SUMMER 2022

experience

THE MAGAZINE OF NORTHEASTERN UNIVERSITY

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EXPERIENCE MAGAZINE

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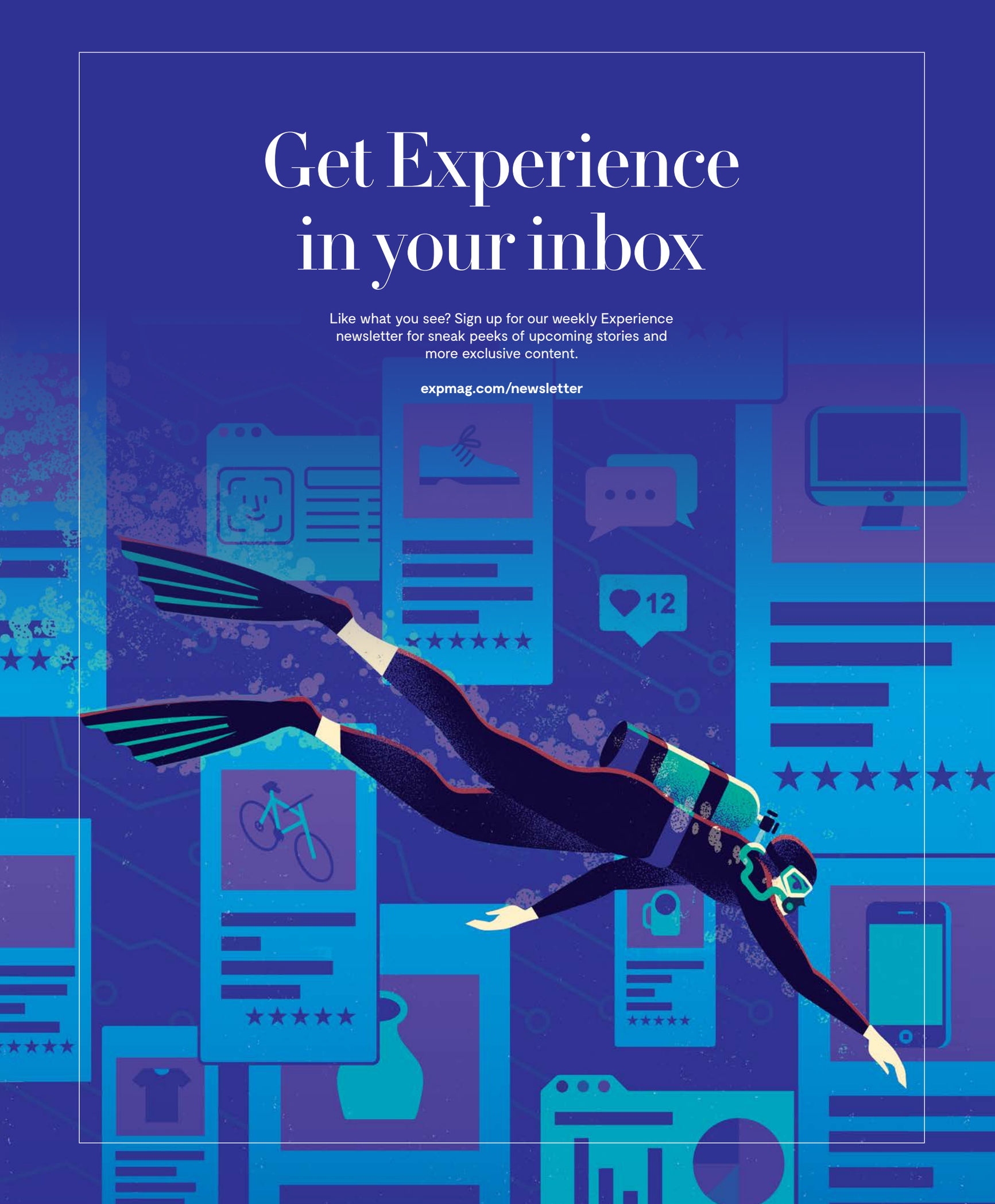

Joseph E. Aoun

The value of play

As I walk through Northeastern University's Boston campus in the warmer months, I'm always cheered to see students relaxing on the grass and playing games on Centennial Common — balancing their hard work with well-deserved recreation.

But make no mistake: Play can be a serious endeavor. The times when we're relaxed and loose are often the very moments when creativity is sparked, ideas take hold, and people are introduced to new perspectives. Many computer science and business students tell me they've cherished their training in improvisational theater. The skills we develop when thinking on our feet, presenting fresh ideas, understanding an audience, and making people laugh turn out to be useful in every field.

Many of the stories in this issue of *Experience Magazine* highlight the power of play to spur positive change. The broad popularity of online word games shows how puzzles and games can connect people across generations. The technology behind "mind-controlled" drone races and films can be deployed in the health care arena. On Northeastern's Vancouver campus, Professor Michael Running Wolf is working to preserve and teach Indigenous languages and cultures, in part by using video games and augmented reality. In Louisiana, an annual "nutria rodeo" deploys a popular local sporting activity to help save wetlands from erosion. And in the austral summer in Antarctica, tourist cruises carry scientists studying penguin populations — helping in the fight against climate change.

At Northeastern, we are fortunate to share a community of entrepreneurial thinkers who unleash their creativity and playfulness in service to the greater good. I wish you a summer filled with joy, relaxation, and fruitful recreation.

Experience Magazine *tells stories about innovations in work, play, and relationships — and examines inspiring solutions to global problems. Visit us at expmag.com.*

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Photo by David Merron via Getty Images

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"You can have a very frustrating day, and you do a little Wordle, and you feel good about yourself."

BOB DE SCHUTTER, NORTHEASTERN UNIVERSITY PROFESSOR OF GAME DESIGN PAGE 22

DEPARTMENTS

Contributors

"My colleagues and I want to record every step we take. Writing this article helped me take stock of our progress — and rethink the direction of our work."

Sibusiso Biyela
On creating a system for translating science into six African languages (p. 40)

Kara Baskin (Lab-Grown Meat is Coming, p. 34) has written about food, parenting, and more for the *Boston Globe, Boston* magazine, *Bon Appétit, McSweeney's, Elle,* the *New York Times*, and the *Washington Post*. She lives in Boston.

Sibusiso Biyela (Expanding the Language of Science, p.40) has written for the South African investigative publication *Noseweek Magazine* and works as a science communicator at ScienceLink and SciBraai. He lives in Johannesburg.

Chelsea Brasted (Shoot a Rat, Save the Swamp, p. 62), a writer based in New Orleans, has written for *National Geographic*, the *Wall Street Journal*, the *New York Times* and *Bon Appétit*. Her reporting has found her following parades, interviewing celebrities, wading through floodwater, and, once, adopting a puppy on assignment.

Matt Crossman (Chasing the Wind, p. 56), a writer based in St. Louis, never turns down an outdoor adventure he can find a life lesson in, whether it's fishing, hot-air ballooning, or jogging while fully outfitted in biotracking technology. His 2021 *Experience* story about a bullriding competition on an aircraft carrier won a Gold Award from the Society of American Travel Writers.

John Fox (Cat and Mouse, p. 28), the parent of a 2022 Northeastern University graduate, has written for *Smithsonian, Outside*, and *Salon*, and is the author of the books *The Ball: Discovering the Object of the Game* and A*round the World with a Million Kids: Adventures of an Online Explorer*. He lives in Boston.

Tony Rehagen (Emojis, Decoded, p. 50) has written for *USA Today, ESPN The Magazine, GQ*, and the *Washington Post*. He lives in St. Louis, where he is also a contributing editor at *St. Louis Magazine*.

Hannah Thomasy (Brain Power, p. 44) has written for *Undark Magazine, OneZero, Hakai Magazine*, and *Atlas Obscura*. She has a Ph.D. in neuroscience from the University of Washington and is a global journalism fellow at the Dalla Lana School of Public Health at the University of Toronto. She is based in Toronto and Seattle. ▯

A busy corner newsstand in Mexico City, shown with a piece by artist Maick Aguilar, serves as a kind of rotating outdoor gallery,

PHOTO BY JOHN FOX

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BEHIND THE PHOTO

Carrying history on their backs

BY CHLOE PROCK

Josie Li, a 2021 Northeastern University graduate, found herself home in Chongqing, a city along the Yangtze River in China, when the pandemic broke out. In her remote class on Contemporary Practices in Documentary Photography, she decided to cover the Chongqing porters, also known as the "Bang-Bang Army" – laborers who spend long days carrying heavy cargo from the docks along the river to locations throughout the city.

"Chongqing is surrounded by mountains and the terrain is very steep," Li says. "So, stairs are everywhere. In the past, due to the underdeveloped transportation system, cargo [had to] be transported by people. A lot of rural people with little or no education could only participate in manual labor. The porters became the cultural symbol of the city."

Changes in technology and shopping habits have made the job less necessary, Li says, and younger generations aren't taking up the work. "It's important to document the story of the last generation of Chongqing porters. I don't want to forget their contribution to this city." ▯

THE FUTURE OF ...

Dining out — with a dash of tech

Robots in the kitchen. Better online menus. Plant-based everything. We asked faculty and students with expertise in different fields to tell us how restaurants will change — and what they should be doing now. — KARA BASKIN

Robot sous-chefs

We will never replace chefs, because chefs bring the strengths of humankind into the whole operation. However, we will have robot sous-chefs who can do mundane tasks: "These onions need to be peeled." Some jobs might be replaced as a result, but the idea is to make humans' jobs easier, better.

How many times have you needed hot sauce or a drink refill, but you wait for it? If we have robot servers who can be called upon by a push-button, that will provide better experiences to customers and restaurant workers. It's all about augmenting human abilities with technologies that are meaningful.

Taskin Padir, *professor of electrical and computer engineering; director, Institute for Experiential Robotics*

Less meat, more plants

The environmental benefits of a plant-based diet are remarkable. Gen Z is more conscious about climate change than previous generations, as our future depends on it. Plant-based foods are growing more popular, and it won't be long until the demand for them starts to seriously compete with animal agriculture.

In 2021, Burger King opened its first fully plant-based restaurant in Germany. I believe we'll see chains following that lead in the U.S. within the next decade.

Izzie Malkani, *class of 2023; President, Cruelty-Free Northeastern*

Hearing a better meal

Our sensory experiences are intrinsically linked. There's talk of "sonic seasoning": If you change the way a chip sounds when you crunch on it, does that change the way you taste the chip? Restaurants might be moving toward personalized and individualized experience design, by tailoring a person's sound experience to what they enjoy.

You could imagine crafting a piece of ambient music, or installing sounds, related to the specific courses that people are tasting. With more awareness of this intrinsic correlation between different sensory experiences, people could become more mindful.

Psyche Loui, *professor of creativity and creative practice; director, MIND Lab*

Menus with pizzazz

People are no longer walking down the street, seeing a sign, and just dropping into a restaurant. Instead, they review everything online: menu, allergy information, vegan options. Then they make reservations. Restaurant websites need to be a space for storytelling about their service, business, food.

Restaurants are competing within a whole city. They have to think about a feature to make customers remember their store; they need a menu that will make people order from a downtown location instead of from the corner pizza store next to their apartment.

Miso Kim, *professor of experience design*

PHOTO BY ERIN CLARK / THE BOSTON GLOBE VIA GETTY IMAGES

CO-OP TO CAREER

From war zones to the anchor chair

BY SCHUYLER VELASCO

Leila Fadel is a host of NPR's *Morning Edition* and *Up First*. Since graduating from Northeastern University in 2004, she has reported around the world, covering events including the Iraq War, the 2014 fall of Mosul to ISIS, and the protests in Minneapolis over the killing of George Floyd. In May, she was Northeastern's 2022 graduate school commencement speaker.

What made you want to be a reporter?
I grew up in Saudi Arabia. Being an American and watching American news, or reading our newspapers — often a current event that I was living through, whether it was Gulf War I or the civil war in Lebanon — I didn't always feel people that I knew were reflected in the larger coverage. I thought, "OK, I'll go into journalism and tell the stories I don't see."

How did Northeastern prepare you for your career?
My first co-op was working at the *Boston Globe,* and I took every opportunity I could to write stories. I wrote obituaries. I did a little work on the arts desk. It taught me the nuts and bolts of how to take what I was learning at school and actually go out and get a job, because you can't just graduate from college and go cover the White House. I had to have clips, and I had to be able to show that I knew how to tell a story.

What was your first job?
I worked at the *Fort Worth Star-Telegram* as a night cops reporter, which was a fascinating beat because you could delve into all these important societal questions that center around crime, but then also the absurdity of humanity. I worked on a story about a teenage girl who was the understudy of a play, and she tried to poison the lead with a bottle of Mountain Dew filled with Clorox.

How did your work as a global correspondent influence how you covered domestic issues?
For more than a decade, I was covering other people's countries. Coming back, I felt the same desire to understand process and people, and not just make the assumption that, "I'm from this country, so I know this country." The interesting thing about the 2016 election is that a lot of U.S. citizens woke up and thought, "Well, maybe I don't know." It has helped me look at the U.S. without assuming that we all understand, as a society, the same things about what it is to be an American.

How, if at all, has journalism changed for the better since you graduated in 2004?
People have more access than they've ever had, but there's also a lot more noise in that landscape — what is something to be trusted and what is not?

What's been your favorite story you've worked on?
In Iraq, we did a story about having a baby in the middle of the Iraq War. Being on the roads was dangerous, so people were scheduling Cesareans left and right for when they felt was the safest time to get to the hospital, or inducing and just sitting in the halls of the hospitals so that they didn't go into labor in the middle of the night and possibly get shot on the road. Those types of stories, that tell you how life changes when things can't be safe, stick with me.

What was your first day hosting *Morning Edition* like?
The first time I guest-hosted, I did think, "Is it possible to die when the on-air sign comes on? Can you have a heart attack in this chair?" So nervous.

What time does your alarm go off?
2:30 [a.m]. Am I getting up early, or am I staying up late? That's the big question. ▯

ILLUSTRATION BY NABIL NEZZAR

TAKE 5 MICHAEL RUNNING WOLF

Can new tech protect old ways of life?

BY SCHUYLER VELASCO

Michael Running Wolf is a computer science instructor at Northeastern University's Vancouver campus and a citizen of the Northern Cheyenne Tribe. He is developing programs that combine artificial intelligence, natural language processing, and augmented reality to revitalize Indigenous languages. Here are five things to know about his work.

1 LANGUAGES ARE DISAPPEARING AROUND THE WORLD. According to UNESCO, there are approximately 6,000 languages worldwide at risk of going silent – from the Basque language in Spain to minority tongues in Hindi-dominated India. The problem is acute in North America: Before colonization, there were an estimated 4,000 Indigenous languages spoken on the continent. Today, about 400 remain.

2 NATURAL LANGUAGE PROCESSING COULD HELP. Running Wolf, a software developer who worked on Amazon's Alexa, wants to use speech recognition technology to build up databases of endangered Indigenous languages. The project, still in the early stages, will prioritize a more limited lexicon than most language AI projects, with the aim of preserving and sharing the essentials of Indigenous speech. "Our goal is not to build a Google assistant, but to prioritize what's critical for second language learners," he says.

3 SOME LANGUAGES ARE HARD TO REPRODUCE WITH AI. Building a language-based AI usually requires thousands of hours of audio, cross-checked with written documentation, such as books and transcripts. But many Indigenous languages survive mainly through oral tradition. That's why "voice recognition primarily [has been] the domain of Western languages," Running Wolf says. But as speech-recognition technology has improved, so have the prospects of doing more with less: In 2019, a team of data scientists in New Zealand built a Māori language AI based on just 300 hours of audio.

4 TO LEARN A LANGUAGE, PLAY WITH IT. Running Wolf's long-term vision isn't just to preserve languages in amber, but to teach them to future generations, in part through immersive games. "Imagine having to control a character in Crow or Lakota, and you're doing language exercises out of necessity while hunting or horse racing," he says. "There's a lot of research around how gamification enhances language acquisition." He envisions other augmented reality experiences – walking tours, history exhibits – that teach Indigenous language and culture at the same time.

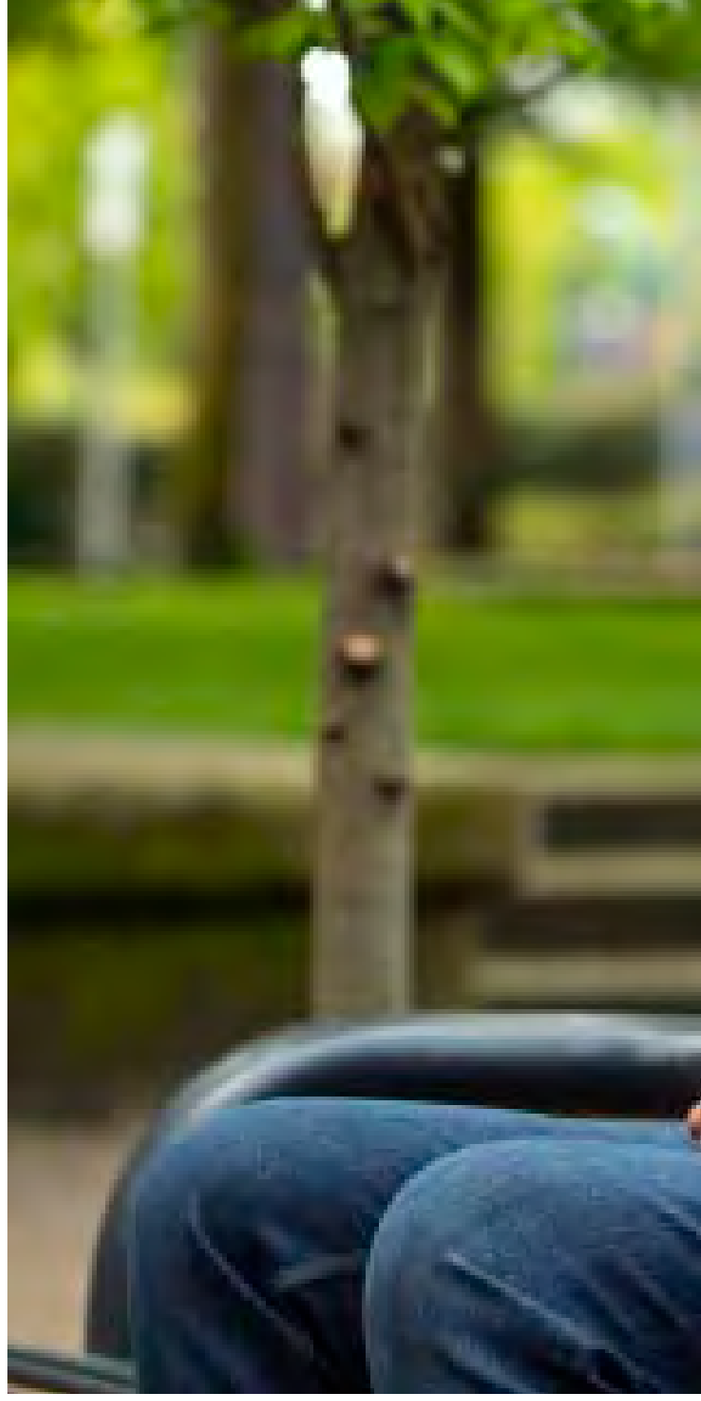


PHOTO BY TAEHOON KIM

Michael Running Wolf, a software developer who worked on Amazon's Alexa, wants to use speech recognition technology to build up databases of endangered Indigenous languages.

"I could be walking around downtown Boston with an augmented reality headset and see what the Indigenous people there called certain things," he says. "You can make it accessible to everyone."

5 BRINGING TECH TO UNDERREPRESENTED COMMUNITIES COULD BRING THOSE COMMUNITIES TO TECH. Running Wolf hopes involving Indigenous peoples in the project will also crack open a pathway to the tech industry for a severely underrepresented group. "Last year, there were two Indigenous [computer science] doctoral graduates in all of North America, but there are tens of millions of us," he says. "We need to start building a pipeline from village to college so [aspiring computer scientists] don't feel like they need to give up their home to conduct this kind of research." ▯

MIGUEL PORLAN

PLAYLIST

The songs of summer

We asked some Northeastern University scholars to share their summer song recommendations.

"SCHOOL'S OUT" BY ALICE COOPER There's nothing like hearing the kids (and teachers!) singing "School's Out" on the last day of school — summer has really arrived!

— Heather Littlefield, professor of linguistics

"IN THE SUMMERTIME" BY THIRSTY MERC It's the opening song for the Australian TV series *Bondi Rescue*, which my family and I watched on sabbatical in Sydney. So it's associated with summer in January!

— Randall Hughes, professor of marine and environmental sciences

"CALIFORNIA DREAMIN'" BY THE MAMAS & THE PAPAS When I received word that I got my first internship in Santa Monica, right out of college, I blasted this song for hours on end at full volume in celebration.

— Anthony De Ritis, music professor

"HERE I COME," BY DENNIS BROWN Anything reggae makes me think of summer, but if there's one song to kick back to, it's this one.

— Cedric Douglas, former artist-in-residence

"AAJ MERA JEE KARDA (KAWA KAWA)" BY SUKHWINDER SINGH I come from India, where summer is HOT but the monsoon helps break the heat. This is the classic monsoon song, from the movie *Monsoon Wedding*.

— Hanumant Singh, director of the Field Robotics Lab

To listen to these songs and more summer tunes, open the Spotify app, tap search, then tap the camera icon to scan this code. Or go to expmag.com/summer-playlist.

Penguins are sentinels of climate change, so scientists are counting them — more precisely than ever.

BY ERICK TRICKEY | MAPS BY LOU SPIRITO

ON THIN ICE

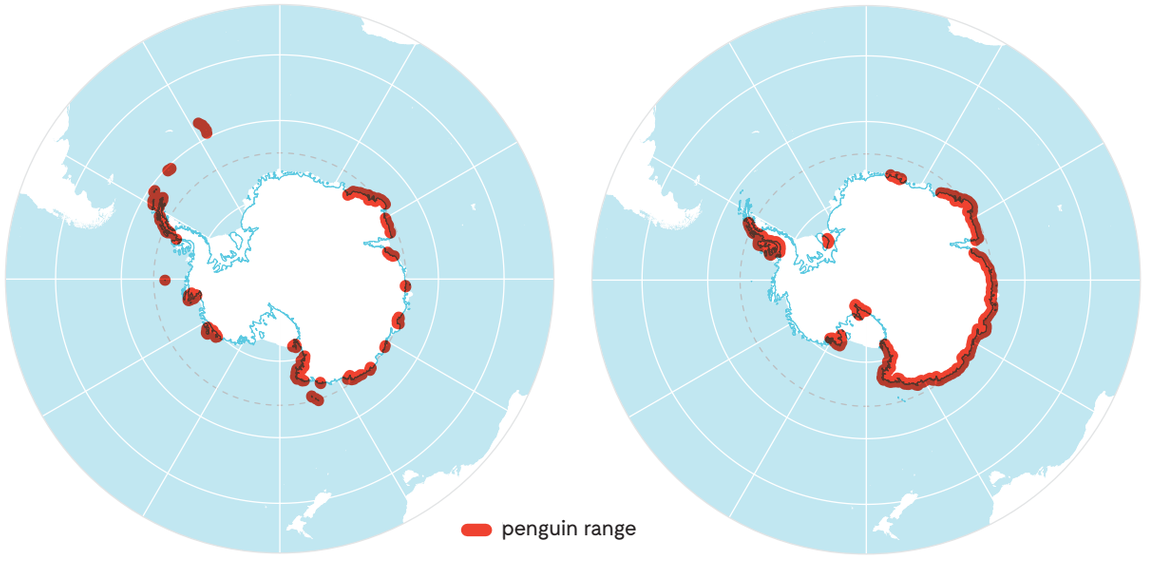
PHOTO ON THIS PAGE BY JASON EDWARDS VIA GETTY IMAGES; PREVIOUS PAGE PHOTO BY DAVID MERRON VIA GETTY IMAGES; MAPS MADE WITH NATURAL EARTH VIA NATURALEARTHDATA.COM

Even in the Southern Hemisphere's summer, shards of sea ice surround the aptly named Danger Islands off the tip of the Antarctic Peninsula. The 10 scientists and graduate students who sailed for the rocky archipelago in December 2015 didn't know if they'd reach their destination, let alone accomplish their mission.

But the clouds and the ice parted, and the small, nimble expedition ship *M/V Hans Hansson* finally anchored off the coast of one of the seven islands. The biologists, zoologists, and robotics engineers rode an inflatable boat from the ship to land, looking for Adélie penguins.

Penguinologists frequently travel to Antarctica to check on the location and health of penguin populations and discover new penguin colonies – with the ultimate goal of understanding how the Southern Ocean is changing.

Antarctic penguins and where to find them



Adélie

Named after a French explorer's wife, Adélie penguins are declining on the western Antarctic Peninsula as it warms.

Emperor

The largest penguins, emperors stand almost four feet tall. They could go extinct by 2100 due to climate change.

Satellite imagery of some of the Danger Islands had revealed the telltale pink tint of penguin guano — so much of it that the islands appeared, from high above, to be an unrecognized penguin hotspot. Even so, the team was awed by what it saw with its own eyes: penguins across the entire field of vision, clustered on gray-white rocks. The two-and-a-half-foot-tall, black-headed birds, with white rings around their eyes and little orange beaks, mingled and squatted on nests, giving the scientists wary side-eye glances.

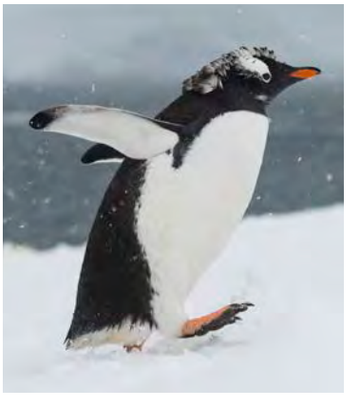
"When we first roll up, the scale really is pretty magnificent and you're thinking to yourself, 'Okay, there's a lot of penguins here,'" says Casey Youngflesh, an ecologist on the team. "Once you start adding it up day after day, it's like, 'Okay, on so-and-so island, there's however many hundreds of thousands of birds.'"

The team needed an exact number, so that future researchers can measure whether the colony grows or shrinks, and why. It tried to count them by sight — but that proved overwhelming. Expecting that, a graduate student working for Hanumant Singh, a Northeastern University robotics professor who was working at the time at the Woods Hole Oceanographic Institution, had brought a set of 14-inch-wide drones, each equipped with a camera. Amid temperatures just on either side of the freezing point, the student flew the drones more than 100 feet above the Adélies to take photographs that captured every penguin and each nest. Afterward, Singh's image-processing team did something no one had done before: They combined the photos into vast mosaics, which they ran through a machine-learning program that counted each penguin. The scientists checked the program's work by comparing it to their sample hand counts.

The result: the team counted 1.5 million Adélie penguins on the Danger Islands — 751,527 breeding pairs, to be exact. (That count doesn't include the pairs' just-hatched penguin chicks, which were nestled under their parents' feathers, or other Adélies too young to breed.) It turned out that the Danger Islands were home to more Adélie penguins — pronounced *ah-del-ly* by English-speaking penguinologists, *ah-day-lee* by French-speaking ones — than the rest of the Antarctic Peninsula region combined. Thanks to that discovery, a proposed marine protected area for the western Antarctic Peninsula has expanded to include the islands.

PHOTOS BY ASSOCIATED PRESS

Chinstrap
Known for the black line that frames their face, chinstrap penguins are declining across Antarctica and beyond.



Gentoo
The world's fastest-swimming birds at up to 22 mph, gentoo penguins are moving south, finding a warming Antarctica to their liking.

"Adélies are the most studied species in the entire Antarctic," says Heather Lynch, an ecologist and penguin expert at Stony Brook University and an organizer of the Danger Islands expedition. "They're a good sentinel species for what's going on in the Antarctic. They've established themselves as a real metric of Southern Ocean health."

In Antarctica and beyond, scientists don't just study penguins for penguins' sake, but also because their peril is a harbinger of larger changes in the Southern Ocean that will affect many other species, large and small. And not every finding is as encouraging as the discovery of the 1.5 million Danger Islands Adélies. Taken as a whole, the new penguin research shows how our rapidly warming world is changing the ocean and the animals that rely on it. The new technology also shows this: if humanity doesn't address climate change very quickly, some species of Antarctic penguins could become threatened — and the emperor penguin, the largest and most famous of all penguins, may well go extinct by the century's end.

That threat gives the scientists who study penguins a sense of urgency and mission. Many people find the flightless, waddling birds cute, intriguing, and even inspiring. So scientists hope that their work will sound alarms and help people see how curbing our reliance on fossil fuels could save penguins' icy homes. Saving any species is important. And this species, with its formidable charms, is one of nature's best advocates for itself, for Antarctica, and for fighting climate change.

THE POET E.E. CUMMINGS wrote, "A poet is a penguin — his wings are to swim with." A penguin waddling around her breeding ground is prosaic; a penguin swimming is poetry. Penguins spend 80% of their time in the waters where they live — across the Southern Hemisphere, in South America, South Africa, Australia, New Zealand, and even on the equatorial Galápagos Islands. Flightless, their wing structures have evolved to swim. They can swim for hundreds of miles in the Southern Ocean, even thousands, floating on the waves to sleep. About once a decade, a wayward Antarctic penguin turns up on the shore of New Zealand, 3,000 miles away.

Getting to know Antarctic penguins in the wild used to mean extended in-person study, usually of penguin colonies near research bases, and almost entirely in the

The team counted 1.5 million Adélie penguins on the Danger Islands — 751,527 breeding pairs, to be exact.

austral summer — November to February in the Southern Hemisphere. "Until about 10 or 20 years ago, wildlife biology would have looked very familiar to Darwin," says Lynch.

But in the past 10 years, advancing technology has created a kind of revolution in penguinology, allowing scientists to study Antarctic penguins year-round, despite their remoteness from human civilization. Drones and satellites now gaze down upon penguin colonies, counting birds and nests. So do time-lapse and sensor-activated cameras, installed and serviced once a year. Miniaturized "crittercams" taped to penguins' feathers for a few days allow scientists to see their graceful flights through water and their hunts for tiny crustaceans and fish. Time-and-depth trackers, attached to penguin legs like tiny watchbands, track the birds' foraging trips across the Southern Ocean. Machine-learning algorithms analyze the vast new streams of penguin images, learning from humans how to recognize penguins and their nests. Point Blue, a California-based conservation science organization, travels annually to Antarctica's Ross Island to work with one of the world's largest Adélie colonies, also attaching tiny "penguin Fitbxits," the size of a dime, to their legs to track their foraging swims and dives.

"My passion is, how do we take robots and technology and use them to solve problems of high social relevance or societal relevance?" says Singh, who is now director of Northeastern University's Field Robotics Lab. "Suddenly, with the use of these robots, we're now collecting lots of data that's actionable. A lot of our end users are used to annotating these images by hand, because they're used to getting 100 images. When you suddenly give them 100,000 images, they can't do that anymore." Instead, Singh's drones collect so many photographs that scientists need machine learning to sift through them all. "We've gotten so good at getting this data now that we have to use these new techniques."

For their part, penguins often take more interest in the humans than in their technology. That was the case, at least, in January 2020, when researchers from the Field Robotics Lab arrived with drones to count chinstrap penguins on Elephant Island, 160 miles north of the Danger Islands. Some of the 106,000 chinstrap penguins on the island pointed their black beaks to the sky to look up at the little dot 100 feet above them, but they soon turned their attention back to land.

But when Yang Liu, then a graduate student in the lab, sat down on the island to eat, one especially curious chinstrap walked up to him, bent down, and pecked Liu's shoe with his beak.

The humans tried to give the penguins space, but sometimes they had to pass through a penguin colony to do their work. As they treaded within inches of the 2 1/2-foot-tall chinstraps, some of the birds ignored them — but others tried to shoo off the interlopers. The chinstraps honked, pecked at the researchers' legs, and even beat them with their flippers. "They can get aggressive," says Vikrant Shah, another Northeastern graduate student on the expedition. "They hang onto your pant legs by their beak." One reason: The penguins were protecting their nesting chicks, fuzzy gray and three weeks old.

Chinstrap penguins are named after the black line that frames their face just above the neck and connects to the black tops of their heads. They're loud — their throaty honks can combine to sound something like a pack of barking dogs. "If you are in a large colony," Shah recalls, "you would see one side start to go 'yak, yak, yak' — and then that would, just like a wave, go through the whole colony."

Singh had deployed Shah and Liu to help several scientists conduct the first census of the island's penguins since 1971. The team hitched a ride on a Greenpeace boat, the *M/V Esperanza*. Among their shipmates: actors Marion Cotillard and Gustaf Skarsgård, who visited several

Hanumant Singh, director of Northeastern University's Field Robotics Lab, deployed drone operators to Antarctica to photograph penguin colonies, so that machine learning could count the birds precisely.

LEFT PHOTO BY MATTHEW MODOONO / NORTHEASTERN

PHOTO BY PAUL SANCYA / ASSOCIATED PRESS

The Detroit Zoo's Polk Penguin Conservation Center includes a 326,000-gallon swimming tank that showcases penguins' waterborne grace.

islands in the Southern Ocean to draw attention to how climate change has affected Antarctica.

The penguin census results confirmed those warnings. The chinstrap penguin population of Elephant Island had dropped from 122,500 breeding pairs in 1971 to 53,000 in 2020, a 57% decline. Much of that population collapse is likely recent. A survey of five Elephant Island chinstrap colonies, by the same December 2015 expedition that visited the Danger Islands, showed that the colonies had declined by 26% to 38% in just four years. Chinstrap populations "are collapsing quite rapidly," says Lynch, who worked with Singh to plan the Elephant Island expedition and co-authored a study of the global chinstrap population in 2020. The paper found that, across Antarctica and beyond, 45% of chinstrap colonies studied in the 1980s have declined, while only 16% have grown.

Scientists are using the new counting technology to pinpoint the exact reasons for the decline. "We're trying to understand the relative importance of climate change as a cause of the population changes we see, versus fishing and tourism," says Lynch. So far, she says, research suggests that tourist visits don't cause penguin populations to drop. Fishing has more effect. Penguins on the Antarctic Peninsula eat krill: pink, shrimp-like crustaceans about the size of a large paper clip. Seals and whales eat them, too. "Pretty much everything in the Antarctic eats krill or eats something that does eat krill," says Lynch. The international krill-fishing industry — which supplies fish food for aquariums

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Word play

It's not just Wordle. From Spelling Bee to Wordscapes to the regular old crossword, word games are more popular than ever. Here's why they've become a common language.

BY SCHUYLER VELASCO
ILLUSTRATIONS BY EVA BEE

On March 23, Sam Ezersky took to Twitter and posted an update that would strike terror in the hearts of his 22,000 followers.

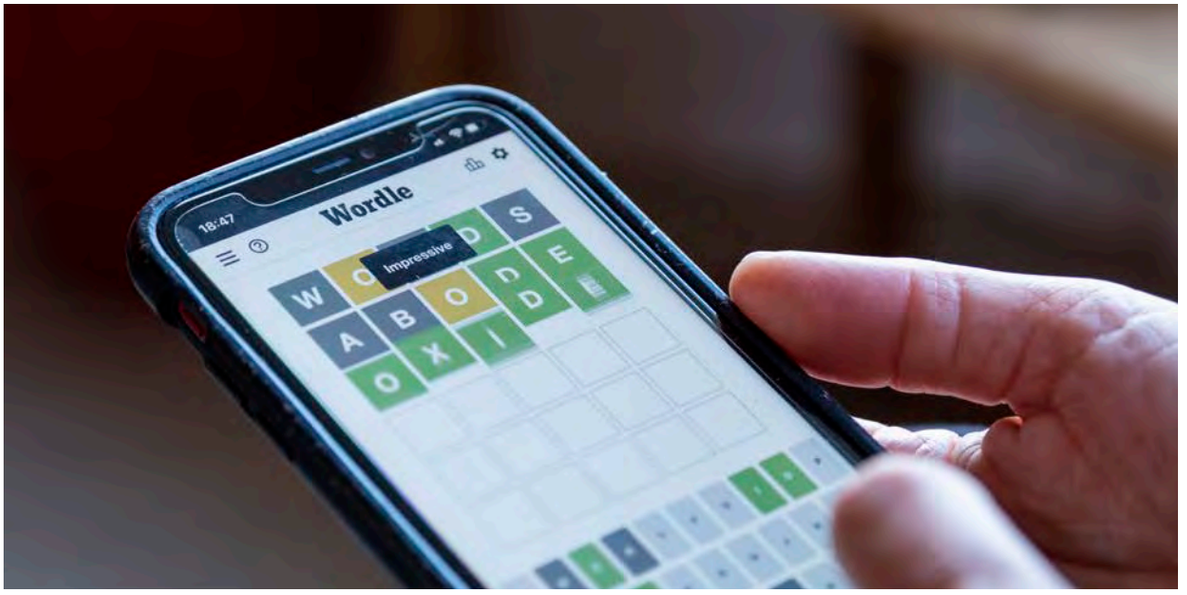
"No no no … there couldn't possibly be a Spelling Bee scheduled with a Z as the center letter … right?"

Ezersky, 26, is the editor of Spelling Bee, the *other* popular, daily online word game hosted by the *New York Times*. The game, introduced in 2018 as a breezier, more accessible accompaniment to the *Times* crosswords, presents seven letters arranged in a honeycomb shape. As with Boggle or Bananagrams, the objective is to make as many words out of those letters as possible, always using the letter at the honeycomb's center. So compared with others, a z-centered puzzle would be — forgiveness, please — a doozy. I play Spelling Bee most days, and I gasped "Oh, Lord" audibly when I read the tweet on a crowded commuter train.

The replies were a mix of faux outrage, trepidation, cheeky wordplay, and a palpable sense of "game on." "No! Bad Sam! No!" tweeted one user. "So you're building a buzz, is what you're saying," quipped another. "I've been waiting! Also X sometime," one requested.

Such online chatter is integral to the Spelling Bee experience. That's doubly true when it comes to Wordle, the guess-a-word game created by Brooklyn software developer Josh Wardle in 2021. The game, which gives players six tries to solve for a five-letter word each day, quickly grew from 90 daily users to about 2 million before it was acquired by the *Times* in February 2022. According to a May earnings report, the game has been responsible for drawing "tens of millions" of new users to the *Times* in the months since. People post their Wordle scores as routinely as they chat about weather; my office has a Slack channel dedicated to it. The day's puzzle trends frequently on Twitter, especially if the answer is difficult. There have been bootleg variations riffing on everything from geography to Taylor Swift lyrics, thinkpieces and memes dedicated to the phenomenon, even knitting patterns appropriating its yellow-and-green square design. Celia Pearce, a professor of game design at Northeastern University, calls Wordle the "binge-streaming" of the game world; in the manner of a beloved TV show, people are proudly obsessed with discussing it.

Wordle might be the most extreme example, but it's part of an explosion of word games that have flourished on mobile devices, reaching new heights of popularity and cultural relevance. Words With Friends, an app-based Scrabble knockoff, became a phenomenon in the early aughts. Wordscapes, an app-based puzzle game released in 2017, is routinely among the top-selling games for Apple and Android devices. The vast online universe of word-related games ranges from PuzzleJuice (a mash-up of Tetris and a word search) to Letter Boxed (another *Times* game, in which the object is to use up all given let-



Wordle soared from 90 daily players in November 2021 to nearly 2 million by the time the *New York Times* bought the game in February 2022.

PHOTO BY MIKE KEMP / IN PICTURES VIA GETTY IMAGES

ters to create words in the fewest turns) and Word Crush (Candy Crush, with letters).

Word play, in analog form, has been around forever. Crosswords have been a staple in newspapers since an initial craze in the 1900s; Scrabble, whose layout was inspired by those early newspaper crosswords, is 84 years old. But as versions of those games migrated to smartphone apps, their social dimensions broadened dramatically. What were once solitary pursuits, or discrete events experienced among a handful of people, have now become community sharing points. Even crosswords, traditionally a personal challenge, are suddenly shared games: On apps, players can compete against each other to solve a given puzzle fastest; people who want to improve their skills can watch other crossword solvers on the social gaming platform Twitch.

That sense of community is what word games foster especially well. Many editors and designers of word-based games say the social aspect is as important as the puzzle itself. They attribute part of the games' popularity to a desire to share in something positive in a time when so little of what we collectively experience is hopeful. (Ezersky notes that Spelling Bee's popularity soared in the depths of the COVID-19 pandemic.) And their appeal goes even deeper, developers and language experts say. Thanks to their ease of use, word games can facilitate conversations across demographics and generations. They can even create a lighthearted space for discourse about inclusivity, multiculturalism, and the evolution of language. It's hard to converse in a straightforward way sometimes — but in their own small way, these games can make talking to each other easier.

WHEN WORDLE STARTED TO blow up, Paul Bettner — the co-creator, with his brother, of Words With Friends — couldn't help but chuckle. "It was very déjà vu, I'll tell you that," he says.

Looking back, the frenzy around that game at its peak feels like a warmup for the Wordle craze. Musician John Mayer tweeted about it. Alec Baldwin caused a tabloid news frenzy when he got kicked off a flight for refusing to stop playing the game and turn off his phone. Hasbro manufactured a physical board game. The Bettners sold Words With Friends and the rest of their startup, Newtoy, to gaming company Zynga for $180 million in 2010; today, there are more than 200 million registered Words With Friends accounts.

Bettner says they would never have had that much success with a game that didn't focus on words. He would know; they tried. Their company's initial goal, Bettner says, was simply to create a hit game for the then-new iPhone. "We came up with this idea of replicating the feeling of sitting around a table, playing board games with our family," he remembers. They put together a list of classic turn-based games to reinterpret for mobile, aiming to mimic the asynchronous-yet-intimate feeling of text mes-

Bob De Schutter, a Northeastern University professor of game design and a non-native English speaker, has learned new words ("pilaf," "bimah") from playing Wordle.

saging. They tried Pictionary, chess, and simple matching games.

"Every one of those games that wasn't a word game was fundamentally less compelling," he says. "We actually did chess first, and it was like this little blip. Then we did Words with Friends and it exploded."

Why? First, Bettner says, the word game had essentially no learning curve. For non-gamers, playing on a console like Xbox or PlayStation felt like "learning a new musical instrument," he says. But with Words With Friends, if you could tap on a screen, you already knew how to play. Second, and more crucially, he argues, Words With Friends allowed players' personalities to come through over mobile gameplay in a way that other games didn't.

"When you got that move from this other person in your life, you could feel them in the move. It was just enough to make it a social experience and not like you could have been playing a bot," he says. "If you got a chess move, you're like, 'okay, whatever.' But when you got that Words with Friends ping, it was like, 'I can't wait to see what my friend did. What word did they make?'"

Wordle, Bettner says, takes that personal connection to the next level. The game's big sticky factor, he notes, is the "share" function, which lets players post their journeys toward finding that day's word, via text or on social media, without actually giving away the answer. "You have the feeling of, 'this is like my thumbprint that I'm putting out,' that it took four tries or five tries or whatever," he says.

Joel Fagliano, a puzzle editor at the *Times* who oversees the daily Mini crossword, says that personal dimension is elemental to the paper's entire slate of word games. Under the paper's "Wordplay" section, puzzlemakers and editors host daily forums, write puzzle-related columns, and encourage players to share their own experiences – a feature that, he says, is best suited to word games. "You can't really talk about a Sudoku with someone else. Like, 'Oh, that nine was crazy,'" he says. "It doesn't work that way. Whereas the crossword clues evoke memories, stories, reactions – I hated this, I loved this."

Rachel Fabi, who constructs crosswords and writes a thrice-weekly column about them for the *Times*, says her column has a hundred or so dedicated commenters who "very fiercely engage" with each other every day. While the commentary is robust, she says, it pales in comparison to the chatter generated by Ezersky and the daily Spelling Bee forums.

"People get a lot angrier at Sam than they do at the crosswords," she says.

But "anger" is a relative term. For the most part – in contrast to much of the internet – there's a lighthearted quality to the complaints. Indeed, as with Wordle, the discourse around Spelling Bee arguably is as much fun as the gameplay itself. Ezersky hand-curates the list of acceptable words for each day's puzzle, and the "hive mind," as he calls the Bee community, loves to argue with him about words he did or did not include, gripe about especially hard pangrams (top-point-getting words that contain all seven letters), and post screen shots of silly, obviously unacceptable finds like "badonkadonk," "Gogurt," and "Chewbacca."

"I truly hoped that if the whole beehive typed *Jumanji* into the Spelling Bee today at the same time, we would escape this parallel universe," tweeted one player in January, namechecking the 1995 Robin Williams movie and its recent remakes, "but alas, it was not to bee."

The game has even reached the big leagues, so to speak. Ezersky is a big Baltimore Orioles fan, and at the start of the MLB season, Kevin Brown, the Orioles' TV play-by-play announcer and a Spelling Bee player, tweeted a promise to include the daily pangrams into each of his broadcasts, starting with "vegetable" on Opening Day.

Ezersky says the online conversations around Spelling Bee started early on, and he knew the game was becoming a success when celebrities started tweeting about it. In early 2020, he neglected to include the word "clickbait" on a list. Among the many, many people who complained was comedian Steve Martin. "He's like, '*New York Times*, you got to get out more,'" Ezersky remembers. "And I was like, 'Oh my God, Steve Martin's playing my Spelling Bee.'"

MUCH OF THE SPELLING Bee chatter centers on what words the game will accept or not. Rather than use a set dictionary as the standard, Ezersky tries to limit the daily list to "everyday" words that most of the public would recognize. It makes for a better game – if the entire English lan-

PHOTO BY ADAM GLANZMAN FOR NORTHEASTERN UNIVERSITY

"These bite-size niblets are a much more viable way to play, and having them on your phone makes them a lot more accessible."

Celia Pearce
Professor of game design at Northeastern University

guage were in play, he argues, the game would be all but impossible to beat.

But that creates a lot of gray area, because everyone's personal lexicon is different. A niche medical device might be an everyday word for a surgery technician, but unheard of for most players; *elote*, grilled Mexican corn, might rise to the level of a common word in San Antonio, but not in Minneapolis. "I had no idea starting out that this was going to be such a point of contention," Ezersky says. "Everybody has their own bugaboos with the word list." His own father texts him his personal complaints about the word list almost daily.

But unfamiliar words are also a gentle opportunity for education, or even the sharing of cultures. Bob De Schutter, a Northeastern University professor and game designer who is a non-native English speaker, keeps a log of the new words he has learned from Wordle. "Pilaf, a rice dish — I had never heard of that in Europe," he says. "Bimah, B-I-M-A-H [a podium in a synagogue], is a word I guessed at some point that I had no idea existed."

The argument over what counts as a "word" is part of the fun of word games writ large; Scrabble has always had a set protocol for players to challenge each other's words. But the "word or not?" question is all the more interesting for the current crop of English-language word games, because English itself is changing and expanding more rapidly than ever, says Peter Sokolowski, a lexicographer at Merriam-Webster.

"It used to be that informal language was not well represented in our dictionaries. The true slang really wasn't there," he says. That's because slang was mostly spoken, he says, and dictionaries require written evidence to justify the inclusion of a new word.

But social media and texting constitute written media, he says. "So now we have this phenomenon where we see the informal language before we hear it — we have arguments about how to pronounce 'GIF,' for example. That's turning language upside down and driving the creation of new vocabulary."

That, in turn, makes Spelling Bee and its fellow word games even richer debate fodder on social media, in forums, and even in dedicated CONTINUED ON PAGE 70

PHOTO BY MATTHEW MODOONO / NORTHEASTERN UNIVERSITY

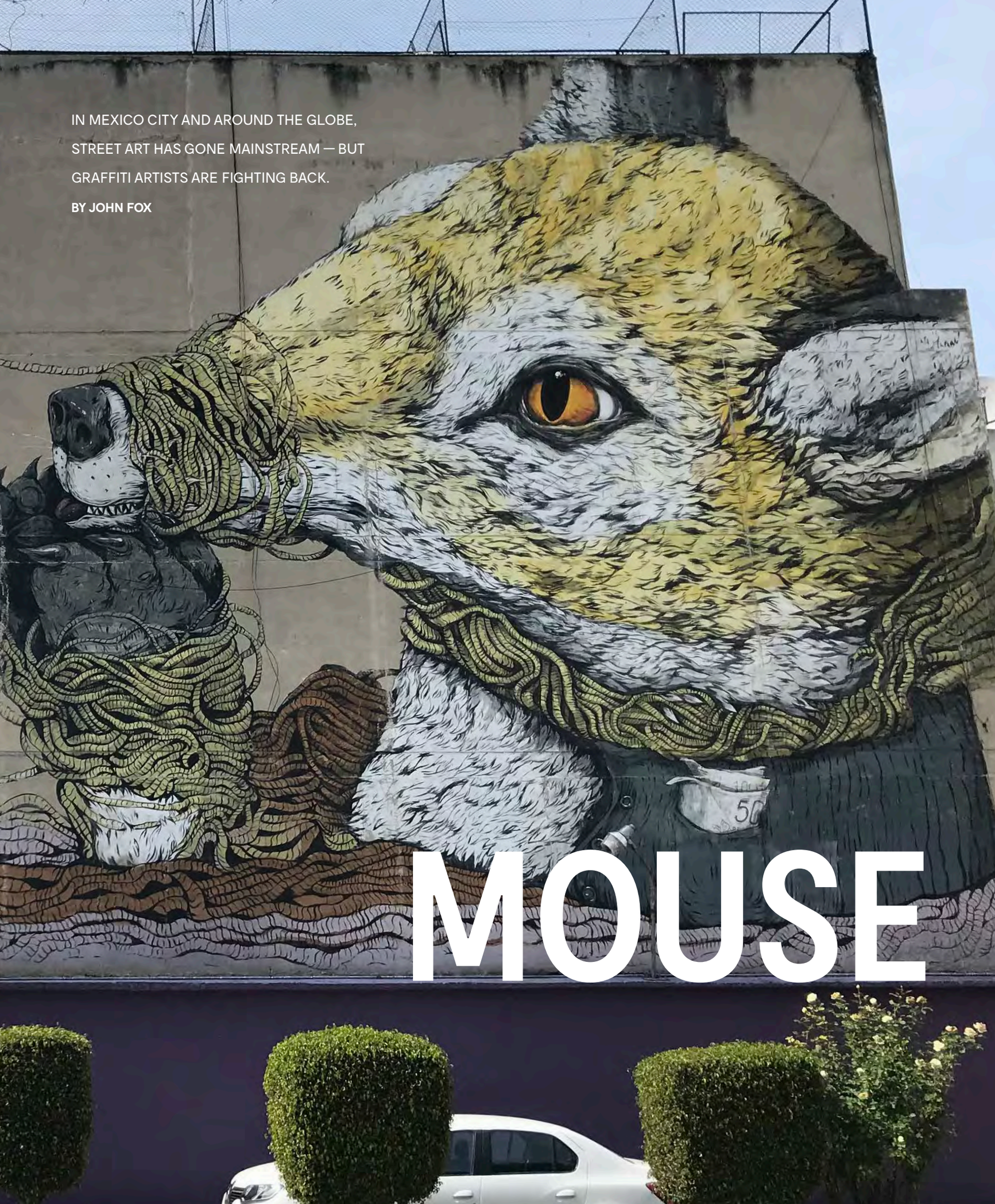
CAT AND

An epic painting by Ericailcane, an Italian street artist, covers the sides of two five-story buildings in Mexico City.

IN MEXICO CITY AND AROUND THE GLOBE, STREET ART HAS GONE MAINSTREAM — BUT GRAFFITI ARTISTS ARE FIGHTING BACK.

BY JOHN FOX

MOUSE



ONE DAY A FEW YEARS AGO, a life-sized painting of the couch from *The Simpsons* appeared on a street-level wall in Mexico City. "We just thought it'd be fun to do," says Alex Revilla, one of the artists responsible. It was an instant hit. That same day, passersby started posing "on" the couch and posting photos on Instagram.

But that night, a graffiti artist "bombed" the mural, carefully placing his tag astride the couch. Revilla, who signs his work as "Juicy Colors," recalls huddling with his collaborators to come up with a fitting response. "We knew if we just left it at that, the taggers would have won, and we'd lose respect," he later told me. Rather than paint over the bombs, they incorporated them, surrounding the invasive tags with familiar images of Simpsons characters. "Todo queda en familia," Revilla wrote in an Instagram post. "All in the family."

Such games of cat-and-mouse play out every day on the streets of Mexico City, North America's most populous city, as world-renowned muralists and illegal graffiti taggers compete over the same sprawling urban canvas. As street art here becomes more mainstream, commercialized, and – some argue – gentrified, illegal taggers respond by defacing elaborate murals, asserting their claim to self-expression. Artists sometimes restore beloved work, but most accept tagging as a kind of public commentary, amplified by social media – the inevitable price of bringing art to the streets.

The tangled roots of street art and graffiti run deep in Mexico, tracing back to two wildly different movements – one native, the other imported. In the 1920s, the decade after the Mexican Revolution, muralists including Diego Rivera, José Clemente Orozco, and David Alfaro Siqueiros liberated art from elite galleries and brought it into the

Left, a mural depicting a couch from TV's *The Simpsons*, top, was "bombed" just after it was painted. At bottom, the original artists incorporated the tag with new *Simpsons* characters. Above, wheat paste art by Mauricio Groenewold featuring traditional Day of the Dead motifs.

public domain. They painted massive murals in government buildings and public spaces, intending to unify the Mexican people around a national identity rooted in socialist ideals. Today, Mexican street art continues both the form and the politics of that homegrown muralist movement. More often than not, street murals contain subtle or explicit socialist messages, commenting on national issues like economic inequality, political corruption, and the ongoing struggles of Mexico's Indigenous peoples.

Contemporary graffiti was born in the subways and streets of 1960s Philadelphia and 1970s New York City, where it was decried as vandalism — a symbol of the cities' struggles with crime and urban decay. From there it spread to other U.S. cities, then to Tijuana and eventually the Mexican capital in the 1980s. In those early days, local gangs used graffiti to mark their territory, says Alejandro Otero Ortíz, a filmmaker producing a documentary about Mexican street art. "In my house I learned that all graffiti was bad, something gang members and criminals did," he recalls. In the 1990s, Mexico City police took a page from then-New York City mayor Rudy Giuliani's "broken windows" playbook and formed an anti-graffiti unit. (The now-controversial policing method targeted petty crimes like graffiti and public drinking as a way of enforcing order and preventing more serious crimes.)

Since then, social attitudes and policing practices have shifted. City residents often see legal street art as a way to beautify their gritty neighborhoods and foster a sense of community. Attitudes toward graffiti have tempered, as well. "The police anti-graffiti unit changed its name to just 'graffiti unit,'" says Ortíz. Instead of just cracking down on illegal graffiti, local authorities now work with community organizations and encourage youth to trade their spray cans for more sanctioned and accepted forms of artistic expression.

TO GET AN UP-CLOSE perspective on these dynamics, in 2019 I joined a walking tour of the city's Roma neighborhood with Street Art Chilango, an organization founded by Revilla and Jenaro de Rozenzweig in 2013 to promote Mexican street artists' work (Revilla has since left the organization). My fellow tourists were a mix of Americans and Canadians along with a woman from Bahrain. Our guide was Chris

LEFT PHOTOS BY ALEX REVILLA; PREVIOUS PAGE AND RIGHT PHOTOS BY JOHN FOX

Cedric "Vise1" Douglas, pictured beside the mural he designed for Northeastern University, says that even underground and anti-establishment movements like graffiti come with their own unwritten rules and codes of conduct.

Lüders, a hip 37-year-old German with a ponytail and aviator glasses.

We met up at a busy corner newsstand that serves as a kind of rotating outdoor gallery. "Dulce is kind enough to let us use it," Lüders said, pointing out the owner-turned-art-patron, who flashed a smile from behind a stack of newspapers. The work displayed on the newsstand's street-side wall showed a young child wearing a shirt decorated with watermelons, a common symbol for the tri-color Mexican flag. She cradled planet Earth in her arms. The piece, by Mexican artist Maick Aguilar, was labeled with a hashtag, #cuidemoselplaneta – "take care of the planet."

Lüders ran down the differences between street art and graffiti, as if to alleviate our worries about being complicit in any wrongdoing. "Street art is almost always legal," he said. "Artists get permission from building owners and local authorities. Graffiti, by contrast, is illegal." Street art, he continued, is image-based, has a message, and invites interaction. Graffiti is letter-based and conveys only the tagger's name. Street art uses a wide variety of techniques: paint, stenciling, stickering, and wheat-pasting (which uses a flour-based glue to cover a surface with printed images). Graffiti artists simply use spray paint. "That's how they get respect," said Lüders: whether they can tag a prominent or hard-to-reach space before the police catch them.

Down the block, around a corner, a building-wide Technicolor horse pranced over fields of agave and cactus. The work of New Zealand artist Aaron Glasson, it had been commissioned five years earlier as part of a gallery-sponsored art walk.

As Mexico City becomes known as a hotbed for street art, more works of visiting or invited international artists have graced its walls. That further provokes local graffiti artists. The prancing horse painting was barely dry before it got bombed. The neighbors loved it so much that they came together to restore it – until it was bombed again: splotches of graffiti partly defaced it. "It's the graffiti artists' way of saying, 'These are our streets, too,'" said Lüders with a resigned shrug.

The tension between sanctioned street art and illegal graffiti is inherent in the art form, says Cedric "Vise1" Douglas, a Boston-area street artist and former artist-in-residence at Northeastern University. (His mural on the side of the Boston campus's Behrakis Health Sciences Center depicts a giant Tyrannosaurus Rex amid a splash of shapes and colors.) "Graffiti came out of early hip-hop, when people broke into buildings and tapped into city power lines to throw illegal house parties," Douglas says. "It came from living in a city where no one knows your name, using creativity to have a voice when you're marginalized."

But Douglas – whose "Vise1" moniker stands for "Visually Intercepting Society's Emotions, One Image at a Time" – stresses that even underground and anti-estab-

PHOTO BY MATTHEW MODOONO / NORTHEASTERN UNIVERSITY

lishment movements like graffiti come with their own unwritten rules and codes of conduct. "If you go over a tag with bubble letters, or 'throw-ups' as they're called, you're allowed to do that. Dead letters, which are more complex letters, can go over throw-ups. But if, say, you get a commission for a street mural and go over someone's throw-ups, that's not cool."

As Douglas sees it, street art always has the potential to be contested, because it always involves painting over someone's art. "If you think about it, a building is someone's art. A mailbox was designed by someone, is someone's creation."

Amy Halliday, a curatorial consultant for Northeastern University's Boston and London campuses, says the tensions between legal street art and tagging are also playing out in Bristol, England, where she lives. Bristol's graffiti scene started early, in conversation with Philadelphia's and New York's. Now, in Bristol's Stokes Croft area, "the whole neighborhood is really associated with murals," Halliday says. "Local organizations create commissions and get permission to do street art." The neighborhood hosts Upfest, Europe's largest street art and graffiti festival, every May.

Meanwhile, the Bristol City Council has increased tag removal and enforcement of anti-graffiti laws. It's also tried to divert tagging to designated places. "The city actually established a corridor of legal graffiti walls," says Halliday, "spaces that were set apart for people to practice, experiment, to try things out, to mess around."

In Mexico City, now that street art has become mainstream and hip, our tour guide Lüders explained, some worry that the movement risks selling out its anti-establishment roots and ideals. He pointed out a wall on the side of a tall building that was stenciled with an abstract pattern resembling a QR code. "That was done by two artists who now mostly work on the interiors of rich people's homes," he lamented. Across the street, a massive painting by Mexican artist Revost depicted serpents wrapped around a towering tree. It was one of three paintings that Absolut Vodka commissioned for their "Absolut Street Trees" project. The paintings were meant to promote environmental awareness and clean air, in a city with some of the worst air pollution in the world. They employed a special paint, called Airlite, that helps to neutralize contaminants in the air through a process similar to photosynthesis.

Disney commissioned Revilla and de Rosenzweig and their art collective, SACH Crew, to paint scenes from the *Lion King* franchise in Mexico City as guerrilla marketing for the 2019 remake, putting images of the characters Simba and Rafiki on the entrance to a busy garage. The artist collective did similar work to promote Disney's *Star Wars* films. Does Revilla worry that commercial work defies the principles and politics of the street art movement? "Not at all," he says. "The first time that we did work for Disney, everyone loved it. I think the people appreciate good art and they don't care if it's corporate advertising or original ideas."

Douglas is more skeptical of street-art-as-advertising. "Yes, it's good that artists can make a living," he says, "but at the same time, it can lessen the value and meaning of the work. Personally, if I do take on a commercial project, I try to put my spin on it. I'll figure out how to inject a social message in it, something that can make the world a better place — even if it's just subliminal."

OUR TOUR ENDED IN a parking lot, where we gazed up at a mural that Lüders described as his favorite piece of street art. An epic painting by Ericailcane, a well-known Italian street artist and illustrator, the mural covered the sides of two five-story buildings. On one building, a jacket-wearing fox appeared to be bound by rope, like a prisoner. On the other, a bunny in a sweater gnawed on strands of the same rope, which cleverly ran between the buildings, joining the animals' fate. Lüders smiled and rubbed his hands together eagerly. "No one knows what this is about. The artist never said. So what do you think?"

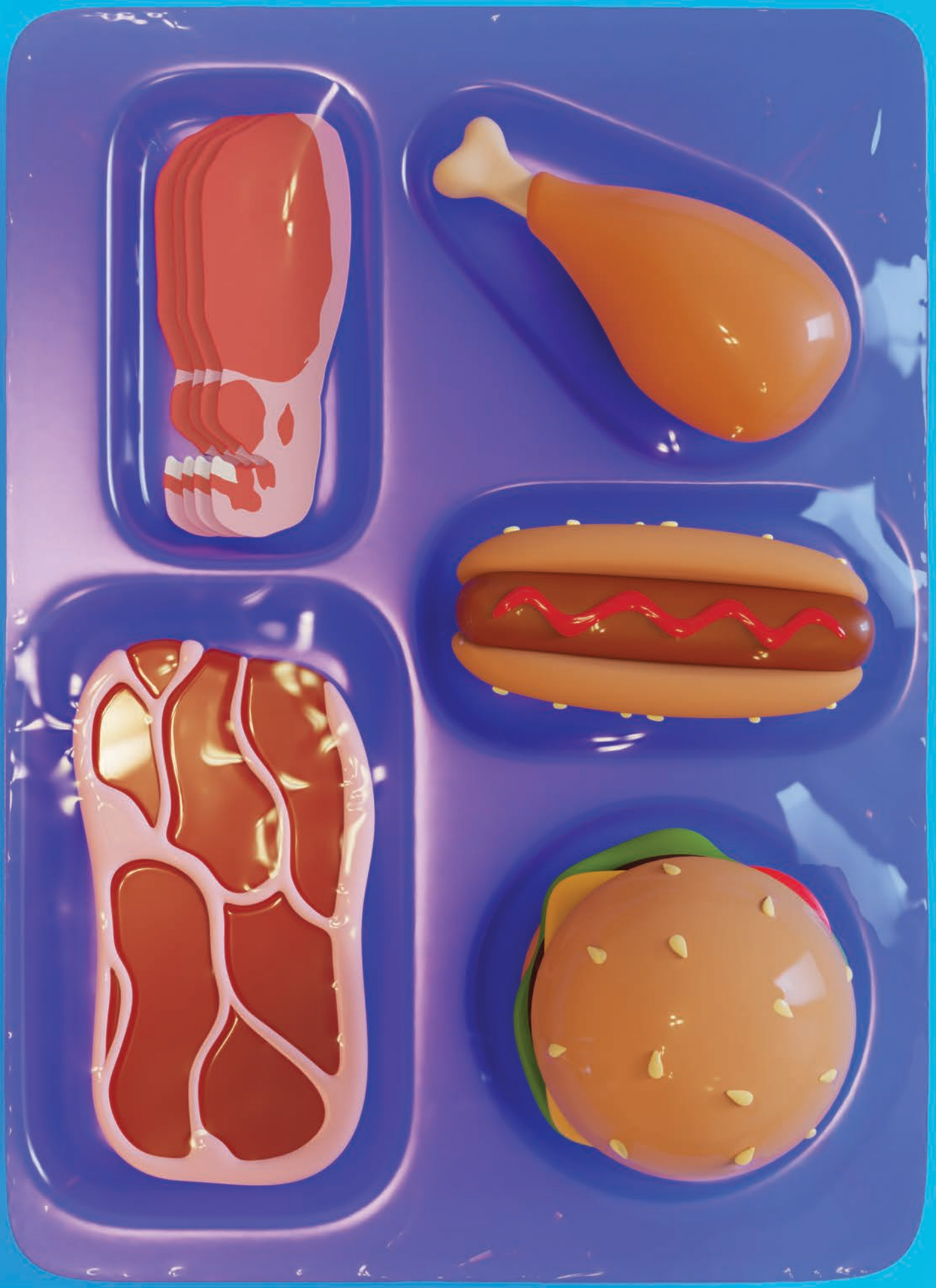
"One's a predator and the other's the prey, but they each depend on the other," offered one tour participant.

"The fox has all the power, like corporations," offered another. "And the bunny is the common person being tricked into unleashing that power."

We stood in the parking lot for some time, six people from four countries craning our necks, discussing and reflecting, even though — or because — there's no right answer, just a conversation. ▯

Detail from "Las dos Fridas," a mural by artists CHA and Elfmilk that takes its name from Frida Kahlo's famous self-portrait.

PHOTO BY JOHN FOX



LAB-GROWN MEAT IS COMING. THE NEXT CHALLENGE IS GETTING PEOPLE TO EAT IT.

BY KARA BASKIN | ILLUSTRATIONS BY PETER CROWTHER

A decade ago, consumers might have laughed into their McFlurries at the idea of non-meat burgers at the drive-thru. Who could have imagined that a patty called the McPlant would be rolled out at select McDonald's, with the fanfare once reserved for a McRib? Yet plant-based foods are now a mainstream product and a global industry worth $20 billion. That makes food-tech scientists optimistic about an even more exotic frontier: Real beef, but from a petri dish.

In labs from Singapore to San Francisco, scientists have been developing methods of generating actual meat cells that could be assembled into a meal, without the interim step of the slaughterhouse – everything from cultured caterpillar cells that mimic the properties of a fleshy burger to cow muscle cells, dripping with blood, built upon a scaffolding of spinach.

Many of these products haven't reached the marketplace, but they're coming. In 2020, Singapore granted regulatory approval to the first lab-grown chicken nugget for mass consumption. San Francisco's Upside Foods is developing lab-grown chicken, beef, and duck – and has a contract with Michelin-starred chef Dominique Crenn, who has pledged to serve Upside's products at her restaurants as soon as they become legal in the U.S.

Lab-based meat proponents tout the products as a potential global food source and even a way to save the planet. Animal agriculture – especially beef – is responsible for a significant percentage of greenhouse gas emissions. Manure and fertilizer are major sources of water pollution.

"Among all the different types of food, beef is the most carbon-intensive," says Matthew Eckelman, a professor of civil and environmental engineering at Northeastern University. "Anything we can do to find popular and affordable substitutes for beef will be a win in terms of the climate."

But for all its promise, it's unclear how quickly lab-grown meat can go mainstream. Traditional meat is still big business. Eco-friendly buyers consider locally grown, locally sourced food, including meat, to be … well, a sacred cow.

And compared to the descriptions of plant-based meat – it's just protein made from peas, like a better veggie burger! – the process of creating meat cells in labs has an undeniable weirdness factor. Even the most bullish food industry experts worry that adventurous consumers might still see beef from a petri dish as a little too much adventure.

"Everyone wants the latest and greatest computer, the latest and greatest wearable tech," says Adam Melanos, CEO of Chew, a Boston-based food innovation lab. "But somewhere, consumers have drawn a line and said, 'Oh, food's too far. I want technology in my pocket and in my

life, but not in my food.'"

That's why companies are taking a deliberate approach to sharing these products with consumers – using lighthearted, whimsical marketing to make an unfamiliar process seem down-to-earth, or zeroing in on an audience that might be willing to take a high-tech culinary leap. Lab-grown meat is the future, they insist. It's just a matter of making the right pitch.

LAB-GROWN MEAT FIRST MADE headlines in 2005, when then-University of Maryland doctoral student Jason Matheny – who later founded the cellular-agriculture research firm New Harvest – co-wrote a paper describing a process for growing meat cells in the *Journal of Tissue Engineering,* which is admittedly a far cry from *Bon Appétit*.

The article outlined how stem cells could be extracted from an animal and grown in cultivators, or bioreactors. The cells, fed nutrients like amino acids and glucose, would rapidly divide into muscle, fat, and connective tissues, just like traditional meat.

That year, the *New York Times* speculated that the technology could be ready "in a few years' time." But it has taken longer than that, not just to develop the lab processes, but also to imagine a market. The consumer market is tricky, where science is concerned; there's still a lingering resistance to genetically modified foods – which some detractors have dubbed "Frankenfoods" – despite a lack of evidence that they're detrimental to human health.

"Nobody likes to feel like they're part of an experiment," says Michael Leonard, CEO of Boston-based Motif FoodWorks, which develops technologies to help plant-based foods look and taste like the real thing, such as a plant-based dairy product that stretches and melts like real cheese.

Plant-based meat – made from ingredients like soy protein, coconut oil, and methylcellulose – once faced the same skepticism. As plant-based products have progressed in the marketplace, many companies have worked hard to demystify the science behind their food. Impossible Foods' packaging, for instance, endeavors to make plant-based meat feel like a lifestyle, not a lab experiment, using bright colors, clear language, and instruc-

"CONSUMERS HAVE DRAWN A LINE AND SAID, 'I WANT TECHNOLOGY IN MY POCKET AND IN MY LIFE, BUT NOT IN MY FOOD.'"

ADAM MELANOS, CEO OF CHEW

“ANYTHING WE CAN DO TO FIND POPULAR AND AFFORDABLE SUBSTITUTES FOR BEEF WILL BE A WIN IN TERMS OF THE CLIMATE.”

MATTHEW ECKELMAN, PROFESSOR OF ENGINEERING AT NORTHEASTERN UNIVERSITY

tions on speaking to skeptics. Its website even has an online guide that advises young consumers on how to talk to their parents about a plant-based diet; it deliberately mimics a sex-ed class, with sections labeled “Confusing Feelings,” “The Earth’s Body is Changing,” and “That Awkward Convo.”

Now, cell-based companies are following a similar playbook. Vow, an Australian startup focused on harvesting cells from exotic animals, has a website that looks like GOOP crossed with Eric Carle, with a peach-hued background, Jacqueline Susann-style font, and whimsical sketches. Finless Foods, an Emeryville, California-based company that produces plant- and cell-based tuna, doesn’t just showcase glossy fish photos on its social media feeds. A recent post included the “do’s” and “don’ts” of cell-cultured jargon: Please, call it “cellular agriculture,” rather than “sci-fi meat.”

“When people are confronted with terms like this, they get incorrect ideas about the production and what these products actually are, creating a psychological barrier,” says Finless’ chief strategy officer, Shannon Cosentino-Roush. Special lingo also creates an in-crowd feeling; these companies need to cultivate cells, but also affinity.

Peeling back the curtain on food production is another way to make lab-based products sound less intimidating, Cosentino-Roush says. “The process, though refined and fascinating, borrows from the ways in which we make beer and your favorite cheeses,” she says. “We also produce in a clean, well-regulated food facility and not a lab.”

Indeed, some scientists believe that lab-based meat would get a boost if marketers leaned into the appeal of food grown in controlled environments, far from farms and slaughterhouses. “Every day, every week, there’s a new problem with food contamination or COVID-related issues with food, right? Or meat-packing plants, and so on,” says David Kaplan, a cellular agriculturalist and professor of engineering at Tufts University.

Eckelman, at Northeastern, thinks a better under-

standing of how most conventionally-produced food is made could make products like lab-grown meat seem less alien to consumers. "There's this idea, you go to the store, and you're getting things that are natural, but there's a lot of industrial processing that occurs," he says.

Kate Krueger, managing partner at Cambridge, Massachusetts-based Helikon Consulting, is more blunt. "I don't like to go for low blows, but current food production is pretty gross, and I say that as an omnivore," says Krueger, whose company specializes in alternative proteins and high-tech food. "When you think about how vegetables are grown, they're grown in manure. There's a lot of filth that goes around, even in milk production. We get to avoid that if we're making things in hyper-sterile environments."

EVEN SO, A PHYSICAL cow (or chicken, or pig) is a formidable thing to abandon. Meat is a cultural touchstone. We eat hot dogs at baseball games; we carve turkey on Thanksgiving; we cook burgers at summer barbecues. Traditional menus spur fierce loyalty. And pushing against meat can be polarizing, especially across generations: Think of the mom who rolls her eyes when you announce you're vegetarian on your first visit home from college.

"If we said we were taking away burgers, all hell would break loose," says Maureen Timmons, the former director of dining services at Northeastern University and a leader in the Menus of Change University Research Collaborative, a nationwide network of colleges and universities researching how to effectively promote plant-forward diets at campus dining halls. At Northeastern, for instance, chefs have tested out new dishes on students (lentil Bolognese, anyone?) and hosted plant-focused cookbook authors and chefs in demonstration kitchens. Timmons says Menus of Change has discussed introducing cell-based meat, as well.

Colleges could be the perfect places to build a lab-based meat market from scratch, says Amy Chen, chief operating officer of the Berkeley, California-based food-tech company Upside. "Gen Z consumers, more than any generation before them, care about the planet and their role in preserving it," Chen says. "They are willing to vote with their wallets, and they will bring the rest of the world along with them."

Some college students say the experience of COVID-19 created an even greater sense of urgency to reduce the use of animals as food sources. "If the pandemic has taught us anything, it's that our interaction with and mistreatment of animals negatively affect public health," says Izzie Malkani, a third-year Northeastern University communications major and president of the student group Cruelty-Free Northeastern.

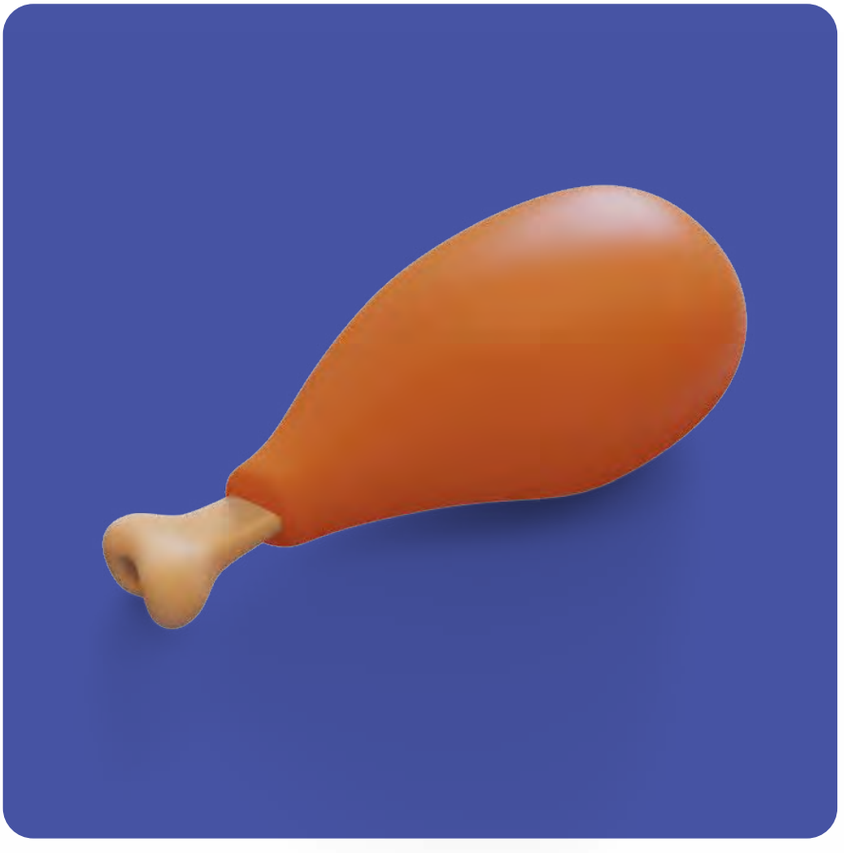
Other lab-based meat companies are eyeing a different route to market: giving their products an upscale allure. In this vision, cell-grown meat could become the gustatory equivalent of driving a Tesla. It's already happening. In Singapore, lab-grown meat is on the menu at members-only club 1880. In February, Finless offered cell-based tuna samples at the swanky South Beach Wine & Food Festival.

To a high-end market, the lab-grown process could have other advantages. The cell-building process makes it possible to produce specific replicas of animal meat, which could make rare delicacies more accessible. "One company I know is working on jamón Iberíco, which is this very specific product made in Spain: marbled fat from a pig with a special genetic lineage that feeds on acorns for all of its life," says Helikon's Krueger. "They can get these specific terroirs because they have cell lines that are from these animals."

Meanwhile, Paris-based venture Gourmey is attempting to create lab-grown foie gras using duck cells. (In 2021, the company closed a $10 million funding round.) British biologics company Caviar Biotec is experimenting with a cell-based caviar product called Cellviar.

Ultimately, food experts say, it's flavor — rare or common — that will make or break the future of alternative meat. "Taste will remain the number-one thing that companies need to get right in order to attract consumers, but then also get consumers to adopt once they have tried these products," says Emma Ignaszewski, a strategist at the Good Food Institute, a nonprofit that promotes plant- and cell-based meat.

And while plant-based meat companies have sometimes struggled to promise that their products look and feel like the real thing, experts say lab-created meat won't have that disadvantage. It will taste exactly like meat — since, on a molecular level, that's what it is. Close your eyes, banish all thoughts of a petri dish, and you're eating Granny's pot roast. ▯




DINOSAUR
silwane sasemandulo
ISILWANE
DINOSAUR izinto zabelungu
ISILWANE sasemandulo

Expanding the LANGUAGE of SCIENCE

Homegrown projects are encouraging research across Africa. It starts with finding the right words.

BY SIBUSISO BIYELA

ILLUSTRATIONS BY KLAWE RZECZY

A few years ago, I got an assignment to write an article about a new dinosaur discovery in South Africa — for a science website that publishes in my native language of isiZulu. It wasn't easy. The first problem was that there was no isiZulu word for "dinosaur," or for "fossil." I had to figure out a way to convey the scientific discovery in an African language incapable of talking about science.

My workaround was coming up with a new term for "dinosaur," *isilwane sasemandulo*, which translates to "ancient animal." While this term served its purpose in the article, I still didn't have a bespoke term for "dinosaur." I knew that I couldn't coin this and other science terms by myself. I'd need to build a consensus among scientists, linguists, and translators — who understand that, globally, knowledge often begins with having the right words.

"It would basically be a democratization of information. You expand the brain power that is possible."

Heather Littlefield
Director of Northeastern University's linguistics program

Ask anyone what the language of science is and the answer you'll most likely get is English. And to some degree, that is true. The biggest journals in science are published in English, and scientists use English to communicate among themselves from across the world. In casual conversation, the Zulu language speakers of South Africa often say, *"izinto zabelungu"* – literally, "a thing for the white people" – when referring to anything scientific or technological.

But now, Indigenous peoples in once-colonized African countries are engaging in their own solutions using science. Projects like AfricArXiv (pronounced "Africa archive"), a repository of African research by African scientists, aim to usher in an African Renaissance.

The natural next step is to enable scientists, teachers, journalists and science communicators to discuss and talk about science in African languages. But so far, there haven't been enough resources or political will to adapt African languages to scientific discourse, the same way Afrikaans was adapted for science in apartheid-era South Africa.

The Decolonise Science project, where I am the lead science writer and "decolonisation specialist," aims to change that – by leveraging artificial intelligence.

THE PROBLEM OF AFRICA'S science-language barrier is much bigger than my inability to write about dinosaurs. African institutions contribute to less than 1% of the world's published research, but Africa suffers the highest disease burden on Earth. Clearly, the continent does not do enough science. The African Union has set a goal for African governments to contribute 1% of their gross domestic product to research, in order to develop the continent.

Improving homegrown scientific understanding would not only boost Africans' ability to conduct science on the continent, but also help local communities control their own destinies. For example, I helped a waste disposal company translate its complex emissions report into isiZulu, because the community did not trust a report that it could not understand.

I rewrote the complex scientific language about chemicals and atmospheric processes into simple English, then translated that version into isiZulu. In the end, this effort did not help the company, but it did help the community. They expelled the company from the area – and they did it with a better understanding of the science.

Still, the work that goes into making any language capable of explaining science can seem insurmountable, if it means starting from scratch. That's where the Decolonise Science project comes in.

Decolonise Science was cofounded by Jade Abbott, a Johannesburg-based software engineer and data scientist, and supported by the Lacuna Fund, a collaboration of several international foundations and the Canadian and German governments.

Abbott envisions a tool that could instantly translate a complex scientific text into any of six African languages: the West African languages Yoruba and Hausa, the East African languages Luganda and Amharic, and the southern African languages isiZulu and Northern Sotho. "The long-term goal of the project is to have a Google Translate for science in African languages," she says.

Ultimately, Abbott wants Decolonise Science to create easily usable tools, such as plugins for Google Docs or Microsoft Word, access to the growing list of translated science terms the project is churning out. If we succeed, AfricArXiv will be able to translate the research submitted to them so that universities can create content in local languages, like the work the University of KwaZulu-Natal is doing in South Africa.

The final product would be useful for anyone trying to create science content in an African language, including scientists who want to create knowledge in their native tongues. It could also help professional translators looking to standardize African languages for science.

"It could be a revolutionary idea," says Heather Littlefield, the director of Northeastern University's linguistics program. "It would basically be a democratization of information, which is really valuable."

Littlefield, who has taught a class on African linguistics, says the effort reminds her of a debate in late-1600s and early-1700s Europe. "Right around Sir Isaac Newton's time, there was a huge battle in Europe about whether or not to use Latin as the language of academia or whether to use local languages like English, French, German, and Russian," she says. Translations in local languages won out because they outsold the Latin texts. "If you only write in Latin, you have constrained the information to a few people. But if you write in English and then translate it into French, some farmhand out in the middle of nowhere, who's interested in this, could learn about it and revolutionize something."

Similarly, Littlefield says of Decolonise Science, "you expand the brain power that is possible through this project."

THE CHALLENGE OF TRANSLATING scientific terms became clear in the early stages of the project, when we appointed professional translators from each of the six languages to translate African research articles from their original English. The papers ranged from pharmacology to biochemistry to physics research from the last two years.

The translators had no issue understanding basic English. But we came to realize that a lot of field-specific science vocabulary requires a different approach to translation. For example, the words "work," "energy," and "power" have meanings that most people take for granted in everyday use, but in physics they have technical meanings.

Some academics, seeing that challenge, have asked whether science can be translated into African languages at all. In a 2009 study, Rosemary Wildsmith-Cromarty, a professor of applied linguistics at the University of KwaZulu-Natal, analyzed professional translations of academic science documents into isiZulu, and found that many scientific terms were loosely translated, in ways that lost their scientific meaning.

For instance, when translated directly into isiZulu, the term "condensation" becomes *ukujiya,* which means to "thicken" or "congeal" – not an accurate description if you're talking about how water vapor changes into a

liquid.

But we at Decolonise Science believe that African languages are as capable as any others of hosting scientific discourse. It's just that, because they weren't developed for science, they need an extra step.

The project has employed science-writing specialists to clarify scientific jargon for the translators. But this step, we found, can be painfully slow. So we aim to use machine learning to brute-force the translation of technical science texts into clearer language, then use those simplified texts as the basis for the African-language translation.

The task is not as hard as would have been a decade ago, thanks to advances in natural language processing, says Byron Wallace, a professor of computer science at Northeastern University. Still, the best machine learning tools are only as good as the data that's fed to them, he says, so they're limited by how much data is available and how long it will take to create each plain-language summary.

At Decolonise Science, it takes about four hours for one writer to create each summary. In his own work, Wallace has used up to 4,000 summaries to create an effective program.

"It can be very expensive to compile these training datasets, especially for scientific articles," Wallace says.

We still have a lot of work to do before we can even start automating the African language translations. Once we do, we'll involve more linguists and translators, scientists who speak African languages, science communicators, and teachers, because we need all the help we can get.

"We have to do a lot of the groundwork now," says Abbott, "to make this ultimate science translation tool a reality." ■

BRAIN POWER

Recreational mind control — from drone races to video games — could help researchers understand the brain in new ways.

BY HANNAH THOMASY

ILLUSTRATION BY RYAN GARCIA

THE GYM GROWS QUIET as the audience in the bleachers watches a pair of drones, about to take flight.

"Three!"

"Two!"

"One!"

"Go!"

A high-pitched buzzing fills the room as the drones gently lift into the air and fly forward. They're piloted by two university students, their brows furrowed with concentration — and their hands at their sides. They aren't using controllers. In fact, they're not moving at all. Instead, electrodes placed on their foreheads and scalps are picking up on the electrical signals produced by their brains, effectively letting them fly the drones using only the power of their minds.

The audience, seated behind a web of protective netting in case of a rogue drone, cheers as the first drone crosses the finish line.

This is the annual Brain-Drone Race, designed to test the pilots' concentration abilities and demonstrate the power of brain-computer interface technology. ("Attending feels like a mix between a research conference talk and a basketball game," says Chris Crawford, co-founder of the Brain-Drone Racing League, which held its first event at the University of Florida in 2016.)

In this instance, at the University of South Florida in February 2019, the interface is based on a technique called electroencephalography, or EEG. Different brain states – such as sleepiness or attentiveness – produce different patterns of electrical activity, also known as brain waves. Electrodes on the pilots' scalps relay these electrical signals to computers, which analyze the activity patterns. In the Brain-Drone Race, the computers signal the drones to move forward (via Bluetooth) when they detect high levels of a type of brain activity called a beta wave, often considered a marker of concentration and focus.

So, when the race pilots enter a state of intense focus, their drones fly forward. The EEG headsets are consumer-grade, so they only have a few electrodes, which means they can only perform simple movements. (A research-grade device could have hundreds of electrodes.) On the flip side, these consumer-grade headsets are easy to take on and off, and they don't require much training to use. "We lean toward consumer-grade devices, since this is an entertainment application, and our goal is to provide participants their first experiences with this technology," says Crawford, who is also director of the Human-Technology Interaction Lab at the University of Alabama. "This also means that we break a lot of devices."

Though the Brain-Drone Race has the air of science fiction, the technology behind EEG recording has been around for a very long time – nearly a century, in fact. Brain-wave readings have long been used by doctors to diagnose certain medical conditions such as epilepsy or sleep disorders. Researchers have also been developing brain-controlled wheelchairs and robotic arms and studying military uses for EEG.

A student at the University of South Florida flies a drone using EEG. Events like EEG drone races could enrich the work of brain researchers by taking it out of hyper-controlled laboratory settings.

PHOTO BY RYAN NOONE / UNIVERSITY OF SOUTH FLORIDA

Gene Tunik, director of the Laboratory for Movement Neuroscience at Northeastern University, studies how the brain controls physical movements in healthy people.

But in the past decade, decreasing costs of EEG recording devices and improvements in our ability to decipher their signals have made this technology much more accessible to the public. Now, brain-controlled technologies are popping up for recreation — from toy helicopters you can buy on Amazon to mind-controlled flamethrowers made by creative do-it-yourselfers. And technologists say those simple uses of brainwave technology are just the beginning. In the future, EEG could change how we play video games, experience cinema, and function in our daily lives.

What's more, events like EEG drone races — and the technology that makes them possible — could enrich the work brain researchers can do, says Gene Tunik, a physical therapy, movement, and rehabilitation sciences professor and the director of the Laboratory for Movement Neuroscience at Northeastern University. Brain science "has traditionally been done in very confined laboratory settings," Tunik notes. "Understanding how we behave in the real world is very different. [Studying] the brain in more naturalistic environments is a really important future direction."

BEFORE NEW DEVELOPMENTS IN EEG technology, creating a detailed link between brain activity and robotic movement — for example, with an ultra-precise robotic arm — required implanting electrodes directly into the brain. It was a risky procedure that was generally only used as a last resort.

But in 2019, Bin He, a professor of biomedical engineering at Carnegie Mellon University, published a paper describing the first non-invasive robotic arm that could track a moving cursor on a computer screen, using electrodes on a headpiece that the user wears.

Rather than assessing overall brain state, as in the Brain-Drone Race, the many EEG electrodes used to control He's robotic arm pick up signals in the motor cortex, the area of the brain that controls movement. For exam-

PHOTO BY MATTHEW MODOONO / NORTHEASTERN UNIVERSITY

ple, if the participant thinks about moving their right hand, the computer will be able to detect this and move the robotic arm to the right.

It's one of several recent innovations in more targeted – yet less invasive – ways to learn about how the brain works. In 2021, Northeastern University received a grant from the National Science Foundation to house a machine – one of just four of its kind in the U.S. – that can deliver transcranial magnetic stimulation, or TMS. Used in combination with neural recording equipment, it allows researchers to non-invasively stimulate parts of the brain and record what the brain does in response – something that previously could be done only with invasive lab procedures or on animal models.

"You can say, I perturb brain circuit X, I record activity in these other brain circuits at the same time and see the causal effects," Tunik says. "Now you're really getting the full story."

The technology, Tunik says, could provide useful insights in research ranging from memory and movement disorders to fine motor function.

In the near future, some artists believe that the same kind of technology used in neuroscience labs will allow them to create the next generation of interactive films. Traditional interactive entertainment, like the 2018 TV movie *Black Mirror: Bandersnatch*, asks people to choose between different options by using a remote control or other handheld device. That interferes with the audience's immersion in the film, says filmmaker Richard Ramchurn. "It takes you right out of the story."

But Ramchurn's futuristic short film *The Moment,* released in 2018, allows viewers to control the movie passively. They do so by wearing an EEG-recording headset, which resembles a pair of headphones with an extra band across the forehead. By analyzing the EEG, a computer can detect when the viewer is paying attention or not and alter the film accordingly, changing which scenes it shows.

The Moment follows three main characters as they navigate a dark future world in which certain people, called Outliers, are hunted and killed by militias. The film has three main narrative threads, but how much of each narrative is included depends on the viewer. Perhaps a viewer is bored of following Astrea, the Outlier on the run, but fascinated by the story of Andre, the former militia member. The film can alter itself accordingly. "The narrative which the viewer pays the most attention to will become more prominent in the next scene," says Ramchurn.

The computer also analyzes a person's attention during specific elements of the film, Ramchurn says, "and so it makes a decision on what elements are going to be in the next scene based on that. So the film really can play in lots of different combinations."

Researchers also have high hopes for the innovations that non-invasive brain-computer interface could bring to gaming, although this exploration is still in the early stages of development. Mike Ambinder, an experimental psychologist at the video game company Valve, says that measuring players' brain waves as they play – quantifying their emotion and cognition – could one day help creators design games that adapt, in real time, to what players are feeling or thinking.

"If a player is feeling happy or sad, challenged or bored, frustrated or engaged, learning a concept, forgetting a concept, in an exploratory mood, dealing with a toxic player, entering into a flow state, struggling with accessibility, and so on," Ambinder says, "the game will be able to respond to that information and shape gameplay accordingly."

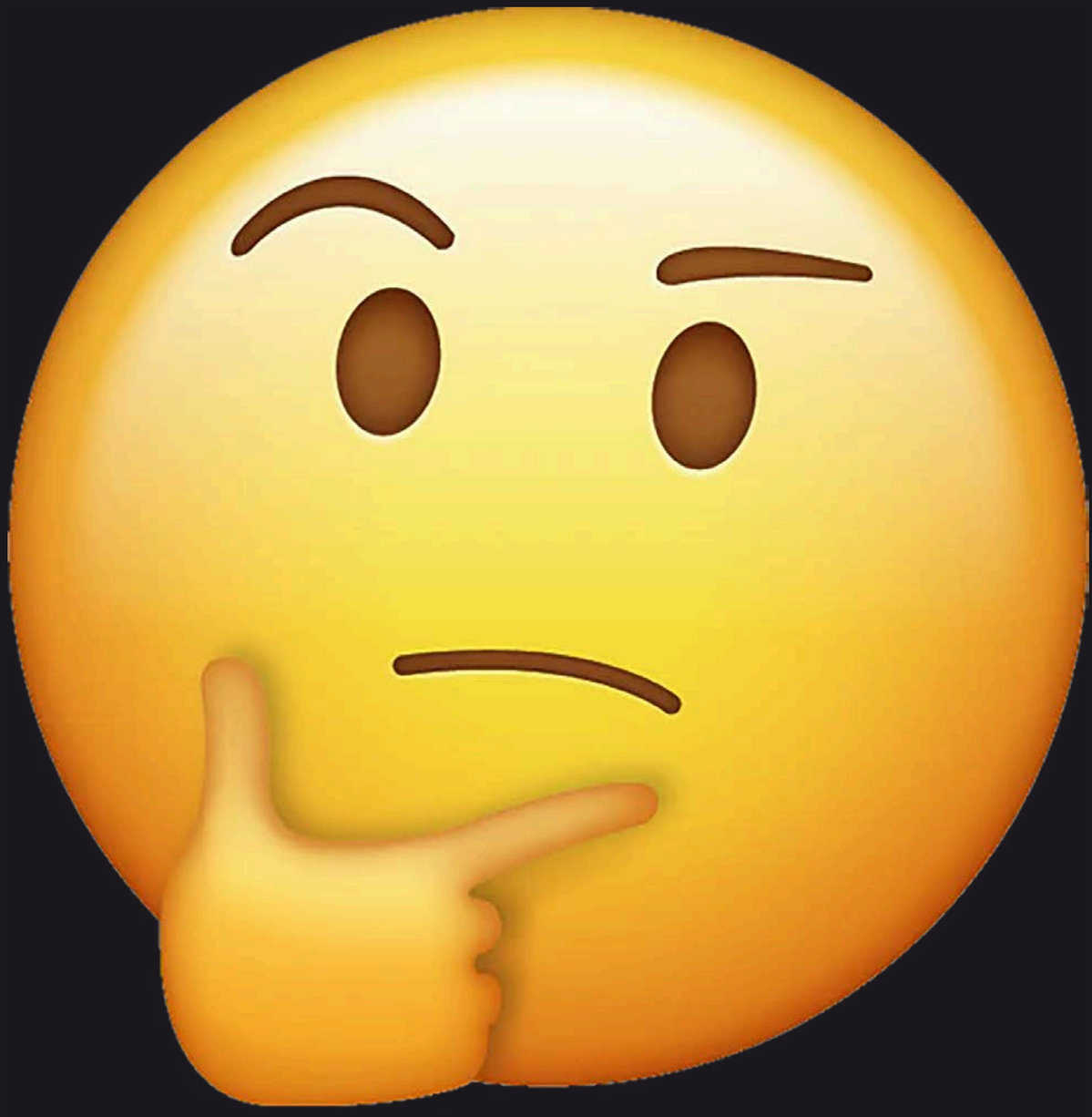
Ambinder says there's a lot of work to be done before brain-controlled gaming can become a reality. "The trick is being able to transport these findings outside of the lab and into the real world – playing on your couch, sitting in front of your desktop," he says.

Both hardware and software improvements are needed to allow EEG-based technologies to reach their full potential, he says. Better hardware could improve signal quality. Larger data sets and improved algorithms could classify mental states in a wide variety of people with unique neuroanatomical and psychological quirks.

But one day, these technologies could be as much a part of our daily lives as assistants like Siri and Alexa are today. Bin He, the biomedical engineer, is working on assistive devices for people with disabilities. He says he hopes someday to develop a non-invasive brain-controlled device for use as an everyday personal assistant for the public.

Theoretically, your mind could then control anything that a computer controls. A mind-powered phone could send text messages. A mind-powered drone could bring you a snack from the kitchen. And a computer hooked up to your brain signals could play the right music or movie to suit your mood. You could be in complete control over your environment without having to lift a finger, living in a science-fiction paradise. ■

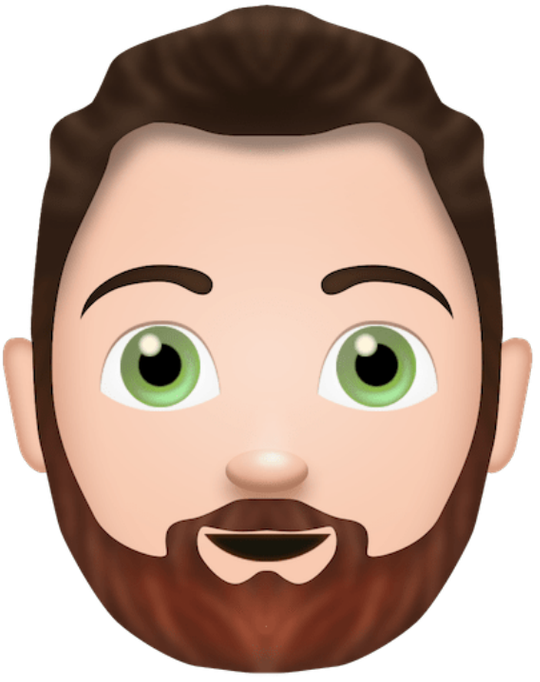
> "If a player is feeling happy or sad, challenged or bored, frustrated or engaged, the game will respond to that and shape gameplay."
>
> **Mike Ambinder**
> Experimental psychologist at the video game company Valve



EMOJIS, DECODED

The internet's favorite little pictures can cause big confusion when their meanings change. But there's a website to help.

BY TONY REHAGEN

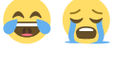


In spring 2021, as flowers were blooming across Ireland and the world was rolling out vaccines for COVID-19, Keith Broni was sitting at his computer in Dublin, wondering if the world was actually getting sadder.

Broni's job title is editor-in-chief at Emojipedia, the Web's go-to database and reference site for all things emoji. His role is to oversee changes to emoji sets from all major vendors (like Apple and Google) and to watch for online trends and common usages of the omnipresent little pictograms. Broni, a business psychologist by training, refers to this practice as "social listening."

Keith Broni, editor-in-chief of Emojipedia (pictured above in emoji form), conducts "social listening" from his Dublin computer, determining how emoji are used in social media.

Over the previous few weeks, Broni had noticed a change across social media platforms: an increased use of the "loudly crying" emoji, the yellow face with mouth agape and tears streaming from squinting eyes. For years, the "laughing crying" emoji, a guffawing face with a single tear squirting from each eye, had been Twitter's most-used emoji. But by April 2021, the "loudly crying" emoji, originally seen as a stand-in for deep sorrow, had surged into that top spot.



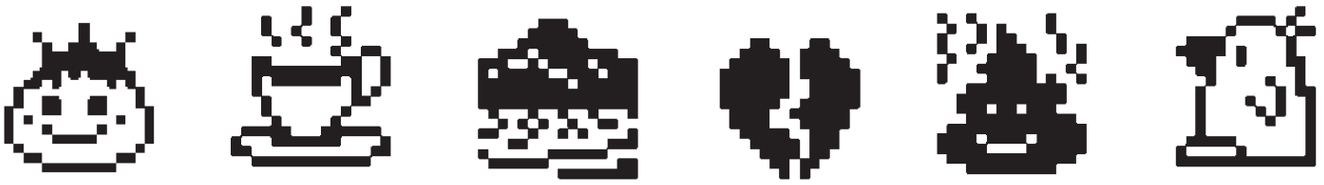
"On the surface, that seems grim," says Broni. "It was as if everyone had laughed themselves into abject melancholy."

But upon closer review of individual tweets, Broni came to the realization that the entire internet wasn't miserable. Rather, tweeters were now using the "loudly crying" emoji to convey extreme laughter instead of sadness — it had completely reversed meanings and literally replaced its "laughing crying" cousin.

"Just like 'LOL,' the 'laughing crying' emoji has become so ubiquitous that it's lost meaning," says Broni. "Meanwhile, people have come to view the 'loudly crying' emoji as maybe a little too melodramatic to adequately express sadness or grief."

Broni wrote a blog post about the tectonic shift and posted it to emojipedia.org. Then he and his team adjusted the site's official definition accordingly: *Loudly Crying Face: May convey inconsolable grief but also other intense feelings, such as uncontrollable laughter, pride, or overwhelming joy.*

The mystery was solved. The internet sped on.



1997 The first emoji set, created by Japanese carrier SoftBank

2022 Apple's most recent emoji set

Such is a day in the life of a virtual scribe working on the 21st century's answer to the Rosetta Stone.

As of September 2021, there were 3,633 emoji (or emojis; both plurals are acceptable) in the Unicode Standard, the recognized authority in ensuring consistency across most of the world's writing systems. That number includes numerous emoji variations based on gender, skin tone, and flags of all sorts. If you've bought an electronic communications device in the last five to 10 years, you have access to a keyboard with that manufacturer's version of most of them.

Ninety-two percent of the world's 4.7 billion internet users use emoji. That's a testament to the symbols' universality — along with their shorthand ease of use and ability to communicate emotions, such as sarcasm, where mere text often fails. Emoji reduce complicated ideas into simple, one-click pictograms (and darn cute ones, at that) which everyone, everywhere can quickly and definitively understand. Right?

EMOJI HAVE AN INNOCENT enough origin story. Developed in Japan in the late 1990s, the first emoji were successors to the text-only emoticons — for instance, ;) — from the previous decade. They were heavily pixelated, almost blurry, but straightforward once you figured out what they were pictures of: A red heart. A broken red heart. An angry face. A happy face. A soccer ball. A snowman.

The practice caught on quickly in Japan. Multiple sites and mobile carriers started designing their own sets of emoji. Naturally, a bit of chaos ensued as people struggled to communicate across platforms. Enter the Unicode Consortium, a nonprofit organization created in 1987 to standardize character encoding. The consortium makes sure, for instance, that the 't' I just typed on my Mac appears as a 't' on your Android. In 2007, Google appealed to the organization to do the same for emoji.

At the time, emoji were more or less homogenous. All professional faces were one color. All were male. There weren't even any redheads or people with curly hair. But, of course, the pictographic Tower of Babel has only gotten more crowded as emails, chats, texts, direct messages, and tweets have become the world's default forms of communication. As the little characters gradually escaped Japan, crossing oceans and boundaries both national and cultural, more and more emoji were added to the lexicon.

It was inevitable that the meanings of some of these pictograms were going to get lost in international translation. (Just ask any Japanese vegetable farmer who searches for 2010's purple phallic "eggplant" emoji, which once innocently symbolized the first night of the New Year and meant "good luck.")

The first emoji, developed in Japan in the late 1990s, evolved into more than 3,633 images in the Unicode Standard today.

Emojipedia founder Jeremy Burge began the site with a question about the doughnut emoji on his iPhone keyboard.

"All language is a tool for expression and communication, and people are adept at modifying things to their needs," says Emily Brewster, senior editor and editorial ambassador at Merriam-Webster, Inc. "But there needs to be transparency, so the person you are communicating with can understand." With emoji, Brewster thinks, that understanding isn't guaranteed. "They are just an image that can call to mind a variety of things," she says. "The potential for miscommunication is still there."

Jeremy Burge founded Emojipedia in London in 2013 to solve a much less complicated social quandary: He wanted to know whether the doughnut emoji on his iPhone keyboard had always been there. Unable to find an answer on Wikipedia or anywhere else online, he decided to create a website that would answer his own question — and many others. (The answer: yes, the doughnut dates to 2010's Unicode 6.0, the first Unicode update to include emoji.) Upon the release of Unicode 7 the following year, users crashed the Emojipedia site, trying to learn which 250 new ideograms had been added to the standard. By 2017, Emojipedia was a voting member of the Unicode Consortium. At one point, Burge served as vice chair of its Emoji Subcommittee.

Today, the ad-driven Emojipedia site is run by Broni. (Burge stepped down at the end of January 2022.) It has its own lexicographer, Jane Solomon, and sees as many as 50 million hits a month. (In August 2021, it was acquired by Zedge, a content distribution platform for mobile devices.)

But Emojipedia is more than a successful business. It's also the Merriam-Webster of the pictorial world. Its work — including definitions, histories, and content providing cultural context — is filed in the Library of Congress's Web Cultures Web Archive. The hallowed definitions include:

Pleading face: *A yellow face with furrowed eyebrows, a small frown, and large "puppy dog" eyes, as if begging or pleading. May also represent adoration or feeling touched by a loving gesture.*

Sparkles: *The glittering flashes of sparkles. Generally depicted as a cluster of … four-point stars, with one large sparkle and two small ones to its left or right. Commonly used to indicate various positive sentiments, including love, happiness, beauty, gratitude, and excitement, as well as newness or cleanliness. May also be used as a form of emphasis or to convey sarcastic or mocking tones.*

Pile of poo: *A swirl of brown poop, shaped like soft-serve ice cream with large, excited eyes and a big, friendly smile. May be used to represent feces and other bathroom topics as well as stand in for their many related slang terms. It also enjoys a wide range of idiosyncratic applications, such as conveying a sense of whimsy or silliness, given its fun, happy expression.*

ANYONE CAN MAKE EMOJI. They can come from artists and designers or any random user. Companies can create them and program them to automatically populate social media posts and promote an event or product. Most new emoji are created by vendors and providers — like Twitter, Samsung, or TikTok — who simply want to expand their offerings to customers.

Every emoji is born with an intended meaning. "New emoji don't just fall from the sky," says Meryl Alper, a professor of communication studies at Northeastern University who focuses on the social and cultural implications of communication technologies. "As with most tech developments, it's both a top-down corporatization and a bottom-up user-driven form of innovation. They are commercialized to the point where they're almost meaningless, and yet at the same time, they present almost endless possibilities for expression and communication."

Before an emoji reaches the fingertips of a user, no matter where it comes from, it must first go through the

In 2020, Emojipedia found that “face with medical mask” and “microbe” were most used to represent COVID-19.

Unicode Consortium. The creator submits the proposed design and name. The approval process takes months and months. “Rightly so,” says Broni. “Once an emoji is added to the keyboard, it’s there forever.”

Every September, Unicode announces which lucky emoji made the cut. (In 2021, Unicode 14.0 saw the additions of “Melting Face,” “Low Battery,” and “Beans.”) Then the emoji go out to the vendors, whose developers and designers go to work on building out their new keyboards. While Unicode issues the basic description, different versions of the same emoji still vary slightly by vendor in terms of shade, size, and small details. But while the individual design is technically proprietary, no one owns an emoji. And no one person or entity gets to define it.

Meanwhile, Emojipedia announces the list — and waits. “We are constantly watching and listening and assessing,” says Broni. “We watch on Twitter and other social media and really see how people are using this and to what extent.”

Broni and company then update their definitions accordingly. When they spot something newsworthy, they’ll post a story on the Emojipedia blog. In 2016, the site issued an analysis that showed that the “peach” emoji had come to represent a butt. In 2020, it found that “face with medical mask” and “microbe” were most used to represent COVID-19.

Emojipedia has been referenced in comedy bits on *Jimmy Kimmel Live*. The site has even been presented as an expert in court. In 2019, actor Geoffrey Rush won a defamation lawsuit in the Federal Court of Australia. He had sued a news outlet that reported he’d sent inappropriate messages to a co-star, including one that contained an emoji of a face with the tongue out.

The defense argued that the emoji was “panting,” but Rush’s barrister countered with the Emojipedia definition of “an attempt to be wacky, zany, or otherwise joking.”

Emojipedia rarely involves itself in emoji design (though the company did work with Tony Hawk to craft a more realistic-looking skateboard emoji). Nor does it jump into online debates about definitions. In fact, Broni says, sometimes the most important thing to do is not comment, as when some TikTok users in the fall of 2021 decided to try to rally fans to accept and spread use of the “chair” emoji as the new sign for laughter. It did not catch on.

Meanwhile, as generations grow up with emoji, the fun little characters continue to expand their roles. With the rise of telecommuting, for instance, more coworkers are communicating via email, direct message, and other online platforms, increasing the emoji’s use in the workplace — a formalization that increases the stakes when it comes to misinterpretation.

“An emoji can lessen work [by being succinct], but it can also add work,” says Alper. “It adds the time and emotional labor of trying to figure out exactly what someone meant.”

How long emoji will dominate the digital conversation is up for debate. Gen Z-ers — the digital emoji natives — occasionally appear in hot-take stories about how kids are taking to TikTok with claims that emoji aren’t “cool” anymore. But from Broni’s seat, it doesn’t appear that the little characters are disappearing anytime soon.

“Emoji have never been more popular than they are today,” he says. “Whether they are used genuinely or ironically, it ebbs and flows. Gen Z isn’t canceling emoji — they’re changing meanings.”

For instance, where older generations might see something benign in a slight smile, Gen Z might use it as a sign of frustration or rebuke. It helps to have Emojipedia to keep up with the times. ■

“An emoji can lessen work, but it can also add work — the time and emotional labor of trying to figure out exactly what someone meant.”

Meryl Alper
Professor of communication studies at Northeastern University


chasing

the wind

Hot-air balloonists have to go where the weather takes them. A new app helps predict where they'll end up.

BY MATT CROSSMAN

As rural Ohio rolled by slowly below us, Al Nels stood at one end of his hot air balloon's wicker basket, telling stories. Above, keeping us aloft, the nylon balloon also told Nels' life history: images sewn into it included a plane for his pilot son, the name of one daughter's bakery, and an apple for his other daughter, who is a teacher.

Nels also shared memories that weren't in the panels, about flying Walter Cronkite in a hot air balloon in France and catching his childhood neighbor's garage on fire with a toy balloon powered by candles.

Then, his eyes dancing, he joked that he was going to show me a high-tech way to measure the wind below us. He sprayed shaving cream over the side of the basket and watched it drop. "Barbasol falls at 500 feet per minute," he said, his white goatee framing his smile. Wherever the shaving cream went, that's where we'd go, too … if we were at that altitude.

As with every hot-air balloon flight, Nels could control our altitude and that's it. There is no way to steer; a balloon goes where the wind blows it and nowhere else.

Hot-air ballooning, described in stark terms, does not sound like something we would start doing in 2022 if we weren't already doing it. Like, seriously — you go up in an aircraft with no way to steer, no way to know where you're going to land, and all you can control is your height?

Nobody would get in a car or plane with only a vague sense of where it might end up. Balloonists would like to know better. Mark West, past president of the Balloon Federation of America, told me the missing link in balloon navigation has long been precise information about what direction and speed the wind is blowing at what altitudes.

Now Nels, 69, a retired engineer from Ohio, is helping to find those answers. He's conceived an app that blends high technology, smartphones, and a child's toy balloon. He and West believe the app, called WindExplorer, will make hot-air ballooning easier and safer, and therefore more popular.

That sounded good to me, as I looked down at houses and bridges. Before Nels and I took off, I had spoken with Randy Wells, a friend of Nels who piloted a separate balloon that day. "I know I'm going to land somewhere that way," Wells had said, waving his arm to the north and east, toward miles and miles of highways, homes, parking lots, and farms.

"That way" was pretty broad, I thought, as the Barbasol disappeared below us. We floated as if in a dream — the kind of dream where we show up for the final exam of a class we never attended. I've had a version of that, where I'm on stage in a rock band playing the bass, though I don't actually know how to play it.

We were high in the air. Where were we going to land?

Until now, the tools to measure the wind were imprecise. "You always have to ask yourself, what's the scale of the turbulence versus the scale of the object you're trying to fly?" says Luca Caracoglia, a professor of engineering at Northeastern University.

Humanity's first flight came not in a plane, but in a hot-air balloon. It was piloted by Frenchmen Jean-François Pilâtre de Rozier and François Laurent, Marquis of Arlandes. Launched November 21, 1783, in Paris, that balloon reached at least 500 feet high and flew for about 20 minutes, covering 5 miles. Benjamin Franklin was there to see it, and he wrote in his journal: "We could not help feeling a certain mixture of awe and admiration."

And maybe a little fear. They had run test flights with animals in the basket, just to be safe. King Louis XVI, a witness to these early flights, suggested criminals should make the first manned flight because (paraphrasing here), if they died, who cares? I bet the bad guys lined up to volunteer for a ride in a vehicle going somewhere nobody could predict. Easiest escape ever.

Alas, that idea was abandoned.

When Laurent and de Rozier took off, they had no clue where they were going or where they would land. Balloonists today have a clue, but only a clue. It all depends on the wind, which is generated by movement of air from areas of high pressure to areas of low pressure.

As you fly higher, the wind typically becomes faster, but also smoother. Landing a balloon in a city is especially challenging, if not impossible, because buildings — like any other large object on the ground — disturb the wind, says Luca Caracoglia, a professor of engineering who leads the Wind Engineering Research Group at Northeastern University.

"Flying a balloon in the Midwest is easier than flying a balloon in New York City," says Caracoglia, who has taught and written about the effects of wind on structures and how to harness wind as energy. "You always have to ask yourself," Caracoglia says, "what's the scale of the turbulence you're dealing with versus the scale of the object you're trying to fly?"

The answer would come from measuring the wind, but up until now, the tools to do so have been imprecise. One tool comes from the National Weather Service, which, twice a day, releases 92 unmanned balloons to gather weather information, including pressure, temperature, and relative humidity. From that info, meteorologists create forecasts, including about the wind. Balloonists pore over that information like mountaineers pore over trail maps.

But those forecasts are notoriously unreliable, so balloonists also draw data by observation. Before they launch their hot-air balloons, pilots release a small helium balloon, known as a "pibal" (short for "pilot balloon"). Many balloonists simply watch where the pibal goes and make educated guesses about what that tells them about the wind. It's pretty much exactly like watching the Barbasol fall out of the basket, only the pibal goes up instead of down. Some balloonists use a scope and compass to chart where the pibal goes, measuring the balloon's location at timed intervals. The difference between the points reveals how fast and in what direction the wind is blowing. But it still involves a lot of guesswork.

Super-serious balloonists use a theodolite, a device that looks like a cross between a video camera and a microscope. It follows the same basic premise of charting the pibal while allowing for more accurate measurements. But theodolites are difficult to use and very expensive; there are only about 10 in use in by balloonists in the United States.

For all but the very select few, then, precise information is scarce. "We need actual, real data," West says. "We need something that's really accurate as to what's going on."

Al Nels thinks he has the answer.

As a boy in Ohio in the early 1960s, Nels built hot-air balloons out of dry-cleaning bags, using straws for the framework, with heat from a torch and candles. He affixed postcards to his balloons with the hope that someone would find one and send it back. A farmer discovered one in a potato field in West Virginia months after its launch and mailed it to Nels.

In college, while studying engineering, Nels joined a balloonist's crew. A week after his first flight, he started flying lessons; a month later, he had his commercial pilot certificate. His career was in manufacturing management, but his passion was ballooning and the competitions that draw thousands of balloonists — he's a two-time national champion and two-time world champion sport balloonist. And for decades, with a curious, what if? thought process, he conjured novel ways to improve the flying experience.

In the 1990s he was, he says, the first pilot to bring a laptop in his basket. A friend of his, a software engineer and ham radio operator, figured out how to transfer information to the laptop via ham radio. "I was the only one who had remote readings coming up to my basket for probably 20 years," Nels says. "It was great."

Not long after smartphones came out, Nels thought up an idea for an app that could track the wind. He had an aha moment when he realized smartphones had built-in ways to measure everything he needed to know — including his location in time and space, due north, and the movement of a pibal.

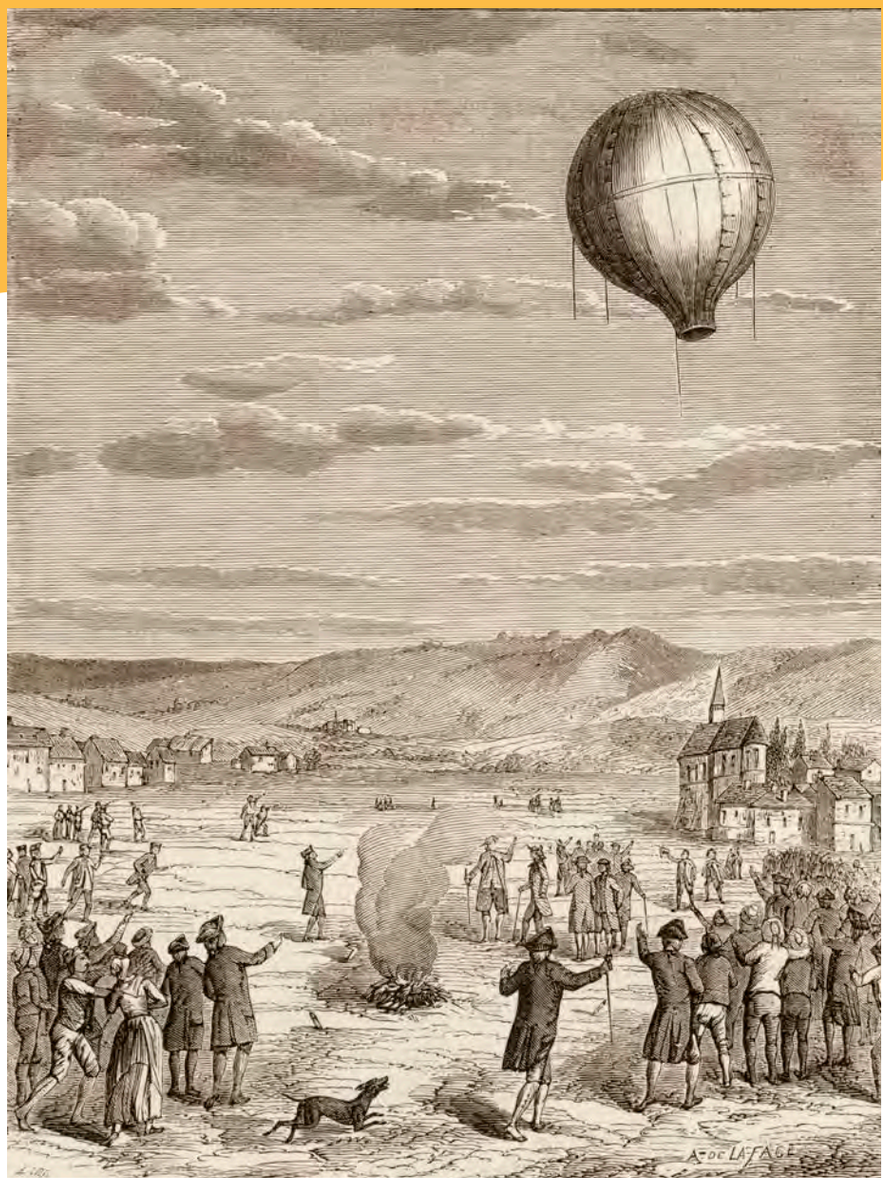
At first, Nels imagined his navigation idea as a way to gain an advantage in competitions.

In any given contest, competitors have up to six tasks to complete per flight. Sometimes they take off where they want and try to fly to a location set by judges. Sometimes they take off where they want and try to go to a location they choose. Sometimes both the takeoff and location are dictated. Sometimes they have to drop a bean bag on a giant X.

Knowing more about the wind than everybody else is an obvious advantage. "I like to win," Nels says. "Ballooning is a game played from the shoulders up. It has nothing to do with your physical skills. If you have brains and can reason things, you can be a very good competitive pilot."

Symbolic images decorate pilot Al Nels' nylon balloon, aptly named *Time Flies*.

PHOTO BY MATT CROSSMAN



On June 4, 1783, a crowd of bewildered onlookers in France watched as the Montgolfier brothers launched an unmanned hot-air balloon into the sky, marking the first public demonstration flight.

But on the way to slow-moving, high-flying, wind-directed glory, Nels changed his mind. His app could serve a higher purpose, he decided, than just adding trophies to his collection. A better wind-reading system could make ballooning easier, safer and more accessible, to retain current balloonists and attract more. Not knowing where you are going is an obvious barrier to entry for someone who might otherwise become a pilot. If that barrier were removed, Nels says, more people would fly balloons.

So he decided to make the app free to members of the Balloon Federation of America, whose membership has dropped by 10% to 15% over the last few years, according to West. "I'm concerned about our sport," Nels says. "What good is it to be the one who can win with nobody to compete against? We need more people doing this."

Once Nels decided the app would be free for BFA members, he had to find someone to create it. He shared his idea with the University of Dayton, where Howard Evans, an adjunct professor of engineering – and retired Air Force navigator – was intrigued by the idea of an aircraft with no navigation.

Between 2018 and 2021, Evans' students developed WindExplorer, which is scheduled to be released this year. The app uses the phone's gyro sensor – which measures the angle at which a phone is held – to record measurements at every 100 feet of the pibal's ascension, as a user holds the phone to track the little balloon. The phone's GPS and timer root the action to specific times and places. So if the pibal was at point A at time Y, and it moves to point B at time Z, it's a relatively simple math problem to figure out the wind speed and direction that blew it there. WindExplorer posts that data immediately to Google Drive, so other balloonists with access to that account can see it.

The most practical challenge the Dayton students encountered was how to point the phone at the pibal. They experimented with different ways, including mounting it with a scope and attaching it to a gun stock, but opted against those. They decided instead to offer three options: use the camera in portrait, use the camera in landscape,

ILLUSTRATION VIA GETTY IMAGES

Early balloonists learned to carry champagne to give out, legend has it, after property owners attacked them with pitchforks, thinking they were demons.

and — as Nels and Wells prefer — hold the phone sideways and point it, using the edge like the barrel of a rifle.

I felt no wind on the soccer fields where Nels, Wells and I prepared to take off on a splendid fall afternoon under a sky of God-showing-off blue. Nels let me use the burner to fill his balloon with hot air, and I watched Wells use the app. He looked like a boy using his phone as a gun to pretend to shoot the pibal. This was when he told me he knew he would "land somewhere that way."

Here's a way to think about "that way" and how the app shrinks its boundaries. Imagine you are standing in the middle of a giant clock. With no wind data, you'd have no way of knowing if you will fly toward 12, 3, 6, 9, or anywhere in between. But WindExplorer showed we would fly between (roughly) 1:04 and 1:13 on the clock, depending on our height: 700 feet put us at 1:13, while 1,700 put us at 1:04.

On the day we flew, the wind patterns held steady. But they sometimes shift dramatically. During a competitive flight in Nebraska in 2019, says Wells, winds shifted 90 degrees over an hour or two. That's the equivalent of thinking you're going to fly to noon and instead heading toward 3.

WindExplorer shows pilots if the winds are unusually strong or stronger than predicted. That's important to Wells, a relatively inexperienced pilot. If the app tells him the wind is too strong, he won't fly.

There are possible non-ballooning applications, too. Nearly any hobbyist whose passion relies on wind — drone pilots, hang-gliders — could potentially use it. After a gas leak, the app could tell emergency management officials what path the fumes will follow.

Before our flight, I parked at a rural airport east-northeast from where we eventually took off. Based on wind forecasts, that's where Nels thought we might land. But the wind wasn't strong enough to blow us all the way there. Nels gave me flying lessons until we descended onto what appeared to be an estate — a nice house with a huge yard and pond. With Nels coaching, I had already handled filling the balloon, takeoff and some of the flying. Now he turned over landing to me, too.

Landing is "easy." All you do, for most of the time, is nothing. The air in the balloon cools, and you sink. As we neared the ground, Nels gave me instructions. I can't take notes and land a balloon at the same time, so this is from memory: Wrap this rope around your arm — no, don't grab it, wrap it around your arm so you don't lose it (repeat that a couple times) — now pull on that rope, pull it hard PULL IT HARD — and the next thing I knew, we were on the ground.

The rope I pulled opened a vent at the top of the balloon. Warm air poured out and cooler air replaced it. That slowed our descent until we hit the ground, at which point our buoyancy and gravity reached a détente. There's an old pilot's joke that a good landing is one you walk away from, and a great landing is one in which you can use the plane, helicopter, or balloon again. In that sense, this was a great landing, even if we laughed later at my inability to follow Nels's instructions.

Early balloonists carried champagne to give out when they landed. They learned to do that, legend has it, after property owners attacked the earliest balloonists with pitchforks, because they thought they were demons dropping from the sky.

I didn't see any pitchforks, or demons, or champagne. A few other balloons landed there before us. The homeowners came outside to see what was going on. After chit-chatting for a few minutes, they retreated inside.

Nels is a passionate photographer, and after we landed, he saw in his mind's eye a compelling photograph of his balloon reflected in the pond. We moved the balloon to its banks, and he ran to the other side of it to take the picture. The late afternoon light bathed everything in a warm glow. The balloon's vibrant, story-telling panels jumped off the water, which was perfectly still because there was no wind. ■

SHOOT A RAT SAVE THE SWAMP

The annual Nutria Rodeo in Louisiana is more than a hunting competition. It's a battle in the war against climate change.

BY CHELSEA BRASTED

ILLUSTRATION BY FABIO CONSOLI

JUST SHY OF SUNSET on a cold February day, Gabe Macormic cracks open a fresh beer, tightens the American flag bandana keeping his mullet in check, and gets back to work counting the nearly 2,000 dead swamp rats piled up on the marina decks in Venice, Louisiana.

The dead rats — more correctly called nutria — are the result of the 2022 Nutria Rodeo. Each one was shot and killed in an attempt to take back the delicate, endangered ecosystem along the Louisiana coastline.

At the moment, though, there's nothing delicate about the scene on the marina decking. Full-grown nutria are somewhere between the size of a large housecat and a middling raccoon, so the piles of hundreds at a time quickly stack up. On the deck beyond, a zydeco band warms up for the party that will cap off the hunt's second and final day. It all ends with a nutria toss, rewarding the man and woman who can throw the body of a swamp rat the farthest.

"Driving around on the boats in the water with friends, it's a good time, and if you feel like you accomplish something good, it helps you feel like you have a better time," Macormic says during a break in counting. "We definitely wouldn't be here if [the nutria] weren't an invasive species."

Louisiana's nutria problem is decades in the making. As the nutria population has grown — to 20 million, by one estimate — so, too, has the havoc the rodents wreak on the state's receding coastline. That's why shooting them for sport is more than just a good time for hunters: It's a key part of the land management strategy for fighting the impacts of climate change.

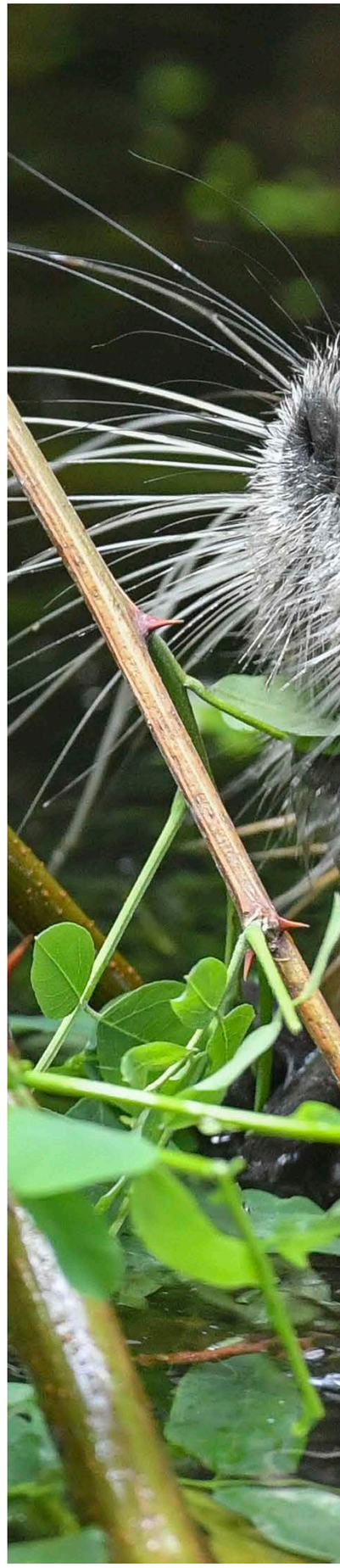


PHOTO BY PATRICK PLEUL / PICTURE-ALLIANCE / DPA / AP IMAGES

A nutria feasts on marsh plants. The giant, invasive rodents with macaroni-and-cheese-colored teeth have been responsible for more than 100,000 acres of coastline damage in Louisiana.

"We've seen species introduction fail time and time again across every continent."

Ben Dittbrenner
Environmental science professor at Northeastern University

"I'm a big duck hunter, and I love hunting and fishing. Down the coast, we see first-hand the loss of land down here," Macormic says. "[Hunting nutria] is one of the things we can do to help."

After a years-long break when the original event organizers ended their participation, Macormic, a south Louisiana native, revived the Nutria Rodeo in 2021. This year, the event more than doubled in size, with about 200 hunters signed up to participate. A homegrown nutria mitigation effort like Macormic's, which in 2022 hauled in 1,934 rats, takes just a small bite out of what, in Louisiana, is an expansive problem.

Nutria (pronounced NEW-tree-ah) are fast-breeding, semi-aquatic rodents who thrive in colonies along swampy coastlines and lakes. They're a particularly hungry invasive species. They feast on the roots of marsh plants, loosening the soil below. As the tides come in and out, the water takes the loosened soil into the Gulf of Mexico, and with it, Louisiana's natural defense against coastal erosion and major storms. At one point, according to the Louisiana Department of Wildlife and Fisheries, nutria were responsible for more than 100,000 acres in coastline damage.

"It's the plants that are the glue that hold our marsh together," says Jennifer Hogue-Manuel, who manages the Louisiana Department of Wildlife and Fisheries' Coastwide Nutria Control Program. "[Nutria are] pulling that glue apart, and that can really exacerbate the erosion of our coastal marshes. Once they're lost, they're lost forever. There's no good way to regenerate naturally."

A SINGLE HIGHWAY TAKES YOU to Venice, Louisiana, in the very toe of the state's boot. Pass through smaller and smaller towns in Plaquemines Parish, and you may spot a dead nutria on the side of the road. The trees nearby are still filled with tangled debris left by Hurricane Ida, which passed through the area in late summer 2021.

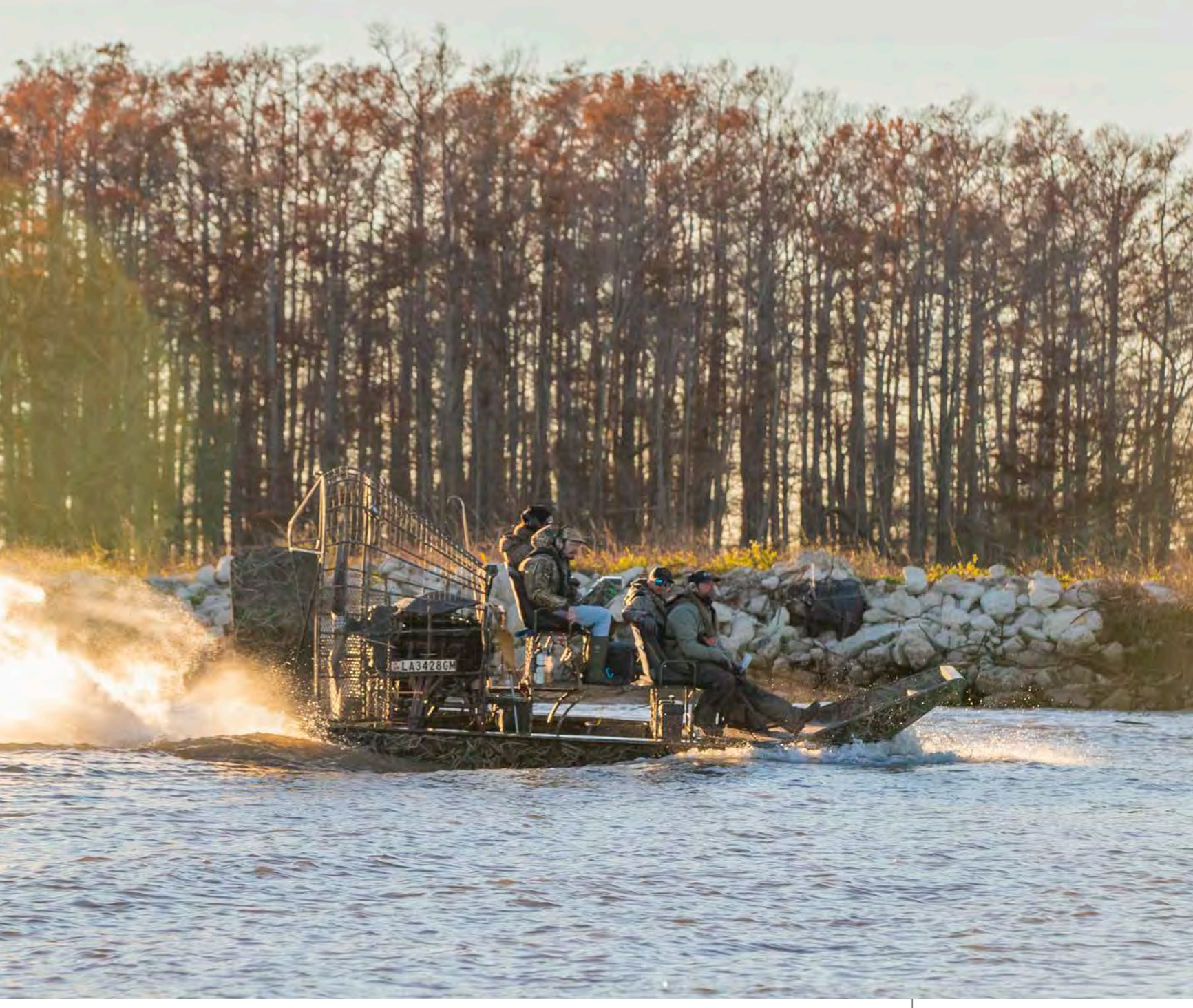
The road itself, Louisiana Highway 23, knits together what's left of the landscape. The longer you drive, the closer the water appears on either side. Eventually, there's barely even a shoulder before the roadway drops off into the Gulf of Mexico. Meanwhile, the homes here get taller, their foundations just stilts jutting out of the earth.

Even without nutria, this part of the country would be endangered – a fact that becomes ever clearer with every passing hurricane season. The coastline here, weakened by man-made problems such as miles of oil and gas companies' canals, is chewed away as sea levels rise and stronger storms batter the state. The swamp rats' destruction just hastens the process, to which Venice has long held a front-row seat. The small, close-knit community is at the very edge of the state, a location that has earned it the nickname "the end of the world." Maps for this part of Louisiana can easily deceive a newcomer, where what looks like solid ground can be anything but. Venice itself has been nearly wiped off the maps by multiple storms, including Hurricane Katrina in 2005.

As the sun sets on the Nutria Rodeo's second day, the zydeco band kicks up; the crowd of hunters and curious onlookers is all bundled up in camouflage waders, knit beanies and the satisfaction of a job well done. On the Venice Marina dock, a dry erase board bears the latest tallies as Macormic's team readies itself to crown the day's victors for "most nutria shot" and "heaviest nutria killed." The contenders for the latter hang by the tail from the marina's rafters, their limp bodies rotating slightly in the breeze. From behind, a nutria is decidedly unremarkable – their fur comes in shades of dark brown – but you know you've spotted one by the two-inch, macaroni-and-cheese-colored teeth that draw down from their noses.

The last of 62 teams check in as the 6 p.m. deadline nears, each one arriving on an airboat that took them into the swamplands, hauled behind a pick-up truck. In the trucks' beds are oversized, gray Rubbermaid trash cans, each one heavy with dead swamp rats. To count each one,

LEFT PHOTO BY MATTHEW MODOONO / NORTHEASTERN UNIVERSITY



ABOVE PHOTO BY SOPHIA GERMER / THE NEW ORLEANS ADVOCATE

A boat with nutria hunters returns to the Venice Marina during the Nutria Rodeo.

they're tossed into plastic wheelbarrows. There's steady laughter and chatter, and the air smells like sour beer and recent death.

Nearby, hunter Jonathan Landry holds in his pocket a baby nutria he rescued earlier in the day, offering curious onlookers a first-hand understanding of just how soft the little swamp rats are. Steam rises from chef Philippe Parola's pot as he stirs his nutria gumbo. The sign offering bowlfuls offers another take on the day: "If you can't beat 'em, eat 'em!"

THE NUTRIA ORIGIN STORY is infamous here, routinely told in middle-school science classrooms. Local businessmen, including E.A. McIlhenny, the son of Tabasco hot sauce founder Edmund McIlhenny, once hoped to capitalize on the fur trade. In the 20th century, they brought in nutria from South America in the hopes of establishing a quickly renewable and profitable source. It turned out, however, that few members of the well-to-do class wanted to wear swamp rat, and the fur trade for nutria never took off. But the population sure did.

"They quickly went rogue, became invasive, and started causing problems all over the place," says Ben Dittbrenner, an environmental science professor at Northeastern University.

The nutria story is hardly unique, he adds.

"We've seen species introduction fail time and time again across every continent, with people bringing in other species because they CONTINUED ON PAGE 69

On thin ice

CONTINUED FROM PAGE 21 and krill-oil dietary supplements for humans — competes with penguins for their prey, and scientists are trying to figure out how much that hurts penguins. Research insights could lead to new restrictions on large-scale commercial fishing under the Antarctic Treaty.

But climate change is emerging as perhaps the biggest cause of penguin population decline. "Rain has a really devastating impact on penguins," says Lynch. "It can snow all at once and penguins are happy, but as soon as it rains, that soaks their chicks, and their chicks very quickly die." As the Antarctic Peninsula warms, it's getting more rain and less snow. "Air temperatures are hovering right around freezing, somewhere between 30 and 35 degrees on a typical day," Lynch says. "Even a very small amount of warming tips that balance from a snow-dominated environment."

Climate change doesn't just hurt penguins on land. Even more important is what happens to them in the ocean, where they swim and forage for food. "Climate change is changing the distribution and the timing of sea ice," which is a nursery for krill, says Lynch. When sea ice declines, forms too late, or breaks up too early, that hurts the krill population. "We think that there's less krill in the ocean for the penguins, or the krill that is there is just not in the right place," she says.

That's a direct threat to species like emperors, made famous in movies like *Happy Feet* and the documentary *March of the Penguins*. Standing almost four feet tall and weighing about 88 pounds, they're listed as "near threatened" by the International Union for Conservation of Nature, and they're under consideration for inclusion in the U.S. Endangered Species Act.

Stéphanie Jenouvrier, a biologist at the Woods Hole Oceanographic Institution on Massachusetts' Cape Cod, has studied emperor penguins for 20 years, investigating how they respond to climate change, especially declines in sea ice. She began by studying the emperor penguin colony on the Pointe-Géologie archipelago, near the French Antarctic research station Dumont d'Urville, named for the French explorer Jules Dumont d'Urville, who discovered the area in 1840. (Adélie penguins are named after his wife, Adèle.) Since then, Jenouvrier has collaborated with other penguinologists to study Antarctica's entire emperor penguin population via satellite imagery.

Though the Pointe-Géologie emperor population has been stable in recent years, it has never recovered from a fast decline in the 1970s as sea ice grew more scarce. That's a harbinger of what a warming Antarctica will mean. Jenouvrier's work at Pointe-Géologie, combined with satellite-based estimates about the continent's other emperor colonies, has resulted in a chilling prediction: If sea ice declines at the rate projected by climate models, emperor penguins will be extinct by the end of the century.

To prevent that, Jenouvrier says, the world would have to meet the goal set in the 2015 Paris Climate Accords: limiting greenhouse gas emissions enough to keep global warming to no more than 1.5 degrees Celsius, or 2.7 degrees Fahrenheit, compared to pre-industrial temperatures. "It's a huge commitment to mitigate the effect of climate change," Jenouvrier says. "We are not on the route to meet those agreements. This is the only way we can save emperor penguins."

NOT EVERY PENGUIN SPECIES stands to suffer as a result of warming seas. For gentoo penguins, native to the Antarctic Peninsula and other islands north of Antarctica, a warming climate means more area for breeding and eating. Gentoos, who have bright red-orange beaks and big white patches above their eyes, are the world's fastest-swimming birds, capable of reaching 22 miles per hour. They can dive hundreds of times a day to forage for prey, to depths of up to 600 feet.

"Gentoo penguins are actually a winner when it comes to climate change," says Fiona Jones, a British zoologist who studied penguins for her doctoral thesis at the University of Oxford. "We're seeing their population shift down the Antarctic Peninsula into more southern regions, which previously weren't hospitable to them because they were too cold and too icy."

Some of the latest research on gentoos is being conducted by Andrea Raya Rey, an ecology professor at Argentina's University of Tierra del Fuego. She's deployed 40 cameras on islands off South America's southern coast to capture the habits of penguins, cormorants, and doves. She records the sounds penguins make to monitor their behavior, takes blood and feather samples to deduce where in the ocean penguins forage, and also tracks their foraging directly with GPS devices and depth data loggers, using machine learning to predict their migration. "Given climate change and global warming, we are trying to understand what will happen with the penguins," Raya Rey says. "Where are they going to move? Where are they going to forage?"

Raya Rey and the University of Oxford penguin researchers have found that the changing climate is affecting gentoos and other penguins in more ways than just migration. For instance, they've learned that gentoos are breeding earlier in the year now because of climate change. "So you have penguin chicks when there is not enough food," Raya Rey says. "Usually, penguins have their chicks in summertime, when there's more food in the ocean." That could cause penguin populations to decline.

A few times a year, Raya Rey also tapes a camera to a penguin's back, for a rare gentoo's-eye-view of the ocean. In one video, taken in December 2021, a male gentoo penguin zooms through the water off Tierra del Fuego, Argentina, with a crittercam taped to his back and plunges into a school of sardines. CHOMP! He snags a sardine in his beak. The fish squirms. The gentoo gulps it down. The camera catches glimpses of other penguins, as well as diving cormorants and an albatross — all swooping to gorge themselves on the sardine feast.

Raya Rey is one of several penguinologists around the globe who processes her vast arrays of penguin images with the help of Penguin Watch, a citizen-science project. The University of Oxford research team travels each year to Antarctic penguin colonies to count nests, fly drones, and replace batteries and memory cards on the penguin-cams they've installed there. With 100 cameras in Antarctica and on nearby islands, each taking a picture every hour, they have more than a half-million images to process per year. "As a tiny team, we just couldn't possibly analyze all of that data manually," says Jones. But crunching the data is possible because 50,000 registered Penguin Watch volunteers have tagged penguins in 6.5 million images since 2010. "It's really easy!" Jones says. "We encourage children to do it." The human counts help train Pengbot, a computer vision algorithm that uses machine learning to better recognize penguins in images. "We call it Pengbot, because why not?" Jones says.

It's easy for Penguin Watch to find volunteer penguin-taggers. "People love to learn about penguins," Jones says. "They're a group of animals that really capture people's imaginations and their hearts. They're very charismatic." Ecologists hope that a love for penguins will translate into support for conserving their homes. "All of these things contribute to people becoming advocates for the environment," Jones says, "and inspire them to maybe take part in their own conservation initiatives."

Visiting penguins in a well-run zoo can also inspire humans to help save the species and, by extension, the planet. In the Northern Hemisphere, the only places to see penguins' waterborne grace are penguinariums like the Detroit Zoo's Polk Penguin Conservation Center, which claims to be the world's largest penguin facility, thanks to its 326,000-gallon swimming tank. The zoo is home to 78 penguins: 20 gentoos and

four chinstraps, 18 kings, 18 macaronis, 17 rockhoppers, and one hybrid, a macaroni-rockhopper. ("I didn't know they could get together," I told Jessica Jozwiak, the Polk Center's supervisor, when she described the single cross-breed penguin to me. "We didn't either," she replied. "It was a real sneaky, sneaky thing.")

On the ground level, five types of penguins hop, bottom-heavy, across rocks meant to imitate Antarctic and South American landscapes. But the real wonder comes when human visitors descend to the building's lower level, past an exhibition about explorer Ernest Shackleton's ill-fated Antarctic expedition, and see the penguins behind a giant glass wall, gliding past like birds in flight, in water bluer than sky.

The zoo's 20 gentoos are gregarious and active, always on the move. Fun-loving, they'll bat around tennis balls attached to PVC pipe. Gentoos greet each other with an open-mouth scooping motion.

"They'll bow their heads down a bit," says Jozwiak. "They also hiss at you if they're not happy with you being too close."

The Polk Center's penguins are a huge draw; a half-million visitors saw them in summer 2018 alone. On the day in 2022 that I visited with Jozwiak, a small crowd of zoogoers started chatting. Just by staring at the glass, some had gotten to know how gentoo behavior is different from other penguins'. "They're very sociable — they get into everybody's business," a woman standing at the exhibit said to Jozwiak. "The kings will be over here, chilling," she added, "and then the rockhopper and the macaronis are over in the corner. Then here come the gentoos — like, 'Hello! I want to hang out with you guys!'"

Meanwhile, at the bottom of the world, tourist fascination with remote Antarctica and its penguins is growing. In the 2019-2020 austral summer, just before the pandemic, 74,400 tourists visited the frigid continent, double the number that came four years earlier. Tourist visits to emperor penguin colonies quadrupled during the same time. Though COVID-19 wiped out the 2020-2021 Antarctic tourist season, several cruise-ship companies began sailing to Antarctica again in the 2021-22 austral summer.

Indeed, like other penguinologists, Jones often gets to Antarctica by hitching a ride on cruise ships. "We give onboard lectures to tourists," she says, "and hopefully inspire them to become Antarctic ambassadors."

Scientists hope that people who make a personal connection with Antarctic penguins will become advocates for taking action against climate change. "If you care about a penguin," says Raya Rey, "you are going to be more careful with your use of the planet Earth." ▯

Shoot a rat, save the swamp

CONTINUED FROM PAGE 67 think they'll be valuable … or help control another population of nuisance animals," says Dittbrenner, whose research primarily focuses on beavers. That animal had essentially the exact same trajectory as nutria, but in Argentina: They were brought there to create a fur trade, then took to the environment a little too well. The population is responsible for colonizing nearly 30,000 square miles in that country.

It's a story repeated around the world. Giant African snails, introduced in Hawaii as garden ornaments, exploded in numbers. Soon, the invasive wolf snail was introduced to control them. Kudzu, native to Japan, was introduced in the United States as an ornamental plant and has since exploded in coverage area. In Australia, cane toads were brought in to help control a beetle population, instead becoming a problem all on their own.

Looking around, it can feel like the hunters at the Nutria Rodeo have really made a dent, but the nutria population here is so staggering, local officials measure it only by the amount of land it destroys. (The U.S. Fish and Wildlife Service, however, pegs Louisiana's nutria population at around 20 million.) This led the state to develop its own bounty program 20 years ago.

The state offers $6 a tail to registered hunters, creating a demand for the dead rats where otherwise there wouldn't be one. On the open market, the pelts, Hogue-Manuel says, are worth only about $2 apiece, with the fur heading to some more adventurous and environmentally conscious textile-makers. (Macormic's Nutria Rodeo doesn't cash in on the state-offered bounties; instead, some of the rats were offered up to the local zoo and an alligator farm as food. The rest were buried.)

This season, state officials hope to get rid of 400,000 nutria. Since the program's inception, it has helped to draw down the state's damaged acreage from its height of more than 100,000 to just under 15,000 acres at last count.

The state "looked at all kinds of things — sterilization, poison, all kinds of things for controlling nuisance wildlife — and this program had the lowest cost and highest benefit," Hogue-Manuel says. "And it's quite popular with the public."

That aspect — public buy-in — is a crucial part of controlling and, even better, eradicating invasive species, especially with nutria. This was a problem caused by people, and it'll have to be solved by people, too.

That was the case in Maryland, which also suffered from the marsh-eating problems that come with an invasive nutria population. In looking to eradicate them, the state never used a bounty system, says Trevor Michaels, a wildlife biologist for the U.S. Department of Agriculture's Animal and Plant Health Inspection Service in the Chesapeake Bay. Bounties work better when management is the goal, as in Louisiana, versus eradication, which was more feasible in Maryland.

Eventually, constant pressure, trapping, and public education about how to spot a nutria paid off. Michaels says his team hasn't seen a sign of a nutria since 2015. Nutria haven't been formally declared eradicated there — it is physically impossible to prove something doesn't exist — but officials believe they're close. And it wouldn't have happened without the community on board.

"We always depended on the public," says Michaels. "We needed all those private landowners for access, because nutria don't obey property boundaries."

> Constant pressure, trapping, and public education about how to spot a nutria paid off.

The size of Louisiana's nutria population likely makes it impossible to eliminate them entirely, but the fight continues, season after season. For his part, Macormic, who lives half of the year on a houseboat in the Venice Marina and the other half on his medical cannabis farm in California, will make sure it does.

As the count at the Nutria Rodeo winds down, Macormic acknowledges that he wasn't able to do much hunting of his own while he managed the event. Still, he and his team were able to nab 60 rats — a number he still feels good about, even as the leading teams roll in with several hundred.

At 37, Macormic has already seen the landscape here change too much in his own lifetime not to understand what's at stake. "The marsh is just so different. Random ponds are now just open water."

If the Nutria Rodeo can help protect that land, it seems an easy way to do his part.

"They're taking our land from us, so we're here to take it back," he says. "One shot, one dead rat at a time." ■

Word play

CONTINUED FROM PAGE 27 podcasts. It's also had an impact on how the puzzles themselves are constructed. Fagliano says that in the online era, crossword puzzle clues have evolved to be less reliant on arcane trivia that might cater to a certain type of solver's knowledge base, and more on clues that might have a verbal trick to them, or draw on a broader range of pop culture references.

"Historically, [there have been] things you just need to know in order to do a crossword," he says. "You need to know a word like étui, or that Elvis Presley's middle name is Aaron. That's the sort of obscurity that we're trying to reduce."

THE GOAL, FAGLIANO AND other game designers say, is to be accessible to as broad a range of players as possible: easy to learn, hard to master. By definition, that makes these games appealing to people who might not traditionally have turned to multiplayer gaming. When Words With Friends emerged, Pearce says, there weren't many casual multiplayer games available on mobile phones.

"If you wanted to play with other people, you had to go to some fantasy, Tolkien-esque thing and play for many, many hours," she says. "Adult people who have children or are taking care of their parents or have multiple jobs do not have time … For them, these kind of bite-size niblets are a much more viable way to play, and having them on your phone makes them a lot more accessible." (In terms of facilitating casual play, Bettner puts the idea more bluntly: "Our job was making toilet games. There's the time limit, and if you can play it before you're done, then it's a good game. Wordle has that characteristic.")

Wordle, in fact, has ridden that low barrier to entry to such ubiquity that even people's reasons for not playing are ripe for conversation. Sokolowski has never solved a Wordle, and told me almost apologetically that he's discovered through Wordle's attendant frenzy that many in the dictionary business "just don't" play word games. Pearce, active in the indie gaming design community, prefers the more obscure, weirder Puzzle Juice. Fagliano, to his great disappointment, can't play anymore — when the *Times* acquired Wordle, he was charged with helping edit the six-year-long list of daily answers that came with it, effectively spoiling the game for himself in perpetuity.

Wordle's broad appeal presents an opportunity for the gaming industry writ large — especially now that mobile phones have overtaken computers and consoles as the fastest-growing gaming platforms. Pearce says many game designers are now tapping into an older demographic that the industry has long overlooked. She notes that her father's wife, in her 70s, has never touched a PlayStation or an Xbox, but plays games on her phone all the time.

"This is an audience that is almost entirely ignored by the video game industry," Pearce says. "It is the largest demographic. It has the most disposable income and the most free time. So they're missing a huge market."

Intentionally or not, she adds, the most popular online games have a more accessible design as well — including the most beloved word games. "All of these games have very giant letters, super easy to see. It's kind of a weird ableist thing that people don't realize: When you get to a certain age, you just can't see tiny things anymore. My students never think about it. I was teaching mobile game design several years ago, and I kept saying, 'You guys need to make these fonts bigger.'"

De Schutter, who has collaborated with AARP to research older gamers, has thought a lot about how he and other game designers can incorporate learnings about that group. "When I started interviewing 50-plus-year-olds, I found that many are looking for more than the cheap thrills that you often find with games," he says. "They wanted games that were eudaimonic" — a Greek term for a type of contentment that's achieved through having a meaningful purpose.

"I think what we're going to see is games that aren't just about dexterity and reaction speed — whether it's making a tactical game more turn-based or having ways to slow things down," he continues. "Because once you're past 25, your reaction speeds drop. So [you want] more problem solving, language, skills that require a little bit more thought."

Word games meet those needs, but have an emotional payoff, too, he thinks — something that enhances their broad appeal. "You can be working your butt off or have a very frustrating day or whatever and you do a little Wordle, and you feel good about yourself. I think Wordle has a lot of longevity to it. I could still see people 10 years down the road [playing] Wordle. It's just super fun, and it's something that everybody can play."

To that end, rich stories of personal connection have stemmed from many of the most prevalent word games. During the height of the pandemic, when international travel was all but impossible, Ezersky received a message from one U.S.-based fan thanking him because Spelling Bee had helped her feel close with her parents in India. During Words With Friends' heyday, there were more than a few reports of couples getting married after meeting through the game's "random opponent" feature, which matches strangers together for matchups. Wordle has even been credited with saving lives. This past February, a California woman called the police to check on her 80-year-old mother in Illinois when, uncharacteristically, she failed to text her daily Wordle score; it turned out the mother was being held hostage by a mentally disturbed stranger in her own home.

My own play hasn't yielded anything so dramatic, but it's a good excuse to nudge the people I love, a small way to let them know I'm thinking about them. My mom and I text each other our Wordle scores. My childhood best friend, Jessica, and I message each other screen shots of rejected Spelling Bee words whenever they make us laugh (most of those shouldn't be printed here).

And with the rest of the Hive Mind, we both eagerly awaited the "Z" Spelling Bee, which finally came out on April 6. I got one pangram, "razoring," but missed the other, "organizing." There was no "P" in the puzzle, so "pizza" didn't make an appearance, but don't think I didn't try "zaza." Alas, it wasn't a word. ▯

"Crossword clues evoke memories, stories, reactions."

Joel Fagliano
New York Times puzzle editor

THE EXPERIENCE QUESTIONNAIRE **BELLA POLLEN**

Accidental adventures

Bella Pollen is a travel writer, the author of five novels, and a philanthropist who has raised money for the Marefat High School in Kabul, Afghanistan. The mother of a Northeastern University graduate, she was a featured speaker in Northeastern's Women Who Empower series.

Where do you come up with your best ideas?
Invariably someplace where I don't have a pen to write them down. I think most movement cures block. You are driving, or you are hanging off the edge of a mountain.

What's the most useful mistake you've made?
I have no sense of direction. Nine times out of ten I turn right instead of left, which means that I get lost a lot. My geographical mistakes have always ended up leading to adventures that I might never have had otherwise or leading to people that I might never have met. They're welcome mistakes.

What is the most unexpected place that gave you inspiration for a novel?
There was an escaped grizzly bear on the Outer Hebrides, a northwest Scottish island chain that I spent my holidays on as a teenager. There are no bears at all in the United Kingdom, let alone a grizzly bear. It belonged to a wrestler who had adopted it from a zoo, and he brought it up as his child, as a human being. Then it ran away from him, and it was loose on a flat island for a month with no food. Eventually it was spotted, and a chopper airlifted it out of a loch. It never killed anyone. It was on death's door, but it survived. I think it went on to live a ripe old life. That led to *Summer of the Bear*.

What is the most important lesson you've learned about leadership?
You have to be able to lead by example. I know that's a cliché, but I think it's true. Attention to detail, being a step ahead of yourself all the time.

What advice do you have for people who want to get public exposure for their art?
All press is a double-edged sword. If you are skillful, you can use it to send out a message. If you are not skillful or you end up on the wrong side of it, then that original press story does tend to be the story that people are remembered by.

What profession would you like to try that you haven't?
I would like to be a criminal lawyer.

How do you relax?
I play the piano. I like to walk up mountains. ▯

ILLUSTRATION BY JOEL KIMMEL