

ISSUE 57 FALL 2023

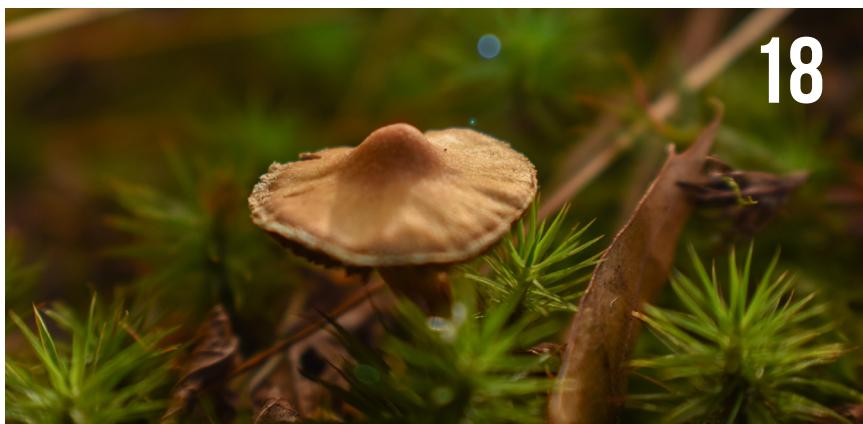
# NU SCI

# ENTANGLED

# TABLE OF CONTENTS



11



18



21

## BIOLOGY

- 4** Hello computer  
*Brain-powered biocomputers*

- 6** How cuckoo are cuckoo birds?

## IN BOSTON

- 8** A deep dive into dinosaurs and DILFs
- 12** Meet the lizards of the Fenway Victory Gardens

## HUMANS & NATURE

- 15** Forest fires and contaminated waterways  
*Unspoken consequences of the war in Ukraine*
- 20** Venerated to vermin  
*A brief history of pigeons*

## PSYCHOLOGY & CULTURE

- 29** Physician-assisted suicide  
*The patient's right*
- 30** How the Buddha's journey to enlightenment reimagined neurotherapeutics

## MEDICINE

- 33** Hormone replacement therapy  
*A delicate balance*

- 38** Opinion: The invisible pill

## ARTIFICIAL INTELLIGENCE

- 40** How AI is changing the journalism industry
- 42** Cracking the code behind TikTok's 'For You' algorithm

# LETTER FROM THE EDITOR

**I**t spurred a revolution in forest ecology. A former forester who grew up roaming among old-growth trees showed that trees don't exist simply as individuals, but live deeply connected lives. Complex chemicals flow from tree to tree as they communicate, and their trunks, branches, and canopies hold an uncountable number of creatures in their embrace — from deer to lizards, bugs to birds. The forest becomes an entity of its own: trees as neurons in the forest brain with roots and fungi as its synapses.

It was Suzanne Simard's PhD thesis, published in *Nature*. Over the quarter century since, the research supercharged the environmental movement. Western medicine has slowly recognized the healing powers of many chemicals used by trees to communicate. Simard's work also became a core inspiration for Richard Powers' Pulitzer-winning novel "The Overstory," challenging ideas of human exceptionalism and individualism.

Her ideas melded with ecology, culture, medicine, and activism until their boundaries blurred. Like the physical systems she studied, her research became entangled. In our complex and dense reality, these entanglements exist everywhere as the stitches pulling our world into a single tapestry. They create complex webs of ideas and influence, and physical networks of cause and effect that effortlessly leap from one domain to another.

The results of these entanglements are often mindbending; In this issue of *NU Sci*, we explore them. We cover how artificial intelligence is transforming journalism, education, and social media. We dive into how nature and human life are inextricably intertwined: an arctic research station that pollutes the very ecosystem it studies and racist redlining policies that affect where birds live. We look into how — like Simard's studies of trees — the psychology of individuals meshes into the dynamics of the whole culture, from the rise of physician-assisted suicide to neuroscience learning what Buddhism discovered centuries ago.

As you read, I hope these stories entangle into your own worldview, gifting you with a wider appreciation of our universe's profound interconnectedness. I thank our writers, designers, and photographers; the members of our web and software, outreach, and social media teams; our e-board; and our readers — all of whom have contributed to this issue of *NU Sci*.



A handwritten signature in black ink, appearing to read "Noah Haggerty".

Noah Haggerty  
Editor-in-Chief

# STAFF

## PRESIDENT

Reshika Sai Devarajan

## EDITOR-IN-CHIEF

Noah Haggerty

## SENIOR EDITORS

Reshika Sai Devarajan • Dassy Dusichka  
Nethra Iyer

## HEAD OF COMMUNICATIONS

Lily Garrett

## TREASURER

Nethra Iyer

## HEADS OF DESIGN

Jasmin Patel • Vianna Quach

## HEAD OF MARKETING

Tonia Curdas

## HEAD OF OUTREACH

Caelah Cross

## HEAD OF PHOTOGRAPHY

JiaJia Fu

## HEADS OF WEB & SOFTWARE

Raisa Bhuiyan • Ethan Szeto

## WEB & SOFTWARE TEAM

Aidan Roche • Sutton Spindler • Daniel Zhao • Kalan Nguyen • Emma Klekotka  
Stephanie Chen • Patrick Donnelly  
Arushi Aggarwal • Priya Singh  
Seleena Desai • Ashley Winnor  
Isabella Iype • Sree Kandula  
Adharsh Kandula • Jessica Luo  
Kevin Lu • Jonathan Zhang

## EDITORS

Isabelle Brandicourt • Maya Brinster  
Aanchalika Chauhan • Sophie Donner  
Anna Ducroiset • Maggie Eid • Caroline Gable • Mackenzie Heidkamp • Ananya Jain • Divya Ravikumar • Lilly Schar

## OUTREACH & MARKETING TEAMS

Maya Brinster • Deborah Oke

## DESIGN TEAM

Deya Arnold • Anjana Balakrishnan  
Nicholas Berry • Michael Chang • Annie Christie Josephine Dermond • Kathryn Furnab • Sophie Donner Ananya Jain Jennifer Medina • Naseem Mohideen Samadhi Wijethunga

## PHOTOGRAPHY TEAM

Clara Barsoum • Carla Delgado • Mimi Perez • Vatsal Mehta



# Hello Computer

## Brain-powered biocomputers

BY JIAJIA FU, BIOENGINEERING, 2026

DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

With the staggering advances of AI and brain-computer ventures like Neuralink, an “organo-technological” cyborg-like future seems to be on the not-so-distant horizon. However, some researchers are pioneering the reverse: brain powered computers. The burgeoning field of organoid intelligence posits future computer systems to run on networks of human brain cells. Organoids are stem-cell derived 3D matrices of cells grown in the lab to simulate organs and tissues without having to test on living subjects. Brain organoids, coined “intelligence on a chip,” are not functioning independent brains but rather dot-sized networks of interconnected neurons which communicate and replicate simple neurological functions.

Our 3-pound brains are truly exceptional organs — the adult human brain runs continuously on around 12 watts of power while a typical desktop requires 175 watts to function. Not only are brains extremely energy efficient, but also they also simply have unmatched computational power. The brain can perform an exaflop, or one billion-billion mathematical operations per second. In fact, the Oak Ridge Frontier, one of the most powerful supercomputers in the world, required one million times more power to demonstrate exaflop computing!

The natural sophistication of the brain inspired the development of the computer altogether. Pioneering mathematician George Boole established Boolean algebra in which 1s and 0s are logically associated with true or false operations — neurons can either fire or be inactive when transmitting neural signals. This paradigm was later confirmed by logicians Walter Pitts and Warren McCulloch in 1943, who proposed the first mathematical model of a neuron based on accumulating and transferring electrical signals in the form of spikes. The

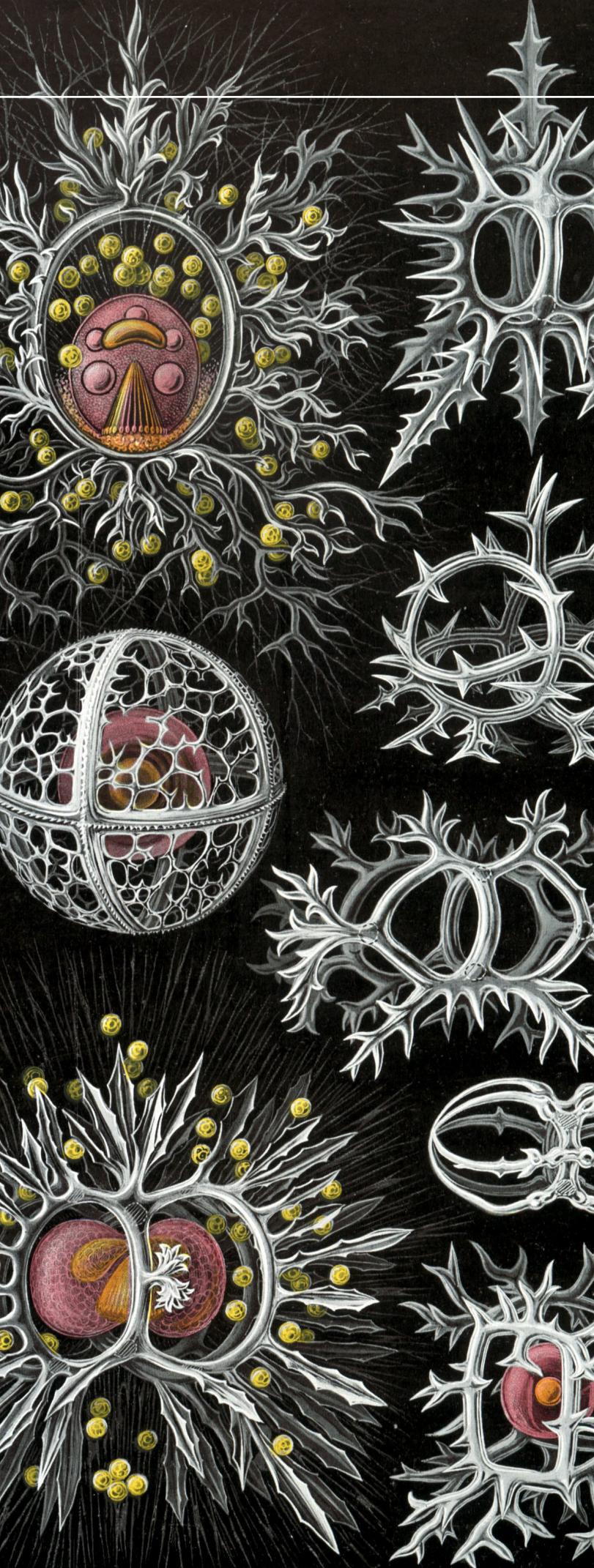
dense network of billions of interlinked neurons sparked the conceptual neural network which has revolutionized deep machine learning by allowing computers to “learn” and improve from past inputs.

Since 2012, Dr. Thomas Hartung and his team at the Johns Hopkins Bloomberg School of Public Health and Whiting School of Engineering have been developing brain organoids. They predict that organoid intelligence is the new frontier for both neurological and computing technology. Organoids trained against stimuli can “remember” pathways and simulate Boolean logic gates in computers, connect with external sensors, and communicate with each other. The team envisions a future of biosupercomputers capable of parsing massive databases to identify new therapeutics for diseases like Alzheimer’s or exceed current computers when augmented with machine learning.

The possibility of biocomputing is exciting, but prompts thorny philosophical and ethical questions — can organoids become conscious? Are they considered sentient life? What would their role in society be? The vast majority of the brain’s molecular mechanisms and pathways are still shrouded in mystery. The biological origin of consciousness is entangled in emergent properties and quantum mechanics, and we still don’t know how it arises or at what state an organism (or organoid) is considered conscious. Perhaps we should first strive towards unlocking the underlying nature of the mind before replicating them on chips.

*Frontiers in Science* (2023). DOI: 10.3389/fsci.2023.1017235

PHOTO VIA SHUTTERSTOCK



# RADIOLARIA

## A LIVING SPECIMEN OF THE SCIENCE BEHIND ERNST HAECKEL'S EVOLUTIONARY ARTWORK

BY GABRIELLE WEINER, BIOLOGY, 2026

DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

Ernst Haeckel, a German contemporary of Charles Darwin, made significant contributions to the field of evolutionary biology. He is responsible for the exploration of primarily marine organisms, and in some cases, identification of entirely new species. More recognizable of his legacy, though, is his artwork. Some of his most iconic images depict a species called Radiolaria.

A radiolarian is a unicellular prokaryote, known as a protist, with a beautifully intricate mineral skeleton, whose fossils have been observed by scientists for centuries. Despite their abundance and rich genetic history, there is a lack of knowledge of their particular importance to marine ecosystems in modern science. A fossilized radiolarian represents a fantastic preservation of a palaeobiological system. As scientists work to piece together the ecosystems of the past, there is a clear role that Radiolaria plays in the carbon and silicon cycles, due to the chemical composition of their skeletons, that raises a question of the extent of their influence on such communities. The species is found in abundance, seeing waters from the polar regions to the tropics and depths from the sunlit shallows to the bathypelagic. This is a classification of organisms that is clearly diverse in its ecological niche as well as genetic composition — which may explain why it's so difficult even today to understand prey capture and digestion in radiolaria. The high diversity in a wide range of ecosystems could be a biased assumption, however, due to Radiolaria's high intracellular variability in genetic composition. A biological topic which is spoken of with such uncertainty is incredibly nuanced, but the scientific debate that has surrounded Radiolaria for centuries is what makes it so fascinating. Studies of Radiolaria by today's generation of evolutionary biologists challenge its traditional morphological identifications, making it difficult to recognize diversity patterns.

Haeckel originally classified Radiolaria into four groups, all of which were divided among two subclasses, but modern classification identifies six groups with one subclass. The organisms can be associated with photosynthetic partners, or they can form large colonies. Each study of Radiolaria reorganizes our understanding of its purpose and function, but Ernst Haeckel's artwork remains unchanged — establishing an infatuation with an entire biological realm beyond our eyesight. We are still working today to understand the exact contributions of the species to the marine carbon pool for example. Nonetheless, the art of Ernst Haeckel demonstrates the intricacy with which our world is built.

*Environmental Microbiology* (2022). DOI: 11/1462-2920.16004

PHOTO VIA FREE PUBLIC DOMAIN ILLUSTRATIONS

# HOW CUCKOO ARE CUCKOO BIRDS?

ARTICLE AND DESIGN BY ANNIE CHRISTIE, ENVIRONMENTAL & SUSTAINABILITY SCIENCE, 2023

**N**ature's intricacies often reveal themselves in unsettling ways, and the cuckoo bird is a striking example. For hundreds of years, bird enthusiasts have been intrigued by the sight of a little reed warbler mother feeding a young cuckoo bird, a species that will grow to five times her own body mass. In fact, Aristotle recorded one of the first known observations of cuckoo birds 2,300 years ago: "The cuckoo ... does not build a nest. Sometimes it lays its eggs in the nest of a smaller bird."

The common cuckoo, also known as the European cuckoo, is famous for its parasitic behavior. After laying a solo egg in the nest of the reed warbler, the mother cuckoo abandons her offspring. The unsuspecting foster mother broods the cuckoo's egg and soon after, the cuckoo's offspring emerges — an intruder in an unfamiliar home. Upon hatching, the interloping cuckoo pushes any competing eggs or hatchlings from the nest to fall to their deaths. The warbler mother will raise the cuckoo chick as if it were her own, unaware of the loss of her biological offspring. The young cuckoo will never meet its real mother.

Over millions of years, the cuckoo bird has evolved several unique traits that have aided in its deceptive abilities. Around the time of egg laying, certain mother cuckoos may produce a call resembling that of a Eurasian sparrowhawk, a common predator of the reed warbler. This sound drives the warbler away from the nest, affording the cuckoo an opportunity to lay her eggs and make her escape without detection. Furthermore, some species of cuckoo have evolved to lay colored eggs that closely resemble the eggs of their hosts, making foreign eggs difficult to identify. Even the chicks have developed adaptive behaviors. After pushing the other hatchlings out of the nest, the newborn cuckoo makes begging noises many times louder than the host parents' normal chicks, deceiving the unsuspecting mother into providing more food. The cuckoo's ability to imitate and deceive is more commonly known as "mimicry," a phenomenon characterized by superficial resemblance between two genetically unrelated organisms.

This intricate scheme known as "brood parasitism" raises intriguing questions about how the cuckoo instinctively possesses this knowledge, given that it grows up without any role models from its own species. While most animal behavior is influenced by both nurture and nature, the unique behavior

of cuckoo birds comes down to genetics. William Feeney and a team of researchers at the Australian National University revealed that brood parasitism in cuckoo birds likely evolved through a combination of genetic mutations and natural selection favoring individuals that exhibited superior mimicry and deceptive behaviors. This process, commonly known as "coevolution," occurs when two or more species reciprocally affect each other's evolution through natural selection.

While mother cuckoos have evolved to deceive host species into brooding their offspring, many host species have developed the ability to detect foreign eggs in their nests and reject them. In response, cuckoos have developed counter-adaptations such as mimicry of host eggs. To combat difficulty in recognizing cuckoo eggs, some host species have evolved the capacity to identify cuckoo chicks once hatched. This pattern has been termed favorably by scientists as a "coevolutionary arms race." The cuckoo-host relationship has served as a valuable case study for scientists studying coevolutionary processes.

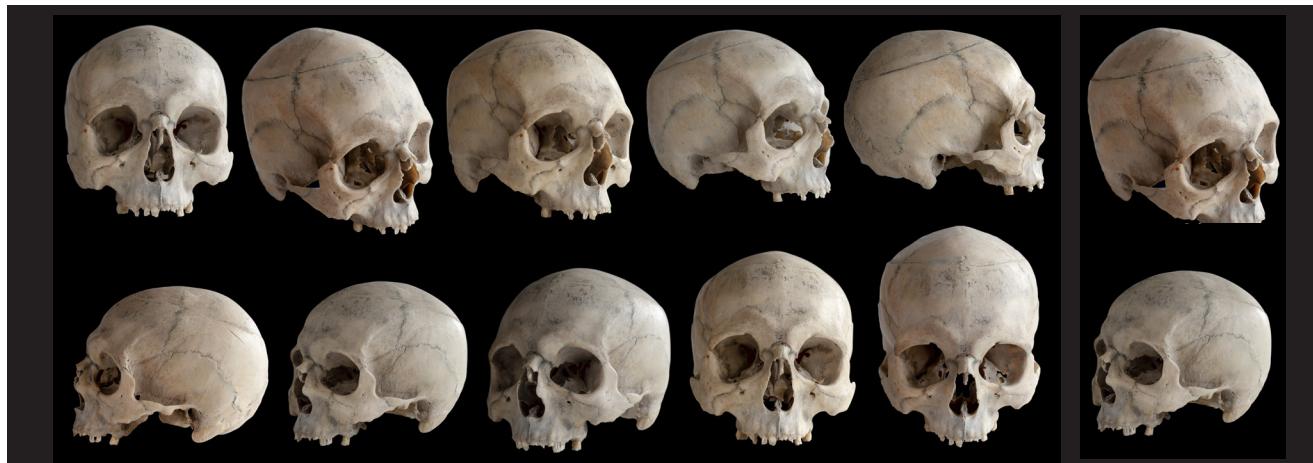
Generations of cuckoos have learned to depend on foster mothers for childcare, as is the unfortunate but predetermined fate of the host species. While the cuckoo may come across as the antagonist in this story, they are merely adhering to a lifestyle shaped by millions of years of evolution. This reciprocal relationship between cuckoo birds and host species underscores the profound interconnectedness of the natural world.

*Fowler's Zoo and Wild Animal Medicine* (2015). DOI: 10.1016/B978-1-4557-7397-8.00022-0  
*Journal of Experimental Biology* (2017). DOI: 10.1242/jeb.147694  
*The History of Animals* [Translation] (2020). ISBN: 979-8664001327  
*Animal Behaviour* (2012). DOI: 10.1016/j.anbehav.2012.04.011

PHOTOS VIA SHUTTERSTOCK



# The discovery of a 300,000-year-old fossil, and what it means



BY AKSHAY DUGGAL, BIOLOGY, CLASS OF 2025

DESIGN BY NASEEM MOHIDEEN, GRAPHIC DESIGN, 2026

**I**t is not every day that a fossil of an entirely new species is found, let alone that of an early human, estimated to be 300,000 years old. This recent discovery adds an entirely new chapter in the story of premodern human history.

In 2019, a team of scientists led by Xiu-Jie Wu and Wu Liu from the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing discovered fragments from the skull of a hominin in the Hualong Dong cave just west of the Yangtze River in China. This species is very closely related to modern humans and lived in eastern China approximately 300,000 years ago. A year after the discovery, the team recovered half of the mandible — the lower jawbone — believed to belong to the individual, known as HLD 6 after the Hualong Dong cave. From this singular fossil, the group determined that it was likely from the skull of an adolescent of an entirely undiscovered species of primitive human.

The scientists used geometric morphometric analysis, which is a computerized measuring technique used to compare and contrast shape and determine relationships between them, to study mandibles from 83 different hominins from a variety of time periods. The measurements revealed a statistically significant difference between other pre-modern

humans, which led to the conclusion that HDL 6 is most likely a unique, first-of-its-kind subgroup — a revelation that has added a new layer to the already complicated timeline of human evolution.

The discovery of HDL 6 has also forced anthropologists to rethink the origin of *Homo sapiens*, or modern day humans. Described as a “mosaic,” the HDL 6 skull remnants contain features seen in both extinct bipedal primates and modern-day humans. While certain aspects of its skull resemble those in other hominins from the late Middle Pleistocene age (between 774,000 and 129,000 years ago), HDL 6 bears a flat face and thinner upper jaw structure: more modern morphological features. This mosaic pattern has “never been recorded in late Middle Pleistocene hominin fossil assemblages in East Asia,” Wu and Liu wrote in their study.

While it is unlikely that the appearance of a few present-day attributes in an individual in eastern China will push back the timeline of the existence of the first modern humans, the fossils recovered from Hualong Dong prove that traits found in humans today are also found in fossilized remains from as early as 300,000 years ago and precede the arrival of *H. sapiens* in the region.

It is difficult to fully understand how characteristics of *H. sapiens* popped

up in China 70,000 years prior to the existence of the first modern-day humans in Africa. As of right now, the best explanation lies in thousands and thousands of years of cross-breeding with other species of ancient humans and the pressures the environment applies to a species’ appearance. In the case of the Hualong Dong people, the culprit could be the shift in the subspecies’ food consumption from being heavily reliant on large animals and tough meat to a more plant-based and varied diet.

“More fossils and studies are necessary to understand [the Hualong Dong people’s] precise position in the human family tree,” María Martinón-Torres — a palaeoanthropologist at the National Research Center on Human Evolution in Burgos, Spain — told *Nature*. Although it would be misguided to jump to paradigm-shifting conclusions based on a handful of remains, the discoveries of multiple sets of fossils that challenge the current understanding of human evolution and migration are still certainly exciting.

*Nature* (2023). DOI: 10.1038/d41586-023-02924-8  
*Journal of Human Evolution* (2023). DOI: 10.1016/j.jhevol.2023.103411  
*Proceedings of the National Academy of Sciences* (2019). DOI: 10.1073/pnas.1902396116  
*Nature* (2017). DOI: 10.1038/546212a

PHOTO VIA SHUTTERSTOCK

# A DEEP DIVE INTO DINOSAURS and DILFs

BY NETHRA IYER, CHEMICAL ENGINEERING, 2024

DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

**N**ortheastern, one of the best schools in the country for experiential learning, is also well-known for its wide variety of clubs. From intramural sports to the Cheese Club, there are many student organizations encompassing a wide variety of niche interests. However, what about one where students can talk about fossils and prehistoric life ... as well as older men?

Welcome to the Prehistoric Life club — colloquially known as the Dang, I Love Fossils (DILF) club.

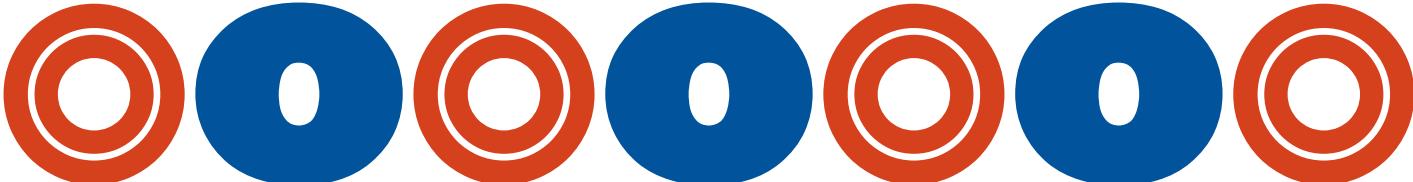
While it may seem odd, the DILF club actually strives to make education its mission. Coupled with raunchy humor, this new club has been a great way for students to learn both about rare creatures and the Earth's timeline and evolution. According to club founder Matthew Murphy, the goal of the club is to "lure people in with 'dilfs' and reignite the passion they have with prehistoric life." When asked what inspired him to start it all, he recalled how he always loved dinosaurs, from playing with dozens of toys to watching various movies — "I never grew out of it. Many DILF club members never did." With a regular turnout of 25 DILF lovers, along with newer members joining throughout the year, it is not surprising that Murphy and his team are so passionate about this club.

This passion can be seen through the level of detail in the presentations each meeting. The general blueprint for each presentation consists of three older male celebrities and three fossils per meeting, alternating and always following a theme. These themes can range from monarchies to media. In fact, one of the most recent meetings followed the theme of video games, with a discussion on how dinosaurs are negatively depicted, as designers often show these creatures as enemies meant to eat or attack the protagonist. The

meeting concurrently also described a few famous older male celebrities in video games, such as Joel from The Last of Us played by the Emmy-winning Pedro Pascal. At the end of the day, Murphy and the team's goal is to ensure that people leave with newfound knowledge regarding obscure creatures and famous male celebrities. "If you leave knowing one more thing about a fossil and a 'DILF,' I feel like I've succeeded," Murphy proudly said when asked about his mission for the club. Murphy also went on to talk about how one of his favorite parts of the club is the people who show up with a genuine interest in either celebrities, prehistoric creatures, or both! "It's my favorite and weirdest part," Murphy explained. "People also have heated disputes about many topics, so we have foam swords, take a timer out, and duel." Painless and fun, the team's motto is to not just learn but also have fun doing so.

As niche as the club is, that is not to say Murphy and his team face challenges. According to him, some of the club's biggest hurdles are coming up with interesting and creative themes to keep engagement and enjoyment at a high. With each meeting being between 45 minutes to 1 hour long, it is vital for Murphy and his team to spend it well. Murphy ended his interview with "People could be doing anything else, but I want to make sure they are having a good, fun time."

DILF club might be new and only tentatively recognized by Northeastern, but its growing popularity due to its strong social media presence and vibrantly unique flyers all around campus have piqued the interest of many students, from a range of majors including communications to chemical engineering. There is no doubt that this niche group will soon become a student organization of enormous proportions, one "DILF," and dinosaur at a time.



# Stuck in BOSTON traffic?

## Blame the cows, partially

ARTICLE AND DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

PHOTO BY VATSAL MEHTA, COMPUTER SCIENCE, 2025

**1** 7th century  
Boston most likely never imagined it would grow into the major urban center it has become 300 years after its founding. The cluster of neighborhoods that make up its landscape developed at their own paces and paved their roads in a manner that suited them. These roads are known historically to have catered to domesticated cows and their farmers, resulting in the winding paths seen in maps of the city — yes, urban developers used the same routes created by ancestral livestock. Of course, commuting cows from three centuries ago cannot take all the blame.

Anything and everything from the time of day to whether the Patriots are playing can affect daily traffic patterns in the city. A study published by the Central Transportation Planning Staff found that highway congestion significantly worsens on Fridays. While the severity differs for each highway, drivers also may find their speed reduced by over 30 mph during the most congested time of the day (compared to approximately 20 mph during a typical weekday). Other factors found to increase congestion were holiday weekends, such as the Wednesday before Thanksgiving, and sports events like Patriots and Red Sox game days. These factors, along with Boston's large car population and population density in general, create the perfect environment for traffic to propagate. The number of commuters coming in and out of the city means that rush hours fill the streets with many people desperate to get to work on time or go home as fast as possible. This is especially true when a large number of these commuters live further out of the city where there is more affordable housing available, causing major highways to quickly clog with an influx of cars at nearly the same time. These conditions not only create unhappy and impatient commuters but also compromise road safety. Central Transportation Planning Staff's study found that these factors and events can increase the rate of crashes compared to typical days.

The New England weather plays a role in commuting conditions, as well. As the temperature cools enough to cause snow and ice, roads are one of the first things affected. Boston receives an average of 23 days of snowfall per year, creating nearly a month of dangerous road conditions. The

Department of Transportation claims that driving speeds on the freeways diminish as much as 40% in the presence of heavy snow due to the limited maneuverability and visibility of the roads. Not only that, the use of road salts over time deteriorates the streets through concrete corrosion. Consequently, the risk of vehicle damage and accidents increases, requiring undesirable costly maintenance for the city. Forced road closures, especially for busy roads, may create or worsen traffic jams on other routes by concentrating vehicles into denser areas of the city.

The global recognition of Boston's traffic performance also serves as proof of its problem. The 2022 Global Traffic Scorecard published by traffic analytics company INRIX found that Boston ranked fourth for worst traffic congestion globally and second nationally. On average, drivers lose over five and half days per year to their commutes. These motorway conditions are not only inconvenient to drivers but are also dangerous. The Massachusetts Department of Transportation documented 132,559 total crashes in 2022, 23% of which resulted in non-fatal injuries. Hearing these statistics may steer you towards walking, but that does not eliminate the danger. Parties involved in these crashes can include pedestrians, cyclists, and motorcyclists, with nearly 83% of pedestrian-involved accidents resulting in either fatal or non-fatal injuries in 2022.

The factors that create the messiness of Boston traffic itself cannot easily be controlled. One cannot yell at the sky to stop snowing, nor would the city's economy survive without the numerous workers traveling in to maintain its commerce. That said, the best way to avoid the traffic may simply to avoid the times that it exasperates. Urban planning in Boston may have been unconventional to say the least, but it created a unique cityscape with an even more distinctive history.

Materials (Basel) (2019). DOI: 10.3390/ma12060912

PHOTO VIA RAWPIXEL

# A SURFACE-LEVEL LOOK INTO QUANTUM STATES FROM A CHEMISTRY MAJOR FASCINATED BY ELECTRONS

BY SASHI NALLAPATI, CHEMISTRY, 2026

DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING &amp; DESIGN, 2024

**T**he electron exists in a state of superposition: They inhabit multiple states simultaneously. For example, an electron can be in one quantum state as well as a different one. This doesn't mean that it is in both states at once but that it is in a superposition of both states. It is both and none of them at the same time.

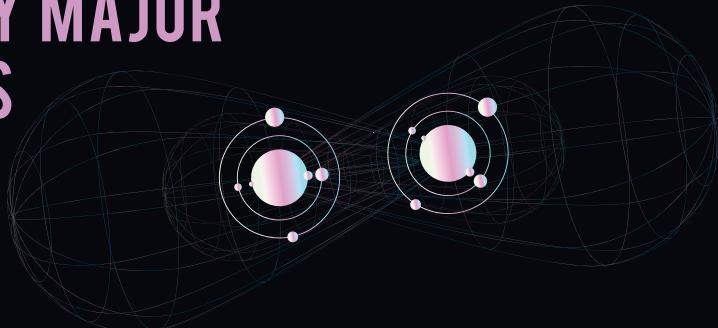
At first glance, this spectacle doesn't seem to be all that interesting. A closer look and the greater implications slowly reveal themselves. In the fields of astrophysics, quantum computing, AI, and virtually every other scientific field, the study of electrons and their properties of duality can be applied.

This seemingly arbitrary fact of quantum mechanics diverges significantly from the intuitive laws of classical physics. Classical physics is the basis for describing all physical phenomena excluding quantum particles. Its limitations were discovered only a century ago with the advent of Max Planck's famous proposition for the quantization of light—the idea that light exists in discrete units. This discovery paved the way for studying a new subset of the physical world.

Louis De Broglie's 1924 paper in the Philosophical Magazine kicked off a new wave of scientific thinking. His declaration of the electron behaving as a wave was a major divergence from the elegant calculations of classical physics and a huge step forward in quantum mechanics. Then came Werner Heisenberg, who proposed the uncertainty principle, and Erwin Schrödinger who theorized a way to describe the physical motion of a particle in the quantum state. Heisenberg boldly attributed a wave-particle duality to electrons, which detailed how the electron acts as both a particle and a wave and cannot be separated from either identity.

In college chemistry, these technicalities of electron behavior are never discussed. For those interested in the physics side of chemistry, this basic knowledge of quantum mechanics is troubling. I can't help but wonder what these quantum particles mean in the context of my basic chemistry classes.

My main qualm is with molecular orbitals, which utilize the wavefunction in the form of  $\Psi^2$  to approximate electron probability. This idea is used to represent orbitals using spherical shapes that recognize the locations of electrons within molecules. These orbitals are used to predict molecule stability, bond energies, and a multitude of other incredibly important chemistry concepts. Now, employing a quantum mechanical lens, the subjugation of electrons under the atoms it "belongs to" in a spherical cloud suddenly seems like a much squishier concept.



In my organic chemistry lectures, I find myself puzzled on how quantum mechanics might agree with or defy the class's major concepts—the course curriculum glazes over important connections to quantum theory. For example, partial donation of electrons from one atom to another is closely related to superposition, but the concept is not taught in tandem with superposition. Further, the delocalization of electrons can be confusing. This term refers to the idea that electrons are not simply fixed between two atoms in a covalent bond but shared between multiple atoms and bonds. Yet, chemistry courses often leave out the underlying quantum mechanics explanations: How might the wavefunction predict this? In other words, if the position of a delocalized electron is measured, will the measurement reflect or contradict the position organic chemists might predict through the use of molecular orbital theories?

Within the field of quantum mechanics, there is a myriad of theories, philosophical discourse, a rich history of discovery, and an interesting evolution of scientific thinking. This has provided the world with a variety of plausible yet romantic speculations based on mathematical derivations and philosophical assumptions. Einstein gave us the possibility of hidden variables in quantum states, which proposed inconsistencies in quantum mechanics, and Hugh Everett gave us the many worlds interpretation, which rationalizes how every measurement of a particle in a state of superposition causes infinite instantaneous fragmentations of the universe. Now, we have quantum superposition in quantum computing and electron-based advancements in medicine.

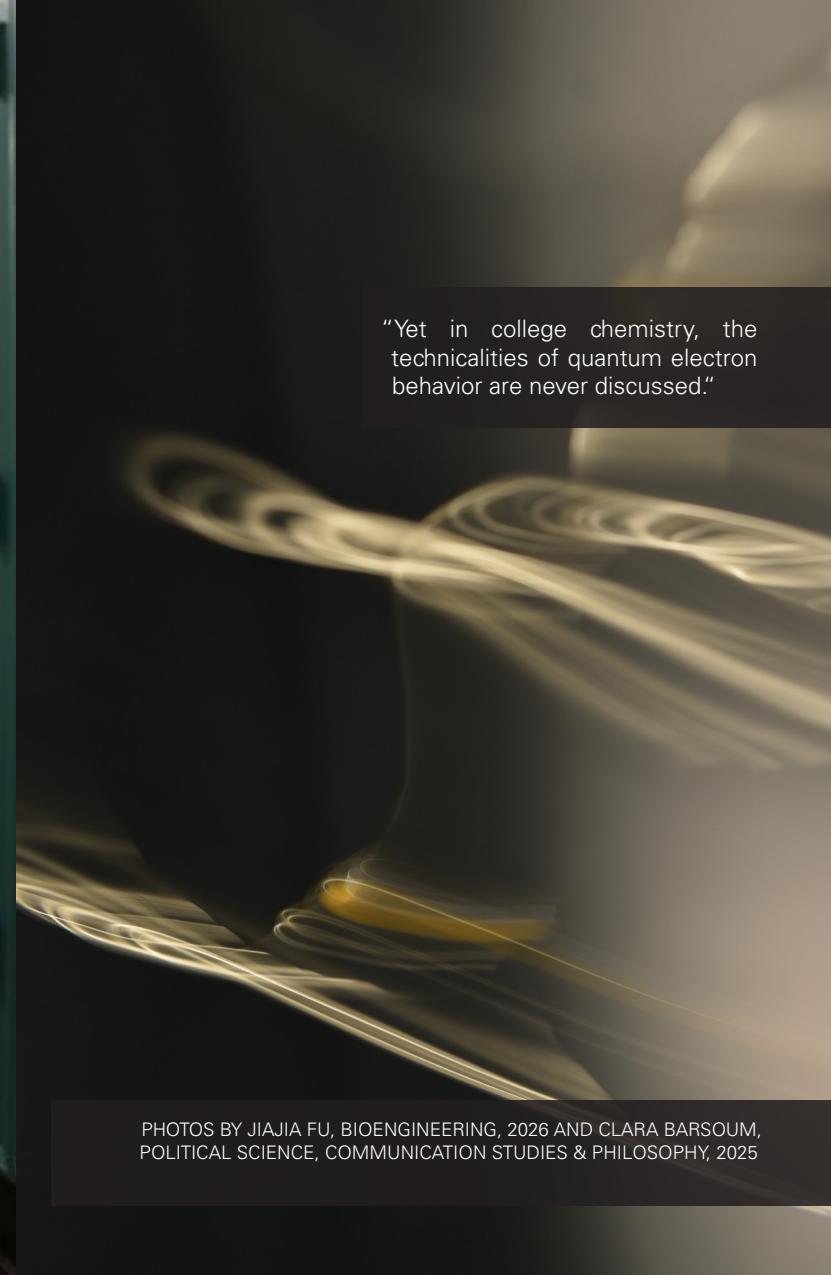
The electron is first introduced to us as an inconsequential subatomic particle, but in reality, it has an infinite number of complex applications and its own set of governing rules separate from classical physics. It is perhaps the most curious and perplexing particle of the natural world, and I wonder if college chemistry courses will ever delve into the nuance of this concept, or more importantly, if modern science will ever be able to perfectly portray it.

Frontiers in Chemistry (2019). DOI: 10.3389/fchem.2019.00848

Philosophical Magazine Letters (2006). DOI: 10.1080/09500830600876565



"The study of electrons and quantum properties are fundamental to the future of astrophysics, quantum computing, AI, and virtually every other scientific field."



"Yet in college chemistry, the technicalities of quantum electron behavior are never discussed."

Meet the

# LIZARDS

*of the Fenway Victory Gardens*



BY ELLA MESSNER, BIOLOGY & MATHEMATICS, 2023

DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025



An Italian wall lizard in the Fenway Victory Gardens

PHOTOS BY JIAJIA FU, BIOENGINEERING, 2026

In the Fenway Victory Gardens, just minutes from Northeastern University, lizards reign supreme. The Italian wall lizard, *Podarcis siculus*, is a non-native species that recently established itself in the gardens. This small green and tan lizard has remarkably managed to survive and thrive in Boston — and in several other cities and towns in the northeast of the United States — despite the region's differences from its native Mediterranean habitat.

Evolutionary ecologist Colin Donihue learned of Fenway's *P. siculus* population in 2016, when a gardener emailed him a blurry photo of a lizard she'd spotted in her plot. A postdoctoral fellow at Harvard University at the time, Donihue was interested in the ways that species adapt to novel and human-dominated environments — a new population of lizards in Boston was the perfect case study. "I'd been jumping around the world studying this kind of question," said Donihue, "and lo and behold, right here in our backyard was a prime example." So, he grabbed his lizard-catching gear, hopped on the train, and headed to Fenway to investigate.

The Italian wall lizard population was in its infancy when Donihue began studying it. In the fall of 2016, he estimated that 15 to 20 lizards lived in the gardens — likely transported to Boston the prior year from a well-established population in New York City. Since then, the Boston population has exploded, growing to hundreds of individuals. As generalist insectivores, the lizards eat all sorts of bugs found in the garden; Donnihue's team identified everything from ants to earthworms to beetles in their stomachs. In fact, the diversity of invertebrate life in the gardens may explain why the lizards have been able to flourish there. Although the Fenway Victory Gardens are located along a system of connected parks, which seem like an appropriate *P. siculus* habitat, the lizards have not spread beyond the gardens, possibly because food is harder to come by in the surrounding areas.





Food availability is likely not the only factor confining *P. siculus* to the Fenway Victory Gardens; the lizards' survival strategy in winter may also explain the population's limited range. Native to southern Europe, *P. siculus* does not normally encounter the frigid temperatures characteristic of winter in Boston — how this Mediterranean lizard survives the extreme cold remains a mystery. One hypothesis is that the lizards spend the winter in the garden's massive compost piles. When microbes break down the organic material in compost, they generate heat, possibly creating a warmer haven for the lizards. Dependence upon compost piles could explain the population's failure to expand beyond the Fenway Victory Gardens.

It is possible that the lizards have also developed the ability to dramatically slow their metabolism in the winter or be supercooled, enduring temperatures below the freezing point of water without actually freezing. Donihue believes that Boston's wall lizards survive the cold through a combination of physiological and behavioral adaptations, but admits that scientists know little about what the population does during the winter. He fantasizes about solving this mystery by outfitting lizards with a GPS backpack of sorts that would track their location and activity throughout the cold months. Unfortunately, he hasn't found a tracking device small enough for the lizards to carry, so their winter whereabouts remain unknown.

Although *P. siculus* is not native to the northeast of the U.S., Donihue does not believe the lizards pose a threat to the region's ecosystems. There are no native lizards in Massachusetts, so *P. siculus* is not displacing or threatening another species. Furthermore, wall lizard populations in the Northeast are confined to human-dominated areas. "If they were to really jump those areas and go into more natural ecosystems, I think there would be more cause for concern," said Donihue. Such a jump seems implausible; due to their likely reliance on human-created heat sources, Donihue suspects that the lizards would struggle without proximity to humans.

So what do we do about our new reptilian neighbors? According to Donihue, we should simply watch and enjoy! On sunny days in spring, males can be spotted perched on rocks, flicking their heads, or doing push-ups to impress potential mates. By July, tiny baby lizards scamper across the gardens. "They're just doing their own thing and they're not going to bother you," said Donihue. "They're just on their own little journey."

*The American Midland Naturalist* (2002). DOI:

10.1674/0003-0031(2002)147[0368:FHOANY]2.0.CO;2

*The IUCN Red List of Threatened Species* (2009). DOI: 10.2305/IUCN.UK.2009.RLTS.T61553A221687194.en

*Herpetological Review* (2017). ISSN: 0018-084X



# NATURE'S FURY, HUMANITY'S STRUGGLES

BY LYRIC WESTLUND, BEHAVIORAL NEUROSCIENCE, 2025

DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

**N**atural disasters not only wreak havoc on communities, but also on the nation's blood supply. Floating cars, broken buildings, and contaminated water are just a few of the intense secondary effects that natural disasters leave in their paths. Grieving families, hospital visits, and shattered homes leave communities in an overall state of loss and immense sadness. Natural disasters, such as earthquakes, wildfires, and hurricanes, are tragedies that people all over the world have to suffer through.

As natural disasters rage, they are highly disruptive at best, deadly at worst.

Recently, Americans have felt a lot of nature's fury: Hurricane Idalia, floods in both California and Alaska, Hawaii wildfires, and more. Unfortunately, not only are these events causing severe consequences across the nation, they are also a likely cause of a national blood shortage. According to the Red Cross, "Hurricane Idalia, which struck Southeast this [August], has forced the cancellations or closure of blood drives and donation centers, resulting in about 700 blood and platelet donations to go uncollected." In addition, natural disasters close schools, businesses, pharmacies, and other places

where blood drives tend to happen. As natural disasters often reach a



large area and create lasting effects on the population, this creates an extensive period of time where blood collection is simply not an option. This limits the capacity of places like the Red Cross to keep up with the growing need of blood to support medical procedures.

Sadly, the future does not seem too bright. The Red Cross reported in 2022 that there has been a 23% increase in blood drive cancellations since 2013. Due to continued acceleration of population growth and manmade development, as well as the effects humans have induced on climate change, it is expected that there will be more natural disasters coming our way. The World Wildlife Fund agrees that as humans continue to accelerate climate change, this development will continue to worsen and multiply natural disaster occurrences.

Humans and nature are deeply entangled. The way we have lived and continue to live has a profound effect on our world. The increase in climate change encourages natural disasters, which damage the land and our communities. Further, these damages can prevent normal functioning and interfere with necessary processes, such as blood collection. This is one way that these disasters can reach people outside of the span of physical damage.

The call for climate action and sustainability is becoming more and more crucial to our functioning as a society. It is important to recognize the domino effect that climate change can have on both natural disasters and blood shortages.

PHOTOS VIA SHUTTERSTOCK



# FORESTFIRES, CONTAMINATED WATERWAYS, AND DISRUPTED MIGRATIONS

## Unspoken consequences of the war in Ukraine

BY DANIEL DALZELL, ENVIRONMENTAL & SUSTAINABILITY SCIENCES & ECONOMICS, 2025

DESIGN BY ANJANA BALAKRISHNAN, ART, 2026

In the year and a half since the Russia-Ukraine War began, there have been an estimated 500,000 casualties between the two sides. Ukraine has also experienced infrastructural damage totaling hundreds of billions of dollars. Yet these aren't the only significant and tragic losses the region has suffered — the conflict has had a grave and dire impact on the environment.

Ukraine's dense forests and vast grassland are a hub for biodiversity. While Ukraine makes up just 6% of the continent's land area, it hosts 35% of Europe's biodiversity. Since Russia's invasion in February of 2022, over 600 animal species and 750 plant species have been affected.

The nation's forests have been severely impacted, with more than 1,000 individual fires ravaging through them and emitting over 33 billion tons of carbon dioxide. In a land that is already predisposed to wildfires because of its agriculture-intensive land use and particularly flammable pine trees, forest fires are even further exacerbated by artillery and rocket launches. Coniferous forests, which pose the highest fire risk, cover 43% of the total area in Ukraine, with pine stands, primarily found in the northern regions, making up 35% of this coverage.

The Black Sea Biosphere Reserve, in particular, has suffered significant damage as a result of the conflict. The reserve consists of forest, desert, and a salt marsh and is home to 3,500 different species, including 2,200 species of insects, 304 species of birds, and 65 species of vertebrates. Migratory birds traveling through the reserve are threatened by loud explosive noises, which disorient them and can force them to spontaneously change their migration patterns without landing. It has ultimately led to extreme exhaustion and death for many of the 120,000 birds that spend their winter at the Black Sea reserve.

Just off the coast of the reserve, marine animals in the Black Sea have also suffered significant consequences.

Ivan Rusev, a Ukrainian marine biologist, has estimated that more than 50,000 cetaceans — including porpoises, common dolphins, and common bottlenose dolphins — have perished. According to Rusev, the deaths are a result of Russia's use of mines and sonar, which emits high-decibel noise that damages the acoustic systems of these cetaceans. Since cetaceans rely heavily on their sense of hearing, any alterations to their hearing system may significantly affect their ability to perform essential tasks. Additionally, the

“

Nature knows no borders.”

explosions caused by the battle for Ukraine's Zmiiny Island — which lasted four months — and the missile launching at Odesa's sea trade port have created severe disruptions to the Black Sea.

Other waterways that provide water for agriculture and drinking have been contaminated. Bombings of fuel depots have created chemical spills and runoff that have degraded the water quality and killed off anything living in the waters. Additionally, firefighting chemicals have penetrated the groundwater near cities that have fallen victim to airstrikes.

The devastating ecological consequences of war can be observed all across the globe. Historically, armed conflicts have created natural resource over-exploitation, land degradation, and air pollution emissions, which can cause major disruptions to the biodiversity of ecosystems worldwide. In 2021, the United Nations General Assembly, in an attempt to encourage transboundary cooperation, summed up the issue with a powerful statement: “Nature knows no borders.”

*JRC Technical Report (2021). DOI: 10.2760/34094  
Scientific Reports (2017). DOI: 10.1038/srep41848v*

PHOTO VIA SHUTTERSTOCK



## OPINION

THE  
NATURE  
PILL

BY ELIZABETH LUO, CELL &amp; MOLECULAR BIOLOGY, 2026

DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

We have all heard the phrase, "Go outside and take a breath of fresh air." When facing a mental block or feeling frustrated and stressed, stepping outside can be therapeutic and relaxing. In fact, nature can be so therapeutic that some psychiatric professionals have even begun prescribing nature breaks to their patients.

Mental health is a struggle that most people face. Around 1 in 5 US adults live with a mental illness, and 1 in 25 U.S. adults live with a serious mental illness like schizophrenia, bipolar disorder, or major depression. Whether it be long-lasting or temporary, we have all dealt with some form of mental health conflicts. There are many causes of mental illness, ranging from traumatic childhood experiences, to medical conditions, to substance use, and more. Despite its prevalence, it is essential to address the problem and to seek professional help when needed. Many patients are prescribed medications and therapy to address the illness, however some psychiatrists are beginning to take a step back and slow down the aggressiveness in medical treatment, opting for a more organic and calming form of therapy: nature.

Nature is essential to the livelihood of humans. In a study done at the University of Michigan, Dr. MaryCarol Hunter and her colleagues found that spending 20–30 minutes outside per hour led to a 21.3% decrease in salivary cortisol, a stress hormone secreted into saliva. Additionally, nature visits have been linked to better cognitive function and emotion regulation. Phytoncides, an insect-repelling chemical released by plants and inadvertently breathed in by humans, allow us to produce more natural killer cells, aiding in fighting cancer and viruses in our body.

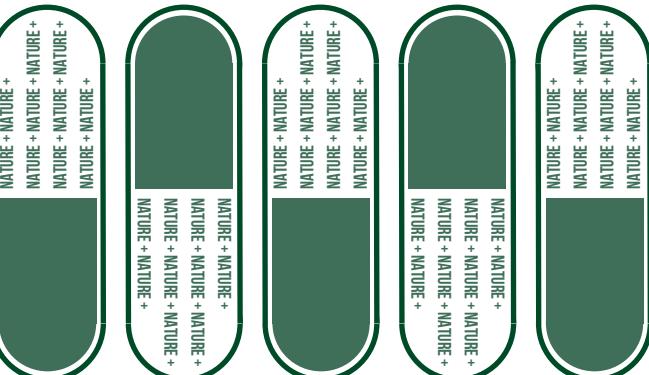
There are many methods to incorporate nature into daily life, even when you live in the middle of a city. Taking an outdoor breather in the middle of the workday or moving your lunch

break outside can help add nature and fresh air into your daily routine. After work, visiting arboretums or watching the sunset from the local park can be an effective de-stressor. On the weekends, joining a hiking club can be a method to unwind for those who desire companionship, motivation from others, and an extended time with nature. Regardless of how you incorporate nature into your daily life, even just a few changes can make a huge difference!

Changes on a personal level are certainly important, but governments can also help out by adding aspects of nature even in the most urban of areas. Planting trees along the road and integrating small parks are just a few of the many ideas that seem insignificant but can encourage interactions with nature. A study done by Alessandro Rigolon and his colleagues found that public green spaces are extremely beneficial to low-income areas. Often, areas of low-income lack green spaces for those people to interact with, inhibiting them from experiencing the essential physical and mental benefits that these spaces provide. Because of the lack of greenery in low-income areas, they commonly suffer from air pollution and heat-related health problems. Incorporating even just a few islands of nature can decrease the air pollution, improving the air quality, as well as provide areas of shade to lower heat issues and provide areas of relaxation. Incorporating even just a few small areas of greenery can be beneficial both physically and mentally.

Green spaces are essential to the health of all people. Whether you are feeling stressed, overwhelmed, or bored, taking a walk outside and visiting local parks can improve mental health by decreasing physiological stressors. These responsibilities do not have to rest on the shoulders of individuals, governments can also instill green areas locally to improve the wellbeing and the mental health of the public. By the efforts of both individuals and the government, programs can be enacted to increase easy access to green spaces. Efforts in doing so can not only strengthen the health and the wellbeing of individuals, but also encourage interactions and connections between people, helping to build a strong sense of community. So, next time you are feeling overwhelmed and stressed, it might be a good idea to take a break and take a walk outside!

*Science Advances* (2019). DOI: 10.1126/sciadv.aax0903  
*National Library of Medicine* (2014). DOI: 10.3305/nh.2014.29.5.7273  
*MDPI* (2021). DOI: 10.3390/ijerph18052563  
*Frontiers* (2019). DOI: 10.3389/fpsyg.2019.00722



# RATS!

## How terrestrial invasion can have unexpected impacts on tropical reef food chains

BY TONIA CURDAS, BIOCHEMISTRY, 2025

DESIGN BY NASEEM MOHIDEEN, GRAPHIC DESIGN, 2026

**T**he spread of the black rat (*Rattus rattus*) across the globe has been inextricably linked to the spread of human civilization from as early as 2000 BCE. They've easily survived worldwide expansion due to their skills in cohabiting with humans and taking advantage of our gathered food and resources. From raiding pantries to spreading devastating diseases, black rats have long impacted human society and behaviors. As technology progresses, we continue to look for new ways to eradicate these furry pests. However, rat eradication might not only be beneficial to our terrestrial civilizations but also to marine communities.

Black rats have managed to infest even the most remote islands such as those in the Chagos Archipelago, which is 500 km south of the Maldives. In a recent ecological study that took place on ten islands within this archipelago, Sally Keith and a team of marine researchers observed a concerning effect of these rat infestations on the behavior of herbivorous damselfish, *Plectroglyphidodon lacrymatus*. These fish inhabit coral reefs off the shores of tropical islands which are densely populated by seabirds. The birds feed in the open ocean and return to the islands, depositing nitrogen-rich droppings that accumulate to form guano. When the guano is washed into the ocean by the tides, the nitrogen is deposited onto the algae that cover the reefs. These nitrogen-rich algal covers provide a high-nutrient diet for *P. lacrymatus*.

However, near rat-infested islands, the conditions are quite different. The black rat's predation of seabirds

disrupts a crucial step in this marine food chain. With fewer seabirds, there is less nitrogen-rich runoff into the algae, which decreases the amount of nutrients available for damselfish to feed on in their small territories. Keith and her team found that the territory sizes of damselfish impacted by rat infestation were larger than those whose food supply was undisturbed. When a region is high in nutrients, damselfish don't have to travel far to meet their energetic demands.

for aggressively defending their small feeding territories. They are quick to spend energy protecting their boundaries and were observed swimming rapidly toward other fish, butting into them, and even going as far as to bite their unfortunate trespassers. In smaller territories with high nutrient quality and concentration, there is a greater benefit in aggressive territory defense compared to being passive. The energetic cost of confronting other fish is quickly overcome by the ease of feeding. With rat infestation causing a decline in nutrient availability, these aggressive behaviors are no longer observed. The energy spent protecting their now larger territories from invading fish is no longer offset by foraging. The nutrient benefits do not outweigh the energetic cost of confronting other fish. The territorial aggression of *P. lacrymatus* plays an important role in the organization of coral reef communities.

Overall, the black rat's predation of seabirds has extremely detrimental effects on these delicate ecosystems. Seabirds are crucial contributors to the marine food chain, increasing coral and fish growth rates and enhancing marine biodiversity through nitrogen deposits. When these bird populations are decimated, the negative downstream impacts can be seen in marine life behavior, reef fish ecosystem organization and population, and the overall resilience of the ecosystem. As rat eradication efforts increase on land, we have a chance to support our marine communities and restore balance in cross-ecosystem interactions.

PHOTOS VIA SHUTTERSTOCK

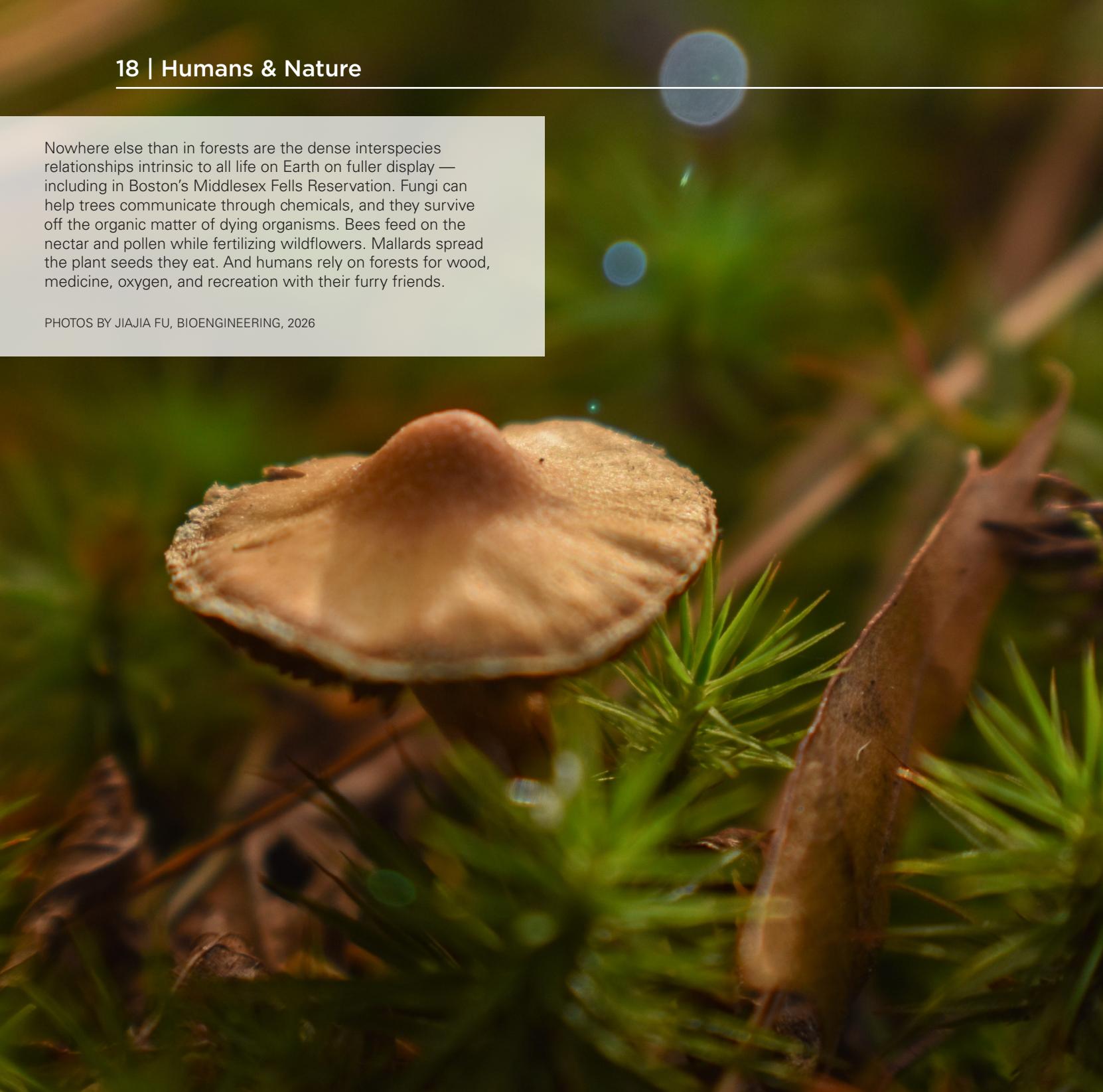
When each damselfish defends its territory, it affects the spatial and social organization of all other species of fish that cohabit the reef. This ecosystem organization is essential for the functionality of the reef."

However, as the quality of nutrients declines due to the decrease in nitrogen, many *P. lacrymatus* have to travel farther than usual for sufficient nutrients. The decline in resources is also detrimental to damselfish growth rates, which can impact the role they play in their marine ecosystem.

While the nutritional disruption caused by black rats directly affects *P. lacrymatus* physically, there are also behavioral effects. The change in territory size corresponded with a significant change in damselfish behavior. Damselfish are known

Nowhere else than in forests are the dense interspecies relationships intrinsic to all life on Earth on fuller display — including in Boston's Middlesex Fells Reservation. Fungi can help trees communicate through chemicals, and they survive off the organic matter of dying organisms. Bees feed on the nectar and pollen while fertilizing wildflowers. Mallards spread the plant seeds they eat. And humans rely on forests for wood, medicine, oxygen, and recreation with their furry friends.

PHOTOS BY JIAJIA FU, BIOENGINEERING, 2026



# DOES THIS MOSS HAVE IT COVERED?

## CHAMPION EVOLVER MAY NOT HAVE WHAT IT TAKES TO SURVIVE CLIMATE CHANGE

BY MAGGIE EID, ENVIRONMENTAL &amp; SUSTAINABILITY SCIENCES, 2025

DESIGN BY ANANYA JAIN, BEHAVIORAL NEUROSCIENCE, 2025

**O**n the harsh, icy cliffs of the Tibetan Plateau, an ancient moss carpets the ground. Covered by snow for eight months of the year, *Takakia* is a highly specialized moss and one of the fastest-evolving plants ever documented. Surviving four mass extinctions, this 390-million-year-old moss species saw the rise and fall of dinosaurs and the formation of the Himalayas. Yet, as this moss population continues to decline in the face of warming conditions, even its speedy adaptation rate may not be sufficient to save one of the world's oldest extant plants from the threats posed by a changing climate.

The genus *Takakia* consists of two species, *Takakia lepidozoides* and *Takakia ceratophylla*, which exist together only in the Tibetan Plateau. *Takakia* possesses unique characteristics that differentiate it from other mosses, both phenotypically and genetically. For many years, *Takakia*'s evolutionary history appeared ambiguous; researchers were uncertain if the genus was more closely related to algae or to other early nonvascular plants called liverworts. A study published earlier this year reports the sequenced genome of *T. lepidozoides*, providing genetic confirmation of previous research that *Takakia* is indeed a moss.

Along with the newly sequenced genome, the report documents a decade's worth of field observations for a *Takakia* population living 4,000 meters above sea level in the Tibetan Plateau's southern corner. From 2010 to 2021, the research team recorded information on the plants and their surrounding ecosystems at 68 sample sites. To examine the trajectory of *Takakia*'s evolution, the researchers analyzed this genomic and observational data, assisted by the oldest *Takakia* fossil from 165 million years ago. Outwardly, the moss has not changed much, retaining its ancient body plan. Inwardly, however, *Takakias* genetics have evolved drastically. With 121 fast-evolving genes, several of which are adaptations to the Tibetan Plateau's extreme conditions, the moss holds the record for the greatest number of fast-evolving genes recorded in a plant.

This rapid evolution was essential to *Takakias* survival as the Himalayas began to uplift 65 million years ago. As the mountains rose, the moss's environment dramatically shifted to more extreme conditions. Higher elevations caused a sharp increase in harmful UV-B radiation, a sudden drop in temperature, and a longer period of snow cover. *Takakia* proved its resilience; the moss adapted to repair damaged DNA, produce more lipids that help absorb dangerous UV-B rays, and develop enhanced freezing tolerance.

Despite its historical ability to withstand momentous environmental transformations, the moss is now under threat from climate change. In 2000, the International Union for Conservation of Nature's Red List of Threatened Species categorized *T. ceratophylla* as globally vulnerable due to the declining area and quality of its small, fragmented habitat. From 2010 to 2021, *Takakia* coverage decreased by 1.6% annually, faster than four common mosses on the plateau. This population decline corresponded with a temperature increase of 0.43 degrees Celsius per year during the same period, the most drastic documented increase at this high altitude.

*Takakia* is the result of millions of years of adaptive evolution to the Tibetan Plateau's unique set of environmental conditions. Unfortunately, this high specialization now presents a greater risk of extinction when rapid climate-driven habitat alterations occur. This is not a problem unique to *Takakia*. Across numerous phyla, populations of specialist species are declining due to disturbances caused by human activity and are being replaced by generalists. In contrast to specialists, generalist species possess a broad niche, meaning they can thrive in a wide range of habitats with a variety of environmental conditions and resources. As habitats quickly shift from their historic states, specialists suffer with no time to adapt, allowing generalists to outperform them.

Some scientists are concerned that this replacement of specialists by generalists may lead to a functional homogenization of communities, which could alter and harm essential ecosystem functions and services. Functional homogenization refers to the decrease in a community's functional diversity, meaning that an increasing number of species fill similar niches while fewer species supply a variety of roles. Generalists typically do not fill highly specific functions or do so less efficiently than specialists. Therefore, the loss of specialists can impact the overall functioning of an ecosystem and decrease the community's resilience to future change.

The research team plans to sequence more *Takakia* genomes to gain further insight into the history of the moss's evolution, along with its population dynamics and genetic diversity. The fate of the *Takakia* population serves as a warning for the dangers of global climate change. As temperatures continue to climb, it is possible that the Tibetan Plateau will lose this ancient and rare moss.

*Cell* (2023). DOI: 10.1016/j.cell.2023.07.003*Frontiers in Ecology and the Environment* (2011). DOI: 10.1890/080216

PHOTO VIA SHUTTERSTOCK

# VENERATED TO VERMIN

## A brief history of pigeons

BY MICHAEL OZGAR, ENVIRONMENTAL &amp; SUSTAINABILITY SCIENCES, 2027

DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING &amp; DESIGN, 2024

**I**n the state of Massachusetts, it is punishable by imprisonment to frighten a pigeon. This law may seem surprising to most modern-day Bay Staters, many of whom abhor the seemingly infinite number of so-called “rats with wings” multiplying across their urban areas, but to people from the not-so-distant past, this law is a way to protect one of humanity’s greatest companions.

First domesticated roughly 10,000 years ago in the Mediterranean region, the ancestors of the modern pigeon would more likely be nicknamed a “flying dog” than a “flying rat.” Humans bred them as a reliable food source, a tool for long-distance communication, and as pets distinguished by their noble beauty and athletic prowess. Most notable for their unsurpassed homing abilities, pigeons carried messages across vast expanses of land from roughly 1000 BCE until 1948 CE. In the 1960s, people falsely attributed pigeons with spreading disease at a higher rate than other animals, beginning the downward spiral of their reputation to their modern-day status as detestable pests.

Ancient Mesopotamians first saw value in pigeons as a domesticated food source. In fact, it was for this reason that colonists, in need of a reliable food source, later brought pigeons to the Americas in the 1600s. Upon living with the creatures, early inhabitants of the Mediterranean region soon recognized their beauty, intelligence, athleticism, and unique skill set. Some pigeons were bred for their wide array of fabulous colors; the black, gray, and white feathers many pigeons possess today are a direct result of those colors being chosen for their visual appeal. Others were selected for their speed and endurance, being used for sporting events such as the still-practiced pigeon racing.

Pigeons possess the unique ability to utilize the sun, their memory, and Earth’s magnetic field to travel back to specific locations over long distances; the pigeons bred for this homing skill were named “carrier pigeons.” The Roman, Mongol, and Persian empires all famously used carrier pigeons to spread information to political and military officials stationed across the known world. The practice of breeding carrier pigeons for wartime communication continued through World War II. Thirty-two pigeons — the most of any animal — were awarded the PDSA Dickin Medal for their gallantry during the war, the highest award granted to an animal for its military service. By the start of the Cold War, however, advancements in communication technologies had rendered carrier pigeons obsolete.

No longer essential for long-distance communication, pigeons’ veneration began to fade. Their reputation fell further in 1963, when a New York Times article reported

a link between pigeons and two human deaths, leading American officials to push the narrative that pigeons were harmful to human health. Although the article was later shown to have no concrete scientific basis, this stigma would follow pigeons into the modern day, opening the door for a billion-dollar pigeon pest control industry. This narrative of pigeons as disease-spreading vermin has permeated through society in large part due to misinformation from pest control corporations to promote their products. However, pigeons spread diseases, deadly and otherwise, to humans at a lower rate than common house pets and chickens. Many people also detest pigeons for their noise and droppings. Yet, these factors are more noticeable due to their large population, rather than an inherent character of the species. These reputational black marks on pigeons as a species have led to their downfall in prestige, and today, many people treat them as flying rodents that infest our world’s cities.

Despite pigeons’ low esteem, some scientists are still making efforts to recognize their incredible intelligence. There are many opportunities for utilizing pigeons’ intellect for societal good, especially in the realm of pattern recognition. In a study conducted by a team of researchers from the University of California, Davis, pigeons developed the ability to differentiate between normal and cancerous tissue samples at an accuracy that rivaled trained humans, boasting an 85% success rate after 15 days. At airports, pigeons could be trained to reduce the chances of terrorist attacks, alerting security officers to items associated with terrorism and even the faces of known terrorists.

Past humans venerated the pigeon for its utility and beauty. Today, we look down on the pigeon as a representation of filth and pestilence. By learning from the storied history of one of humanity’s most cherished animal partners, perhaps we can amend the relationship between pigeons and humans for the benefit of both species.

*PLoS ONE* (2015). DOI: 10.1371/journal.pone.0141357

PHOTO VIA SHUTTERSTOCK



# Redlining's reach

## Disparities in bird data

BY RESHIKA SAI DEVARAJAN, HEALTH SCIENCE, 2025

DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING & DESIGN, 2024

**R**edlining, a historical practice of discrimination, has had lasting effects on racial inequities that remain persistent today. However, recent analysis of ecological diversity has revealed that the effects of redlining reach far beyond impacting humans. Specifically, bird diversity and population experienced a marked decline in areas subject to redlining. This means that though one street might have hundreds of birds present on a day-to-day basis, the very next street over could hold a fraction of the same amount, despite being so geographically close together. Redlining is a process that has not only created long-lasting structural inequities between the humans that inhabit these locations but also devastated the local wildlife and environmental diversity. So how does avian abundance relate to the impact of grading neighborhoods on safety?

Redlining was originally a government-led practice that began in the 1930s as an effort to grade areas on their relative safety for investment in real estate. A major factor that went into this grading process included the neighborhood's racial makeup. This led to high development in regions that were largely white and limited development in areas that were inhabited by people of color because these areas were seen to have more financial risk. This eventually led to inhabitants of areas that were graded low being denied insurance, loans, and other financial services.

An after-effect of redlining is that "red" or low-graded areas were also bought by industries as cheap land and used to build things such as factories and power plants. In contrast, "green" or highly graded areas were heavily invested in and beautified. This has led to severe health effects — the industrial development in "red" areas has led to these areas being prone to more pollution and fewer green spaces. Residents of historically redlined areas have an increased risk of asthma, diabetes, hypertension, heart disease, preterm births, and earlier mortality. There are also likely to be fewer community resources such as hospitals, schools, and grocery stores. In today's climate, the racial makeup of green districts and red districts has had limited change, leading to disproportionate negative effects on communities of color.

An indirect effect of the practice of redlining is the destruction of natural greenery and the degradation of environmental habitats. With fewer spaces to live and thrive, birds and other species have migrated to greener areas — the same areas that have been invested in and are predominantly occupied by white Americans. The lack of bird and other ecological diversity can lead to a lack of funding in these areas to protect wildlife. Without this funding, there are few

opportunities to help revive biodiversity in "red areas." On the other hand, "green" districts are likely to receive funding to conserve their ecological diversity, thereby increasing their physical capital and resources. In a negative feedback loop, the gap between resources and the status of these areas grows.

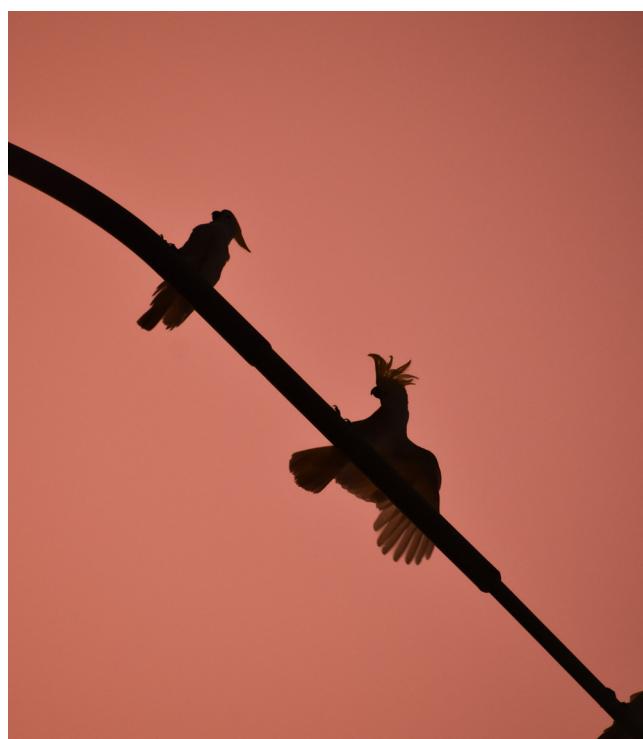
Modern challenges exacerbate these issues. Scientists often survey the same areas — those that tend to have the most biodiversity — leading to a lack of knowledge about species and ecology in redlined areas. In addition, there is a lack of resources to help record observations and gather data in historically red areas as well.

It is clear that redlining is not merely a sociological issue — discrimination permeates all aspects of life, even shaping our environment. Policy changes and environmental initiatives are crucial to helping remedy the long-lasting effects of redlining and build a more equitable future, both for humans and biodiversity alike.

*Nature Human Behavior* (2023) DOI: 10.1038/s41562-023-01688-5

*Journal of General Internal Medicine* (2023) DOI: 10.1007/s11606-023-08051-4

PHOTO BY JIAJIA FU, BIOENGINEERING, 2026



# An Antarctic research station produced massive amounts of waste

## What will they do about it?

BY JULIA LAQUERRE, JOURNALISM & ECOLOGY & EVOLUTIONARY BIOLOGY, 2025

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**T**he ocean surrounding the Windmill Islands of East Antarctica is polluted, and an ecological research station is to blame. The pollution jeopardizes some of the most unique ecosystems on the planet — and scientists' ability to study them. It's a stark warning to the other hundred research stations at the South Pole, and now, the question among the Antarctic scientists: How do they reverse the damage they created?

Casey Research Station opened in 1969 as a data collection base studying the structure, geology, and glaciological process of the East Antarctic ice sheet. But by 1997, they had mishandled so much waste that the surrounding marine sediment was contaminated beyond international guidelines for sediment quality, found Jonathan Stark, the chief investigator for the Casey Research station, and his lab.

For its first 11 years, the center dumped its waste either directly into the ocean or into landfill sites. Their garbage included ice vehicle parts, batteries, metal, plastics, rope, construction materials, asbestos, cement, rubber, drums of unidentified waste chemicals, and waste oils.

It wasn't until the Protocol on Environmental Protection to the Antarctic Treaty was established in 1980 that Casey started monitoring how they disposed of their waste. The treaty prohibited all research stations within a designated area from degrading "areas of biological, scientific, historic, aesthetic or wilderness significance." Since their disposal practices had "significant adverse effects on air or water quality," they had to change their practices — and fast.

From then onward, researchers at Casey have been working hard to study, reduce, and properly dispose of the waste they create, and their efforts are still ongoing. The station now exports most of its waste out of the Antarctic. From 2003 to 2004 the station removed and transported 1,800 cubic meters of waste material and contaminated soil to Australia.

They have also created meltwater trenches, which capture melting snow, preventing it from running through the waste

disposal site and carrying dissolved metal contaminants into the ocean. And any wastewater the station produces is filtered to remove metal contaminants before they pump it into the waters.

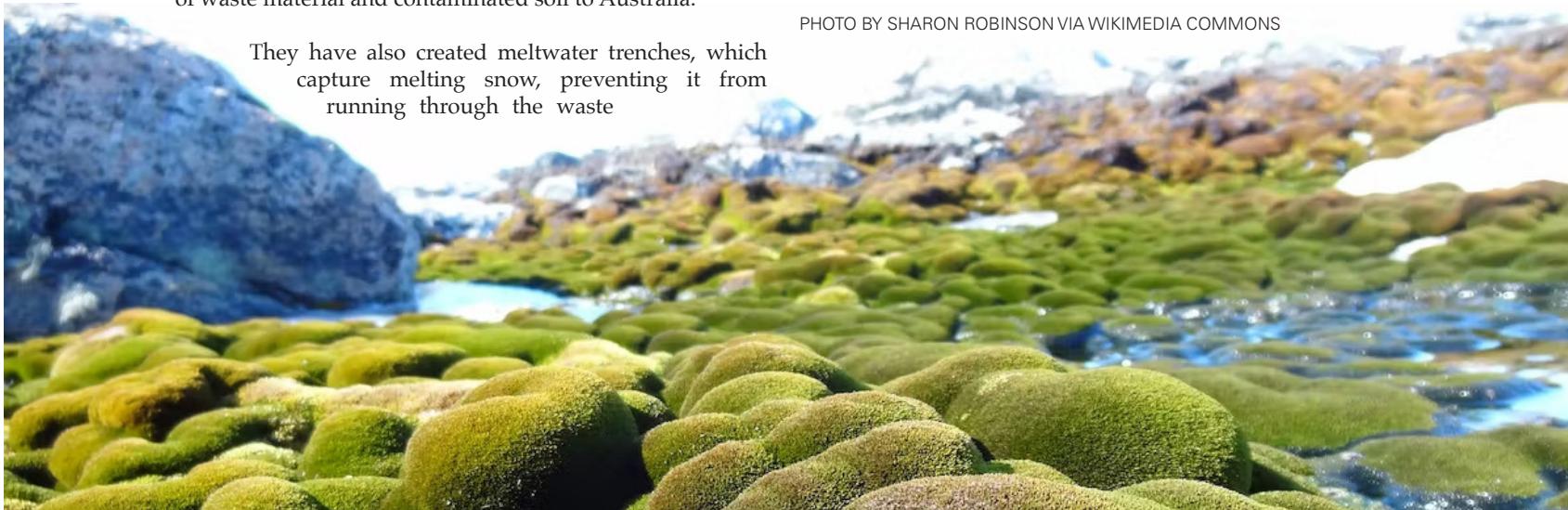
But simply limiting future contamination isn't enough. Stark's lab found that sites with increased levels of deadly pollution are less biodiverse. And despite all they are doing to mitigate the effects of prior waste dumping, Stark and his team of researchers conclude in their study that "Antarctic research stations such as Casey are likely to pose a moderate level of long-term ecological risk to local marine ecosystems through marine pollution." And with the 112 research stations located in Antarctica, there is a lot of waste contaminating its waters and icy terrain.

Some research stations are trying to reverse the damage, not just mitigate it. Martínez Álvarez and his coauthors conducted a study analyzing how they could remove hydrocarbon contaminants — a class of chemical compounds found in gasoline and kerosene — from waters on either side of the Antarctic. They showed promising results, but they were unpredictable. In the study's first year, they successfully removed three-quarters of the hydrocarbon, but in the second year, it dropped to around half.

Incidents like the one at Casey are not isolated, and many research facilities at the poles pose long-term threats to the very environment they are studying. Even today, with waste management regulations made to mitigate pollution, research sites are taking up precious land and resources. Without reversing the damage to the Antarctic, it may harm the unique and precious ecosystems not found anywhere else on the planet.

PLOS ONE (2023). DOI: 10.1371/journal.pone.0288485  
*Nature* (2023). DOI: 10.1038/d41586-023-02740-0  
*Cold Regions Science and Technology* (2020). DOI: 10.1016/j.coldregions.2019.102915

PHOTO BY SHARON ROBINSON VIA WIKIMEDIA COMMONS



# CATCH BASIN FOR MICROPLASTICS

## Sedimentary storage of plastics in Narragansett Bay

ARTICLE AND DESIGN BY SOPHIE DONNER, ENVIRONMENTAL & SUSTAINABILITY SCIENCES, 2025



**W**ithin just the top two inches of sediment covering the shorelines and seafloor of Narragansett Bay, over 1,000 tons of microplastics reside. As a relatively new factor in the sedimentary system, plastics have reached the majority of ecosystems on the planet, from the highest mountain peaks to the deepest parts of the oceans. Microplastics vary in density and material, and they consist of any plastic particles smaller than 5 millimeters. These particles can take the form of primary microplastics, such as nurdle pellets from plastic production, or secondary plastics from the breakdown of macroplastics.

Narragansett Bay — New England's largest estuary, formed from drowned river valleys — is primarily fed by low-sediment yield rivers, including the Providence and Seekonk Rivers, the Palmer and Barrington Rivers, and the Taunton River. The rapid development of Providence and surrounding areas during the Industrial Revolution sparked the known history of pollution in the watershed, particularly with organic pollutants and heavy metals. With these densely populated urban areas present at the mouth of the rivers draining into the bay, plastics are frequently introduced into the estuary. Narragansett Bay is an extremely valuable natural resource, protecting coastlines from erosion, naturally filtering runoff, providing home to thousands of species, and contributing billions of dollars to Rhode Island's economy through fishing and tourism. The estuary is extremely vulnerable, as the ecosystem's health is affected by activity upstream in the watershed, which consists of much of Rhode Island and Massachusetts. The presence of microplastics in the bay has been recognized; however, the fate, transport, and impact of microplastics in Narragansett Bay, or any estuary, have been relatively unknown until recent studies.

In the first-ever system-scale study of microplastic sedimentary storage in estuaries, PhD candidate Victoria Fulfer and a team of researchers at the University of Rhode Island have revealed the extent and potential impacts of microplastic pollution in Narragansett Bay. Fulfer sampled multiple transects from the upper beach, mid beach, intertidal, and subaqueous zones at various sites — from the upper bay near Providence to the lower estuary — to

identify a gradient in sedimentary plastic deposition and storage. Every sample contained microplastics, with the highest concentrations found at Bold Point Park in East Providence. More rural areas near Aquidneck Island and Narragansett surprised scientists with similarly significant microplastic concentrations. Of all plastics found, 70% were composed of polyethylene, polypropylene, and polystyrene, which are common in single-use plastics. River input alone is estimated to release around 14 tons of plastic each year into Narragansett Bay.

While the impacts of microplastics are vastly understudied, there are many known negative effects on marine organisms and humans. Sea birds that ingest small plastic particles can experience forced satiation: not receiving nutrients and eventually starving. Fish exposed to microplastics suffer from restricted growth, oxidative stress, and neurotoxicity. In a model exposing mice to microplastics, polyethylene decreased glial fibrillary acidic protein expression, leading to depression and Alzheimer's disease. The potential effects of microplastics on humans and ecosystems are still poorly understood. Gert Everaert and

**“Riverine input alone is estimated to release around 14 tons of plastic each year into Narragansett Bay.”**

a group of scientists from the Flanders Marine Institute in Belgium performed a risk assessment of the environmental impacts of microplastics and estimated a threshold of 540 particles per kilogram of sediment, above which ecosystems could experience harmful effects. Nearly 80% of the samples taken from Narragansett Bay exceed this threshold.

However, Fulfer's findings could introduce the possibility of more efficient plastic removal from the environment. As seen through the significant microplastic storage in Narragansett Bay, estuarine environments could serve as a target for management of microplastic pollution. Similar to catch basins that require cleaning to continue functioning properly, these microplastic filtering ecosystems could be "cleaned" to prevent plastics from escaping sedimentary storage and re-entering the water column. Management of plastic waste is still a widespread issue, so taking action to reduce inputs and avoid single-use plastics is crucial in protecting estuaries and other valuable coastal ecosystems that bear the burden of microplastics.

PHOTO BY SOPHIE DONNER, ENVIRONMENTAL & SUSTAINABILITY SCIENCES, 2025

# Fishing for happiness

## Omega-3 and seasonal affective disorder



ARTICLE AND DESIGN BY JOSEPHINE DERMOND, ECONOMICS, 2026

**A**s the days get shorter and the weather colder, keeping that frown upside down becomes an arduous task. While you might think you have what it takes to bear the elements through sheer willpower, your genetics and neurochemistry disagree.

Studies of seasonal affective disorder (SAD) in Iceland and in various regions globally show that genetics and a diet that nourishes the brain play a vital role in combating SAD as well as other life-altering mood disorders like anxiety and depression.

Seasonal affective disorder is a medically-recognized mental illness with a set criteria to diagnose. Treatment comes in the same forms as other mental illnesses — psychotherapy, medication, lifestyle changes, and light therapy — and symptoms of SAD include lethargy, appetite changes, and a variety of depressive symptoms. SAD can occur during any season, but the majority of people with SAD demonstrate the onset of these changes during the fall and winter, with symptom remission in the spring on a recurring basis.

For decades, scientists believed the dominating factor causing SAD was the amount of light people were exposed to: that clock genes, responsible for much of our circadian rhythm, made people sensitive to light conditions that fluctuate with seasonality and latitude. Studies in the U.S. revealed that SAD was significantly higher in winter months at higher latitudes, providing evidence of the link to light exposure.

Nevertheless, more recent studies of Icelandic and Japanese populations have complicated the picture. One famous example comes from a study that found, despite Iceland's closer proximity to the Arctic and shorter days, it had significantly lower rates of SAD compared to the U.S. Additionally, seasonality demonstrated little to no impact on SAD in Iceland when comparing summer and winter rates. It turns out it isn't only the geographic latitude of the nation itself that's responsible for this result; genetics matter as well. Numerous studies have measured a lower prevalence of SAD in Icelandic descendants who recently immigrated to Canada than in the Canadian population.

Another study dating back to the late 1990s by Joseph Hibbeln dove deeper into the role of diet and discovered a negative relationship between fish consumption and levels of mood disorders. So not only does the Icelandic population have a genetic boost against SAD — they've developed a dietary one, too. While the average person's fish consumption in other countries is around 50 to 70 pounds per year, it's 225 pounds in Iceland. Japan has a similarly high rate of seafood consumption and has also displayed low rates of SAD.

To further analyze the correlation between fish consumption and mood, scientists looked into the relationship of omega-3 fatty acids, a key nutrient in fish. Omega-3 fatty acids are unsaturated fats most commonly found in marine life. As the Western world becomes more developed, fewer omega-3 unsaturated fats have been incorporated into its foods. Individuals with depressive disorders indicate omega-3 deficits in biological markers, while omega-3 supplementation was correlated with improved mood.

The Iceland and Japan cases refute the latitude hypothesis and highlight the importance of analyzing other factors, including diet and genetics, that can contribute to mood disorders like SAD. Although eating more fish and nuts high in omega-3 fatty acid concentrations can help, it is certainly not the only approach. More research needs to be conducted into the benefits and risks of increased omega-3 intake before it could be used as a treatment for SAD. As anxiety, depression, and SAD become more prominent, the potential of omega-3 looms large.

*American Journal of Psychology* (2006). DOI: 10.1176/ajp.2006.163.6.969  
*Dialogues in Clinical Neuroscience* (2007). DOI: 10.31887/DCNS.2007.9.3/levitan  
*The Lancet* (1998). DOI: 10.1016/S0140-6736(05)79168-6  
*The Canadian Journal of Psychiatry* (2002). DOI: 0.1177/070674370204700205



PHOTO VIA ISTOCKPHOTO

# Written in our genes

BY ISABELLE KESSOCK, BEHAVIORAL NEUROSCIENCE, 2026

DESIGN BY SAMADHI WIJETHUNGA, BEHAVIORAL NEUROSCIENCE, 2025

**A**strology has long been a topic of interest in society, dating back to the Babylonians and the Greeks. More recently, Millennials and Gen Z have led a resurgence in its popularity. We continue to be enthralled by the idea that some otherworldly source knows everything about us simply from our date of birth. But are the stars truly able to foretell avid details about your personality and major life events? Enter: genetics. Genetics is somewhat similar to a horoscope — it tells you all about yourself and can be interpreted to predict different events throughout your life. While there may not be any scientific support behind zodiac signs and their influence on personality, season of birth is a prominent factor when it comes to gene expression.

Researchers at Columbia University developed an approach called Season-Wide Association Study (SeaWAS) that investigated associations between birth month and various diseases within a sample population taken from Columbia

“ Nine of the newfound associations are cardiovascular-related, six of which share a high-risk peak in March and April.”

University Medical Center’s patient records. They then pulled out any traces of correlation between birth month and disease in existing literature and used previous studies as a comparison to assess the quality and accuracy of SeaWAS results. Remarkably, SeaWAS found associations between birth month and thirty-six conditions. SeaWAS was then replicated to establish birth month trends in twenty of the associated conditions, such as asthma, attention deficit hyperactivity disorder (ADHD), and reproductive performance. However, the remaining sixteen brought novel connections between conditions including atrial fibrillation, congestive cardiac failure, and coronary arteriosclerosis. Nine of the newfound associations are cardiovascular-related, six of which share a high-risk peak in March and April. This calls forth the idea that specific disease categories may have intrinsic trends of high-risk birth months.

Seasonal patterns within these conditions can all be traced back to circannual variation within white blood cells and the overall immune system. More than 4000 protein-coding mRNAs have seasonal expression profiles in white blood

cells, adipose tissue, and within the cellular composition of blood. Interleukin-6 (IL6) receptor complex and C-reactive protein (CRP) are two biomarkers for risk of cardiovascular, psychiatric, and autoimmune diseases that have shown increased levels of expression during European winter, suggesting a pro-inflammatory immune response.

Xaqin Castro Dopico and his team of researchers at the University of Cambridge hypothesized that *Artnl* expression would also follow a seasonal expression pattern. *Artnl* (*Bmal1*), a clock gene, influences circadian rhythms and has been shown to influence psychiatric disorders. When studied in mice, the knockdown of *Bmal1* in the mammalian circadian timing system led to behavioral abnormalities that are linked to depression and anxiety disorders. When comparing samples from the United Kingdom, Australia, and the United States, *Artnl* was found to have seasonal variability. It was found to have peaks in its expression during summer months, followed by troughs in winter months, lining up with the onset of seasonal affective disorder. In mice, *Artnl* controls the number of monocytes within the immune system and while *Artnl*’s effect on the human immune system is not known, monocytes have the highest levels during winter in Europeans, when *Artnl* expression is at its lowest. It is possible the combined effects of lower levels of *Artnl*, as well as higher expressions of IL6 and CRP have an influence on the increased frequency of cardiovascular disease-associated deaths in European winter.

How can we apply this formative data to make a difference in the way we approach these diseases? Preventative medicine is at the forefront of the healthcare industry. With further research into seasonal variation’s influence on gene expression and related diseases, we may be able to use these trends in treatment plans. Cancer is consistently the second-leading cause of death for Americans but is generally treatable when caught in early stages. However, most people don’t discover they have cancer until it has progressed into other organs, at which point very little can be done. By combining birth trends with existing risk factors found through genetic testing, we can advance our understanding of true risk factors for disease development and improve overall patient prognosis. Additionally, it has been suggested that season of inoculation may influence the success or quality of a vaccine response. This research also has the potential to improve diabetes treatments, immune response variability, cardiac risk factors, neuropsychiatric symptoms, and more. Zodiacs and birth trends can allow one to feel aligned with the stars, but they have only been theorized as a cause of real diseases. While learning about “genetic horoscopes,” be sure not to treat these trends as laws.

# Nothing beats good old pen & paper

BY ASHNA SHAH, BEHAVIORAL NEUROSCIENCE, 2025

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**T**aking notes in class. Signing a lease. Making a grocery list. All of these activities used to require a very important tool: our very own handwriting. Nowadays, we tend to rapidly jot down notes during class on our laptops or use autofill to put signatures on important documents. Because the faster we get these things done, the better ... right?

Wrong! Though it is possible for adults to type over 40 words per minute compared to the measly rate of 40 handwritten letters per minute, we tend to gloss over the meaning of words and fail to absorb potentially important information when we type. Handwriting is a crucial tool for proper brain development and improves learning outcomes.

Our relationship with handwriting begins at a young age as children learn the alphabet through tracing, repetition, and reading. Handwriting is closely linked to activity in particular brain regions. The brain itself has four main lobes: frontal, parietal, temporal, and occipital. Both writing and speaking are associated with the frontal lobe (also important for motor control and reasoning), as well as the parietal lobe which helps humans interpret language.

Aside from the physical act of handwriting improving our fine motor skills, writing more can impact our recall abilities and memory. A 2021 study based in Japan from the University of Tokyo noticed enhanced brain activation after writing down appointments on a physical calendar as opposed to on a digital tablet or phone. Functional magnetic resonance imaging showed that physical writing sparked activity in the bilateral hippocampus (major learning and memory structure), occipital lobe (visual cortex), and similar frontal regions.

Although a somewhat outdated statistic, a paper titled "The Influence of iPads on Course Performance and Student Perceptions of Learning in Human Anatomy" described a massive jump in iPad usage amongst undergraduate students: 16% to 47% between 2013 and 2014. This trend appears to be continuing and the number has likely increased in the year 2023.

It may be surprising that differences exist between cognitive brain activity in tablet and stylus users compared to the traditional pen-and-paper experience. Interestingly, handwriting on paper compared to handwriting on a tablet yielded increased activation of the brain and this is likely because "the material substrate of paper provides physical, tactile, spatiotemporally fixed cues to the length of the text" according to a study in published in the International Journal

of Educational Research. This is also very important for visual learners, as writing on paper may allow them to remember specific details within the context of where they are on the page.

Much of the existing literature on handwriting illustrates a causal relationship between handwriting and improved academic performance. This is attributed to the fact that writing concepts in your own words and creating more concise memos is a more interactive form of studying.

A paper titled "Motor Learning of Handwriting and Developmental Dysgraphia" was published in July of 2023 and examined the impacts of handwriting disorders (HDs) on children in elementary school. The term "dysgraphia" refers to neurological disorders involving the impairment of writing ability. This can manifest as wrist instability, more jagged handwriting, and a lower word per minute rate. The authors state "the hypothesis of cerebellar dysfunction in children with HDs is accepted in the literature," meaning that not only does our handwriting impact our brain, but our brain impacts the way we write. The authors highlight the need for more research on this topic.

Handwriting also shifts as we age. The IRCCS Neuromed Institute of Italy partnered with the University of Cincinnati to study the differences in handwriting between younger adults, middle-aged adults, and older adults using machine learning. One major pattern emerged: older adults tend to have smaller stroke sizes which is a sign of declining ability. Unfortunately, it is natural for our fine motor skills to decline as we age. But, we can prolong this decline by engaging our motor skills in other activities. When we repeat certain motor activities, it strengthens existing neuron networks in our brain. For example, taking time to write in a journal daily, picking up crocheting or knitting, or doing puzzles with smaller pieces will generally improve our motor abilities as we go through the aging process!

Culturally and historically rich, integral to society and communication, and key in taking an active role in learning, the ability to write by hand is not something to take for granted. Going "old-school" isn't necessarily a bad thing and might even help you boost your grades!

# OPINION: The cultural significance of handwriting is too great to lose to keyboards

BY CJ CROMBIE, CELL & MOLECULAR BIOLOGY, 2026

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

The earliest example of physical writing is widely considered to be Cuneiform, a system of wedge-shaped inscriptions dating back to 3000 BCE. Attributed to the Sumerians of ancient Mesopotamia, the informal system was utilized namely for communication and maintaining transactional records. Although this physical remnant of Sumer offers invaluable insight into ancient civilization, most anthropologists do not consider Cuneiform to be true "writing." It conveys basal-level information without any dependence upon an actual language. However, like many other quintessential modern cultural practices, it was during the reign of the Roman empire that writing became what we know it to be today — that is, an essential tool for academic pursuits, storytelling, recordkeeping, and communication in greater depth.

"

In an age where the technology was limited to chisel and stone, handwriting is uniquely essential to human history."

As writing has flourished across human history, technology has kept an equal, if not greater, pace. Tools such as the printing press, typewriter, word processor, and ultimately the keyboard have all entered into existence seeking to improve efficiency and ease. But it appears as though the slow and gradual transition to digital technology has now eclipsed handwriting in terms of both value and usefulness. What began as an exciting prospect for its potential to propagate knowledge and communication has blindsided us in its rise to utility, now more reminiscent of a crutch, or perhaps even a prosthetic limb: something essential to our ability to engage in many aspects of our daily lives — something without which, we'd be practically incapacitated.

In the broadest possible lens, handwriting is perhaps most highly significant to humankind for its cultural contributions. Not only does written language both retain and expand the depth of many cultures, but it also allows for a greater cross-cultural connection. It bridges the gap between individual cultures and the rest of the world. Consider, for example, the Rosetta Stone, inscribed with the same decree in two Egyptian scripts and one Greek script. This first multilingual text allowed for a previously untranslated Egyptian hieroglyphic system to finally be deciphered. The outcome? An entirely new understanding of ancient Egyptian civilization and communication.

Handwriting and the disciplines of history and anthropology are ultimately inherently intertwined. Firsthand accounts such as written letters, diaries, books, and ledgers are uniquely essential to our current understanding of human history. This is because, in an age where the technology to produce such accounts was limited to a chisel and stone or quill and ink, handwriting was the only way to ensure that information endured across time. The Mandarin system epitomizes this, having endured 3,000 years as a highly-practiced written language and serving as an essential element of Chinese art, literature, and cultural retention since its inception.

Additional vouchers for the significance of handwriting are the other, more interpersonal aspects of the practice. Communication in a handwritten format is a meaningful, effortful manner of interaction, especially as opposed to the alternative. Handwritten letters, cards, and notes all indicate a level of thoughtfulness not transferable to typing, simply because of the time and careful consideration it takes to produce a birthday card signed with your name in ink.

It is imperative that handwriting does not become yet another obsolete cultural practice, sparking intrigue only within inquisitive anthropologists and museum curators of niche interest. But in a digital age prioritizing rapid information intake, mass data production and storage, and ultimately, efficiency, how can we preserve this lapsing bit of humanity?

I have some suggestions. Write a letter, be it to your friend at camp or your family at home. Make a physical to-do list, which is not only something you likely do anyway, but you might find it helps organize your thoughts. Keep a wellness journal, a field journal, *any* journal documenting your unique human experience. Take your lecture notes by hand, or, if you prefer, perform a review and active recall by writing down information. Write silly notes to your roommates, words of affirmation to yourself, or messages you stick on your apartment door for other residents to cherish. Take up calligraphy or practice the cursive they tried to teach you in the third grade but never quite completed. Most importantly, just *keep writing*. You don't need to be a historian or a proponent of the Mandarin script for your writing to be meaningful — you may even just be grateful for the physical memories you've left yourself in many years' time.



# The healing power of music

BY SANIYA BURMAN, BEHAVIORAL NEUROSCIENCE, 2026

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**M**usic is a universal language that has the power to evoke various thoughts and emotions and reduce stress and anxiety. According to a research study from Harvard Medical School, music has the power to affect "cognitive function, quality of life, and even happiness." From classical to pop, through its many genres, music has the power to improve brain health, elicit various emotions, and prevent cognitive impairment.

As the Greek philosopher Plato once said, "music gives wings to [the] mind." A new field of study that analyzes the intersection between music and neuroscience, called Neuromusicology, focuses on how the brain is affected by the waves of sound. Listening to music is helpful in reducing stress and anxiety by causing the stress hormone, cortisol, to decrease and releasing endorphins to cope with pain. In addition, the formation of dopamine, a neurotransmitter associated with pleasure and happiness, is stimulated when listening to music. For example, if you hear the introduction of your favorite song while listening to your playlist or while shopping in the mall, your brain triggers a boost of dopamine, thereby resulting in a wave of positive emotions. Dopamine is a naturally occurring neurotransmitter that results in a feeling of reward and happiness.

The study at Harvard Medical School involved a 20-minute online survey where 3,185 adults answered questions relating to the impact of music on cognitive and emotional well-being. This study proved that music activates some of the broadest and most diverse networks of the brain. Specifically, it activates the auditory cortex in the temporal lobe (which is near your ears) of your brain. In addition, music activates emotions and our motor system which causes one to tap their foot to the beat!

Like the positive impact on memory retention, supplemental music therapy can be used in healthcare to improve mental health and promote healing. Music Therapy is a systemic intervention process that uses various techniques including listening to music and musical activities and can be used as an alternative treatment method. The biological effects of music and sound can be harnessed to improve patient outcomes for those suffering from cognitive decline through conditions like Dementia and Alzheimer's disease. Research suggests that listening to music, playing instruments, and singing can result in emotional and behavioral benefits for people with Alzheimer's and other neurodegenerative diseases.

Specifically, a research study from the Alzheimer's Association analyzed the effects of rhythmic music on game performance in patients with Alzheimer's disease and dementia. Each participant took a brain training/matching game test over a period of 18 days. The experimental group performed the cognitive tasks while listening to music while the control group did not listen to music. At the end of the study, it was clear that music is associated with an increase in cognitive testing scores therefore implying the positive cognitive benefits of music.

Music and cognitive stimulation are connected in many case studies with mental health patients worldwide. Through its many genres, the physics of music and its sound waves have been proven to improve brain health, cause different emotions, and prevent memory loss. The next time you listen to music, think about how it activates the connections in your brain and the memories associated with it!

*Alzheimer's Association (2017). ISSN: 1552-5260  
National Library of Medicine (2018). PMCID: PMC6022981*

PHOTO VIA RAWPIXEL

# Physician-assisted suicide

## The patient's right

BY MEI DOWNEY, BIOCHEMISTRY, 2027

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**I**s suicide a constitutional right? The answer is complicated. In The United States, citizens can take their own lives at any time, but what about when a person is looking for permanent relief from a terminal illness? Physician-assisted suicide (PAS) is an option for qualifying terminally ill patients who feel death is favorable to life. The practice is illegal in most of the United States. PAS is available in only eleven states and is not an accessible or easy process. Generally, the patient must qualify as an adult with a sound mind, terminally ill, and have six months left to live. All of the criteria up to the discretion of an attending physician. As a physician, what is the benefit to participation?

“

Physician-assisted suicide (PAS) is an option for qualifying terminally ill patients who feel death is favorable to life.”

The answer is patient autonomy. The Oregon Health Division examined the first year of legalized PAS in Oregon (1997). The report found, compared to a control group, there were no significant differences between the reasons for considering PAS for patients. The reasons were concerning financial issues, insurance coverage, or concern over being a burden to loved ones. The primary distinction was about bodily autonomy and the loss of one's bodily autonomy. PAS is achieved through a mix of barbiturates and narcotics. These prescriptions are tailored for each patient, ensuring a safe and peaceful death. The patient or a trusted agent can pick up the prescription, meaning the patient has a choice over the time and place of their death. Patients participating in PAS are concerned with the quality of life – not the length of it.

On August 29, 2023, two patients and two physicians filed a lawsuit against the New Jersey government. Judith Govatos and Andrea Sealy are both patients with cancer who wish for access to PAS and the gift of choice over their manner of death. Dr. Paul Bryman and Dr. Deborah Pasik, both licensed in New Jersey, are contacted by out-of-state patients who are looking for PAS, yet Dr. Bryman and Dr. Pasik are unable to help without penalty due to their state laws. Together, the four are filing the lawsuit because the requirement of the residency status violates

the Privileges and Immunities Clause (Art. IV, § 2), the Commerce Clause (Art. I, § 8), and the Equal Protection Clause (Amend. XIV, § 2) of the United States Constitution.

The legalization of PAS in the United States is protected under the Death with Dignity Act, enacted in 1994. Its goal is “...to ensure people with terminal illness can decide for themselves what a good death means in accordance with their values and beliefs.”

Even though the Death with Dignity Act is expanding to other states, PAS is still a laborious process for patients. After a patient finds a participating physician, there are still multiple forms, requests, and agreements needed to be eligible. Chin, Hedberg, Higginson, and Fleming found that five of the twenty-one patients seeking PAS had died without any control from their terminal disease before being able to obtain a prescription for a peaceful death. In 1998, most hospitals in Oregon did not participate in PAS, and 40% of patients seeking PAS were not able to begin the prescription process with their first physician. PAS was, and still is, a highly contested medical practice, leading to many participating physicians feeling isolated from their colleagues. Death is an all-consuming notion that weighs on both the patient and the physician. Both for the patients who want control over their death, and the burden the physicians must carry assisting such death. PAS is surrounded by a hazy cloud of misunderstanding, where patients have little to no outlet to express their experiences and emotions. Physicians who are not willing to perform PAS contribute to patients feeling a loss of autonomy during the end of their life.

PAS and its support from the DDA are meant to provide patients with a feeling of control over their life and how it will end. Many patients have been through an arduous battle

with their terminal illness. These patients have faced pain for too long and need another option. Death is such a personal journey that the patient should have as much control over as they are able to. PAS offers physicians a place to ensure a safe, comfortable death with as little pain as possible. There is no perfect answer to the question at hand, but people like Judith, Andrea, Dr. Bryman, and Dr. Pasik are hopeful to expand, with the DDA, the accessibility of PAS to the entire nation.

PHOTOS VIA RAWPIXEL



# Riches to rags

## How the Buddha's journey to enlightenment reimagined neurotherapeutics

BY SAMADHI WIJETHUNGA, BEHAVIORAL NEUROSCIENCE, 2025

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025



The accumulation of years, cognitive and physical decline, and reckoning with death's inevitability drew the spoon-fed prince Siddhartha Gautama away from a life of copious riches and political popularity. While embarking outside his palace, the sight of a humble ascetic inspired a quest to understand the universal experience of suffering, or in other words, life. Guatama's ultimate shift and growth in perspective resulted in the formation of one of the world's greatest religious influencers, the Buddha. His wisdom has passed through generations, giving rise to over 500 million individuals who identify as Buddhists, and millions more who practice mindfulness. The practice, neuroscientists say, has helped many in a landscape where over a quarter of U.S. adults with mental illnesses fail to receive the treatment they need.

Buddhists developed restrictive lifestyles and disciplines with the hope of ending the constant rotation of suffering — the cycle of death and rebirth. Notably, they practice the Eightfold Path, detailing the moral, physical, and mental conduct that guides followers to nirvana, when living beings are removed from the continuous cycle of reincarnation and are freed from suffering. One of the most important approaches Buddhists take to reach nirvana is mindfulness meditation. Meditation, the Sanskrit word for "remember," teaches followers to be constantly aware of the present moment. Hence, mindful meditation has been defined as an increase in the awareness of one's self through physical and mental concentration, calming the body and mind.

Out of the over 50 million American adults who have experienced mental illness, 28% reported they were unable to receive the treatment they needed. Thus, many neuroscientists

have found the practicality, versatility, and cost-effectiveness of mindfulness meditation appealing. They have even been studying the neurological mechanisms involved in mindfulness meditation and how these processes influence human mental health and well-being, especially in mitigating psychiatric conditions.

Previous research findings suggest mindfulness meditation is associated with a decrease in symptoms of neuropsychiatric disorders, including rumination and a lack of attentional control. Furthermore, attention to breathing, a core tenet of mindfulness meditation, fosters emotional regulation. Neuroscientists study these effects by looking at the networks or regions in the brain responsible for the neurological symptoms. The intersection between attention, emotion, and awareness is the centerpiece of mindfulness meditation; an increase in the functional connectivity between them in the brain decreases susceptibility to neuropsychiatric disorders and advances one's mental resilience.

In one study from a team at the Technical University of Munich, researchers aimed to identify the specific neural impact of mindfulness meditation training on health and cognition. Participants were randomly assigned to 31 days of web-based meditation training or health training, which included familiar healthcare practices. Functional magnetic resonance imaging (fMRI) was then employed to monitor blood flow and measure data on the functional connectivity among three core networks in the brain: the default mode network, responsible for controlling rumination and attention; the salience network, responsible for coding stimuli from an environment; and the central executive network, responsible for managing higher-order cognitive functions. The results demonstrated a statistically significant increase in connectivity between these three networks in the experimental group that took part in the mindfulness training in comparison to the conventionally trained control group.

In a nutshell, mindfulness meditation training biologically encourages interaction between the default mode, salience, and central executive networks, and it behaviorally prevents a loss of attention and awareness characteristics of neuropsychiatric conditions. The research is a modern authentication of what Buddhists have known for centuries. The promotion of mental and physical well-being holds testament to the Buddha's way of life: meditate, restructure, reinvent, repeat, and reignite.

*Nature* (2022). DOI: 10.1038/s41598-022-17325-6

PHOTOS VIA RAWPIXEL

# Beyond relief

## The neurobiology of MDMA therapy and its implications for mental health

BY CAROLINE GABLE, HEALTH SCIENCE & PSYCHOLOGY, 2026

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**P**ost-traumatic stress disorder (PTSD) is a debilitating mental health condition that has long eluded easy treatment solutions due to its common comorbidity with other behavioral health conditions such as depression, anxiety, and substance use disorders. However, a novel approach has emerged in recent years: MDMA-assisted therapy. This revolutionary treatment involves the controlled use of MDMA, also known as "ecstasy" or "molly," in a therapeutic setting. While this therapy has shown great promise in clinical trials, what sets it apart is its efficacy and the intriguing neurobiological mechanisms that underlie its success.

In individuals with PTSD, there is often a dysregulation of the serotonin system and hypothalamic-pituitary-adrenal (HPA) axis, leading to symptoms like depression, anxiety, and emotional numbing. This dysregulation is due to the persistent activation of the HPA axis in response to trauma-related triggers. This continual activation leads to elevated cortisol levels which exacerbate serotonin dysfunction and thus decrease serotonin release. Understanding the dysregulation of the HPA axis and serotonin system in PTSD is a core concept behind MDMA therapy.

MDMA is an entactogen that promotes monoamine reuptake inhibition. This means it is a psychoactive substance that encourages reuptake of neurotransmitters like serotonin. When MDMA is administered in a controlled therapeutic environment, it causes a surge in serotonin levels. This increase in serotonin enhances emotional processing, increases empathy and trust between patients and clinicians, dampens amygdala activity, and may promote neuroplasticity for healthier neural connections in individuals with PTSD.

Several clinical trials have proven MDMA therapy to be highly effective at mediating and treating PTSD. In a 2023 study published by a team of researchers out of the University of California, San Francisco, 86.5% of participants treated with MDMA and psychotherapy achieved a "clinically

meaningful benefit" and 71.2% of participants no longer met criteria for PTSD by the end of the 18-week trial period. This is the first psychedelic treatment study with more than half of the participants coming from an ethnically or racially diverse background, meaning that the effectiveness of MDMA-assisted therapy is confirmed to extend beyond ethnic and racial majority groups.

While MDMA therapy has shown significant promise in treating PTSD, researchers are exploring its potential applications for other behavioral health conditions. Given MDMA's effect on serotonin reuptake in the brain, the possible implications of MDMA-assisted therapy

on major depressive disorder are clear. Major depressive disorder affects an estimated 5% (or 400 million) of adults worldwide and is one of the most common behavioral health disorders. A 2022 study proposal from a team of researchers at the University of Oslo stated that "significant and immediate antidepressant effects of MDMA-assisted therapy are demonstrated in published PTSD trials." This study and others are currently ongoing to

determine the effectiveness of MDMA for the treatment of major depressive disorder. As research continues, MDMA-assisted therapy could become a valuable tool for behavioral health, offering hope to those who have struggled with conditions that are notoriously difficult to treat.

MDMA-assisted therapy represents not only a breakthrough in PTSD treatment but also a fascinating glimpse into neurobiology and the brain's potential to heal. By understanding this and the function of MDMA, the broader applications of psychoactive treatment in the realm of behavioral health are endless. MDMA therapy may be the answer to offering relief and healing to a wide range of individuals grappling with the complexities of PTSD and other psychological disorders.

*Nature Medicine* (2023). DOI: 10.1038/s41591-023-02565-4  
*Dialogues in Clinical Neuroscience* (2011). PMCID: PMC3182008  
*Frontiers in Psychiatry* (2022). PMCID: PMC9645093

# Dead yet conscious

## Some CPR survivors recall events during heart failure

BY ADITI SWAMY, BEHAVIORAL NEUROSCIENCE, 2027

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**H**ow long can the brain function without oxygen from the heart? For a long time, scientists thought that the answer was about 6–10 minutes before the brain undergoes permanent damage. However, recent research reveals that 1 in 5 people who undergo cardiopulmonary resuscitation (CPR) and survive can remember events from when they were “dead.”

When patients undergo cardiac arrest, the heart suddenly stops pumping blood and vital organs like the brain can cease to function. While starting CPR immediately can double or triple the chance of survival, it can take up to an hour to fully restart the heart. New research published in *Resuscitation* conducted by Dr. Sam Parnia, an associate professor at the NYU Langone Health Department of Medicine, and his team of researchers reveals that some patients can recall events during this period, even while their brain is deprived of oxygen. Scientists call this idea “lucid death.” Cultures around the world have recorded signs of it, referring to them as hallucinations or dreams. It is only recently, though, that researchers have attempted to take a biological approach to studying it.

Parnia and his team conducted a study called AWARE II. Teaming up with 25 hospitals in the U.S. and U.K., they recorded any signs of consciousness while patients underwent cardiac emergencies. In one of two methods they used to do so, they monitored patients’ oxygen and brain activity while playing audiovisual stimuli through bluetooth headphones and a tablet screen during CPR. The audio named the words “banana,” “pear,” and “apple,” and the visual stimuli displayed 10 images. If the patients who survived were able to recall the names of the fruits played or any of the images displayed on the screen, it would support the researchers’ hypothesis that lucid death is real and that the patients were still aware of their surroundings despite being unconscious.

In the study, 53 of the 567 patients survived. None could accurately recall the images, and only one recalled the names of the fruit. However, researchers found “flurries” of hidden brain activity in the patients who survived instead of an electrical flatline, which suggests that there is some sort of brain activity occurring in patients, even while not receiving sufficient oxygen. They found brainwaves in these spikes of activity over an hour into CPR. These waves normally occur in conscious people’s higher mental functions like thinking, memory retrieval, and perception. About 40% of patients experienced electrical

activity that re-emerged at some point with normal to near-normal brain waves, which are consistent with consciousness. This activity was restored up to around 60 minutes into CPR. Therefore, even with a lack of oxygen, the patients’ brains were still functioning similar to that of a conscious person.

Additionally, Parnia’s team interviewed 126 people in the community who had undergone cardiac arrest. They found that 40% of patients had some sort of awareness of the event and 20% had specific memories. For example, participants described perceptions of separation from the body, undergoing a re-evaluation of their life, or observing events without pain. Researchers categorized participants’ memories by type of sensation — such as dreams and delusion — and time of occurrence, like during or post resuscitation. These “themes” of recalled experiences will allow further research into the biochemistry of the lucid death phenomenon to be more specific and specialized.

The team hypothesizes that dying people gain access to their entire consciousness as a transition from life to death. They believe that the brain’s natural braking systems are released, which allow access to the depth of a person’s consciousness. Their findings can impact the way that clinicians and families treat patients undergoing cardiac emergencies. According to Dr. Lakhmir Chawla, an intensive care physician at Jennifer Moreno Department of Veterans Affairs in San Diego, California, families should have the opportunity to see their dying patients, as it is very possible that the patients can hear them. He also believes that the findings should inspire clinicians to treat these patients as if they were awake, which is something that currently does not happen.

Further research could also investigate the evolutionary purpose of lucid death as well as the possible long term psychological effects of CPR, as we now know that the brain is aware of being resuscitated. Parnia’s team is also currently looking toward finding specific biomarkers of lucid death that could provide concrete evidence of this phenomenon. Although more research must be done, the fascinating field of lucid death has allowed for the emergence of a scientific perspective on the transition between life and death, and who knows what it might lead.

# Hormone replacement therapy

## A delicate balance

BY HEIDI HO, PUBLIC HEALTH & JOURNALISM, 2027

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**G**rowing older is a blessing for many, but it doesn't come without its downsides. Nicknamed "second puberty," menopause happens between the ages of 45 and 55 for those with female reproductive systems. It is the body's way of telling reproductive organs their job is done. Many women struggle with carrying out daily activities, yet 73% do not treat their symptoms. Although it is a natural process of aging, symptoms such as hot flashes, thinning hair, dry skin, slow metabolism, mood swings, vaginal dryness, and sleep disturbances can be debilitating.

Hormones, the chemical messengers that aid in growth and development, are to blame for such somatic chaos. Estrogen and progesterone are unique to the female reproductive system, but during menopause, those hormone levels drop sharply. The rapid loss of estrogen increases the risk for osteoporosis and heart disease, but some argue that hormone replacement therapy, or HRT, may be the solution. HRT replenishes the body's depleted levels of estrogen by supplementing estrogen — often combined with progestin — orally, transdermally, or vaginally. By 1999, 38% of postmenopausal women reported using HRT, but the drug market sales fell after a 2002 clinical trial by the Women's Health Initiative was truncated due to concerns of increased cancer and heart disease. Adding to the public's confusion, a 2017 study found that HRT had no impact on mortality. The question still remains: Is HRT worth it?

In regards to the controversial 2002 study, critics argue that the experiment did not use an age-representative sample. It is generally recommended for women to start HRT when they are below the age of 60 because the older individuals are more likely to have established cardiovascular disease. Because bone density loss is most significant at the onset of menopause, HRT is most effective if started within the first four years of symptoms.

In an effort to retain their "femininity," women in the past took estrogen supplements to stave off the effects of aging. For those with an intact uterus, progesterone was added to their therapy regimen to prevent uncontrolled endometrial lining growth. To this day, most women take their HRT orally or transdermally. As more research is conducted, it

seems that the most important factors to consider when it comes to starting HRT is age, health conditions, dosage, and family history.

“

The rapid loss of estrogen increases the risk for osteoporosis and heart disease, but some argue that hormone replacement therapy, or HRT, may be the solution.”

HRT maintains bone density and reduces the risks of fractures and osteoporosis. One of the most common symptoms of menopause, hot flashes, were reduced by 87% under HRT. As a result, women's mental health often improves when their physical health improves. It is important to note that HRT tends to be more effective for those who have more severe rather than mild symptoms. Regardless, these promising results give women the potential to get their life back. There are also different ways to manage menopausal symptoms and aging in general. Smart lifestyle choices such as eating a balanced diet, exercising, or abstinence from tobacco and alcohol have been shown to alleviate symptoms. Prescription medications might also help with symptoms and hormone balance. For those who are younger than the typical menopausal age, consuming enough calcium during growth helps reduce the risk of osteoporosis. However, HRT is a great option for those who already exhausted other means of relief.

Although HRT is currently the most effective treatment, it is highly individualized to a patient's medical history. Nonetheless, as new doctors graduate, there is hope in the future of women's healthcare. HRT is just one achievement that has the potential to improve the lives of older women — and healthy women are happy women.

*Nature Review Endocrinology* (2017). DOI: 10.1038/nrendo.2016.164  
*Hormone Replacement Therapy* (2023). PMID: 29630243  
*JAMA* (2017). DOI: 10.1001/jama.2017.11217

# DEFEATING PARALYSIS

## Revolutionary brain implant allows woman to speak after 18 years

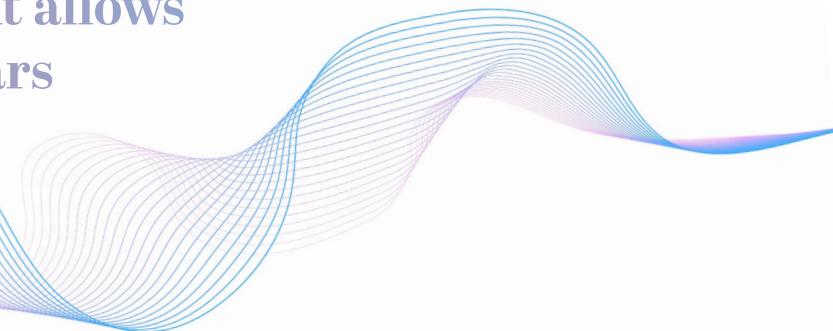
BY MAYA BRINSTER, BEHAVIORAL NEUROSCIENCE, 2025

**I**n 2004, a sudden brainstem stroke left the then 30-year-old Ann Johnson completely paralyzed. It took years of physical therapy for her to regain enough muscle control to express emotion on her face and breathe independently, but the muscles controlling her speech remained stagnant. Her daughter, 13 months old at the time of the stroke, lived her entire life never hearing her speak. But now, 18 years later, the development of a new brain-computer interface (BCI) technology is giving Ann her voice back.

On August 23 of this year, a group of researchers led by Dr. Edward Chang, chair of neurological surgery at the University of California San Francisco, published a paper in *Nature* describing findings from their clinical study testing this BCI device on Ann. A BCI is a technology that, simply put, allows people to control machines with their thoughts by using brain signals to control output devices such as cursors or prostheses. Findings revealed that this specific device can rapidly decode neural signals associated with speech in paralyzed people and subsequently accurately generate text, synthetic speech audio, and facial movement on a digital avatar.

Study co-author Gopala Anumanchipalli and co-lead author Kaylo Littlejohn explain that previous findings from Chang's lab contributed to the development of this device. In 2019, researchers at the lab first established that it was possible to use neural activity to synthesize speech. They then found that a speech neuroprosthesis device, an electrode array implanted onto the brain's surface that's used to record electrical activity, can utilize brain activity to decode full words in paralyzed people. In a subsequent study, they used the same speech neuroprosthesis technology to develop a spelling interface of a much larger vocabulary (over 1,000 words) that allowed the participant's brain activity to be decoded directly into text in real time with high accuracy.

This recent study aimed to generate speech audio and corresponding digital facial movements in addition to just text. The team attached a paper-thin rectangle consisting of 253 electrodes to the region of Ann's brain responsible for speech that could intercept signals that control movement in the tongue, jaw, larynx, and other facial muscles that allow for the production of speech. For weeks, they trained



DESIGN BY JASMIN PATEL, BEHAVIORAL NEUROSCIENCE, 2025

artificial intelligence (AI) algorithms by having Ann silently attempt to repeat sentences from an over 1,000-word vocabulary until the computer could recognize specific neural patterns associated with each sound. Once decoded, the device turned signals into audio waveforms, which were then played as audio feedback. Audio resembled Ann's voice, a feature made possible by using a past recording of her speaking. Instead of recognizing complete words, the AI system decoded signals associated with phonemes, the shorter subunits of speech that form words. The computer only needed to recognize 39 phonemes to decode any word, which allows for rapid decoding and enhanced accuracy and thus the ability of the user to communicate almost as rapidly as the average human. Ann states that hearing the voice for the first time was like "hearing an old friend."

The device also used the discrete code generated by translating brain signals associated with muscle movement during speech to accurately control a high-quality digital avatar that expressed the same facial expressions as Ann would have while speaking. The avatar, which realistically resembled Ann, could act happy, surprised, and sad in high, medium, and low intensities and also perform non-speech articulative movements.

The development of a technology that enables a paralyzed person to rapidly and accurately generate speech audio while simultaneously controlling a realistic digital avatar is groundbreaking. Ann explains that she finally feels like her life has meaning again: "Being a part of this study has given me a sense of purpose. I feel like I am contributing to society ... this study has allowed me to really live while I'm still alive!" In the future, researchers plan on reducing the delay between the user's thoughts and the production of speech from the avatar until the process can feel real-time. Although there is room for improvement, this device is a revolutionary step in improving the quality of life of those affected by paralysis. Ann states, "I want patients ... to see me and know their lives are not over now."

*Nature* (2023). DOI: 10.1038/s41586-023-06443-4

*Nature* (2019). DOI: 10.1038/s41586-019-1119-1

*The New England Journal of Medicine* (2021). DOI: 10.1056/NEJMoa2027540

*Nature Communications* (2022). 10.1038/s41467-022-33611-3

PHOTO VIA SHUTTERSTOCK

# Crystal clear: Acrylic skull windows revolutionize post-craniectomy recovery

BY TRICIA KRAKOFF, BEHAVIORAL NEUROSCIENCE, 2026

DESIGN BY JENNIFER MEDINA, BIOCHEMISTRY, 2025

**T**ucker Marr, an avid hockey player and analyst at Deloitte, suffered a fractured right skull and a subdural hematoma after falling down a flight of stairs. These injuries are critical and warrant emergency surgical treatment, a procedure called a craniectomy.

Craniotomies are performed to reduce swelling, pressure, or bleeding in the brain, all of which are extremely dangerous and may cause severe brain damage. In this emergency surgery, causes are usually drastic and happen promptly after a traumatic injury, stroke, clot, or hematoma. The procedure usually goes as follows: the patient must shave their head near the incision site, the surgeon will make the incision and expose the skull, the surgeon will then remove a piece of the skull, treat the reason for the craniectomy, cover the brain with a mesh material, and finally close the incision. However, this leaves patients with a visible malformation of the skull and the brain exposed directly under the skin. In the future, patients are able to go back and possibly have the malformation corrected with a piece of skull bone placed back into the head, a risky and costly procedure called a cranioplasty.

After the surgery, Marr put his active lifestyle on hold and was required to wear a helmet for protection and to keep the indentation on his head hidden. As the days went on, Marr lacked confidence and felt dizzy and fatigued, as his brain was unshielded from atmospheric pressure. Marr and his family knew that they needed to explore other options.

After researching the tried-and-true skull replacement surgery, Marr discovered that this surgery had a high rate of infection and would be costly in the long run because of monitoring procedures such as MRI or additional surgeries to see into the brain. Marr took initiative and investigated a cutting-edge surgery that utilized modern additive manufacturing: instead of placing the skull bone fragment back, it would be replaced with a different prosthetic fragment. He presented a procedure that was still in the early phases of research, using a 3D printer to manufacture an acrylic prosthetic skull fragment to replace the part of his skull that had been removed. Dr. Netanel Ben-Shalom, a neurosurgeon and assistant professor of neurology, took notice of Marr's request, resulting in a collaboration to create this patient-specific implant to replace the resected area of the skull.

Using an acrylic material to replace the bone offers a notable advantage to medical professionals – now, only an ultrasound is needed to look at the patient's brain. This idea is dubbed "acrylic windows" since the clear material offers a quicker and minimally invasive way to assess a patient's brain post-operation. Currently, very few medical centers offer acrylic windows for patients since the procedure is still in the initial stages of research.

Marr eventually received the surgery he wished for, and after the acrylic prosthetic was implanted, he felt more confident, regained his physical abilities, and reported that his symptoms from the exposed brain had dissipated. Now, working with Dr. Ben-Shalom, Marr is able to have easy check-ups and teaches medical students about this state-of-the-art technique.

However, new advancements in the medical field are often met with both support and resistance. Favors of this technique argue that this development is extremely valuable – especially since patients with craniotomies often require long-term monitoring and regular brain imaging. By using acrylic windows, medical professionals can easily assess the physiological causes of symptoms by using an ultrasound rather than other expensive and limited methods such as CT and MRI scans (which often require resources and analysis from other departments, such as radiology). On the other hand, other medical professionals believe that further evidence is needed to confirm that ultrasounds are equally as accurate as higher-order scans. Due to the early stages of this research technology, some medical professionals are still wary of the ability of ultrasounds to match the imaging details seen in higher-order scans.

Dr. Ben-Shalom told the *New York Times* that, in his experience, as long as the acrylic window is placed in the correct spot, the cavity of interest would be clearly demonstrated. Looking into Marr's brain at his regular checkups, Dr. Ben-Shalom can see how the midline of the brain that separates the two hemispheres looks (as this was pushed to the side after his initial craniectomy), the structures of his brain, and even the pulsing of his brain. If Marr were to ever have symptoms that would warrant Dr. Ben-Shalom to look into his brain, it would be done quickly and with ease. Dr. Ben-Shalom continues to specialize in this reconstructive surgery, and offer more patients who have undergone craniotomies the chance to look and feel like themselves again.

# BIOPRINTING THE FUTURE

BY DIVYA RAVIKUMAR, BIOENGINEERING & BIOCHEMISTRY, 2025

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**W**ith over 100,000 people on the transplant waiting list, not all of them have a chance to receive a matching organ in time. Due to insufficient supply and long waiting times, organ failure is one of the leading causes of death. To combat this, scientists are stepping up to counter this challenge by developing 3D bio-printed organs, ensuring that each patient has equal and quick access to life-saving organ transplants.

Though the field is relatively new and upcoming, there has been considerable progress showing hope for the future. Recently, a mini human heart has been 3D printed by a Boston University research team using stem cells, or cells that can develop into many different specialized types, and the heart (made of living tissue) is able to beat. The researchers are excited about the prospects this opens up for studying how the heart is affected under various conditions, such as how the heart behaves when affected by disease, or how it performs when new drugs are administered. There is a long way to go before bio-printed organs can be transplanted into patients, but these small achievements and discoveries prove that steps are being taken in the right direction.

One of the most important pieces to the puzzle of 3D printing is the printing process and technology itself. Scientists start by directly taking cells from the patient from the target organ or tissue, and they force the cells to revert to pluripotent stem cells, which are capable of differentiating into a variety of cell types. Scientists can then place them in specific conditions to influence them to become the desired cell type that would form the final bio-printed organ.

Since the cells are derived from the patient themselves, researchers can first test treatments on the bio-printed organ to observe its reaction before administering the treatment to the patient to avoid any risks or adverse effects. Patients can avoid undergoing multiple treatments that could put a strain on their bodies while scientists can find the optimal method of working on the bio-printed organ. Moreover, a transplant would have a greater chance of being accepted by the patient's immune system because it would recognize its own cells.

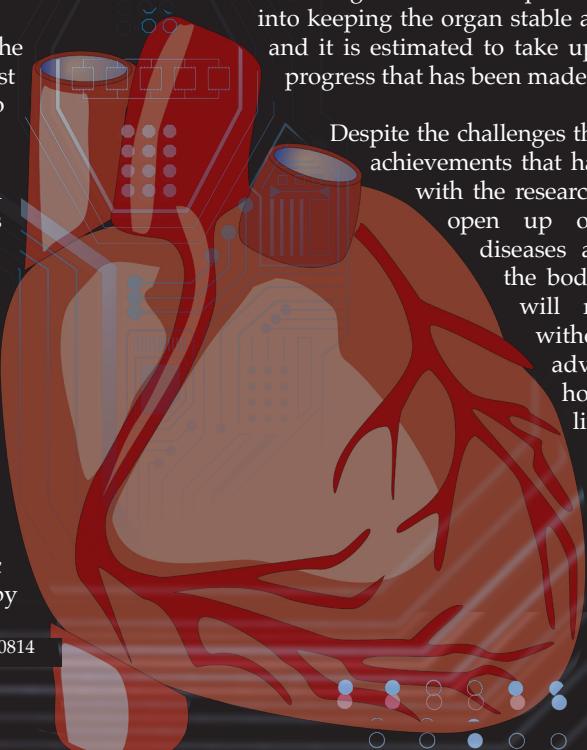
Next, cells are then cultivated in a sterile bioreactor that imitates the conditions of the human body. Specific nutrients are provided to the cells by

immersing them in media, a fluid that supports cell growth, to influence their differentiation. Then the cells are combined with bio-ink, a mixture of living cells, and hydrogels that mimic the body's extracellular matrix, cell media, and growth factors. The combination ensures that the cells will continue multiplying into the desired type. The most popular materials for hydrogels are collagen and gelatin because they are non-toxic and biodegradable, preventing any adverse reaction from the immune system.

The bioprinting process is very similar to typical 3D printing; however, instead of loading a plastic material, the bio-inks are loaded into the printing chamber, where each one corresponds to a certain cell type. The printer is programmed with the shape of the organ and the patient's personal characteristics from previously collected data in order to replicate a compatible tissue. The organ is built layer by layer, and the process duration can take up to several hours depending on factors such as the type of organ, the number of printheads, and the precision of printing. In total, the timeframe from taking a patient's biopsy to transplanting the organ is between four to six weeks, a significant improvement compared to the current months-long or year-long wait to get off the waitlist.

Creating a bio-printed organ seems straightforward, but the process has a long journey in optimizing the process and creating a fully functional organ. Organs are extremely sensitive and require a lot of effort to maintain and fully mature, so they will perform as needed in the human body. Resolving these issues requires even more thorough research into keeping the organ stable and sustaining it in the body, and it is estimated to take up to a decade even with the progress that has been made.

Despite the challenges that lie ahead, the tremendous achievements that have been made, for example, with the research team at Boston University, open up opportunities for studying diseases and medications outside of the body to make sure the patients will receive effective treatment without side effects. With more advancements in the future, the hope is that we can save more lives with bio-printed organ transplants without putting others at risk.



# When your hair just won't go flat

BY RAISA BHUIYAN, COMPUTER SCIENCE & MATHEMATICS, 2025

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**L**et's face it, hair care is not an easy task. Personally, it takes me around four to five minutes of brushing my hair to get it looking presentable, and even then, the outside world could easily not cooperate and mess up my look. However for some people, no matter how hard they try, their hair will just not go flat. Why is that? Well, one possible reason is what's known as uncombable hair syndrome.

What exactly does that mean? Uncombable hair syndrome, also known as spun glass hair, is a genetic disorder where a person's hair cannot be combed smoothly. This condition is associated with lighter hair colors such as silver, light brown, or blond. Other symptoms include frizzy and dry hair, hair that grows outward in multiple directions rather than downward, and hair that looks shiny, sometimes described as "a synthetic doll hair-like look," according to a study published in the *European Journal of Medical Genetics*. The condition affects children up to age 12, typically starting in infancy. In addition, the condition usually presents itself only on the scalp; hair on other parts of the body usually remain unaffected.

The syndrome is caused by mutations in either the *Tchh*, *Padi3*, or *Tgm3* genes. These three genes are responsible for structuring our hair strands. *Tchh* produces a protein called trichohyalin, which is then modified by proteins produced by *Tgm3* and *Padi3*. After that, the trichohyalin is able to bond with other trichohyalin proteins and keratin. These bonds create cross-links, which happen when the function

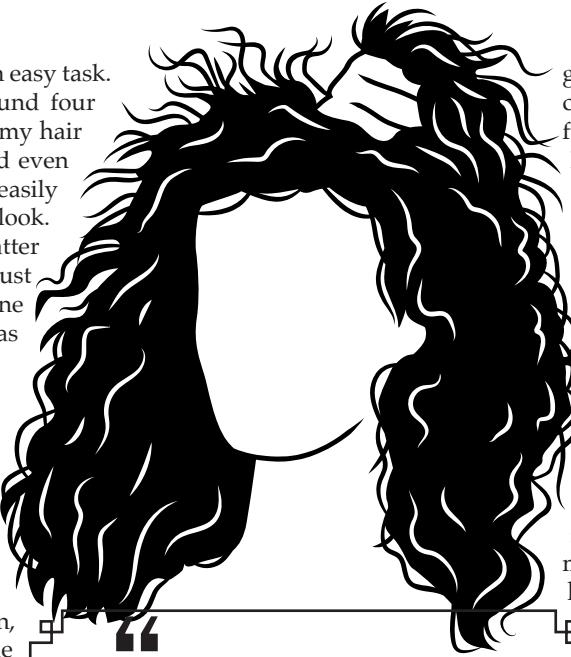
group from one polymer chain connects to another polymer chain's functional group, and these cross-links are responsible for shaping our hair. In the case of uncombable hair syndrome, mutations in these genes lead to hair becoming more angular rather than cylindrical. As a result, it becomes virtually impossible for the jagged hair strands to lie flat; in addition, the shape of the hair allows it to reflect light in a way that makes it look shiny.

It turns out that a way to diagnose this condition is through studying samples of hair under an electron microscope to identify if the strands have an angular shape. "The hair sample can be submitted for electron microscopic evaluation to assess for the classic findings of triangle-shaped hair shafts," dermatologist Adam Leavitt told the *Dermatology Times*.

In average cases, there typically aren't any other conditions associated with this condition. However, there have been instances where uncombable hair syndrome was found along with ectodermal dysplasias — conditions affecting hair, teeth, and nails. As of now, there does not appear to be any treatments for uncombable hair syndrome. However, in average cases, the condition resolves itself by the time adolescence comes around.

*European Journal of Medical Genetics* (2007). DOI: 10.1016/j.ejmg.2007.03.002  
*Pediatric Dermatology* (2007). DOI: 10.1111/j.1525-1470.2007.00475.x

PHOTO VIA SHUTTERSTOCK



“Uncombable hair syndrome, also known as spun glass hair, is a genetic disorder where a person has hair that cannot be combed smoothly.”

# Opinion: The invisible pill



ARTICLE AND DESIGN BY ANANYA JAIN, BEHAVIORAL NEUROSCIENCE, 2025

**A**s patients, doctors have earned our trust and attention. We choose them based on experience, recommendation, or prestige, but ultimately, we put our care in their hands. Despite this trust, we expect to maintain free will when deciding to continue or decline treatment. For those with exacerbated neurodegenerative diseases and various mental disorders, would you and your loved ones let a doctor be the final decider?

Though patient autonomy means the right to be in control, doctors have the responsibility to act as they see fit for the health of the patient, which may contradict the patient's wishes. In most cases, losing patient autonomy equates to the loss of decision making capabilities. In the case of mental hospitals and elderly care facilities, doctors often employ "covert medication" to ensure consistent treatment. Covertly medicating a patient involves sneaking pills into their food or drink. It is by no means the default method of administration, however, it is used in special cases when a patient constantly refuses care or is deemed incapable of decision making. In these cases there are three options: covertly medicate (with family consent), not treat at all after patient refusal, or inject medications intravenously by using physical force and restraint.

Thus, an ethical dilemma is presented. One side of this debate argues to stop covert medication, believing the physician and patient bond should not be jeopardized. If a patient were to find out they were receiving treatment even after declining, it could taint their view on both the medical field and its professionals no matter the status of their health. The opposing side believes that, under the Hippocratic Oath pledged before receiving one's medical degree, a physician reserves the right to decide if a patient is unable to decline treatment. So if a nonautonomous patient refuses and they relapse or their condition deteriorates, the doctor could be liable for malpractice as a result of doing nothing to treat them. Even though doctors have the right to treat, patients also have the right to be treated.

Noted in a 2010 study, "covert medication occurs in 43% to 71% of nursing homes in the United Kingdom," especially for those with either dementia or schizophrenia. Such a large range suggests that, while present, this is happening at an unpredictable and untrackable level. In a controlled

study performed by the *Indian Journal of Psychiatry*, 67 "non-compliant" patients with schizophrenia were medicated surreptitiously; after becoming aware, 26% opted to continue treatment while only 18% became resentful. Overall, 91% showed clinical improvement as a result of treatment. The alternatives to this deception lead to burnt out nurses, physically restrained patients, and an increased likelihood of condition deterioration.

When it comes to covert medication, a moral aspect comes into discussion. Though the issue concerns medical professionals, the ethical considerations can be reviewed through the lens of philosophy. Simplifying this ethical dilemma can lead to two schools of thought, represented by philosophers like Immanuel Kant and Peter Singer and summarized

by Northeastern Professor Jung Lee. Kant's philosophy is rooted in categorical imperatives, which assert that a morally right decision is always correct, regardless of the consequences. The categorical, or "moral," choice is often ignored, as nursing homes and mental hospitals around the world abide by their secretive method. On the other hand, Singer's consequentialism

posits that the ends justify the means. In the context of covert medication, Singer's perspective may seem more appealing due to its focus on the overall result. At first glance, abiding by patient wishes could seem like the obvious choice. However, in situations where a patient lacks the capacity to make clear decisions, medical professionals hold the responsibility of making choices that align with the patient's best interests. The chance for long term condition stability or improvement outweighs the "right" choice in many cases.

When considering the alternative that patients may suffer more due to their choices, covert medication can, surprisingly, be the more humane option. In this context only, Singer's approach safeguards patients from the dehumanizing process of restraint and the painful, protracted process of intravenous administration that strains medical staff. Non-autonomous patients can and should rely on their families and healthcare providers to act in their best interest, even during moments of non-compliance. Ultimately, this ensures that patients continue to receive treatment for their afflictions.

*Journal of Psychiatric and Mental Health Nursing* (2010). DOI: 10.1111/j.1365-2850.2010.01613.x  
*Taylor & Francis Online* (2018). DOI: 10.1080/15265161.2017.1409844  
*Asian Philosophy* (2013). DOI: 10.1080/09552367.2013.776741  
*Postgraduate Medical Journal* (2023). DOI: 10.1093/postmj/qgad003  
*AMA Journal of Ethics* (2021). DOI: 10.1001/amajethics.2021.311  
*Indian Journal of Psychiatry* (2012). DOI: 10.4103/0019-5545.102427

# Oral phenylephrine Placebo, in tablet form

BY SHELLEY JEON, PHARMACY, 2025

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**O**n Sept. 12, 2023, an FDA advisory committee concluded that over-the-counter (OTC) oral phenylephrine — the main active ingredient in Sudafed PE — is ineffective as a treatment for nasal congestion. This finding did not strike healthcare practitioners as “especially surprising” given that its efficacy has been controversial for decades. Despite this, the ingredient is in at least 250 different cough and cold products and remains a popular option for Americans during cold and flu season. In 2022, 242 million bottles (or packages) of products containing phenylephrine were sold, creating nearly \$1.8 billion in sales.

The evidence presented at the two-day advisory committee meeting did not support the efficacy of oral phenylephrine for nasal decongestion compared to placebo. A placebo is a pharmacologically inert substance used as a control in testing new drugs, such as a sugar pill. A meta-analysis conducted in 2007 pushed the FDA to start reviewing efficacy data that year and was also among the studies presented at the 2023 advisory committee meeting. This study found that, based on data from eight studies that included 138 patients, there was no difference between oral phenylephrine and placebo on nasal airway resistance (NAR) in patients with nasal congestion.

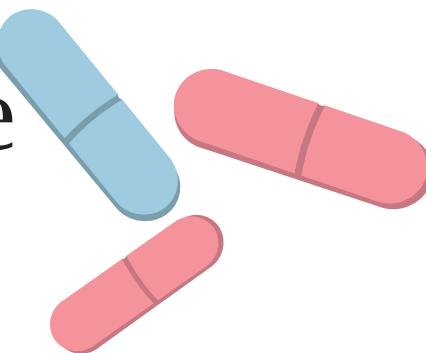
These findings led the study authors to submit an FDA citizen petition in 2007, requesting changes to the drug’s dosing on its monograph. An FDA citizen petition is a process that allows individuals and community organizations to ask the FDA to issue, amend, or revoke a regulation. Following four additional studies that also failed to demonstrate the efficacy of oral phenylephrine, the same study authors submitted an additional citizen petition in 2015 — this time requesting that oral phenylephrine be removed from the OTC monograph for nasal decongestant products entirely. An OTC drug monograph is a “rulebook” for each category of drug (e.g., nasal decongestants) that recognizes which active ingredients are allowed along with their approved uses, doses, routes of administration, labeling, and testing. If an OTC drug adheres to the requirements in a final FDA monograph, it can be manufactured and marketed in the United States without FDA pre-approval.

It is important to note that this data applies specifically to the oral formulation of phenylephrine; nasal sprays that contain the ingredient are still very effective. It is only the oral route that is ineffective because the drug must first pass the gastrointestinal tract and the liver — where it is rapidly metabolized, or broken down — before it reaches the nose.

Thus, there is very little drug that actually reaches the nose to treat the congestion. While oral phenylephrine itself is not useful, it is not dangerous. The multi-product formulations it is often found in (such as Tylenol Cold & Flu Severe, Vicks DayQuil, and Mucinex Sinus-Max) may offer some relief through their other ingredients.

What popularized phenylephrine as a decongestant was the Combat Methamphetamine Epidemic Act of 2005 (CMEA), which was enacted to place restrictions on over-the-counter medications that could be used to produce illicit methamphetamines. In order to curb its abuse, the CMEA required that the OTC medication pseudoephedrine (Sudafed) — which has well-documented data for relieving nasal congestion — be moved “behind the counter” of U.S. pharmacies and mandated that purchasers present photo identification. In response to the CMEA and concern about sales, drug manufacturers quickly reformulated most of their OTC products to replace pseudoephedrine with phenylephrine. In other words, while Sudafed was moved behind the counter and became subject to purchasing restrictions, Sudafed PE was easily accessible on pharmacy shelves.

It is certainly in the best interest of the consumer to quickly remove placebo-like products from the market, as they only create unnecessary costs and delay sickness recovery. There are also significant ethical implications associated with drug manufacturers marketing an ineffective product to consumers. However, the events to follow the advisory committee’s decision are still unclear. Multiple class-action lawsuits against Johnson & Johnson, the manufacturer of name-brand Sudafed PE, have already been filed by citizens across multiple states. The FDA will now need to officially decide whether to remove the drug’s status as Generally Recognized as Safe and Effective (GRASE), which would lead to its removal from the monograph. This decision could potentially be delayed for months by lawsuits and lobbying instigated by drug manufacturers, which leaves the ultimate fate of phenylephrine still up in the air.



# How AI is changing the journalism industry

BY EMMA KLEKOTKA, COMPUTER SCIENCE & JOURNALISM, 2026

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

In the age of Hollywood writers striking over the use of artificial intelligence in writers' rooms and AI-written articles, many have expressed concerns over the capabilities of artificial intelligence to replace journalists and media producers alike. Instead, some see artificial intelligence as a tool to expand the capabilities of the creative and journalistic industries.

For David Trilling, co-founder of the AI-generated Inside Arlington newsletter, large language models have the potential to fulfill the growing lack of news coverage in local communities.

"In a town of Arlington's size [~46,000] ... there was still very little local media about what was going on in town ... we do have a wonderful local online paper that does its best, but it's severely underfunded and understaffed," said Trilling.

Trilling began the newsletter with co-founder Winston Chen after Chen wanted to make changes in leash laws in the community, but did not have the time or resources to be informed about community meetings. Inside Arlington uses a combination of preexisting artificial intelligence tools, such as ChatGPT, which are then trained on recorded meetings and meeting minutes to create brief newsletters detailing the events that occurred at community meetings. While the newsroom relies on AI to write the articles, the technology does not replace journalists, according to Trilling.

"I don't think this is replacing journalists because at least in our case, there were no journalists doing this ... no one is covering these meetings," said Trilling.

Others are looking to AI to assist in the editing process of local newsrooms. Michelle Johnson, a fellow at Boston University's Hub for Civic Tech Impact, is currently developing Editor AI, a tool that aims to help local journalists edit their work to the standards of their newsrooms. The product is still in development, but Johnson hopes to target small, local publications, who may otherwise be limited in their capabilities.

"This is not for big audiences, it's not for the Boston Globe. They have money and people to build custom stuff, proprietary stuff. I'm talking about some little publication in a small town where there's one person," she said.

As AI is being deployed to help writers and editors, the possibility of an AI-takeover of creative industries is not far off. While the technology is not yet able to replicate the work done by journalists, it serves as a cheaper and quicker solution in an increasingly shrinking news industry.

Some newsrooms have even begun to deploy autonomously written articles. Media giant Gannett recently came under fire after the company was forced to pause its use of Lede AI, a sports writing AI tool, after the technology made multiple errors in stories about high school athletics. However, this issue will continue to persist as long as companies value profits over products, according to communications expert Julie Rafferty.

"The world is driven predominantly by money, and not by accuracy and creativity. If a company [can] feel like [it] can get something that's good enough using AI rather than AI plus humans, jobs will be lost, quality will decline," said Rafferty, founder of Rafferty Communications and a former journalist.

Though artificially intelligent large-language models have strong capabilities, they are limited in their nuance. Essentially, the large-language models behind AI chatbots like ChatGPT are trained to identify patterns in the mechanics of writing through viewing a variety of writing samples gathered from a broad array of sources, including news articles. This gives these models limited ability to create factual stories without human oversight.

"A language model is ... like a giant autocomplete system that's finding statistical patterns in language and trying to predict the next word over and over again until it has something coherent," said Jack Bandy, professor of computer science at Transylvania University in Lexington, Kentucky.

Ultimately, the future of artificial intelligence in newsrooms is up to journalists, according to Bandy.

"There are implications and there are applications of new technology, but people get to decide what those are. It's not guaranteed to be a doomsday for journalists or to put all journalists out of jobs ... journalists will get to decide how they use it and what they want to do with it," he said.



# Making AI more “human”

## A conversation with Northeastern AI professor Lawson Wong

BY KEVIN LU, COMPUTER SCIENCE & MATHEMATICS, 2026

DESIGN BY VIANNA QUACH, PHARMACEUTICAL SCIENCE, 2025

**W**hat is “intelligence”? Large language models like ChatGPT have showcased an impressive ability to generate human-like responses that appear highly intelligent. The current trend in AI development seems to revolve around creating increasingly larger models, with billions upon billions of parameters, as a path toward achieving general-purpose AI.

However, Yann Lecun, chief AI scientist at Meta and a Turing Award recipient, envisions a radically different future for AI and questions the long-term viability of ChatGPT. In a recent seminar held at Northeastern’s ISEC auditorium this summer, he made a bold prediction: “Five years from now, nobody in their right mind would use [ChatGPT].”

Instead, he foresees the emergence of AI models that exhibit more “human-level” intelligence, possessing the ability to plan, reason, make decisions based on “common sense,” and comprehend the physical world and its properties. He thinks researchers can accomplish this by changing the architecture and structure of AI models instead of just making current designs bigger.

This year, Lecun and his team at Meta introduced a groundbreaking image classification AI model called I-JEPA, which represents the initial steps toward achieving a more “human-like” form of AI. The model employs a predictor network, which serves as an internal rudimentary model of the world, emphasizing high-level image information rather than pixel-level details.

To gain further insight into these claims and to explore the true nature of “intelligence,” I spoke with Northeastern Khoury College of Computer Sciences professor Lawson Wong. He teaches CS4100, Artificial Intelligence, at Northeastern, and his research focuses on autonomous robotics through the use of AI.

The following is a condensed and edited version of the conversation.

**In one of your lectures, you touched upon the idea that “intelligence” doesn’t always manifest in ways readily comprehensible by humans, as demonstrated by systems like Google’s AlphaGo. In your view, what constitutes genuine “intelligence,” and how do you evaluate it?**

Let’s agree that, in its simplest form, it’s some kind of decision-making agent that has some interface with the environment, and we look at the outputs. Anything that answers “correctly” most of the time exhibits a form of

genuine intelligence — artificial or biological, it doesn’t really matter. It’s just about the answers there. I don’t care what’s on the inside, all I care about is the outputs. There are some caveats to what I said there: A lookup table, for instance, is not “intelligent,” but at the same time, some of biological intelligence is hardwired as well. And I can’t discount that it’s not intelligent.

**Yann Lecun came to Northeastern this year and made a bold claim: Large language models like ChatGPT are going to become “irrelevant” in the next 5 years. How did you interpret Yann Lecun’s ChatGPT prediction, and do you agree?**

I mostly believe it. This type of prediction has been correct for about everything [in AI research]. Everything that is popular in AI has suffered from at least one “winter” in the past few decades. So things like deep learning, reinforcement learning, and neural networks were once shunned by the field, before being hyped and then shunned again. It’s very cyclical. And so, I almost have no doubt that the same applies for language models.

It’s not that [ChatGPT] is not useful — clearly it’s very useful — but almost inevitably, people will read too much into its capabilities. I think humans are hard-wired to find intelligence where there isn’t. It’s not that the thing isn’t intelligent — again going back to the question about its outputs, I think there are clearly some good outputs there. But it is very easy for us to overestimate the capability of certain systems just because we see it doing a few very interesting things. I might be proven wrong about this, and therefore Yann LeCun too, but I think language models clearly make mistakes that most people would not easily make. In that respect, there is something kind of lacking there. So if we were to say that [ChatGPT] will be the end system that will change everything, I think it might be a bit much.

**What is the next step for the future of AI?**

One other big problem in AI that everyone understands is important, but no one really knows how to do well, is abstraction. It’s not hard to save all the information in the world, but clearly most of it is irrelevant, stale, or useless. This is essentially what the entire area of representation learning is trying to explore on some level. What should I know about the world, but also what should I choose to forget or ignore? I think getting an AI system to decide that by itself is beyond our current techniques.

*arXiv Preprint* (2023). DOI: 10.48550/arXiv.2301.08243

*arXiv Preprint* (2022). DOI: 10.48550/arXiv.2202.05333

PHOTO VIA SHUTTERSTOCK

# Cracking the code behind TikTok's 'For You' algorithm

BY DESSY DUSICHKA, COMPUTER SCIENCE & BIOLOGY, 2025  
DESIGN BY VIANNIA QUACH, PHARMACEUTICAL SCIENCE, 2025

**T**aylor Swift. Northeastern memes. That concert you went to last weekend. Endless scrolling through countless short videos until you zone back into reality. This is a typical experience on TikTok's "For You" page. Somehow, the mysterious TikTok algorithm never fails to yield an entertaining assortment of content, stealing hundreds of precious active hours with its ability to captivate, entertain, and even educate audiences across the globe.

The elusive TikTok algorithm is a powerful feat of computer science developed by the Chinese company ByteDance. This computer program creates AI-generated content recommendations based on user interests. It pays attention to what a user likes, rewatches, searches, and comments on, and it also factors in their location and the time spent on particular videos. Under the hood, the algorithm uses natural language processing and computer vision to analyze hashtags, comments, and video content to classify videos and appropriately recommend them.

"TikTok is a relatively unique social media in that the user experience is mainly algorithm-driven and not connection-driven."

TikTok is a relatively unique social media in that the user experience is mainly algorithm-driven and not connection-driven. Unlike other platforms, TikTok relies less on users to find content by "following" users and instead leverages artificial intelligence to power content recommendation.

The For You algorithm starts working the second a user creates an account to discover what they are interested in. Users are initially presented with a set of generic, highly-viewed videos to gauge interest. Every interaction with a video is taken into account, especially the length of time spent engaging. The algorithm preferentially ranks video topics and hashtags that the user interacts with more frequently, but also regularly incorporates new content to help discover new facets of the user's personality.

The Wall Street Journal conducted an experiment using newly created bot accounts with pre-programmed interests to uncover how quickly the algorithm can figure out its users. This study found that the TikTok algorithm could start delivering highly personalized content after just 40 minutes of analyzing these bot accounts.

Users tend to find themselves in specific subcommunities on TikTok based on their interests. For example, #BookTok has a significant user base and offers a space for people to discuss their literary interests. A study described how this leads to "the experience of 'silosociality' — an intensely communal and localized sociality of subcommunities on TikTok." The phenomenon of silosociality highlights how TikTok's powerful recommendation system can actually unite users who ordinarily would not have connected. Additionally, TikTok references are a form of social currency in real-life friend groups, almost representing a unique cultural language.

Despite being a collection of application code, this powerful algorithm is often humanized by users, who discuss it with personifying language. A study analyzing user perception of the algorithm noted users describing how the algorithm "got to know" them after improving its recommendations based on user data. This places the algorithm in a unique role — "rather than being merely an element or building block in the infrastructure of the platform ... or another independent ego with whom users can interact (as they would with a friend), the algorithm exists somewhere in between," the researchers say in the study.

Adding to this mystique, much of the algorithm's implementation details are secret. According to a study analyzing the social perception of algorithms, "No singular person can make a definitive claim toward how the TikTok algorithm works; perceptions of what the 'TikTok algorithm' is, are quite clearly culturally specific, temporally-bound, and socially constructed as 'folk theories.'" Although the public knows very little about how this powerful algorithm works, it has garnered considerable status and attention, demonstrating the enigmatic intersection of technology and culture.

An ultra-personalized For You feed comes with the drawback of user privacy concerns. Most users are aware of this and willing to accept this as a tradeoff for high-quality, relevant content. However, this is definitely a concern for some users and the app has come under intense governmental scrutiny. Congress recently passed the "No TikTok on Government Devices Act" in December 2022 in an attempt to protect state secrets. Ultimately, TikTok is working hard to reassure users their data is safe and keep them engaged with this AI-powered application, highlighting the delicate balance between privacy and personalization in today's digital age.

*Social Media + Society* (2022). DOI: 10.1177/20563051221086241  
*International Journal of Human-Computer Interaction* (2023). DOI: 10.1080/10447318.2023.2233138  
*Journal of Computer-Mediated Communication* (2022). DOI: 10.1093/jcmc/zmac014

# ChatGPT, an AI chatbot and now a published author?

BY MACKENZIE HEIDKAMP, BIOCHEMISTRY, 2026

DESIGN BY KATHRYN FURMAN, COMPUTER SCIENCE &amp; MATH, 2025

**T**he public has scoffed at students for “cheating” their way through classes with AI homework helpers. Many feel as though it is dishonest to use technology for assignments, so how would those same people feel if they knew that reliable and credible scientific journals are starting to list one of these same “homework helpers” as a co-author of their research?

An artificial intelligence chatbot called ChatGPT has been listed as a fellow author on four different published papers. ChatGPT is a tool that utilizes a large language model and a vast bank of data. Its language model allows it to understand and generate text to sound like a natural human conversation. This feature makes it appealing to people who need to write an essay for class, a letter to a friend, and now, maybe a portion of a scientific journal. With this new surge of researchers using ChatGPT as a tool, other scientists are voicing their disapproval.

“Reliable reproducibility is a core value in the scientific community, and the lack of this component causes a source to lose all credibility.”

According to the journal Nature, experts and publishers have pointed out that ChatGPT does not meet the necessary requirements to be listed as an author of research. In order to be a co-author on a journal, the co-author needs to be able to be held accountable and responsible for the content of the paper. As an online tool with no ability to consent or defend the integrity of its work, ChatGPT does not fulfill the current standards held for authors. Richard Sever, the assistant director of Cold Spring Harbor Laboratory Press, pointed out that this issue has brought up our “need to distinguish the formal role of an author of a scholarly manuscript from the more general notion of an author as the writer of a document.” An author needs to be able to respond to any detection of scientific misconduct,

behavior resembling plagiarism, false conclusions, or misleading data. While ChatGPT does have access to a large source of data, it has been proven to often make inaccurate statements, making it very liable to scientific misconduct.

In one instance, a group of researchers found that when they asked the chatbot to find citations that evaluate the association between liver cancer risk in Japan and coffee intake, it provided a title of a non-existent journal with a digital object identifier that actually correlated to a completely unrelated topic with different authors. The same group of researchers also found that when they asked for the top causes of death in Japan in the year of 2020, it responded with “1. Cancer: 29.5% of deaths, 2. Heart disease: 15.1% of deaths, 3. Pneumonia: 8.4% of deaths.” However, a quick google search found that the actual causes of death that year were malignant neoplasms at 27.3%, heart disease at 15%, and senility at 8.8%.

The lack of consistency with its accuracy is a concern, since fabricated publications could mislead society and have detrimental effects. ChatGPT only encompasses data up to the year 2021, so it can not be relied upon for current information, and it works by learning through AI trainers. Essentially, AI trainers have the chatbot generate responses which are then scored and fine-tuned for conversational purposes. The bot is not recommended to be used as a source for current information, as it is best used for its language abilities. It also responds differently depending on the phrasing of the question and sometimes even responds differently when asked the same question. Varying responses might be convenient for someone who needs help writing an email, but consistency tends to be crucial in scientific research. Reliable reproducibility is a core value in the scientific community, and the lack of this component causes a source to lose all credibility.

Despite the surge of opposition, some researchers believe that ChatGPT should be allowed to be used as a tool but properly cited as a source rather than as an author and thoroughly fact-checked. The AI program may be the key to new research, but for now many scientific journals, including Nature, will not publish a paper if this controversial author is listed.

PHOTOS VIA RAWPIXEL &amp; PEXELS



*Nature* (2023). DOI: 10.1038/d41586-023-00107-z  
*Journal of Epidemiology* (2023). DOI: 10.2188/jea.JE20230078



Follow us: @nuscimag  
Read our work: nuscimag.com  
Contact us: nusciencemag@gmail.com

Northeastern University  
College of Science

Supported by the  
**Student Activity Fee**