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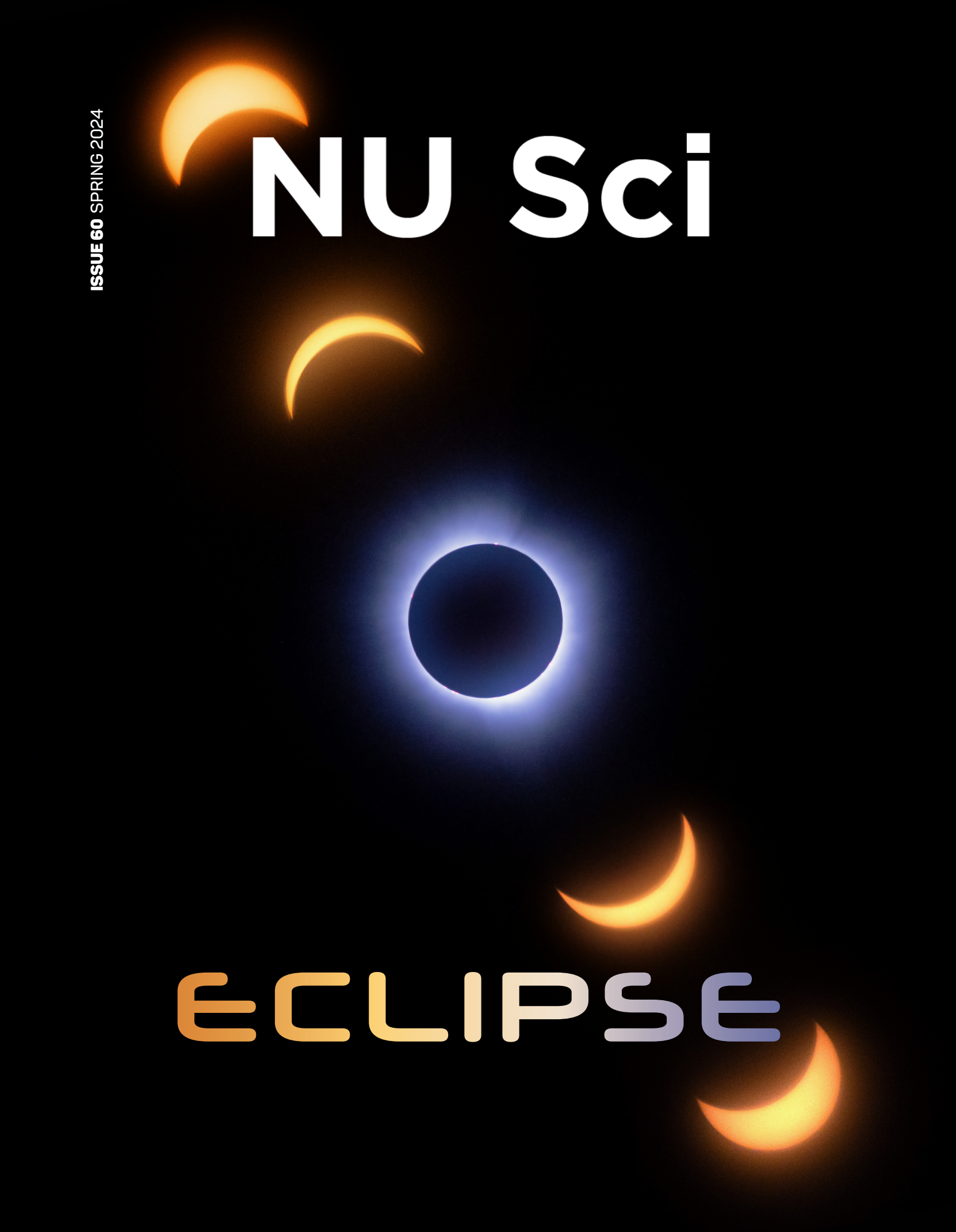

ECLIPSE

Spring 2024

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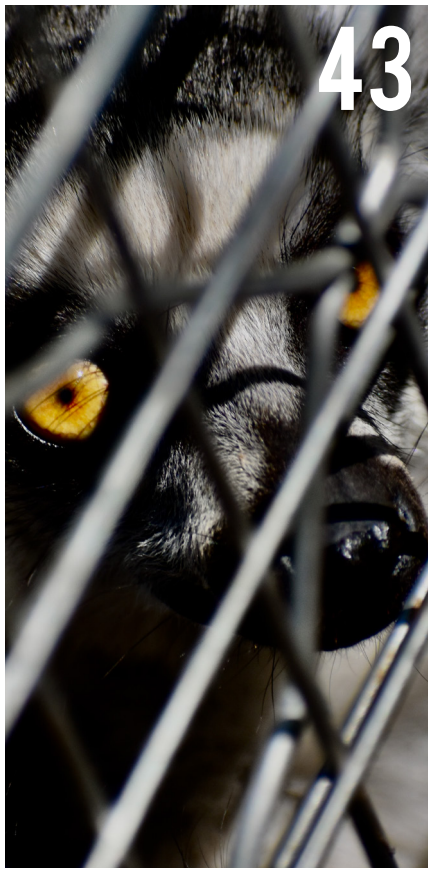


LETTER FROM THE EDITOR

I woke up in a hotel on April 8, 2024, to the sound of rain. My heart sank — I didn't take a seven-hour Amtrak and ride four hours in a car to Erie, Pennsylvania, for some clouds to ruin the total solar eclipse. I consulted the NOAA sky cover projections, formulated a plan, and rallied the troops: my parents and sister.

After another two-hour drive to Cleveland, Ohio, we sat down in a park next to Lake Erie. Hundreds of people were waiting patiently with telescopes, cameras, and glasses. Then, in a single second, the shadow of the moon raced across the sky, plunging us into darkness. The light of planets speckled the sky. The temperature dropped. Pinks, oranges, and yellows glowed on the horizon, surrounding us. People screamed, laughed, cried, used expletives in front of their children, and cried out to their higher powers. In place of the sun was the most inexplicably stunning and surreal sight I had seen in my life. The blackest circle, crowned with sweeping radial twists of glowing-white magnetic fields and fountains of erupting red plasma.

I'll confess, the spectacle is only part of the reason I'm drawn to eclipses. The true joy is experiencing it with complete strangers — watching their pure awe of our utterly unique and unendingly beautiful universe alongside mine. In this issue, we share the pieces of science that fill us with this sublime wonder, from solar eclipses to the northern lights. We explore the hidden intelligence of plants, sex-crazed marsupials, and rats controlling objects with their minds. We look at the mysteries of aging — in people and whales — and the complex peculiarities of our political spectrum.

This transcendent feeling of wonder belongs to all of us. Everyone has a universally-anointed right to stop and watch a sunset, to sit in amazement of how intimately related all living things are. It is the role of the science communicator to gift people this understanding and awe of our universe.

For my last time as editor-in-chief, I thank all of our editors, e-board members, writers, designers, and photographers; our social media and outreach team; and our web team. It has been a great honor to work with passion in this community, to both learn and teach this craft, to play a small part in sharing the sublime nature of science. May the sunset never stop filling you with wonder.

Noah Haggerty
Editor-in-Chief

STAFF

Cover Photo by Noah Haggerty
Back Cover Photo by JiaJia Fu

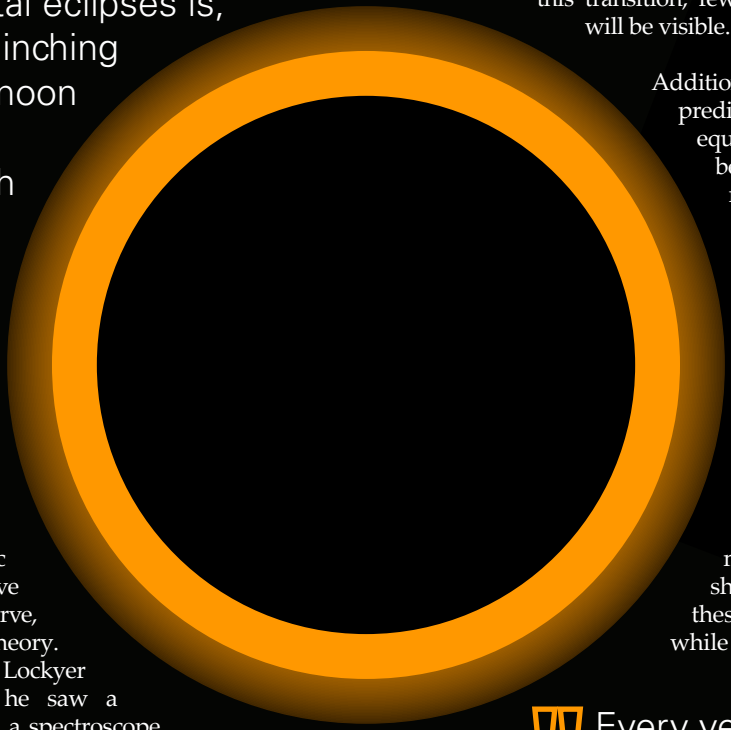
THE END OF THE ECLIPSE

BY ISABELLE KESSOCK, BEHAVIORAL NEUROSCIENCE, 2026

DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING & DESIGN, 2024

For centuries, the rare cosmic occurrences known as eclipses have both inspired and terrified onlookers. Signs of both spiritual and scientific marvels, solar eclipses have often coincided with major historical events, sometimes even rewriting their outcomes. According to ancient records, for example, a great shadow descended over a battle in 585 BCE between the Lydians and Medes in Greece, causing their forces to end the fighting and bring about peace terms. Total eclipses were also seen as a sign of displeasure and even ire from the gods to many people and cultures.

> "This era of total eclipses is, quite literally, inching away as the moon distorts itself from the Earth every year."



Another principal eclipse occurred in 1919, which helped prove Einstein's theory of general relativity and began to consecrate Einstein as the scientific figurehead we know him as today. Multiple teams of astrophysicists photographed this iconic eclipse during totality to prove that matter causes space to curve, as described in Einstein's theory. Moreover, Joseph Norman Lockyer discovered helium when he saw a yellow line of light through a spectroscope during the solar eclipse of 1868. Many thought it was sodium, but nearly thirty years later, terrestrial helium was discovered, finally confirming Lockyer's findings. Eclipses have inspired and aided scientific investigation and innovation for centuries.

This era of total eclipses is, quite literally, inching away as the moon distorts itself from the Earth every year. The exact distances between our planet, its moon, the sun, and the orbital patterns of each determine whether an eclipse occurs, and the eclipses that result in total darkness are only possible because of the equilibrium in these measurements. These specific conditions for occurrence are why these cosmic abnormalities are rare and growing rarer each year. Every year, gravitational forces pull the moon 3.8 centimeters away from Earth, making the diameter of its surface smaller than our planetary perception. While this may not seem alarming at first glance, this change will cause the moon's shadow to become minuscule compared to the sun over hundreds of millions of years. During this transition, fewer and fewer total eclipses will be visible.

Additionally, it is impossible to predict every aspect of this equation. The distance gained between our planet and its moon may remain constant or could drastically increase or decrease one day. These uncertainties bring about the question of human interference: could humans somehow end this separation or even reverse the ground lost so far? Unfortunately, these factors are not amenable to human action, at least not by currently known means. Simply put, people should focus on enjoying these special cosmic events while they last.

> Every year the moon puts an additional 3.8 centimeters between itself and the Earth."

Eventually, these miraculous phenomena will cease to exist. So take advantage of them. Grab your friends and family to see this once-in-a-lifetime event.

PHOTO VIA SHUTTERSTOCK

THE CROWDED HIGHWAYS OF THE ATMOSPHERE

BY JARED DESIMONE, MECHANICAL ENGINEERING, 2027

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

In the current age, satellites are an integral part of a person's life. These useful tools improve and save lives around the globe. They provide GPS and weather forecast data, enable wireless financial transactions, and allow us to predict and track natural disasters. There are 8,261 satellites currently orbiting Earth, and 4,852 of them are active as of January 2022. This is a staggering amount that many scientists find concerning, considering that major aerospace company SpaceX has only sent out about 13% of the satellites they plan to.

As more objects have entered Earth's orbit, the likelihood of collisions has increased. Satellites orbit the Earth at around 7,000 miles per hour, and operators have to be careful about maintaining a safe distance from other satellites to prevent crashes. The consequences of two satellites colliding go beyond the disaster of losing these satellites; as more collisions occur, the risk of future collisions increases. A crash will cause the satellites to splinter into pieces, creating additional obstacles for other satellites and beginning a chain reaction of more collisions. To prevent this, satellite companies calculate how likely a crash is to occur and then maneuver based on those probabilities. In 2022, the number of predicted events of satellites and other space debris becoming dangerously close was 134% greater than in 2020. While these predictions were not all near-collisions, this increase highlights that managing traffic in space is becoming more difficult.

Contributing to this space traffic challenge is SpaceX, an American aerospace company founded by Elon Musk in 2002. Among SpaceX's famous products are its Starlink satellites, designed to provide internet service around the globe. There are currently over 5,000 Starlink satellites in orbit, and the company hopes to eventually launch up to 42,000. SpaceX claimed that its Starlink satellites had enough fuel to perform 350 collision avoidances in their five-year lifetimes. From 2020 to 2022, each satellite had to perform an average of 12 avoidances. However, this number is increasing nonlinearly each year as more satellites launch into orbit, and the Starlink satellites might run out of fuel earlier than their expected lifetimes as they must perform more collision avoidances. This potential impending disaster underlines the need for research into better methods to orchestrate this web of satellites to minimize collisions.

New satellites are not the only thing that scientists find concerning, however. The European Space Agency estimates that there are 36,500 pieces of space debris larger than 4 inches orbiting the Earth. This debris comes from old satellites and rocket parts, and this number rises every time there is a collision that causes satellites to shatter, launching materials in all directions. With more space debris, the risk of collisions also grows. There was a close call on January 27th, 2023, when two large fragments of space junk almost collided. Scientists were watching with fear as these two objects approached each other, and if they had not missed by 20 feet, they would have launched large pieces of debris into orbit for centuries, causing a ripple effect that could have produced increasingly more space pollution. These heightened dangers emphasize a severe need to find methods to eliminate space debris.

The increase in new satellites mixed with discarded space debris has left Earth's orbit as a dangerous minefield that needs constant watch to prevent crashes. There is no straightforward answer to determine how many satellites can safely orbit the planet. Many factors go into this, like whether it is possible to clear current space debris, or whether space companies can design satellite constellations more collaboratively to minimize how close they get. Unless more effort is put into addressing this issue, humanity may discover the maximum number of satellites the "hard way."

PHOTOS VIA SHUTTERSTOCK

Relativity

How one man eclipsed physics

BY PATRICK J. DONNELLY, ELECTRICAL & COMPUTER ENGINEERING, 2026
DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

Born on March 14, 1979, Albert Einstein entered a world similar to, but also irreconcilable with, the one from which he would eventually leave. His birthplace, Ulm, had recently entered the German Empire following decades of petty territorial conflict and an optimistic peace had settled over the region.

From an early age, Einstein pondered the nature of the universe, becoming lost in the invisible pull experienced by the needle of his father's compass, and nevertheless dissatisfied by the electrical engineer's best efforts to explain this pull's origin. Entering school at the age of six, however, he quickly found formal education to be anathema.

While the young boy excelled in matters of creativity, writing small hymns as young as six, and was prodigious in mathematics, mastering geometry and calculus before the age of fourteen, his burgeoning genius went unappreciated by the Bavarian school system, which valued rote memorization of classical literature and languages above all else.

Making matters worse was the social inequality Einstein grew to abhor. Being devoutly Jewish in the majority-Catholic German state, his family faced ostracism and hence took to general reclusion. Although accepted at first by his peers, compulsory religious education soon taught them the skepticism toward the Jewish faith expected of all well-educated Germans.

Einstein was nevertheless happy drifting through school. That is, until his family left him alone with his childhood innocence. Following a series of failed business ventures, his parents relocated to Milan, Italy in search of better opportunities which sadly would not come. Einstein, meanwhile, was left to complete his studies in Bavaria.

The adolescent could see the writing on the wall: his family could not support him forever and he had to become self-sufficient, sooner rather than later. And so, desperate to fulfill this silent edict, he applied for matriculation to the more prestigious Polytechnic Academy at Zurich in lieu of graduating from his secondary school, the Luitpold Gymnasium.

The entrance exams were a disaster. Being out of practice on account of his parents' relocation and generally disinterested in the liberal arts, Einstein failed out and was forced to return to secondary school. Completing his compulsory education and attaining his matriculation certificate, Einstein was eventually admitted to Zurich Technical Academy, the center of science in the German Empire.

Einstein's time at the academy was arguably the most influential of his life. While there, he voraciously studied — not in the classrooms and lecture halls, which he found to be as stifling as those of his old gymnasium, but in the solitude of his modest dwellings, where he consumed every monograph on physics he could find. Graduating in 1900 with a certificate to teach mathematics and physics, Einstein found few opportunities as an aloof, unconnected, Jewish foreigner, despite the acclaim of his professors.

To support himself, Einstein scraped by with temporary teaching positions. That is, until an old schoolmate recommended him to Director Fredrich Haller of the Confederate Patent-Office at Bern. In 1902, Einstein began working at the patent-office, which, though he often found it quite boring, gave him the freedom to meditate upon open problems in physics, especially light.

Prior to the turn of the century, light propagation was explained using the luminiferous aether model, which describes light as a wave moving through an invisible, omnipresent medium. Were this the case, light should have slightly different propagation velocities depending on the Earth's relative motion to the aforementioned aether. However, experimental and cosmological observation continuously yielded identical values for the speed in all circumstances.

The year 1905 saw Albert Einstein publish four papers in the German scientific journal *Annalen der Physik (Annals of Physics)* which tackled this problem and others related to it. The significance of this cannot be understated, earning the year itself the moniker of Einstein's *annus mirabilis.*

His first paper dismantled the theory of the luminiferous aether by explaining the photoelectric effect through light quantization. His second described Brownian motion, indirectly proving the existence of atoms. His third tackled the problem of light propagation directly by presenting the theory of special relativity, with his fourth describing its direct consequence, the principle of mass-energy equivalence, $E = mc^2$.

Einstein's solution to the paradox of light was incredibly straightforward: the speed of light is, in fact, the same in all inertial reference frames. The only paradox comes from the implicit assumption that the passage of time is the same for all observers. According to special relativity, it is only relative to the observer.

> "The answer, keeping in theme with the rest of Einstein's work, is surprisingly simple: wait for the Sun to go out."

Einstein knew, however, that his work was incomplete. After all, his theory only applied to inertial reference frames, hence the name "special" relativity, as it is a special case. What he was truly after was a universal model of physics, a "general" theory of relativity, the development of which would consume the next decade of his life.

The basis for general relativity revolves around the problem of gravity. By this point, the theory of quantum mechanics emerged as the theoretical basis for microscopic phenomena. However, no mechanism for the gravitational force had been found yet, leaving no defensible explanation for the phenomenon itself or its effect on quantum particles.

Einstein's answer to this problem, the theory of general relativity, came in 1915, with surprisingly similar austerity to that of special relativity. Put simply, he posits that gravity is not a force at all, but a bending of space-time, whose resulting curvature affects matter in a manner quite similar to a Newtonian force, although it is in fact a fictitious force.

While undoubtedly revolutionary, and eventually becoming the basis for our current model of macroscopic physics, neither special nor general relativity were immediately accepted by the scientific community at large. The severe paradigm shifts each theory proposed aroused skepticism, not to mention the distinct lack of experimental evidence for either phenomenon at the time.

Additionally, given the political climate at the time, many scientists were dubious of "German science," with some British journals even outright boycotting its distribution. Given the fact that Einstein himself was German-born, his ideas were slow to spread outside of central Europe until after the end of World War I.

Nevertheless, general relativity explained several astronomical mysteries, including irregularities in the orbit of Mercury and gravitational redshifting. Of particular note was gravitational lensing, or the bending of light around massive bodies, through which relativity could be objectively tested.

For light bent around the Sun, the difference in expected lensing between Newtonian and relativistic theory is a factor of two, with the latter expecting the greater deflection. Thus, with accurate enough measurements, one could empirically determine whether the universe is Newtonian or relativistic.

The problem then became how one could possibly measure the curvature of light around such a massive light source. The answer, keeping in theme with the rest of Einstein's work, is surprisingly simple: wait for the Sun to go out. That is, take photographs of a total solar eclipse and measure the deflection of the stars near the corona.

The opportunity to do just this came in the form of Sir Arthur Eddington, Secretary of the Royal Astronomical Society, who was among the first British scientists to be persuaded by Einstein's papers, going so far as to translate and explain them for his colleagues.

Eddington spearheaded two concurrent expeditions on behalf of the Royal Society of London to the island of Príncipe, in the Gulf of Guinea, and Sobral, a town in Brazil, in anticipation of the total solar eclipse expected on May 29, 1919. The results favored Einstein's theory over Newton's, a fact soon corroborated by subsequent expeditions and independent experiments.

And so, in the span of two decades, physics was irrevocably changed by Albert Einstein, one man who dared to apply Occam's razor to the universe itself.

Historical Studies in the Physical and Biological Sciences (1986). DOI: 10.2307/27757561
Historical Studies in the Physical Sciences (1980). DOI: 10.2307/27757471
The Meaning of Relativity (1921). ISBN: 9780691023526
Relativity: The Special and General Theory (1920). ISBN: 9781587340925

PHOTOS VIA SHUTTERSTOCK

The awe of the few brief minutes in the totality of a solar eclipse comes from not only the striking black orb glowing above your head but also how it transforms the entire sky. The bright blue of midday fades within seconds almost to black. The yellows, pinks, and oranges that typically only decorate the sky during sunrise and sunset now fill the horizon in every direction. And if you're lucky, you might even be able to make out a few stars.

PHOTO BY JIAJIA FU, BIOENGINEERING, 2026

Nature's light show: Breaking down the 2024 aurora super season

BY DIVYA RAVIKUMAR, BIOENGINEERING & BIOCHEMISTRY, 2025

Auroras — dazzling phenomena that paint the night sky with a myriad of colors — have fascinated humans for thousands of years. Occurring in both the Northern and Southern hemispheres, they are known as the aurora borealis and australis, or northern and southern lights, respectively. At the start of 2024, auroras entered a super season, meaning their activity will peak for the next couple of years.

Auroras are formed when energized particles, or ions, from the sun collide with the Earth's upper atmosphere at speeds up to 45 million miles per hour. The sun is continuously releasing energy and ions into space, with the most common form being solar winds. Aside from constant solar winds, there are also less common solar storms, or coronal mass ejections, that release an extremely large amount of energy at once. The Earth's magnetic field protects its surface by redirecting the ions towards the North and South Poles. Without the magnetosphere, solar energy would destroy the atmosphere and prevent life from thriving.

Though most of the solar winds are blocked, ring-shaped ionospheres near the poles about 1000 kilometers above the surface trap ions for a short while. Ionospheres are a shell of electrons and electrically charged atoms in the Earth's upper atmosphere. The interactions between the energized solar particles and the gases in the Earth's atmosphere create the stunning visuals of auroras. Oxygen emanates green and red lights while nitrogen shines blue and red. Hydrogen and helium also result in blue and purple, but these shades on the electromagnetic spectrum are rarely detectable by the naked eye.

The most vibrant auroras happen when the solar activity is the strongest, which is why auroras will be at their peak for the next few years. The sun is currently approaching a solar maximum, or its highest rate of activity, after its solar minimum in December 2019. Solar cycles are periods of solar activity driven by the sun's magnetic field and defined by the frequency and intensity of the sunspots visible on its surface. Although scientists cannot say for certain exactly when the sun's activity will reach its peak, the National Oceanic and Atmospheric Administration's Space Weather Prediction Center recently predicted it to be between January and October of 2024. This prediction is based on historical records, statistics, and models of the solar dynamo, which is the flow of ionized gases inside the sun that generate its magnetic field.

Two major factors are causing the coming super season. First, the current solar cycle is classified as "moderate." This means that, in contrast to "strong" cycles whose activity peaks last for just less than a year, it will likely produce a flat and extended solar maximum for about two years and consist of two or more sub-peaks of activity during this timeframe. Second, the characteristics of active regions on the sun vary throughout the solar cycle. Since the sun is in the declining phase of the cycle, there is a larger proportion of giant and more magnetically complex sunspots, which are more prone to solar flares that would trigger strong auroras on Earth. Because of these factors, the best auroras in a solar cycle happen several years after the peak of the cycle itself.

With the super season on the horizon, this is one of the best chances to be amazed by one of the prettiest natural phenomena Earth has to offer.

DESIGN BY KATHRYN FURMAN, COMPUTER SCIENCE & MATHEMATICS, 2025

PHOTOS BY ETHAN SZETO, COMPUTER SCIENCE & MATHEMATICS, 2026

GENETIC PROGRAMMING
HOW MACHINE LEARNING IS EVOLVING TO SOLVE MATH PROBLEMS

BY KEVIN LU, COMPUTER SCIENCE AND MATHEMATICS, 2026

DESIGN BY VIVIAN LIN, BIOCHEMISTRY, 2026

In 1859, Charles Darwin published his groundbreaking theory of evolution in "On the Origin of Species," where he introduced the world to the concept of natural selection. In the struggle for existence and reproduction, the strongest would survive, passing on their advantageous genes to their offspring. Never could Darwin have envisioned that centuries later, such a phenomenon would manifest in artificial intelligence.

A team of researchers at Google's DeepMind lab has pioneered a model that combines large language models (LLMs) with the process of natural selection to create computer programs. In the model, the LLM create new offspring programs with mutations, while an "evaluator" algorithm acts as the mechanism of natural selection, eliminating invalid or weaker programs and allowing stronger ones to propagate to the next generation. When presented with a problem, their model — FunSearch — is tasked with developing multiple programs to solve it, where each program represents a distinct "genetic line." Each program receives a score from the evaluator, and those with higher scores are passed into FunSearch's LLM as prompts, giving birth to new programs.

Rather than training a model that considers a number of factors and variables for a given problem and outputs a computer program, FunSearch uses a "Darwinian" approach by evolving the code in the solution programs themselves. Preliminary results from this approach show FunSearch was able to outperform traditional machine learning methods in solving difficult math problems.

The team applied a few more key techniques to improve the evolution of FunSearch programs. First, programs are divided into clusters, based on their "genetic signature," which is calculated from their evaluator scores and code characteristics. Much like the Galapagos islands, each cluster exhibits unique traits, fostering diversity within the ecosystem. Underperforming clusters then die off, while promising ones continue to flourish and diversify. Researchers also provide boilerplate code to FunSearch, giving them greater control over the path of evolution — FunSearch only evolves code governing the critical program logic, while the researchers determine the code structure.

FunSearch has shown surprising results, exceeding state-of-the-art solutions to the mathematical problem known as the "cap-set problem." The problem consists of finding the largest set of points (called a cap set) in a multidimensional grid where no three points lie on a line — it's like playing a Connect Four ripoff called Connect Three and intentionally trying to lose. Solutions to the cap set problem are useful for designing error-correcting codes used in transmitting data between computers, as well as developing complex cryptography for online security.

FunSearch generated solutions (in the form of programs) that computed the largest cap sets ever found, and it was the single biggest step forward in solution size in the last 20 years. Moreover, by outperforming state-of-the-art computational solvers, FunSearch has cemented its status as a revolutionary tool in mathematical problem-solving.

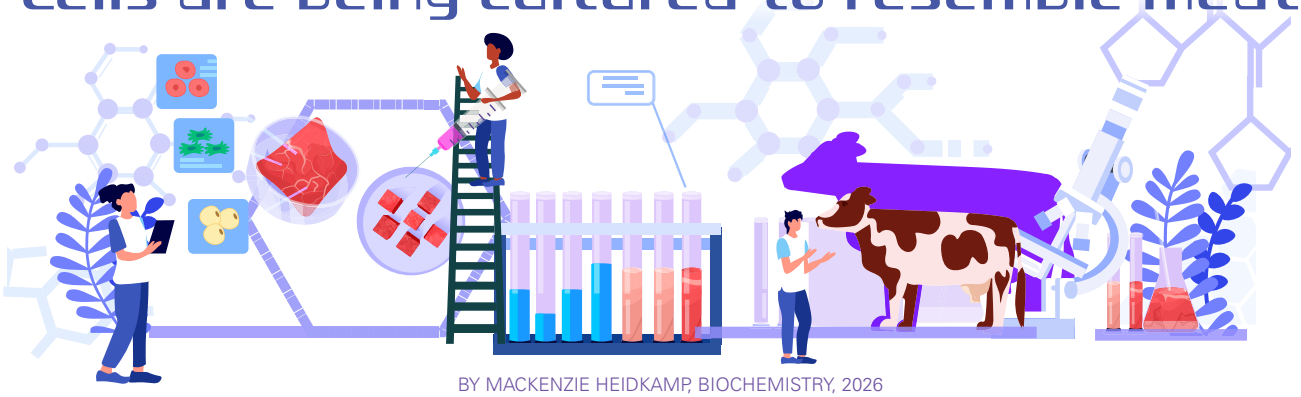
FunSearch represents the newest breed of LLM applications. Complex logical optimization problems in math have been some of the largest hurdles for AI in the last decade, yet this model surpasses even human performance on these problems. These developments are exciting yet terrifying — what other capabilities might AI possess that remain undiscovered? For now, humanity remains in control, but as a species, we must adapt in tandem with technological progress. In "On the Origin of Species," Darwin famously wrote, "It is not the strongest of the species that survives, not the most intelligent that survives. It is the one that is the most adaptable to change."

Nature (2023). DOI: 10.1038/s41586-023-06924-6

PHOTO VIA SHUTTERSTOCK

Scientists by day, chefs by night

Cells are being cultured to resemble meat



BY MACKENZIE HEIDKAMP, BIOCHEMISTRY, 2026

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

Knowing that animal agriculture is responsible for at least 14.5% of all carbon emissions, scientists have been researching alternatives to the traditional meat diet, with the current leading alternative being meat analogs or "fake meats." The menus of vegan-friendly, trendy restaurants and even your run-of-the-mill spots, like Burger King, have been featuring items such as quinoa burgers, black bean patties, soy chicken, and tofu-flaxseed eggs. In an effort to promote these foods, chefs have been able to make extravagant and seemingly delicious dishes with these ingredients. However, these meat analogs have yet to reach mass acceptance in the general public for one leading reason: People like meat. A 2021 poll by Ipsos found that 89% of Americans report consuming meat on a regular basis, and a majority of those people also reported associating eating meat with the "American way of life." To combat this issue from a different angle, many startups have been investigating a way to somehow serve "real" meat without raising livestock.

> The task of convincing an avid meat lover to eat a steak freshly grown in a lab may arguably be their biggest obstacle yet."

Bioengineer Yaakov Nahmias has been developing a way to produce meat using fermentation tanks and animal cells. His company, Believer Meats Kitchen, takes a piece of animal tissue and selects cells that are capable of self-renewing into fat and muscle cells, which are the cells that make up meat. These cells are then placed in a nutrient-rich broth and multiply until they start to resemble chunks of meat. Nahmias emphasizes that his company does not harm animals and is actively hoping to not only transform the planet but also help countries become food independent. "Our food production ecosystem is unsustainable," Nahmias told the journalism nonprofit *ISRAEL21c*. "We are using more than 30% of the land and 30% of the global freshwater supply to make meat, and we're running out of both." Manufacturing meat from cell lines and tanks requires 98% less water and 95% less land. This means that countries that are currently producing meat through agriculture could use water and land for other purposes, and countries that are reliant on other livestock-raising countries could potentially self-produce.

While this technology seems to be checking all the boxes, many experts are not confident in its widespread appeal. Meat-eaters may be skeptical of eating anything grown in a lab and anything that does not have the exact texture and taste of traditional livestock. A study conducted by social scientist Chris Bryant found that consumers were less willing to try this new line of meat when they were told it was "lab-grown." They expanded that the process seemed unnatural and were generally concerned about potential health risks. Even the founder of Believer Meats Kitchen's 10-year-old son told the Associated Press that he will continue to eat animals because "they are yummy."

Currently, researchers in the field are working to either make a perfect meat equivalent or a cheap alternative. They are aware that consumers will not spend extra money on their fermentation-tank meat if it does not taste exactly the same. However, the aspect of lowering cost proves to be challenging at the moment due to the extremely essential yet expensive ingredient: growth factors. Without the bath mixture of growth factors and amino acids, the cells will not divide and turn into the desired meats.

Once they discover cheaper methods and how to shift cultural norms, Believer Meats Kitchen may be the next Perdue Chicken or Cargill Meat. However, the task of convincing an avid meat lover to eat a steak freshly grown in a lab may arguably be their biggest obstacle yet.

Nature (2023). DOI: 10.1038/d41586-023-02095-6
Appetite (2019). DOI: 10.1016/j.appet.2019.02.021

PHOTO VIA SHUTTERSTOCK

Could inhalable nanosensors become the future of cancer research?

BY HAVISHA NEELAMRAJU, DATA SCIENCE & BIOLOGY, 2026

DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING & DESIGN, 2024

Researchers at MIT have developed a novel approach that has the potential to increase the accuracy and efficiency of early lung cancer detection. The new diagnostic test is based on nanosensors, capable of entering the body via an inhaler or nebulizer, and a strip-based paper urine test that can identify DNA barcodes associated with particular lung cancer-linked proteins.

The technology could potentially replace or supplement the leading biomedical process used for lung cancer diagnosis: low-dose CT scans. Known to decrease mortality in those with a high risk for cancer, these non-invasive scans function as special X-rays that take multiple pictures of the subject's chest as they lie on a table and slide in and out of the CT machine. Despite CT scans' popularity and delivery of accurate results over the years, nanosensors, combined with the paper urine test, can serve as an accurate and reasonably priced alternative for underprivileged populations in low- and middle-income countries.

"The epidemiology of lung cancer globally is that it's driven by pollution and smoking, so we know that those are settings where accessibility to this kind of technology could have a big impact," Sangeetha Bhatia told *MIT News*. Bhatia is a professor of Health Sciences and of Electrical Engineering and Computer Science at MIT, and a member of MIT's Koch Institute for Integrative Cancer Research and the Institute for Medical Engineering and Science.

Bhatia's lab has spent the last few years developing nanosensors to improve early lung cancer detection. Their study involved coating polymer nanoparticles with a reporter such as a DNA barcode, which can be cleaved from the particle when the nanosensor locates the protease enzyme in cancer-associated proteins. Considering that these enzymes are identified by their overactivity in

PHOTOS VIA SHUTTERSTOCK

tumors, the DNA reporters are responsible for tagging cancer-linked proteins and eventually accumulating in the individual's urine.

While previous versions of the sensors were designed to be inserted through the veins and utilize mass spectrometry to analyze urine samples, the team was keen on creating a version of the sensor that could be inhaled in order to increase accessibility in resource-deprived areas. With that consideration in mind, a lateral flow assay was developed to detect four specific DNA barcodes, using a paper strip.

> "With adequate funding, inhalable nanosensors have the potential to reduce the resource threshold for cancer detection."

"We were really pushing this assay to be point-of-care available in a low-resource setting, so the idea was to not do any sample processing, not do any amplification, just to be able to put the sample right on the paper and read it out in 20 minutes," Bhatia told *MIT News*.

The system was tested in mice that were genetically engineered to develop tumors similar to those observed in humans. In the first set of experiments, the scientists administered the sensors to the mice after 7.5 weeks since this time period aligns with stage 1 or 2 of cancer in humans. Although 20 distinct sensors were used to detect different proteases, the team was able to identify four particular sensors that accurately detected the early-stage lung tumors in the experimental mice. While it is possible that humans may require a greater number of sensors for an accurate diagnosis, using four or more paper strips — each of which detects four or more different sensors — can achieve the same results as the study.

As a next step, the researchers plan on analyzing human biopsy samples to verify that the sensors work as expected when detecting human cancers. In fact, a company called SunBird Bio has already run phase 1 trials on a similar sensor developed by Bhatia's lab, which proved to be useful in diagnosing liver cancer and nonalcoholic steatohepatitis (NASH).

"The CT scan is a good tool that can see a lot of things," she told *MIT News*. "The problem with it is that 95% of what it finds is not cancer, and right now you have to biopsy too many patients who test positive."

In a fast-paced, technologically advancing world, Polaris Market Research predicts that the global market for disposable medical sensors is expected to grow from $10.4 billion to $42.4 billion in 2032, representing a 16.9% annual growth rate over the next decade. With adequate funding, inhalable nanosensors have the potential to reduce the resource threshold for cancer detection; enhance cancer screening and detection tools to provide a more rapid diagnosis and treatment; and improve global health by providing underprivileged populations with a reasonably priced, simple-to-use, and efficient alternative.

Science Advances (2024). DOI: 10.1126/sciadv.adj9591

LIVE FAST, DIE YOUNG

THE MYSTERIOUS LIFE OF AUSTRALIA'S SEX-CRAZED MARSUPIAL

BY SAI TUMMALA, CELL & MOLECULAR BIOLOGY, 2026

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

Guys literally only want one thing. Or at least, the male antechinus, an Australian marsupial, seems to prioritize one thing over everything else: sex. These mouse-like animals live fast and die young, forgoing sleep in order to reproduce during their short fertile window. Scientists are, naturally, fascinated by these pocket-sized marsupials and their exciting, mysterious lives.

In the animal kingdom, where survival of the fittest is a fact of life, the two most important things to a critter are staying alive and reproducing. While most vertebrates are iteroparous, meaning they have multiple reproductive cycles in their life, the antechinus is semelparous, having only one reproductive episode. Dubbed "suicidal reproduction," semelparity means that the male antechinus dies shortly after mating. One group of Australian researchers sought to determine whether this early death is related to the male antechinus's lack of sleep during the mating season.

First, the researchers wanted to confirm that male antechinus did indeed sleep less during mating season. Using an electroencephalogram (EEG), they measured the time the antechinus spent awake versus asleep. Additionally, they measured levels of oxalic acid, a biomarker of sleep, before and during mating season. As the team predicted, there was a decline in oxalic acid during the mating season, indicating a decrease in the amount of time spent sleeping. On average, a male antechinus lost three hours of sleep each night. Unexpectedly, there was not a large difference in oxalic acid levels between male and female antechinus, which the study says hints that "[female antechinus] are sleep deprived in the wild, perhaps owing to male harassment."

So what does this sleep deficit have to do with the short life span of male antechinuses? In general, sleep deprivation has disastrous impacts on the health of most organisms. A famous study by researchers at the University of Chicago discovered that reducing the sleeping time of rats by 70%–90% led to the death of all the rats within two to three weeks. However, John Lesku, a zoologist involved in the Australian research study, believes that male antechinuses die early due to a factor other than sleep deficit. In fact, Lesku argues that the sleep deficit is completely unrelated to the shortened lifespan of male antechinuses. He believes this because, in his words, "Three hours of sleep loss is not lethal in any animal we know of."

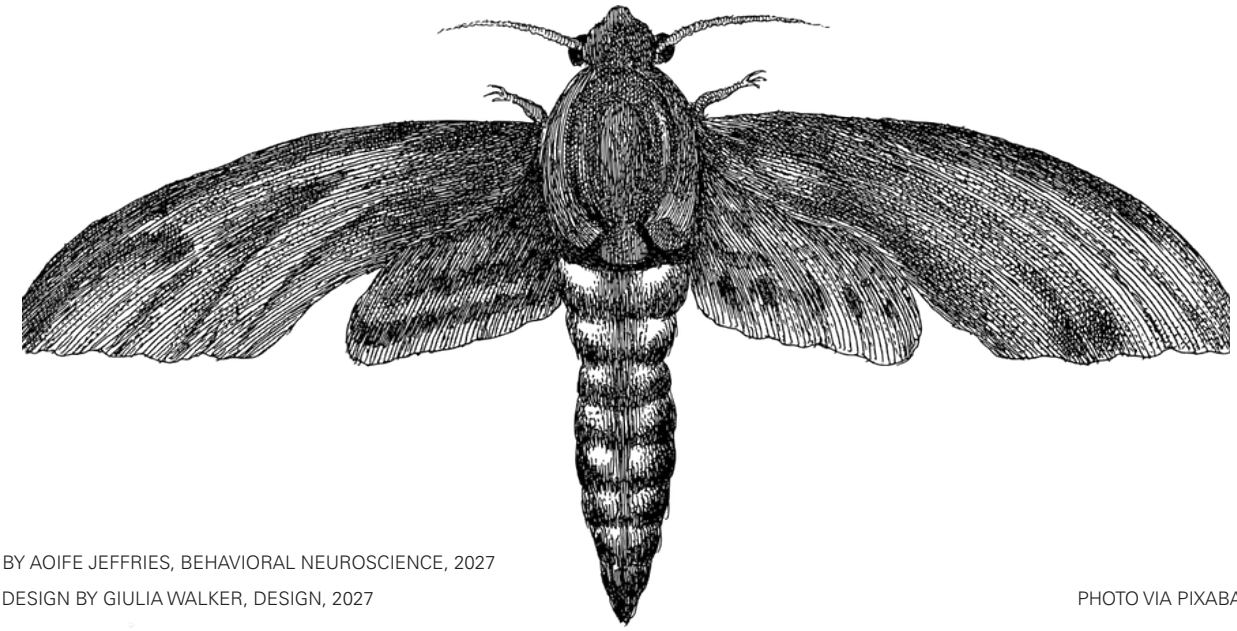
The Australian researchers have proposed multiple hypotheses for the cause of male antechinuses death. One proposal is that increased testosterone levels during mating season lead to an elevated corticosteroid level. Corticosteroids catabolize, which breaks down proteins, often causing muscle loss to a fatal degree. Another theory is that the corticosteroid increase makes male antechinuses more susceptible to parasite infestation early during mating season, dooming the organism to an early death. Corticosteroids have been found to suppress key mediators of the immune response to parasites. The mystery of the male antechinus remains unsolved, but the Australian research team plans to continue to investigate what kills these restless marsupials.

Current Biology (2024). DOI: 10.1016/j.cub.2023.12.064
Sleep (2002). DOI: 10.1093/sleep/25.1.18

PHOTOS VIA SHUTTERSTOCK

LIKE A MOTH TO A FLAME

WHY INSECTS ARE ATTRACTED TO LIGHT



BY AOIFE JEFFRIES, BEHAVIORAL NEUROSCIENCE, 2027

DESIGN BY GIULIA WALKER, DESIGN, 2027

PHOTO VIA PIXABAY

Watching swarms of tiny insects dive into burning fires can be fascinating, but what drives them to this fiery death? From the first man-made fire to modern light fixtures, artificial illumination has drawn insects in, often to their deaths. Until now, it has been widely theorized that insects are attracted to light, even when it goes against their drive for survival. This theory of fatal attraction seems plausible as we watch moths, beetles, and flies race toward the light, but in reality, they're just confused.

Over the last two years, a team of researchers led by Samuel Fabian collected field data in Costa Rica that shed light on this peculiar behavior. Using high-resolution motion capture and stereo-videography, the researchers were able to capture the flight trajectories of ten orders of insects as they flew in the presence of artificial light. Analyses of the three-dimensional flight data allowed the scientists to reproduce a model of the insects' behavior and orientation throughout their flight, demonstrating that an innate behavior is responsible for the light-entrapment phenomenon.

The insectual desire to tilt backward toward a light source is driven by navigational needs. Since long before the existence of humans, insects have relied on the light from the sun, stars, and moon to orient themselves as they fly through the air. This is due to the presence of a natural "dorsal light response" that leads insects to orient their dorsal axes towards the light, which helps them move along a consistent flight path. This was an effective mechanism back when the sky was the only light source at night, but the advent of artificial light has created some major complications.

When insects are exposed to unnatural light sources, it interferes with their environmental markers of direction, so they end up getting lost and disoriented. The mixed signals they receive from their surroundings cause them to lose track of which way is up, and they end up plummeting to the ground. It turns out that a singular artificial light source, even a small one, can literally turn an insect's world upside down, and it's all the result of a simple biological wayfinding process.

The researchers wanted to understand exactly how insects are altering their flight paths towards unnatural light. They identified three primary flight behaviors in their study: orbiting, stalling, and inversion. Orbiting was characterized by a relatively stable circular flight path with constant speed, stalling was identified as a steep climb facing away from the light with declining speed until coming to a stop, and inversion occurred when insects flew directly over a light source and rotated, resulting in a steep dive to the ground. These behaviors disrupted their flight paths because they ended up facing the sky, opposite to their normal orientation. Examining this phenomenon is one way of understanding how humans have impacted the evolutionary programming of wildlife.

When we consider the lengthy span of insect existence, artificial light is a recent introduction. With increasing human development and destruction of natural ecosystems, the detrimental effects of artificial light on insects will only continue to worsen. Future studies could aim to modify artificial light sources to reduce their effects on insect navigation, in order to preserve the lives of the small, but critical creatures that keep our environment healthy.

Nature Communications (2024). DOI: 10.1038/s41467-024-44785-3

Going green

Reducing urban agriculture's carbon footprint

BY MAGGIE EID, ENVIRONMENTAL & SUSTAINABILITY SCIENCES, 2025 DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING & DESIGN, 2024

Nestled between the brick and concrete buildings of Boston, a flash of green stands out. Joyous voices carry through the urban bustle as a group gathers in a verdant garden, eager to try the first tomatoes of the season. After several months of careful tending, the fruits have finally ripened on their sprawling vines, gleaming in rich red hues. Faces alight as the gardeners taste their deliciously rewarding harvest, warmed by the summer sun.

With nearly 200 community gardens scattered throughout Boston, such scenes enliven neighborhoods around the city. These lush oases are one type of urban agriculture, which is the practice of cultivating food or livestock in an urban area. From backyard gardens to communal plots to larger farms, urban agriculture initiatives have immense social and environmental benefits. However, though a seemingly sustainable way to acquire fresh, local food, not all urban farming practices are climate-friendly. The carbon footprint of urban-grown food is up to six times larger than its conventionally-grown counterpart, a new study reports.

Researchers from the University of Michigan examined 73 urban agriculture sites in cities throughout Europe and the United States. The selected sites all employed low-tech growing practices, which consist of open-air, soil-based plots as opposed to more energy-intensive operations such as vertical farms. The study followed the lifecycle emissions of food grown in individual plots, community gardens, and urban farms. To estimate the carbon footprint of urban produce, the researchers accounted for the impacts of farming activities, processing, and transportation. The results indicated that urban agriculture emits more greenhouse gases per serving for many fruit and vegetable varieties. Compared to conventional farms maximized for production, the lower yields of urban gardens are more resource-intensive, requiring proportionally greater amounts of water, fertilizer, and other materials.

> "By adopting more climate-friendly practices, the benefits of urban agriculture can be reaped for years to come."

Despite urban agriculture's higher carbon footprint, 17 of the study sites outperformed conventional farms. By analyzing factors contributing to the lower emissions of these sites, the researchers identified multiple practices crucial to reducing the climate impacts of city-grown food. One proposed strategy is to preserve farm infrastructure as much as possible. Infrastructure is the largest contributor to urban agriculture's carbon footprint, producing 63% of emissions. Raised beds, compost systems, and other structures such as sheds and greenhouses emit substantial amounts of carbon throughout their manufacturing and construction processes. Extending the life of existing materials significantly lowers these environmental impacts, and upcycling old building materials for new infrastructure can reduce emissions by over 50%.

Additionally, efforts to reuse food waste and water are critical to growing urban food in a climate-friendly manner. Composting reduces reliance on synthetic fertilizers produced from fossil fuels and diverts food scraps from landfills, which are significant sources of methane. Proper compost management can decrease the amount of greenhouse gases released by almost 40%. Meanwhile, recycling rainwater and greywater lowers emissions associated with pumping, treating, and distributing water.

Another strategy to lessen urban agriculture's carbon impact is to prioritize crops that are carbon-intensive when farmed conventionally. Tomatoes are one example; many commercially produced tomatoes are grown in large greenhouses, which consume considerable amounts of energy and resources. Comparatively, tomatoes cultivated through low-tech urban agriculture have an equivalent or lower carbon footprint. Growing this produce locally in open-air plots is a viable way for urban growers to mitigate their carbon emissions.

By adopting more climate-friendly practices, the benefits of urban agriculture can be reaped for years to come. These green spaces enrich their surrounding communities, improving food access and security, boosting physical and mental health, and providing opportunities for economic development. As a powerful educational tool, urban farming enables people to build tangible skills while learning about food production and the natural world. Along with these social benefits, urban agricultural spaces support higher levels of biodiversity, enhance pollinator habitats, and alleviate the urban heat island effect. With a lower carbon footprint, urban agriculture's numerous rewards can grow even greener.

Nature Cities (2024). DOI: 10.1038/s44284-023-00023-3
Journal of the American Planning Association (2017). DOI: 10.1080/01944363.2017.1322914
Basic and Applied Ecology (2015). DOI: 10.1016/j.baae.2015.01.005

PHOTOS VIA SHUTTERSTOCK

Uncovering the ocean's depths

/scientists discover record-breaking cold-water reef in the Atlantic Ocean

BY LYDIA NORMAN, INTERNATIONAL BUSINESS & AFFAIRS, 2026

DESIGN BY ANJANA BALAKRISHNAN, STUDIO ART, 2027

Marine scientists at the National Oceanic and Atmospheric Administration have discovered the largest known deep-sea coral reef in the world. This cold-water reef located off the Atlantic coast of the United States spans from Florida to South Carolina. This totals to a length of around 310 miles and is equivalent to three times the size of Yellowstone National Park, according to the finished maps.

The scientists, led by Derek Sowers, Mapping Operations Manager for the Ocean Exploration Trust, located the reef after an effort to map more of the United States' coastline and marine structures. They hoped that knowing what lies off the coast would help them better understand and protect deep-sea marine life, since few researchers have previously explored the ocean's depths. They focused part of this mapping effort on gathering more information on the Blake Plateau, a flat, elevated area covering the deep-sea ocean floor from Florida to South Carolina, since many believed it to be full of previously unstudied reef systems. Once they began exploring, the scientists quickly realized that its sheer size was unique from any other previously documented cold-water reef.

There are many similarities between the two known types of coral reefs (cold and warm-water reefs), with one of them being that the coral living within them largely determines their structures. Coral provides the foundation on which these ecosystems grow, since many different species depend on it for food, shelter, and general ecosystemic support.

However, cold-water corals (CWCs) differ in some ways from their warm-water counterparts. For example, deep-sea reefs rarely come into contact with sunlight due to their depth. Harsher conditions of the deep cannot support typical algae-reliant feeding as they do for warm-water corals, which forces deep-sea reefs to sustain themselves through filter-feeding particles. Due to the nature of their conditions, cold-water corals also tend to be more fragile and susceptible to breakage. However, they can support structures not seen in warm-water reefs, such as lengths of coral growing up instead of out. This unusual behavior might be attributed to the open space the deep sea offers in contrast to the more densely occupied shallow waters in which warm-water reefs thrive.

These initial findings in the cold-water reef in the Blake Plateau can support future endeavors by scientists trying to better understand cold-water environments and how to protect these reefs. Worldwide, coral reefs, especially warm-water reefs, are threatened by the changing climate, and scientists hope to understand more of the behavior of the CWCs in order to better conserve them. By understanding unique habits, like that of the upwards-growing coral in the Blake Plateau, scientists can plan ways to help them avoid threats of the human world.

The Blake Plateau CWC is only one example of the new discoveries scientists may make if scientists continue efforts to explore and research the depths of the oceans. Further mapping of the deep sea will uncover even more information about marine structures and wildlife and expand scientists' knowledge of one of the most uncharted ecosystems on the planet, deepening our overall understanding of how the world works.

Geomatics (2024). DOI: 10.3390/geomatics4010002

PHOTOS VIA RAWPIXEL

Talking trees

The story and science behind tree communication

BY MICHAEL OZGAR, ENVIRONMENTAL AND SUSTAINABILITY SCIENCE, 2027
DESIGN BY KRISHNA VASIRAJU, BEHAVIORAL NEUROSCIENCE, 2027

Since ancient times, humans across the globe have consistently incorporated talking trees into their mythos. Commonly depicted as slow-moving and wise, these trees that can talk often serve as the guardians of mystic forests and dark woods. Surprisingly, it seems that these mythological depictions of trees may not be so far from reality. Trees can communicate with each other, just perhaps not in the way these stories describe.

The real story begins at the end of the 20th century in the University of British Columbia's Simard Lab. Suzanne Simard, a forest ecologist, was beginning to develop an experiment with her research team. Simard knew that trees existing in isolation from other trees tended to have a much shorter lifespan than trees in proximity to one another. Hypothesizing that nearby trees assist each other by sharing nutrients, Simard's lab organized an experiment in a greenhouse.

> "This led the researchers to a groundbreaking revelation: trees could communicate their needs to each other and act on that information."

They had two populations of trees: one population shaded from the sun to prevent photosynthesis, and one population injected with carbon dioxide — a compound trees turn into nutrients — that had been altered to be traceable via radiolabeling. Radiolabeling is when a certain element in a molecule (carbon, in this case) is replaced with an isotope of itself that can be more easily tracked by scientific instruments. Simard and her team found that the trees injected with radiolabeled carbon dioxide sent nutrients to the trees shaded from the sun. This led the researchers to a groundbreaking revelation: trees can communicate their needs to each other and act on that information.

This discovery produced another question: how do trees make contact? In the last few decades, Simard and her lab, along with other ecologists, have sought to further illuminate the answer. To do so, the ecologists focused on the fungi that grow around tree roots. On the surface, fungi appear as mushrooms protruding from the earth. However, underneath the soil, fungi consist of tiny threads that inject into or ensnare tree roots; these threads are called mycelium. These mycelia connect different trees through their roots, establishing a web of communication known as the mycorrhizal network that can span entire forests.

The relationship between the fungi and trees is mutually beneficial; trees benefit from sharing nutrients and information, and the fungi gain energy from the sugar produced by the trees during photosynthesis. Additionally, the fungi transfer useful nutrients like nitrogen and phosphorus from the soil into the trees.

The ability to communicate can substantially increase the survivability of trees in various situations. In the mycorrhizal network, the oldest trees with the most fungal connections nicknamed "mother trees" play a critical role. Through chemical signals sent throughout the network, these mother trees can detect when younger trees are struggling to gather enough critical nutrients to sustain themselves. Their height and depth give them access to more sunlight and water respectively, and upon receiving these distress signals, they can send excess nutrients to the trees in need, in some cases saving their lives. Eventually, those young trees may grow up to become mother trees themselves, perpetuating the cycle and sustaining the population.

"The ability to communicate can substantially increase the survivability of trees in various situations."

The mycorrhizal network also acts as a functioning alarm system for the connected trees. When a tree attached to the network is afflicted by drought or disease, that tree sends a chemical distress signal along the mycelial threads, effectively warning all other trees of the coming danger. This alert allows nearby trees to prepare, giving them time to adapt to drier conditions or produce defensive chemicals that can fight an advancing plague.

Almost 30 years after her team's initial experiment, Suzanne Simard still leads research into the mycorrhizal network. Simard and ecologists like her continue to unravel the mysteries of tree communication. Their work not only provides us with intriguing insights into how forests operate but also a greater understanding of how some of Earth's most critical organisms sustain themselves under stress.

Nature (1997). DOI: 10.1038/41557

PHOTOS VIA PIXABAY

PLANTS AND THE ROOTS OF COGNITION

BY DESSY DUSICHKA, COMPUTER SCIENCE & BIOLOGY, 2025

DESIGN BY ANANYA JAIN, BEHAVIORAL NEUROSCIENCE, 2025

The pink, squishy organ inside our heads is often considered the ultimate biological control center. There is no doubt that the brain is extraordinary, complex, and great at its difficult job of controlling organisms; however, it is not the only player in cognition. Instead, scientists are now realizing that other types of cells possess forms of intelligence as well.

Scientists are slowly starting to regard plants as intelligent organisms despite not having brains. They face challenges in nature the same way animals do — fulfilling basic energy and nutrient needs, avoiding predators, and reproducing, all while managing limited resources. To survive, plants have evolved strategies to achieve each of these tasks and continue to survive in dynamic environments. These discoveries are part of a larger emerging field called basal cognition, where pioneering scientists are noticing indicators of intelligence like memorization, learning, and problem-solving both within traditional brain structures and beyond them. Not all scientists are convinced though, sparking new debate about what it truly means to be intelligent.

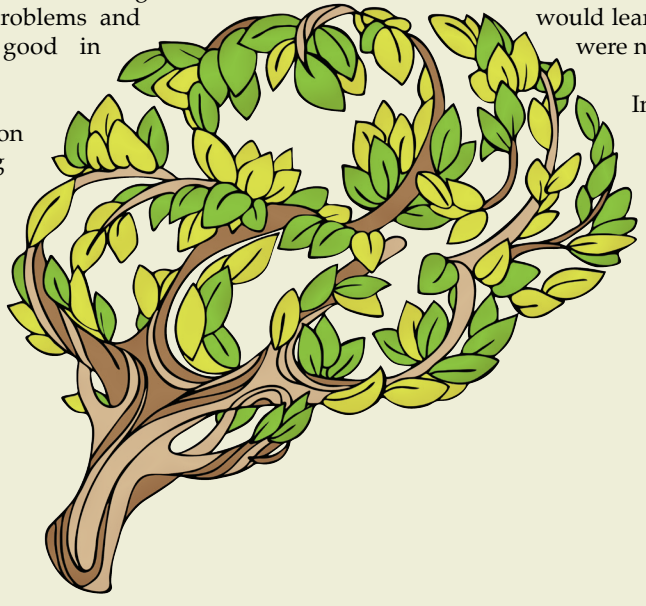
Some of the proposed intelligent behaviors of plants include dynamic communication with neighboring plants and predators, as well as the ability to learn from past experiences and adapt their behavior accordingly. Stefano Mancuso, an Italian botanist and professor, told The Guardian simply that "intelligence is the ability to solve problems and plants are amazingly good in solving their problems."

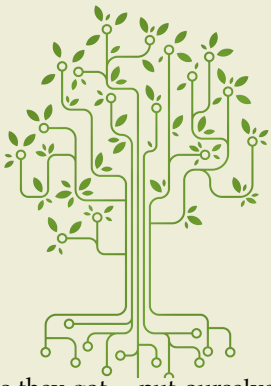
Plants like to keep tabs on their neighbors, using light and acoustic cues, mechanical stimuli, and sensing airborne volatile organic compounds. Plants synthesize and emit these compounds constantly, which effectively conveys information about their current conditions to nearby receiving plants and helps them form communities. A 2019 study from the Swedish University of Agricultural Sciences on this phenomenon found that these compounds were the primary way trees identified their neighbors since other cues such as light blocked by another tree, a branch touching a neighbor, or the sound of leaves rustling nearby aren't as reliable.

In response to changing stimuli from their environments and neighbors, plants react accordingly in the form of physiological changes with the ultimate goal of optimizing their performance. The research shows that plants can make intelligent decisions to utilize resources most effectively and ensure their survival. They can also sense when their neighbors are under attack and turn on their own defense mechanisms. Often, they release toxic chemicals in their leaves, sending a strong message to predators to leave them alone.

Plants also seem to have the ability to hold onto memories and learn from past experiences. One group of researchers from the University of Western Australia applied behavioral techniques typically used with animals to the touch-me-not plant known for folding its leaves in response to physical disturbances. The researchers specifically studied if the plant was able to form habits, essentially testing if the plants would learn that their repeated stimuli were non-threatening.

In the study, the plants were dropped onto foam platforms, initially closing their leaves in response. After repeated exposure





to this, though, the plants stopped recoiling as they got used to the stimulus. Then the scientists left the plants alone for a month, and when they dropped the plants again, the touch-me-nots were still unphased, signaling that they remembered their past experience. Biologically, this makes sense, as plants don't want to waste energy on defense mechanisms if there is no real harm.

So, how exactly do plants demonstrate these clever techniques without a nervous system to orchestrate them? It turns out that a lot of these behaviors boil down to bioelectricity, which allows cells to store information and memories through voltage gradients. It's what Mancuso has spent the past 20 years exploring in his research.

"The neuron is not a miracle cell, it's a normal cell that is able to produce an electrical signal," he told The Guardian. "In plants, almost every cell is able to do that."

> "Rather than relying on one single control center, plants disperse their intelligent capabilities throughout their bodies, making them more versatile in the face of harm."

Rather than relying on one single control center, plants disperse their intelligent capabilities throughout their bodies, making them more versatile in the face of harm. "This is why plants have no brain — not because they are not intelligent, but because they would be vulnerable," Mancuso told The Guardian. As a result, plants can lose up to 90% of their biomass and still survive. Humans can't even afford to lose one-hundredth of a percent of their most important organs, like the parts of the brain stem that control functions like breathing and the heartbeat.

However, Mancuso's pioneering ideas are still radical for many scientists. Skeptics argue that since plants do not have nerves and cannot make truly conscious decisions, they cannot accurately be classified as intelligent. Mancuso believes that the vast differences between humans and plants make it difficult for us to put ourselves in their shoes. Plants operate on a much slower time scale than humans, creating the perception of them as passive. Even though they are indeed reacting to outside stimuli, it's difficult for humans to notice and appreciate it.

Mancuso and other present-day researchers are not the only ones to have explored the intelligence of plants — Charles Darwin himself was interested in this phenomenon in the 1800s. Darwin was one of the first believers in plant intelligence after recognizing that plants can react to sensation. He even once described how a plant's root tip "acts like the brain of one of the lower animals."

Now, over a century after Darwin, studies are finding that animal brains likely evolved from clumps of regular cells that got good at collaborating to orchestrate biological tasks, eventually forming the optimized, complex neurological system we know today. There is even evidence that basic aspects of cognition can be observed in the behavior of bacteria, hinting that a molecular infrastructure for intelligence existed long before neurons, brains, and complex central nervous systems. It was ultimately Darwin's own work that showed plant and animal intelligence are as intimately related as he intuited, highlighting the evolution of life and the parallel evolution of scientific thought.

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PHOTOS VIA SHUTTERSTOCK

OPINION: Why the legacy of 'twilight' lives on

BY RAISA BHUIYAN, COMPUTER SCIENCE & MATHEMATICS, 2025

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

Everyone knows the story, even if they haven't read it or seen it for themselves. They've probably heard some of the iconic quotes, ranging from "Where the hell have you been, loca?!" to "You better hold on tight, spider monkey." But in case you haven't figured it out, I'm talking about the "Twilight" series — the five-film series starring Kristen Stewart, Robert Pattinson, and Taylor Lautner. Even though it's been 12 years since the last movie ("The Twilight Saga: Breaking Dawn — Part 2") came out, the series still maintains its popularity, with many fans referring to the series's resurgence as "the Twilight Renaissance." With the series growing popular again, it's hard not to wonder what makes this series so popular more than a decade later.

The first "Twilight" movie came out in 2008, making around $70 million on its opening weekend and $193 million through its entire domestic run: 2008's 12th highest-grossing film. A huge part of the film's appeal was that it was made for women, by women. The book series that the movies were based on was written by a woman, and the first film was directed by a woman, which was rare to find in 2008. As such, the series was appealing to a demographic Hollywood was afraid to touch.

Melissa Silverstein from the advocacy group Women and Hollywood described it best. "The general consensus in Hollywood is that films and books made for men and boys are seen as 'universal,' and things that are made for women and girls are somehow seen as the 'other,'" she told *The Guardian*.

Women and especially teenage girls were a huge reason why "Twilight" became successful. This forced Hollywood to acknowledge that movies about women could be successful, and marketing to women and girls could be successful. Once the industry realized they had a relatively untapped audience they could market to, there was a boom of movies that were targeted towards young girls, including "The Hunger Games," "Divergent," and "Wonder Woman."

The impact of 'Twilight'

"Twilight" had an outsize impact on the writing industry, spurring both the popularity of the young adult (YA) genre and paranormal romances. After the success of "Twilight," we saw more romance books that appealed to young girls such as "The Hunger Games," "The Mortal Instruments," "Shadow and Bone," and "Divergent." These books often copied the formula that made "Twilight" so popular: The main characters in these books were female, and they were often caught in a love triangle between two male characters that fans would grow invested in. In addition, there was a rise in supernatural-themed television shows and movies after "Twilight," such as "The Vampire Diaries," "Teen Wolf," and "Jennifer's Body."

Another massive impact associated with "Twilight" is the growing popularity of fanfiction. The famous series "Fifty Shades of Grey" started as "Twilight" fanfiction. Author E.L. James originally published her work on the popular fanfiction site Fanfiction.com in 2009 before removing all references to the original series and then publishing her story for the world to read. The success of "Fifty Shades of Grey" led to many publishers combing through fanfiction sites to find stories to adapt and sell. Many of the romance films and books today have roots tying back to fanfiction.

> “Fans took comfort in ‘Twilight’ as a way to escape reality.”

What was it about ‘Twilight’ that people liked back then?

Psychologists say “Twilight” performed well because audiences wanted the romantic relationship that the main characters Bella Swan and Edward Cullen have. Psychologist Niloo Dardashti made a documentary in 2012 in an attempt to understand why women were drawn to “Twilight,” and she concluded that female audiences enjoyed seeing the love Edward had for Bella.

“He’s kind of like this ultimate example of someone who would be just totally validating to their partner,” she told *U.S. News*.

Stephen Snyder, assistant clinical professor of psychiatry at Mount Sinai School of Medicine, thinks people are drawn to this idealized, unrealistic relationship between Edward and Bella. “Nothing she ever does is boring to him. He never gets restless … It’s all Bella, all the time,” he told *U.S. News*.

The rise of social media only heightened the success of “Twilight.” The series came out around the time that a lot of fandoms were digitized. Youtube, Tumblr, and Twitter (now X) were all relatively new applications where users could discuss their love of “Twilight” among other pop culture icons. This is where fans had the famous Team Jacob and Team Edward debate. Social media provided the outlet for fans to express themselves and find like-minded individuals all while keeping track of what was new in the series. In fact, the “Twilight” Twitter account became the first to reach a million followers in 2012, right around when the film series was coming to an end.

How did ‘Twilight’ maintain this popularity?

It’s now been 12 years since the series came to an end and 16 years since the first film was released. A lot of the opinions around the films have changed as fans become more aware of the flaws surrounding the films, such as the blandness of Bella character, the awkward acting, and the even more awkward one-liners. Fans have become aware of the fact that Edward and Bella’s relationship isn’t as ideal as people used to think it was; Edward’s habits no longer come off as dedicated and romantic, but rather as creepy and stalker-like. So then why can’t we resist engaging with the series?

One reason is hate-watching — when you watch to laugh at it or criticize it. Many fans derived joy from criticizing “Twilight” and acknowledging its flaws. The fun of watching these movies is remembering how insane it was and finding new details to obsess over.

As for the “Twilight Renaissance,” it has to do with the nostalgia the series brings with it. During the pandemic, people were looking for anything to take their minds off of the stress of their everyday lives. So, they took comfort in “Twilight” as a way to escape reality.

At the end of the day, “Twilight” did its job of appealing to a new audience, and hopefully more people can watch the movies and appreciate the chaotic insanity that it is.

PHOTOS VIA SHUTTERSTOCK

Using your shoes to step over your roommate's line

ARTICLE AND DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

It is something you don't think about until you see someone else do the opposite. Cultural influences play a large role in what seems normal, impacting even small decisions like what to do with one's shoes. For those who lived their entire lives taking their shoes off before going inside their house, it may seem gross to see others not doing the same. For those who keep their shoes on, the other side might seem bizarre. Nonetheless, once people from these opposing camps decide to become roommates, it is one of the first battles they must overcome before moving in. Choosing the right argument for either side determines the fate of their apartment and should be thought through carefully.

The biggest concern, and perhaps the most obvious, against wearing shoes indoors is sanitation. An article in The Washington Post about this very topic cites a virology professor who found various fecal bacteria on nearly all shoe samples taken, and *E. coli* on several as well. But it is not just gross material that can trek its way into one's home. Toxins and pollutants could find their way in as well, thus contributing to their build-up indoors and increasing the risk of accidental inhalation or ingestion of these health hazards. In addition, it increases the cleaning burdens — with this habit, floors build up dirt faster and require more regular maintenance so as to prevent damage.

Coincidentally, those on the opposing side also have health concerns with not wearing shoes inside, primarily with young children and their growing immune systems.

> "So not only do immune cells need to recognize these foreign molecules from their own bodies but they also need to distinguish the threats from the harmless and program themselves to only attack the threats."

Much like a pet, the immune system requires training. As these immune cells develop, one of the most important things they learn is recognizing the differences between foreign and "self" molecules. This might seem like a simple concept — immune cells need to attack threatening invaders but not the body — but it is much more complicated than that. In reality, not all foreign molecules are harmful.

PHOTOS VIA SHUTTERSTOCK

PHOTO BY CARLA DELGADO, COMPUTER SCIENCE, 2025

So not only do immune cells need to recognize these foreign molecules from their own bodies, they also need to distinguish the threats from the harmless and program themselves to only attack the threats. This concept is called tolerance. Of most relevance here is peripheral tolerance: training immune cells to ignore signals from foreign but harmless molecules, pollen being one example. For this to happen though, the body needs to be exposed to pollen. After all, if the body never gets to meet these molecules, it will never know that it needs to tolerate them.

For this reason, some studies have found that children raised in environments void of microbes, both nonharmful and harmful, are more likely to develop allergies. They argue that these overly clean homes prevent children from developing peripheral tolerance. When the developing immune cells do not meet different types of foreign molecules, they may end up overreacting to anything new that they encounter later on, unsure whether they are being threatened. This is particularly relevant in modern society as hygiene practices have significantly improved over many decades, and even more so in cities.

But would wearing shoes inside really mitigate the risks of developing allergies? It seems unlikely. While exposure to harmless microbes is healthy, this practice also increases risks in exposing the household to harmful microbes, which to most, is not a good tradeoff to make.

Many other arguments exist for and against wearing shoes indoors. Climate, the house's condition, and other foot-related health issues may cause one to lean more towards one side than the other. Some take to wearing indoor shoes to gain the same benefits of wearing footwear inside while preventing the spread of dirt and microbes across their home. Whatever the decision is, it is important to be conscious of these hygiene habits between everyone in the household to ensure no one steps on each other's toes, with or without shoes on.

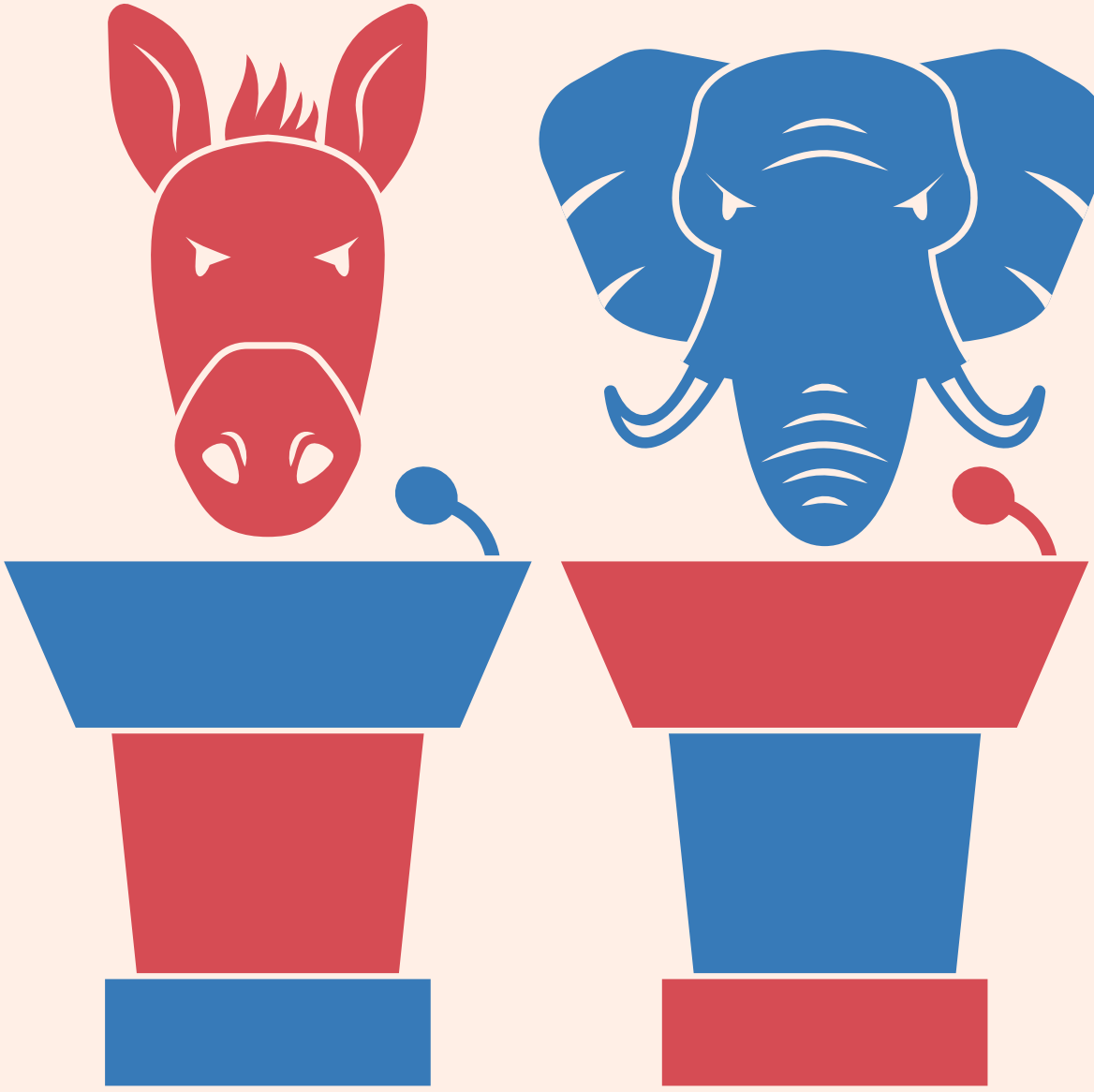
Clinical and Experimental Allergy (2006). DOI: 10.1111/j.1365-2222.2006.02463.x

OPINION

FREE SPEECH AND DEMOCRACY IN A PARTISAN SOCIETY

BY LILLY SCHAR; HISTORY, CULTURE & LAW; 2025
DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

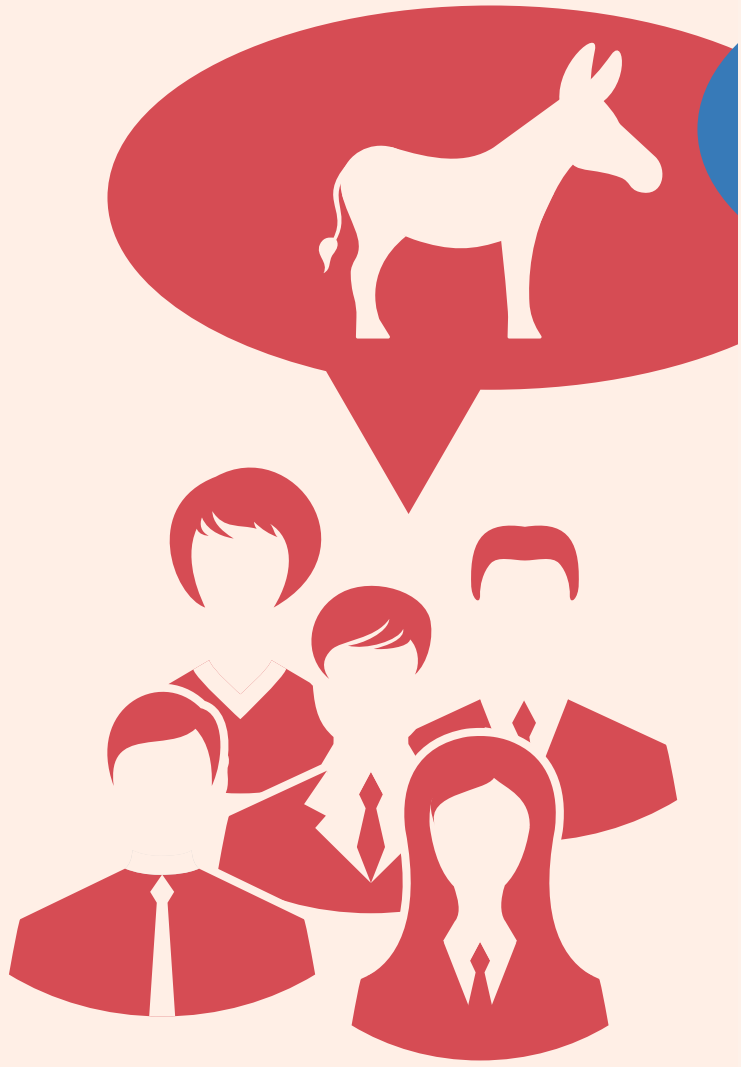
Following the Oct. 7 Hamas attack on Israel, the Harvard Undergraduate Palestine Solidarity Committee penned a letter calling Israel "entirely responsible" for the attack. It was followed by swift and intense backlash. The student signers were "doxxed," and Jewish alumni demanded a list of the students in order to avoid inadvertently hiring one of them. The animosity between supporters of Palestine and supporters of Israel has grown to particularly concerning heights on college campuses that have led to clashes over censorship.



Without addressing the merits of either side's arguments, the reaction that stemmed from such intense disagreement illustrates the normalization of ideological insulation in our country. We have become quick to disregard those with views we disagree with rather than attempt to coexist under a shared understanding of the essential role free speech has in a democracy. The lines in the sand have been distinctly drawn and we readily and willingly categorize people as "with us" or "against us." This mindset is, at its best, at odds with the founding ideals of our country and, at its worst, an imminent threat to well-functioning democracies on the national and international scale, hindering the peaceful resolution of disputes and diplomatic relations. Rather than settle deeper into the folds, it is necessary to work toward finding some semblance of commonality — enough that reaching across the aisle does not entail dislocating your shoulder. Though political scientists have theorized where these commonalities may be found, these theories are not entirely compatible with the reality of a dynamic and nuanced space. These false commonalities are therefore incapable of bridging the gap.

As a staunch supporter of freedom of speech, I deeply appreciate the Communists handing out fliers on campus as much as I do the Young Republicans recruiting for meetings on the same corner the next day. The beauty of our country lies in our ability to express separate opinions from each other and from our government, but in no way should that limit the discussion across the ideological spectrum. As much as the members of the MAGA party insulate themselves from those who disagree with them, there is also blame to be placed on the opposite end of the spectrum for doing the same. Surrounding yourself with "yes-men" only serves the continuity of factions that refuse to have anything to do with each other so long as they disagree.

No one person can enlighten millions of people who feel politically and personally isolated into coming together and singing "Kumbaya." However, that does not mean each of us cannot or should not search for alternative perspectives that might serve to realign a country divided. This is how I first came across horseshoe theory. It's a political and sociological theory that imagines the ideological spectrum in the shape of a horseshoe: Those on the far right and those on the far left bend toward each other rather than remain on purely opposite ends.



In the American context, one of the most commonly identified differences between the Left and Right is the proper role of the government in regulating citizens' lives. The Right believes there should be less interference by the government in personal lives, while the Left believes the government should interfere when necessary to ensure the protection of individual rights. But horseshoe theory points out that those on the Left display some anti-state tendencies, too, in their calls to defund the police or abolish the prison system. Another example of this is the perception of cancel culture. At the core, cancel culture is just a statement of disagreement with the ideas and people one does not like, and neither the Left nor the Right are opposed to doing away with the ideas and people they do not like. Horseshoe theory would posit that ideological insulation does not account for the commonalities of values in the extremes on both sides.

Ideological insulation is not a new concept, but rather one that has been reinforced over years of organizational strategy most commonly used to deign certain perspectives as conservative or liberal. The conservative and liberal legal movements have taken clear stances on "hot-button" issues such as gun control, abortion, voting rights, and federal regulation that serve to represent their own political ideology, but also to contrast and invalidate the other side's opinion. Truly, the beauty of a democracy is that we are capable of holding differing opinions while participating effectively and equally in society, but what happens when those beliefs create such a great divide that we can no longer execute the goals of democracy? The current partisan nature of the United States pits people with opposing views against each other (sometimes physically) and stalls the cooperation essential to a functioning government.

All that being said, horseshoe theory, too, does not perfectly or fully encapsulate the activities and values of political parties. For all the similarities, there are still incredible and indelible differences across the ideological spectrum. Defunding the police and abolishing the prison system emphasizes largely different fundamental values than the general conservative push for less government interference. Cancel culture has arisen out of the severity of such fundamental differences. Horseshoe theory is tempting as a method to bridge the divide, but research has shown otherwise. A recent study published in *Political Research Quarterly* found antisemitism to be a rarity on the Left and more commonly held by the Right. Though the study hypothesized that the ideological left's dislike for the Israeli government might induce more antisemitism, it found that the ideological left does not construe its dislike for Israel as dislike for American Jews. The ideological right, on the other hand, assigns stereotypes and thus moral value to American Jews that lead to antisemitic views. It cannot be denied that certain and opposing manifestations are present on the Left and Right. It is therefore clear that applying horseshoe theory is not an overarching solution to the divisiveness our country currently faces. There are gaps in horseshoe theory that do not account for the technicalities of the differences in moral methodology, or how the ideological left and right assign value to people and ideas.

Another study in Belgium emphasized that there is a considerable amount of variation in the extremist camps of both sides — both in ideology itself and the value systems they use to arrive at that ideology. This, too, is evident in the current discourse on the Israel-Palestine conflict. The subject has divided liberals and demonstrated their capacity for antisemitism, as outlined in the *Political Research Quarterly* study. Horseshoe theory does not accurately describe the political climate around this issue, but the issue demonstrates the necessity of meaningful and productive interactions between the conglomeration of contradicting views that exist side-by-side with the few that unify political camps in order to enact democracy while doing away with discriminatory hate. Political labels are psychologically necessary, but they must maintain a level of flexibility to capture the essence of democracy.

Insulation among common identities subjects people to boxes with boundaries that fail to consider the holistic identities of people with a diversity of backgrounds and life experiences. Though finding commonality will be useful to progressive politics, forcing commonality through a faulty theory is not an efficient or effective way to coalesce.

There is a larger philosophical conversation to be had about the methods used to design the value systems that dictate ideology. Indeed, historical inequalities typically play a large role in such beliefs. A difference in value systems is thus inevitable in our country's political system. However, our founders expected and intended for this to be the case, as implied by the rights enshrined in the First Amendment. What they did not intend was for these differences to relegate an ineffective government. A representative government cannot act for the purpose of two opposing collective interests simultaneously. It is up to the people not to convince others to accept their own view but to understand the source of the opposing view. There are dangers in concepts like horseshoe theory that assert we do not need to look far for commonalities. Our commonalities will be found at the depths of our philosophical existence, the very reasons we choose to participate in a democracy. There is no clear solution to our current division, but it will not be found by censoring speech out of fear or dislike.

Political Research Quarterly (2022). DOI: 10.1177/10659129221111081
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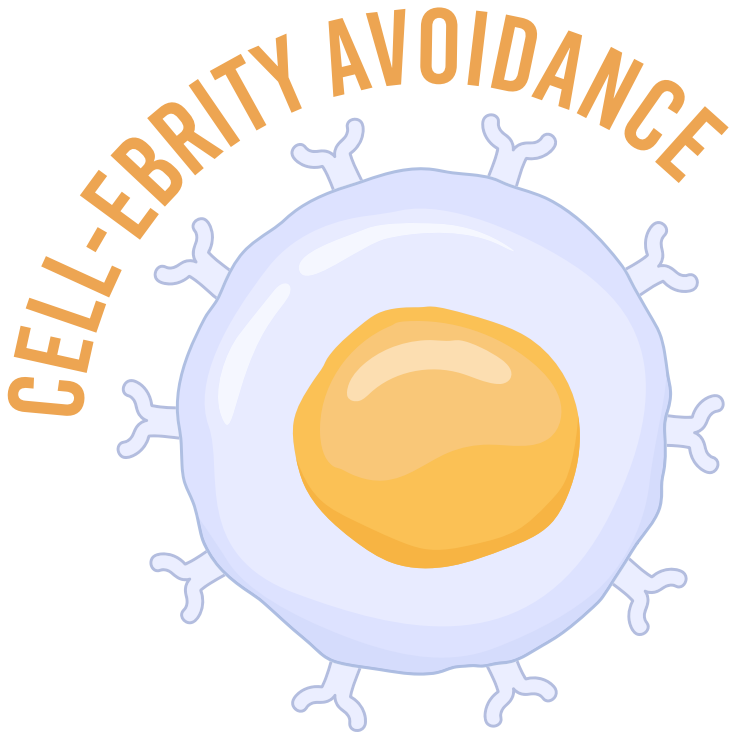
PHOTOS VIA SHUTTERSTOCK



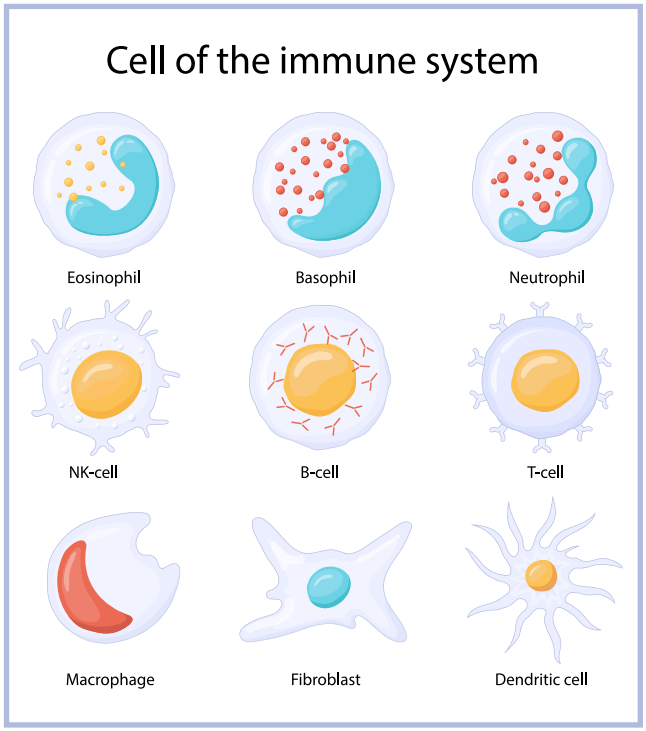
HOW TUMORS AVOID IMMUNE CELLS

BY RESHIKA SAI DEVARAJAN, HEALTH SCIENCE, 2025
DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

Our immune system consists of hundreds of specialized cells dedicated solely to maintaining our well-being. This branch of our body is dedicated to fighting pathogens such as bacteria, viruses, parasites, and even our own mutated cells. Fundamentally, the cells of the immune system can be categorized into two main varieties: the innate immune system and the adaptive immune system.

The innate immune system is the first defense our body has against foreign invaders and involves responses that are not specific to the identity of the pathogen. The general functions of innate immunity encompass inflammation, surveillance for cells exhibiting abnormal activity, and initiating immediate responses to contain and eliminate threats. This response is rapid and serves as an initial step to curb infection and activate the adaptive immune system.

In contrast, the adaptive immune system consists of specialized cells that are finely tuned to target a specific pathogen or harmful cell with high accuracy. This system also is unique because it involves the creation of memory



cells, which are replicas of these specialized cells, adept at recognizing and reacting to a specific pathogen upon future encounters. The adaptive immune system can be further divided into humoral immunity (B cells) and cell-mediated immunity (T cells). B cells are involved in humoral immunity and are precursors to antibodies, cells created to target and mark specific invaders for destruction by other immune cells. T cells include helper T cells, which activate B cells and other immune cells, and cytotoxic T cells, which kill infected target cells. T cells and B cells are the most vital components to maintaining a dynamic and adaptive response that extends past the general responses initiated by the innate immune systems.

Tumors are uncontrolled growths of abnormal cells that can travel to and destroy various parts of the body. Where T cells and B cells make their presence known, often activating and recruiting other cells to aid in an immune response, tumors seek the opposite. Tumors rely on slipping through the cracks of our immune system in order to grow their harmful cells, while avoiding attacks from our immune system.

One primary method that cancerous growths use to evade recognition is downregulating the expression of their own antigen presentation machinery. All cells are programmed to display parts of their cells on their surface for cell-to-cell recognition but also so immune cells can recognize any unfamiliar activity or pathogenic material. By downregulating the amount of molecules that a cell produces, it makes it harder for the immune system to recognize and subsequently target these cells for destruction.

Another method that tumors use to survive in the body includes T cell exhaustion. With a chronic disease, such as various types of cancer, constant activation of T cells can decrease the function and efficiency of T cells. As T cells remain constantly stimulated, T cells in the body adapt by expressing inhibitory receptors which when bound, decrease T cell activation levels. Eventually, with long-term stimulation, T cells may lose their functions, affecting their ability to effectively recognize and eliminate cancer cells. This phenomenon, known as T cell exhaustion, decreases the immune system's ability to control tumor growth.
Cancers can even avoid cell death. Normally, certain immune cells can induce apoptosis, or programmed cell death, in cells they suspect have been compromised or are malfunctioning. However, cancer cells often develop mechanisms to resist or evade this process. Some cancers have been able to create systems to downregulate signals that induce apoptosis. This evasion of cell death contributes to their survival and future proliferation.

The immune system is a complex and remarkable system that has evolved over millions of years. However, despite its efficiency, it is not immune to manipulation by cancerous cells. In the same way the immune system has evolved to serve numerous purposes and has created many avenues to target infected cells, tumors have devised intricate strategies to exploit natural vulnerabilities in the immune system and evade their death.

Frontiers in Pharmacology (2022). DOI: 10.3389/fphar.2022.868695
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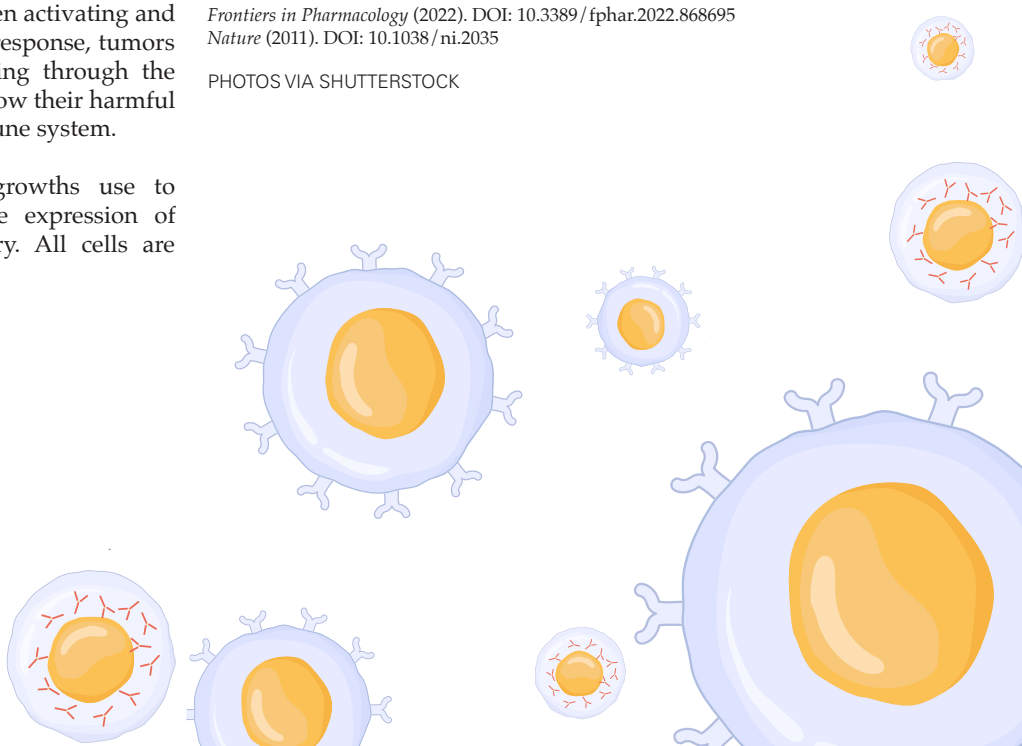

NAVIGATING THE SHADOWS OF BLACK-BOX SYSTEMS

BY ALLISON TARBOTTON, PUBLIC HEALTH, 2026

DESIGN BY SAMARTH KEERTHIVASAN, CELL AND MOLECULAR BIOLOGY, 2027

Don't look. Or, more accurately, you can't look. You wouldn't be able to see anything if you tried.

A few banalities to start us off: Artificial intelligence (AI), A few banalities to start us off: Artificial intelligence (AI), specifically machine learning systems, is increasingly being used to make high-stakes medical decisions. This includes decisions regarding diagnoses, surgical outcome predictions, technical skill evaluation, and disease risk scores. Despite the technology's pervasiveness – and use in increasingly critical roles – little is known (even to its makers) about how AI makes decisions. Together, these all have enormous ethical implications for those subject to these decisions.

Medical care involves decision-making by a number of actors: the patient, their primary care physician, specialists, pharmacists, and almost always an insurance provider. But what happens when a machine learning system is introduced into this team? Recent applications of AI tools in healthcare are altering the scope of medical decision-making. These systems have already proven to make quicker and more accurate diagnoses than their human decision-making counterparts, showing exceptional promise for tailored patient recommendations and outcome predictions. Despite these advancements, the increased use of these systems in healthcare has come under scrutiny. Many of these AI systems are black boxes, meaning the mechanisms by which they generate information are uninterpretable to most humans.

Careful consideration regarding the role of algorithmic systems in medical decision-making is essential to their ethical use, as many of these technologies can increase discrimination in healthcare settings. Further, scholars widely debate the morality of using AI in these settings. Who can be held responsible for an AI-generated decision? Does AI challenge the epistemic authority of medical professionals? Should there be a special degree of explanation owed to decision subjects as moral beings? Thus far, arguments have largely focused on best bias mitigation techniques. However, these alone may be insufficient to capture the host of ethical and epistemic quandaries that accompany AI medical decision-making.

A study conducted by Matthew Groh, an assistant professor at the Northwestern University Kellogg School of Management, tracked the diagnostic accuracy of dermatologists, primary care physicians, and machine learning models through an analysis of 364 images spanning 46 skin conditions. The results reported that while the machine learning models had a 33% higher rate of diagnostic accuracy, it exacerbated the already large accuracy gap across skintones.

Many thinkers attempting to develop guidelines for the ethical usage of AI in decision-making support the development of "fairness metrics" to mitigate bias in data and correct decision distribution among different groups. There are numerous points within the development, training, and deployment of these models where bias can appear. Some argue that treating this as a trivial technical problem is insufficient, and greater efforts should be made to understand the complexity and morality of today's socio-technological environment. Data is a mere representation of external systems and conditions. Because these models are trained on real-world data sets, the biases in our social, political, and economic infrastructure influence their decisions, either directly or indirectly. Trishan Panch, a co-author of a study examining the effects of AI bias on health systems, told the Harvard T.H Chan School of Public Health that "there will probably always be some amount of bias because the inequities that underpin bias are in society already and influence who gets the chance to build algorithms and for what purpose."

Since the mechanisms by which these systems make decisions are not fully understood (or are buried beneath the opaque surface), these biases are especially challenging to address. Nonetheless, just because something cannot be seen, doesn't mean that it's not there. While the opacity of these systems masks the correlates used to produce a decision, the factors that lead to systemic bias are quite clear. So, to best mitigate algorithmic bias, the social conditions that lead to this must too be addressed.

> "Trishan Panch, co-author of study examining the effects of AI bias on health systems warns, 'There will probably always be some amount of bias, because the inequities that underpin bias are in society already and influence who gets the chance to build algorithms and for what purpose.'"

The ability of algorithmic systems to operate at a scale that contributes to systemic discrimination and injustice is reason enough to tread carefully as these technologies become more widespread. However, it is certainly worth theorizing about how these systems might be used to address the bias that frequently undermines them. Healthcare and society would be remiss not to acknowledge and even look for the glint of opportunity potentiated by these powerful systems.

A potential path forward? Panch thinks this "will require normative action and collaboration between the private sector, government, academia, and civil society." There is a unique opportunity to take preemptive action in creating ethical and regulatory guidelines for the widespread use of this technology. Further, understanding the moral underpinnings of implementing these into vastly interconnected institutions can better inform policymakers' regulatory goals and our own relationship with AI. Ultimately though, rather than looking for a flicker in the darkness to address these ethical dilemmas, one must look at the bigger picture. These systems are a reflection of our societal values, and the healthcare field cannot address complex and intersectional social phenomena alone. Collective action by social, legal, and political entities is necessary to work towards a more equitable environment, especially in healthcare. Only then can healthcare move forward intentionally and responsibly with this technology.

> "A potential path forward? Panch thinks this 'will require normative action and collaboration between the private sector, government, academia, and civil society.'"

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PHOTO BY IPOPBA VIA ADOBE STOCK

USING AI TO PREDICT DISEASES

BY AARUSHI THEJASWI, COMPUTER SCIENCE & BEHAVIORAL NEUROSCIENCE, 2027
DESIGN BY VIVIAN LIN, BIOCHEMISTRY, 2026

Although still a relatively new field, the applications and possibilities of artificial intelligence (AI) are rapidly expanding. AI technology has been utilized in virtual assistants and chatbots in customer service, fraud detection and risk assessment in finance, surveillance and threat detection in law enforcement, and much more. Especially in this past year, AI has made significant advancements in the healthcare field.

Healthcare has mainly made use of AI regarding IoT (Internet of Things) devices. Glucose monitors and ingestible sensors can provide data for AI to analyze, interpret, and automate. Recent technological advancements have allowed for the exploration of artificial intelligence as a tool to even predict disease.

Using optical coherence tomography (OCT), doctors can now assess ocular diseases and identify biomarkers of other systemic diseases. OCT is a rapid, non-invasive imaging technique that uses a machine to take cross-section pictures of the retina using light waves, allowing for the analysis of different eye components. Some examples include retinal layers, fluid, or vasculature, in which OCT can detect abnormalities that can indicate early signs of disease. Research has found that structural changes in neurosensory retinal layers can indicate the presence of Alzheimer's disease.

The automated detection of these biomarkers allows for early diagnoses, which are crucial and can be life-saving. For conditions with known cures, early interpretation of biomarkers can catch diseases in their early stages, resulting in increased effectiveness of treatment and a faster cure due to early intervention. Though some diseases, such as Alzheimer's, do not currently have cures, early detection can greatly improve the treatment and quality of life experienced by patients — and maybe even extend their lives.

There are still, however, some potential risks regarding AI technology. Image interpretation can be subjective, and the accuracy and ability of AI to replicate the expertise of doctors with medical degrees and years of experience is a concern. In addition, the security of patient health data and personal information is an issue with the machines and AI algorithms accessing this data. Despite these concerns, the novelty of this field signifies there is much to explore and unlocked potential to harness. The applications of this rapidly expanding field of technology show great promise in terms of healthcare and longevity.

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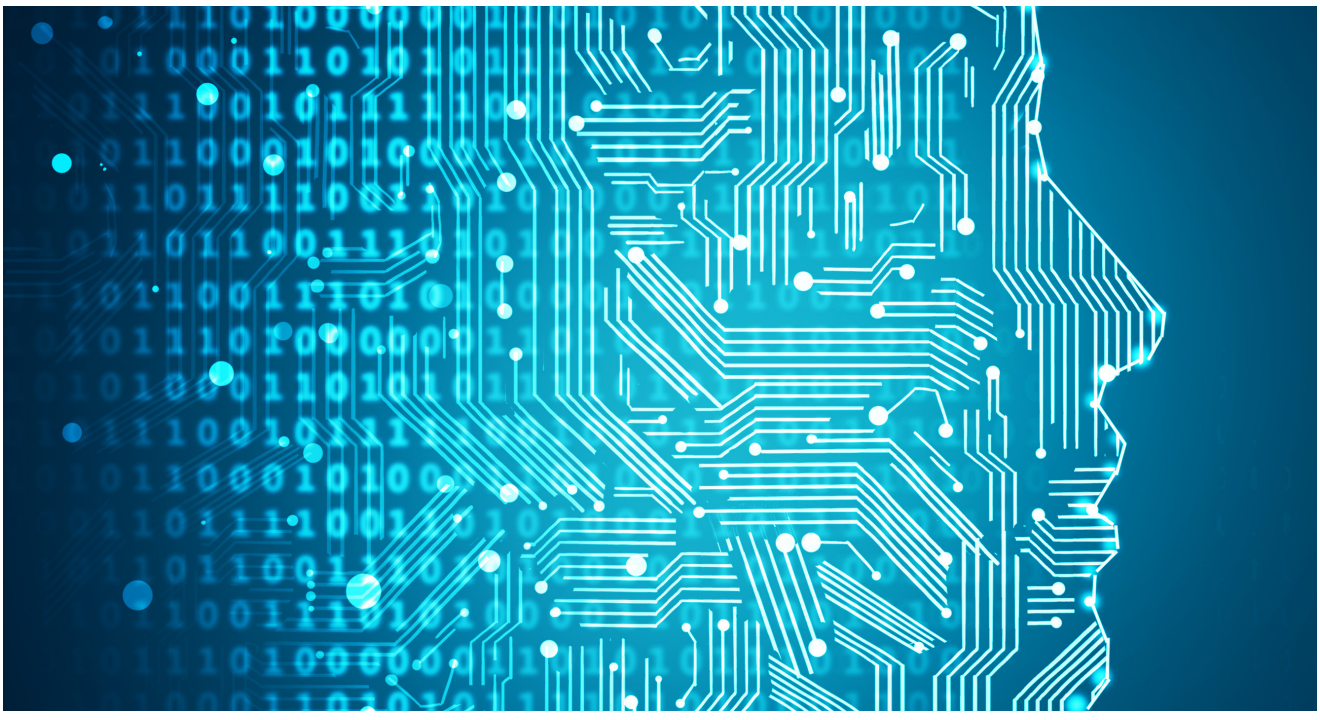
PHOTO VIA SHUTTERSTOCK



THE WHALE THAT LIVES FOREVER: CANCER PREVENTION MECHANISMS IN THE BOWHEAD WHALE

BY GABRIELLE WEINER, BIOLOGY, 2026

DESIGN BY HANNAH MATHEW, HEALTH SCIENCE, 2027

Theoretically, the more cells an organism has, the higher the incidence of malignant transformation. If this were true, humans should be considerably more cancer-prone than something as small as a mouse; however, this is not the case. "Peto's paradox" describes the phenomenon that, despite the increase in cell number, instances of cancer don't increase in larger, more complex animals. Researchers over the past several decades have determined that the complexity of organisms such as humans, elephants, and whales coincides with the evolution of more advanced tumor suppressor mechanisms.

Typically, in defense against cancer, the p53 gene induces an apoptotic response, effectively killing cancerous cells to prevent further carcinogenesis. P53 is present in high numbers in the elephant genome, answering Peto's paradox. Consistent cell death can prevent cancer but does not necessarily promote longevity. The ability of bowhead whales, for example, to seldom experience cancer while also experiencing centuries of life is certainly catching the attention of researchers looking for more effective cancer prevention and treatment for humans.

The bowhead whale's lifespan is longer than that of any other mammal, exceeding 200 years. The whale species is the second largest animal on Earth. According to Peto's paradox, they should possess one of the most complex cancer prevention mechanisms. The minimal occurrence of oncogenesis in conjunction with such a long lifespan, however, is a mystery.

A team of scientists at the US National Institutes on Aging studied the accuracy and efficiency of DNA double strand break repair in bowhead whales, a process that astonishingly explained the long and cancer-free lifespan of the species. The team began by testing p53 activity in transfected mouse, cow, human, and bowhead fibroblasts. To their surprise, activity of the gene was lowest in the bowhead cells. From that, they were able to rule out apoptosis as a primary cancer resistance mechanism in the species. The researchers then created fibroblast cell lines of each species with knockout tumor suppressor genes and, surprisingly, found that the bowhead knockout cells needed only two mutations to become cancerous. This means that the species does not target cells after they experience cancerous transformation — rather, the cell has a mechanism that prevents the transformation from occurring at all. Additionally, the bowhead strain seemed to be most resistant to senescence (deterioration), which in conjunction with telomere shortening, describes aging at the cellular level.

The collected data demonstrates that the bowhead species is exceptionally evolved to avoid both cancer and accelerated characteristics of aging, but now scientists must ask how we may apply this new information to human oncology. The same team at the US National Institutes on Aging measured and compared DNA repair proteins in the whale using multiple assays and found that there was an abundance of cold-inducible RNA-binding protein. This protein, in conjunction with its partner PARP1, is a major player in the non-homologous end joining DNA repair pathway. Overexpressing the proteins in human fibroblast lines increases DNA repair efficiency and improves genomic stability overall.

Peto's paradox accurately describes a general pattern in an evolved response to the threat of cancerous mutations. The theory doesn't explain the unique mechanisms of the bowhead species though, perhaps suggesting a shift in the dialogue of cancer research. The pathways explored by cancer and aging scientists are certainly complex and intertwined, but the correlation between DNA repair and the prevention of death by cancer in the bowhead species is undeniable. The next step? Finding a way to increase the efficiency and accuracy of non-homologous end joining in humans to treat cancer before it even happens.

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PHOTOS VIA NOA FISHIERES & PEXELS

STUDENTS WORK TO BRIDGE THE GAP BETWEEN HEALTHCARE PROVIDERS AND AUTISTIC INDIVIDUALS AT THE HUSKY HEALTHCARE INNOVATION CHALLENGE

BY EMMA KLEKOTKA, COMPUTER SCIENCE & JOURNALISM, 2026 DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING & DESIGN, 2024

Roughly 3 in 4 autistic adults report having difficulty when visiting a healthcare provider. One Northeastern club is looking to change that.

At this year's Husky Health Innovation Challenge, or HHIC, students generated digital solutions to healthcare communication issues faced by those on the autism spectrum, ranging from role-playing apps to wearable technology that tracks stress events.

The annual challenge is hosted by ViTAL, Northeastern's healthcare innovation club, and tasks students with developing a concept for a digital solution and a full-scale business plan for a provided case topic. This year was focused on autistic individuals, but prior challenges have tasked students with coming up with solutions to gut-brain disorders, pediatric caregiver burden, and geriatric nutritional modeling.

This year, the competition drew in 80 students across 33 teams, the most the challenge had ever received, according to HHIC director Rupsa Jana, a third-year biochemistry student. In the end, the HHIC organizing team selected four proposals to be judged by a panel of healthcare professionals and autism advocates at the challenge's final pitch day, which took place on Feb. 24 at the Raytheon Amphitheater in Northeastern's Egan Research Center.

For some teams, the challenge struck a personal note. First-year behavioral neuroscience and data science student Noa Yiddiah was inspired to join the competition after seeing her older brother Gilad, who has autism, struggle with anxiety over doctor's appointments.

"I was a part of ViTAL and interested in the innovation aspect," Yiddiah said. "Then I came to the first meeting, and it was something I had knowledge with."

She joined forces with first-year biology student Alaina Fernandes and first-year behavioral neuroscience student Riya Kadakia to create the app Med2Care, which placed second in the challenge. Med2Care takes a three-pronged approach to aiding autistic patients in healthcare settings. It helps users prepare for an appointment, communicate during the visit, and locate a medical professional who understands the accommodations they may need.

Creating the proposal wasn't always easy for the team of first-year students. None of the members had a background in computer science or technology, which made it difficult to understand how to implement the AI features they wished to integrate into their app.

"We had to do a lot of research on AI to know about the regulations," said Kadakia.

For the team behind the winning project — Tour Guide at the Hospital, or TaLIAH for short — the most difficult element of the challenge was finding the time to squeeze another task into their busy schedules.

"We just spent many, many late nights together," said third-year bioengineering student Kaitlyn Ramesh. She created TaLIAH with her roommate, third-year behavioral neuroscience Janani Elumalai.

TaLIAH is an app that educates users on the healthcare process to allow for preparation and consideration before appointments. It allows users to view a step-by-step guide on their visit, highlighting instruments that may be used during appointments.

At each step, the app also points out aspects of the facility that may be hard for those who have sensory difficulties and prompts users to reflect on how they might advocate for their sensory needs by presenting different phrases they could use to request an accommodation. For example, the app describes that the material of a hospital gown may be uncomfortable and prompts the user with a way to ask for a different option.

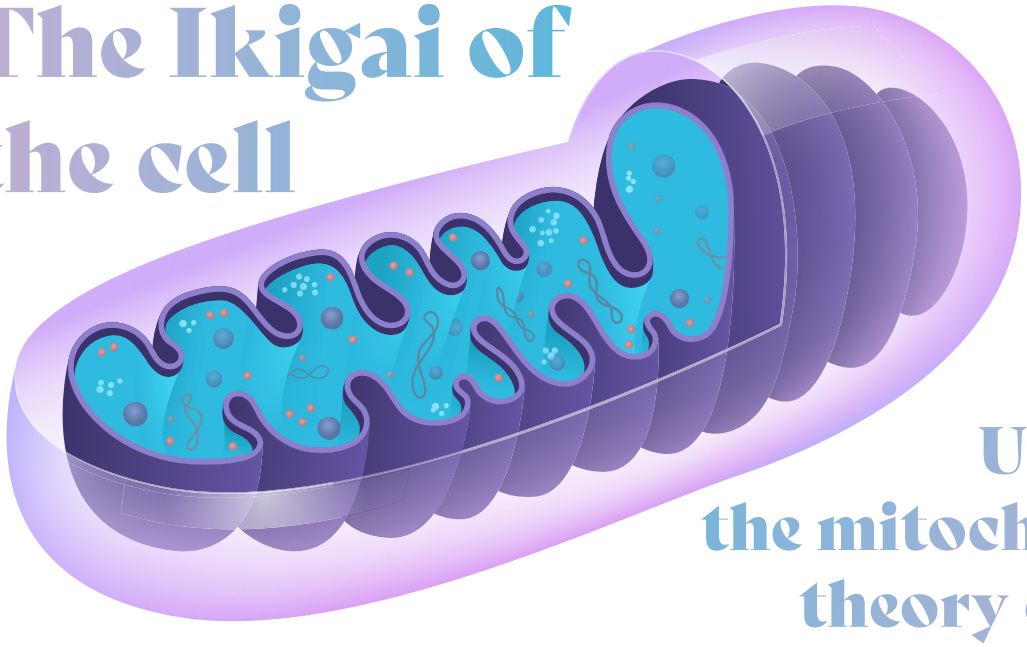
Following their win, the team behind TaLIAH is looking into ways to expand their project after the challenge. "We're definitely not closing any doors yet, " said Ramesh.

> This year, the competition drew in 80 students across 33 teams, the most the challenge had ever received."

PHOTOS VIA SHUTTERSTOCK

PHOTOS BY JIAJIA FU, BIOENGINEERING, 2026

The Ikigai of the cell



Unveiling the mitochondrial theory of aging

BY SAAKSHI SHAH, BIOTECHNOLOGY, 2025

DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

Imagine the sun-kissed shores of Okinawa, where residents embrace the Ikigai philosophy — a lifelong pursuit of purpose intertwined with passion, skill, and societal contribution. This idyllic island serves as a testament to the potential for extended, vibrant lives. Now, let's embark on a journey, into the microscopic realm of cells, where the mitochondrial theory of aging paints a compelling picture of the intricate dance between energy and the passage of time.

The theory proposes that aging, and its associated diseases, stem from an imbalance between cellular energy supply and demand. Enter the mitochondria, the powerhouse of cells, responsible for converting food into the fuel that drives life itself – adenosine triphosphate (ATP). When these tiny energy factories malfunction, it creates a ripple effect, particularly in tissues that rely heavily on their output. This disruption in energy production, coupled with the mismanagement of reactive oxygen species, can pave the way for age-related metabolic diseases.

As we delve deeper into the cellular world, we encounter another crucial player in aging: genomic instability. This hallmark of aging involves the accumulation of DNA damage and mutations, leaving cells vulnerable to malfunctions that disrupt their normal functions. Like a broken record skipping, the cell's ability to repair these errors diminishes with time, amplifying the risk of harmful mutations.

At the heart of this narrative lies mitochondrial dysfunction — a gradual decline in the vigor of these cellular powerhouses. Oxidative stress, mutations in mitochondrial DNA, and impaired mitophagy (the process of clearing out damaged mitochondria) all contribute to this decline. This dysfunction casts a long shadow, impacting energy production, metabolism, and overall cell health.

Further complicating the story are mitochondrial DNA (mtDNA) mutations. Unlike nuclear DNA, mtDNA is inherited solely from the mother and accumulates with age, further hindering mitochondrial function and ATP production. These mutations often manifest as mitochondrial diseases, highlighting their significant role in cellular health.

Another key player in aging emerges — cellular senescence. This irreversible growth arrest of cells accumulates over time, with these "aged" cells contributing to tissue dysfunction by releasing inflammatory molecules. Triggers like DNA damage and telomere shortening orchestrate this symphony of cellular aging. However, the extent to which mtDNA mutations directly drive the aging process remains a subject of debate, as the number observed in normal aged tissues appears lower than the threshold required to significantly impact mitochondrial function.

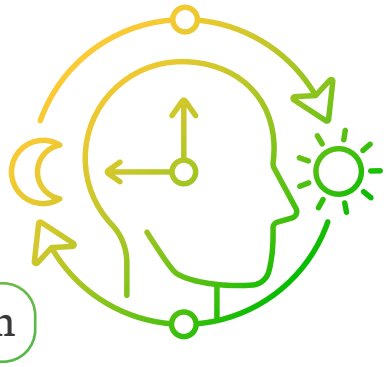
Finally, we encounter epigenetic alterations — changes to DNA and associated proteins that influence how genes are expressed. Over time, these marks undergo alterations, shaping cellular identity, function, and responses to environmental cues. Understanding the interplay between genomic instability, mitochondrial dysfunction, cellular senescence, and epigenetic changes is crucial in this complex story of aging.

This exploration is not just a scientific endeavor; it's a quest to unlock the mysteries of human aging, paving the way for strategies to promote healthy longevity. By understanding the intricate clockwork of life at the cellular level, we can aspire to live longer, healthier lives, echoing the spirit of Ikigai — finding purpose and vitality even as time unfolds.

Nature Reviews Endocrinology (2022). DOI: 10.1038/s41574-021-00626-7

PHOTO VIA SHUTTERSTOCK

The circadian rhythm and Parkinson's



How major sleep deficits could worsen neurodegeneration

BY CECELIA KINCAID, BEHAVIORAL NEUROSCIENCE, 2027

DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING & DESIGN, 2024

Parkinson's disease, the second most common neurodegenerative disease, is characterized by the gradual loss of dopaminergic (dopamine-producing) neurons, leading to motor symptoms including stiffness, slowness of movements, and involuntary tremors. Parkinson's can also present nonmotor symptoms such as digestive issues and sleep deficits. Unfortunately, there is currently no effective therapy that can delay or stop the progression of the disease.

In recent years, researchers have been exploring the connection between Parkinson's and circadian rhythms. Circadian rhythms drive many behavioral and physiological processes including the sleep-wake cycle, feeding behavior, body temperature, and more. They are crucial to an individual's homeostasis, or steady physiological equilibrium.

Parkinson's disease is frequently accompanied by disrupted sleep and circadian rhythms. These issues typically appear before motor symptoms, suggesting that a disrupted circadian rhythm could contribute to the disease's development. A 2023 review by Priya Rathor and Ratnasekhar Ch proposed that circadian rhythms influence the expression of genes involved in neural activity and synaptic plasticity. This association could explain why disruption of the circadian rhythm increases the risk or extent of neurodegeneration associated with Parkinson's disease.

The current challenge for scientists today is to uncover the exact relationship between circadian rhythms and Parkinson's disease. Michaëla Dorcikova from the University of Geneva led a study exploring neurodegeneration in male fruit flies. It has previously been shown that disruption of a fly's circadian rhythm can lead to lifespan reduction and even increased mortality in response to oxidative stress. Oxidative stress occurs as a result of imbalanced chemical activity in the body, leading to damaged tissue or disease. Researchers can use oxidative stress to learn more about how the body reacts to disrupted circadian behavior, especially in conjunction with neurodegeneration.

Dorcikova and her team used fruit flies as models of the human brain with Parkinson's disease. They noticed that functional impairments or a loss of dopaminergic neurons were frequently seen in a nerve cluster called PAM neurons. Upon further examination, they found that the loss of the circadian clock gene per exacerbates the loss of dopaminergic neurons in the PAM cluster. This is because per typically regulates the sensitivity of PAM neurons to oxidative stress. If this gene isn't functional, the neurons' vulnerability can be altered, leading to changes in sleep that are frequently observed in Parkinson's. This study suggests that not only is there a correlation between circadian rhythms and dopaminergic neurodegeneration, but perhaps also a causal relationship.

Other researchers are interested in the phenotype of individuals who have Parkinson's disease, rather than the molecular processes in the brain. Massimo Marano and his team from the Università Campus Bio-Medico di Roma investigated the relationship between chronotype, daytime motor activity, and disease phenotype. Chronotype, a key aspect of circadian behavior, is the body's natural inclination to sleep and wake at certain times of the day.

One of the major findings from Marano's lab was an association between the moderate morning and intermediate chronotypes and a typical Parkinson's phenotype. Individuals with these chronotypes tended to struggle with more significant axial motor impairment and motor fluctuations, as well as a generally decreased quality of life. The intermediate group, which is usually considered an evening chronotype, showed more widespread impairment in regard to motor complications and quality of life. This result implies that people who prefer to be more active in the evening and sleep and wake up late may develop more extreme Parkinson's symptoms.

Studies like Dorcikova's and Marano's help establish connections between circadian rhythms and the progression and severity of Parkinson's disease. While researchers understand that they are related, more work will need to be done to determine the exact role that circadian behavior plays in the disease's development. Since sleep deficits and other related circadian disruptions are frequently associated with Parkinson's, these and other findings create a better understanding of the disease and its risk factors, as well as insights into possible treatments.

Nature Communications (2023). DOI: 10.1038/s41467-023-41540-y
Biology (2023). DOI: 10.3390/biology12101294
Neurobiology of Sleep and Circadian Rhythms (2023). DOI: 10.1016/j.nbscr.2023.100094

PHOTO VIA SHUTTERSTOCK

Opinion

Weight loss drugs highlight the flaws of the US healthcare system

BY EMMA KLEKOTKA, COMPUTER SCIENCE & JOURNALISM 2026
DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

In recent years, the production of weight loss drugs has exploded across the United States. Though these drugs have promising potential in combating the obesity epidemic in the United States, I worry these drugs will widen healthcare inequities for the very patients who need access to weight management care the most.

In clinical studies, injection-based weight loss medications, such as Ozempic and Wegovy, have resulted in roughly 10-15 pounds of weight loss after 12 months of treatment. The medications stimulate weight loss by mimicking the gut hormone glucagon-like peptide-1, or glp-1, to slow digestion rates and suppress hunger signals sent to the brain. As a result, patients on medications such as Ozempic and Wegovy have suppressed appetite and increased levels of satiety.

Weight loss has been proven to have life-changing health benefits, such as lowered risk of heart attack and type 2 diabetes. But between high costs and an increasing demand, weight loss medications have become inaccessible to many of the people who need them the most.

According to the Kaiser Family Foundation, weight management medications can cost upwards of $1,000 a month in the United States, nearly $750 more than in other nations. High costs have not only impacted out-of-pocket access to weight loss medications but also the willingness of insurance companies to provide coverage.

Beginning in April, weight loss medications will no longer be covered by North Carolina state employees after weight loss prescriptions comprised over 10% of the state's healthcare spending. The University of Texas and the Mayo Clinic have also implemented strict restrictions to their coverage of weight loss drugs, while other companies have limited their coverage to those whose weight places them above a certain body-mass index.

The refusal of insurance companies to provide aid is concerning for all patients, but especially for low-income individuals on Medicare. The Medicare Prescription Drug, Improvement, and Modernization Act of 2003 prohibits the coverage of weight loss medications under Medicare, excluding roughly 80 million Americans from access to preventative medications.

Denying access to prescription weight loss medications to low-income populations widens the gap in preventative healthcare among people of color, who have historically faced higher frequencies of obesity and poverty than white Americans.

More than anything, the reluctance of insurers to cover weight loss medications highlights the social stigma associated with obesity. In a 2021 study from the University of Connecticut, researchers found that over two-thirds of overweight adults faced judgment from healthcare providers based on their weight, despite studies suggesting that inherent factors such as genetics and hormonal imbalances can play a role in obesity.

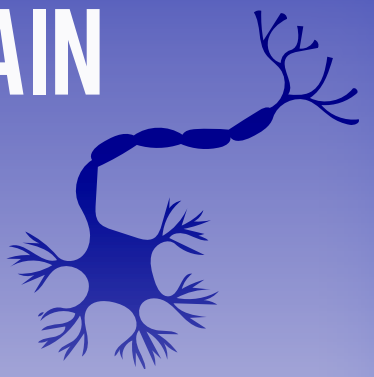
As the market for weight-loss medications grows, I can only hope insurance companies may come to see how crucial these medications could be in helping patients lose weight and maintain weight loss. Though the medications provide a hefty cost upfront, they could save thousands of dollars in medical care for both patients and insurers alike by preventing lifelong healthcare conditions associated with obesity.

Front Endocrinol (2020). DOI: 10.3389/fendo.2019.00883
Plos One (2021). DOI: 10.1371/journal.pone.0251566

PHOTOS VIA SHUTTERSTOCK

3D-PRINTING THE BRAIN

IS THIS THE NEW WAY TO TREAT BRAIN INJURY?



BY IBA BAIG, DATA SCIENCE & BEHAVIORAL NEUROSCIENCE, 2026

DESIGN BY KATHRYN FURMAN, COMPUTER SCIENCE & MATH, 2025

Is it possible to 3D print human brain tissue? Beyond the intricacies of the cells themselves, brain tissue is also organized in complex structures that are difficult to replicate. But what was once considered science fiction has now proven not only to be a novel remedy for not just traumatic brain injuries but also a revolution in medical practices. Using 'bioinks' developed from human stem cells, a team of researchers at the University of Oxford have developed 3D printing methods for assembling neural cells into the architecture of the cerebral cortex.

The key to correctly replicating the structure of the brain lay in the cells used for printing: pluripotent stem cells (hiPSCs). Pluripotent stem cells, particularly human induced pluripotent stem cells (hiPSCs), possess the remarkable capability to differentiate into a wide array of cell types, including neurons and glial cells, which are essential components of the brain's structure. The cells can then be grown using a concoction of growth factors and chemicals into structures housing the two layer cerebral tissue.

The printed tissues were then implanted into mouse brain slices, which showed strong integration of neural processes and signaling activity. Because hiPSCs are stem cells, they are capable of being integrated into the host system without triggering the immune response targeting foreign cells. Moreover, 3D printing facilitates personalized implantation of brain tissue, crucial for ensuring immune acceptance of treatments. The success of these experiments signifies a groundbreaking advancement in future approaches to treating traumatic brain injury, shedding light on mechanisms previously not fully comprehended.

> "3D printing neural tissue becomes the forefront of research in treatment of brain injuries."

Beyond medical treatments, 3D printed brain tissue has the potential to revolutionize the way we study neurological diseases. In order to gain valuable insight for clinical practice, researchers often seek to understand the underlying microarchitecture of the brain and its relationship with diseases. A team of researchers at the University of Wisconsin also utilized human induced pluripotent stem cells to print neurons that mimicked the functionality of healthy cells. The cells were then placed in low-oxygen environments similar to the conditions of ALS brains, thereby offering a novel platform for studying disease mechanisms. This new neuron production technique has opened a new avenue for drug testing, understanding complex diseases, and understanding cognition.

However, despite these advancements, the printed tissues are time-expensive and relatively thin. As a result, these techniques lack the capacity to fully recreate tissues with the complexity of an entire brain. This does not prevent the scientists from envisioning printed tissues as a primary front in treating damaged brain tissue, which will transform the future of healthcare.

Nature Communications (2023). DOI: 10.1038/s41467-023-41356-w
Cell Stem Cell (2024). DOI: 10.1016/j.stem.2023.12.009

PHOTOS VIA PICKPIK, PXHERE & STOCKVAULT

A NEW HOPE

RAT RECOLLECTION AND A GLIMPSE INTO THE FUTURE OF PROSTHETICS

BY TONIA CURDAS, BIOCHEMISTRY, 2025

DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

Moving objects with your mind has always been an element of science fiction, popularized as an iconic feature of the "force" in the pop culture-defining series "Star Wars." But recent advancements in brain-machine interfaces, or BMIs, are working to bring fantasy to fruition. With the power of deep learning algorithms, even lab rats are becoming tiny Jedis, able to move virtual objects with only their brains. Their telepathic abilities offer us a promising glimpse into the future of computerized prosthetics and potentially restoring lost motor ability to individuals in need.

Dr. Albert Lee and his team of researchers at the Howard Hughes Medicine Institute were interested in hippocampal activity and its role in imagining and recollecting movements. They connected lab rats to BMIs which monitored the firing activity of neurons in their hippocampus. The hippocampus, located deep in the temporal lobe behind the ears, is an important center for memory and learning. It is essentially responsible for the development of our cognitive maps, a mental model of our experienced environment. This cognitive map is developed by "place cells" that fire selectively based on relative or absolute perception of a physical environment. The firing of these place cells can be recorded as electrical signals using electrodes and an external computer.

Three rats were harnessed into an immersive virtual reality (VR) environment made up of a surrounding screen with a VR projection and a spherical treadmill to allow for three-dimensional movement. As the rats moved around on the treadmill, their virtual location was updated accordingly. Hippocampal neural activity was measured as the rats acclimated to their environment, and a decoder was able to associate specific neural firing signals to the rats' location in virtual space. Then the treadmill was deactivated so that the rats' physical movement no longer affected their virtual movement. As the rodents adjusted, they were able to recall past locations in their virtual environment, and their BMIs were able to interpret the brain signals from their recollections and project an updated virtual location onto the surrounding screens.

PHOTO VIA SHUTTERSTOCK

Once Dr. Lee and his team confirmed the rats' abilities to recall their past locations, they tested their ability to recall object locations in what was known as the "Jedi task." Rats were able to navigate freely using the treadmill again and were rewarded for moving an object to a desired goal on a virtual screen. Their neural activity was recorded while they moved the objects. Afterward, the treadmill was once again disabled. The rats were able to successfully envision the goal location of the virtual object in multiple trials, and the BMI decoder was able to convert their brain signals into virtual object movement on their surrounding screen.

The rats were able to envision specific locations in their cognitive map through the underlying mechanism of selectively activating hippocampal neurons. As model animals, these results in rodents give insight into how humans are able to vividly recall physical environments and movements. As BMI technology advances to better interpret brain signals, there is potential for better mental control of motor aids and prosthetic limbs.

Motor disabilities due to limb loss or paralysis greatly impact quality of life and individuals struggle with carrying out daily tasks. Currently, prosthetics and mobility aids rely on signals from sensors or electrical signals from muscles. Advancements in BMIs could allow neuronal motor signals to be directly converted into commands for computerized prosthetics such as prosthetic limbs, electric wheelchairs, exoskeletons, or virtual keyboards. With greater fine motor control of mobility aids, there is a potential for increased quality of life for amputees and individuals with other motor disabilities.

"Jedi rats" sounds like an epic sequel concept for a beloved franchise, but these rodents hold serious significance in an increasingly computerized world. As deep learning and AI become more intertwined with our daily technology, they're on track to play a major role in medicine. Combining the traditional practice of animal models with novel advancements in algorithmic modeling has the potential to bring about a new hope of restoring motor function to individuals with disabilities across the galaxy.

Hippocampus (2016). DOI: 10.1002/hipo.22587
Science (2023). DOI: 10.1126/science.adh5206
Handbook of Neuroengineering (2022). DOI: 10.1007/978-981-15-2848-4_35-2

Black lemurs, with their archetypal yellow-orange eyes, are active both night and day. Depending on the availability of food and the activity of their predators, the lemurs shift their sleep schedule so they can forage for fruit in the canopy of Madagascar's northern coastal forests in safety. Scientists have found little evidence that their striking eyes play any evolutionary role beyond helping fellow black lemurs recognize each other.

PHOTO BY JIAJIA FU, BIOENGINEERING, 2026

Quantifying common sense

New research suggests it's not so common

MAYA BRINSTER, BEHAVIORAL NEUROSCIENCE, 2025

DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

Common sense, or the practical knowledge shared by the majority of the population regarding everyday matters, is ambiguous: It is difficult to know exactly why something is common sense even though it is intuitively clear. Many often assume that something clear to one person is also clear to another, but this may not be the case. Some skeptics, therefore, claim that common sense does not even exist, contrary to what is widely believed. Computational social scientists Mark Whiting and Duncan Watts at the University of Pennsylvania tackled this paradox in their study published in Jan. 2024, which reveals that "common" sense actually may not be common.

Common sense has been a difficult concept to study as there has not been an empirical method to calculate the extent to which a claim classifies as common sense or the percentage of people who are knowledgeable about such commonsense claims. Whiting and Watts began their research by establishing an equation to do so, which incorporates the mathematical calculations of two quantities that define common sense: consensus, or a population's disagreement or agreement with a certain claim, and awareness, or individuals' ability to predict others' agreement with such a claim. According to Whiting and Watts, a claim's common sense is the square root of the product of these two quantities.

After mathematically defining individual common sense, the scientists created a graphical method of analyzing collective common sense, represented as pq: the fraction of claims (p) shared by a fraction of people (q). If common sense is actually common, most people would agree on most claims, and the value of pq would be close tofraction would be close to 1. On the other hand, if not many agree on a set of claims, this number would approach 0.

To generate data, Whiting and Watts asked 2,046 participants to rate whether they agreed with 50 claims, if they thought most people would agree with the claims, and if they thought the claim was common sense. They used a total of 4,407 claims taken from various sources such as humans' responses to prompts such as "write a claim you believe to be common sense about math and logic," real-world claims from political campaigns, emails, and other sources, and AI-generated claims. To determine whether specific types of knowledge are more or less common, Whiting and Watts sorted each claim into 13 knowledge domains, such as geography and places, culture and the arts, and history and events, to determine whether specific types of knowledge are more or less common. They also looked at how variations in people affect common sense scores by classifying participants according to specific demographic groups such as age, gender, race, income, and personality assessment scores.

After extensive data analysis using the participants' ratings of each claim, Whiting and Watts made several compelling findings. Individual common sense analyses revealed that common sense varied substantially across all types of claims but not across people of varying demographics, and — perhaps the most surprising finding — collective common sense is actually rare. According to the data, there were 0 claims with both universal and perceived consensus, and only a tiny fraction of people (p) agree on even a small number of claims (q). Only 8% of the sample size agreed with 25% of claims, and 0% agreed with 50%, revealing that only a small number of people within any population share even a small fraction of seemingly commonsense beliefs. Therefore, if defining one's common sense as their total collection of commonsense beliefs, it would be almost impossible for two people to share the same conception of common sense since the perception of claims' commonality varies so drastically across individuals.

Further studies regarding the quantification of common sense could explore how specific contexts may impact the commonsense of a claim, how common sense has changed throughout time or within specific countries, or the impact of common sense in real-world situations. How does the use of commonsense claims in politics or writing, for example, impact the audience's beliefs? The methods used in this study could even be used to determine whether machines can learn common sense, and thus serve as a foundation for the future of AI.

The idea that common sense does not actually exist is rather paradoxical, as it seems like there are an endless number of claims that almost everyone would agree with. Hopefully, though, these findings will provide some comfort the next time you do not know something that is apparently "common sense" — after all, it is likely that less than 8% of the population knew it, too!

Proceedings of the National Academy of Sciences (2024). DOI: 10.1073/pnas.2309535121

FUNCTION OF DREAMING IN HUMANS FROM AN EVOLUTIONARY PERSPECTIVE

BY LYDIA NORMAN, INTERNATIONAL BUSINESS & AFFAIRS, 2026
BY ANJANA BALAKRISHNAN, STUDIO ART, 2027

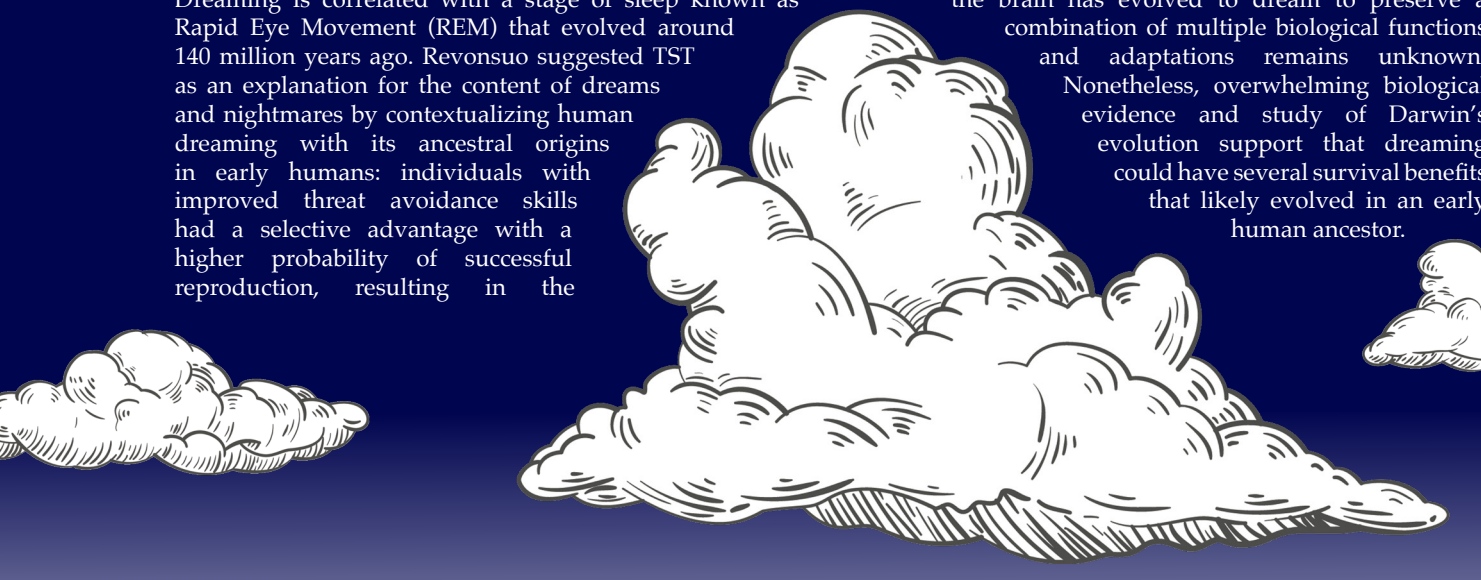
Sometime around 2500 BCE, the earliest recorded dream in history was documented. This was Sumerian king Dumuzi's dream, from the ancient civilization of Mesopotamia, and was recorded in cuneiform. In this vision, the king sees subjects moving before him with various objects in their hands and on their heads, which was a perplexing story to the public. Dreaming has served as a 4,000-year confusion to humanity — if dreaming has been a collective human experience dating back thousands of years, how do we continue to encounter the same phenomena as our ancestors? Though there is no definitive answer for these sensory experiences while we sleep yet, scientists in the neuroscience field have theorized why we dream, using psychology and evolutionary science as explanations.

For years, popular theories to explain dreams have included: physiological theories that the brain stores information from waking experiences with dreams, conditioning theories that dreams allow the preservation of specific areas in the brain, Freud's wish-fulfillment idea that we dream to express subconscious longings, and many more. Recently, there has been a rise in another dream theory, known as the threat simulation theory (TST).

In 2000, Finnish Neuroscientist Antti Revonsuo proposed the threat simulation theory, suggesting that the brain has evolved with the biological function to dream to simulate threatening events, allowing the dreamer to rehearse threat perception and threat avoidance in a safe environment. Dreaming is correlated with a stage of sleep known as Rapid Eye Movement (REM) that evolved around 140 million years ago. Revonsuo suggested TST as an explanation for the content of dreams and nightmares by contextualizing human dreaming with its ancestral origins in early humans: individuals with improved threat avoidance skills had a selective advantage with a higher probability of successful reproduction, resulting in the neural basis of dream production persisting in successive populations. As a result, the brain produces dreams riddled with threatening events to simulate real-life dangers as an evolutionary survival mechanism.

Revonsuo's theory was applied to current human populations, hypothesizing that the brain continues to rehearse common threats in the same environment. TST is supported by evidence of dreams in children exposed to traumatic experiences where post-traumatic dreams evolved as a threat simulation response. A 2003 study observed a correlation between threatening dreams in a trauma group and a control group. Scientists found that traumatized children who experienced the effects of military violence, or the presence of ecologically valid threat cues in their environment, had a higher frequency of dreaming threatening events during REM sleep than less traumatized or non-traumatized children. By observing nightmares and dreams as an evolutionary adaptation illustrated by post-traumatic dreams in children, Revonsuo's threat simulation theory remains a plausible explanation for human dreams.

Robust proof of why the brain can conjure vivid sensory experiences and evoke intense emotions while we are asleep remains an enigma in the field of neuroscience. Whether the brain has evolved to dream to preserve a combination of multiple biological functions and adaptations remains unknown. Nonetheless, overwhelming biological evidence and study of Darwin's evolution support that dreaming could have several survival benefits that likely evolved in an early human ancestor.



Behavioral and Brain Sciences (2000). DOI: 10.1017/S0140525X00004015
Consciousness and Cognition (2005). DOI: 10.1016/S1053-8100(03)00019-9

PHOTOS VIA SHUTTERSTOCK

GRADUATING SENIORS

Congratulations to the graduating class of 2024 from all of us at *NU Sci***!** This talented group has helped the magazine flourish with their expertise in writing, editing, and design — along with their kindness and humor beyond the pages. Their passion for science communication shines brightly, inspiring both current and future generations of *NU Sci* members to continue sharing the wonders of science with the world. Throughout their time here, they've produced well-crafted and expertly designed articles and gifted us with a wealth of wisdom, laughter, and memories, helping to shape the club into the vibrant community it is today. We thank them dearly for the effort and dedication they've given to *NU Sci*, and we wish them lots of luck and happiness in their future pursuits, confident that they will continue to shine wherever life takes them.

DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING & DESIGN, 2024

NOAH HAGGERTY

NU Sci quickly became a home for Noah. He joined during his first semester, and through his time at Northeastern, he's served as an editor, the head of outreach, and editor-in-chief. Creating a space for budding science communicators to learn, practice, and share their work has been his proudest contribution to *NU Sci*. Noah believes that the wonder of discovering how our universe works belongs to everyone and that science has the power to radically change people's lives through informing policy and advancing technology. Outside of *NU Sci*, Noah has completed research co-ops with the Department of Energy and written for Northeastern's College of Science and the provost of research, *The Huntington News*, *The Boston Scope*, and *Woof Magazine*. Now, Noah is heading west to write for the *Los Angeles Times* as an AAAS Mass Media Fellow.

NETHRA IYER

A lover of science and writing, Nethra joined *NU Sci* during her first semester at Northeastern … from 8,000 miles away amid the COVID-19 lockdown. At *NU Sci*, she has served as an editor for two years, and a senior editor and treasurer for her final year at Northeastern. For Nethra, *NU Sci* became more than an extracurricular — it became a world where she could delve into topics ranging from mathematical madness to profiles of scientists. Outside of *NU Sci*, Nethra is passionate about law and engineering and hopes to make complicated STEM concepts accessible to everyone. As a chemical engineering major with an English minor, Nethra found research is where her future looks clear. After graduation, she will attend Columbia University for a PhD in chemical engineering. She would like to thank everyone at *NU Sci* for making the magazine what it is today: a family dedicated to sharing science.

ISABELLE BRANDICOURT

A self-proclaimed nerd about almost all things science — including life in outer space, plant root structures, and unique physics phenomena like lightning — Isabelle took to *NU Sci* to discover more about the world outside of her major, electrical engineering. Getting completely absorbed in researching and writing about reincarnation or time travel in space was an enriching way to procrastinate her circuits homework as well as learn something new. Beyond the science, Isabelle found the writing process to be quite enjoyable and became an editor to help other writers craft their own articles. On a broader academic scale, Isabelle has been working to combine the fields of electrical engineering and marine science into a career. She found that *NU Sci* helped her to explore this combination from a different angle and encouraged her to practice her science communication, a skill that will be instrumental as she moves forward. After graduation, Isabelle is excited to backpack through Asia before starting her PhD in oceanography at the University of Washington this fall.

NICHOLAS BERRY

NU Sci has been a constant presence in Nicholas' life during his time at Northeastern. He enrolled at Northeastern as an undeclared engineering major and joined the *NU Sci* design team during his first semester. He wanted to explore his more creative side and found that designing pages for the magazine's print issues was a great way to do that. *NU Sci* allowed him to learn a lot of new design skills by working in a team with other great designers. His passion for design only grew, resulting in him finally declaring his major as mechanical engineering and design. After graduation, he will move back to London to get a master's degree in innovation design engineering at Imperial College and the Royal College of Art and Design.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