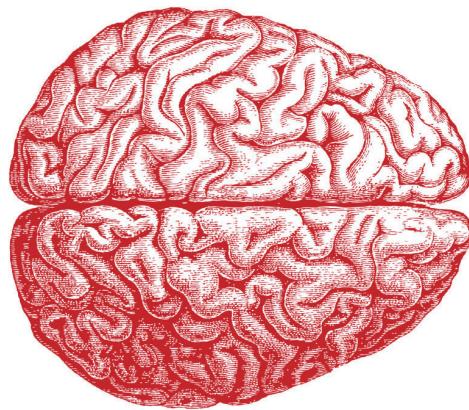
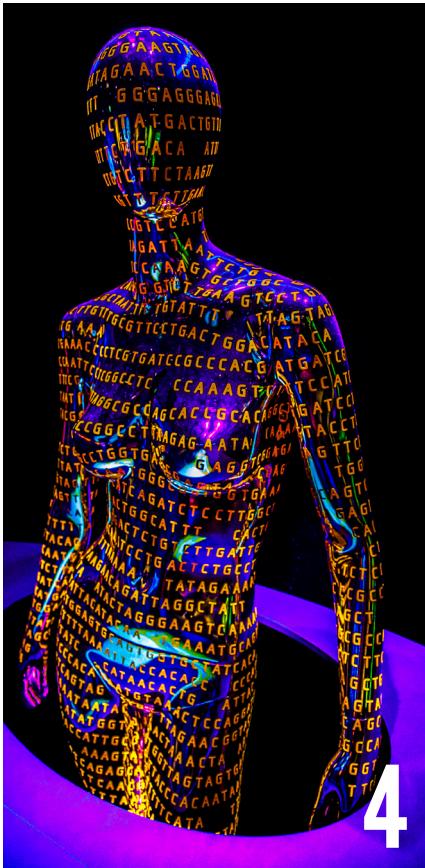


ISSUE 36 Spring 2018

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INTERACTION

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LETTER FROM THE EDITOR

STAFF

Atoms colliding. Scientists collaborating. Species coexisting. Students producing a science magazine.

The list could go on and on. Whether you specialize in one very particular field, are interested in the interdisciplinary nature of many fields, or are curious about the links between science and other fields, this theme is full of endless possibilities of exciting science. And so, I'm proud to kickoff our first magazine of the Fall 2018 semester - Issue 37: Interaction.

We are thrilled this year to have so many talented writers, designers, marketers, and photographers joining our teams. While it may have been a little intimidating to have had over 60 new members fill up the room at our first meeting of the year, we are inspired by the commitment and passion for communicating science to the Northeastern community and beyond. I'd like to give a special shout out to the e-board and our fantastic new president, Jackson Griffiths - this would not be possible without you all.

I would also like to thank Professor David Budil, our new faculty advisor who stepped in over the summer and is excited to get involved and help us share our stories far and wide. Additionally, we are incredibly grateful to the College of Science and the support they continue to show us each semester. It is through their generous contribution this fall that we are able to print this beautiful issue.

In this issue, we hope you'll join us in reading about how gravity interacts with matter, how insects can be the key to solving a murder, how social media impacts scientific advancements, and so much more. If you enjoy searching the night sky for UFOs, check out the article on the attempts to interact with other life forms. If the inner workings of the brain are more your thing, read about Northeastern Professor Ajay Satpute and his thoughts on the mind-brain relationship. Or, if you're reading this to procrastinate studying for that big exam, turn to page 30 to find out how the aroma of coffee can help improve your studying performance.

Our continually growing club, bolstered by enthusiastic new members, had so much to say about science and interaction that we could only fit a fraction of our incredible content in this print issue. However, we are lucky to have an excellent web team that publishes all our work at nuscimag.com. If the interactions you find here aren't enough, there are over 30 more web-exclusive articles that you can find online!

And with that, I sincerely hope you enjoy what we have in store this issue.



A handwritten signature of the name "Sage Wesenberg" in black ink.

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Jackson Griffiths

EDITOR-IN-CHIEF

Sage Wesenberg

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Cover Design by Gwen Friedman

HOW YOUR ENVIRONMENT AFFECTS YOUR GENES: THE EPIGENETIC LANDSCAPE

BY LUCAS COHEN, BIOLOGY, 2018

DESIGN BY KAI GRAVEL-PUCILLO, ENVIRONMENTAL SCIENCE, 2021

We like to envision our genome as a static code – a set of finite, immutable instructions that build us from the ground up and remain consistent whether they work with us or against us, at least until gene therapies become routine. The biological reality, however, is that this code is far more dynamic than this simplistic understanding allows.

Even when the sequence of DNA bases that make up a gene in two different organisms are identical, those two organisms might express entirely different phenotypes. This notion forms the basis of epigenetics, a field now widely broadcast that explores the origin and consequences of modifications to gene expression emerging not from changes to the genetic code itself, but from a number of factors that, in highly anthropomorphic terms, sit on the genome. These epigenetic modifiers occur as an inevitable result of both exposure to various environmental stressors and inheritance. The nauseating significance of these processes is this: the decisions made during one's lifetime might impart noticeable and heritable changes to their DNA.

Geneticists have long maintained that lifestyle choices and environmental characteristics have conspicuous effects on gene expression – the mechanisms of which are, indeed, well-understood. DNA methylation and histone modification are perhaps the most prominent epigenetic markers. Methylation implies the addition of a methyl group at the 5' position in cytosine by DNA methyltransferases (DNMTs); within gene promoters, methylation usually causes gene repression. Though DNA methylation occurs naturally throughout development, environment can also impart changes to methylation patterns. Diet, for example, has been broadly cited as a regulator of methylation-based epigenetic change. Some research has demonstrated that various polyphenols, micronutrients derived from plants, modulate DMNT activity. This seems especially evident in the context of cancer, where polyphenols may inhibit DMNTs in a manner that prevents or even reverses malignant transformation.

Histone modification, on the other hand, is a broad term that encompasses several changes that occur in histone proteins, the structural units responsible for packing DNA into chromatin. These changes in histones have the potential to regulate chromatin structure in a manner that leads to alteration in transcription, the process by which DNA is copied into RNA. Histone modifications like acetylation by histone acetyltransferases (HATs) promote gene

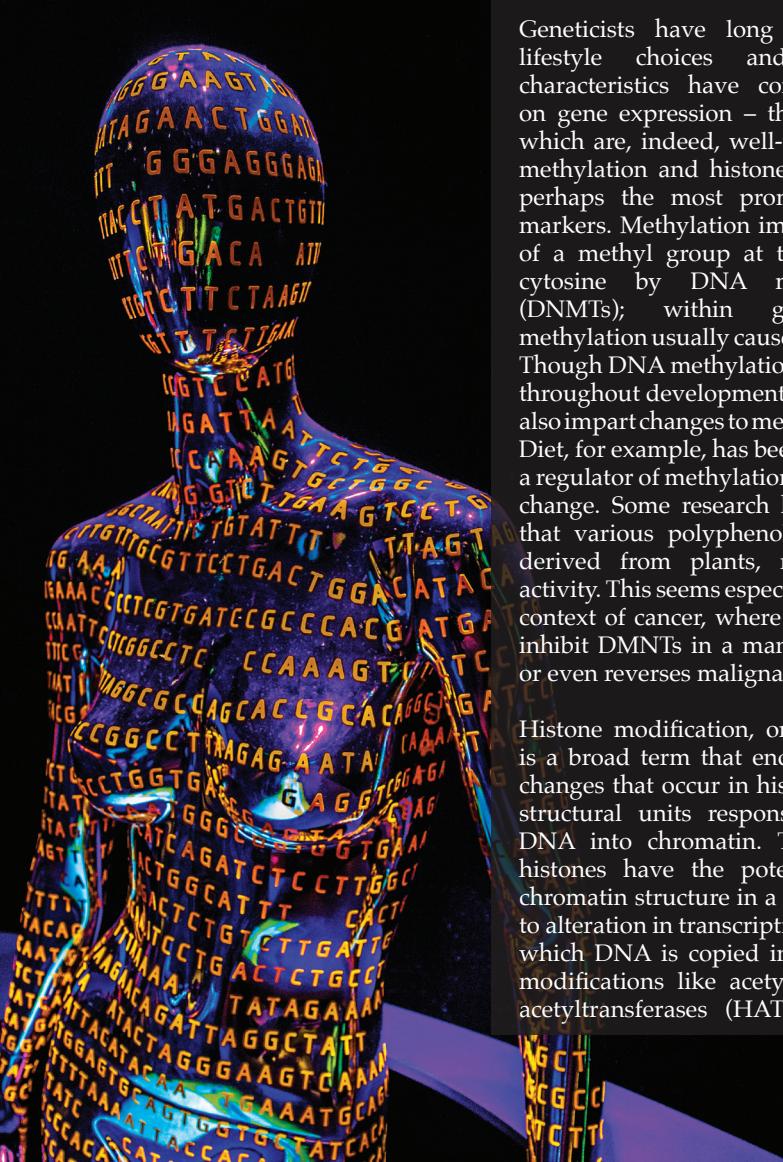
expression by essentially unravelling chromatin from its histone moorings, leading to transcriptional activation. Histone acetylation has been identified as a key component in addiction formation, such as nicotine-associated acetylation at the FoSB promotor in the brain, known for its role as a "molecular switch" in the development of addictions.

Of course, other types of molecular machinery can also influence epigenetic change. Last year, researchers at the Salk Institute for Biological Studies harnessed a version of CRISPR-Cas9 (a hugely-influential gene editing tool derived from a bacterial immune system) to modulate epigenetic changes in mouse disease models with a mild form of Duchenne muscular dystrophy (DMD). Typically, Cas9 is directed to regions in the genome by synthetic guide RNAs (gRNAs) to induce double stranded breaks in DNA as a means of adding, removing, or otherwise adjusting genetic information. The Salk researchers, however, fused multiple transcriptional activation domains to a

“The decisions you make during your lifetime might impart noticeable and heritable changes to your DNA.”

complex of gRNA and a catalytically-inactive version of Cas9 known as “dead” Cas9 (dCas9). By packaging gRNAs into adeno-associated virus (AAV) vectors and injecting these vectors into dCas9-expressing mice, the researchers were able to achieve target gene activation that relieved the symptoms of DMD. In essence, the researchers used a mode of epigenetic control of gene expression as a tool for creating an effective gene therapy.

This research represents an important step in the realization of epigenetic therapies. Modulation of the epigenome using methods analogous to those used by the Salk researchers could be implemented as a means of broader regulation of gene expression, meaning we might one day live in a world where harmful epigenetic change can be ameliorated or beneficial epigenetic change occasioned. Should we choose to expand this field of research, the epigenetic consequences of poor lifestyle choices or unwilling exposure to harmful environments might be curable.



Experiences to epigenetics:

Debunking “nature vs. nurture”

BY DENNY TRUONG, CHEMICAL ENGINEERING, 2020

DESIGN BY EMMA ESTBERG, COMPUTER SCIENCE AND DESIGN, 2023

What makes people the way that they are? Is it their personalities, their behaviors, or their medical conditions? Is it their genetic makeup or is it their upbringing and surroundings? The debate between nature and nurture has been fierce within the scientific community, with researchers fighting to see which of the two components are more responsible for the development of human beings. However, a stunning study posed a new possibility – what if nature and nurture are interconnected?

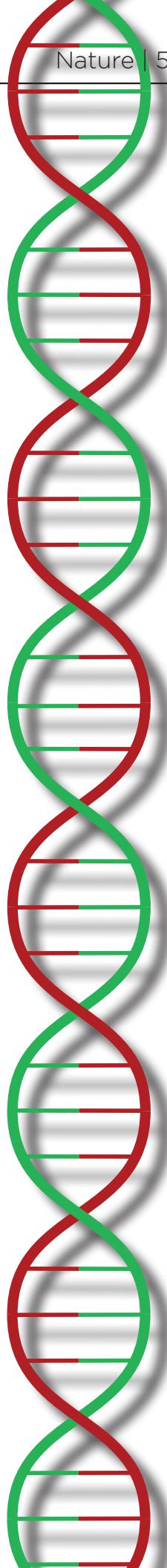
“Nature” refers to every individual’s genetic information – the 23 pairs of chromosomes that were inherited from our parents – that gives each human being unique characteristics, such as skin color, eye color, and height. On the other hand, “nurture” refers to the social surroundings and experiences that each person goes through. Previously, these two components were thought to work independently to contribute to the behaviors and personalities that differ from person to person. However, Tracy Bedrosian and her colleagues at the Salk Institute published a study in which they found a correlation between early childhood experiences and genetic changes. Therefore, it is possible for experiences to directly lead to changes in our basic genetic makeup. In the study from early 2018, Bedrosian and her fellow scientists assigned and observed two groups of mice pups: one received high, quality maternal care provided by its mother, and one received low, poor maternal care provided by a stranger mouse. They then examined the brain of each mouse for genomic changes.

The results indicated a clear negative correlation between maternal care and the genome’s mobile DNA component called retrotransposon, specifically long interspersed nuclear element 1 (LINE1). Retrotransposon are segments of DNA that can be copied and jumped into an existing DNA sequence. In mice with poor maternal care, the amount of retrotransposon increased in the limbic structure of the brain, especially in the area responsible for memory, known as the hippocampus. In mice with high maternal care, retrotransposon amounts were significantly lower. In addition, there was also a correlation between the number of DNA methylations – a process that is key in expression and regulation of certain gene sequences – and maternal care, with low maternal care corresponding to decreased methylation.

The effects of the changes in retrotransposon and methylation processes are still relatively unknown, and so is the effect of a changed genome in behaviors. However, with this discovery, there is evidence that suggests an interaction between nature and nurture, a feedback loop thanks to the brain’s amazing plasticity. The discovery offers insight about several disorders, such as ALS, where the disease is linked to the regulation of these mobile DNA segments. Bedrosian’s research offers hope that some genetic disease can be managed by care and support that the patient can receive.

At the very least, it settles the longstanding debate; it is not nature versus nurture, but nature *and* nurture.

DOI: 10.1126/science.aah3378



The aftermath of an amphibian apocalypse

BY GWENDOLYN McMANUS, MARINE BIOLOGY & ENVIRONMENTAL SCIENCE, 2022

DESIGN BY MICHELLE LEE, DESIGN, 2019

On September 23, 2004, biologists in the El Copé region of Panama found a frog with a fungal infection. By the next February, this infection—known as chytridiomycosis, or chytrid fungus—would kill half of the amphibians in the region. By 2008, more than 40 percent of those species would be locally extinct.

The fungus behind chytridiomycosis, *B. dendrobatidis*, had been on scientists' radars since 1998, when it was identified as the culprit behind the mass amphibian die-offs that had been occurring across the globe for several decades. Affected animals grow lethargic as the fungus spreads, until their skin thickens and starts to slough off. The loss of function in such a vital organ, which in amphibians is responsible for taking in water and maintaining electrolyte levels, causes cardiac arrest and death within a few weeks. As far as the scientific community is aware, it has already driven nearly 200 species extinct.

The situation in El Copé was no less severe than it had been elsewhere, with one small caveat: by the time chytridiomycosis reached Panama, its spread was being monitored. Biologists in El Copé knew that the fungus would eventually hit the region, and had spent years studying the local amphibian populations in preparation. In-depth knowledge of the healthy community was crucial to their research both during and after the outbreak.

A study published on October 3 in the journal *Ecological Applications* is the culmination of some of this work, and it offers hopeful news for the damaged ecosystem of El Copé: the remaining frog populations are stabilizing, with some species even increasing in number. It is not because chytrid fungus is gone; the pathogen is still widespread, and as virulent as it was in 2004. It is because of the frogs themselves, and something the study's authors call eco-evolutionary rescue. Tests indicate that frogs living in El Copé now are able to tolerate infection with chytridiomycosis because the mucus secreted by their skin inhibits fungal growth, an evolutionary response by the species that were more able to resist the infection during the initial outbreak. Scientists hope that something similar is happening in other areas affected by the fungus; if so, it may be a good sign for the future of amphibians worldwide.

"It is because of the frogs themselves, and something the study's authors call eco-evolutionary rescue."



THE BUZZ ABOUT BEES

BY SINAIA KEITH LANG, BIOLOGY, 2022
DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

Beans? While a popular 'Cards Against Humanity' answer, European honeybees are also known in the animal behavior community for exhibiting one of the most popular animal communication methods: the waggle dance. With this routine, honeybees can communicate to unemployed bees in the hive where the best nectar is with high accuracy.

The waggle dance communicates the direction and distance between the hive and the nectar during the "straight run" (central horizontal line) of a figure-eight motion. The number of waggles and the duration of the straight run indicates how far away the nectar is. The angle of the straight run in relation to the vertical hive surface is the same as the horizontal angle between the sun and the nectar relative to the hive. The angle has an average error of only three degrees! Colonies without this dancing ability harvest 40 percent less nectar than those with functional waggle dances. 'Cards Against Humanity' should really change the question mark to an exclamation point!

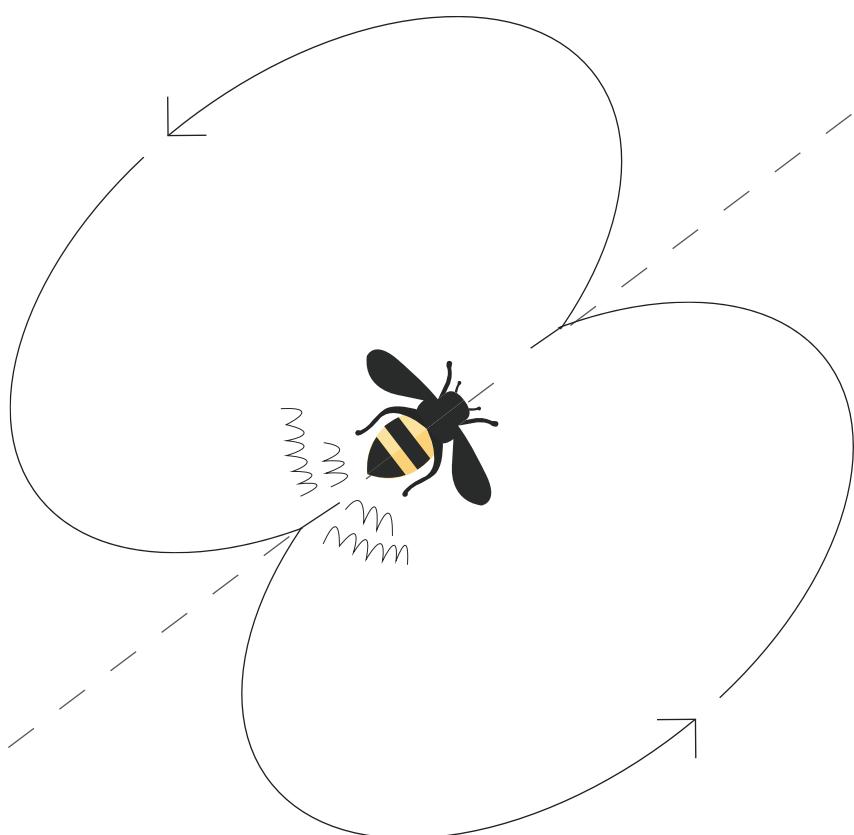
When the best nectar is within 200 meters ($\frac{1}{8}$ of a mile) of the hive, returning bees perform the round dance instead of the waggle dance. This entails dancing in a path that resembles yin and yang being pulled apart. During this dance, the returning bee passes out a sample of the nectar to the other bees so they can more easily identify the nectar when they get to it.

Dances also play a role in colony alarm when the hive is threatened. Upon detecting a threat, an Asian honeybee will emit a very short vibratory signal to warn nearby foraging bees. The frequency of the vibration directly correlates to

the level of danger the threat poses. This was one of the first communication methods observed in a super-organism (bee colony) that discouraged a behavior instead of encouraging more of a behavior, like the waggle dance does. If a hornet, which can kill 40 bees in a minute, manages to enter the hive of Japanese honeybees, the bees will swarm it and vibrate, generating an incredible amount of heat until their collective temperature is just two degrees below the maximum temperature they can withstand, which is one degree higher than the invader's threshold. Essentially, the hornet gets burned alive, thus preventing the location of the beehive from being communicated back to the hornet colony.

Bees are crucial to life on Earth - they pollinate the crops that feed about two-thirds of the human population. Should honeybees go extinct, the plants that they pollinate would die, as would every animal that feeds on those plants and all the animals higher up on those food chains. Between pesticides, climate change, habitat loss, pests, and the so-far inexplicable Colony Collapse Disorder (CCD), bee populations are extremely threatened today. While the causes of CCD are still being investigated, colonies affected by it typically have relatively abundant nectar reserves, so it is unlikely that it is related to the waggle dance. Even so, CCD impacts a strikingly large number of hives and is a major cause for concern.

Spreading the word about how essential these awesome creatures are helps bring attention to the plight they are facing. With increased awareness comes more research and more ideas that can help bees save the world. So next time you see a really pretty flower, wiggle a little in solidarity!



When the nectar in question is more than 200 meters away from the hive, honey bees will perform the waggle dance to communicate the location of the source of the nectar to the other bees.

New study finds link between forest conservation and coral reef preservation

BY BINH DANG, BEHAVIORAL NEUROSCIENCE, 2022

With over 90 percent of the Great Barrier Reef already damaged, and large percentages of coral reefs worldwide faring the same, the future doesn't look promising for these stony polyps. Climate change has pervasive impacts on all of Earth's ecosystems—especially on the coral reefs of the world. It causes ocean warming, which bleaches corals since they can only survive in a small range of temperatures over a long period of time. It also alters precipitation patterns, and that increases the amount of sediment and land-based pollutant runoff into the ocean—another threat to coral reefs. However, scientists are continuing to look for solutions to prevent further loss of reefs and even reverse the negative impacts of climate change on them.

One such solution has been proposed by researchers at the University of Hawaii at Manoa and the Wildlife Conservation Society who have found a link between forest conservation and coral reef preservation. In a study published in August 2018 in the journal *Scientific Reports* Dr. Jade Delevaux and her colleagues indicate that by identifying priority areas on land, both conservation and preservation efforts at those sites can have a cascade effect by yielding highly beneficial effects for downstream reefs. In other words, the location of conservation efforts on land can amplify pre-existing conservation methods' effects on both land and sea.

For their study, the researchers chose sites in Fiji, with a particular focus on the Kubulau District on the southern part of the island, to monitor the effects of human activity on marine ecosystems. This area was chosen because logging and commercial agriculture compete with forest conservation and the potential livelihoods of fisheries. Therefore, the district is a strong model for observing the effects of site-specific conservation efforts as well as the detrimental effects of human development. Traditional conservation methods manage the conservation efforts on land and sea separately. The integrated conservation practice of the study considers the beneficial and detrimental effects of conservation on land at critical sites with respect to the downstream effect on coral reefs.

Multiple scenarios were modeled using InVEST SDR sediment delivery framework as well as geographic

DESIGN BY KRISTINA KLOSOWSKI, BEHAVIORAL NEUROSCIENCE, 2022

information systems (GIS) models. These scenarios include traditional conservation, deforestation, and integrated land-sea conservation practices. The two conservation scenarios showed gains in fish biomass and habitat quality, which are predictors of coral health, while the deforestation scenario predicted great declines in both. The conservation and deforestation impacts on the terrestrial sites near the coral reefs in Fiji led to an integrated land-sea model for reef preservation. The proposed land-sea framework accounts for sediment export, topography, coral reef predictive models—based on area survey data, current conditions of reefs, and fish biomass—and marine drivers such as waves and tides.

These factors amplify the harmful effects of human activity, specifically commercial agriculture, logging, and land development. These actions all increase sediment and nutrient runoff into the ocean, which kill coral and in turn the organisms that rely on them. In a statement published by the Wildlife Conservation Society, the lead author of the study, Dr. Delevaux of the University of Hawaii, said:

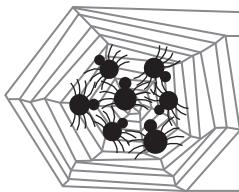
"This novel tool relies on two freely available software packages and can be used in open access geographic information systems (GIS). As more and more remote sensing and bathymetry data become freely available to serve as data inputs, the model can serve even very data-poor regions around the world to allow for better management of linked land and sea areas."

The findings in Fiji and the new integrated model can be applied to other islands in the Pacific and can inform policy makers on decisions to promote effective coral preservation and reef resilience. The dwindling populations of corals are partially a byproduct of negligent human development, which is itself a byproduct of a lack of planning tools for decision makers. The model of this study is a promising decision-making asset for productive changes to development and restoration efforts.

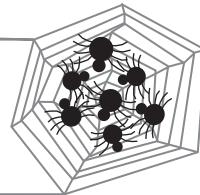
Despite the low odds of coral survival in the future, there may be some hope to slowly build up the populations in the Pacific. Any chance of coral growth, no matter how slow or small, is still an improvement from the decline they experience today.

DOI: 10.1038/s41598-018-29951-0

PHOTOS BY FLICKR



SOCIAL SPIDERS



BY KAELEN ENCARNACION, BIOLOGY AND ENGLISH, 2021

Picture the connectivity of our world: billions of tiny lines of communication spanning across the globe, allowing us to interact with the rest of the world's population and work together as a comprehensive international network. Now, like the wild premise of a horror movie, imagine those lines are the threads of a massive spider web.

Although spiders are generally considered to be solitary and sometimes aggressive to their own kind, there are approximately 25 species that live in communal nests, as would bees in a hive or ants in a colony. Not to be mistaken with the few hundred species of colonial spiders, who live together in a large web, but defend their own territory, catch their own prey, and breed independently, social spiders actually work together in the web to hunt, breed, and raise their young as a community, which can range from dozens of members to tens of thousands.

Much ethological research has been done on the varying behaviors of these spiders, which has yielded interesting results. Spiders who live in these communal webs have been found to play specific roles for the good of the community, or as they have often been referred to, "personalities." In one study published in July 2014 from the University of Pittsburgh, Colin Wright and his team of researchers focused on the behavioral patterns of a well-known species of social

DESIGN BY EMMA ESTBERG, COMPUTER SCIENCE AND DESIGN, 2023

spider, *Anelosimus studiosus*. They found that "animal personality aligns task specialization and task proficiency in a spider society."

In this matriarchal colony, approximately 50 individuals gather to spin a large communal web, with the females generally falling into two personality types: docile or aggressive. Docile females take on a parental role, watching over the eggs and feeding the young, similar to how a mother bird would care for her hatchlings. Aggressive females, conversely, are responsible for building the communal web, catching prey in groups, and defending the nest. Strangely, these different personalities are not necessarily determined by the size or build of the spider, but are simply "known" by the spider the moment they are born. While it is not clear why they have this instinctual sense of their own personality, it is believed to be largely inherited.

While more research is needed to fully understand how these spiders naturally fall into this hunter-gatherer dichotomy and how they interact with other personalities, these studies have helped provide some important insights into the complex interactive networks of these scary yet misunderstood creatures.

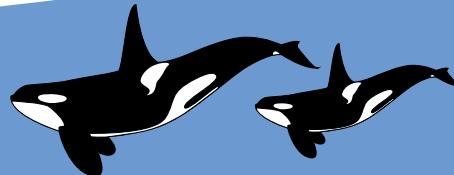
DOI: 10.1073/pnas.1400850111

AN UNBREAKABLE BOND

BY TAYLOR MANNES, MARINE BIOLOGY, 2020

Within the northern Pacific Ocean, the Southern Resident Killer Whale (SRKW) population has been declining the past couple of decades, to the point of endangerment. The SRKW population, made up of three distinct pods and approximately 75 individuals are spotted around Washington and the south-west coast of Canada fairly frequently. Around 25 percent of their population has been lost since the mid 1990s, with about 66 percent of population pregnancies unsuccessful. Of those, 33 percent end in the late stages of pregnancy or immediately after the calf is born.

This summer, a calf was born to a SRKW orca named J-35, a 20-year-old orca who has an 8-year-old son still living in the pod. Following a previously unsuccessful pregnancy, J-35's new calf was born in July, the first healthy calf to be spotted in the area in several years. Within a half hour of the calf's first sighting, it had died. J-35 continued to carry the dead calf around for 17 days. It's not uncommon for these "tours of grief" to occur, especially in dolphin populations, but they usually only last a few hours or a couple of days. No one knows whether dolphins and whales have the ability to conceptualize death, but the behaviors of J-35 and others



further the idea that they can feel grief. They are social creatures and exhibit altruistic behaviors, most famously by saving humans under the threat of sharks. To researchers, it seemed plausible they are willing to sacrifice themselves for their own kin.

Orca pods are matrilineal, which means individuals like J-35 are responsible for organizing hunts and travel. Scientists began to grow worried when J-35 was expending tons of energy to keep her dead calf afloat. If she sacrificed eating, the rest of her pod would suffer too. J-35 would pause to rest, dive to recapture the calf after it had slipped, and circle back to keep it within her reach. After 17 days, and over 1,000 miles, J-35 was spotted hunting with the rest of her pod, resuming normal behavior and health.

Whatever the reason that dolphins and whales risk their own wellbeing to help others, it's clear that their social circles are vital. Having carried her calf in utero for 17 months, J-35's mourning behavior suggest a special, innate bond between mother and child that extends past the social fabric of that killer whale population.

Local compost company flourishes

BY HANNAH BERNSTEIN, JOURNALISM AND ENVIRONMENTAL SCIENCE, 2021
DESIGN BY IAN PROULX, BIOENGINEERING, 2023

When Emma Brown was growing up in small-town New Hampshire, her community switched to a pay-as-you-throw system, where town residents were charged per bag for their waste. Rather than paying to throw out food waste, Brown's family decided to compost.

"When that program went into place, my mom was like, 'Alright. We're going to compost,'" Brown said. "We staked out a little spot in our backyard on the edge of the woods and put up some chicken wire."

In college at the University of New Hampshire, her apartment-style dorm had a compost system, so she made all her roommates compost their food scraps. After graduating four years ago, she moved to Boston looking for work. By chance, she found Bootstrap Compost, a local compost service. She began working shifts picking up waste bins from downtown offices, and after a lot of hard work, she's now their director of operations. Brown's been composting for a long time.

She'll also be the first to tell you why composting is so important.

"Bootstrap — and composting — are a really easy, cost-effective way to reduce your overall carbon footprint,"

Brown said. "By making compost and applying compost, you're actually creating the ability to absorb more carbon from the atmosphere so you can reduce greenhouse gas emissions."

All of that comes down to how compost works — surprise, it's not all about worms. Actually, Brown said, worms are picky eaters, and aren't the best option for creating quality compost. Instead, compost is a controlled breakdown of organic materials. Organic, Brown defined, just means it was once alive.

Bootstrap sends most of their compost to Rocky Hill Farms in Saugus, an industrial compost facility. Unlike some small-scale farms, Rocky Hill can compost difficult items, like compostable plastics, bones, meat, or seafood. Every weekday, Bootstrap brings two tons of waste to Rocky Hill. That's 4,000 pounds, five times a week.

• • • • • • • • •
 • **“It's a living,
breathing
process.”**
 - Emma Brown
 • • • • • • •

Composting is more complicated than throwing banana peels and carrot skins in a bucket and waiting for dirt to appear. Good compost must be monitored like any chemical reaction. It's a mixture of carbon feedstock like wood chips or dried leaves, with nitrogen feedstock like manure or fresh plant clippings. Without enough of each type, the compost won't be as high-quality.

"It's a living, breathing process," Brown said. "To make it work, you have to introduce air, which is turning the compost pile. If it gets too hot, sometimes you have to introduce moisture — water. And you monitor the conditions of the pile."

Once the chemical reaction between

the nitrogen and carbon components heats the pile to 130 degrees Fahrenheit and sustains that over multiple weeks, the compost has successfully reached the pathogen kill temperature. The pile can then be used on crops.

"It looks like dirt, tastes like dirt, smells like dirt," Brown said. "It's a soil amendment, so it shouldn't be used as a soil by itself, but it's really rich in nitrogen, phosphorus, and potassium. That will help add nutrients to the soil and plants."

But composting is hard in a city like Boston, where the majority of residents live in apartments without a backyard. Even an accessible strategy like freezing scraps to minimize odor and then taking them to a compost drop-off is difficult without large freezers. However, there are still a few options for college students looking to begin their own compost, and Bootstrap is one of them.

"We're a really easy, no-hassle solution," Brown said. "We give you a clean bucket, all you have to do is put the food scraps in the bucket and put your bucket out on the steps. We'll do the rest."

The City of Boston also operates a compost drop-off program, with public bins in East Boston, the North End, Brighton, Jamaica Plain, City Hall Plaza, and Grove Hill Plaza. While these are great options for first-time composters, the bins don't accept meat, bones, fish, or cheese, and it's only a pilot program. Across the river, Cambridge recently instituted a free curbside compost pickup for eligible units, and drop-off locations for those outside the program.

Whatever composting method people choose, Brown said making quality soil is the most important part. By returning food to where it originally came from, people can reduce the harmful effects of climate change in an individual way — and lots of people doing the same thing can make a big impact.

"People don't really understand the full effect of compost and healthy soil yet," Brown said. "It's getting there. Soil is getting its moment."

FORESTS OF THE FUTURE:

How a changing climate impacts trees

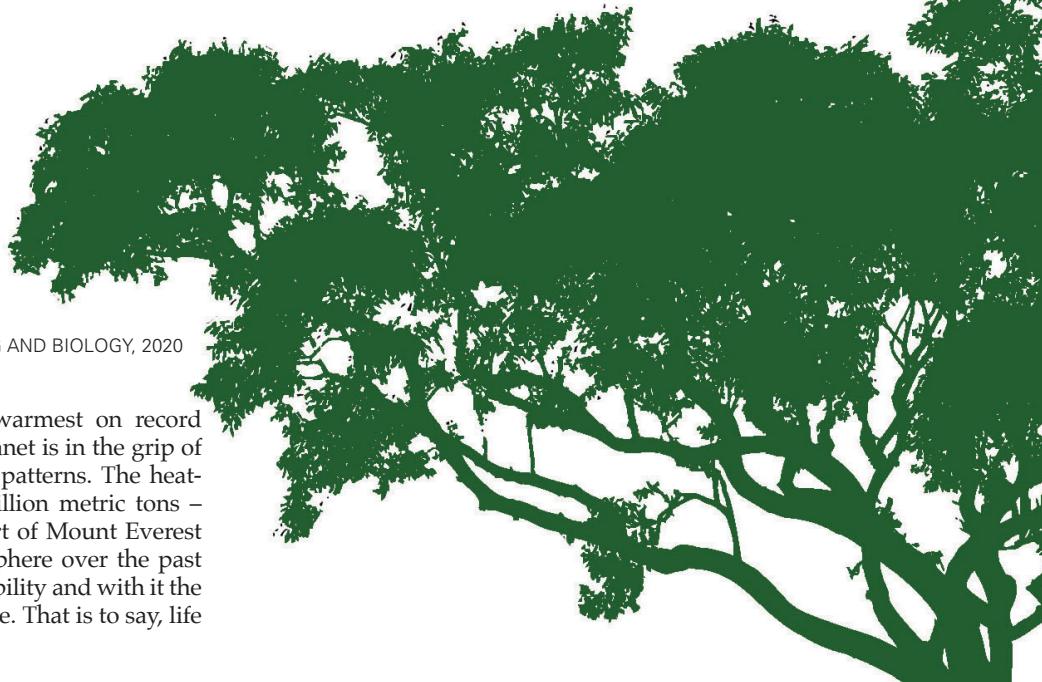
BY DAVID ROSENBERG, CHEMICAL ENGINEERING AND BIOLOGY, 2020
DESIGN BY KATIE GREEN, BIOENGINEERING, 2021

As this past summer – the fourth warmest on record across the U.S. – reminded us, the planet is in the grip of dramatic changes in global weather patterns. The heat-trapping capacity of the roughly two trillion metric tons – about 12 times the mass of the rocky part of Mount Everest – of CO₂ we've pumped into the atmosphere over the past 150 years is ending a period of relative stability and with it the current structure of ecosystems worldwide. That is to say, life as we know it.

Trees may seem indifferent to their immediate surroundings, but their growth and survival depend on many factors, including temperature, humidity, groundwater levels, soil nutrients, light, and attack by insects. Their size and slow growth mean that any changes take a long time to become noticeable. The impacts of climate change aren't easy to predict, either. Carbon dioxide release could follow many trajectories, and it interacts with a highly complex and varying system of air and water currents in ways that are not fully understood. However, there is a consensus that most regions of the world will experience rising temperatures and more frequent and severe fires and storms. Dry places will become drier and wet ones will become wetter with more frequent flooding.

This is especially concerning for forests, since trees have huge water demands and comparatively little ability to store water or adjust to dryer conditions. When water is plentiful, trees invest in structures that allow them to gather more light and carbon for growth. However, the pores that allow CO₂ in also allow water out when the humidity drops. Eventually, trees are forced to shed leaves and branches, reducing growth and making them more vulnerable to other factors. Severe water loss creates gaps in the channels that carry nutrients between roots and leaves, killing the tree. Although trees can cope with water loss in the short term, sustained or frequent drought reduces their resilience. An estimated 70 percent of all forest species are vulnerable to drought. This is already starting to show, as forests in Catalonia, Italy, and California have seen losses in warmer regions, and large die-offs tens to thousands of square kilometers in area are expected to become more frequent over the next century.

While heat and drought kill off forests, storms and fires may make them more dynamic. As trees grow, they take up space and light required by newer saplings. In well-established forests, the death of an older tree allows those under it to grow rapidly and compete for the space it leaves. Events that clear portions of the forest spur overall growth and reduce the dominance of aggressive species. In such circumstances, a higher frequency of storms and fires would increase the diversity and growth of forests. This can help them weather



drought if different species draw water from different depths. However, in forests that already have a healthy mix of species or if such events become too frequent, fires and storms could have the opposite effect by preventing slower-growing trees from establishing themselves.

In the long term, changing weather patterns will replace current species with those better able to survive the new local conditions. As temperatures rise and water becomes scarce, drought-hardy species such as scots pines in northern Germany and lemondrop mangosteens in parts of Panama are expected to become more common in their respective habitats, while thick-barked, fire resistant, and fast-growing species such as the Siberian larch are predicted to flourish in much of Russia. By 2300, New England may see its northern spruce and fir forests replaced by warmth-loving varieties of poplar, pine, and oak. Species of all kinds are expected to migrate north and upward as temperatures rise, and to some extent this will be true for trees but the entrenched nature of many forests and the long-time scales of tree growth mean that many populations may not be able to keep pace.

In forests under human management, steps are being taken to best prepare woodlands for the changes ahead. Hardier trees can be planted where they will thrive under the new conditions, more diverse plantings are replacing uniform forests, and assisted migration strategies allow species that adjust too slowly on their own to survive by shifting northward. Ultimately, however, there is a large degree of uncertainty in our understanding of how different regions will be impacted and the effects of heat, precipitation, and natural disasters will interact with many other factors that are changing as the world becomes hotter and more industrialized.

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Pollen allergies on the rise

BY JOHN DROHAN, BIOLOGY 2019

Spring is a beautiful time, the birds start chirping and the early bloomers make their first flowery appearance. Unfortunately so does pollen. People everywhere suffer from some form of pollen allergy, and it can really ruin any springtime fun. Even animals are susceptible to everyday hay fever. But what actually is hay fever?

Hay fever, or Allergic Rhinitis, is a body's over-sensitivity to everyday outdoor allergens, including dust, mites, and especially pollen. The body's immune system detects the allergens, and responds by attempting to remove the foreign contaminants. This immune system response is what causes the allergic reactions that so many people, and animals, have grown accustomed to.

To make matters worse, evidence has shown that due to Climate Change, pollen levels everywhere are on the rise. Plants use Carbon Dioxide as fuel for photosynthesis, and studies have demonstrated that plants have responded to an increased temperature and Carbon Dioxide level, by increasing the amount of pollen they produce. Not only have the pollen levels increased, but the season at which pollen levels are the highest, has been extended all around the world. In some cases, the pollination season for certain plants can happen as much as three weeks earlier. The future does seem bleak for pollen allergy sufferers everywhere.

"The future does seem bleak for pollen allergy sufferers everywhere."

Luckily, there might be a way to help protect yourself from pollen allergy this season. Most people have probably heard that local honey helps pollen allergies, but few people actually understand the science behind this mysterious, yet effective remedy. The only reason pollen allergies exist is because the human body is sensitive to any unknown substance. By consuming local honey, which contains small traces of pollen, the body is trained to recognize the substance as non-threatening, so it can learn to respond differently. Keep in mind, that the honey must be locally produced or else it may not have a high enough pollen count for the remedy to work. Also, the honey must be eaten every day, and typically before the start of allergy season for it to be most effective. Certain animals can also benefit from this remedy as long as the owner is careful to make sure it is safe for the animal to eat. Cats and Dogs, are usually ok with honey in small doses, as long as they have no other health related issues, while guinea pigs should not be given honey.

Hopefully you still remember all this when spring comes around because it could save you from a season of allergies.

Pollen, peanuts & latex: oh my!

BY HEATHER OFFERMAN, BEHAVIORAL NEUROSCIENCE, 2019

It seems like everyone has an allergy these days. Whether it be a sibling, a friend, or even yourself, allergy incidence is increasing at an alarming rate for a reason that scientists have yet to agree on. Hospitalization records and self-reports have shown that more than 50 million Americans suffer from allergies, with reactions that can range from mild sniffles to life-threatening inflammation. So, what exactly is an allergy, and what happens in the body when we face these seemingly threatening particles?

Once in contact with a typically harmless substance, also known as an allergen, the immune system almost immediately recognizes the particle as a threat. Immunoglobulin E (IgE) antibodies are rapidly produced and bound to the particle to protect against uncontrolled allergen distribution in the body. There is a specific type of IgE for each type of allergen exposure, which is what allows people to often have more than one allergy. Once bound, IgE orchestrates a chain of cascading events, including intra-cellular signaling, and eventually the release of inflammatory mediators that cause the familiar allergic reactions such as nasal blockage and airway constriction. An allergy can be thought of as a disorder of the immune system due to the overreaction to non-threatening substances.

What has changed that would lead to an increase in these adverse reactions? There is no single way to answer why there has been a 21 percent increase in childhood peanut allergies since 2010, or why the prevalence of Americans with seasonal allergies increased from 10 percent to over 30 percent since 1970. Awareness and self-reporting play a role in the rise of allergy recognition, but with extremely mild allergies being reported, the incidence increases along with sensitization. People are avoiding these allergenic substances, which weakens the immunologic regulatory mechanisms overtime, increasing the likelihood of diseases.

Many physicians attribute the national allergy increase to be a consequence of cleanliness. The popular "hygiene hypothesis" suggests that the obsession with sterilization and killing germs in Western cultures is a primary source of allergy development. Babies are being exposed to fewer infectious agents and natural microorganisms than they once were decades ago, increasing the susceptibility of the immune system to mistake a basic food particle as a harmful germ. Our interaction with the environment, or lack thereof, is detrimental to natural immune development. As our society becomes more industrialized while increasing the amount of time spent indoors, we don't allow ourselves to build up the normal defense response to pollen and other natural elements.

While our vulnerability to developing allergies may be due to a combination of factors including genetics, local climate, hygiene habits, and dietary choices, it's safe to say that there is not enough research conducted on particle sensitization over time. This epidemic is beginning to create awareness for how we interact with foods, materials, and our environment, an issue essential to the wellbeing of generations to come.

The Weight of a handshake: Living with and among cystic fibrosis

BY SAGE WESENBERG, BIOLOGY AND JOURNALISM, 2019

DESIGN BY ANGELA WU, COMPUTER SCIENCE, 2022

Inside and out, our bodies are covered with germs and bacteria. In an interactive world, we leave our mark on everything from fingerprints on a handrail to the exchange of bacteria from a simple handshake. Most of the time, these actions are harmless.

However, for the approximately 30,000 people in the United States living with cystic fibrosis (CF), close contact like a handshake can sometimes be the difference between a healthy week and an infection requiring a hospital stay.

CF is a genetic disease passed down from parents who are carriers of a defective CF gene, with severe symptoms including reduced lung function, coughing, inability to gain weight, and more. The mutations cause a malfunction of the cystic fibrosis transmembrane conductance regulator (CFTR) protein, which maintains salt and water levels in the body and within cells. Without proper function of the protein, chloride gets trapped inside cells and prevents water from reaching the cell surface, ultimately leading to a sticky mucus lining the lungs. This mucus becomes a breeding ground for germs and bacteria that have the potential to cause severe and sometimes life-threatening infections.

In the 1980s, researchers' understanding of CF was not as complete as it is now. Doctors knew that bacteria in the lungs of CF patients, like *Pseudomonas aeruginosa* and *Burkholderia cepacia* complex, were harmless to normal lungs, but they did not know how easily the bacteria could infect the CF community. However, in the 1990s, a dangerous strain of *B. cepacia* was found that had spread between a group of children at a CF summer camp.

Suddenly, the interactions around CF drastically changed. CF camps closed and the Cystic Fibrosis Foundation (CFF) implemented huge adjustments in infection control efforts across the country to minimize the possibility of one CF patient infecting another with their bacteria. Mostly focused on patients with the more dangerous *B. cepacia*, these guidelines included recommendations for them to schedule clinic visits at different times from other patients with CF and to not attend indoor CFF events.

In 2003, stricter guidelines arose after a breakout of a new bacteria, *Burkholderia dolosa*, among CF patients at Boston Children's Hospital caused over 20 patients to suddenly decrease in lung function and cause the death of one woman.

Now, CF patients are recommended to keep at least six feet of distance between each other, farther than any germs can travel through open air. The 2013 Infection Prevention and Control Clinical Care Guidelines from the CFF also

include suggestions on hand hygiene, contact for health care personnel, and limitations of only one person with CF at any CF-related event.

But CF is hereditary, so what happens if there are two or more people with CF in the same family?

In 2015, a study showed that siblings with CF can be risk

“ **However, for the approximately 30,000 people in the United States living with cystic fibrosis (CF), close contact like a handshake can sometimes be the difference from a healthy week and an infection that requires a hospital stay.”**

factors for each other. Siblings with CF, while inheriting the same mutant genes from their parents, see different rates and symptoms of disease expression and progression. In many families with more than one sibling with CF, the same strain of bacteria often colonizes their airways. The goal of this study was to analyze the impact of disease expression and its outcomes for families with multiple siblings with CF. They conducted a retrospective study of two different groups – two siblings with CF and three or four siblings with CF – using patient data like age, gender, and mutation type as well as bacterial colonization counts, number of hospitalizations, and forced expiratory volume (FEV1). Each sibling in the study was compared with another CF patient similar in every aspect except having siblings with CF.

The study concluded that patients in families with three or more siblings show a significantly lower FEV1 leading to a faster decline of lung function, more bacterial airway colonization, more hospitalizations, and a significantly higher need for lung transplants. Additionally, the FEV1 rate was lower for the youngest sibling in the family. However, for families with only two siblings with CF, there was not a significant impact to differences in disease expression or rates. This study proved that multiple family members with CF can be risk factors for each other in addition to many other environmental risks.

Although most living with CF cannot meet in person, there is a virtual community for patients, caregivers, and advocates to support each other through any obstacle and every celebration. While they won't spread germs with a handshake, they can continue to spread messages of hope.

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PHOTO BY USDA ARS



Patient-provider miscommunications

The United States has a secret leading cause of death

BY KATIE MCCREEDY, HEALTH SCIENCE, 2021

Getting to the doctor is hard enough, yet once there, patients must divulge their deepest, personal concerns to a physician. A combination of medical history, what the patient says, and what the physician hears and asks, will determine the diagnosis. This one conversation is pivotal to getting proper treatment — but it does not always work.

In 1972, researchers at Children's Hospital of Los Angeles conducted a now-landmark physician communication study. They surveyed 800 pediatric emergency clinic visits, and found 26 percent of parents reported not discussing what concerned them most with their physician. It wasn't because they forgot, but because they were never given an opportunity to do so. In the study, as is often common practice, providers focused on getting a diagnosis by asking pointed questions and interrupting the parents, leaving little time for them to discuss their own concerns.

The last few decades since the study was released saw little improvement in communication outcomes. A 2016 study from the British Medical Journal revealed that more than 250,000 Americans

die each year because of medical error, which is completely preventable. If medical error were a disease, it would be the third-leading cause of death in the United States. Lapses in communication are a main cause, causing about 60 percent of preventable deaths from medical error, according to a report from the Joint Commission on Accreditation of Healthcare Organizations. A patient forgets to divulge a medication allergy, a physician informs only the day nurse of a medication change and not the night nurse — any seemingly small gap in communication can be deadly.

An ideal solution is collaborative communication, a health communication theory that encourages open communication between patient and provider to achieve a shared goal. However, it's not that simple. It's often difficult for physicians managing large caseloads to find time and energy to communicate effectively. A Medscape survey reported that 42 percent of physicians experience burnout, or a loss of enthusiasm toward work and overwhelming exhaustion. Medical error is a complicated health policy and public health issue that will require improvements in the organization of healthcare systems, medical education,

and health care spending. Until then, patients are left to avoid medical error by advocating for themselves.

Pauline Hamel is an associate clinical professor in the Bouvé College of Health Sciences, where she teaches Communication Skills for the Health Professions, among other courses. She is also board-certified in geriatric physical therapy. Hamel said in an interview that she believes successful health communication between patient and provider is integral to patient outcomes.

"Patients need to be empowered, they need to be reminded that they have a voice," Hamel said.

Hamel says patients can bring lists to their appointments to keep the physician on track with the problems and questions they would like to address. Patients should also create a one-page health history to bring to every health examination. They can also be assertive and tell their providers exactly what is bothering them or why they are struggling with their suggested treatment.

"Be clear, ask questions in a straightforward way, and don't wait until the last minute with doorknob disclosure," Hamel said, referring to the communication error patients make when they wait until their provider is

"Any seemingly small gap in communication can be deadly."

exiting the exam room to reveal critical information.

When a physician gives a recommendation, patients should feel comfortable admitting whether or not that recommendation can be realistically added to their lifestyle. Patients should also ask for paper handouts when possible for more information on their recommended treatment if they do not understand it.

"It's important that patients express to their physicians that they want to work together," Hamel said. "The whole goal is to collaborate and be on the same team."

Modernized prosthesis technology:

Where did we come from, where will we go?

BY RAFI RAZZAQUE, ENVIRONMENTAL SCIENCE, 2019

DESIGN BY KATIE GREEN, BIOENGINEERING, 2021

Did you know prosthesis technology dates to the Ancient Egyptian era? Modern developments in microprocessors, electronic controllers, and the advent of robotic prosthesis promise a future where patients can have a prosthetic limb integrated into their nerve and muscular systems, a far cry from the crude bronze and iron legs fashioned for amputees during the Roman era.

Today, advancements and technological refinement ensure cheaper and stronger prosthetic options, along with a degree of realism for users. Developmental research points towards a tomorrow where artificial limbs are well-personalized towards individual users, providing valuable tactile feedback that can be registered by the user.

In the past, prosthetics were crude in form and function; usable, customized prosthetics were expensive and affordable only by the wealthy. The Renaissance periods introduced materials such as iron, steel, copper, and wood, but true improvements were made after the Civil War and World War II, given the rise of injured and amputee soldiers. Government funding in the National Academy of Sciences in the US, as well as funding into Veterans Administration post-World War II triggered newer developments in prosthesis for a wider audience, emphasizing usability and affordability. Developments such as hinged knee implants, shock absorption in limbs, as well as a focus in capturing the natural gait and movement of the human body aided in further improving prosthetic usability. During the post-WWII development period, myoelectric prosthesis came into fruition. Myoelectric technology controls prosthetic limbs by muscle-generated electric signals in residual limbs. Thus, when electric signals are sent from the brain to the limb, sensors in the prosthetic limb engage a powered controller which engages the needed joint. Myoelectric prosthesis is available for upper-limb amputees, including solutions for elbows, wrists, and fingers. Additionally, myoelectric prosthesis provides a natural 'look' and function compared to body-powered prosthetics, or prosthetics that operate mechanically by hooking cables from other muscles to instigate movement of prosthetic limbs.

Computer technology made its way into prosthetics as well; myoelectric prosthesis was initially developed in the late 1950s but is better supplemented today by computer technology. Microprocessor-controlled

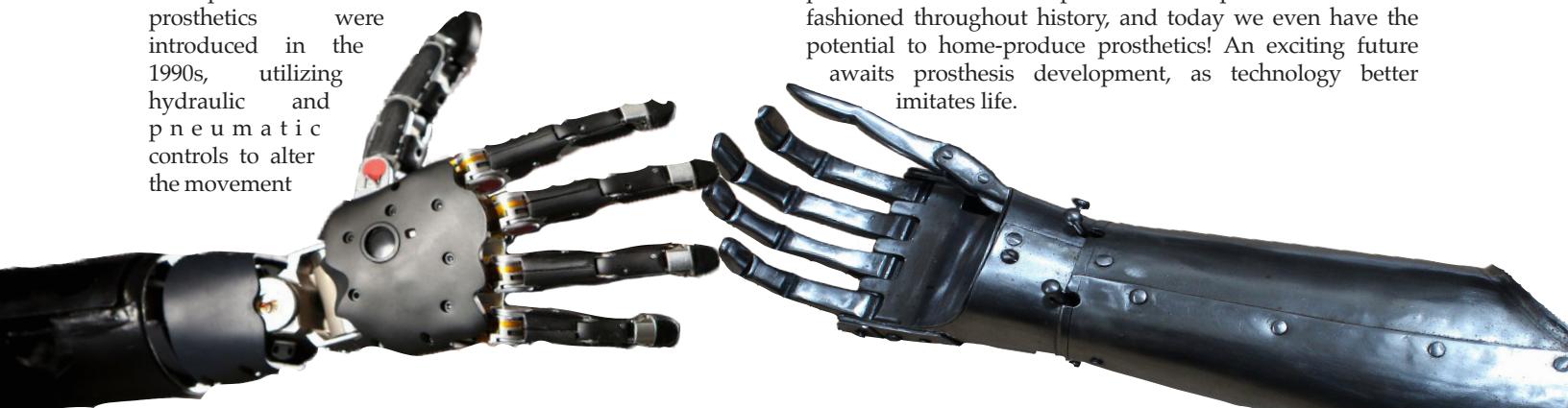
prosthetics were introduced in the 1990s, utilizing hydraulic and pneumatic controls to alter the movement

in limbs. Programmable changes in microprocessor prosthesis allow for a more natural gait for individual users, especially across differing terrains. In the future, technological developments seek to better integrate prosthesis into the human body, including research into bionics, and engaging a degree of 'feel' into the user's body when utilizing their limbs to touch or interact with an object. Neural plasticity, the ability of the brain to change its neural mapping has been targeted by scientists to introduce sensation into prosthetic limbs.

The recent rise in technology has had its effects on prosthetic costs, in addition to prosthetic technology; costs have significantly lowered due to the growth in 3D printing. With 3D printing, recycled plastic polymers can be utilized to create upper limbs for as low as \$45; their non-printed alternative can cost thousands. Although there are limitations—only upper limbs can be produced, as the recycled plastic filaments cannot bear the forces exerted on lower limbs—the cost savings are immense and lead to the possibility of cheaper prosthetic production that provides a user-custom fit. Other recent developments in prosthesis involve using materials that have improved the appearance and function of prosthetics, such as carbon fiber and titanium. These materials increase the strength of the limbs while minimizing weight, thus better mimicking the movement of traditional limbs. Overall, prosthetic limbs have increased durability over time, while gaining a more natural appearance and motion. Maintaining cost-effective developments that can be used by many will continue to be a challenge for scientists.

Our current-day technologies still have room for improvement, necessitating a high demand for prosthetic research. As recently as 2004, a poll by the Amputee Coalition of America found one-third of their responses reported dissatisfaction in the comfort of their devices. Costs incurred by these devices, along with varied coverage by insurance plans means the best prosthetic technologies may be out of reach for those who need them most. Individual users may have unique demands that will require custom-fit prosthetic solutions, rather than a catch-all universal solution.

Nonetheless, future prosthetic developments promise a range of prosthetics that can be cheaply and widely available, that prove stronger and more user-friendly. Improvements in prosthesis have come leaps and bounds past the crude fixes fashioned throughout history, and today we even have the potential to home-produce prosthetics! An exciting future awaits prosthesis development, as technology better imitates life.



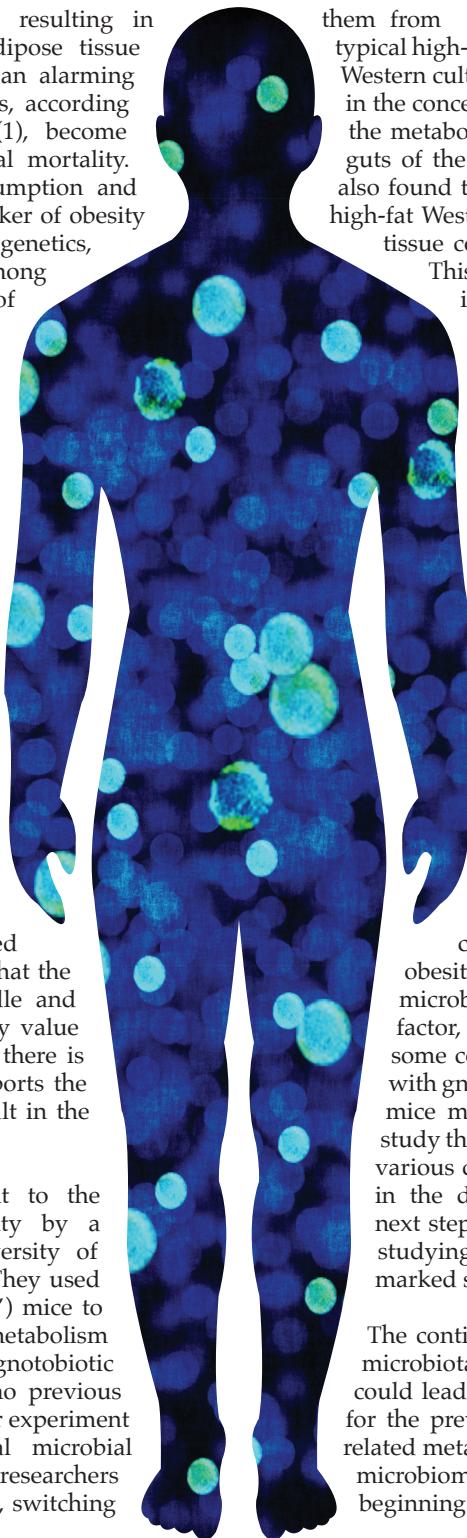
The human microbiome and what it reveals about obesity

BY RACHEL GRIEP, BIOLOGY, 2022

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

Obesity, a metabolic disorder resulting in the rapid accumulation of adipose tissue within the body, has reached an alarming rate of prevalence worldwide, and has, according to the World Health Organization (1), become the fifth leading risk factor for global mortality. The imbalance between energy consumption and energy expenditure that is the key marker of obesity is traditionally said to have its roots in genetics, behavior, and environmental factors, among other things; however, the exact causes of obesity still remain a grey area within the scientific community. With the recent commencement of the Human Microbiome Project (HMP) by the National Institutes of Health in 2007, scientists are beginning to look at the relationship between gut microbes and metabolism as another possible indicator for metabolic disease. While advanced technologies and methods necessary for a complete understanding of microbial effects on metabolism are still yet to be developed, the prospects of this information cannot be understated. Microbial cells within the body outnumber human cells 10:1; thus, the effects of microbes on human health and disease are vast (4). Not to mention that the greatest concentration of microbes found in the body is located within the large bowel of the gut. Microbes are involved in the breakdown of many molecules that the human digestive system cannot handle and are thus deeply involved in the energy value that humans obtain from food. And, there is already compelling evidence that supports the theory that certain gut microbiota result in the perpetuation or prevention of obesity.

Some of this evidence was brought to the attention of the scientific community by a group of researchers from the University of Washington in Saint Louis Missouri. They used humanized gnotobiotic (or “germ-free”) mice to analyze the effects of digestion and metabolism on the microbiome and vice versa (gnotobiotic refers to the fact that the mice had no previous exposure to microbes). They began their experiment by transplanting adult human fecal microbial communities into gnotobiotic mice. The researchers then manipulated the diets of the mice, switching



them from low-fat, plant polysaccharide diets, to typical high-fat, high-sugar diets that are often seen in Western culture. Immediately, they noticed a change in the concentrations of specific microbe species and the metabolic functions of these species within the guts of the mice. Unsurprisingly, the researchers also found that when they switched the mice to the high-fat Western diets there was an influx in adipose tissue concentrations in the bodies of the mice.

This supported the hypothesis that changes in diet could cause significant changes in the human microbiome, possibly contributing to numerous ailments, including obesity. Perhaps what was even more interesting was what occurred when they placed a sample of the microbiota found in the mice given the Western diets into other germ-free mice given the plant polysaccharide diets. For a time, these new mice developed a marked increase in adipose tissue within their bodies, as well. This further served as support for the theory that certain microbes in the human microbiome influence a person’s susceptibility to obesity and other metabolic disorders. (4)

One difficulty researchers have found in working with the human microbiome is distinguishing between causal and correlational relationships.

It is the typical what came first-- the chicken or the egg-- scenario. Does obesity influence the microbiome or does the microbiome influence obesity? Does a third factor, such as diet, influence both. Perhaps it is some combination of factors. Through working with gnotobiotic animals, such as the gnotobiotic mice mentioned in the experiment above, can study the effects of controlled microbiomes under various controlled conditions. This, in turn, aids in the discovery of causal relationships. The next step for scientists to take would be to begin studying gnotobiotic animals that have more marked similarities to humans, such as pigs.

The continued study of the relationship between microbiota and metabolism is important because it could lead new therapeutic targets and treatments for the prevention and delay of obesity and other related metabolic disorders. The study of the human microbiome is still relatively new. This is just the beginning.

THE MYSTERIOUS SIGNAL: UNCOVERING THE CAUSE OF MS

BY GAURI NARAYAN, BIOLOGY, 2019

DESIGN BY YEECHAN YANG, PSYCHOLOGY, 2022

Though it's a debilitating disease that affects approximately 2.3 million people around the world, medical professionals are still unsure exactly what causes it. It is understood that those suffering from it experience a systematic deterioration of the protective shell surrounding their nerve fibers. When this shell (known as myelin) is lost or permanently damaged, vital nerve fibers are left vulnerable and impaired. The loss of myelin and the resulting impaired nerves are features of the devastating disease recognized in the medical community as multiple sclerosis (MS).

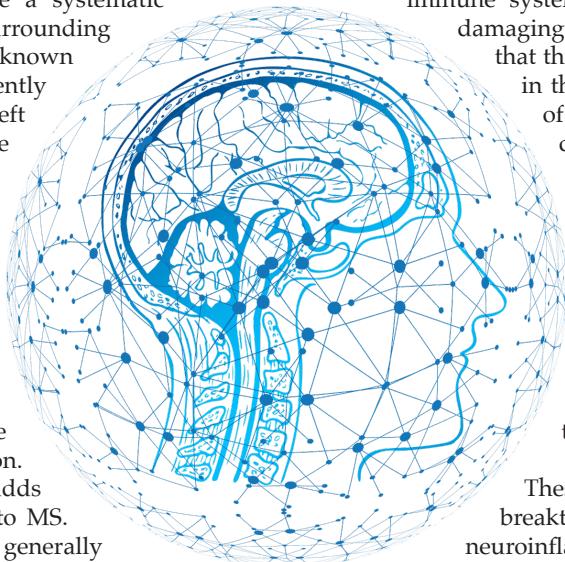
What makes MS especially difficult to diagnose is the fact that nerve damage can manifest itself through a variety of symptoms, the presence of which vary from person to person. This high variability in symptoms adds an additional layer of complexity to MS.

Though symptoms are far ranging, generally the damaged nerve fibers interfere with the brain's ability to send appropriate signals to the spinal cord and the rest of the body. With so much unknown about this progressive and degenerative disease, scientists have been working hard to uncover more information on the causes of MS. This is primarily in hopes that developing a deeper understanding of the roots of the condition could ideally unearth potential treatment options, or perhaps even a cure.

Potentially coming one step closer to this goal, researchers from the University of Virginia in Charlottesville have recently discovered a mysterious signal being sent from the brain to the lymph nodes that they suggest might serve as an explanation for MS. Their findings, published last month in *Nature Neuroscience*, were based on the same team's earlier groundbreaking discovery that the brain has what are called "lymphatic vessels". These vessels are essentially pipes in the brain that are used to process waste found in blood vessels. This connection between the brain and the immune system, established by researcher Jonathan Kipnis and his team, shed light onto what system might be responsible for MS. This was the basis for Kipnis' new research, which investigated the effects of this interaction on MS progression.

According to their published piece in *Nature Neuroscience*, Kipnis and his team explained that neuroinflammatory diseases like MS involve the brain being overrun by T-cells. These cells are part of the immune system's defense, as they attack other cells that are deemed to be invaders. In MS, T-cells are responsible for the destruction of the protective myelin sheath. Armed with this understanding as well as

the knowledge of lymphatic vessels in the brain, the research team used a mouse model to study how interfering with the lymphatic vessels might alter the brain's signal to the immune system. Upon blocking and surgically damaging the lymphatic vessels, it was found that this resulted in lower levels of T-cells in the brain, which reduced the effects of MS in the mouse model. This clearly demonstrates that there is a key interaction between the brain and the immune system, which is facilitated by the lymphatic vessels. Understanding this interaction and the role that lymphatic vessels play in inflammation would be critical for MS treatment, as more research can be done on therapies that target these vessels in the brain.



These findings are not only a breakthrough for MS, but other neuroinflammatory diseases like Alzheimer's and Parkinson's as well. These neurodegenerative

disorders could be related to this uncontrolled brain-to-lymph node interaction, and the idea that the results from this one study could be applied to therapies for a whole class of disorders is monumental. While Kipnis and his team have had a major breakthrough, there are still a number of unknowns. Though evidence suggests there is vital communication between the brain and the immune system leading to these pathologies, the nature of this signal being sent from the brain is still an enigma. This would

These findings are not only a breakthrough for MS, but other neuroinflammatory diseases like Alzheimer's and Parkinson's as well.

be the next question to answer, as that information could help with the development of further targeted therapies that wouldn't require disruption of the lymphatic system.

Additionally, it is important to note that researchers were not able to stop the initial development of MS. This suggests that there are most definitely other factors at play contributing to onset of the disease. Despite this, the research conducted by Kipnis and his team is still a big step forward, and the discovery of this mysterious signal will hopefully act as a catalyst for further research.



Why is breakfast the most important meal of the day

BY PRIYANKA PANJWANI, BEHAVIORAL NEUROSCIENCE, 2019

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

How many times have we heard the old adage, “Eat breakfast like a king, lunch like a prince, and dinner like a pauper?” This saying is finally receiving the attention it deserves from the scientific community. Recently, I had the pleasure of sitting down and talking with Dr. Nina Vujovic, a postdoc researcher at Harvard Medical School who examines the relationship between circadian rhythms and metabolism. Her findings are part of a growing body of evidence examining meal timing and the consequences of when you choose to eat your meals.

A circadian rhythm is an intrinsic, 24-hour rhythm driven by molecular feedback loops present in every cell. It is important that our schedules and behavioral patterns line up with our circadian rhythms because our organs are better positioned to perform their functions when they are entrained to a consistent schedule. There are findings that suggest that when we stray from our consistent schedules because of sleep loss, shift work, or jet lag, there are metabolic consequences such as weight gain or decrease in metabolism; this has been shown in both field studies and highly controlled laboratory studies.

Even among those of us able to keep a regular sleep schedule, when we eat can still affect our health. A study performed by Dr. Satchin Panda at the Salk Institute indicated that people tend to eat over a fifteen-hour period by snacking throughout the day, and that confining caloric consumption to an eight- to 12-hour period might prevent diabetes, high cholesterol, and obesity. Another study by Marta Garaulet demonstrated that earlier timing of food intake greatly improved the chance of success in a twenty-week weight loss treatment. In the study, “late eaters”—who consumed most of their calories in the afternoon and at night—lost less weight, even though physical activity and caloric intake were similar between both groups of subjects. Dr. Vujovic aims to look

at some of the mechanisms underlying this effect in overweight and obese adults, by isolating the effects of meal timing alone in a laboratory study where daily caloric intake, dietary composition, and sleep duration are kept consistent. Her team’s preliminary findings indicate that eating your meals later in the day can alter hormone expression in such a way that risk for weight gain is increased, both through decreased metabolism and increased cravings to overeat.

In a perfect world, we could all follow the advice emerging from these studies and keep a regular schedule, get enough sleep every night, and eat our meals within the first eight to 12 hours of the day. Fortunately, for those of us who cannot, Dr. Vujovic has four suggestions derived from the research of her colleagues in the sleep and metabolism field, to help people minimize the health risks of all-nighters and irregular schedules: When you are sleep deprived, know that you will experience cravings for more, and often less healthy, food. This is normal; you can plan for it and eat what you plan instead of what you crave, or you can plan to spend a little extra time at the gym that week instead. Don’t snack continuously all day long – it is healthier to give your body a three- to four-hour break in between meals. Even if you cannot sleep on a regular schedule, it can be beneficial to still eat on a regular schedule – one that includes breakfast. Finally, plan for rebound sleep after facing sleep deprivation. Be realistic about when you can make it happen, and let people who might be trying to reach you then know that you’ll have your devices off. Not being “on call” during rebound sleep opportunity can help increase the duration and quality of the sleep.

Three things will remain constant in the lives of students: the sun will rise, the sun will set, and we will roll out of our beds to make morning classes. Just do your body a favor and grab something to eat on the way out.

DESTRESSING WITH DOGS

BY THERESA CHUNG, PHARMACY, 2024

For many, the only thing that could relieve stress from being away from home or studying for finals is a dog sitting in one's lap, listening to worries and rants. There's a reason why the sight of a dog can make any stressed-out college student break out into a smile.

Dogs are special in their own way as therapy animals because of their capability of recognizing a human's behavior, whether it be pointing to something or crying. It has even been found that dogs will leave their owner's side to comfort someone who is crying, licking their face, or nuzzling them.

Humans have always recognized dog as "man's best friend" due to the level of companionship and loyalty they offer. It has been reported that having a dog by their side provided those in the military with a sense of security, stability, and safety while also preventing them from losing their humanity or morality as they struggle through the war.

A study conducted by the Higher Education Research Institute in 2015 found that college freshman have reported a

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

25-year high stress level along with all-time low records of emotional stability and coping. Many do not have a friend to talk to or any way to de-stress, and often feel as though meeting with a therapist is not a viable option. A dog is a perfect candidate for a therapist, as it can listen to problems without judgment. Simply petting a dog can reduce the effects of stress on the body; research has found that merely by interacting with a therapy dog, a person can experience their heart rate and blood pressure dropping to resting rates. Oxytocin, one of the happy hormones, also rises, while cortisol, the stress hormone, falls. Therapy dogs can also help in reducing feelings of depression, homesickness, and loneliness.

Many different areas of the country have recognized the power that dogs have in promoting happiness and relaxation in humans. Universities have held therapy dog sessions during finals week for students to come in and take a break while chatting with their canine companion. Students' grades have even shown that these times have paid off. So, the next time a dog is being walked on campus, take a break to give them a good pet- for your health!

Diffraction peaks and discovering primes

BY JENNIFER GARLAND, APPLIED PHYSICS, 2021

Crystal structures are symmetric and periodic, and they form some of the more predictable patterns in the universe. However, the 2011 Nobel Prize in Chemistry shook up the field of crystallography when the winners introduced a natural occurrence of quasicrystals — materials whose atomic structure forms regular patterns but never repeat. In a surprising discovery published in 2018 in the Journal of Statistical Mechanics: Theory and Experiment, scientists at Princeton University described finding quasicrystalline structure that reveals order in the randomness of prime numbers.

Prime numbers are important to modern encryption because it is very difficult to determine the prime factorization of large numbers. In the commonly used RSA algorithm, two prime numbers that can be thousands of digits long are multiplied together to get a key that would take even very powerful computers a long time to guess and check for factors. Finding any sort of pattern in the primes could reveal vulnerabilities in current systems that use public key encryption. On the flip side, being able to find higher prime numbers will allow for stronger cryptography keys, and potentially give insight into number theory.

In the study, x-ray diffraction was used to determine the arrangement of atoms in quasicrystals, and stretches of prime numbers were mapped to the Bragg peaks produced. Instead of regular peaks that are produced by normal crystals, there were smaller groupings between each pair of peaks. This occurrence of "self-similarity" is what is displayed in fractals, which repeat patterns at multiple scales and are often found in nature. Computer simulations showed that when prime numbers were treated like atoms, they produced the same type of diffraction pattern. This research has categorized prime numbers to be hyperuniform, meaning they do not show order on small scales.

Comparing prime numbers to particles opens up pathways to predicting larger prime numbers from nature and tying in pure math with materials science. Mathematicians have looked for patterns with digits and frequency using computer programs in the past, but this discovery in crystal structure could lead to a more advanced prime number algorithm. While both prime numbers and quasicrystals do not repeat themselves, it appears that patterns can sometimes be found where they are least expected.

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PHOTO BY PIXBAY

NO QUANTUM WALK ON THE BEACH

BY JAMESON O'REILLY, PHYSICS AND MATH, 2019

DESIGN AND PHOTO BY GUS MUELLER, BIOENGINEERING, 2022



Many Northeastern students will undoubtedly be familiar with the sight of a group of friends walking home from the Hill late at night. They begin close together, leaving ample room for others to pass them on the sidewalk, but none of them walk perfectly straight. Instead, each person moves either a little to the right or a little to left with each step, eventually causing the group to spread out and engulf any unfortunate passers-by. This phenomenon is known as a random walk and is an important tool for the study of many random processes.

The example given above is of a classical random walk, in which some party either takes a step to the right or to the left. At each point in time, the walker in question has a definite position and randomly decides, either with a coin flip or impaired balance, which way to move next. While this is more than enough mathematical framework for a typical Saturday night, an international group of scientists led by PhD candidate Siamak Dadras and Professor Gil Summy, both of Oklahoma State University, recently implemented a new, more robust quantum version of such a walk.

Instead of moving back and forth in space, their walkers, which were laser-cooled and trapped rubidium atoms, either lost or gained a set amount of momentum at each time step. Instead of flipping a coin, this was decided by whether the “spin” of their outermost electron was pointing up or down. The electrons are not literally spinning, but physicists use this word to refer to an intrinsic property of subatomic particles that acts like an angular momentum and can be in one of two possible directions.

During each step, an atom is put into an equal quantum superposition of up and down, similar to the Schrodinger's Cat state of being both dead and alive at the same time. If someone were to measure the atom's spin, they would get “up” 50% of the time and “down” the rest of the time, but the atom is not truly in either state until the measurement occurs. Rather, it is in a superposition of both. Crucially, in a quantum walk, this measurement is not made until the very end, after many time steps. Once

the spin superposition is achieved, the momentum change is implemented.

As previously mentioned, the direction of the momentum change will depend upon the spin. Once again, this is not a deterministic process like it would be in the classical case. Instead, because the spin is in a superposition, the atom is put into a superposition of increased and decreased momentum. This process repeats during each time step until a measurement is finally made at the very end of the quantum walk.

Upon measuring, Dadras and his collaborators found that their atoms almost always had either the highest or lowest possible momentum instead of being clumped in the middle like in a classical walk. Classically, random walkers tend to end up near where they started out, with further ending positions becoming steadily less likely. This is because there

are many more ways to have near-equal numbers of left and right movements (such as LLRR, LRLR, RRLL, etc.) than there are ways to end up at the extremes (LLLL or RRRR). In the world that we are used to, the probabilities of these different sequences add together to create what is called a normal distribution of end points. In the world of subatomic particles and atoms, these

different sequences with identical endpoints interfere destructively and cancel each other, leaving behind only the two most extreme outcomes.

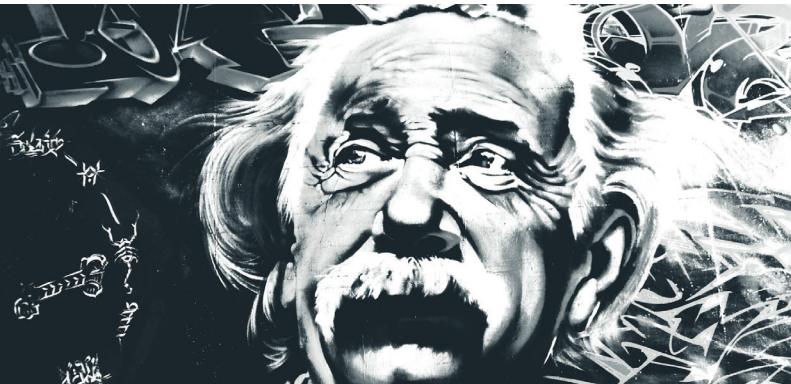
Although this is strange, it is also exactly what quantum theory predicts and what the group was looking for as a sign of quantum mechanics at work. They were not the first ones to implement such a quantum walk, but their technique of doing so in momentum space could have greater flexibility, be more robust, and allow for higher-dimensional walks than previous techniques. If so, their quantum walks could be used to study exotic new materials and perform quantum search algorithms that may be helpful for analyzing large datasets. Unfortunately, they do not promise to solve inconsiderate sidewalk use any time soon.

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Instead of flipping a coin, this was decided by whether the “spin” of their outermost electron was pointing up or down.”

MATTER, GRAVITY, AND EINSTEIN'S GENERAL THEORY OF RELATIVITY

BY DATTU KALLURI, BIOCHEMISTRY, 2022



At the dawn of civilization, humans believed that the sun and planets moved in a concentric disk attached to the earth. After all, this theory was consistent with the movements of the stars and a moving earth should fling us all into space. In 1543, Nicolas Copernicus published his groundbreaking theory that all planets orbit the sun. Many were scared to agree due to threats from the church and because there was no data to prove it. This all changed when Tycho Brahe came along. On an island off the coast of Denmark, Brahe gazed up at the night sky and painstakingly recorded the movements of celestial bodies. He decided to hire Johannes Kepler, whose analysis suggested that the planets follow elliptical orbits around the sun and that there is a mysterious force emitted by the sun keeping everything in orbit.

This insight helped inspire Isaac Newton to propose his famous inverse square law. He believed that all matter exerted a gravitational force and discovered that elliptical orbits were merely a consequence of such a force following an inverse square law. His theory accurately predicted the motions of the planets and explained why the acceleration of an object does not depend on its weight. There were, however, lingering problems.

In the 1900s, Mercury did not move around the sun as predicted by the Newtonian theory of gravity. The precession of its perihelion was taking 43 arcseconds per century longer than predicted. Many explanations were proposed such as invisible dust or undiscovered planets. Einstein provided a completely new idea: Newton's law was just an approximation that worked in areas of low gravity. Gravity was not a force, but a consequence of the interactions between matter and spacetime. Matter curves spacetime around it as a ball curves the fabric of a trampoline.

When Mercury's precession was calculated using this new theory, Einstein was proven correct. It also explained why light itself was pulled in by gravity despite having no mass. Objects are not pulled into gravitational fields. Rather, they move in curved spacetime. Dozens of experiments have confirmed Einstein's General Theory of Relativity since its proposal. Some, however, argue that this theory is not complete. General Relativity requires momentum and energy to be defined everywhere, which does not agree with quantum mechanics' uncertainty principle. A theory to reconcile these two paradoxical explanations of reality remains elusive.

DEVELOPING QUANTUM TIME CRYSTALS

BY ANNABELLE MATHERS, CIVIL ENGINEERING, 2022

In a familiar tale, an individual wakes up to discover the previous day repeating itself each morning. Now, suppose this individual is an ion in its ground state, or lowest energy level, quite lethargic in the morning. During the day, the ion acts randomly, indifferent to the particular stimuli around it. No matter how its actions differ, the outcome is constant: the ion wakes up in the same position on the same day. Such behavior approximates the paradox of an ion within a four-dimensional space-time crystal.

Essentially, time crystals involve ions that periodically alternate between random and synchronized motion. Their kinetic and potential energies do not change, regardless of their movement or interaction with the lasers that drive this motion. MIT Professor Frank Wilczek, a 2004 Nobel laureate, was the first to suggest that such a system might be possible.

His theoretical model sparked intrigue in the scientific community. Professor Norman Yao, of the University of California, Berkeley, initiated experimental efforts by



proposing an ionic ring formation made rigid by counteractive magnetic, laser, and inter-molecular forces. In 2016, a University of Maryland lab, led by Professor Chris Monroe, coupled trapped ytterbium ions with driving lasers to finally realize the disputed time crystal. Straying from Wilczek's original parameters, this experiment showed that systems outside of thermal equilibrium or the ground state can still yield time crystals as long as the ions oscillate at a rate different than that of the external forces that induce their atomic spin.

This oscillation, ideally an integer multiple of the driving laser, breaks time symmetry, which dictates that the laws of physics and energy conservation must remain the same at all times. The independence from external forces and energy loss, combined with the signature periodicity of movement, signifies that the laws of physics within this system are no longer dependent on external time. In order to gain this independence, the localized ions rely on Coulomb repulsions that create inter-ionic disorder and further oscillation, distracting the ions from other stimuli. Potential energy among the ions consequently becomes disordered, inhibiting the energy provided by external forces from contributing to the ionic energy levels.

Taking a step back, the idea of a perpetual motion machine in the form of time crystals seems, quite fittingly, inexhaustible in its ability to provoke theoretical questions. What more can the world expect when presented with law-breaking phenomena of atomic *déjà vu*?

Unifying Forces: A Marriage of the Centuries

BY MELISSA FRANCO, BIOLOGY, 2020

DESIGN BY VICTORIA PAJAK, BEHAVIORAL NEUROSCIENCE, 2021

For a long time, one of the largest caveats in the field of physics has been that of its discontinuity. While each subfield is more than capable of explaining the subject it describes, there is a major disjunction between them. For example, while the Newtonian mechanics model can predict the motion of objects on Earth to a high level of accuracy, it loses validity while describing objects of significantly larger scales, such as planets and galaxies. This is corrected for with the use of relativity, which outlines the expected differences in motion relative to size.

A main point of contention within this incongruity is the relation between mechanical and electrical forces. It is known that both exert force on objects, but these impacts are typically measured separately, each with entirely unique equations. Recently, however, there has been impressive research showing progress in this field. Based out of the University of Tennessee at Chattanooga, Ling Jun Wang and his team have put forth a method of unifying these forces. Essentially, they use a more general form of the classic Newtonian gravitational force equation and adjust it

to account for electric forces as well. Their model can still accurately predict the motion of objects, meaning it retains function, while satisfying both the conservation of mass and momentum. It is inspired by the relative similarity between the mechanical gravitational force equations and the electromagnetic Coulomb's equation. Using these parallels, the team of scientists were able to create a cumulative formula that describes the motion of particles in a fourth dimension, electric charge.

This model's success in combining the description of two major forces shows progress towards the unification of all physical forces. By understanding the current forces and their interactions, it will soon be possible to create a set of equations and laws that can describe the entirety of the universe around us. Dr. Wang and his team seem to have made significant progress towards this ultimate goal. Hopefully these efforts and others will continue to unite the vast field of physics.

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STEMOUT: MAKING FUN SCIENCE ACCESSIBLE

By 2022, the U.S. Department of Education projects that STEM job markets will experience an increase of over nine million new jobs, an average expansion rate greater than that of any other occupational average. However, this expansion may exacerbate an already existing problem: the lack of racial and gender diversity facing many STEM fields. One way to combat this is to make STEM education fun and accessible for all students, and Northeastern University's group STEMout is working to achieve just that.

A volunteer outreach arm for the Center for STEM Education, STEMout unites different students, organizations, and community partners to bring exciting programs to students in the Boston area. From solar panels to robots, these young students are exposed to a wide range of activities that spark an interest and appreciation for STEM. STEMout President Nathalie Leger ('21 COE) described the fulfillment of seeing these students become increasingly more passionate with each activity. Laughing, she claimed that, "without a doubt, every student's favorite program is paper rockets."

Their largest and most established outreach program is at the Jamaica Plain Branch of the Boston Public

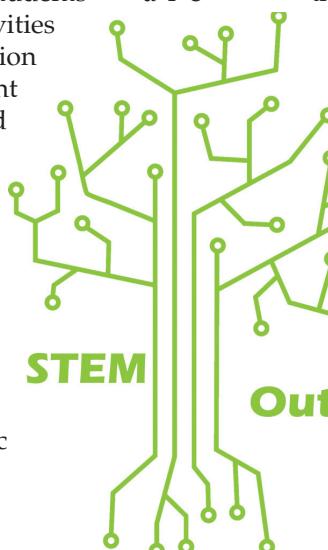
BY ADRIANNA GRAZIANO, BIOLOGY, 2019
GRAPHIC BY NORTHEASTERN UNIVERSITY STEMOUT

Library, where elementary students arrive every Saturday for STEMout volunteers to begin their activity. Orianna Kane ('21 COE), STEMout secretary and committed volunteer, speaks highly of this collaboration: "I'd like to think that this program keeps the love of STEM alive in kids from different cultures, age groups, and genders. I'm always in awe of what the kids can teach me." Though their main goal is to enrich these students' minds and opportunities, the program is clearly mutually beneficial due to the relationships formed between volunteers and the students they serve weekly.

Formed only in 2016, STEMout is always looking for more volunteers from a broad range of STEM majors to help expand their efforts. Aside from the gratification that comes from working with K-8 students,

STEMout is also a great resume builder because of its leadership opportunities. In addition to their A- and E-board positions, they also offer Lead Volunteer positions that require 10 hours of volunteering per academic year, among other requirements. They also accept one-time volunteers for Friday field trips on Northeastern's campus.

Interested in getting involved? Learn more from their website, email them at neustemout@gmail.com, or attend a regular meeting on Tuesday at 6:30pm in 153 Snell Engineering.



THE CURIOUS CONNECTION BETWEEN BUGS AND BODIES

BY BEIYU (PAM) LIN, BIOLOGY, 2021

Right off the bat, investigators knew that the woman was shot. Upon initial examination of the decomposing corpse found in the house's basement, a bullet wound matching the shape of a caliber rifle was immediately detected. However, what ultimately led to both a confession and conviction from the killer was not the wound in the woman's head, but instead the larvae and pupae of two fly species that were discovered at the site. After forensic specialists brought the specimens back to the lab, they were able to study the stage of development that the flies were currently in and what kind of timespan would correlate to the specific environment. They determined that the woman had been dead for 28 days. Not long after, a likely suspect confessed to having killed her 28 days ago on the dot.

The interplay between the environment and forensic science may be unexpected in itself, but the study of insects and arthropods for criminal investigation, also known as forensic entomology, is nearly unheard of outside of the scientific and legal community. Insects and crime don't seem to organically relate, but the natural interaction between some bugs and the environment provided by human remains has pushed for a medicolegal perspective of entomology. For those who suffer from the widespread disdain for bugs, it can be unsettling to acknowledge that they have contributed critical service in solving a number of cases.

As a human body starts to decompose, bacteria in the gastrointestinal tract will begin to produce chemicals, which include hydrogen sulphide and carbon dioxide. These molecules, known as apeneumones, attract several species of insects depending on which stage of decomposition the body is in and which insects are already present in the environment. True flies in the Calliphoridae and Sarcophagidae family, or blow flies and fresh flies respectively, are both attracted to the chemicals coming from the body in the earlier stages of decomposition. In contrast, a family such as Piophilidae, or cheese skippers, tend to be attracted to the tissue later on. By researching the developmental biology of these insects, considering the environment, and understanding all of other factors of corpse insect colonization, significant

DESIGN BY MARISSA KEESEY, BIOENGINEERING, 2022

information pertinent to crime investigation can be garnered.

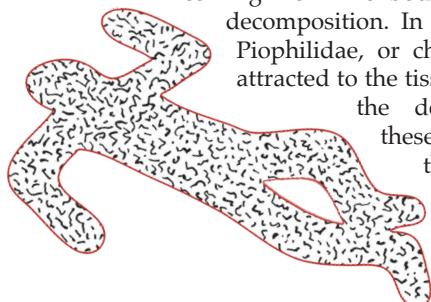
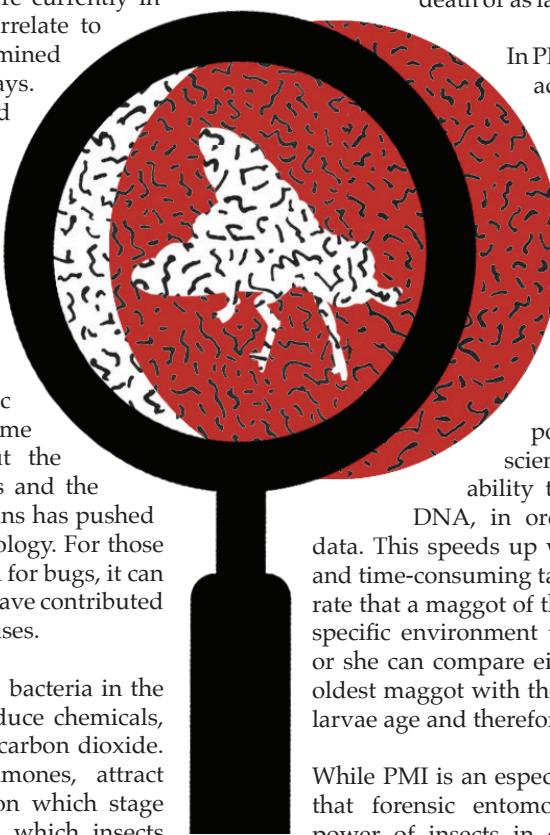
Forensic entomology's largest role in crime investigation lies in its ability to help approximate post mortem interval (PMI), which is the amount of time a human or animal has been deceased. Being able to determine the time between death and discovery of a corpse is perhaps the most critical tool in crime scene investigation; its benefit can be as small as discovering more details about the circumstances of death or as large as ruling out a prime suspect.

In PMI, scientists must first determine accurate species identification.

Maggots, which are insect larvae, are the biggest players in this practice and have the ability to accurately identify the time since death for up to one month. However, in order for their presence to be utilized, the maggots' species must be confirmed. Often times, the genome of the larvae will be amplified through polymerase chain reaction, a scientific technique that has the ability to amplify a minute amount of DNA, in order to compare it to reference

data. This speeds up what can be a very monotonous and time-consuming task. Then, if a scientist knows the rate that a maggot of that species would develop in the specific environment that the body was found in, he or she can compare either the length or weight of the oldest maggot with the ones at the site to approximate larvae age and therefore PMI.

While PMI is an especially useful piece of information that forensic entomology helps to determine, the power of insects in criminal investigation does not stop there. For example, certain insects will colonize around wounds that have been uncleaned or unmanaged, which can lead to investigative theories about cases of neglect or abuse. Forensic entomology can even indicate the presence of drugs in the body, as the insects themselves will end up ingesting the drugs when they colonize. Scientists can then run the same toxicology tests that they do on human tissue in order to determine if drugs had been present in the living human. The amount of information that insects can uncover continues to grow as scientists learn more and more about the natural interplay between bugs and human flesh. While some may squirm at the idea of forensic entomology, its benefit is near undeniable.



CHINESE RESTAURANT SYNDROME

The result of poorly conducted science

BY FAHEEM NAGPURWALA, CELL AND MOLECULAR BIOLOGY, 2022

DESIGN BY GWEN FRIEDMAN, COMPUTER SCIENCE AND DESIGN, 2022

MSG, or Monosodium glutamate, is a common additive found in many manufactured foods including instant ramen and potato chips. It is the salt of glutamic acid, a naturally occurring amino acid found in grapes, tomatoes, and mushrooms and results in an umami taste. Umami, translated from Japanese to mean “savory”, is the distinct fifth flavor the human tongue can sense, along with sweet, salty, bitter, and sour. MSG and the umami flavor were first discovered in 1907 by Kikunae Ikeda, a professor at Tokyo Imperial University. He extracted the compound from seaweed which was used for centuries in Japanese cuisine and was known to add a distinct flavor. Since then, MSG became a popular seasoning used in foods all across Asia. The compound's popularity spread to the U.S. in the 1930s and was used in almost all processed foods that needed a savory taste such as macaroni and cheese, canned soup, and even military rations.

The utilization of MSG in the U.S. was very common throughout the early 20th century, but the seasoning's use and reputation would be disrupted as a result of false claims. In 1968, Dr. Ho Man Kwok, a Chinese-American physician, described “a headache, a feeling of being flushed, being feverish” after a meal at a Chinese restaurant. The phrase

“Chinese Restaurant Syndrome” was coined to describe these symptoms in a letter to the New England Journal of Medicine, suggesting that MSG may be the culprit. Suddenly a frenzy of letters arriving at the journal, talking about absurd symptoms such as heart palpitations and back numbness, villainizing the MSG found in Chinese food exclusively. In order to sustain their businesses, Chinese restaurants were forced to remove MSG from their recipes and place signs advertising MSG-free food to ease their American customers' worries.

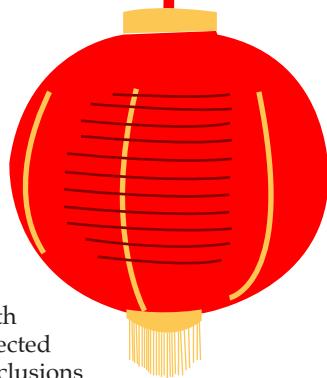
False research in response to these letters involved inappropriate procedures and as a result, caused people to blame Asian cuisine for unrelated health problems. Studies published in 1940 observed “brain

lesions, stunted skeletal growth, obesity, and female sterility in mice treated with MSG.” The studies were flawed using inconsistent samples of MSG with extreme doses, some even being injected into the subjects. Inaccurate conclusions were drawn about MSG and Americans inaccurately blamed Chinese food for their problems. It wasn't until 1984 that the FDA determined there is “no definitive evidence of a link between MSG and these symptoms. MSG is generally safe to consume” after research with proper methods were evaluated.

So the question remains, why was MSG unreasonably accused of causing severe health problems; in addition, why is Chinese food held to a double standard on the issue?

Researcher Thomas Germain, the Editorial Associate at Consumer Reports and freelance reporter, argues that Chinese Restaurant Syndrome is a symptom of blatant racism towards Asian immigrant groups. During the cold war, communism, in the eyes of America, was the biggest threat to the country and Americans grew afraid of foreigners from communist countries. “In order for Americans to justify their fears, they latched onto MSG. Moreover, “scientific”

was no longer an appealing attribute; it made MSG seem strange. Just like the Chinese,” said Germain in an article in a Columbia University journal. MSG is an important ingredient in Chinese cuisine; forcing a people to change its culture in order to be accepted is discrimination and bigotry. This is a lasting effect of the stigma created by poorly conducted science and is an example of cultural assimilation in America. This incident exemplifies the importance that science remains independently unbiased from societal feelings or beliefs. The interaction between society and science is important in order for proper and reliable research to be conducted. MSG is still under scrutiny by many and is not widely used in the restaurant industry, even though it is recognized as generally safe by the FDA and EMA.



“ The interaction between society and science is important in order for proper and reliable research to be conducted.”



Bridging the gap:

The law behind the science and the science behind the law

BY KRISTINA KŁOSOWSKI, BEHAVIORAL NEUROSCIENCE, 2021

It's fair to say that the last few years have given us unprecedented advances in health-related, medical, and bio-technology. These advances, while already proving extremely beneficial, bring up two follow-up questions. The first question we always tend to ask is: how do we apply these breakthroughs to solve problems, treat chronic diseases, and advance the field of medicine? The second, and maybe less obvious question, is how do we regulate them? This leads to a host of other inquiries. Do they fit within existing regulations we already have in place? If not, how do we determine if they are ethical? For example, where do we draw the line in gene and stem-cell therapy between potentially life-saving and morally questionable? We must keep in mind that regardless of where the technology comes from, it is ultimately the law and policymakers that determine our ability to use it.

Historically, it has been difficult to bridge the gap between those who do the research and those who use the research, because they operate on a much different timeframe and arguably a different mindset within their lines of work. Generally, lawmakers face a push to reach a conclusion before additional studies can be conducted or evidence gathered, which can be detrimental to public health. In the early 2000s, stem-cell research and therapy was significantly slowed by limitations in funding.

“ More than anything, we need people to act as mediators between the two fields who can both understand the science and translate it into terms understood by a legislative body.”

While it was a controversial issue, there was public and government misunderstanding of both the actual science and the implications it had for the treatment and cure of chronic diseases. As a result, life-saving advancements were halted for more than a decade. More recently, gene-editing generates much buzz as a way to reduce the risks of inheriting or contracting certain genetic diseases. As they appear in their natural form, genes are not patentable.

DESIGN BY GWEN FRIEDMAN, COMPUTER SCIENCE AND DESIGN, 2022

However, if they are isolated, snipped or chemically recreated in the lab, the rights to their use for research can be patented. Other such laws regarding intellectual property are inconsistent and conflicting, which reflects a lack of understanding of the science behind them. More than anything, we need people to act as mediators between the two fields who can both understand the science and translate it into terms understood by a legislative body.

So realistically, how can we aim to connect the gap between the labs and the laws? The good news is that there are growing efforts to foster collaboration. Stanford Law School is home to the University's Center for Law and the Biosciences, which brings together scientists, policy makers, practicing lawyers, and students. Dr. Emily Murphy, now an associate professor of law at UC Hastings, did postdoctoral work there after obtaining a Ph.D. in Behavioral Neuroscience. In contrast to translating science into legal terms, her colleagues emphasized that she, the scientist, needed to "think like a lawyer," which she recalls at the time not understanding. Subsequently, she pursued J.D. from Stanford Law School, and now holds a career at the intersection of law and neuroscience.

While there is no straightforward path for those like her who work at this junction, experiences like these are vital to bridging the gaps between science and policy. If members of all parts of such a diverse field are able to come together through academia, and we can learn to think like lawyers and scientists, we will ultimately be able to create a much better parallel in the field.



The other citizen science:

Social media and the distribution of scientific information

BY RACHEL POWELL, UNDECLARED, 2022

DESIGN BY NEELOY BOSE, BIOENGINEERING, 2022

Social media allows people around the world to communicate and share ideas with one another faster than ever before. People have limitless scientific information at their fingertips, and this can create opportunities to access current research and interact with scientists in various fields. At the same time, the information that goes viral is not always as unbiased as the original articles found in academic journals.

Popular social media platforms such as Twitter and Facebook can introduce the general public to new scientific ideas and advancements, connect patients experiencing the same diseases and treatments, and allow researchers to network with colleagues and participate in open peer reviews more efficiently. During a recent study, researchers at the University of Alberta found that discoveries promoted through Twitter were cited more. New research seems to disseminate more quickly via social media than it does by more traditional methods.

According to a 2013 article published in PLOS Biology, when scientific research goes viral, it can reach a global audience. Researchers can also use blogs and social media to exchange details about articles, opinions, and conferences with one another.

"Social media has certainly made things a lot more visible," said Dr. Thomas Koenig, a sociology professor at Northeastern University. "The disadvantage is it can also distort things, and the most interesting story tends to win."

Although social media has brought scientific information into daily life, it has the potential to be biased, miscited, exaggerated, or taken out of context. Koenig said that rules and norms in academic research focus on the ways in which information must be explained. Articles in academic journals must describe various factors including sample size and limitations to the data. Academics tend to be cautious about making claims and carefully describing the context.

"One of the things you do in an article is to lay out all the limitations, and the idea is that people are

supposed to, with goodwill, then build on this," Koenig said. "Once something goes viral and is turned into a universal truth, it becomes very difficult to do that."

A 2017 study published in the Oxford Research Encyclopedia of Climate Science investigated the relationship between social media use and awareness of climate change. The study concluded that although social media can bring environmental activists together and promote meaningful discussion, it can also give skeptics a platform and a way in which to publicize their perspective to a global audience. Therefore, political groups with opposing views on the issue of climate change can both use social media to spread the message that reflects their beliefs.

"People usually read media that they tend to believe, so the center gets wiped out," Koenig said. "People get caught in an echo chamber."

This phenomenon can be compared to the game of telephone, in which information is passed from person to person with each individual adding their own bias. It can be used as a political tool when the information is controversial, emotional, or vague. Furthermore, organizations may fund research in ways that suit their individual agendas, and this biased research can be quoted widely. Koenig said that information can get used in various ways as long as it sounds true. This is also common with information obtained during studies conducted on college campuses, because the sample size is limited and students are a diverse populace that varies by campus.

"I've seen a lot of things that might be done with a small number of students at one university that then get blown up as if they are human nature," Koenig said. "People hear these things, and frequently they have no outside way of checking anything. You often find if you trace things back that there is very little there in the first place."

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DOI: 0.1371/journal.pbio.1001535

DOI: 10.1093/acrefore/9780190228620.013.369



UNDER THE (MEDIA'S) INFLUENCE:

How television and social media are promoting substance abuse

BY CAITY FORGEY, BEHAVIORAL NEUROSCIENCE, 2020

DESIGN BY GWEN FRIEDMAN, COMPUTER SCIENCE AND DESIGN, 2022

In this day and age, you're unlikely to find someone without access to a phone or television. You frequently rely on these technologies to tell you how to dress for the weather, what your Great Aunt Sue made for dinner last night, and to direct you from point A to point B. There is also a good chance you have an account on at least one social networking site, if not 20, and you probably check them as often as you breathe. Nearly every decision you make is influenced by the shows you watch and the people you follow - including whether or not you use drugs.

According to the Council on Communications and Media (CCM), many forms of media influence the decision of children and adolescents to use or abuse tobacco and alcohol, as well as prescription and recreational drugs. Members of the 2009-2010 CCM Executive Committee indicated that commercial advertising encourages the use of nicotine products, alcohol, and even prescription drugs. In fact, advertisements against drugs could be piquing the interest of young drug-virgins wondering what the hype is all about,

**“ That's right,
D.A.R.E. was a
waste of your
precious fifth
grade education.”**

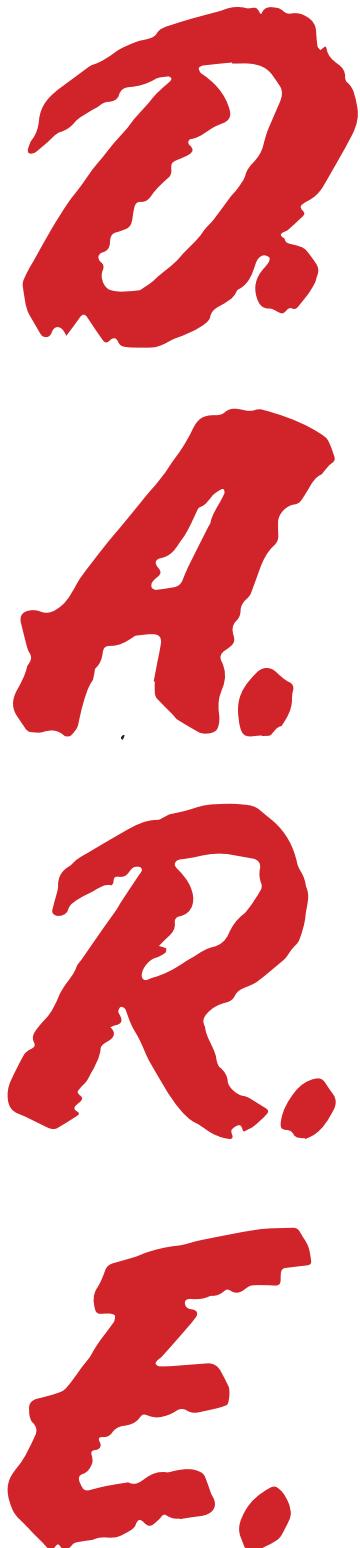
according to a study from Ohio University. Researchers found that adolescents viewing anti-drug propaganda began comparing themselves to their peers and wondering why drugs are so popular. Anti-drug programs have shown to be inefficient, potentially even detrimental, in influencing students and children away from substance use. That's right, D.A.R.E. was a waste of your precious fifth grade education, as the program showed no significant effect on preventing substance use of any kind. Although the Super Bowl ads for beers may be incredibly appealing, they

aren't the only media source playing a role in developing substance use.

Movies and television shows, specifically those with stricter film ratings, often show characters using alcohol, tobacco, or recreational drugs. A quick search on Netflix brings up over 600 shows, movies, and documentaries with a focus on drugs. Among these are award-winning titles: Breaking Bad, Narcos, and Weeds. The CCM Executive Committee finds this prevalence of illicit drugs most frequently in movies with ratings of PG-13 or R, clarifying that scenes involving drugs are present in nearly one-quarter of all films with these ratings.

The rise of the social media era has only enhanced the media influence on young adults and adolescents. Smartphones and tablets have made networking sites and online markets accessible at the touch of a single button. This trend has not gone unnoticed. Researchers from a variety of institutions including the University of Pennsylvania and Seattle Children's Hospital found a spike in Twitter profiles that reference illicit drug use or links to cyberpharmacies, which provide an illegal online market for prescription and recreational drugs. Earlier this year, the anonymous discussion thread site, Reddit, experienced backlash from members when they announced a new policy banning transactions for specific merchandise. One popular discussion board provided information on accessing these cyberpharmacies. This subreddit, called r/darknetmarkets, was removed from the site. The Center for Substance Abuse Treatment (CSAT) has found that online discussion boards for substance users play a heavy role in promoting drug cultures. The CSAT claims these sites provide a community for anyone interested to learn more about drug experiences, drug interactions, or information on purchasing substances. Easy access to this information may be leading to increased use.

These advertisements, television, movies, and social media appear to be fostering drug use in today's society. Children and teenagers, who spend lots of time interacting with the media, are most at risk for succumbing to something they may not truly understand. The information age certainly has its benefits, but at what costs?





Why you should take your exams in a coffee shop

...Or at least study for them there

BY JULIET HOINKIS, UNDECLARED, 2021

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

We've all heard the buzz – drinking coffee can make you less likely to develop type 2 diabetes, dementia, and Parkinson's disease, as well as protect you from certain cancers, heart disease, and liver failure. One 2012 study from the National Institute of Health (NIH) even found that coffee drinkers have an overall lower risk of death. This is all satisfying news if you find joy in your morning cup of coffee.

But what if you are part of the minority that just can't seem to delight in the taste of a cup of joe?

The latest research shows that you could still be doing yourself a favor by studying in a coffee shop. Coffee's benefits extend beyond consumption – according to researchers of Stevens Institute of Technology, Temple University, and Baruch College - the aroma of coffee alone can enhance your performance on academic tests and influence your behavior in general.

In the study, 114 undergraduate business students entered separate rooms, indicated their performance expectations, and then took the same ten-question algebra test consisting of questions taken from Graduate Management Aptitude Test (GMAT). Some worked in a computer lab which reeked of coffee (but contained no actual airborne caffeine or other stimulants), and others worked in a non-scented room. Not only did those in the coffee-scented room perform better, they also predicted that they would perform better before they began the test.

These initial expectations of improved performance and the outcome of improved performance that followed led researchers to initiate a second component of their study. They recruited 208 new participants and asked them to imagine whether the presence of regular coffee scent, decaffeinated coffee scent, floral scent, or no scent would

impact their alertness if they were about to take an analytical test, such as the GMAT. Not surprisingly, the participants imagined they would feel most alert and aroused in the presence of regular coffee scent, leading the researchers to describe the olfactory phenomenon induced by coffee aroma in the first part of their study as a placebo effect that caused people to feel and behave similarly to the way they would have had they actually consumed coffee.

“Not only did those in the coffee-scented room perform better, they also predicted that they would perform better before they began the test.”

Co-author of the study Adrianna Madzharov is convinced that “olfaction is one of our most powerful senses.” Therefore, she argues based on her work that subtle scents can be used in the workplace to shape employee experiences within their environment, calling it an “area of great interest and potential.”

So, where does that leave us as students? Maybe it's time to forget about Snell – it is already too busy in there anyway. Head to a coffee shop the next time you have an exam to study for, and maybe even ask your professor if you can bring your coffee brewer into the testing room. The placebo effect instigated by coffee's aroma just may help you and your classmates ace that exam.

DOI: 10.1016/j.jenvp.2018.04.001

Oobee doo, I want to be like you: Feral children and the return to communication

BY MICHAEL ISKOLS, BEHAVIORAL NEUROSCIENCE, 2021

Mowgli, Tarzan, Peter Pan, and the Lost Boys have sparked imaginations for over a century, amplifying the call of the wild by romanticizing a departure from established society. Underlying fantasies of Neverland and talking animals are dreams of relinquishing the responsibilities and restrictions that are an inherent burden of growing up. The wild children that inspire these tales, commonly referred to as feral, are pulled from the social world as a result of much darker realities.

While Mowgli of The Jungle Book is initially able to return to the Man-Village after years living alongside wolves, those truly isolated from a young age are deprived of the exposure needed to ever learn the skills characteristic of human interaction. During the first postnatal year, there is a rampant overproduction of synapses, or connections in the brain, followed by a gradual pruning process in the later years. This refining stage works to support the most utilized neural pathways while letting the redundant, unused connections fade away, like a radio playing all stations at once is slowly tuned to the perfect channel. First prepared for all sounds, the infant brain narrows its range to language-related sounds and ultimately to a native language, yet this progression is dependent on having healthy social experiences. Without the necessary building blocks and support of social interaction, children are unable to engage in complex behaviors moving forward.

The predominant investigation of this critical time frame associated

DESIGN BY GWEN FRIEDMAN, COMPUTER SCIENCE AND DESIGN, 2022

with language acquisition was explored the case of Genie, a child who was kept locked in a room by her abusive father between the age of one to 14. She was completely isolated and often left immobilized in a makeshift straightjacket. As her family was forbidden from speaking with her, Genie, upon rescue, served as a rare opportunity for scientists to test theories of linguistic development. Listed in her case report, Genie's initial cognitive age was found to be fifteen months, almost exactly the age at which her isolation began. Surprisingly, after only seven months of working and living with researchers this score jumped to that of a four year old. Genie's linguistic skills relied on this interaction-induced cognitive growth, allowing her to sustain and apply a large vocabulary with little comprehension of syntax. In what appeared to be the early steps of language acquisition, Genie surpassed both the prepubescent critical period postulated by experts and the seemingly impenetrable walls built by her father.

In the fictional worlds of Mowgli, Tarzan, and Peter Pan, welcoming communities of wolves, gorillas, and fairies provide the foundation for development, whereas the Man-Village, in Genie's case, wasn't so human after all.

BIONICS: MERGING WITH ROBOTS

BY PREKSHA GUPTA, BIOENGINEERING, 2022

Is it possible to be a better human? Faster? Stronger? Although, this seems like the plot for another science fiction movie, achieving the impossible is becoming a reality. As our technology becomes more advanced, so do our capabilities. Robots have always been seen as metallic machines capable of doing whatever a human programs it to do. However, in the new field of biotechnology, robots and humans are merging, allowing humans the possibility of new capabilities.

Referred to as bionics, this new field of research allows humans to develop various bionic technologies such as bionic limbs, an exoskeleton spine brace, and a bionic eye implant. Bionics have changed people's lives. For example, the iLimb, an advanced prosthetic arm made by Touch Bionics, allows disabled users to perform tasks that would generally require strength and precision. With iLimb, tasks such as tying shoes tightly and opening a closed tight jar become possible. The technology has made a major impact for those who would otherwise be unable to perform tasks due to their disabilities. This technology is currently already used to give humans with disabilities the same abilities as

typical humans. However, as bionic technology becomes more integrated into our society, this technology could very well be used to better the abilities of the typical human. This, of course, raises many ethical concerns. For example, is it okay to use robotic technology to replace our limbs? What about our eyes? Ears? Where's the limit? More importantly, how far can we go before we become more robotic than human?

It is also important to note that this type of biotechnology is, and will continue to be, quite expensive. Looking into the future, we could be creating a world where the humans who can afford it are bionic and those who can't stay as humans, becoming physically weaker and less capable than those with bionics. As far-fetched as this may sound, the idea of robots and humans merging will soon become a reality. Once bionics can grant capabilities better than humans, it is clear this topic must be thoroughly discussed, and the ethics must be decided on before proceeding with bionic implantations.

Where do you stand?

Pick up the phonograph

Attempts at extraterrestrial interactions

BY THERES ALEXANDER, BEHAVIORAL NEUROSCIENCE, 2022

In 1977 two phonograph records named the “Golden Records” were included aboard the Voyager spacecraft when it was launched into space. The records contained greetings in 55 different languages, which included Mandarin Chinese expressions of “Hope everyone’s well” and “Please come here to visit when you have time,” as well as “Hail” in Hittite. The records also contained numerous images, music, and natural sounds, such as the sounds of crickets, wind, and laughter. The primary objective of this project was to illustrate life on Earth to extraterrestrial beings and express our desire to be a part of a larger community.

Similar attempts have been made in hopes of interacting with life forms outside of Earth. In January of 2017, the Chinese Academy of Sciences made what is now the world’s largest radio dish, which is also the first to be custom-built to listen for a message from outside our planet. More recently, American scientists created a Richter-like scale known as Rio 2.0, which generates scores from zero to 10 to indicate the likelihood that a Seti (search for extraterrestrial intelligence) signal is genuine. A radio telescope called the Karoo was also built this year in South Africa to scan stars and identify potential extraterrestrial technology.

But even if we were to ever make contact with aliens, how would that interaction impact humanity? There are three possible scenarios: the interaction can be either beneficial, neutral, or harmful to humanity. In a beneficial scenario, we would gain a friendly relationship with cooperative aliens, allowing for a constant exchange of information, especially because we believe them to be more advanced than humanity. The neutral scenario also includes the possibility of mere detection of aliens depending on whether you consider simple insight a valid benefit.

Lastly, the harmful scenario is predicted to be as described in popular science-fiction literature: aliens taking over the world. However, this harm may not be intentional; it is possible that physical hazards like transmission of disease and informational hazards like a computer virus could be an accidental consequence of human-alien interaction. As to which scenario is more likely, only time will tell.



A quick, dark history

BY CONNOR WALRATH, PHYSICS & MECHANICAL ENGINEERING, 2023

For many, dark matter is a science-fiction term to explain alternate realities and universes, but for astrophysicists, dark matter is largely a mystery. Dark matter does not interact with the fundamental force of electromagnetism, which means it can neither absorb nor emit light – that’s why it’s called ‘dark!’ Evading both the nuclear fundamental forces, dark matter only interacts with gravity. Contrary to the belief that dark matter interacts with absolutely nothing, scientists depend on its gravitational interaction with visible matter to infer its behavior. The effects of this interaction can be traced all the way back to 1933.

One of the first experiments to be affected by dark matter was in 1933 when Fritz Zwicky published a paper on the dispersion velocity of coma cluster galaxies. His findings produced a velocity so high that a galaxy could not remain stable without the influence of a large mass. However, Zwicky simply waved a hand, forming a hypothesis of unobservable dark matter.

In 1958, Soviet-Armenian physicist Viktor Ambartsumian proposed a hypothesis of dynamical equilibrium to counter Zwicky’s unsteady hypothesis of dark matter and to explain the unusual findings of cluster galaxy studies.

After three years of dispute within the astrophysics community, a conference was held in 1961 in Santa Barbara, CA, to discuss the influential hypotheses associated with mass discrepancies of cluster galaxies. Attendees determined these hypotheses to be inconsistent with the time-scale of the universe, as cluster galaxies would have collapsed in on themselves relatively soon after their formation. However, the alternative to these hypotheses was that all astronomical theories up until then were based on observations of less than one percent of the actual matter in the universe. Though unsuccessful in explaining what was behind the mass discrepancies, this conference instilled a sense of urgency in the scientific community to answer that question.

Still fueled by that urgency, the astrophysics community has recently created The Global Argon Dark Matter Collaboration (GADMC), a collaborative organization of four experiments that use dark matter detectors of liquid argon. Formed in September 2017, these experiments can detect dark matter via a tiny burst of light that is produced if a dark matter particle collides with the nucleus of an argon atom. Although recent strides in dark matter detection could prove fruitful, there is no telling how much longer the search will last.

Who Has Been to Space?

Over 500 people have traveled to outer space since Soviet cosmonaut Yuri Gagarin became the first human to orbit Earth in 1961. Two dozen have also journeyed to the moon, beginning with NASA astronaut Neil Armstrong's historic first steps in 1969.

On Sept. 17, SpaceX CEO Elon Musk announced the first private customer to fly around the Moon on the company's future Big Falcon Rocket (BFR): Japanese billionaire Yusaku Maezawa, who plans to take several artists with him for a project called #dearMoon.

In light of this announcement, here are some of the most interesting numbers and records about our journeys into space.

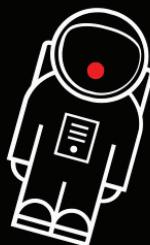
BY ERICA YEE, INFORMATION SCIENCE AND JOURNALISM, 2020



7h 37min 21sec

longest single extravehicular activity (EVA) time on the Moon, set by Apollo 17 astronauts in 1972.

above photo:
Apollo 17 astronaut Eugene A. Cernan rides a Lunar Roving Vehicle while on an EVA.



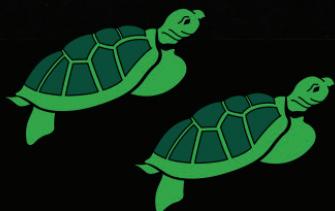
\$35 million

amount paid by Canadian circus billionaire Guy Laliberté to visit the International Space Station (*image right*) in 2009.

7 tourists

the total number of private space travelers so far, of which Laliberté was the most recent. All were flown by the Russian Space Agency.

Sources:
NASA, SpaceX



2 tortoises

the first Earthlings to travel around the Moon, along with wine flies, mealworms, and plants, aboard the Soviet Zond 5 in 1968.

The creatures returned safely.



12 humans

number who have walked on the Moon.

12 humans

additional number who have orbited the Moon.

All 24 were NASA astronauts.



2023

the earliest year SpaceX estimates Maezawa will fly on the BFR (*concept image above*)

DON'T MIND THE BRAIN:

A conversation with Professor Satpute

BY BRYNN VESSEY, BEHAVIORAL NEUROSCIENCE, 2019

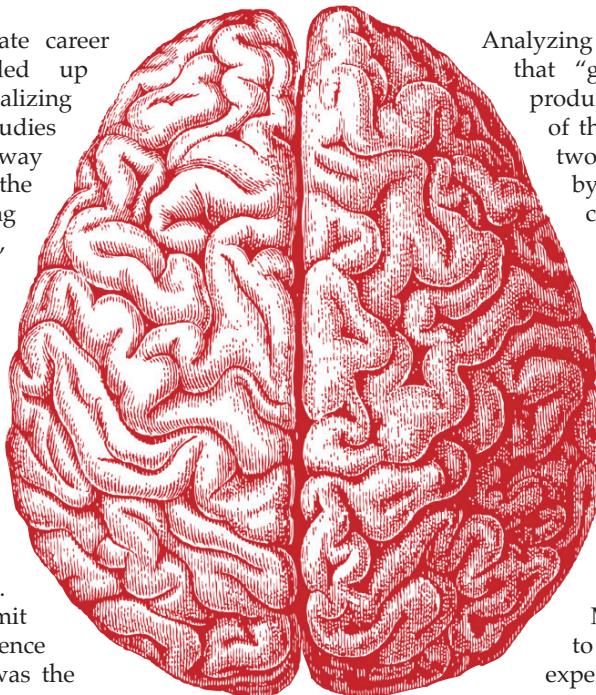
DESIGN BY KATIE GREEN, BIOENGINEERING, 2021

There are some things that just naturally go together, like peanut butter and jelly, spring and flowers, or the mind and the brain. All combinations are exciting, and all have been linked to one another for many years. While all are beautiful, none of the interactions spark quite the scientific conversation as the one between the mind and the brain. To dig further into the link between the two, how they're even defined, and how we can go about researching them, I sat down with Ajay Satpute, a psychology professor and the director of Northeastern University's Affective and Brain Science Lab, to discuss his theories on the mind and brain.

Satpute started his undergraduate career studying chemistry, but ended up switching to psychology after realizing that there was room for empirical studies in psychology. He said, "I saw the way you could take things, features of the mind like feeling conflict, working memory, learning, and emotions, and find a way to study them empirically and make claims about them scientifically." An elective in psychology lead him to an obsession with human intelligence, memory, emotion, and cognition. After finishing his undergraduate career at Trinity University, he then spent two years working as a lab manager to learn more about the brain and neuroimaging. He had been hesitant to commit to neuroscience, as cognitive science had taught him that the mind was the software and only concern of the brain, and that the structure and organization of the brain didn't matter. After his experience with neuroimaging in his research, he went on to University of California, Los Angeles to get a Ph.D. in Neuroscience.

The Stroop Effect was one of the tasks that helped captivate Satpute's attention in neuroscience. A simple test that mismatches the actual color of font with written names of color, for instance writing red in blue ink, The Stroop Effect can measure short-term memory. The task can be used to discover fundamental principles about cognitive control and can be generalized to quitting smoking and eating regulation, as dependent on the assumptions about the mind-brain interaction via its implications in impulse control and decision making.

Of the mind and the brain, Satpute says that his definition of the mind has become that of subjective experience. The way that we are able to see and experience the world is what constitutes the mind, and likely is what separates humans from robots. The brain can be more simply defined, and as Satpute put it, it "is the substrate that gives rise to the mind; it allows the mind to exist." Early philosophy interwove the mind and the brain, and the two are still intricately linked. Studies in neuroscience that try to get to the heart of subjective experience, such as emotion, are trying to measure the mind by looking at the brain itself, as it's not possible to measure the mind.



“ The mind is the fact that we have experience. It's self evident; we see colors and hear sounds, we experience the information as a whole, not necessarily as the bits the compose it.” - Professor Satpute.

Analyzing the mind must occur in a way that "gives credit to the organ that produces it," according to Satpute. One of the earliest methods to look at the two was phrenology, developed by Franz Joseph Gall. Gall coined certain patches of the brain as responsible for specific mental qualities, like the frontal cortex being responsible for color, order, weight, and size. Although the actual mapping and methodology used by Gall to identify the mind-brain relationship has been proven invalid, the idea of certain regions of the brain being responsible for cognitive processes is still a dominant view in the field of neuroscience. Mind-brain mapping attempts to understand how we're able to experience phenomenon, but the question of how the brain gives rise to the mind is still one of the biggest mysteries of modern science.

To understand how human experience revolves around the mind-brain relationship, Satpute studies the effect of fear on this complex organ. He asks, "Does everyone feel fear the same way? If you feel afraid in one circumstance and then in another, is it the same kind of fear? When two people say they feel angry, is it the same feeling or is it just that they lack categories to represent the emotion?" If these questions are as captivating to you as they are to modern neuroscientists, check out the Affective and Brain Science Lab at Northeastern University, and make sure to take a class with Professor Satpute.

ART UNDER SIEGE {

Paintings, sculptures and cultural sites are at risk from microorganisms

BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

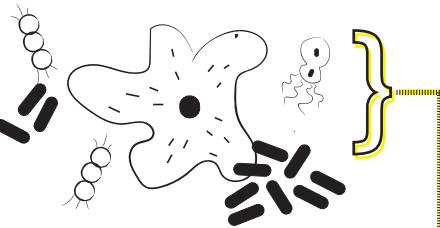
They're everywhere, and they're coming for our art. Nowhere is safe from these tiny invaders; every museum, archive, and historical site is full of them. Who are they? Microbes. And scientists are trying to discover how to keep them at bay.

Microbes are microscopic organisms, including bacteria, fungi, viruses, algae, and protozoa. There is an estimated 10 times the number of microbes in the human body as cells, and the vast majority play a crucial role in body processes. However, microbes that collect on art result in biodeterioration and discoloration of these pieces. Everything — wood, canvas, optical disks and even stone — can be impacted by tiny invaders. Organic materials are most vulnerable, especially paintings, as many artists use an egg-based tempera to bind pigments in their paint. Researchers, including groups in Italy, Portugal, and Spain, have dedicated themselves to

stopping these harmful effects.

Visitors can unknowingly leave behind skin flakes, clothing particles, and other debris when they view artwork. This can lead to microbial growth, which is stimulated by heat and light. In the Altamira Cave in Spain, white fungal colonies have started growing over paleolithic paintings. This is likely caused by the number of visitors to the cave, according to the Environmental Microbiology and Cultural Heritage research group in Spain. The team recommend other caves should stay shut to the public to avoid a similar fate. However, not all art can be placed in climate-controlled spaces to prevent microbe growth.

In a study by P. Fernandes from Lusófona University in Lisbon, Portugal, seven methods of microbial control on artifacts were analyzed for their effectiveness at stopping future growth. These methods



include exposing microbes to oxygen deprivation, fumigation, and concentrated UV and gamma rays. Another solution is to remove organisms by hand, though they tend to redevelop rapidly. Low-pressure power washing has also been used, but water left in pores can cause increased growth in the future.

There has been tremendous progress in conservation efforts, but the microbiological field still requires a better understanding of the interactions between scientific and artistic worlds. Further knowledge of microbes may even lead to improvement of art. Giancarlo Ranalli, a researcher from Pesche, Italy, utilized bacteria to clean the base of Michelangelo's Pieta Rondanini in Milan. Some people, such as artist Peta Clancy, have even been turning microbiomes into art. Who knows what the microbial future holds?

HEAD IN THE CLOUDS {

The interaction between climate and the brain

BY SOPHIA ANAIN, BEHAVIORAL NEUROSCIENCE, 2022

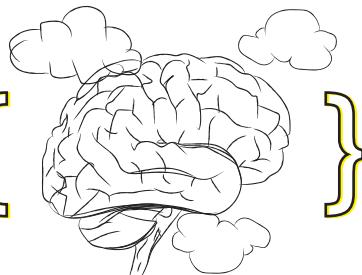
Denmark ranks as the happiest country in the world, says The 2016 World Happiness Report, with Switzerland and Iceland close behind. In the Gallup-Healthways Well-Being Index, which ranks the United States, Montana consistently tops the list. There are obvious reasons as to why wealthier, safer, and cleaner societies have citizens with the healthiest brains, but can a factor as simple as the weather also affect mental health?

Though societal perks such as good health care, education systems, and economies are key contributors to a happy society, temperature plays a significant — yet overlooked — role. While people may be guilty of blaming a bad mood or lack of motivation on one of Boston's grueling winters, it is warm weather, in fact, that hinders the brain's ability to solve complex problems, according to a recent Scientific American study. While winter weather

does not necessarily help the brain process complex information, it does not inhibit cognitive functions the way an 80 degree day certainly would.

The impact of weather comes down to energy use. Every process in the human body requires large amounts of energy, often in the form of glucose. Glucose is used to regulate bodily temperature — the warmer the body, the more glucose is required to cool off, and much more energy is required to cool a body than to heat it. As it turns out, this is the same chemical our brains use to solve complex problems. The more glucose wasted cooling down, the less there is to navigate difficult topics, meaning there are few cities better than Boston to endure finals week.

In addition to hindering the brain's ability to solve complex problems, hot temperatures also affect mood. While



longer days and more sunlight exposure have shown to improve mental health, a recent study conducted by Solomon Hsiang at the University of California Berkeley has proven that too much heat has the opposite effect. There is a significant "climate-violence link" that associates increased crime and violence with hot temperatures. Recent research conducted in Science Magazine claims that with every 3 degrees Celsius that the temperature rises above normal, interpersonal conflict increases by 4 percent, and group conflict by 14 percent. According to this study, when the human body heats up, more blood is drawn toward the surface of the skin as a cooling mechanism. This process results in a lack of oxygen at the areas of the brain that keep our natural human impulses in check. The calm, rational, decisions that are made easily during the winter months are replaced by rather hotheaded responses.

A GRAPEFRUIT A DAY WON'T KEEP THE DOCTOR AWAY

BY CICELY KREBILL, BIOLOGY, 2019

When going to the doctor's for an appointment, most patients anticipate being advised to eat more fruits and vegetables to create a balanced, healthy diet. Increasingly, however, they are being steered away from grapefruit. Although it seems innocuous enough, eating a grapefruit or drinking its juice while on certain medications actually has more concerning outcomes. Grapefruit has been found to interact with certain medications and impair drug metabolism, thus leading to an increase of drug concentration in a person's system.

But why grapefruit? This citrus specifically interferes with the activity of cytochrome P450 3A4 (CYP3A4), an enzyme found in the epithelial cells of the small intestine and colon as well as cells in the liver that terminates the action of many drugs. When these drugs are unable to be inactivated and metabolized, it leads to a higher concentration remaining in the body and ultimately an overdose of intended medicine in the patient. These overdoses are not always as concerning as they sound, as patients sometimes only experience constipation from the interaction. However, of the 85 medications that are impacted by grapefruit, around

DESIGN BY DENNIS KATS, COMPUTER SCIENCE AND MATHEMATICS, 2022

50 percent have the potential to lead to serious side effects ranging from damage to the kidneys to respiratory failure. For example, one tablet of simvastatin, a medicine used to treat high cholesterol and triglyceride levels, paired with grapefruit juice was seen to have the same concentration level in the body as taking 12 tablets with water. In patients, this increases their risk of liver and muscle damage.

Patients on medicines known to interact with grapefruit are advised to avoid all of its forms: freshly squeezed juice, the whole fruit, and even frozen concentrate, because as little as 200 milliliters can lead to an increase of the drug concentration in the body. Though grapefruit has garnered a lot of attention for these effects, scientists are realizing that this interaction is not unique to the fruit. Limes and pomelos have also been found to produce this interaction, leaving the general sentiment that an apple a day keeps the doctor away, but you might want to be wary of the citrus fruit.

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DOI: 10.1503/cmaj.120951

Neural commands for steady hands

BY SARA GANNON, BEHAVIORAL NEUROSCIENCE, 2021

When you lift a spoonful of cereal to your mouth in the morning, the neurophysiological mechanisms that allow you to complete the action without dumping it straight down the front of your shirt are likely the last things on your mind. The ability to generate precise movement is often overlooked. However, for those afflicted with kinetic tremors, it can be a daily tribulation.

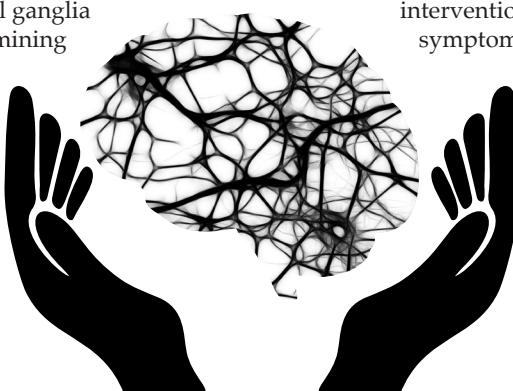
Before delving into the ways that neural systems go astray, it's valuable to first discuss how they succeed. Volitional movement, or the ability to produce voluntary, conscious movement, is complex; it requires communication from a wide variety of micro- and macro-structures. The initiation of a movement begins in the visual cortex, which processes sensory information from the eyes. Next, the frontal lobe is recruited for planning and execution. The spinal cord relays orders from the frontal lobe to the muscles in your arm, where motor neurons communicate with muscles at neuromuscular junctions. The basal ganglia are then responsible for determining the appropriate amount of force needed to complete the movement while the cerebellum coordinates timing and corrects errors. Notably, the basal ganglia are vital for movement precision

and consistency. Clinical studies of damaged basal ganglia often discover correlations with hyper- or hypo-kinetic symptoms--that is, excessive or hampered movement. With this in mind, it's unsurprising to see tremors as a symptom of Parkinson's Disease (PD), as it is characterized by a reduction in activity--specifically, of dopamine, an excitatory neurotransmitter--in the basal ganglia.

To treat tremors in PD, clinicians often prescribe a dopamine agonist, a drug which will act to increase perceived levels of dopamine in the brain. In very severe cases, PD tremors are treated via a deep brain stimulation in the basal ganglia or surrounding regions. Especially relevant is stimulation of the subthalamic nucleus of the basal ganglia, which is implicated in excitatory glutamate pathways. Correspondingly, cases of non-PD kinetic tremors are often treated with propranolol, a therapy that increases the brain's perception of glutamate levels. Successful clinical trials have found that

intervention in glutamate pathways can alleviate symptoms of kinetic tremors, indicating that these glutamate pathways potentially play a vital role in how we coordinate smooth movement, and allow for Parkinson's patients to enjoy their morning cereal.

PHOTOS BY PIXABAY



Hungry hungry hormones

BY MALCOLM SHUMEL, BIOENGINEERING, 2021

What makes you feel hungry? What makes you feel full? These are key questions researchers consider in the fight against obesity.

Researchers have found answers to both questions in the hormones ghrelin and leptin. Ghrelin is secreted by the stomach before a meal, returns to baseline levels afterwards, and signals neural pathways in the hypothalamus that cause hunger. These properties suggest that ghrelin is the messenger for the stomach telling the brain that it's hungry. Given this role, ghrelin has been examined as a target for obesity treatments.

Leptin, a strong appetite suppressant, signals to the brain that it's full. Unlike ghrelin, leptin is not primarily secreted by the stomach, but by adipose tissue. When the body has

“ However, proving how complex energy balance really is, both of these conclusions are wrong.”

gone through its adipose stores, leptin is downregulated and as a result, the body feels hungry. Like ghrelin, leptin was strongly considered for use in therapies to treat obesity, but the reality is that these therapies aren't so simple.

PHOTO BY PXHERE

DESIGN BY DENNIS KATS, COMPUTER SCIENCE AND MATHEMATICS, 2022

This information might encourage two conclusions: ghrelin and leptin levels are inverse to one another, and that obesity can be treated by upregulating leptin and downregulating ghrelin. However, proving how complex energy balance really is, both of these conclusions are wrong as no correlation is seen between leptin and ghrelin levels in humans. Researchers theorize that leptin has more to do with what happens when the body depletes its energy stores than it does with obesity. Although ghrelin is known to be a powerful appetite stimulant, ghrelin knockout mice show only modest decreases in weight, meaning ghrelin's function may relate more to short term energy storage than long term adipose build up.

Despite leptin being an appetite suppressor and ghrelin being an appetite inducer, leptin levels in the bloodstream are higher in people with a higher body-mass index (BMI). More surprisingly, ghrelin levels are lower. Higher leptin levels make sense as it is secreted by adipose tissue. Why doesn't the appetite suffer?

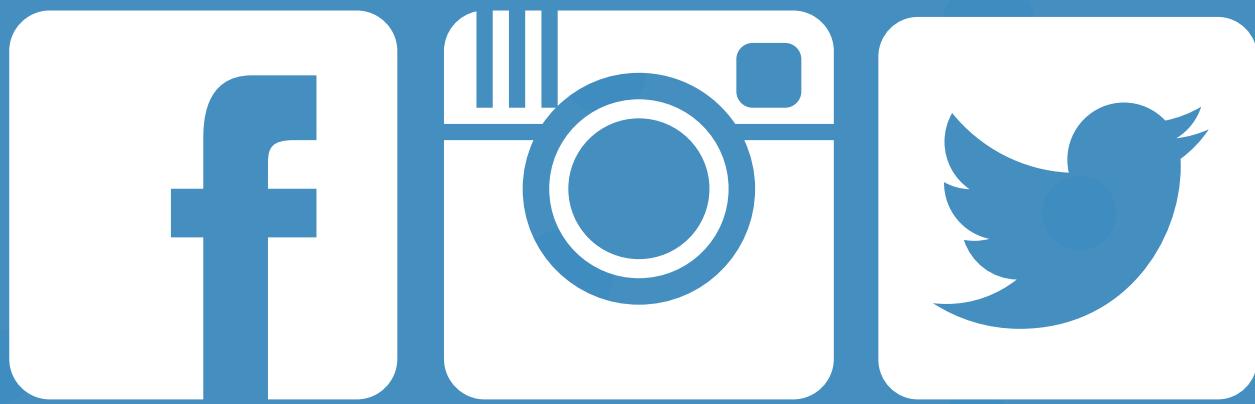
Just as a smoker's brain becomes desensitized to dopamine, the body becomes desensitized to leptin signaling after prolonged exposure. This means appetite doesn't decrease despite continually elevated leptin presence in the bloodstream. It isn't clear as to why ghrelin levels are decreased in obese patients and why this does little to slow appetite. Researchers hypothesize that just as the obese body becomes desensitized to leptin, it becomes over-sensitive to ghrelin. While this isn't well understood, these observations provide promising direction for future metabolism studies.

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