

Catapulta

Spring 2024

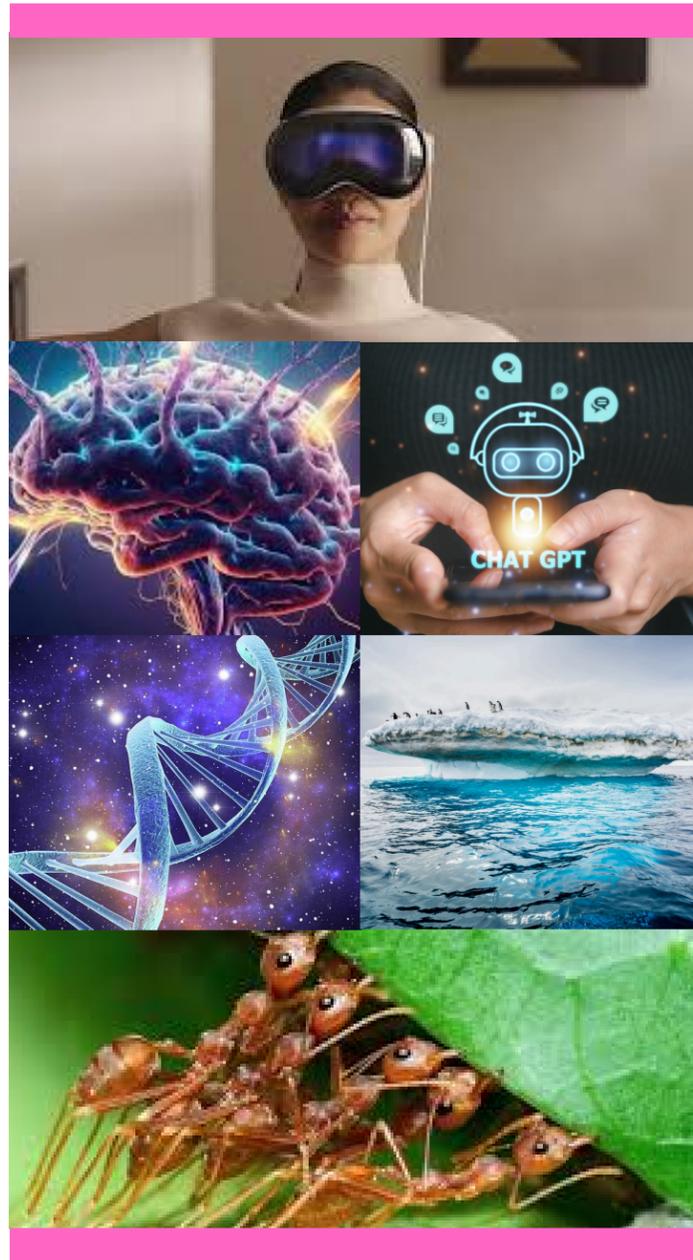


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EDITORS' NOTE

WELCOME TO THE SPRING 2024 ISSUE OF CATAPULTA.

FROM THE FOUR JUSKAITEERS — WE WANT TO THANK OUR WRITERS AND EDITORS FOR YOUR DEDICATION TO THE PUBLICATION AND THE CONTINUATION OF SCIENCE JOURNALISM WITHIN THE SCHOOL. WITH FOUR EDITORS-IN-CHIEF, THIS YEAR HAS BEEN DOUBLE THE FUN FOR US. FROM THE VERY FIRST PEP TALK AT THE COPLEY LIBRARY TO THE LAST FACETIME WHERE WE SENT OUT THE NEXT BOARD'S DECISION EMAILS, IT WAS INDUBITABLY DOUBLE THE PLEASURE TO HAVE BEEN LEADERS OF CATAPULTA. TO OUR SUCCESSORS, EMILY AND WILLIAM, YOU GOT THIS! DON'T GET SENIORITIS AND MAKE SURE LAYOUT STAYS INTACT. WE CAN'T WAIT TO SEE WHAT YOU ACCOMPLISH WITH CATAPULTA. TO THE NEW BOARD, CONGRATS! MAKE LIFE FOR EMILLIAM EASIER. TO YOU, READER, KEEP READING THE CATAPULTA! A PUBLICATION IS ONLY A PUBLICATION IF IT IS READ. CATAPULTA, WE LOVE YOU, IT'S BEEN REAL.

GOOD-BYES ASIDE, WE'VE GOT SOME BANGERS FOR YOU IN THIS ISSUE! FROM HOW THE NEW APPLE VISION PRO WORKS TO GROOVY PIG KIDNEY TRANSPLANTS, WE ENDEAVOR TO MAKE SENSE OF THE NEWEST IN SCIENCE AND TECHNOLOGY WHILE ALSO BRINGING YOU COVERAGE OF THE TIMELESS AND INTERESTING PHENOMENA THAT OCCUR ALL AROUND US. FINALLY, WE HOPE YOU TRY OUT OUR AMAZING PUZZLE; OUR PUZZLE EDITORS SPENT A LOT OF TIME ON IT. HAPPY READING!

SINCERELY,
KAITLYN, JESSICA, JOANNA, AND JESSIE

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USING AI TO TALK TO ANIMALS

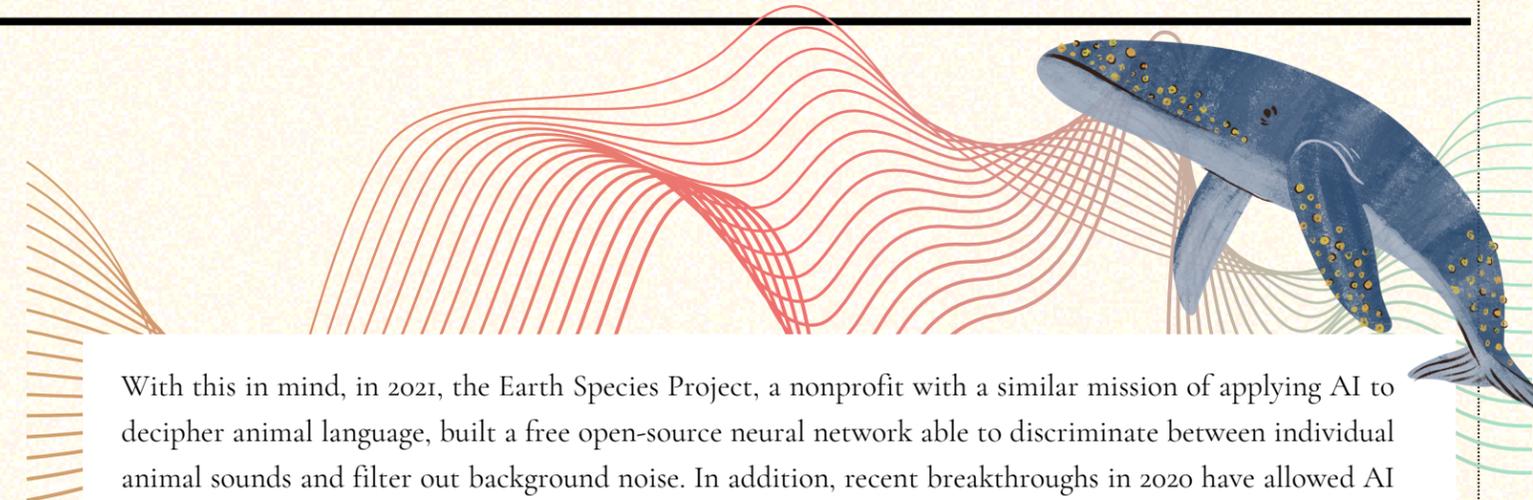
Whether it's listening to a dog's bark, a cat's meow, or a bird's chirp, at some point, we've all wondered what the animals in our daily lives really think. But a quick Google search usually only results in a vague, conflicting list of what experts believe the sound could mean. However, recent advances in artificial intelligence and data collection could help us decipher the true meaning behind the sounds animals make.



"The idea is for neural networks, AI processes that learn by analyzing data, to match sounds that frequently appear together to find patterns in speech."

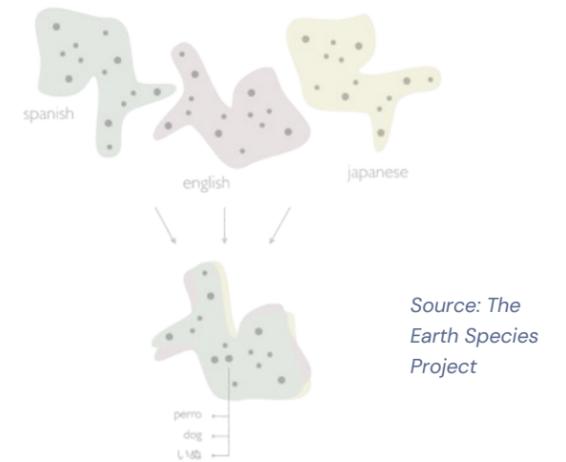
Off the shores of Dominica, scientists at the Project Cetacean Translation Initiative (CETI) have recently applied this to their research of sperm whale codas, specific sounds that the whales make to identify each other. The result? The neural network was able to correctly identify individual sperm whales from a larger dataset 99 percent of the time.

Now Project CETI aims to understand even more of the sperm whale language by using an underwater microphone to record regular vocalizations and feeding them into their neural network. However, this comes with its own challenges: there can be a lot going on in the ocean at a time, and it can be difficult to single out an individual whale's sounds.



With this in mind, in 2021, the Earth Species Project, a nonprofit with a similar mission of applying AI to decipher animal language, built a free open-source neural network able to discriminate between individual animal sounds and filter out background noise. In addition, recent breakthroughs in 2020 have allowed AI to associate shapes that represent text with shapes that represent images with incredible accuracy—something crucial to translating animal communication, which typically involves both vocalization and actions, similar to human body language.

The Earth Species Project also hopes to use AI generated vocalizations to “talk” to animals. They believe that two-way communication will make it easier for scientists to understand the meaning of animal vocalizations, and plan to develop AI models that generate calls to zebra finches to research how they respond. Earth Species Project co-founder Aza Raskin estimates that “in the next year or two... we’ll be able to build this for animal communication.”



Whether they're algorithms trained to translate the facial expressions of dogs or the sounds of pigs, these recent developments have allowed scientists to gain a better understanding of animal behavior. But beyond behavioral research, understanding what an animal is conveying can have other important implications too, from assessing the wildlife-readiness of a captive species to even understanding animals' dreams.

However, in the wrong hands, this new technology can have severe repercussions. Commercial fishers could use it to detect nearby target fish, and poachers could use future “talking” technology to lure endangered species. As Raskin warns, “Every time you invent a technology, you also invent a responsibility.”

Nevertheless, Raskin notes that the use of AI to understand the thoughts and speech of animals will be similar to the invention of the telescope: “We looked out at the universe and discovered that Earth was not the center... These tools are going to change the way that we see ourselves in relation to everything.”



WHY DON'T DREAMS MAKE SENSE?



It's an hour past your usual wake-up time. *You're late!* You rush to class, only to realize everyone is staring ... because you're completely naked. This is a common implausible dream sequence—but why is it that dreams so often don't make sense?

The most vivid dreams emerge during rapid eye movement (REM) sleep, which occurs about 90 minutes into a sleep cycle.

While dreaming, there are a few key areas of the brain that are active, including your secondary visual areas, motor cortex, limbic system and amygdala. The visual areas and motor cortex give your dreams their life-like sensation; you picture people, places, and things, and the dream seems to be a 3D environment. The limbic system and amygdala make your dreams emotionally engaging. There are also parts of your brain that are inactive, namely, the dorsolateral prefrontal cortex. This part is associated with judgment and planning; because it isn't active, these qualities are often lacking from your dreams.

So why, exactly, are dreams so strange? The answer may lie in the way our brain uses dreams. Dreams are a way to connect new memories with old ones, and, from the connections established, better predict how to act in the future. This means your brain is throwing very weakly linked memories together, often resulting in scenes that make very little sense. When you dream, your brain feeds you a limited amount of information about a scenario. It intentionally withholds information about how things will unfold because it needs to know how you'll react next to build a better model and inform your future actions. This is part of their inherent bizarreness—by constantly switching scenes, times, places, and people, your brain pieces together weaker memories with stronger ones, gleaned information from your reactions to observe their connectedness.

Bioluminescence

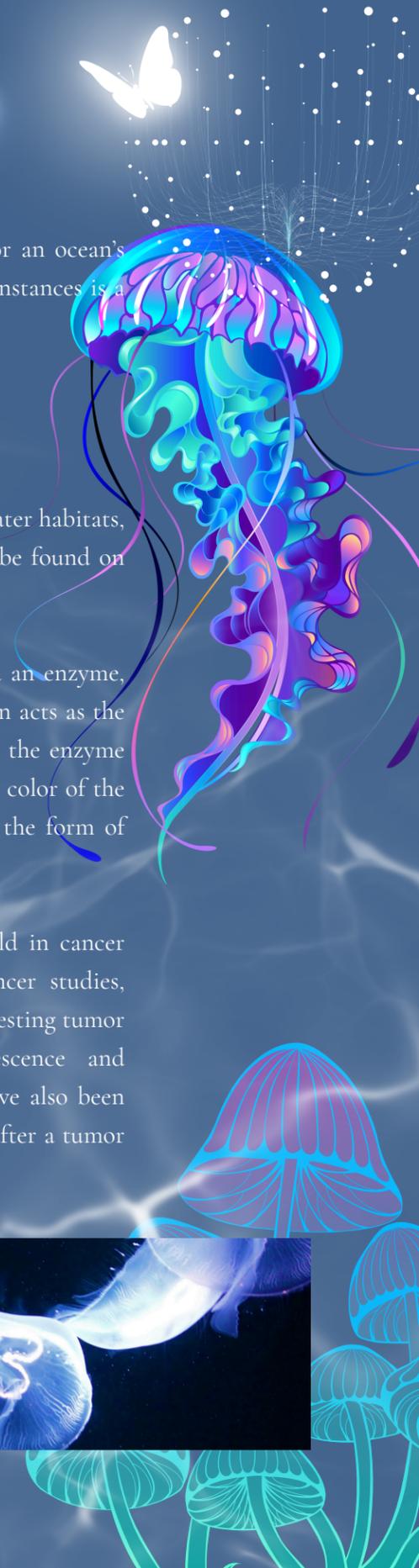
Have you ever seen a swarm of fireflies light up a dark night like stars or an ocean's surface sparkling a bright blue? The radiant, shining light in both of these instances is a natural phenomenon known as bioluminescence.

Bioluminescence is the light produced and emitted by living organisms, resulting from a series of chemical reactions.

Most bioluminescent organisms are marine species exclusively found in saltwater habitats, including jellyfish, fish, and bacteria. Other bioluminescent organisms can be found on land, including fireflies and fungi.

Bioluminescence occurs because of luciferin and luciferase, a molecule and an enzyme, respectively. In the chemical reactions between these two chemicals, luciferin acts as the substrate, which is acted upon by luciferase. Luciferin produces light when the enzyme oxidizes it, and the formation and arrangement of its molecules result in the color of the bioluminescent light. In this process, luciferin molecules release energy in the form of light.

Remarkably, bioluminescence has proven to be useful in the medical field in cancer research, drug discovery, respiratory, and cardiovascular research. In cancer studies, bioluminescence has been able to help with crucial imaging by impressively testing tumor activity through variances in emitted light wavelengths. Bioluminescence and immunohistochemistry—a diagnostic test for looking at tissue samples—have also been used together to determine the effectiveness of cancer drug administration after a tumor continues to grow despite treatment.





THE ETHICS OF CHATGPT



Quickly becoming one of the defining technological innovations of this decade, OpenAI's language model, ChatGPT (Chat Generative Pre-Trained Transformer), has taken the world by storm since its launch in 2022. ChatGPT has been the subject of many different conversations because of its potential impacts on the future of not only artificial intelligence but society as a whole. This prompts the question: what really is ChatGPT? While using the language model itself is simple, it took a lot of work to make ChatGPT what it is now.

How It Works

ChatGPT is known as a large language model (LLM), a recently adopted model in the AI industry. Each LLM has an objective function; ChatGPT's is generating text. These models are trained on large amounts of data, but before data can be fed to them, it must be broken down into units called tokens that allow models to analyze data more efficiently. What is noteworthy about ChatGPT is that it comprises a transformer model, which has the capability to analyze multiple texts at the same time. Models like ChatGPT are trained to analyze tokens and identify patterns among them. The patterns are assigned numerical values called parameters, which are used to keep track of the relationships between tokens. ChatGPT specifically contains hundreds of billions of parameters! According to OpenAI, the information that was fed to ChatGPT came from a number of sources: public information on the internet, information licensed from third parties, etc. After it was trained, ChatGPT was fine tuned using Reinforcement Learning with Human Feedback (RLHF), which helped guide it towards desired outputs through human demonstrations. In the end, this lengthy development process led to ChatGPT's current version, as well as other language models in the field of AI.

The Future of ChatGPT and AI

After the release of ChatGPT, many questions arose about its future implications. People have raised their concerns about a myriad of different issues ranging from the job market to academic integrity. Many well known figures have also talked about their opinions on AI. Notably, Stephen Hawking expressed his fear that AI could mean the end of human autonomy. While companies producing AI models like OpenAI have stated their commitment towards developing this potentially dangerous technology responsibly, these recent progressions in AI still make people worried about the morality of usage. For instance, in 2023, there was an uptick in students that used ChatGPT in their assignments. These students' actions, seen as cheating, created outrage. As a result, schools started adopting AI detectors and even blocking the software. On the flip side, some educators think that ChatGPT could be used to help in classroom settings and in transforming the education system. Ultimately, it will be exciting to see how ChatGPT and the discussion about its ethics change in the future as the technology continues to evolve.



THE TRUTH BEHIND APPLE VISION PRO

On June 5th, 2023 at the annual Worldwide Developers Conference (WWDC), Apple announced their next groundbreaking innovation: The Vision Pro. Commended as the future of virtual reality and society, the Vision Pro was praised as yet another hit by Apple.
At least for the first 2 weeks.



As time passed, the original awe that won over influencers began to die down. There was no purpose in owning the device—not to mention that pesky \$3499 price tag. This, in addition to several other factors, led Apple to make the harsh decision to slash their production by nearly 50% and shelf the planned 2025 edition, practically sweeping this million-dollar invention under the rug.

However, in terms of features, the Vision Pro brought many new innovations to the table. Most of the conversation was around the revolutionary new eye and hand-tracking features. Amazingly, your eyes appear on a screen outside the device, giving the illusion of it being see-through. Meanwhile, the camera records what users would have seen in real life, with the app seemingly floating in space.

We also can't forget the Augmented Reality (AR) technology introduced, as this is what sets it apart from all the other headsets. For most headsets, you go on your computer, download a game, and then BAM, you are in that universe. The Vision Pro, however, is built in reality. You can, if you wish, watch a YouTube video on the go, send a message with your eyes, or play Solitaire while driving (Warning: Do not play Solitaire while driving). . Despite the steep price, the possibilities are endless, and Apple still sold over 200,000 units in the first 10 days. Overall, the Apple Vision Pro is a fascinating device, allowing the further integration of technology and reality.

The Future of Xenotransplantation

World's First Pig Kidney Transplant

Imagine this: the kidney of a pig is now living and performing the normal functions of producing urine and keeping you healthy, all while being supported by the flowing blood in your body. While that may sound unethical or even gross, this is the modern reality of patients who are terminally ill and have to make a heroic choice: whether or not to be the subjects of experimental procedures so that medicine advances for others under similar fates.

Introduction

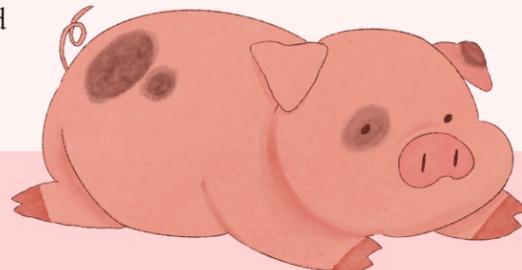
Richard Slayman, a 62-year-old man living with end-stage kidney disease (ESKD), received the world's first genetically-edited pig kidney. Unfortunately, seven weeks later, he passed away from complications. On March 16, 2024, Slayman underwent a four-hour surgery at Massachusetts General Hospital. This event is a significant milestone for the hundreds of thousands of patients still waiting for a miracle donation. It also is a massive advancement for researchers studying xenotransplantation, where animal organs are used instead of human organs, as researchers have long been scrambling to supplement the need for human organ transplant donations.



About Organ Transplants

A procedure involving organ replacement typically occurs when patients suffer organ failure. For example, patients experiencing heart failure may need a heart transplant, those with cystic fibrosis or emphysema may need a lung transplant, and those with deteriorating vision may need a corneal transplant.

To do this, doctors perform a complex medical procedure, which often involves transplants from others who have agreed to donate their healthy organs after they die. These organs, however, must match the patient's criteria. Doctors evaluate donors through three tests: blood type, cross match and tissue typing (HLA typing) to ensure that the patient's organs are compatible.



The process of organ-matching is lengthy, but once the patient receives a match, they must undergo transplantation surgery, an even more complex and lengthy procedure. A team of doctors removes the impaired organ before surgically implanting the new organ. Some organs may even only be viable six hours after donation, further complicating the process. Regular appointment check-ups for the rest of the recipient's life are also necessary to ensure they remain healthy and that the organ is not rejected. Because these organs come from other people, the body views them as "foreign," meaning that immunosuppressive drugs are admitted to help control the immune system from attacking them. This causes many complications, as the immunosuppressants may leave the recipient's body weak and susceptible to infection.

Xenotransplantation

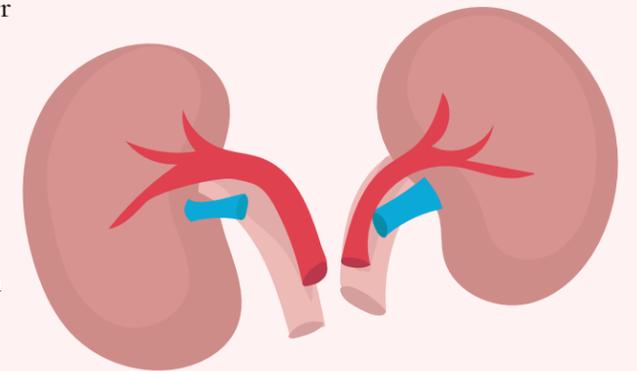
The waiting lists containing over 100,000 people for organ transport can often reach a time frame of 3 to 5 years, sometimes even longer. In fact, seven people die everyday waiting for a miracle organ transplant.

For these reasons, it is no surprise that many scientists have begun exploring alternative ways of organ transplantation. In Mr. Slayman's case, pigs were being used as a potential source. Biotechnology companies usually genetically modify these organs to reduce rejections when implanted into the human body and to reduce the risk of complications and pig diseases.

For the transplant recently performed at Mass General Hospital, the pig kidney was from eGenesis in Cambridge, Massachusetts, and had 69 genomic modifications via CRISPR-Cas9 to protect against porcine endogenous retrovirus by inactivating the genes and adding human genes in place to make the organs compatible with humans.

Mr. Slayman was diagnosed with end-stage renal disease, or kidney failure, and underwent dialysis from 2011 until 2018. He received his first kidney transplant from a human donor at Mass General Hospital but began showing signs of failure five years later, forcing him to restart dialysis. As a result, Mr. Slayman received the procedure under FDA Expanded Access Protocol (EAP), known as compassionate use, to receive treatments when no other treatment options exist.

A carefully selected team of physicians and scientists was chosen to perform the procedure. Many, however, raise concerns about xenotransplantation. For one, the animal organ may carry the risk of infection. There are also ethical concerns regarding slaughtering numerous pigs for this medical procedure. Furthermore, animal organ transplants have all been rejected not long after the procedure. There is no doubt, however, that Mr. Slayman's generosity to partake in this experimental transplantation is a story that offers hope to others in need of organs.



Navigating the Drake Passage



Would you sail 600 miles through turbulent winds and crashing waves to reach a continent without permanent inhabitants? That's exactly what several determined travelers did on their quest to Antarctica through the Drake Passage.

Discovered in 1525, the Drake Passage is a body of water connecting the Antarctic, Pacific, and Atlantic Oceans and is widely regarded as one of the most terrifying bodies of water in the world. To fully grasp the terror of the Drake Passage, it's important to understand its origins.

A split between the continents South America and Antarctica created the Drake Passage. Although named after explorer Sir Francis Drake, the Drake Passage is a misnomer: Drake is not actually the true discoverer. Sir Francis Drake never sailed through the Passage but accidentally drifted near it aboard his ship in 1578. Many feel that the body of water should be named the *Mar de Hoces* after sailor Francisco de Hoces, who is thought to have discovered it in 1525.

Since then, countless sailors have attempted to traverse the dangerous waters for its potential benefits. Many people in the 19th and 20th centuries died trying to cross the Drake Passage for an accessible trading route before the creation of the Panama Canal.

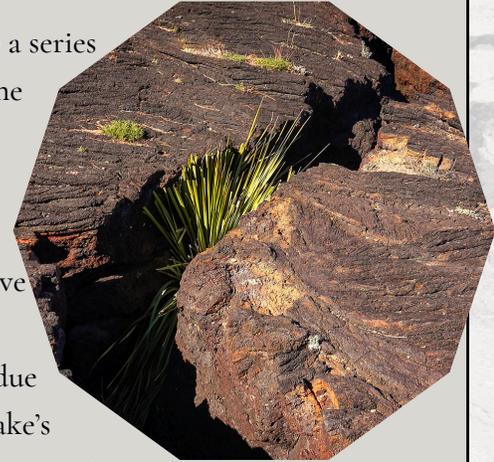
The connection between three major oceans makes the Drake Passage especially unique and contributes to its ability to produce treacherous waves. The Drake Passage is far enough away from land that huge ocean currents along with strong winds are able to steadily move through it without stopping. With no land to serve as blockades against the currents, the Drake Passage is capable of producing waves over 40-feet high. Wind currents surrounding Antarctica can be credited for violent expeditions across the Passage. Sailors have coined nicknames for the extreme currents, including the "Roaring 40s," "Furious 50s," and "Screaming 60s," describing the winds at different latitudes. These winds originate from the Equator but are carried away towards the North and South Poles. Currents moving towards the South Pole results in the drastic conditions around Antarctica and specifically around the Drake Passage.

With a reputation of being one of the most terrifying bodies of water for so long, why has the Drake Passage recently become an area of interest for tourism? The Passage has gained social media popularity, particularly on TikTok. Passengers can board cruise ships starting at Cape Horn, the southernmost point of South America, to the Antarctic Peninsula: a destination for scientists and travelers alike. This trip is the shortest distance from Antarctica to another continent, only taking around 2 days to traverse. However, expeditions via cruise ships can often be scary, with videos online showing passengers struggling to maintain their balance as the ship rattles from side to side. Furniture falling over and waves crashing into windows surely create an exhilarating experience. On the other hand, since the waters are unpredictable, one may even experience calm sailing and an eerie gentleness to the trip, commonly referred to as the "Drake Lake" as opposed to usual the "Drake Shake." Regardless, travelers should still be cautious before crossing these magnificent but frightening waters.

UNDERSTANDING THE TREMORS OF EAST COAST EARTHQUAKES

In early April, many across the northeast United States felt shaking beneath them, especially in New York. So, what caused that?

Though we generally associate earthquakes with the West Coast, where there are a series of active fault lines (where two tectonic plates meet) just off the coast, beneath the East Coast runs a sierra of ancient fault lines, including the Ramapo fault. Stretching from New York down into Pennsylvania and containing a branching network of more minor faults, it was once highly active, serving as a significant player in the formation of the Appalachian mountains. As Ramapo is not an active fault, much of it is unmapped, so it's uncertain if this fault or its tributaries were the source of the recent New York earthquake. Nonetheless, it is a likely culprit due to its many smaller branches, which run into and around the area of the earthquake's epicenter. Additionally, an inactive fault can intermittently become reactivated at any time, so while earthquakes across the northeast seem unlikely, they should not be unexpected.



But how exactly do fault plates cause earthquakes? Tectonic plates constantly move, and their edges get stuck together due to friction. Over time, the friction causes stress to build, and when the fault can no longer handle the degree of stress it is experiencing, energy is released in waves through an earthquake. While most faults on the East Coast are no longer active, stress still grows within them at prolonged rates, occasionally leading to earthquakes. Though earthquakes are less common on the East Coast due to inactive faults, they are felt across greater areas. The rock beneath most of the East Coast is much older, colder, and denser than the rock beneath much of the West Coast, allowing seismic waves to travel much further before dissipating in the form of an earthquake at the Earth's surface. Such is the case with the most recent

East Coast earthquake, which was felt from Boston to Washington, D.C.



BRINGING BACK THE DEAD

300,000 years ago, woolly mammoths roamed the earth as the ancient relatives of the elephants we have grown so familiar with today. Although scientists are not entirely confident in what caused their extinction, whether that was over-hunting or an inability to survive in a rapidly warming climate, one thing is for certain: bringing back the dead is not impossible. At least, that's what Beth Shapiro, the chief scientific officer of Colossal Laboratories and Biosciences, thinks.

De-extinction is “the process of generating an organism that both resembles and is genetically similar to an extinct species by resurrecting its lost lineage,” and it has taken the scientific world by storm in recent years. Animals that humans today cannot even begin to fathom have a chance at being revived with the use of DNA sequence recovery and gene synthesis. Using CRISPR, a genome engineering tool, scientists at Colossal are planning to modify the genome sequence of an Asian elephant from a regular cell by making mutations that mimic the sequence of a mammoth. Shapiro clarifies in a recent interview with STATNews: “We’re not creating a mammoth. We’re taking an Asian elephant and helping it to become something that is more similar to a mammoth by resurrecting the capacity to live in colder climates.” Shapiro’s team has successfully taken elephant skin cells and made them into stem cells: cells that can develop into many different kinds of cells. This was a major technological breakthrough, allowing scientists to create elephant egg cells within a lab rather than take egg cells from actual elephants. Such innovations and methods place Colossal at the forefront of experimental science, but a question is presented: why de-extinction?

This question has sparked what seems like an endless amount of controversy among the science community. Not only do many have suspicions about the practicality of Colossal’s project and what it entails for the future, but they are also concerned with the ethics behind it. Shapiro argues that her team’s efforts are a solution to combat the growing threat of extinction.

With nearly 20% of native land species extinct since 1900 and a third of marine animals significantly threatened, Shapiro and her team believe that our “conservation toolkit” needs to be expanded and modernized. She is confident that the investment of millions of dollars going towards this work is well worth it and helps her team look far beyond the present and into the future. Many, however, do not see it that way. “Why would you even bother trying to save something long gone, when there’s so many things that are desperate right now?”

paleontologist Julian Hume questions. Numerous scientists agree with Hume, finding de-extinction to be counterproductive and ethically wrong. The ecosystems now may not be comparable with an extinct animal’s original habitat and therefore less suitable. It is clear that the divide in the scientific community over where the line should be drawn regarding de-extinction will further intensify, but there is no doubt that Colossal’s efforts at bringing back the dead will mean so much for future generations—for better or for worse.

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Narcolepsy

Head in hand, droopy eyelids, pencil on the paper but strangely not moving—these characteristics are evident of a sleep deprived BLS student. Daytime drowsiness may be a result of staying up to finally submit that one assignment, but could also be a sign of narcolepsy. “Narco” from the Greek root “narke” meaning “numbness” and “lepsy” meaning “seizure,” making the name of the condition, literally, “numbness seizure.”

According to Jazz Pharmaceuticals in 2023, narcolepsy’s five main symptoms are summarized with the acronym CHESS, outlined below. It is important to note that not all five symptoms are present in all patients, as the condition varies from person to person.

Cataplexy - The National Institute of Health characterizes cataplexy as “the sudden loss of muscle tone while a person is awake, lead[ing] to weakness and a loss of muscle control...and is often triggered by sudden strong emotions.” Loss of control can be limited to certain regions like eyelids, but in some cases can affect the entire body. Although this may sound like a seizure, the person notably does not lose consciousness while experiencing cataplexy.

Hallucinations - Hallucinations due to narcolepsy usually take place when the patient falls asleep or wakes up. Scientists have speculated that they may be the visual continuation of a dream after the person has woken up.

Excessive daytime sleepiness - Rather self explanatory. According to the National Institute of Neurological Disorders and Stroke, narcolepsy is a chronic disorder “that affects the brain’s ability to control sleep-wake cycles,” making the person sleepiness-prone regardless of the time of day. This makes everyday tasks such as driving difficult.

Sleep Paralysis - During sleep, the brain will cycle four to five times between two distinct modes of slumber: rapid-eye movement (REM) sleep and non-REM sleep. Within 90 minutes of falling asleep, a person enters REM sleep. People with narcolepsy experience it within 15. During this period, brain waves reach a frequency similar to that while awake: eyes move quickly beneath shut eyelids, and the body is “temporarily paralyzed” while dreams occur. If a person were to wake up during this stage but cannot move, they would experience sleep paralysis that could last anywhere from a few seconds to minutes.

Sleep disruption - Unsurprisingly, with so many symptoms affecting the quality of sleep, frequent wakings are common.



Although the exact cause of narcolepsy is yet to be determined, it’s been linked to abnormally low levels of hypocretin, a brain chemical that maintains awakesness. People with narcolepsy have less hypocretin-producing cells, which may be the result of an autoimmune reaction, when the immune system destroys the body’s own cells.

Unfortunately, there is no cure for narcolepsy, but there are ways to manage the symptoms. Aside from lifestyle changes like taking naps and frequent exercise, stimulants for the central nervous system are commonly prescribed. Patients may also use antidepressants to regulate their serotonin levels, which affects sleep and mood. For the estimated 0.16% of people living with narcolepsy, some days may be a battle between themselves and their fatigue—a battle that we hope modern medicine can one day render obsolete. As for the sleep-deprived student body, there isn’t a cure for your procrastination either. So take care of yourself, even if it means turning in that assignment late.

The Ants Who Farm

As any student of history knows, one of the most distinct hallmarks of human civilization is our ability to farm and domesticate crops and animals. Indeed, the advent of farming allowed for complex civilizations to form, and for the Earth to be able to support billions of people. Agriculture led to innovation and society as we know it today. However, we were hardly the first species to master cultivation; millions of years before the Neolithic Revolution propelled humans into dominance, ants had already started farming fungi and herding insects to feed their community and queen. Across millennia, ants often needed to adapt to scarce resources and harsh conditions. The ingenious ways ants have come together and thrived make them one of the most successful critters on this planet.



Ants are a sociable and hardworking species. Across the forests of the Americas, one can observe orderly lines of workers carrying organic debris back to their nests. A notable example is the leafcutter ant, which, as the name suggests, chews up foliage. These ants do not consume the leaves, but rather bring it back to feed their underground gardens. Over time, a unique form of mutualism has developed between the ants and fungi: the ants feed from specialized structures called gongylidia, the “fruit” growing from the main body, or mycelium. In return, the fungi receive fertilization and can grow. There is evidence that the two sides have evolved together as well. For example, the fungi, through centuries of cultivation, have diverged greatly from their wild counterparts. It no longer has the ability to reproduce sexually, instead relying on ant farmers to transplant part of their body to start a new patch. Likewise, the ants rely on fungi as their only source of sustenance, as they have over time lost the ability to produce arginine, a key protein, themselves. Looking into the genome of these communities, scientists note the ants rely on their crops for a key protein, arginine, having shed the ability to produce it themselves. Due to this dependence, gardens are well taken care of, because in return, ants frequently rid the nest of waste and produce a kind of antibiotic to deter deadly diseases. It is clear that in this symbiotic relationship, neither could survive without the other.

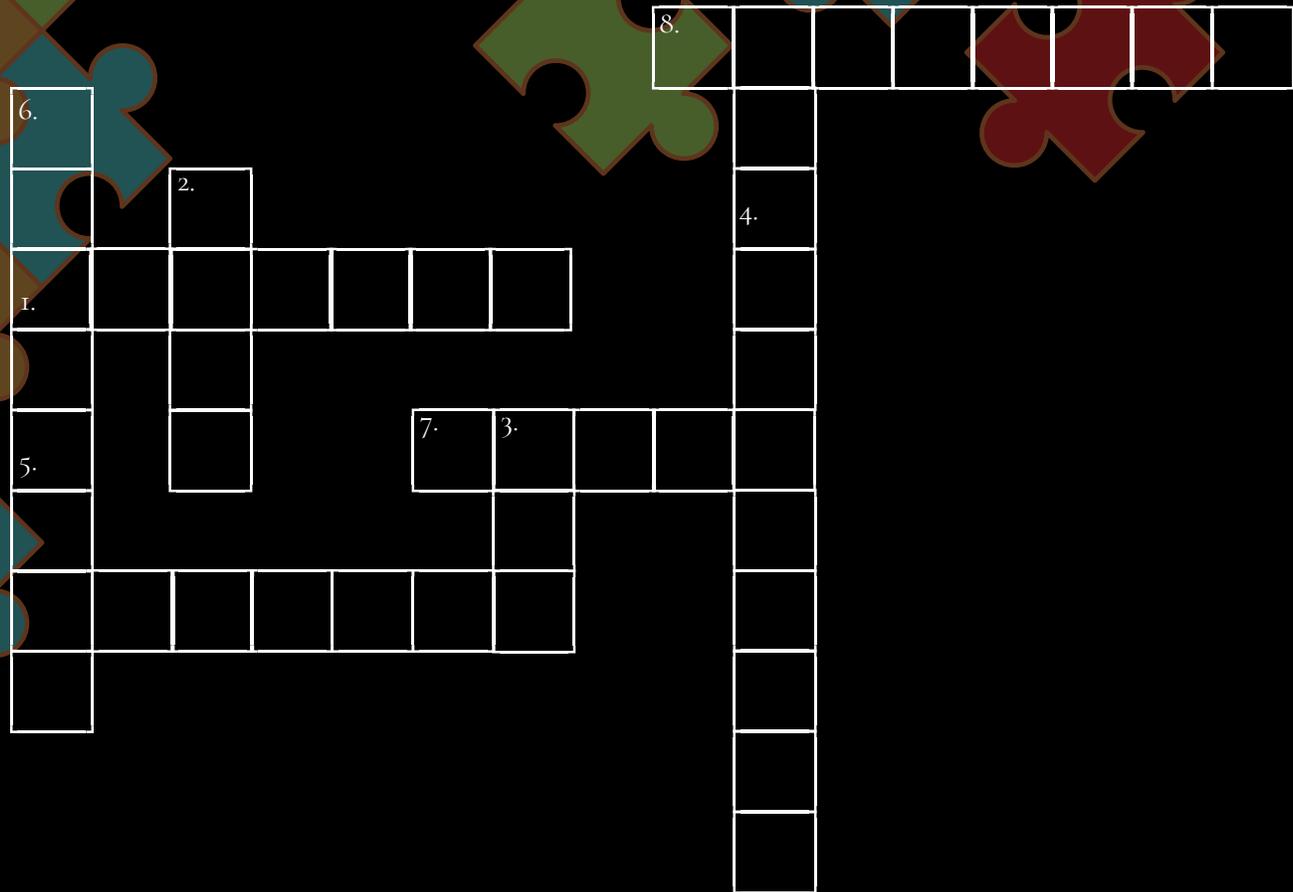
So, why did these insects start farming? It is believed that ants have been farming for up to 60 million years before the Neolithic Revolution. Scientists have extensively researched the complex behavior of these agricultural insects, with DNA examination suggesting a strong correlation between an advanced farming revolution in ants and dryer global climates, as nutrient availability becomes more important through extended periods of isolation.

Another prominent component of human agriculture is animal husbandry. Similar to leaf cutter ants, herder ants utilize aphids to obtain a sugary drink for sustenance. Aphids are insects who suck nutrients from a plant's vessels, or its phloem. They reproduce incredibly quickly and often prove to be a nuisance to farms. For the herder ants, however, the honeydew that aphids defecate are a great source of sugar and proteins, so the ants care for and tend to the aphids. Ants would collect their herds, while the soldiers defend against predators such as ladybugs from attacking the aphids. The flock is guided to better plants and sheltered from weather. Despite the services the ants confer, it's not all sunshine and rainbows for the aphids. For instance, their shepherds regularly tear off their wings to prevent escape and occasionally eat entire individuals. Still, the mutualism that exists between the insects is truly remarkable.

Global estimates for the ant population range around one quadrillion (that's a million billion!) individuals. They are by far the most numerous insects inhabiting the ecosystems of Earth, and for good reason. Although most ants remain foragers and hunters, some have, from the time of the dinosaurs to today, developed extraordinary adaptations to survive. The ability of ants to cooperate with not only their kin but other organisms have made them successful. It's time we give these tiny, industrious critters some respect.



PUZZLE



DOWN

1. What is the cause of hurricanes?
2. Solar system model of an atom?
3. GPE = ?
4. 1969

ACROSS

5. 45, 102.9055 amu
6. Line on a map connecting equal points
7. Plant/flower
8. A fungus