways science does (and doesn't) mirror art, and vice versa.

And our artists and authors blew us out of the water. We learned about unexpected, delightful, and tragic connections. We learned about the ways scientific topics show up in everyday life and might even change lives in the future.

When science and art combine, it is truly remarkable. Science can illuminate and magnify the unseen world, inspiring artistic expression. Art can elucidate science, making complex concepts tangible and engaging. Together, they can challenge our perspectives and drive progress in ways that neither could achieve alone.

Finally, we are tremendously proud of the way EquilibriUM has forged connections between people on this wide, wide campus. With the hard work of 5 editors, 7 illustrators, 8 contributors, 2 editors-in-chief, and 1 layout designer across 12 departments/programs, we have created a community and a collection of art that highlights all of the fantastically surprising connections between science, art, and life. From the smallest components of cells to the evolution of life, each piece in this edition highlights the transformative potential of interdisciplinary connections.

As you read this edition of *EquilibriUM*, we hope you are inspired to reach beyond the boundaries of your everyday life and embrace the connections around you.

Warm regards,
Kate Giffin and Kristen Schuh
Editors-in-Chief

* * *

Kristen Schuh [left] is a PhD candidate in Biopsychology, unraveling the effects of hormonal contraceptives on the stress response and mood. When she's not dissecting data or advocating for women's health, you can catch her painting pet portraits, kicking it on the kickball field, or trying to improve her amateur soccer skills.

Kate Giffin [right] is a poet, mandolinist, and professional nerd (PhD candidate in Neuroscience). In the lab, she studies how severe infections can lead to long-term brain issues like dementia. She is passionate about telling scientific stories through unexpected genres, particularly poetry, to expand the way people think about science and the world. When Kate is not marveling at the brain, she is probably outside marveling at some strange plant.

Photographed by **Hoi Kei (Amy) Choi**

When the Immune System Goes Against the Grain

Deanna Cannizzaro

Sitting down for a meal is a staple of being human. Memories and laughter are shared over food, allowing us to connect with friends and family.

For me, food is no longer a simple part of everyday life; I'm forced to think about a chronic disease each time I want, or need, to eat something. It took months of severe abdominal pain and persistent fatigue in my early twenties to realize gluten had become my biggest enemy.

Celiac [definition]:

My immune system mistakenly convicts gluten, a protein, as a deadly perpetrator. My B-cells memorize gluten's fingerprints by producing antibodies in preparation for future attacks. T-cells ambush my intestines, causing the tissue to become inflamed and obliterating the villi that line my small intestines.[1,2] No villi mean no absorption of nutrients, sending me into a spiral of malnourishment. Celiac is an autoimmune disease, meaning my body tears itself down.[3]

The sensation of being stabbed in the gut wakes me up at 2am. Sweat coats my skin as I find the bathroom floor.

"Maybe we should go to the emergency room," my now husband calls from bed.

I am 30 pounds lighter than I normally am. All I want to do is get a few hours of sleep. Is this my new norm?

"I'm okay, go back to sleep," I whisper, brushing away choked back tears.

Gluten isn't only in bread and pasta? Common foods like cold-cuts and soy sauce were poisoning me unknowingly. Unlike an allergic reaction, eating gluten did not produce harmful symptoms immediately. Delayed reaction and widespread symptoms are primary reasons why Celiac is difficult to diagnose. On top of that, tests to diagnose Celiac are only accurate when you actively eat gluten for 4-6 weeks, during which you are in immense pain, and can still be unreliable.[4]

Before I truly understood the long-term effects gluten would have on my body, I used to cheat. People who were lactose intolerant did it. While it was understandable to deem the two cases of gastrointestinal pain to work in similar ways, lactose intolerance occurs when the small intestine does not produce enough enzyme to break down lactose and causes acute discomfort.[5] Celiac encourages the immune system to harm my own body tissue, causing long-term physiological damage.

Once I accepted the severity of my disease, I buckled down on knowing how to prevent and manage my reactions. I adjusted to the strict gluten-free diet, giving me some hope that I could maintain my health with a chronic disease. Just as I was finding a new normal, all the pain and exhaustion I had overcome started to re-emerge. Control over my autoimmune disease started slipping through my fingers, leaving me confused and in tears as I battled my body once again.

"I can basically guarantee there's nothing physically wrong with you," the doctor smiles.

But, you haven't run any tests. Are you listening to what I am saying?

"You're a young woman who is starting graduate school. You're just stressed. Talking to a therapist will solve your problems."

Yes, I know stress can heighten symptoms. But I think there is something else at play here. I just want to be okay. Please make it okay.

"I mean if you insist on getting the tests, I guess we can."

I have to be my own doctor too? Well... what if he's right? Am I making all of this up?

After 3 gastrointestinal doctors insisted my reactions were nothing but anxiety, I took it upon myself to complete 7 months of food journals, a 40-vial blood test, and 1 extensive skin-based allergy test. Turns out, I had developed 12 additional food sensitivities.

Celiac is about gluten, but autoimmune diseases like to play by their own rules. Known as cross-reactivity, my gluten-specific antibodies became convinced that any molecule that had fingerprints even remotely similar to gluten, like corn, soy, or oat, were gluten.[5] I was following a strict gluten-free diet yet had reactions for 6 months straight. My body flung itself into a state of paranoia, well-meaning to protect me, but heavy handed in execution.

After removing the 12 offending foods for a year, everything from eggs to carrots to dairy, I began re-negotiating with my immune system. *Are grapes okay again? No? I'll check back later...* Healing my gut and bringing down the inflammation allowed my immune system to refocus only on gluten. Some foods I can tolerate in small doses, while others remain on my enemy list.

Smile. I ate beforehand. I'm going to be okay. It's just a party.

"I have a special gluten-free dish for you!"

That was so considerate... but I didn't see them make it. Did they use a dedicated gluten-free pan? A separate sponge to wash it?

"I know you love cookies. Don't worry, I promise it's safe!"

Refusing food feels disrespectful. I want to make a good impression... I knew I should've stayed home.

Getting together with friends and family, whether it's a holiday or a casual night out, can quickly turn into my worst nightmare. Eating gluten-free is one thing, but all it takes is a bit of cross-contamination to cause a full-fledged reaction. Gluten loves to hide in the scratches of pots and pans and makes me just as sick as if I were eating large amounts of glutenous foods.[6] Gluten-free options at restaurants and home-cooked meals can *still* harm me.

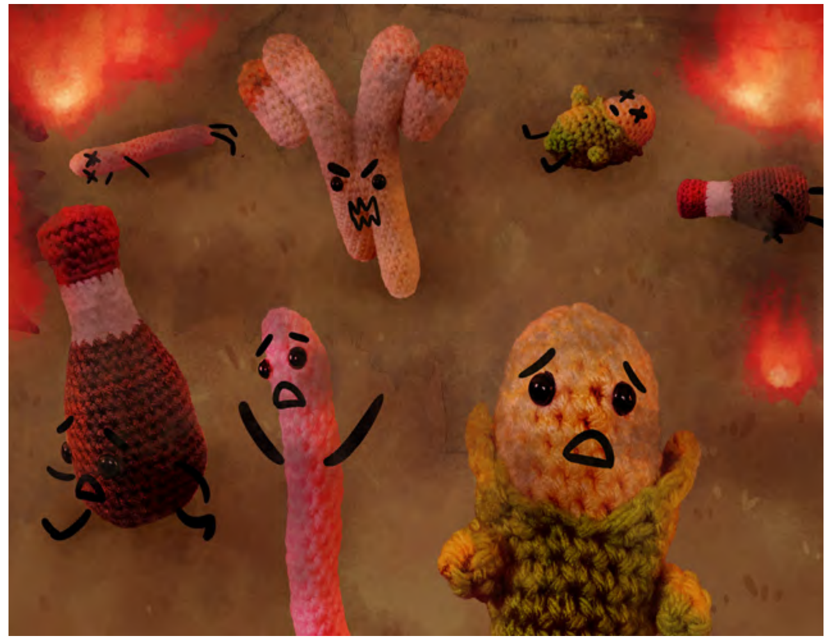
The fear I have when I accidentally consume gluten is unlike anything else; my mind wanders to the potentially permanent consequences of stomach cancer, nerve damage, or infertility.[7]

Celiac [definition, modified]:

My immune system is a leech. It betrays me, hurts me, even when I try my hardest to listen to its constantly changing demands. I start to hide from it. Scared to eat. Scared to anger it. Scared for what it will do to me. What I will do to me.

My immune system formed unhealthy relationships with gluten and others resembling gluten. In consequence, my brain formed unhealthy relationships surrounding food and social events. I didn't want to go out with friends and spend the night in a state of anxiety. I didn't want to feel like a burden if I did tag along, limiting their options. Being visibly outcast as the person with an empty plate or a Tupperware container makes it impossible to fly under the radar.

All these scenarios draw on a not-so-obvious fact: the side effects of Celiac are not solely physical. Many gastrointestinal disorders lead to a higher prevalence of



psychiatric disorders due to the social aspects of food-driven disease.[8] Specifically in Celiac patients, anxiety, depression, and eating disorders are common, though the connection between the disease and mental health is not entirely understood.[9] Adjusting to any chronic disease has a psychological component, and I lived in a state of fear and animosity with myself until there was a mentality shift, namely when I met my husband.

"Okay, I spent way too much money at Costco but LOOK at what I found." His grin is spread from ear to ear as he bounds through the front door.

I blink. He's this happy that he found me new snacks?

"Happy birthday! Let's start putting together our own cookbook with our favorite meals."

A personalized recipe book? He isn't upset we can rarely eat out because of me?

"Perfect timing. Dinner is ready!" I get home from work as he greets me with a plate of lemon-basted salmon and fluffy mashed potatoes.

He taught himself how to cook and now loves it? Is excited to share restricted meal options?

Rather than focusing on the things I lost and my broken connection to food, he showed me that any connection can be repaired and food can still be a strong love language for me. At our wedding he vowed "to always be searching for more Deanna-friendly recipes," and our meals have truly been limitless.

Even though I still face daily struggles, I no longer let Celiac confine my experiences. My wonderful support system helped me love my body, my mind, and my food again.

There are many diseases in this world that I will never understand the details of living. Rather than focusing on the nitty gritty of everyone's health, we can be empathic and inclusive. The invisible ties between body, mind, and society can be pulled, stretched, or cut completely. But they can also be rebuilt – re-tied – through empathy. New connections can form in unexpected places, stronger than the ones we thought we couldn't live without.

Celiac [definition, finalized]:

My immune system is an opportunity to become a home-chef and baker, adapting recipes into fresh and unprocessed meals. A door that opens my palate to naturally gluten-free cuisines such as Thai, Indian, and Vietnamese. An invitation into my home, and a love of hosting and sharing my food with others. A stroke of confidence in putting my health first and advocating for the things I need. A new connection, one that I hope seeps into everyone's lives, tasting sweet of empathy and compassion. *

* * *

Deanna Cannizzaro is an avid reader, writer, and tap dancer. As a neuroscientist, she studies how sensory neurons detect and influence the glands that produce saliva. When Deanna is not daydreaming about fantastical worlds and cool science, she's going on adventures with her husband and two pups.

Artwork by **Jessica Li**
Edited by **Claire Shudde** and **Jessica Li**

Appreciating the Intricacies of Science Through Sculpture:

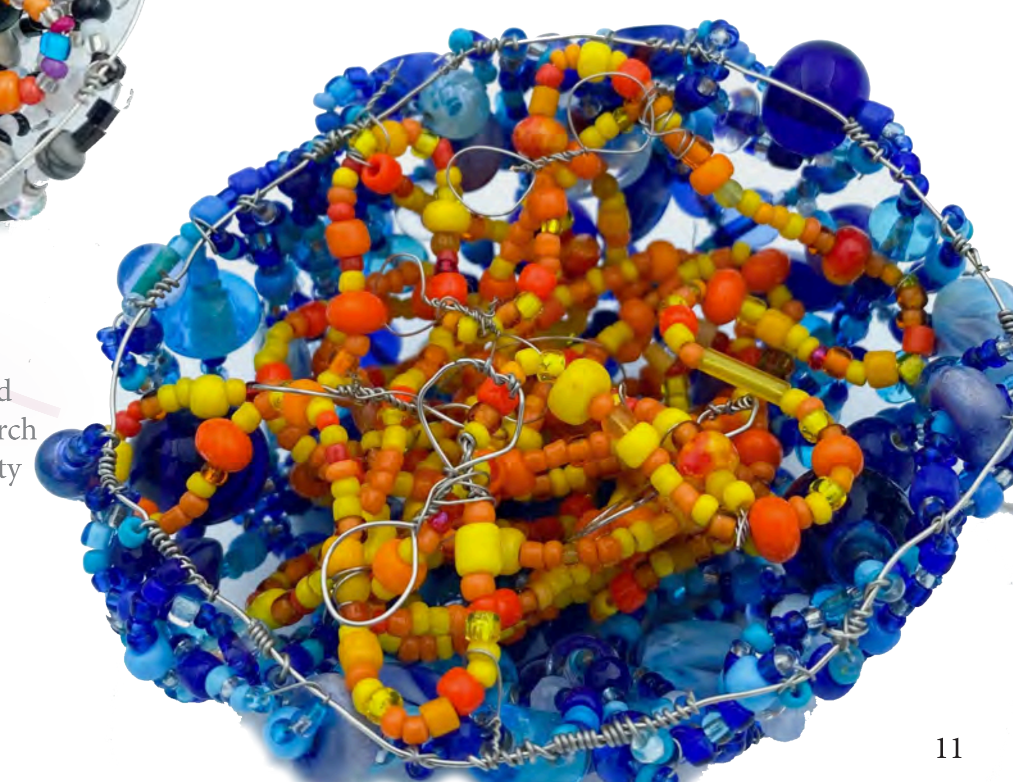
The Powerhouse of the Cell

Emily L. Eberhardt

Amidst the global pandemic in 2020, I began to explore science through art. In my research, I studied mitochondrial proteins (mitochondria are small structures in cells that produce necessary energy), but with lab closures, my hands were idle. With a box of beads, a freshly-passed candidacy exam, and limitless time, I sat and considered the power of mitochondria. Fascinated by their complexity, I began to craft sculptures.

To make my mitochondrial sculptures, I first make a basic hemisphere-shaped frame by stringing a variety of beads onto wire. I then use larger beads and sturdy wire to make the outer mitochondrial membrane. Once I have a network of beads, I weave in smaller beads to fill in the gaps. Next, I move to the inner mitochondrial membrane and matrix, usually choosing a contrasting color to highlight compositional differences in proteins. Once I've molded the membrane and placed the matrix, I finish the sculpture with small wire mitochondrial chromosomes.

Over the years, creating these sculptures has become a form of meditative relaxation. As a scientist, I've spent years poring over spreadsheets, re-reading papers, and racking my brain for solutions to complex problems. Meanwhile, creative exploration has allowed me to gain a newfound perspective on the world around me. As I weave beads and wire and imagine my next completed powerhouse, I often reflect on my research journey. By embracing my imagination, I have become more curious and flexible in the lab. *Altogether, my inspired independent studies have forged a connection between my research and artistic passion.* ★



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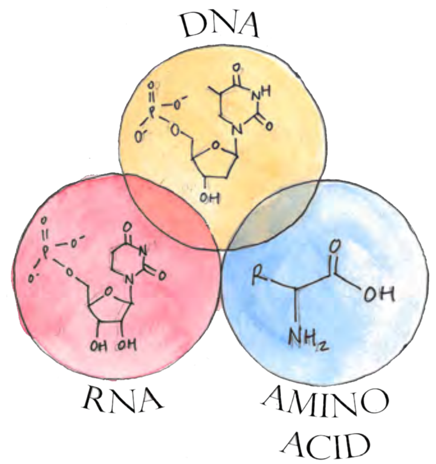
Emily Eberhardt is a researcher, artist, and scicommer. She currently conducts research in pediatric pulmonology at the University of Michigan. As a creative, she makes "bioart," a fusion of biology and art.

Edited by **Kate Giffin**

Out of Many, One

Alex Ford



I. THE TOWER OF BABEL

In the beginning, there was a stone. A stone by itself is simple. Monolithic in concept and function. But introduce a second stone. Place it upon the first. Add another. A stack forms and they become more than the sum of their parts. Before there was life, there were simply stones longing for more. Patient stones that awaited the first tumble to start an avalanche.

Somewhere in the infant Earth, at the grinding edge of a sunken continental plate, magma oozes into deep water. Volcanic fires churn in the darkness and spew black clouds into the crushing depths. In this energy-rich crucible, a lone carbon finds hydrogen, finds nitrogen, and the first organic molecules begin to assemble in the deep.

Above, an asteroid falls to the ocean. Prometheus bearing fire from the heavens. This stone carries the seeds of stars and the child-particles of forgotten galaxies. Mother Earth adopts and nurtures, and among the waves, alien stones find a new home.

Elsewhere, a stormfront roils in thunderous fury above vast waters. Lightning splits the air, and for an instant the sea and sky are connected by energy. Like flower petals unfurling, the arcing pulse of crackling electricity triggers new reactions in the waiting elements below.

Organic pillars are forming that may one day hold up the living world. Threads of fate weave between carbons and hydrogens, nitrogens and oxygens. Information encodes on the fabric of reality, one molecule at a time – like stacking stones into a tower.

Author's note: Here are three of the many theories of the origin of the building blocks of life on Earth. Undersea volcanic vents produce simple organic compounds, as high pressure and heat force reactions with the elements and minerals around them.[1] Some organic molecules have also been found in asteroids falling to Earth which may have come from celestial processes.[2–4] These chemicals have also been seen in high-energy 'primordial soups', as facilitated by events such as lightning, with enough power to break and form molecular bonds.[5]

II. NOW I AM BECOME LIFE

The towers continue stacking, and eons pass. Suddenly, somewhere, a threshold is crossed. The snake eats its own tail and containment is reached.[6]

I am distinct from the environment,[7] floating in a vast cosmos like a star in the emptiness of space. In my simple cell, I experiment and discover new ways of producing useful structures to protect and propel myself – new forms that extend outwards – ever reaching, ever seeking.[8] I discover how to take energy from broken chains of carbons.[9] I hunt and drift. I discover how to catch the light from the air,[10] and sugars from the waters.[11] I even consume myself, engulfing other cells that one day will become mitochondria.[12] I create new ways to grow and survive. It is the first fight. The only fight. And if I persist, I win.

Author's note: In short, early cells managed to progress the first steps of evolution by enclosing RNA-like molecules within simple membranes that possibly self-formed.[13,14] This proto-cellular development is a major milestone in the development of life and is thought to have emerged around 3.5-4 billion years ago.[15] These early organisms relied upon energy-rich environments and simple processes to survive and grow.[16,17] But once alive, selective pressures ensured evolutionary progress would occur.[18]

III. "ENDLESS FORMS MOST BEAUTIFUL"[19]

I have grown and learned and evolved over these long ages. Once there were lonely cells scattered over distant waters. Now there are species scattered over the planet. That ancient network of life has been scaled up, the lines that connect more tangled and interwoven – but the old connections remain. Billions of years ago I first learned how to absorb oxygen, and now I use that in the tissue of lungs,[20] I learned how to send signals with chemical gradients between cells, and now I do so with nerve fibers and electricity.[21] I learned how to replicate and divide,[22] and now my cells continuously renew themselves. I am a network of networks of networks, all the way down to the DNA chains coiled in every single cell.[23] I am infinitesimal and eternal, and still I continue to build.

I extend new fingertips made of scales and hide and fur and shell. I learn new ways to reproduce – spores and seedpods and gametes on the wind. Like dropping a stone from a great mountain, there is no predicting the places of contact on the way down. The bounces and fracturing seem random, but the need to survive is the chisel that carves new limbs, bright eyes, tails and fins out of the stone. I reach out and feel touches on skin, fresh smells and tastes, the blind sight of newborn eyes – blinking open again and again across the breadth of the world.

Author's note: There were periods of explosive growth and divergence into the current kingdoms and classes of life. Periods like the Cambrian explosion[24] are of vital importance in the progression into species level interactions.[25,26] Diverse species interact within their own members, and others, to an increasingly complex degree. According to the Red Queen hypothesis,[27] the interactions between connected species accelerates evolution more than adaptation to the environment alone.[28,29] Thus, more species diversity results in more diverse traits.[30]

IV. "WHAT A PIECE OF WORK IS MAN"[31]

Now, we look out and meet our own eyes – slitted eyes, compound eyes, binocular eyes, prey and predator eyes[32] – we see in our trillions of reflections that we are more than ourselves. We are societies of species, parliaments of phyla. And one form among the many has become judge and jury above all. For we have created a most wonderous, most beautiful creation. A creation as remarkable and revolutionary as a new sense or a new limb. We have evolved the structures and capabilities for language.[33,34] If we persist, we win – and so we have evolved *continuity*.

As humans, we exult in reaching beyond ourselves. We give speeches, we argue, we tell stories before hearthfires – generation after generation. We record our thoughts, and we learn to read clay tablets, then scrolls, then books. We take in memories and emotions, discoveries and questions, and learn the lessons of entire cultures – lives of people that are long since dust. We read the words of those we respect or trust or love – we transcribe the meanings into our neurons[35] so that their memories become a part of us, their threads forever woven into the whole. Like a tree's rings,[36] or geological strata telling the story of an ancient flood,[37] there is memory in the forms. With our words and stories, a thread of connection reaches through time to forge knowledge and empathy[38] in all those that come after. As if in mimicry of the heritable legacy of our genes, we pass down the best of what's within. We pass down ourselves.

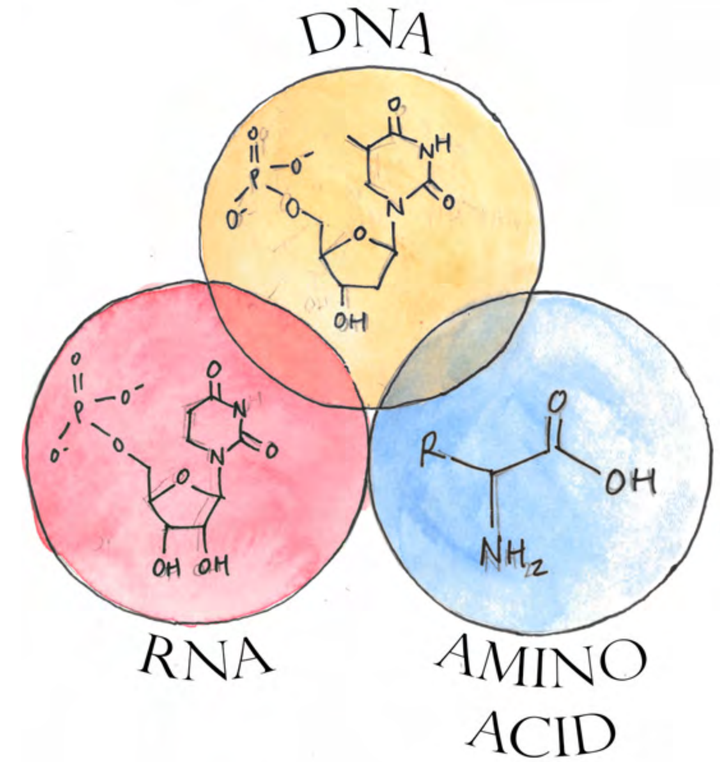
We remember when there was only the reaching for the next hydrogen, the next nitrogen beside volcanic vents. Now we study those ancient towers of stones. Under microscopes and lasers, in vacuum chambers and test-tubes. We capture lightning in bottles, ignite fires of the Sun strong enough to crack mountains, and send ourselves flying into the universe to seek the unknown amongst the infinite stars. Our thoughts propagate across the globe at the speed of light itself. Each communication is a link, each person a node – invisible networks of emotion, knowledge, culture, friendship, love – covering the Earth in an ethereal web that joins us into a whole. We are a sleeping colossus, awakening one cell at a time. Like the nested systems within all levels of life, the growing pattern continues outwards. Ever outwards.

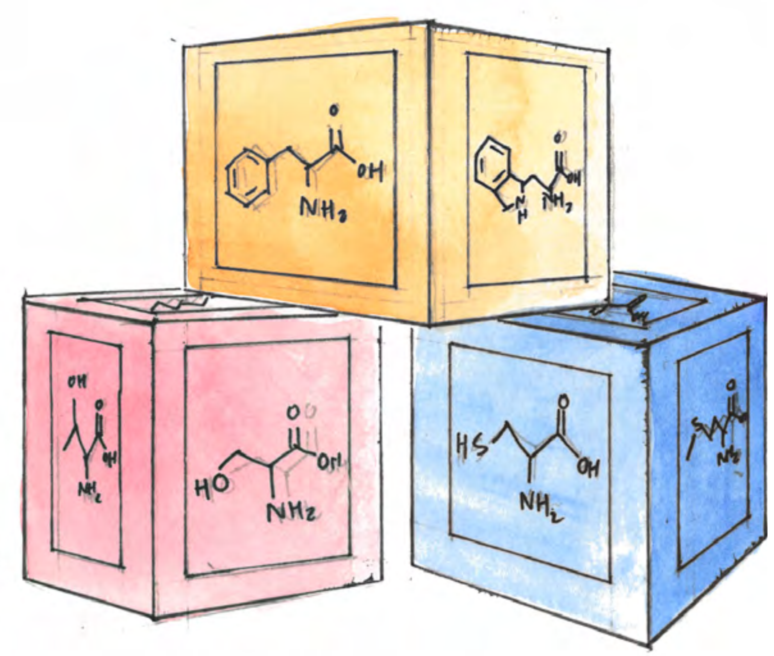
Author's note: At the heart of all living processes and interactions, there is the transfer of information.[39,40] Human intelligence is exceptional, but some of the most effective adaptations social and cultural,[41] joined with the ability to communicate information through language.[42] In the arms race of evolution, social animals tend to evolve faster than solitary animals,[43] and no species has ever approached the speed and success of humanity's development. These unique adaptations enable the human species to function as a true global organism on a scale never before seen on this planet. But though humans live longer than at any point in history,[44] and have overcome most evolutionary pressures, it has been demonstrated that humans are still evolving.[45–48] As a sapient species this continued growth raises questions about the future – about where humanity will decide to go from here – and what directions Earth's web of life will take as a result of those choices.

V. OUT OF MANY: ONE

Now, we look out and meet *your* eyes as you read this page. You, who are a part of us – who give us meaning and life with your very existence – how will you choose your path ahead? How will you, in your own way, shape the story of what we all become?

Out of this multitude of many, how can you be one? *





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Alex Ford is a student and neuroscientist who researches how the brain processes sensory information in the visual system. He has a tendency to seek out the absurd, and frequently attempts to create art. In his free time, he is with friends, family, or a good book under a tree.

Illustrated by **Zoe Yeoh**
Edited by **Hector Mendoza** and **Zoe Yeoh**

Nematodes as Catalysts in Uniting Scientific Curiosity and Cultural Heritage

Mirella Hernandez

El Día de Muertos es una celebración que honra la memoria de los seres queridos que han fallecido. Donde se rinde homenaje a la vida y a la muerte, porque sin vida no hay muerte.

The Day of the Dead is a celebration that honors the memory of loved ones who have passed away, paying tribute to both life and death.

Death, an inevitable facet of human existence, marks the transition from the tangible realm to an enigmatic state beyond our comprehension. Across different epochs and societies, humans have grappled with the concept of mortality, developing a myriad of beliefs, rituals, and ideologies to make sense of this final passage. One such tradition we celebrate in Mexican culture is El Día de los Muertos, or the Day of the Dead, a celebration rooted in pre-Hispanic indigenous and Spanish Catholic traditions that commemorate the return of departed loved ones to Earth. At the heart of this celebration are the ofrendas or altars in which flowers, candles, and calaveras (skulls), are the main decorations. Flowers, particularly marigolds (cempasúchil), are believed to guide the spirits back to the world of the living with their bright colors and strong fragrance, while candles illuminate the path for the spirits to return. Meanwhile, calaveras, often made of sugar and vividly decorated, symbolize death.

Similar to Mexican culture, death also plays an important role in my research studies. To study how death impacts us biologically, researchers have taken advantage of the conserved biological processes that *C. elegans* share with humans. This non-parasite worm has been used in research to study development, genetics, and neurobiology. Now, I use this model organism to study how environmental factors, like death, affect health and aging. This dual perspective enriches my understanding of life and death, blending scientific inquiry with cultural reverence, and allowing me to approach my research with a profound sense of purpose and connection.⋆

⋆ ⋆ ⋆

Mirella Hernandez is a graduate student in the Neuroscience Graduate Program, specializing in sensory perception. She is dedicated to exploring interdisciplinary opportunities that connect science and the arts. As for her, the arts can serve as a powerful medium to make complex scientific concepts more accessible and engaging.

Edited by **Kendall Dean** and **Sheila Peeples**

Illustrated by **Mirella Hernandez and Kendall Dean**

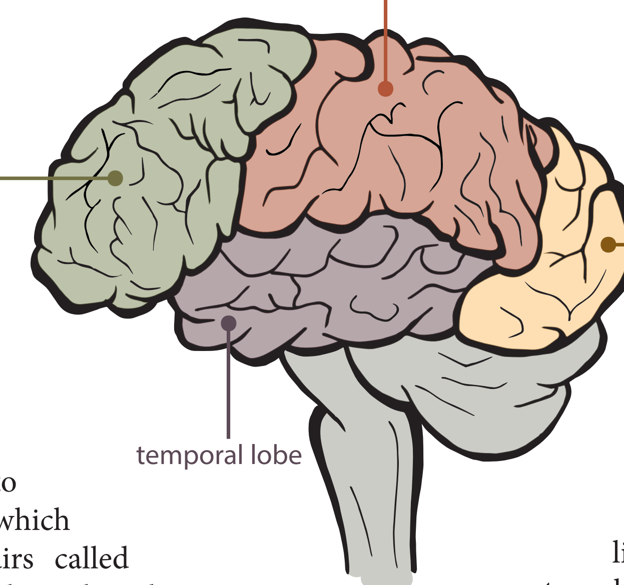
From Synapses to Symphonies:
A Connection Through Sounds

Charukesi Sivakumar

The lights dim as we, the Life Sciences Orchestra, lift our instruments. With the wave of our conductor's baton, the music swells across Hill auditorium and enters the audience's ears, lighting up the brain.

Movement 1: Out the Instrument and into the Brain

The brain is a complex machine that processes thousands of signals in every moment of our lives. But how does the brain know where to process something as specific as sounds? Our brains are split into four different regions, or lobes: frontal, temporal, parietal, and occipital. Each lobe has an area of "expertise."[1] The frontal lobe is the decision-making region, the occipital lobe processes visual information, the parietal lobe processes touch, and the temporal lobe is responsible for processing sounds.



Initially, sound waves pass through the ear canal into an area called the cochlea, which has thousands of little hairs called stereocilia. The stereocilia vibrate based on the frequency of sound and pass that message along through the auditory nerve which directs an electrical signal to the brain. Once in the brain, neurons, a type of brain cell, transmit that signal through synapses, or tiny gaps between neurons. Everyone sitting in the auditorium listening to the orchestra has about 100,000,000 neurons[2] communicating with each other to process the music in a total of 150 milliseconds.

Interestingly, for us to process everything that music has to offer – rhythm, mood, etc. – we utilize every portion of our brain! However, there are many pieces that need to come together for the brain to process music, making it incredibly difficult for us to understand how music impacts us. Since it is so difficult, many scientists spend hours each day trying to understand what happens behind-the-scenes in our brain. Scientists[3] studying music's impact on the brain use animal models to design experiments to answer the many questions we have. In one study[4], scientists showed that music prevented anxiety-like or depression-like behaviors in rodents! Rats that listened to classical music, such as Mozart, had almost no behavior changes compared to rats that underwent the same stressors without music.

Why is that? The study found that listening to music reduced levels of stress hormones, inflammation, and even promoted the growth of new neurons.

Another study[5] also showed that musical environments can promote the connectivity of brain regions after injury, which could be related to the increased production of neural growth factors. Neural growth factors[6] promote the growth of new neurons, which is key for the development of new connections and can improve behaviors such as learning one's environment.[7] However, it is hard to say what the long-term effects of music are on neural development. Further research that needs to be done to connect the dots between the behavior changes seen in animal models to what is going on inside human brain cells.

With a final chord, we come to a silence, a quiet peace filling the room before applause begins to radiate through the auditorium.

Movement 2: A Glimpse into Music Therapy

With the benefits scientists are seeing in animal models, it is no surprise that people are using music as a way to enlighten one's mood. When individuals are asked why they choose to listen to music,[8] responses range from uplifting mood and relieving stress, to using music as a means of self-expression. There are studies[9] that show that playing music or singing with other people can promote the release of oxytocin, a hormone that promotes trust and social bonding. These hormones are associated with positive and calm emotions, something that many individuals strive to achieve when listening to music.

Many scientists strive to connect their work to the medical field, and those researching the effects of music can translate their work into what is known as music therapy. Music therapy has been used in practice since 1789[10] and is described as the use of music to help improve one's quality of life.[11] Music therapists are licensed to use various techniques, such as directed listening, writing, or playing music, to create personalized programs addressing a patient's goals. Research shows that music therapy can be used for a variety of ailments, ranging from stroke and Parkinson's disease to pain and mood disorders. Parkinson's disease[12] is a brain disorder where dopamine neurons that coordinate movement slowly die over time. Studies show that music therapy[13] can help patients with Parkinson's disease improve movement, motor control, mood, and overall quality of life.

Currently, there are no cures for mental health conditions or brain disorders like Parkinson's disease. However, there is a positive trend[14] both in the use of music therapy, as well as in research related to music therapy. To gain further insight into music therapy, more research on how music positively influences the brain is still required.

The audience leaves as we clear the stage. I'm excited to see my friends who came to watch the performance and share in the beauty of the music we all experienced.

Movement 3: Connections Through Sound

Each year, millions of people gather at venues to watch their favorite artists perform. Everyone at the show shares an immediate connection with each other through their love of the artist(s) on stage. The people on stage share a connection with each other as they are creating music with one another. In a band, an individual may start improvising and that may continue throughout the instrumentalists, each one connecting through the music to carry it forward. Within an orchestra, there can be anywhere between 20-100 people playing at once, each one needing to maintain a constant connection with those around them.

At the University of Michigan, the Life Sciences Orchestra[15] was created by a group of physicians, medical students and staff who wanted to share the joy of music with others. Today, it is a 70+ person orchestra that comes together despite busy schedules to create music because it connects us all, no matter the path of life we are on. As a violinist in the orchestra, I find a sense of peace in rehearsal every week leading up to our concerts. After a successful performance at Hill Auditorium, we feel the immense satisfaction of playing challenging music and hearing the crowd cheer across the auditorium. These feelings are no mystery – the release of hormones and the thrill of a performance comes together to strengthen the connections with those around us.

A lot remains to be uncovered about how music positively affects us. However, existing studies support that there are benefits to listening to music, such as with music therapy aiding those going through life changing circumstances. Whether music is for enjoying oneself or to find a community, it is clear that the joy one gets is a shared experience. From the synapses in the brain to the biggest symphonies, we are all connected through sound. *

2024 UM Life Sciences Orchestra at the Hill Auditorium

* * *

Charukesi Sivakumar is a 3rd year PhD Candidate in Molecular and Cellular Pathology at UM, studying the development of the retina. When she's not in the lab, you find her playing disc golf, or immersing herself in music, and finding new ways to connect with the world around us.

Illustrated by **Adriana Brown**
Edited by **Sheila Peeples** and **Jeremy Chen**

Night Shift Day Shift

Julianne Armijo

I worked many years as a night shift nurse. Insidiously, I began experiencing unusual elation, recklessness, and impulsiveness, often followed by depression. For years, this cycle continued, and I didn't know why. I was finally diagnosed with bipolar disorder when a new antidepressant medication catapulted me into a manic episode. After several hospital visits, I stabilized on lamotrigine, a ketogenic diet, and regular sleep. I'm now stable and thriving.

Bipolar disorder is a chronic condition characterized by swings between the lows of depression, the highs of mania, or a mix of the two. These mood states can lead to interpersonal difficulties and professional troubles. While the mechanism of bipolar disorder is poorly understood, genetic, environmental, and neurobiological factors are believed to have a strong influence. The disorder can be managed through a combination of medications, psychiatric care, and therapy.

Self-management can also help through diet, exercise, and, importantly, regular sleep. People of all backgrounds experience bipolar disorder, but those in the healthcare professions, particularly nurses, often work night shifts. Sleep and bipolar disorder experts advise against working night shifts and rotating night/day shifts because rapid alterations to sleep patterns can incite episodes.[1]

I conceived the idea for "Night Shift/Day Shift" as a play on duality: mania and depression, my night and day shift work, and perhaps most poignantly, my experience as a provider and a patient. It's possible to thrive with bipolar disorder and live a whole and content life. However, it takes work and diligence… night and day.

* * *

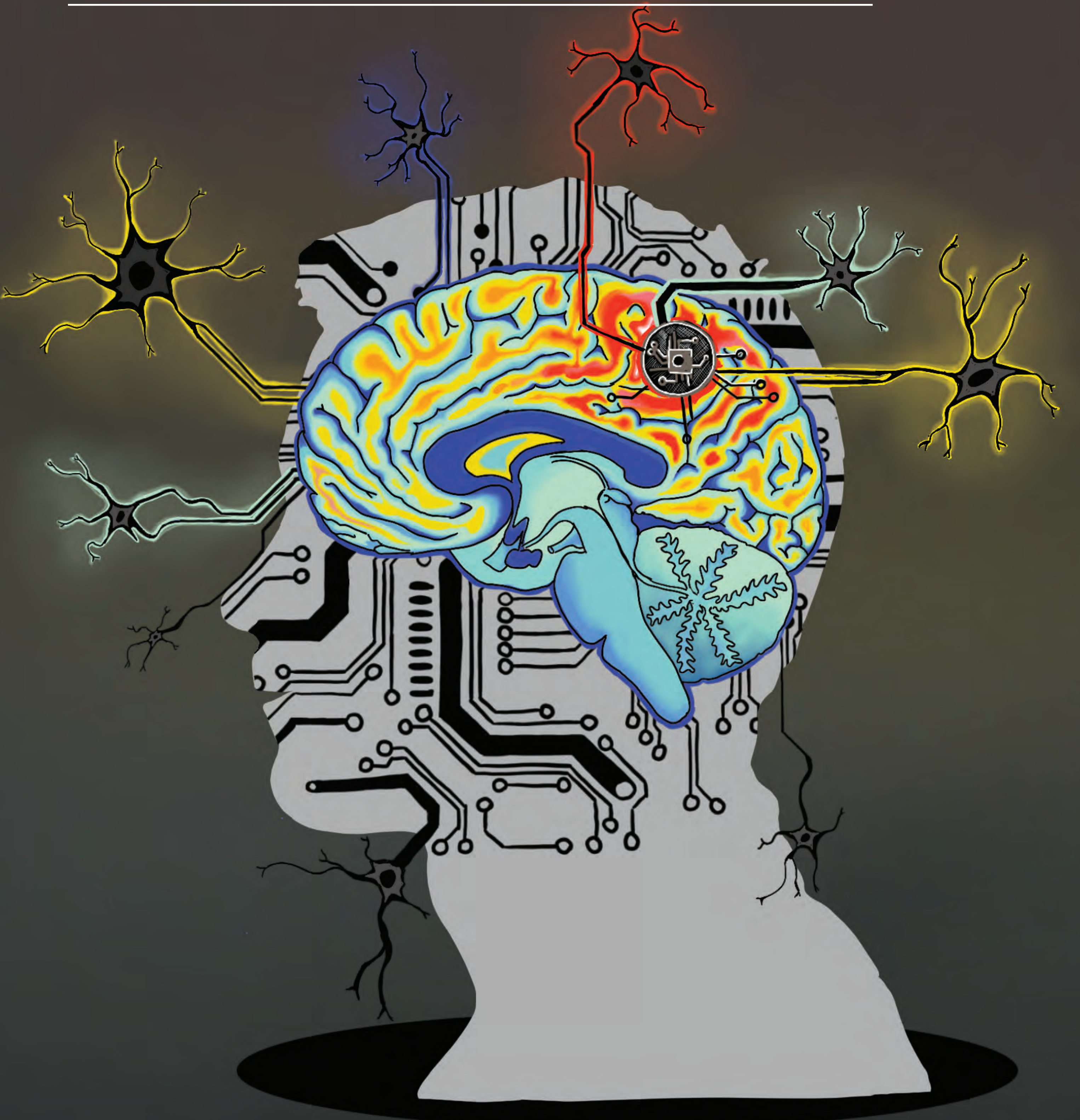
Julianne Armijo, a second-year Ph.D. student at the University of Michigan School of Nursing, investigates the intersections of bipolar disorder, the work environment, and metabolic disorder risk factors. Her pioneering research aims to enhance the quality of life for nurses affected by these complex health issues.

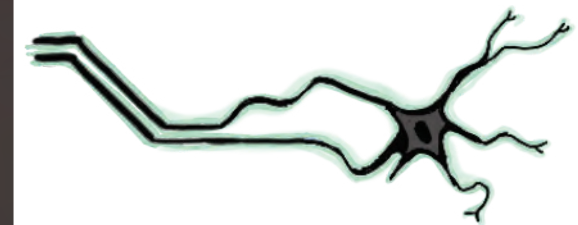
Edited by **Naomi Raicu** and **Claire Shudde**

Cracking the Neural Code:

Monkey Mind Pong and the Future of Brain - Machine Interfaces

Nick Jänne





Humans are mystified by the brain—the software-hardware package behind every book worth reading, every song worth listening to, the start of civilization, and perhaps one day the end of it. Even today, we know very little about what goes on behind the average person's eyes. And while we have uncovered some fundamental properties of cognitive function in the last 4,000 years, curiosity and incomplete understanding have led to science fiction-level fantasies of what might come to pass one more of the truth unravels. We know the popular ones: "The Force" from *Star Wars*, or people using tin-foil hats to block potential mind control technologies. Perhaps most recently you've heard of Elon Musk's company Neuralink. To some, this company seems to promise an all-powerful computer implanted beneath your skull, enabling mind-reading control of the world around you. To the tinfoil crowd, the unthinkable possibilities of this technology prompts a shared vein of fear. However, Neuralink is a single runner in the decades-long race to create the next generation of brain-machine interfaces. What's more, they're beginning to change people's lives for the better—perhaps in ways you might not expect.

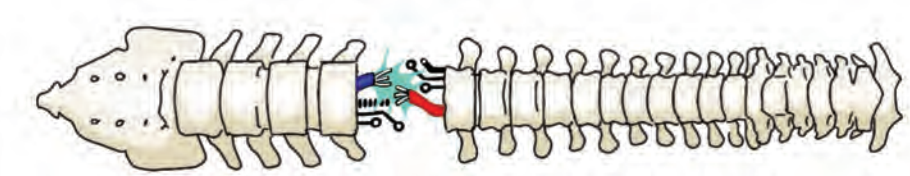
In the 19th century, Emil du Bois-Reymond discovered that the brain uses electricity to communicate with the rest of our body through a subway network of biological communication channels called *nerves*.[1] Just like wires inside a computer, nerves use electrical impulses to carry information between individual cells called neurons. Collections of neurons represent the computational building blocks of the brain's network, and how we utilize our bodies. Broadly, groups of neurons take on specific functions, like sensing at your fingertips, while others are destined to solve calculus homework. Some neurons, like those in the motor cortex, are responsible for moving our limbs and learning how to cartwheel. In essence, the human body is a congregation of electrically-active, purpose-built modules communicating with one another: a biologically driven computer.

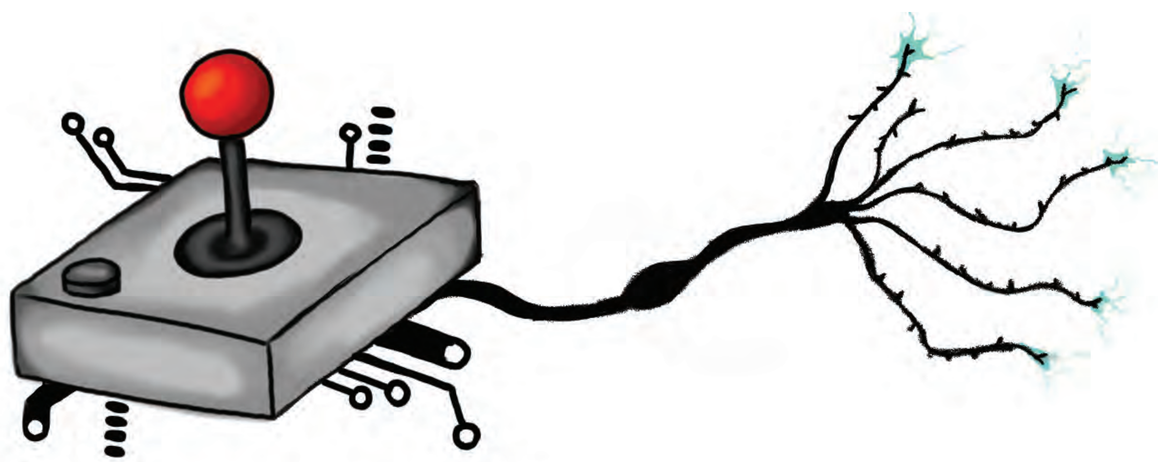
Brain-machine interfaces are devices that act as points of access to the inner workings of this biologically driven computer, the brain. Access is gained through a grid of small carbon electrodes surgically implanted in different sections of brain tissue. Once implanted, these electrodes function like antennae that listen to signals emitted by nearby neurons as they play their part in the larger network. A typical brain machine interface device of today is about the size of a quarter, with each electrode being as narrow as half the width of a human hair.[2]

Where computers and brains begin to differ is in the complexity of their signals. Computers communicate through an agreed upon language known as an encoding. When you press a key on the keyboard, a binary representation of the letter you pressed is sent out, rather than the letter itself. The computer screen receives this representation, decodes it, and transforms it back into the original letter for display. Similarly, brain signals have their own encodings but unlike computers, we don't know the rules that make up this language. This conundrum is the fundamental challenge of neural signal decoding: mutual translation between signals our brains can understand, and signals that computers can.

What would be the significance of cracking the neural code? Consider a case where a person has suffered a spinal cord injury and can no longer move their arms and legs, despite them making the conscious effort to do so. At the site of their damaged spinal cord is a communication gap between signals from the person's brain to move their body and their body actually responding. If brain-machine interfaces can successfully identify and decode this signal to move, perhaps functionality could be restored by "leapfrogging" the injured spinal cord. Short of that, brain machine interfaces might also be able to interpret these signals as control to something else entirely, such as a wheelchair, a set of robot arms, or a truly smart assistive device for those critically impaired.

Monkey test subjects have proven instrumental to the advancement of neural decoding and brain-machine interfaces, despite non-human primate animal research being its own subject of controversy. In 2003, a research





group from Duke successfully taught a monkey to control a robot arm with its brain using some video game trickery.[3] In this experiment, the monkey is first run through a series of teaching trials where it receives food rewards for accomplishing tasks on a video game screen by moving a joystick. Early-stage algorithms used to decode these neural signals were based on mathematical techniques developed from statistical analysis and estimation. Once the brain-machine interface has been given enough time to learn patterns in the monkey's brain activity, the joystick is disconnected. Now, instead of the joystick controlling the robot and game movement, the monkey's decoded brain signals take its place and begin to control the show. While important, unfortunately these kinds of studies have been the subject of accusations of misconduct from animal rights activists. In 2019, Neuralink underwent a probe into violations of the Animal Welfare Act led by the U.S. Department of Agriculture's (USDA) Inspector General. The USDA found no compliance breaches at Neuralink beyond a 2019 incident that had already been reported, but the case highlights the importance of vigilance and ethical conduct in a field where monkeys have been key to many breakthroughs.[4]

These early robot control experiments at the turn of the 21st century were profound, but ultimately, offered a coarse decoding of "left", "right", "up", and so on. Over the past two decades, researchers have improved brain-machine interfaces so that the resulting movement is refined, precise, and human. We can now use neural decoding to type on a full keyboard and control dexterous models of multiple fingers that have the potential for a truly replacement-like hand prosthesis. Parallel advancements in computer science resulted in neural networks taking over as the popular choice for signal decoding, given their flexibility and capacity to model increasingly complex signal patterns.

Budding into popular culture, you may have seen a video titled "monkey mind pong" released in 2021 by Neuralink.[5] This video shows a monkey successfully playing the classic 70's cabinet arcade game *Pong* completely with its mind. The publishing of this video catalyzed a frenzy of new attention on brain-machine interface research, resulting in Neuralink successfully raising over $600 million in the coming three years. And while the technology behind the *Pong* demo itself has existed for at least two decades, Neuralink and others are beginning to use brain-machine interfaces to positively impact patient's lives.

Earlier this year, Neuralink announced its first implantation on a human "Patient 0."[6] This trial participant, Noland Arbaugh, is a 30-year-old quadriplegic man. Before the procedure, he interacted with a computer using an interface constructed of sticks and tubes that he manipulated entirely with his mouth. Once fitted with the Neuralink device, a support team spent months tuning and adapting the brain-machine interface to Noland's specific brain communication patterns. Now fully acclimated, the device enables Noland to operate a computer mouse completely with his mind. In a video shared with the Guardian earlier this year, he describes the technology as "controlling the mouse with 'The Force,'" in that the cursor seemingly follows on the screen wherever he looks or thinks to move it.[7] Noland has been able to rekindle his love for playing online chess and other video games. Delivering a talk in March of this year, Noland stated that moving to the Neuralink device "has completely changed how I live, I'm waking up...excited for the next day, and that's something I thought would never happen to me–ever again."[8]

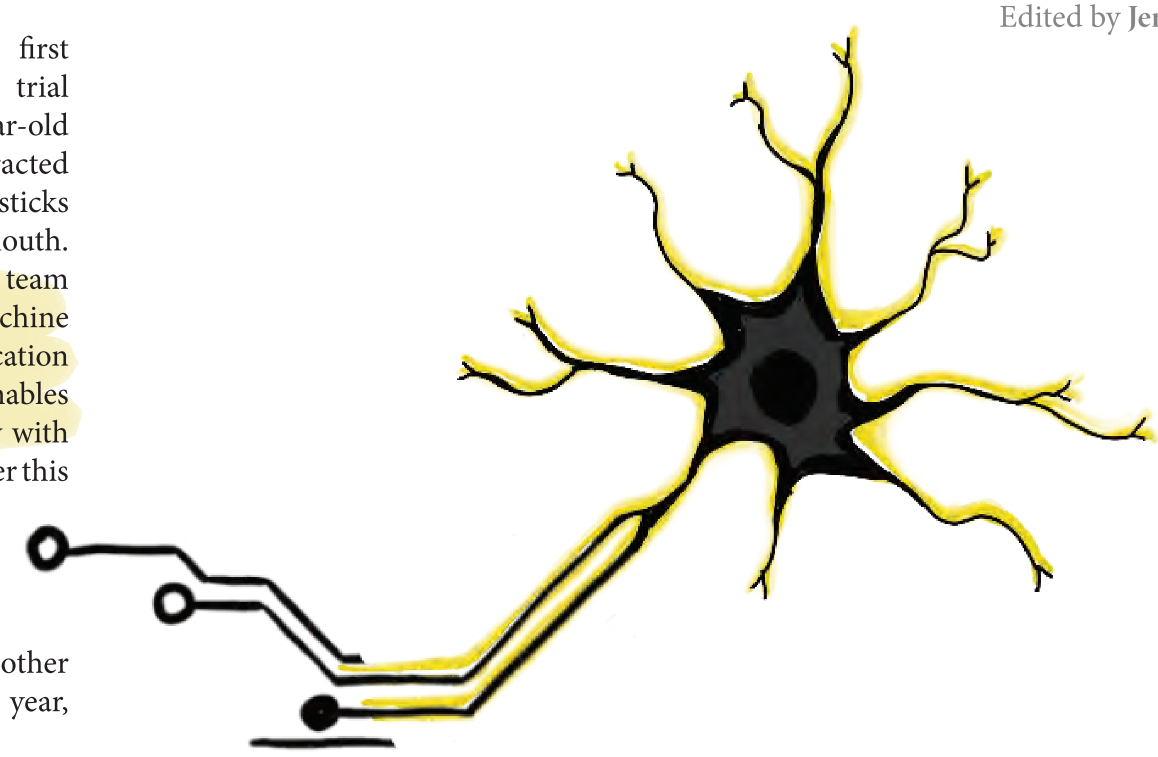
Fundamentally changing someone's life for the better is an inspiring debut for any new technology. However, even as brain machine interfaces positively impact more people, it's important to poke and prod at all the possible ways the next generation of this technology could turn sour. Current research and practical applications mostly center around decoding neural signals in the motor cortex, which humans themselves voluntarily trigger by thinking about or actually performing motor tasks. At the end of the day, there is still an underlying element of consent.

However, there is a growing interest in the research community to expand brain-machine interfaces to other areas of the brain and applications beyond rehabilitation from severe injury. These ideas include more advanced virtual reality video game interfaces, while others are more perverse, such as drowsiness detection as an evaluation of human worker performance or "brain signaturing" for real-time lie detection.[9] Moreover, since most brain-machine interfaces share much of the same underlying technology, funding, and public support, government oversight must balance the great therapeutic potential with what could be co-opted as a true horror. This warning call doesn't have to bring brain machine interface research to a screeching halt. Instead, moments of groundbreaking progress such as the story of Noland Arbaugh can serve as a reminder of where our focus should be. There is still time to direct efforts in the advancement of brain machine interfaces towards goals that suit the public well and are founded in principles of consent. The recent controversies over large language models, such as ChatGPT, illustrate what can happen when society is forced to react to a new technology rather than direct it. The brain machine interfaces of today are the least sophisticated they will ever be. Without a collective envisioning for their future, we'll be caught off guard once again, longing for the days when it was just a game of *Pong*. ⋆

⋆ ⋆ ⋆

Nick Jänne is a PhD student in Robotics, researching how robots can improve their scope of capabilities in the real world by learning from humans. He also hopes to one day build human habitats on the Moon and Mars using a team of robots and humans. Nick received his Bachelors of Computer Engineering degree from the University of Michigan in 2023, and has a passion for reading and writing on the next generation of artificial intelligence.

Illustrated by **Jacquelyn Roberts**
Edited by **Jeremy Chen** and **Claire Shudde**



Lab Notebooks for Art:

A Scientist Develops an Art Practice

Emma Thorton-Kolbe

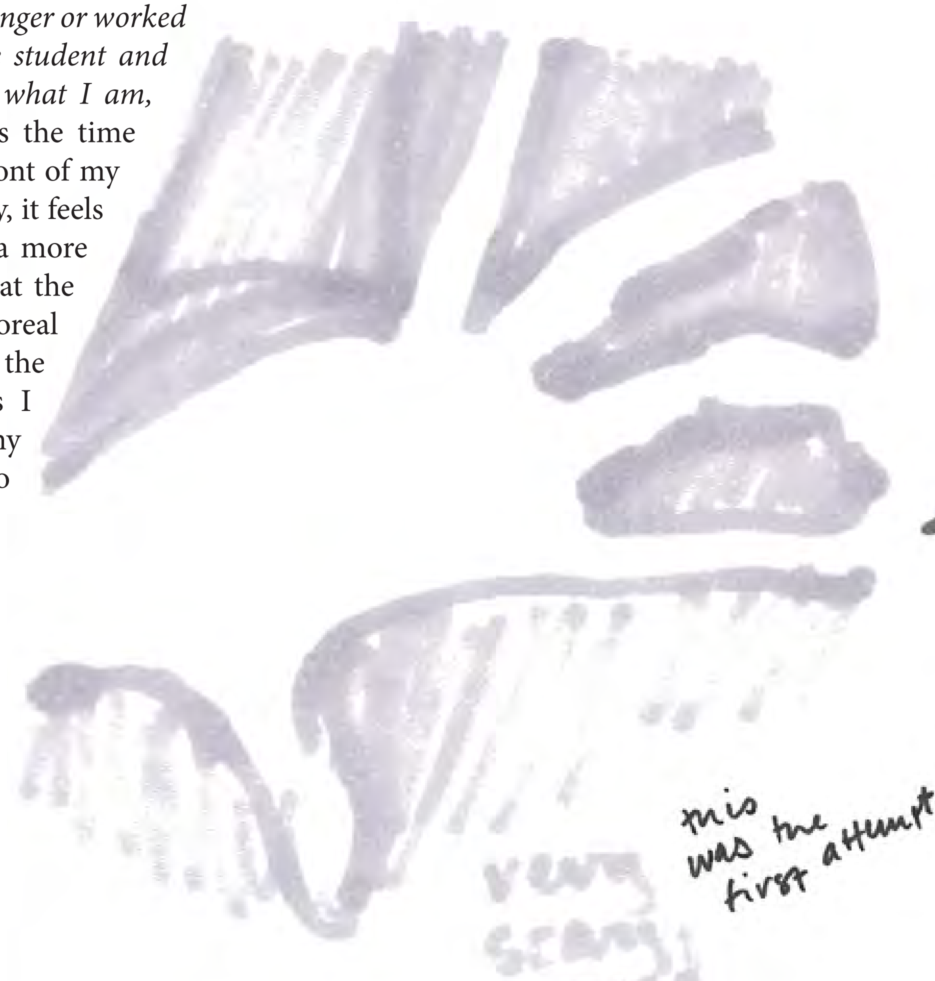
I am a neuroscience PhD student. I spend my days in the lab thinking about how the cells in the fruit fly brain connect to one another during development. I take lots of pictures of those fly neurons. I spend hours staring at a computer measuring different parts of them. I read papers reporting on what other scientists have learned about brain development, and then write papers myself. I love that this is my job. I do it because I think brain development is really neat and because doing experiments requires a balance between creativity and protocol following that appeals to me. In a work day, I can spend mental energy thinking up new ways to visualize my data but also zone out a bit while I do a nice tactile task like brain dissection.

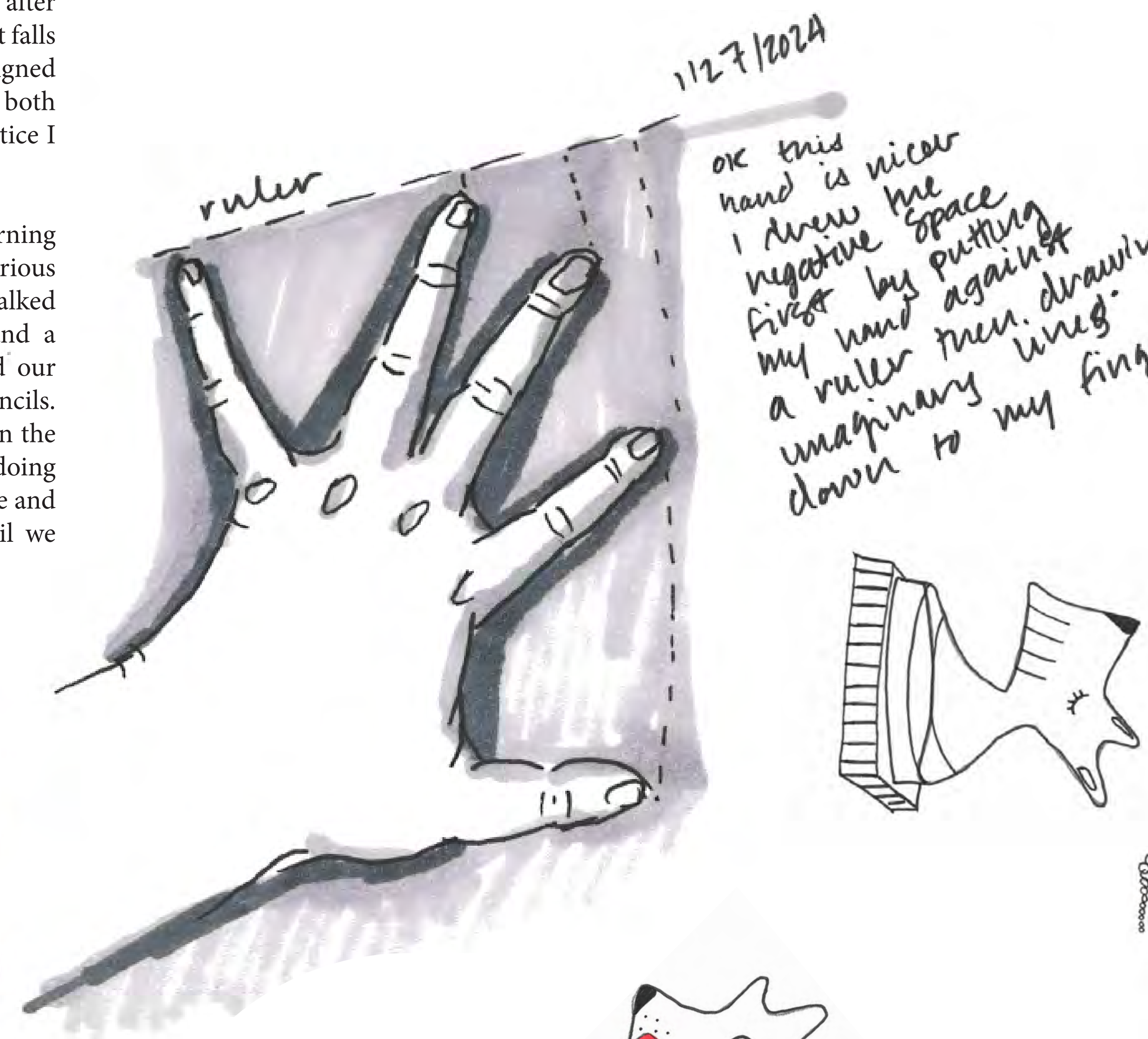
Though I love it, being a graduate student can be all consuming. I usually work a 40-hour week but always feel I could be doing more. There is an underlying feeling that *perhaps if I stayed in lab longer or worked harder, I would be a better graduate student and being a graduate student is most of what I am, so maybe I would be better?* Besides the time pressure, my work is always at the front of my mind. When my experiments go awry, it feels like my life is going awry. Even on a more benign level, I catch myself looking at the branches of the many trees in our arboreal city and thinking that they look like the branches of the projection neurons I study. In an effort to reclaim some of my time, brain space, and self I decided to take another art class.

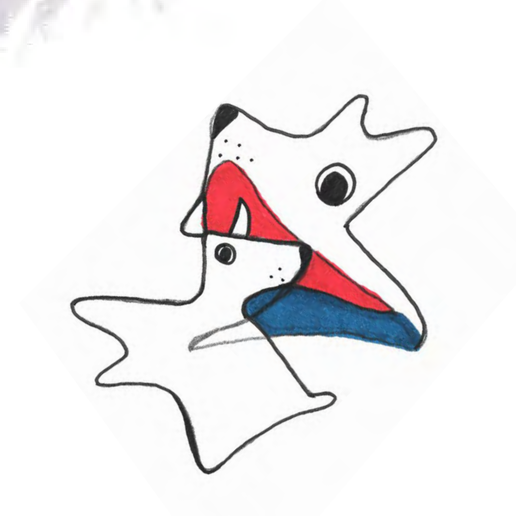
I've always had an interest in art but never found much time for art classes in college alongside classes required for my neuroscience major. My artistic pursuits have been relegated to a hobby which I try to squeeze in on the side. A few times since moving to Ann Arbor, I've hit a breaking point with my work obsession and marked off time in my weekly schedule to take a painting or drawing class at the Ann Arbor Art Center. Unfortunately, after these classes end I somehow loose that time and art falls by the wayside. At the beginning of this year, I signed up for a sketchbook journaling class. I was excited both for the class but also to develop a journaling practice I could hopefully keep up with.

I braved the snow and cold every Saturday morning to go downtown and spend a few hours doing various sketchbook exercises. My classmates and I walked around the art center with a piece of paper and a crayon to collect different textures. We sketched our art supplies to try out all our pens, paints, and pencils. We went and surreptitiously drew people sitting in the Sweetwater's across the street. We were essentially doing lots of art experiments. We were given an objective and then encouraged to try out different things until we found what worked. Once, I drew a very scary hand in a negative space sketching exercise but then hypothesized it would be easier if I could split the negative space into smaller chunks. I lined up my hand against a ruler and drew imaginary lines to my fingertips which resulted in something much less horrifying. As I experimented, I found myself documenting these drawing experiments as I would in my lab notebook.

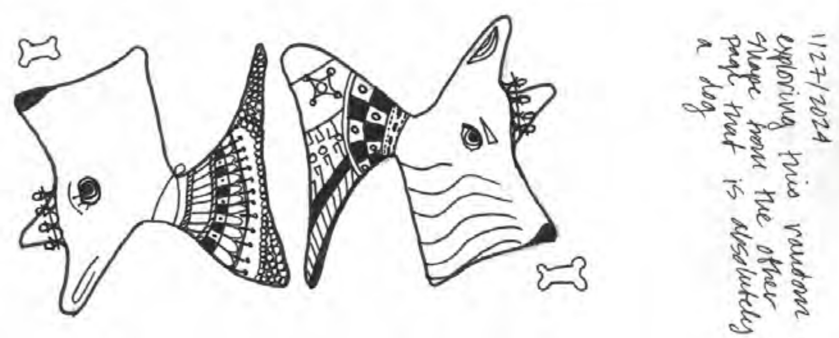
Much of being a successful scientist is keeping a thorough record of experiments in a lab notebook. Some people use physical lab notebooks, some collect loose pieces of paper in a binder, I have a digital lab notebook that I can both type in and use my tablet to hand write in. It's partially a place to keep track of steps in and deviations from a protocol. But more importantly, a lab notebook







is a repository for thoughts. Keeping one encourages deeper thought. For each experiment, I start my lab notebook entry with an objective (why am I doing this experiment?), then I have a protocol or sometimes process notes (what am I doing in this experiment?), and then a graph of my analyzed results (what did I learn in this experiment?). This consistent format serves as a guide. It helps me get started, let's me feel finished, and makes me think about where I want to go next. It structures my practice of science and gives me a scaffold on which to try out new ideas and to be creative.



In my sketchbook, I'd write the same types of notes as I would in my lab notebook. A few quick details of the exercise would go in the margin of a drawing (just in case I wanted to repeat this experiment later). When I figured something out, like a neat kind of line I could make with a brush pen; I'd write down my findings next to the drawing that served as evidence. Because I was writing notes, I paid more attention to the work I was doing; I was alert for things worth noting. This was a springboard for creativity. In writing this piece I transformed one of my sketch book entries into a traditional lab notebook entry. Following this familiar formula lead me to think of more drawing ideas I wanted to try out. Furthermore, I could easily envision how and where I could implement these ideas.

Since the class ended in March, I haven't been keeping up with my art practice. I feel uncertain. Without the regularly scheduled time and someone to tell me what to do I don't know where to start. I enrolled in art class to get some distance from science self but I think I need to soften these boundaries to apply what I've learned as a scientist to structure my art practice. Keeping a lab notebook helped me mature from a student following instructions to an independent scientist following my own interests. Similarly, thinking about what I want to do, trying different ways to doing it, and reflecting on what I've done could help me mature as an artist. Fundamentally, the practice of art and science are not so different so why can't I keep up with both? I suppose I've spent the better part of five years full time dedicating myself to learning to be a scientist and I spend all my time around scientists talking about science. It's maybe not surprising I describe myself first as a neuroscience PhD student. Perhaps, like science, art is also a group activity. Maybe I just need to find some other artists to sit around and do art with.*

* * *

Emma Thorton-Kolbe is a sixth year graduate student in neuroscience. She studies neural circuit development in the fruit fly in the Clowney lab. When not in lab you can find her enjoying her front porch with a novel or a sketchbook or in the yard attending to her garden.

Edited by **Alex Ford**, **Paola Medina-Cabrera**, and **Sheila Peeples**

20240127 Shape Experiment

Saturday, January 27, 2024 11:00 AM

Objective: Find something to draw. Get into the "flow of creating."

Protocol:
From YouTube video "Creating interesting shapes in abstract art" by HelenWellsArtist with additions from Andrea Lozano.

1. Draw a grid. It does not need to be even. - she keeps calling it a "wonky" grid
2. Draw shapes in each square of the grid. Repeat until grid is full. - the volume of shapes takes the pressure off any single one being good.
3. (AL addition) pick the best shape. Trace this shape using tissue paper onto a new page. Rotate and overlap the shape with itself.
4. Do stuff with the shape. Add elements. there were more instructions here that I missed :)

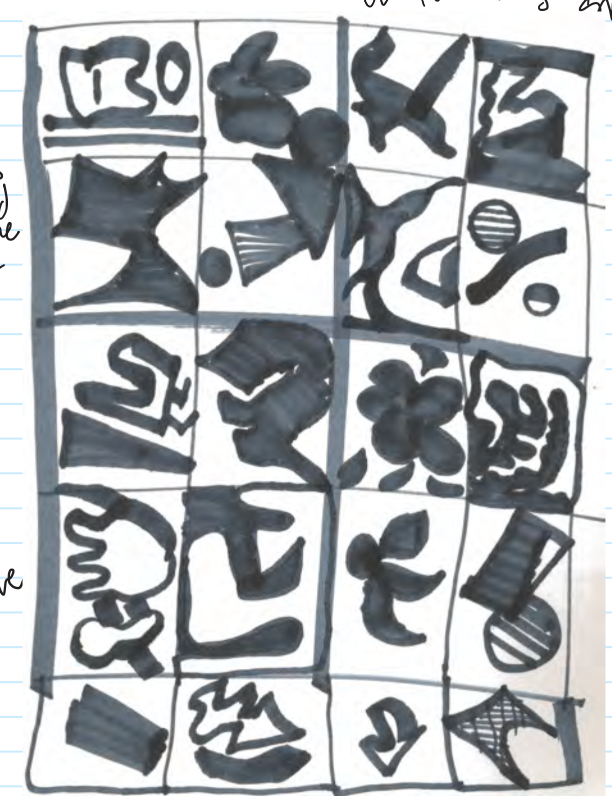
results:

shape grid

some cool shapes in the negative space

I picked this one b/c it looks like a dog

lots of curvy lines in here



overlapped the dog shape and found another dog! modified it a bit to make it work

I put these two opposite eachother like this and it made me think of a playing card. I had a fun time with the patterns of the collars.

conclusion: good experiment. I found so much from just the one shape. I could imagine making either of my results into something bigger/nicer. Could also be interesting to make more stuff out of the other shapes - maybe combining them? It's nice to have this kind of limit on creativity. makes it easier to start.

Appendix

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Cracking the Neural Code: Monkey Mind Pong and the Future of Brain - Machine Interfaces
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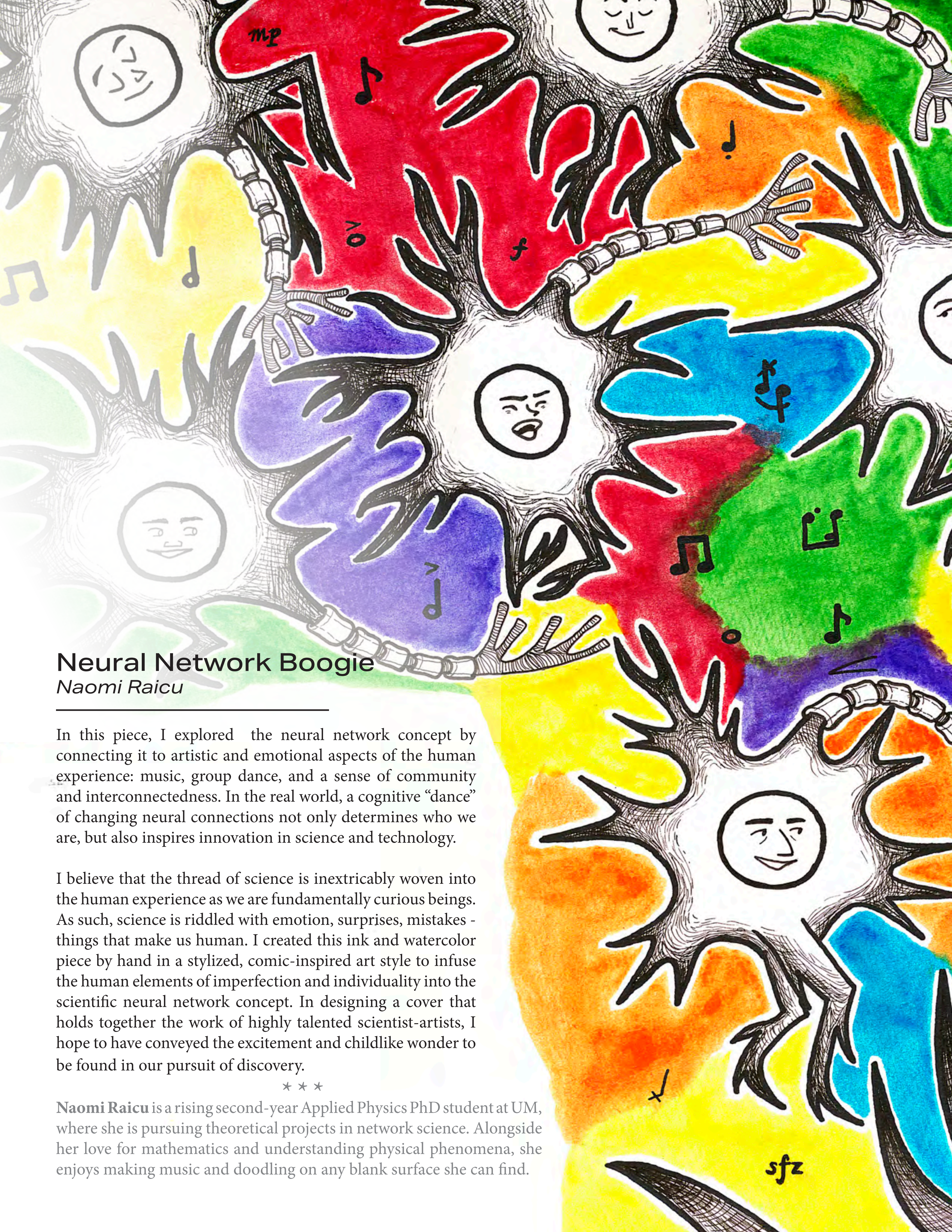

Neural Network Boogie

Naomi Raicu

In this piece, I explored the neural network concept by connecting it to artistic and emotional aspects of the human experience: music, group dance, and a sense of community and interconnectedness. In the real world, a cognitive "dance" of changing neural connections not only determines who we are, but also inspires innovation in science and technology.

I believe that the thread of science is inextricably woven into the human experience as we are fundamentally curious beings. As such, science is riddled with emotion, surprises, mistakes - things that make us human. I created this ink and watercolor piece by hand in a stylized, comic-inspired art style to infuse the human elements of imperfection and individuality into the scientific neural network concept. In designing a cover that holds together the work of highly talented scientist-artists, I hope to have conveyed the excitement and childlike wonder to be found in our pursuit of discovery.

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Naomi Raicu is a rising second-year Applied Physics PhD student at UM, where she is pursuing theoretical projects in network science. Alongside her love for mathematics and understanding physical phenomena, she enjoys making music and doodling on any blank surface she can find.