

ISSUE 38 Fall 2018

NU SCI

People

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LETTER FROM THE EDITOR

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Ninety active members of NU Sci, 14,000 undergraduates at Northeastern, 692,000 residents of Boston, 327.16 million living in the United States, 7.7 billion people on this planet.

That's a lot.

It is critical that we utilize science communication as a way to educate (all of those) people on the impact we are leaving on the world. From amazing scientific discoveries and new technologies to enormous carbon footprints and the overuse of land and oceans alike - it's our responsibility to understand the rapid changes occurring all around us and use our knowledge to enact real change.

With that, I am excited to introduce Issue 38: People. Within these pages, learn about everything from the science behind the #MeToo movement to NASA's aspirations to send people on a mission to Venus. Consider creative solutions for the water crisis in the Middle East and around the globe or take a neuroscientific look into the mind of a sociopath. We hope our words can be catalysts for change and curiosity, and remind you all just how much every action you take can affect those around you.

With nine different sections, including public health, women in science, genetics, and the environment, our articles are as diverse as the people who make up our planet. Read about how our brain recalls faces, how climate change can impact respiratory illnesses, how trauma can play a role in generations of a family's genetics, and so much more.

If that's not enough, check out the many new articles on our website (nuscimag.com) exploring topics such as what the earth would look like without people, how we understand and connect to emotions, and the use of quantum mechanics mathematical models applied to human behavior.

I would be remiss if I did not thank all of the amazing team members that I get to work with every week. It has been a crazy semester for us, and our publications would not be possible without the hard work of our eboard, editing, design, marketing, outreach, and web teams. Shoutout to all of our writers for their creative ideas, passionate articles, and dedication to science journalism. And a special thank you to Northeastern's College of Science for continuing to support us through this semester; we are so grateful for your patronage.

Happy reading and congratulations on another great semester!



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

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TARANA BURKE AND THE #METOO MOVEMENT: THE SCIENCE BEHIND ITS #SUCCESS

BY CHRISTINA MCCONNEY, BIOLOGY, 2021

It's been almost a year since social media exploded with accounts of sexual assault survivors from all different walks of life. These survivors became a unified force on social media, standing behind #MeToo after actress Alyssa Milano asked her Twitter followers to retweet and share their own experiences with the world. Two weeks following the viral post, CNN reported that 1.7 million people, in over 85 countries, had used the hashtag. Tarana Burke, the original creator of #MeToo, would later be given proper recognition for its creation and success.

Surprisingly to most, the #MeToo movement wasn't born last year; in fact, it was created over a decade ago in 2006 by Tarana Burke, who was ashamed that her own past sexual assault prevented her from being able to help a young woman deal with the pain of her trauma. Burke founded #MeToo as a part of Just BE Inc. with the hopes of building a community of advocates driven by survivors and giving the world a sense of the magnitude of this problem. Focused on empowering and guiding young women of color through their youth, Burke's organization helps them navigate the perilous roads of growing up in today's society.

One of the most interesting parts of the #MeToo movement is that it has had such a lengthy lifespan on social media platforms, which are commonly known for their short attention spans. Since the birth of #MeToo, there have been variations all over the world: #BalanceTonPorc in France and #QuellaVoltaChe in Italy, to name a few. Initially, there was a fear that this movement, like so many others before it, would simply be swept under the rug and die out before having the chance to truly make an impact. So what goes into helping these #socialmovements survive both on and off social media, and what is killing them in the first place?

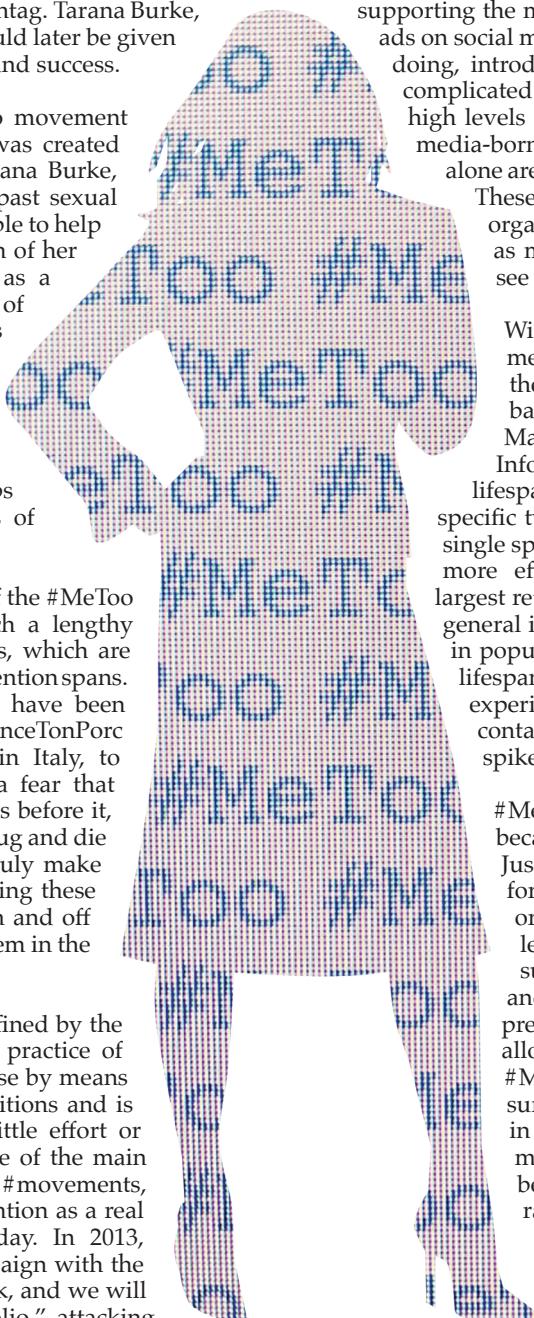
The main reason is slacktivism, defined by the English Oxford Dictionary as the practice of supporting a political or social cause by means such as social media or online petitions and is characterized as involving very little effort or commitment. "Slacktivists" are one of the main reasons behind the failure of many #movements, and they have garnered some attention as a real problem faced by campaigns today. In 2013, UNICEF Sweden launched a campaign with the advertisement "like us on Facebook, and we will vaccinate zero children against polio," attacking



DESIGN BY MARISSA KEESEY, ELECTRICAL ENGINEERING, 2022

the lack of impact that "liking" something on Facebook has on funding the vaccination of children. The goal of this was simply to vocalize that while spreading the messages online is helpful, it does nothing for the cause itself if not accompanied by some physical action of support.

The problem, according to experts, is not that people are supporting the movements by liking and sharing their ads on social media - the problem is that's all they are doing, introducing "slacktivists" into the ongoing complicated equation of success. While sustaining high levels of participation is a key ingredient in media-born movements, social media platforms alone are not enough to establish actual change. These efforts, in conjunction with activists, organizations, and other physical acts such as making donations are the only way to see any real progress.



With the short attention span of social media combined with "slacktivists," the prolonged success of #MeToo is baffling. A team of scientists at Singapore Management University's School of Information Systems investigated the lifespan of tweets and found that event-specific tweets that were shorter in nature had single spikes in popularity and were ultimately more efficient in engaging users with the largest retweet ratio. On the other hand, longer, general interest tweets were found to fluctuate in popularity but overall maintained a longer lifespan. This might explain why #MeToo experienced such high levels of success, containing the characteristics of both single spike and fluctuation tweets.

#MeToo has enjoyed extensive success because of the amount of attention that Just BE Inc. has garnered, allowing for a united force of millions to take organization's aspirations to the next level. Physical manifestations of support -- in this case, recognizing and spreading the word about the prevalence of sexual assault -- have also allowed for the continued survival of #MeToo and its support of sexual assault survivors. Maybe #MeToo's success lies in the consistently relevant nature of its message, and the focus shouldn't only be how does it continue to survive, but rather #HowCanWeHelp?

ASONAM (2014). DOI:10.1109/
asonam.2014.6921598

IMAGE BY FREESTOCKPHOTOS.BIZ

What do video games and medicine have in common?

Benefits of virtual reality in treating phantom limb pain

BY VICTORIA PAJAK, BEHAVIORAL NEUROSCIENCE, 2021

Following a tragic accident or disease where limb amputation occurs, eight out of 10 people will report discomfort where the limb once was. This common yet mysterious phenomenon is known as phantom limb syndrome (PLS) and is characterized by the ability to feel various sensations in the area of a dismembered limb. Out of individuals who experience PLS, many may experience phantom limb pain (PLP). Burning, tingling, and shooting pains in the area of the amputated limb are all symptoms that can cause the amputee to suffer. Although the exact biological reason for developing PLP is unknown, it is speculated that neuroplasticity plays a role. In an interview with Science Daily, Bo Geng, a postdoc at the Faculty of Medicine at Aalborg University in Denmark explains that “the tactile representation of different body parts are arranged in the brain in a sort of map. If the brain no longer receives feedback from an area, it tries to reprogram its signal reception map.” With this knowledge, therapies for PLP have been made involving tricking the brain to believe that the amputated limb is still attached to the body.

Among current treatments, mirror therapy has been shown to be effective. This treatment relies on visual feedback and involves use of a mirror to create a reflection of the intact limb. Seeing a reflection of the missing limb while keeping the amputated stump covered deceives the motor cortex of the brain into believing the body is symmetrical. Sensory conflict from the amputated stump is what the brain may interpret as pain. Since pain is linked to visual input, this deception has been shown to relieve pain associated with PLS. “Even though a person who has had a hand amputated can no longer see it, in many cases he or she can still feel it,” Geng said. Despite the successful progression of visual treatment, there are several limitations to mirror therapy, especially with how easily the illusion may be lost. The patient is confined by space and environmental objects brought into vision can interrupt the illusion. Only symmetrical movements can be created by the individual and movement of the reflected limb is out of their control, giving the treatment poor realistic value.

Although popular in the video game industry, research results show that virtual reality technology may have medicinal benefits by mitigating symptoms of PLP without the limitations of mirror therapy. Virtual reality technology is a computer-based simulation of a real-world environment that a patient is immersed in to be provided with a more accurate representation of their own missing limb. It works to deceive the brain by “transposing movements of amputees’ intact limbs into movements of virtual limbs through sensors attached to the amputated stump.” This technology is more effective than mirror therapy since it provides the amputee with more varied

and realistic visual input. The individual is able to move the limb irrespective of the intact limbs’ movements, and specialized goggles allow for limited visual interference from the environment. These characteristics of VR give it strong potential to create ‘false limbs’ within an individual’s brain, thus contributing to the efficacy of treatment.

Bo Geng and researchers from Media Technology at Aalborg University have recently conducted a study showing the success of this treatment. Two participants were involved and first asked to rate their pain level before engaging

“

Even though a person who has had a hand amputated can no longer see it, in many cases he or she can still feel it.”

with the VR device. Immediately after one hour of playing immersive VR games that heavily involved use of their amputated limbs, the participants were asked to rate their pain severity. Subject one and Subject two’s pain severity decreased by 100 and 93.7 percent, respectively. Furthermore, in subsequent sessions, the subjects reported significantly lower pre-treatment pain severity and a progressive decrease of PLP across four sessions. Although these findings shed a hopeful light on successful treatment of PLP, further studies of higher evidence have not been conducted.

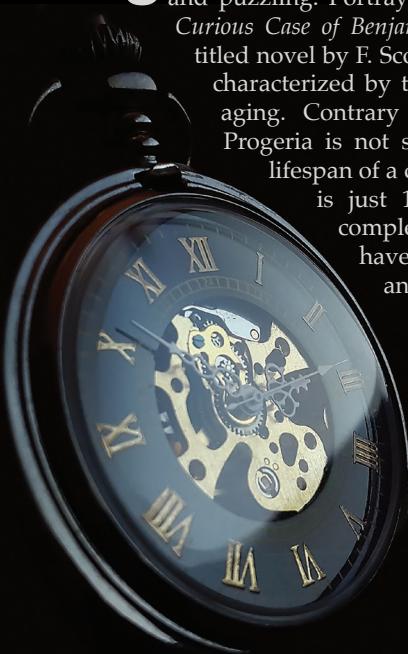
While several studies have produced similar results, more research on VR treatment of PLP is needed to fully explore the benefits of this cutting-edge technology. In addition to phantom limb pain, VR has other implications in medicine such as in treatment of mental illnesses like anxiety or phobias. It has also been shown to play a role in preventing memory loss, treating chronic pain, spinal cord injuries, stroke, and in planning operations. These possible positive outcomes point to a bright future of VR in medicine. Who would have guessed that what was originally used as a cure for boredom could lead to groundbreaking cures in medicine and enhance the lives of many patients.

Frontiers in Neurology (2018). DOI:10.3389/fneur.2018.00067
Disability and Rehabilitation (2007).
DOI: 10.1080 /09638280601107385

A CURE FOR THE CURIOUS DISEASE

BY PAULA HORNSTEIN, BIOCHEMISTRY, 2020

Of the world's rarest diseases, Hutchinson-Gilford Progeria Syndrome, is one of the most recognizable and puzzling. Portrayed in both the 2008 film *The Curious Case of Benjamin Button* and the similarly titled novel by F. Scott Fitzgerald, the condition is characterized by the appearance of accelerated aging. Contrary to the film and literature, Progeria is not simply aging backwards; the lifespan of a child diagnosed with Progeria is just 14.6 years. The condition is complex, yet, recently, great strides have been made in understanding and treating Progeria.



The condition of Progeria occurs due to a mutation in the LMNA gene. When functioning properly, the LMNA gene allows for production of the protein Lamin A, which gives the cellular nucleus its structure and makes it a stable home for a person's genetic material.

The mutated LMNA gene results in an abundance of a weak Lamin A analogue called progerin, resulting in unstable nuclei. This instability leads to the early demise of cells, resulting in accelerated aging in individuals with Progeria. This aged appearance consists of wrinkly skin, stiff joints, hip dislocation, hair loss, and weight loss, although these symptoms do not occur until a year or so after birth. In most cases, children with Progeria die of conditions related to atherosclerosis, such as congestive heart failure and stroke.

In April 2018, however, a publication in the Journal of the American Medical Association advised that this may not be the definitive fate of those diagnosed with Progeria. Funded by the non-profit organization, the Progeria Research Fund (PRF), Boston Children's Hospital and Brown University worked in collaboration to develop a therapy that extends the lives of children with Progeria. The study involved 250 children who had been diagnosed with Progeria, and the results are uplifting--somewhat of a rare occurrence in therapy development for rare diseases. The treatment employs the synthetic protein, lonafarnib, which is a farnesyltransferase inhibitor that, through an unknown mechanism, blocks the modification of proteins that stimulate progerin production. After a median of 2.2 years of lonafarnib monotherapy, the mortality rate of the children with Progeria significantly decreased, from 33.3 to 3.7 percent. These findings provide hope for children suffering from Progeria, so that maybe a child with Progeria can live as full of a life as Benjamin Button did.

Journal of the American Medical Association (2018). DOI: 10.1001/jama.2018.3264

WHAT'S HIS FACE? AI'S ARTISTIC APPROACH TO ANONYMITY

BY HEATHER OFFERMANN, BEHAVIORAL NEUROSCIENCE, 2019

When publicly broadcasting the details of a traumatic event, a controversial opinion, or revealing a lucky lottery winner, protecting an identity can be crucial to keeping the individual emotionally and physically safe. In journalism, anonymity is produced by either pixelating or blurring the face of an individual. Other common practices include turning the person away from the camera or placing them within a shadowed corner. Regardless of the chosen method, the segment is often void of emotion and natural facial expressions due to the visual distortion or blocking of the face. Viewers are unable to empathize with those being interviewed, especially when their voices are also unrealistically altered.

A research team from Simon Fraser University (SFU) recently developed artificial intelligence (AI) techniques to replace the standard blurring with computer-“painted” renderings of human faces that maintain both anonymity and emotions. With the combined applications of computer science, cognitive science, and fine art, their AI software can better convey emotional information specific to each face. According to Steve DiPaola, the head of SFU’s Interactive Visualization Lab, a typical artist paints a portrait by



attempting to capture both what the person looks like (outer) and who the person is (inner). The software, called v.3, is able to decrease the conveyance of outer resemblance, while focusing on capturing inner resemblance – or how the person feels. V.3 was programmed to learn more than 1,000 years of artistic techniques to accurately “paint” each frame of a video clip. Test videos on the lab website show clips of sample participants in what looks like an oil painting in motion, with styles similar to the works of Monet or Renoir.

SFU’s v.3 keeps faces ambiguous enough for viewers to not recognize specific facial features without sacrificing the overall facial movements and emotive expressions; a delicate balance solved through the collaboration of science and art. Emotional connections through anonymous interviews can now be restored. The research team hopes to bring this new tool to the forefront of journalism, and they have already been successful in gaining the attention of the New York Times and the BBC. As ironic as it is, v.3 and other forms of AI are helping us to relate more closely with one another, provoking already innate empathetic reactions by creating a virtual reality to improve human connection.

PHOTOS BY PIXABAY

You can't sit with us for this study:

Exclusion factors in clinical trials

BY CICELY KREBILL, BIOLOGY, 2019

Clinical trial eligibility criteria have played an important role in both keeping trials safe and defining a patient population to study. These criteria are used to exclude patients that are more likely to have an adverse event from the trial as well as those who are unlikely to benefit from it. Criteria such as age, organ function, disease stage, and comorbidities frequently make the list of exclusion factors for particular populations. Although these limits are important, overly strict criteria have been criticized for decreased generalizability and low study populations, with almost 20 percent of publicly funded trials ending because of their inability to continue to run the study. The current state of clinical trials begs the question, how strict is too strict?

One main criticism of clinical trials from the scientific community is that criteria frequently exclude the population of patients that would make up a large portion of its intended-use population following drug approval. In a recent study, researchers explored 297 oncology protocols for clinical trials and examined eligibility criteria. Of these protocols, only three allowed for older patients, with just two allowing for patients older than 65 years, despite the fact that more than 60 percent of cancer cases occur in the elderly. Only 67 allowed for known, active, or symptomatic central nervous system or brain metastases, while around 25 percent of patients with lung cancer and between 10 and 16 percent of stage IV breast cancer patients develop brain metastases. With these numbers, it's unsurprising that many patients are unable to participate in clinical trial opportunities.

What is surprising, however, is that these exclusion criteria are not always justifiable. In a review published in the Journal of American Medical Association, Dr. Harriette Van Spall and her team of researchers looked at 283 randomized controlled trials published in high-impact medical journals, exploring the 2,709 exclusion criteria that they used. Of these criteria, the researchers found that 37 percent of them were poorly justified and that of these trials, 84 percent of trials had at least one poorly justified exclusion criteria.

Researchers propose a two-fold change to clinical trials; they believe some criteria contain non-clinical factors that impact the logistics of the study. For example, distance from study site, language proficiency, and transportation availability were potential exclusion criteria found in these studies. Not

“The current state of clinical trials begs the question, how strict is too strict?”

DESIGN BY KAI GRAVEL-PUCILLO, ENVIRONMENTAL SCIENCE, 2021

only do these factors limit the ability to gather patients for a study, but they also have the potential to indirectly favor certain populations. The researchers also found that despite being excluded from the study, of the patients that were excluded due to a history of prior cancer, 75 percent of them had a localized or regional stage, meaning that their cancer was only affecting particular organs and not the entirety of their body.

Could this history impact clinical values obtained in the trial? The authors of the study believe so, but at the same time they believe more specific clinical values, like blood counts, organ function, or type and timing of prior cancer treatments could be used so that patients with histories of cancer would not automatically be eliminated. These researchers are not the only ones who believe that changes should be made to these restrictions.

In 2016, the American Society of Clinical Oncology (ASCO) and Friends of Cancer researcher launched a joint project, promoting more inclusive eligibility criteria in cancer clinical

trials. They established working groups to address eligibility in five key areas that were considered to be most likely to restrict a patient's eligibility in a trial, but least likely to impact their safety. These five areas are minimum age requirements, HIV/AIDS status, brain metastases, organ dysfunction, and prior and concurrent malignancies. In August 2018, the strategies suggested by these working groups of regulators, industry representatives, advocates, and researchers to improve upon clinical trial inclusivity were used to submit a formal draft of guidelines to the Food and Drug Administration.

While intended to keep patients safe, it appears that exclusion factors are often off base and limit the efficacy and impact of studies. It seems that right now, many researchers, oncologists, and patients view clinical trial exclusions as a barrier to many patients who could benefit and provide crucial information to drug companies. With a current push towards increasing participation in clinical trials, there is a hope that the patient population studied will become more inclusive.

JAMA (2007). DOI:10.1001/jama.297.11.1233
Journal of Comparative Effectiveness Research (2015). DOI: 10.2217/cer.15.27.
Journal of Clinical Oncology (2015). DOI: 10.1200/JCO.2017.73.4186

EPIGENETICS:

BY JEANINE NASSER, HEALTH SCIENCE & BIOLOGY, 2022
DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

The burden of trauma across generations

Regardless of whether a person comes from a family of refugees, survivors of genocide, or war veterans, the burden of trauma is not compartmentalized from other aspects of their lives. In fact, these traumatic experiences can be so severe that they manifest across multiple generations within families. This phenomenon - formally called *transgenerational transmission of trauma (TTT)* - refers to the process in which a traumatic experience that happened to the first generation is passed on to the next. TTT manifests variably across generations and may present as mental illness, chronic illness, and metabolic disease. While some theorists within and beyond academia may attribute passing down the burden of trauma to factors like family structure or socioeconomic effects, recent research uncovered critical evidence of this alteration: epigenetics.

Translating to “above genetics,” epigenetics refers to the mechanisms and modifications used to control how genes are expressed in certain cells - and to what extent - without altering the actual DNA sequence. Therefore, the epigenome consists of more than just the DNA that was passed down to us by our biological parents and allows for gene modifications to collect over a person’s lifetime. One common method to change the level of gene expression is called methylation. At the microscopic level, DNA is wrapped around proteins called histones. Depending on how tightly or loosely our DNA is wrapped, certain genes can be active or inactive as well as change levels of expression throughout a lifetime. Furthermore, if our bodies are unable to control how tightly wound our DNA is to these histone proteins, this irregularity in expression regulation can potentially lead to some adverse health effects.

With this concept in mind, researchers have investigated whether the transgenerational burden of trauma from social and economic depravity is solely genetically inherited or if there are other factors involved. A recent study published by researchers at UC Berkeley used a large sample size to examine the long-term impact and potential reversibility of trauma on children with ex-POW (prisoner of war) fathers. After comparing life expectancies among sons of ex-POWs who experienced starvation, disease, and psychological stress with those who did not experience dire camp conditions, sons of fathers who lived in poor camp conditions were more likely to die earlier than sons of non-POWs and ex-POWs with better camp conditions. However, daughters of ex-POWs did not have their life expectancies significantly influenced by these factors.

The sex-specific transmissions from this study surprisingly stem from an epigenetic effect in which transmission occurs on the Y chromosome due to inadequate maternal nutrition during pregnancy. In an earlier 2014 study, these researchers used mice to investigate the effects of adverse prenatal environments - specifically poor maternal nutrition - on metabolic disease in offspring. When maternal mice were not able to obtain sufficient nutrients, their offspring experienced delays or deficits in DNA methylation. Even in the womb, lack of nutrients important for adequate fetal and embryonic development can put us at long-term risk for certain illnesses like heart disease. When the investigators conducting the ex-POW study noticed that inadequate nutrition during embryonic development could lead to detrimental consequences for offspring, it was found that maternal malnutrition during pregnancy affected the longevity of sons and grandsons, but not daughters or granddaughters. Importantly, when maternal *in utero* nutrition was adequate, there was no impact on children of paternal ex-POW status.

When we apply these findings to other vulnerable populations, minimizing or negating the effects of malnutrition on children of refugees and child refugees themselves can be a critical component in hindering the manifestation of trauma. In a 2011 review published by the Canadian Collaboration for Immigrant and Refugee Health (CCIRH), it was found that members of refugee populations who had accessibility to and increased intake of nutritious foods experienced positive mental health outcomes and lower risk of chronic diseases like heart disease and asthma.

The impact of ensuring accessibility and consumption of nutritious foods across multiple generations is by no means small, as we know that trauma is not an experience that occurs in the past and remains in the past. Rather, the aftermath of trauma accumulates and carries detrimental consequences to future generations, especially in cases where children and child-bearing mothers are forced to flee areas of turmoil and face additional hardships like familial separation. Therefore, ensuring that vulnerable populations who have experienced trauma in some capacity can access and intake nutritious foods will improve their ability to undergo epigenetic regulation and prevent adverse generational health outcomes.

PNAS (2018). DOI:10.1073/pnas.1803630115
Science (2014). DOI: 10.1126/science.1255903
CMAJ (2011). DOI: 10.1503/cmaj.090292

LIGHTS, CAMERA ... SCIENCE!

WINNERS OF THE 2019 BREAKTHROUGH PRIZE

Known as the “Oscars of Science,” the Breakthrough Prize recognizes researchers in life sciences, fundamental physics, and mathematics with a glitzier and more lavish award than the much older Nobel Prize. The nine winners were honored in November at a red carpet ceremony hosted by actor Pierce Brosnan and attended by other celebrities. Award sponsors include Google co-founder Sergey Brin, Facebook co-founder and CEO Mark Zuckerberg with his wife Priscilla Chan, Chinese businessman Jack Ma, Russian entrepreneur Yuri Milner with his wife Julia, and 23andMe co-founder and CEO Anne Wojcicki.

First awarded
2012

\$3 million
to each winner or group
\$22 million
total awarded

3 women
6 men

Adrian Krainer
Ionis Pharmaceuticals



Frank Bennett
Cold Spring Harbor Laboratory

For developing a treatment for children with spinal muscular atrophy, the leading cause of infant death

Angelika Amon
Massachusetts Institute of Technology



For determining the consequences of aneuploidy, when a cell has an abnormal number of chromosomes

Zhijian “James” Chen
University of Texas



For discovering a DNA-sensing enzyme associated with immune system responses inside cells

Xiaowei Zhuang

Harvard University



For discovering hidden structures in cells by developing super-resolution imaging

Charles Kane
Eugene Mele
University of Pennsylvania



For predicting a new class of materials that conduct electricity on their surface but are insulators in the interior

Vincent Lafforgue

France's National Center of Scientific Research



For ground breaking contributions to several areas of mathematics

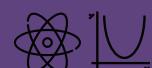
Jocelyn Bell Burnell
University of Dundee
University of Oxford



For a lifetime of scientific leadership and fundamental contributions to the discovery of pulsars



New Horizon Prizes



Six New Horizon Prizes, worth \$100,000 each, were also awarded to seven physicists and five mathematicians for early-career achievements

The radical return of Science for the People

BY JAMESON O'REILLY, PHYSICS AND MATH, 2019

DESIGN BY KATIE GREEN, BIOENGINEERING, 2021

Science is usually portrayed as an objective, apolitical endeavor but in reality it is inextricably linked to power and politics in our society. Misuse of science may seem more obvious today in a world increasingly controlled by technology and on the brink of catastrophic climate change, but these issues have been relevant for as long as science has been an institution. Governments and corporations who fund research often prioritize science for war, surveillance, control, and profit. On the eve of the 1970s, a group of scientist-activists involved with resistance to the Vietnam War founded an organization to reclaim their work and provide a new vision: Science for the People.

Science for the People (SftP) provided a focal point for science activism in the United States throughout the 1970s and 80s. It also published a magazine, called Science for the People, that was the main platform for radical critiques of science and its intersections with society until the movement died out with the end of the 1980s. Since then, technology has continued to be an integral part of how power is manufactured and maintained. Meanwhile, radical scientists have continued to question many of the ways in which this power is used, just without the central organizing body that SftP provided. That is, until very recently.

Now, Science for the People is making a comeback. The effort began in 2014 during a conference at the University of Massachusetts, Amherst; was accelerated by the 2016 election and subsequent March for Science; and reached a major milestone in February when there was a national convention to formally re-establish the organization. There are now local chapters across North America, including here in Boston. Nationally, there are also working groups on topics like Science for Puerto Rico, Reproductive Justice, Climate Change, Science Education, and more.

The new Science for the People has a blueprint, but its members are still trying to work out how the sequel can be most impactful in today's political and scientific landscape. This is especially true as it is still a small organization with broad, ambitious goals. At a recent meeting of the Boston chapter, members discussed upcoming events, including a book launch, and what other organizations they could use their scientific expertise to assist, such as neighborhood groups concerned about climate change-induced flooding. The former makes science and scientists more accessible to the

general public while the latter aims to use scientific expertise to directly improve the lives of marginalized or threatened groups.

This generation also has plans to revive perhaps the most visible aspect of the original SftP, its publication. According to Emily Glaser, the Managing Editor of Science for the People, "we want to live up [to] the mission and goals of the original organization." The first step was releasing a special issue on geoengineering to raise "critiques of the capitalist, techno-fix attitudes toward climate change that are gaining momentum," she said. The full collection is available at magazine.scienceforthepeople.org.

Climate change was not yet on the radar during the original SftP run, but in many ways it was a perfect way for SftP to reintroduce itself. Both the science denial being used to guide policy and rash, knee-jerk proposals that misuse science by ignoring due diligence are dangerous, especially to our most vulnerable communities. Scientists need to step up to make sure that science is used and used responsibly. Ideally, SftP can serve as an organizing force to make this happen and a discussion platform to figure out how to do it most ethically and effectively.

As Glaser explained, "at the core of what Science for the People aims to do is show scientists that their labor has real world impacts, and that their convictions and values do not need to be kept outside the lab." Science for the People is currently accepting proposals for its relaunch issue, themed "The Return of Radical Science," to be released online in Spring 2019.

SftP is a growing, active organization open to anyone interested in making sure that science is used to create a better world. More information about the Boston chapter can be found on Facebook (facebook.com/sftpboston) and Twitter (twitter.com/sftp_boston).

scientists that their labor has real world impacts, and that their convictions and values do not need to be kept outside the lab." Science for the People is currently accepting proposals for its relaunch issue, themed "The Return of Radical Science," to be released online in Spring 2019.



THE BIG SIX

BY VICTORIA MILLER-BROWNE, BIOLOGY, 2020

Have you ever happened upon a random person's profile on any social media platform only to be surprised to find out that you have a mutual friend? The idea of being connected by multiple degrees of separation is an old question that led social psychologist Stanley Milgram and colleagues to create an experiment to understand how small the world really is.

The six degrees of separation theory is based upon the notion we're all connected in some sort of social network, only differing from an average of about six people or degrees of communication. The rules of the experiment, outlined in the 1969 paper *An Experimental Study of the Small World Problem* started with the instructions of mailing a parcel from a stranger in one state to a stranger in another state solely through passing it through acquaintances in order to get it to the specified person. The study had a series of about 300 volunteers, which consisted of two groups from Nebraska and one group from Boston. The remaining people involved in the

study were about 450 intermediaries that aided in passing the package. In the end 64 packages made their way to the right person. The number of passes between intermediated people averaged to be about six per package.

The idea that two strangers could legitimately be connected to each other, especially when taking into account the only types of communication devices were mail, phone, radio and maybe television, was revolutionary in its time period. Yet in the present age, with social media being so much more readily accessible the degrees of separation between us become has only become smaller. As documented in the 2012 paper, *Four Degrees of Separation* in which an algorithm was curated for the entire network of active Facebook users that accounted for the linkages between each other, it resulted in about four degrees of separation. And as social media continues to obtain a larger part of our lives, as said by the Hungarian writer Frigyes Karinthy, who wrote one of the first books about social linkages between human "Planet Earth has never been as tiny as it is now."

Four Degrees of Separation (2012). DOI:10.1145/2380718.2380723
An Experimental Study of the Small World Problem (1969). DOI:0.2307/2786545

ENGINEERS WITHOUT BORDERS

Providing global communities with sustainable solutions

BY YAEL LISSACK, BIOENGINEERING, 2021

Globe-trotting, exploring new cultures, and helping people are common dreams of young college students. For a few ambitious individuals at Northeastern University, these dreams have become reality due to their involvement in Engineers Without Borders (EWB). A chapter of a global organization, their mission is to help communities around the world meet their basic needs by implementing sustainable projects.

The Northeastern Chapter of EWB receives guidance from the national organization on what communities they'll assist. The various projects assigned are based on the nature of the land and the specific requests of its residents. Northeastern EWB has three branches: Panama, Uganda, and Guatemala. In both Panama and Uganda, the challenge most commonly identified is a lack of safe drinking water. At their relatively new Guatemala branch, they are building a school. These projects become integrated into the community, provide long-term solutions, and are entirely self-sustaining.

Once students know what project they will be spearheading, they are wholly responsible for designing, building, and implementing their solutions with help from a professional mentor. The most common technology that they implement is a sand filtration system, which uses layers of increasingly small rocks and gravel to trap unwanted particles in water. The water is then collected and pumped to the entire community.



Having safe drinking water is essential for disease prevention, and having safe water within a community also massively conserves resources and energy.

Once the designs are finalized and ready for implementation, four to six students travel to the target region with their mentor. Working directly with local residents, they get their project up and running. Most importantly, these projects need to be sustainable for success. Thus, the community will form something called a "Water Board," which is responsible for the system's maintenance once EWB leaves. This board allows the community to take ownership of the filtration system so they feel confident in its management and can preserve its longevity.

These projects are incredibly rewarding for everyone, says recruitment officer Sarah Condon: "At the end of the day, you're helping people, and you directly see how your project has an impact on their lives."

When asked what she loves about EWB, Condon said, "It really pushes me to ask the hard questions, and now I know that I can't be afraid to find those answers."

To get involved, email Sarah at recruitment.ewbneu@gmail.com and visit ewb.neu.edu for information regarding meeting locations and times.

DESIGN BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022
 PHOTO BY SMUGMUG

THE MODERN-DAY MORAL PHILOSOPHER

An interview with Professor John Basl

BY LUCAS PRINCIPE, ENVIRONMENTAL SCIENCE AND PHILOSOPHY, 2020

DESIGN BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

Sitting in his office, looking out the window from the third floor of Holmes Hall, Professor John Basl is as close to a stock photo of a philosopher as you can get: great, long beard, hair down to his shoulders, deep in thought. As a moral philosopher specializing in applied ethical issues in relation to non-sentient beings and artificial intelligence (AI), he thinks about the stranger questions in life: are our current machines morally considerable? Do non-sentient beings like trees have a welfare? How should autonomous vehicles be programmed to manage accidents? Not things you'd typically start daydreaming about on the commute home. It's these interesting philosophy of science and technology focuses that make Dr. Basl a perfect on-campus figure to highlight for our "People" issue.

Professor Basl, who received his PhD in Philosophy from the University of Wisconsin-Madison, began teaching at Northeastern in 2013. Originally a biology student as an undergraduate here at Northeastern, Dr. Basl said a boring co-op spent experimenting with bacteria resulted in him thinking about switching his focus. "I didn't really know what I wanted to do," he says. "I was doing a lot of philosophy reading on the side, not useful stuff, but I knew I was interested in it. Then I decided to take some classes in it and immediately fell in love."

Currently, one of his more relevant interests lies in the ethics of artificial

intelligence, which he describes as a "small but growing" field. The field aims to address issues concerning the moral relationships between humans and machines, including such subjects as our moral obligations to machines and their capacities for interests and intelligence. With the boom in AI development in recent years, Professor Basl thinks these questions are more pertinent than ever, and while there are many people, mostly engineers and developers, working on AI ethics, there "just aren't a lot of philosophers" working on this.

One of Professor Basl's main focuses within the field involves evaluating moral patency, which he described as "anything to whom or to which we have direct moral obligations." He believes, "if there's an AI that has attitudes, or the capacity for enjoyment or suffering, if it has a welfare in any plausible sense, then it's a moral patient. The question, though, of when we turn one on, will we recognize its patency, is much harder to answer. And I don't think we have a good answer for that yet."

In his public writings, he has stated that our current machines, even our most advanced AI's, are only "mere machines," so we should not view them as moral patients. However,

when asked if he had any timeline about when we may have to start thinking of AIs as moral patients, he told me he didn't have a prediction, mostly because of "the hard problem of consciousness," which means we don't really have a good theory of what makes things conscious."

Another of his focuses lies in ethical problems surrounding autonomous vehicles (AVs), which have been in the news recently due to high profile cases involving accidental fatalities. This risk, among others, is what has many experts thinking about the potential implications of these vehicles on the road. For Professor Basl, though, the biggest risk is our "unpreparedness." He thinks "we're not ready yet. We haven't answered the important philosophical

questions we need to answer before we turn our lives over to the machines."

When asked about who should be the ones answering these questions, he had a suggestion: "it's tempting to say philosophers... but I think the answer is an oversight model where you use a committee that's constituted by experts from different fields."

Lastly, after being asked why a science major should take a philosophy class at Northeastern, he had much to say,

"Multiple answers. First, it will make you a better candidate for jobs.... second, you can't take an ethics course with us and not leave being a better reasoner. I think that skill applies in every domain....third, it'll just be good for you. It will make you think more clearly about your values and beliefs."

If any of these reasons persuade you, or you'd simply like to take a class with him, Professor Basl will be teaching two courses next semester: "Moral Philosophy" and "Research Ethics". And look out for his new book, "The Death of the Euthic of Life", which further explores the welfare of non-sentient beings and multiple other philosophy of biology issues, set to be released this February.

“We haven't answered the important philosophical questions we need to answer before we turn our lives over to the machines."

Philosophy and Technology (2014). DOI: 10.1007/s13347-013-0122-y



PHOTO BY GUS MUELLER, BIOENGINEERING, 2022

Lamarck's Reprisal

BY SARA GANNON, BEHAVIORAL NEUROSCIENCE, 2021
DESIGN BY IAN PROULX, BIOENGINEERING, 2022

Jean-Baptiste Lamarck, a naturalist at the turn of the 19th century, was one of the first and few biologists to publish a manuscript discussing the inheritance of acquired traits. He proposed that information about an organism's environment can be passed down to that organism's offspring. This unprecedented evolutionary theory proved to be controversial during his life and was ultimately widely discredited. However, in the last 50 years, the scientific community has produced evidence that Lamarck may not have been so far off the mark; maybe there is a mechanism of transgenerational epigenetic inheritance.

The term epigenetic, originally coined by Conrad Waddington in the 1940s, refers to how the phenotype, or observable characteristics of an organism, can be influenced by both an animal's genes and its environment. Thus, transgenerational epigenetic inheritance refers to the capability of an organism to transfer information about its environment to its offspring.

“ Transgenerational epigenetic inheritance refers to the capability of an organism to transfer information about its environment to its offspring.”

The mechanisms of this process are still not fully understood nor agreed upon within the scientific community. However, the most widely accredited process for the transgenerational transmission of information is methylation of DNA. This mechanism involves the addition of one or more methyl groups (-CH₃) to the DNA molecule. Methylation of a section of DNA coding for a specific gene will effectively “silence” that gene without changing or deleting it. This is significant because it means that the process is reversible.

Because methylation is reversible, it is very commonly used by cells in virtually all tissues of the body. It complements the function of mRNA to increase how often particular sections of the DNA are read, thus allowing cells to inhibit or promote expression of specific genes. These mechanisms are well-documented; however, there is a current dearth of understanding of how the mechanisms persist in gametes and germ lines. Alteration of the gametes, or sex cells, would be necessary for a transfer of information to the next generation via genetics.

So what are the implications of methylation that is passed down to offspring? Pivotal studies in this field have examined the connection between environmental stress during a parent's lifetime and the corresponding physiological effects on their offspring. A particularly

PHOTO FROM WIKIMEDIA

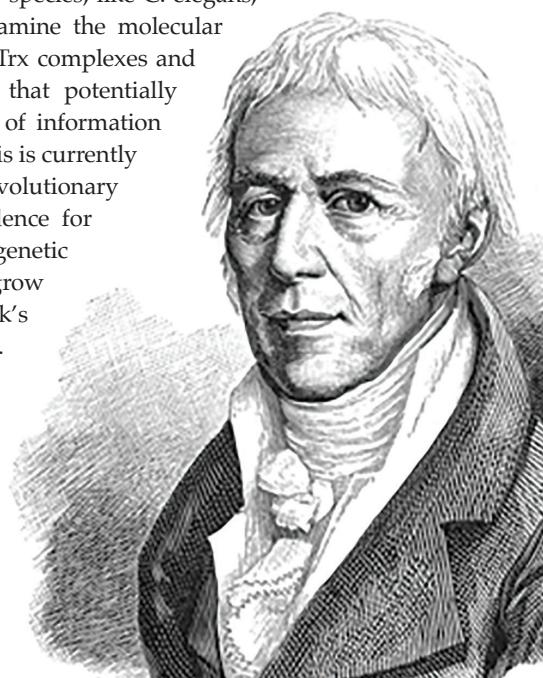
compelling component of this research has focused on the prevalence of famine in the 20th century, as it conveniently lends itself to studying multiple consecutive generations.

A study published in 2008 observed the transgenerational effects on subjects that originated with their parents being exposed to famine in utero in the Netherlands between 1944 and 1945. Through conducting interviews with thousands of subjects, the authors determined significant differences between those prenatally afflicted by the famine and those who were not, as well as differences in their children. They found that the famine-afflicted subjects were anatomically shorter and lighter, and their children exhibited decreased length at birth as well as increased neonatal adiposity, or BMI. Additionally, their children exhibited poor health 1.8 times more frequently than the children of those not afflicted. This indicates that significant environmental stressors have the potential to create transgenerational effects. Furthermore, it suggests that the level of physical or emotional stress that a mother undergoes while carrying offspring can have notable effects on the baby's phenotype, or physical and observable characteristics.

Markedly, similar results were found in a study completed on three generations of German subjects, the first generation of which had been eight to twelve years old during the famine of 1916-1918. The researchers discovered that grandsons of famine-afflicted men and granddaughters of famine-afflicted women maintained higher mental health statuses on average. In addition, a notable conclusion that the authors made was that the differences found in the second generation could potentially be attributed to social and behavioral effects and thus were deemed to be biologically insignificant, or weak evidence for transgenerational epigenetic inheritance.

Most of the research on this topic spans “model organisms,” species that have short reproductive cycles and fast generation turnover, as opposed to humans. Mice and primates alike have been utilized to study the transgenerational effect of maternal care. Smaller species, like *C. elegans*, can be utilized to examine the molecular mechanisms, such as Trx complexes and histone modification, that potentially facilitate this transfer of information across generations. This is currently a hot topic in evolutionary biology, and the evidence for transgenerational epigenetic inheritance is likely to grow far beyond Lamarck's greatest expectations.

BJOG (2008). DOI:
10.1111/j.1471-
0528.2008.01822.x.



From cell to bone

The discovery and future of skeletal stem cells

BY ADRIANNA GRAZIANO, BIOLOGY, 2019

DESIGN BY KYLA VIGDOR, DESIGN, 2021

As stem-cell therapies become a reality for patients suffering from cancer, blood diseases, and immune disorders, the push to discover adult stem cells within major tissue groups has spread throughout research fields and interests. This, coupled with an increasing elderly population supported by advancing medical technologies, demonstrates that regenerative treatments for the skeletal system and the conditions that impact it - such as osteoporosis and arthritis - are needed now more than ever. In attempts to meet this demand, researchers at Stanford University's School of Medicine published a September 2018 Cell paper announcing their discovery of self-renewing human skeletal stem cells.

The endeavor to find human skeletal stem cells began once these researchers successfully discovered skeletal stem cells in mice three years ago. To begin their search in human tissue, they harvested cells from both human adult and fetal growth plate zones and compared these cells to mouse samples. After identifying a population of human cells that produced similar gene signatures as mice via RNA sequencing, they performed a deeper analysis in the search of cell surface markers and eventually isolated PDPN+ CD73+ CD164+ CD146- cells.

Once isolated, these labeled cells were cultured as a pure population to test whether they could actually give rise to further cell types. They found that their suspected stem cells were indeed self-renewing and lineage-restricted, creating progenitors that could only give rise to cells occurring naturally in the skeletal tissue: bone, stroma, and cartilage. However, skeletal stem cells aren't alone in their ability to produce skeletal tissue. In 1976, mesenchymal or "all-purpose" stem cells (MSCs) were discovered with the ability to generate skeletal tissues in addition to fat and muscle. Though MSCs are clinically useful, skeletal stem cells reduce the risk of unpredictable outcomes after differentiating and won't produce fat instead of skeletal tissue, for example. Importantly, they also have the ability to be generated not only from the end of developing bone and fracture sites, but also from specialized fat cells and induced pluripotent stem cells (iPSCs) commonly used in therapeutics.

Not only did this research discover the existence of skeletal stem cells, but they also delved further into their function. Interestingly, stromal progenitors from skeletal stem cells created a nurturing environment in the bone marrow for hematopoietic stem cells, understood as cells that can differentiate into any type of blood cell. These cells were able to grow for up to two weeks without the addition of serum and its growth factors, potentially creating a better

understanding of how skeletal stem cells interact with other cell types in the body.

After utilizing mouse models for initial steps in identifying and characterizing skeletal stem cells in humans, this study also worked to identify evolutionary conserved and divergent pathways of skeletal tissue development attributed to stem cells between mice and humans. Using a family tree of stem cells that are involved in its formation and maintenance, this study found a divergence in the Wnt signaling pathway present in humans and absent in mice, mainly used to modify bone formation. By understanding which mechanisms are conserved between humans and mouse models that are



largely used to create and approve therapeutics, skeletal tissue growth and regeneration approaches can be more targeted and utilized more effectively.

As the aging process inhibits our ability to heal from bone fractures and leaves us without the ability to regrow any new cartilage, the application for skeletal stem cells is wide-reaching and could impact millions of people suffering with arthritis and invasive joint replacement surgeries. Yet, with the discovery of human skeletal stem cells occurring only this year, the road ahead to clinical approval and therapeutic treatment remains uncertain. Despite this, senior author Michael Longaker and lead author Charles K.F. Chan informed Stanford University's School of Medicine News that they are already looking to future applications, envisioning the injection of skeletal stem cells via arthroscopy, a minimally invasive procedure used to treat damaged cartilage. As researchers work to make clinical leaps with skeletal stem cells, it's not difficult to conceive a future where aging could come without the prolonged and debilitating aches and pains.

Cell (2018). DOI: 10.1016/j.cell.2018.07.029



Barking up the wrong tree

How humans have shaped the health of dogs

BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

Bred as a duck retriever in Newfoundland, the Labrador retriever has slowly gained fame from a fisherman's companion to the dog of lords and ladies to a modern family companion. It is now the most popular dog breed in the U.S., topping the American Kennel Club breed registration list since 1991. Now, the lab is recognized for its wide head, black, yellow, or brown fur, and its friendly personality.

In a study by the University of Sydney, Australia, on the health of Labrador retrievers living in the United Kingdom, chocolate labs were shown to have a shorter lifespan of an average of 10.7 years as opposed to 12.1 years for all other labs — this results in over a 10 percent difference in lifespan. Chocolate labs are also more prone to otitis externa, an infection of the outer ear canal, and more than twice as likely to get pyotraumatic dermatitis, a skin infection, than non-chocolate labs. It is possible that the repeated skin and ear infections lead to a shorter life for chocolate labs, but why do these diseases show up so often in this dog?

The color of a dog's coat may not automatically be seen to have a link to

health, but there are other noted cases of this. The piebald gene causes white spotting and has been identified in over 25 different dog breeds. However, the extreme version of this patterning results in deafness in 20 percent of those affected. This is because the locus for this mutation is on the MITF gene, which regulates melanin formation in the skin, ears, and eyes. Therefore, a mutation which changes the pigments in the coat can impact other parts of a dog's development.

It's not just health that can be affected by coat color, either. In a study of purebred English Cocker Spaniels, it was found that solid-colored dogs were much more likely to show aggression than multi-colored ones, and spaniels with red or golden coloring were more aggressive than spaniels with black coats. These results suggest a link between genetics and neuroendocrinies.

Though the genetic linkage of coat color and health can determine a dog's well-being, researchers in the study had another theory as to why chocolate labs' life spans were so short, and it is caused by humans. Lead author Paul McGreevy said the results could potentially be linked to the recessive nature of the

chocolate fur phenotype. "If chocolate coat color is desired in litters, breeders may be motivated to breed from certain lines that may inadvertently increase the ensuing puppies' predisposition to certain diseases," the study concluded.

Even though the coat color itself is not bad for the dog's health, the desirability of an uncommon color can lead to problems. The chocolate gene is uncommon or masked, which could influence a Labrador breeder to overuse certain dogs in order to produce the rarer coat color. Breeding dogs from this shallow gene pool can result in more health problems. If the dogs used frequently in the breeding program have a higher likelihood for ear and skin conditions, this trait can be passed down to their offspring.

In order to breed a Labrador with a brown coat color, two different sets of alleles must align. Black is the dominant coat color and therefore is determined by the dominant B allele. Brown is the recessive trait and is expressed only when the alleles are homozygous recessive, or bb. However, this simple inheritance trend only accounts for two of the three coat color variations. The third color is due to epistatic interactions, or another set of genes affecting the same outcome. This second set is called E. If E is expressed in its homozygous recessive form, or ee, the B allele is masked and the coat will be yellow. In the UK study, the most common color recorded was black labs (44.6 percent) with yellow at 27.8 percent and chocolate the least common at 23.8 percent. The frequency of the chocolate-colored coat has been altered by selective breeding, though it still remains the least common fur color.

Despite the problems with their gene pool, Labrador retrievers, overall, are one of the healthiest breeds of dogs, highlighted as long-lived by the Kennel Club. However, the health of the breed is up to people. It is up to man to protect man's best friend.

Canine Genetics and Epidemiology (2018). DOI: 10.1186/s40575-018-0064-x
Journal of Heredity (1977). DOI: 10.1093/oxfordjournals.jhered.a108792
Canine Genetics and Epidemiology (2018). DOI: 10.1186/s40575-018-0066-8
Applied Animal Behavior Science (1996). DOI: 10.1016/0168-1591(95)01012-2

Making a Metaphor

The Science of DNA Testing

BY BRYNN VESSEY, BEHAVIORAL NEUROSCIENCE, 2019
DESIGN BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

DNA evidence is the stuff of science fiction in the making with a crime almost expertly pulled off, except for the singular piece of hair that ties the crime to the suspect. Famous crimes have been popularized by the media that revolve around the surplus, or complete lack thereof, of DNA evidence. Steven Avery, the man whose questionable guilt led to Netflix's hit show *Making a Murderer* may have brought attention to DNA evidence in 2015, but the science has been used for decades. In 2013, DNA evidence was used to solve a 1964 murder by the Boston Strangler. The science of DNA evidence has come leaps and bounds from its start in the 1920s, and now it's widely utilized in forensic science.

In the 1920s, DNA testing looked significantly different than it does on modern shows like NCIS or Law and Order. There were four different human blood types identified based on the presence or absence of different antigens, and blood type testing soon fell into use for paternity tests. Information blood typing was largely limited and had little efficacy for DNA evidence, with a power of exclusion of 30 percent. In the 1930s, different antigens, or proteins in the blood were identified, leading to the creation of the Kell, Duffy, and Kidd blood group systems. Despite the advance, the technique didn't make it further than advancing paternity test accuracy with a power of exclusion, or the ability to exclude an individual, only at 40 percent.

By the 1970s, the human leukocyte antigen (HLA) was identified. It was found that people of different biological backgrounds had different HLA types. But HLA testing has its disadvantages. Large volumes of blood are required and it increases the power of exclusion to 80 percent. That's 20 percent too high for accurate DNA evidence.

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The science of DNA evidence has come leaps and bounds from its start in the 1920s."

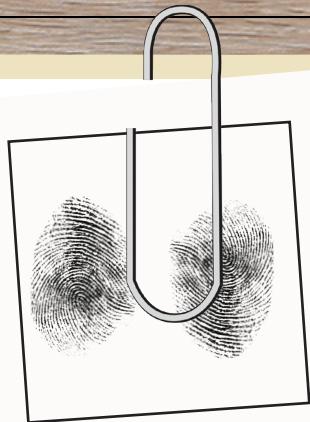
With the new era came advances in science, including better sequencing technologies. In addition to blood, scientists can now use saliva, urine, hair, teeth, bone, tissue, cells, and other biological materials to obtain DNA. The variance in biological sources is advantageous because DNA can be left behind in many ways after a crime.

In the case of the 1964 murder of Mary Sullivan by the Boston Strangler, the evidence left on her body was used to complete short tandem repeat patterns (STR), short repeating sections of DNA, in the blood sample from a nephew of the

Strangler. Every male in a paternal lineage has identical Y-STR DNA profiles, passed from father to son in every generation. Forensic experts analyzed the Y-chromosome of the Strangler's nephew to look at Y-STR inheritance. Y-STR testing showed the nephew of the alleged Boston Strangler had the same Y-STR pattern found in fluid at the crime scene, and the Y-STR match excluded 99.9 percent of the male population. This evidence confirmed the Boston Strangler was Albert DeSalvo by sequencing the Y-STR of his nephew, nearly 50 years after the death of Mary Sullivan.

While stories of crimes solved with DNA evidence are fascinating, the science itself is anything but dull. DNA goes to a lab where scientists first extract it to release it from the cell. Next, it's quantified to determine how much is present, and then it's amplified to produce more copies of it for characterization, followed by separation for later identification. Analysis and interpretation follows, where the evidence is compared to known DNA profiles. Matches can identify someone as guilty or innocent, writing stories of crime and punishment, only 11 years after DNA's discovery by Rosalind Franklin, James Watson, and Francis Crick.

The stories of science and the power of a molecule may not make a murderer, but they can absolutely find that murderer decades later.



WHO'S YOUR MITO-MAMA?

BY AMANDA ZAVALA, CELL & MOLECULAR BIOLOGY, 2020

Building family trees is out of style – and genetic testing is the way of the future. By determining slight variations in your DNA sequence commonly found in people of certain ethnicities, genetic tests can theoretically reveal where your ancestors are from dating back hundreds of years. However, because your chromosomes contain DNA from both parents, there's no way to separate parental lineage by looking at standard nuclear DNA.

Mitochondria are unique in that they have their own separate DNA. Whereas nuclear DNA consists of around three billion base pairs organized in chromosomes, mitochondrial DNA (mtDNA) is a circular plasmid 190 times smaller. mtDNA is passed directly from mother to offspring with no genetic input from the father. The lack of recombination, or crossing over, means that the mtDNA sequence is entirely conserved and can be used to build a family tree of all of human history.

Because there's no mixing of genes to muddle the history, a mutation that develops in a mother will be passed to her offspring and so on down the line, with the offspring developing their own subtle mutations over time. A phylogenetic tree showing how closely related all the different mutational lineages – called haplogroups – are can be constructed by counting differences in mtDNA genomes.

When the mutation rate is known, it's possible to determine how many years ago two lineages separated. Although modern humans have dozens of haplogroups, the lineages all stemmed from one most recent matrilineal ancestor known as the mitochondrial Eve. Over time, her lineage was more prosperous than others and is the only one surviving to the modern day. She was estimated to have lived around 200,000 years ago in Africa.

Sequencing your mitochondrial genome can't reveal what country your mother's lineage comes from, but certain haplogroups are more commonly found in specific regions and so can suggest a continent of origin. These point mutations can also be implicated in diseases, with certain neurodegenerative disorders and complex diseases like cancer and diabetes more prevalent in certain haplogroups. The exact mechanism of disease isn't clear yet, but because of the mitochondria's function in cellular respiration and aging, seemingly small deviations can increase the risk for diseases. There are even disorders specifically caused by mtDNA mutations, but these are usually noticeable without sequencing. That's quite a bit of information to get out of just 16,000 DNA base pairs!

Nature Reviews Genetics (2012). DOI: 10.1038/nrg3295

Get vaccinated:

How public health measures added 25 years to the American lifespan

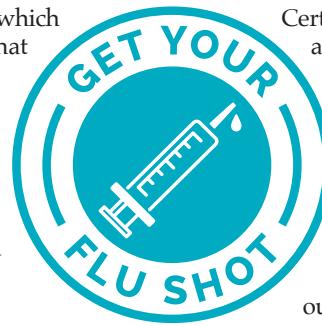
BY KATIE MCCREEDY, HEALTH SCIENCE, 2021

According to the CDC, 25 of the 30 years added to the average lifespan in the twentieth century are due to public health measures, while only five are due to medical advancements. These public health measures are aimed at preventing illness, such as reducing smoking rates and promoting seatbelt use. One of the greatest public health achievements is the wide use of vaccinations, which helped to eradicate polio in the U.S., a disease that once afflicted 35,000 Americans every year.

Despite the renowned impacts, some people choose not to get vaccinated. There is a dangerous myth that vaccines can cause autism. Since 2003, however, there have been nine CDC-funded studies showing that there is no link between vaccination ingredients and autism.

Vaccination side effects also raise concerns. Vaccines can sometimes cause minor side effects, such as soreness and low-grade fever. However, according to the CDC, 99 percent of vaccinated people do not experience any major side effects. The greater concern is that people can contract deadly infections when they forgo vaccination. This generation has the fortunate luxury of not having seen the painful, long-lasting effects of now eradicated diseases, like polio and smallpox, so this disconnect can prevent people from getting vaccinated.

More common infections such as HPV, measles, and mumps



cause regular outbreaks that can be easily prevented with vaccinations. HPV, or human papillomavirus, is a sexually transmitted infection that approximately 80 percent of sexually active people are infected with during their lifetime, according to CDC surveillance data.

Certain people cannot get vaccinated because they are immunodeficient, meaning that they have an immune system that is too weak to handle the vaccination. This is the case for people with leukemia, HIV/AIDS, or those undergoing chemotherapy. These people can still be protected against deadly viruses because of herd immunity, an indirect protection whereby a large enough amount of the population is vaccinated against a given disease such that no outbreaks occur, thus protecting the unvaccinated.

Herd immunity is invaluable for those with immunodeficiency; it creates a free rider problem where people who refuse vaccination are still protected, since many people are vaccinated there are rarely outbreaks. As more people become unvaccinated free riders, those who are unable to get vaccinated are put at a greater risk of contracting deadly diseases.

Getting vaccinated is not only important for your individual health, it also invisibly protects those vulnerable to deadly diseases.

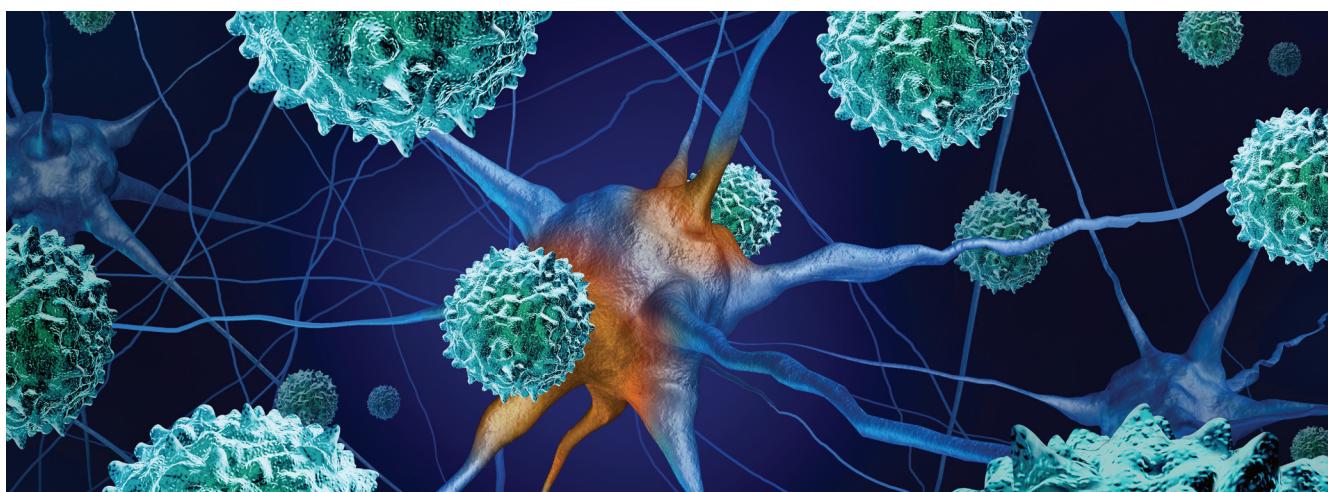
DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

HAS POLIO RETURNED?

The mysterious epidemic of acute flaccid myelitis

BY KAELEN ENCARNACION, BIOLOGY AND ENGLISH, 2021

DESIGN BY KYLA VIGDOR, DESIGN, 2021



In the early 20th century, a frightening disease began to take hold in America. A highly infectious viral disease called poliomyelitis, commonly referred to as polio, swept through towns across the country every few summers, primarily affecting children. Polio was caused by one of three types of poliovirus, which are members of the Enterovirus genus. Its onset typically brought on viral-like symptoms, such as fever, headache, fatigue, nausea, sore throat, and diarrhea. If worsened, it could also lead to neurological symptoms such as light sensitivity and neck stiffness.

In most cases, a patient was able to recover completely; however, its most infamous form, paralytic polio, shook the country in the 1940s and 50s by attacking the grey matter of the spinal cord, leaving thousands in permanent paralysis or dead. In severe cases, survivors of polio had to spend the rest of their lives in a machine known as the "Iron Lung," a full-body ventilator designed to allow them to breathe when muscles in their chest became paralyzed. Thankfully, in 1953 the first successful polio vaccine was discovered by Dr. Jonas Salk, virtually eradicating polio worldwide today, with a few exceptions in Afghanistan, Nigeria, and Pakistan.

However, an outbreak that first emerged in the US in 2014 has shown a strikingly similar pathology to that of the terrifying disease, again mostly affecting young children. As of October 29th, the CDC has so far confirmed 72 cases across 24 states of acute flaccid myelitis (AFM) this year--a disease that, like polio, affects the spinal cord and can lead to paralysis in the limbs with deterioration into respiratory failure in extreme cases. Other symptoms include having trouble swallowing or speaking and facial drooping. In this most recent outbreak, the average age of patients is four years old, while 90 percent of patients fall under the age of 18.

While doctors and researchers across the country as well as the CDC are still unsure of what is causing this disease, there are a few factors currently under investigation. In some cases, symptoms of AFM have manifested after exposure to a previous viral infection such as the mosquito-borne West

Nile virus, adenovirus, or enterovirus. However, it is not known how previous infections have the ability to induce AFM, nor has it been explained why some develop AFM after an infection while others do not.

More conclusively, all patients have tested negative for poliovirus. In addition, it has been found that the initial spike in AFM cases from 2014, in which 120 cases across 34 states were confirmed, coincided with an outbreak of non-polio enterovirus D68, or EV-D68, a virus that typically circulates in the US during the summer and fall and causes mild, cold-like symptoms. Similar spikes have been observed about every two years since then, between August and September. Researchers at the University of Colorado School of Medicine have been looking into its effects on mice, and have found that EV-D68 has a similar impact on their nervous system as AFM has in children. Despite this compelling evidence, the CDC has been hesitant to confirm EV-D68 as the major cause of AFM, to the frustration of doctors and researchers alike.

For now, doctors say that the best way to improve one's chances of not developing AFM is to stay up-to-date on vaccinations and, although it has recently been stated by the CDC that AFM does not appear to be transmissible from person to person, to maintain good hygiene and wash your hands regularly as a precaution.

Although contracting this disease is rare (about one in a million), it is crucial to bring someone suspected of having AFM to the hospital immediately to receive medical treatment. Patients diagnosed with the disease in earlier stages have a better chance to regain some, if not all, mobility with intense physical therapy.

Will this new outbreak reach the levels of disaster that brought America to its knees in the mid-20th century? Due to the rapid advancements currently being made in medical research, it can be cautiously assumed that the answer to this question is no. Nevertheless, be on the lookout for symptoms, and if possible, please vaccinate your kids.

E-CIGARETTES: SAFE OR JUST SAFER?

BY SHREYA SHETTY, HEALTH SCIENCE, 2022

DESIGN BY KYLA VIGDOR, DESIGN, 2021

Between 2011 and 2016, the number of e-cigarettes globally quintupled, and the electronic cigarette industry grew from a handful of small businesses to many national corporations. While intended to aid smoking cessation, public health experts are now concerned about an e-cigarette epidemic. Although the FDA has instituted regulations on e-cigarettes since 2016, the e-cigarette industry remains remiss.

Since e-cigarettes do not involve combustion or tobacco smoke like conventional cigarettes, they are less likely to generate as many carcinogens — a fact that many advocates use as a marketing strategy. In fact, when asked about why they use e-cigs, 17 percent of respondents in the 2016 National Youth Tobacco Survey, which is developed by the Centers for Disease Control and Prevention, selected “they are less harmful than other forms of tobacco such as cigarettes.” However, safer is not synonymous with safe.

The liquid inside e-cigarettes contains either propylene glycol or vegetable glycol; the former when heated, can form formaldehyde, a gas used in adhesives and wood products. In 2009, the FDA’s Division of Pharmaceutical Analysis tested popular e-cigarette cartridges and found diethylene glycol, a lethal toxin used in antifreeze. According to a 2014 study published in the Oxford Journals of Nicotine & Tobacco Research, some sweet-flavored e-liquids also contain diacetyl, a chemical that is associated with respiratory disease, poor lung function, and shortness of breath.

It isn’t just the liquid that’s concerning: A group of researchers at the John Hopkins Bloomberg School of Public Health hypothesized that since e-cigarettes are made of metallic parts and involve heat, the aerosol produced by the machine may contain metal particles. This past year, they found there was the same amount of lead and chromium in e-cigarette aerosols as conventional cigarettes. A 2014 study led by scientists at the Roswell Park Cancer Institute also found some e-liquids labeled “nicotine-free” actually had significant amounts of nicotine.

Nicotine travels rapidly to the brain, where the brain’s reward center is activated via endorphins and dopamine levels increase, which reinforces rewarding behaviors. Nicotine levels peak within 10 seconds of inhalation, so the “high” associated with nicotine is brief compared to other drugs, encouraging people to continue using to maintain the feeling. Repeated exposure to nicotine changes how the body reacts, requiring higher doses to feel the same impact and causing a drug dependency. With that dependency comes withdrawal symptoms that include anxiety, cognitive impairments,

and sleep disturbances, which make cessation all the more difficult.

While nicotine is associated with short-term boosts in memory and attention spans, long-term effects of nicotine on the brain include detrimental changes in brain circuits that are involved in learning and self-control — areas that, according to neuroscientists, continue to develop in adolescents until their mid-20s. The irreversible damage nicotine causes in the developing adolescent brain makes the vaping epidemic among young people even more concerning to public health experts.

Because studying long-term exposure to e-cigarettes in humans is difficult due to the relatively recent boom of the e-cigarette industry, scientists at the University of Miami have only exposed mice and human bronchial cells to aerosolized e-cigarette fluids. In 2016, they found nicotine does irreversible damage to the airway, similar to the effects of chronic obstructive pulmonary disorder (COPD), which was the third leading cause of death in the United States in 2014.

“The irreversible damage nicotine causes in the developing adolescent brain makes the vaping epidemic among young people even more concerning to public health experts.”

Another study done on mice in 2015 found e-cigarettes result in higher levels of systemic inflammation and lower immune defense against infections. In addition, mice that were subjected to e-cigarette smoke had more scarring in their lungs than control mice, indicating that nicotine could be a major factor in lung disease onset and progression. In layman’s terms, e-cigarettes cause more health problems than just nicotine dependency.

Impartial data regarding e-cigarettes as smoking cessation aides remain inconclusive. While e-cigs do release fewer carcinogens than conventional cigarettes and may potentially be less likely to cause cancer, the nicotine and other harmful chemicals in them negate the idea that vaping is harmless. Until more research has been done on the health impacts of e-cigarettes and their manufacturers are held to higher standards, it may be best to lay off yours.

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Fostering the next generation of global health ambassadors

Inside the first annual Northeastern University Global Health Initiative

BY SAGE WESENBERG, BIOLOGY AND JOURNALISM, 2019
DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

What do you get when you combine serious worldwide topics like health care, climate change, access, and pandemic preparedness with enthusiastic students and a wide array of experts? The first annual Northeastern University Global Health Initiative Conference (NUGHI), a two-day event to get undergraduate students involved in global health.

"I've been passionate about global health and epidemiology since high school, but I've always found interacting with that field to be super foreign and hard to define for myself," said fourth-year biochemistry major and NUGHI steering committee member Hugh Shirley. "We ended up deciding that the conference should focus on helping students understand global health and how they could get involved in the vast field."

On Saturday, Oct. 20, I sat down in the auditorium of the Interdisciplinary Science and Engineering Complex on campus, eagerly anticipating the introductory keynote address by Dr. James Cusack, a surgical oncologist at Massachusetts General Hospital who has travelled around the world to address healthcare disparities.

Focusing on his career and global experiences, Cusack discussed the urgent need to provide better healthcare access to underdeveloped countries, especially in sub-Saharan Africa. In Uganda, there are 3.6 million people who have unmet surgical needs but less than 25 percent of the population even has access to a surgically capable facility.

So what can we do to make a difference for problems like these? Cusack closed his keynote by urging students to organize, advocate, coordinate, and most importantly persevere. "I look forward to your ideas as you bring them forth to this endeavor. It's challenging and inspiring and you will cry and see some difficult things, but it is very rewarding," he said.

After leaving the keynote inspired to make an impact on global health, participants were able to choose to attend one of several workshops on topics ranging from HIV/AIDs advocacy to student leadership in global health and more.

I spent my morning in the workshop *Planetary Health: For People and Planet*, a dynamic workshop led by the Planetary Health Alliance (PHA), an interdisciplinary organization dedicated to advancing planetary health. This emerging field looks systematically at the human health impacts of our increasing environmental impacts across the globe.

With participants in the session broken up into three groups - infectious disease, food systems, and mental health - we each worked together to dive into a topic and brainstorm solutions from different perspectives like the government, a nonprofit, and a business.

Coming from several different majors, my group focused on food systems - discussing agricultural biodiversity, food availability in vulnerable populations, the effect of climate change on essential nutrients in our food and pollinators for crops, and more. After reading through several articles as a group, we took on the challenge to come up with

a solution to some of these issues. Though quite difficult, it was interesting to see what people came up with and how each sector must work together in order for any idea to be successful.

"From anthropology, to political science and international affairs - there are so many different aspects of global issues we're facing that we need to tackle in an interdisciplinary way," said Zuzu Oomen-Lochefeld, a third-year international affairs and anthropology major and part of the food systems group.

With more afternoon sessions to choose from and a networking reception over lunch, participants had the chance to explore many different areas of global health and meet other students making a difference in the field.

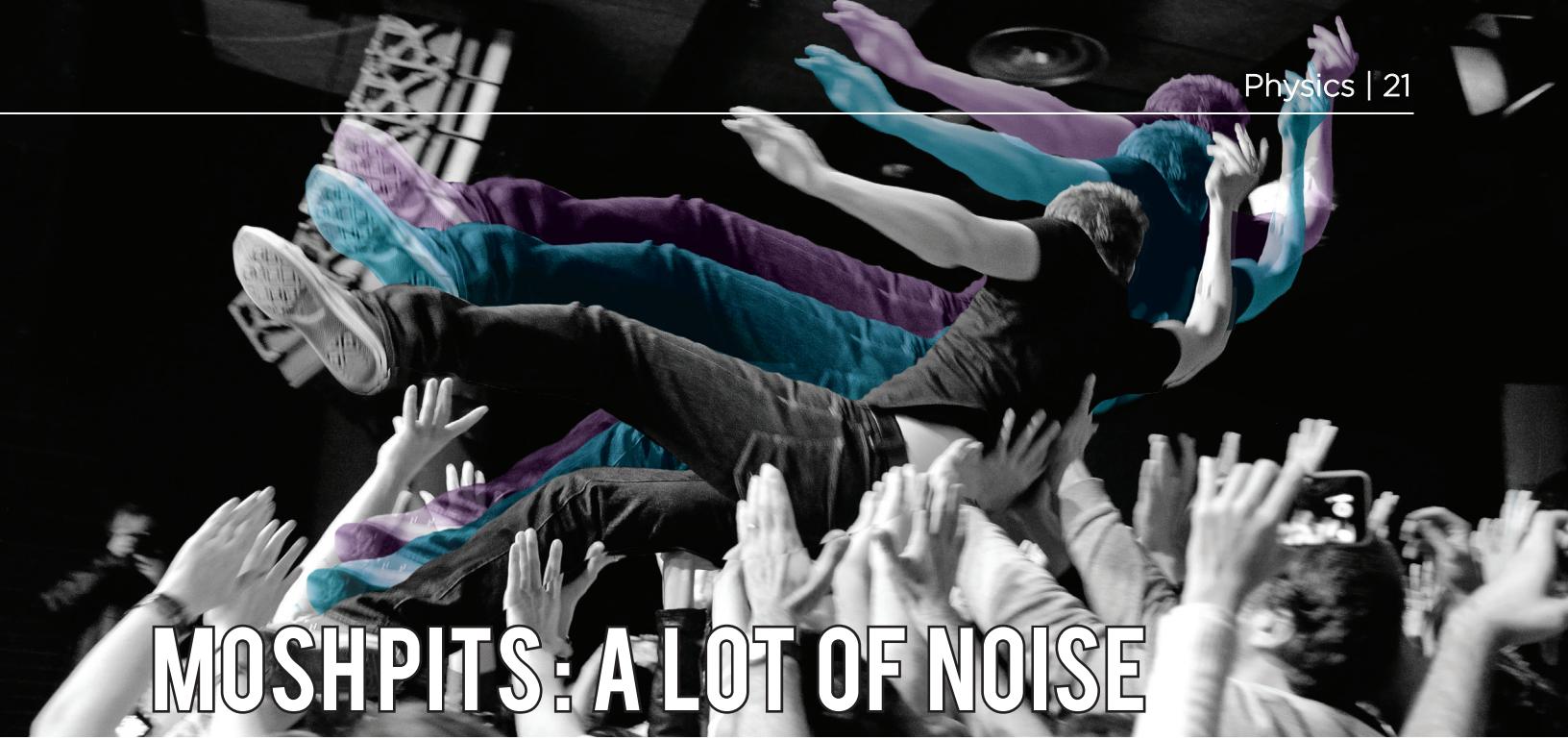
Dr. Michael Pollastri, Northeastern Department of Chemistry and Chemical Biology Chair and NUGHI faculty advisor, was impressed to see such passionate students from across the university, exemplifying just how wide the field of global health is. "For those of us faculty who began the global health initiative on campus, it's amazing to see all this student enthusiasm for it. This group of students



who had the idea for the conference and just ran with it created an unbelievable event," said Pollastri.

The success of NUGHI was evident in every thoughtful discussion, curious question, and idea for the future. Third-year bioengineering major and NUGHI Director Kritika Singh was excited to hear such great conversation ignited by their many workshops. "After a year and a half of preparation for this event, it's especially inspiring to me to see students really engaging with the speakers," Singh said. "I'm so proud of Northeastern and the students here that everyone is excited to be a part of this really great, interactive exchange."

PHOTOS BY JOSEPHINE PETTIGREW



MOSH PITS: A LOT OF NOISE

BY JENNIFER GARLAND, APPLIED PHYSICS AND MATH, 2021

DESIGN BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

Metal concert attendees are familiar with deafening music, bright lights, Lovecraftian graphics, and, of course, rowdy crowds. Bands often encourage mosh pits, crowd surfing, and “walls of death,” creating a chaotic yet controlled environment that has sparked scientists’ interest. In 2013, physicists at Cornell University led by Jesse L. Silverberg published an analysis of these extreme social interactions titled “Collective Motion of Humans in Mosh and Circle Pits at Heavy Metal Concerts.”

Researchers have studied the collective motion of objects ranging from animals to bacteria to molecules and have developed mathematical models to simulate their interactions. In many biological cases, the individuals are self-propelled, meaning they use energy and give rise to a system out of thermodynamic equilibrium. The Vicsek model is widely used to describe the movement of these active agents and is famous for its simplicity and applicability to many phenomena.

In mosh pits, people bump into each other randomly, much like particles in a gas. The Cornell physicists were intrigued because while other collective human motion, such as pedestrian traffic, displays more complex behavior, mosh pits appear to fit well to the Maxwell-Boltzmann distribution, which describes the speeds of ideal gas molecules in equilibrium. However,

because concert attendees are self-propelled, the group used a model similar to the Vicsek model to simulate each human mosher as a “simple soft-bodied particle [dubbed] a mobile active simulated humanoid, or MASHer.”

The particles were divided into active and passive MASHers that represent different types of metal concert attendees. Active MASHers are self-propelled and subject to random fluctuations and flocking, meaning that

“Over enough time, mosh pits act like gases in equilibrium, where particles move randomly and collide.”

individuals move and orient themselves with the group. Passive MASHers tend to stay still.

The researchers ran a simulation with uniformly mixed active and passive MASHers and found that the active MASHers congregated and became enclosed in a circle of passive MASHers - the setup of a mosh pit. The difference in speeds of the two types seemed to cause this development.

After a series of more simulations with varying parameters, a gas-like region

appeared, mirroring observations from concert footage. The key discovery was that “both noise and collisions tend to randomize motion, whereas flocking tends to homogenize motion.” Over enough time, mosh pits act like gases in equilibrium, where particles move randomly and collide, despite being composed of self-propelled people.

When flocking (orientating with the group) was more prominent than collisions and noise, the crowd separated into a vortex instead of a mosh pit. These vortices resemble circle pits, in which people move quickly in one direction around a circle. Though a remarkable realization, a puzzling discrepancy was observed about the direction of movement around the circle pits. In simulations, clockwise and counterclockwise directions occurred evenly and switched back and forth, but real-world data showed that 95 percent of circle pits flow counterclockwise. Possibly due to dominant footedness, the skew reveals more complexity to human interactions.

Though an unexpected subject of research, this analysis of people at heavy metal concerts provides pathways for better understanding crowds, handling emergency situations, and designing safer architecture for music venues and beyond.

Physical Review Letters (2013). DOI: 10.1103/PhysRevLett.110.228701

WREAKING HAVOC ON VENUS

BY ISABEL KAIN, PHYSICS, 2021

DESIGN BY KATIE GREEN, BIOENGINEERING, 2021

For decades, Mars has been the planet in vogue: the possibility of exploration, even colonization, beyond the Earth system captured the imagination of the public (as well as certain billionaires). But such a mission might be more technically challenging than we're ready for. Transit of up to a year each way makes it difficult to abort the mission if something goes wrong, and inhospitable surface conditions upon arrival (hazardous radiation, freezing ambient temperatures, and surface pressures far less than those on Earth) demand significant protective measures. One NASA mission concept, dubbed HAVOC (High Altitude Venus Operational Concept), contends that a mission to Venus – first robotic, then with a human crew – is the practice run needed to make a larger-scale Mars mission go smoothly in the future.

The plan to explore Venus first may come as a surprise, since the Venusian surface is a nightmarish hellscape. At 735 K (863 °F) it's hot enough to melt lead, with crushing pressure 92 times that at Earth's surface; its atmosphere, consisting mainly of carbon dioxide and highly corrosive sulfuric acid, is so thick it blocks nearly all sunlight from reaching the surface. These conditions are so harsh that surface probes landed by the Russian Venera mission only lasted between 23 minutes and two hours before disintegrating.

But above the thick cloud cover, conditions are much more clement. At an altitude of 50 to 65 kilometers, temperatures and pressures resemble those on Earth. The proposed airships would ride winds over 220 mph at this balmy altitude, coasting on an atmosphere rotating faster than the planet itself. Cruising at that altitude provides an

environment stable enough to conduct science, as well as possibly establish permanent settlement.

Mars-related motivations aside, Venus is intriguing as our closest cousin in the solar system. It's theorized that Venus was an Earth-like haven during its first two billion years, with clement temperatures, a shallow liquid water ocean, and a less cloying atmosphere – conditions considered markers of habitability. But then the planet started to heat up, oceans boiling away as the runaway greenhouse effect cooked its surface into a hostile wasteland. Though its heyday of habitability is long gone, Venus is bound to carry fingerprints of its past history, perhaps harboring evidence of ancient life.

Venus presents a unique opportunity not only to learn about Earth's closest analogue, but also to dry-run the technology we'll need to make a Mars mission possible. A trip to Venus will take half the time of a Mars mission, and allows crew to abort back to Earth if things go wrong. It also provides a practice run for creating durable habitats: making radiation-resistant, non-corrosive, inflatable airships poses a daunting engineering challenge that will prepare scientists for even greater hurdles on Mars.

Whether you're compelled more by the scientific or engineering objectives, this mission will ultimately be another exercise in human imagination and resourcefulness. Decades of science fiction could be realized when humanity's first space colony becomes a city in the clouds of a foreign planet.

MARS' PRESSURE IS
TOO LOW TO HAVE
LIQUID SURFACE WATER

VENUS MIGHT
HAVE EVIDENCE OF
ANCIENT LIFE



	At surface	At 50km	At surface	At surface
Temperature:	872°F / 740K	167°F / 348K	59°F / 288K	-82°F / 210K
Gravity:	0.9g	0.9g	1g	0.4g
Pressure:	92 bar	1 bar	1 bar	0.006 bar
Distance from Earth:	261 million km			401 million km
Radiation: (compared to Earth)	8x	1.3x		0.02x
Round-trip Transit: Time	14 months			26 months
Launch Opportunity: Interval	Every 1.5 years			Every 2 years

THE LARGEST DOSE OF
RADIATION PER TIME
OF EXPOSURE WILL
BE DELIVERED DURING
TRANSIT

Segmented mirrors and the search for exoplanets

BY CONRAD CASSIRER, PHYSICS, 2021

Located on the northern tip of Johns Hopkins University is the Space Telescope Science Institute, the control center for the James Webb Space Telescope --- successor to the Hubble --- and home to numerous cutting-edge projects for observing the cosmos.

Within its halls, Rémi Soummer heads the Russell B. Makidon laboratory which is focused on a project called High Contrast Imager for Complex Aperture Telescopes (HiCAT). The goal is to develop high-contrast imaging and coronagraphy techniques that allow for the direct imaging of Earth-like exoplanets --- those that are similar to our own planet but outside of the Solar System --- and possibly bring humanity closer to determining whether there is other life in the universe.

Photographing other Earths is a devilishly difficult task. While several exoplanets can be observed with

existing space telescopes such as the Hubble, or even from the ground, Earth-like exoplanets require a camera capable of an unprecedented contrast ratio: 10 billion to one.

The number of planets that can be detected and studied depends directly on the mirror's diameter because the planets are intrinsically very faint, only shining by reflecting a minuscule fraction of their parent star's light. Building a monolithic telescope with the ability to detect many Earths and study their atmospheric composition would require a mirror so large it would not fit in any rocket that can be built. Therefore, segmented telescopes are the only long-term viable solution.

Soummer's team is one of only a handful in the world pioneering a novel approach to high contrast imaging. The HiCAT project uses segmented mirror technology, consisting of many small hexagonal mirrors stitched together.

Unlike their monolithic brethren, segmented mirrors are foldable and relatively light-weight, making them the favored technology for many future large space telescopes.

According to Soummer and his team, the main challenge with segmented mirrors lies in their complex aperture geometry; unlike the continuity of monolithic mirrors, segmented mirrors have seams and support structures that mask planets due to diffraction effects. Furthermore, despite the highly stable space environment, mirror segments can deform and drift with small thermal changes. With margins of error on an atomic scale, these drifts must be corrected using deformable mirrors and other active control strategies.

Ultimately, the road to determining whether we are alone in the universe is a complicated puzzle, but if the HiCAT project is successful, it will play an integral role in solving it.

Lasers tag a third woman with a Nobel Prize in physics

BY SINAIA KEITH LANG, BIOLOGY, 2022

On October 2, 2018, Dr. Donna Strickland became the third female Nobel laureate in Physics for her development of laser amplification techniques.

The award was given for two different inventions in laser physics. Half of the prize was awarded to Dr. Arthur Ashkin and the other half was shared between Dr. Strickland and Dr. Gérard Mourou. In the 1970s, Dr. Ashkin used lasers to develop optical tweezers, which have since been applied in the biological sciences. While Dr. Strickland was a graduate student at the University of Rochester in 1985, she and Dr. Mourou invented chirped pulse amplification (CPA), an optical technique that allows scientists to create the shortest and most intense laser pulses ever.

The CPA technique Drs. Strickland and Mourou invented involves stretching an ultra-short laser pulse, amplifying

it, and then re-compressing it in order to create high-intensity laser pulses without damaging amplifiers. Prior to this breakthrough method, intensifying laser pulses damaged the machinery, was limited to one pulse per day to prevent overheating, and required impractically large equipment. CPA enabled a billion-fold increase in intensity. High-intensity, ultra-short laser pulses have since become commonplace in many industrial and medical practices such as LASIK eye surgery.

Dr. Strickland joins Marie Curie (1903 and Chemistry in 1911) and Maria Goeppert Mayer (1963) in the small group of female Nobel laureates in Physics. While women are a small minority of nobel laureates in general (5.5 percent), they are particularly underrepresented in Physics. Of all 210 Nobel laureates in Physics, these three represent only 1.4 percent.

Women are generally underrepresented in STEM fields, and physics is particularly male-dominated. According to the American Physical Society, in the past decade, about 20 percent of bachelor's degrees in physics conferred in the U.S. have been to women. For comparison, about 35 percent of all bachelor's degrees in STEM fields are earned by women.

Dr. Strickland is currently a full professor and leads a laboratory at the University of Waterloo in Canada. When the award was announced, Dr. Strickland was an associate professor and had never applied for promotion to full professor, a fact confirmed by the University. While she has not explained why she never applied for the higher-paying position, many criticized the University for creating an environment that so discouraged a Nobel-caliber female scientist.

From Tarzan to Tanzania: The work and legacy of Dr. Jane Goodall

BY CAITY FORGEY, BEHAVIORAL NEUROSCIENCE, 2020

DESIGN BY KYLA VIGDOR, DESIGN, 2021

Dr. Jane Goodall has been a role model for science-lovers across the world for over 60 years. In her childhood, Goodall always had an interest in the African forest and a love for primates. She would credit her interest in these forests to children's books, such as *Tarzan* and *Dr. Dolittle*, and the encouragement from her parents to pursue what she loved. When she was just a baby, her father gifted her a stuffed chimpanzee named Jubilee, which she now displays in a chair in her home today. As a young adult, Goodall's dreams of traveling to Africa and visiting the forests became a close reality. The first time she traveled to Tanzania to live amongst the chimpanzees, her mother tagged along. At the time, very little was known about the species, and people were quite uncomfortable with the idea of a young woman living alone in a forest with wild animals. Her mother decided to accompany her to ease their thoughts and ensure that she would be safe. No one predicted that Jane Goodall would soon revolutionize the field of primatology and set the stage for women in research.

Now 84 years old, her accomplishments began in 1960 at the age of 26, when she started working for the anthropologist Dr. Louis Leakey. Many of Goodall's most notable contributions to science are from the time she spent studying chimpanzees in the Gombe forest of Tanzania. Dr. Goodall is famously credited with being the first person to ever observe non-human animals creating tools for hunting food. One of the chimpanzees she first observed making and using tools was named David Greybeard. He was also the first chimpanzee that trusted Goodall enough to approach her. David Greybeard was only one of many chimpanzees made famous through Dr. Goodall's studies. Other well-known chimpanzees include Flo, Fifi, and Flirt. These animals became treasures of the public; so much so that when Flo died, her obituary was posted in The London Times. Flo, David Greybeard, and all of the other chimpanzees were keys to understanding the lives of the closest genetic relatives to humans. Through long-term studies, Goodall also observed

her primate companions engaging in many other behaviors that were thought to be unique to humans. While living and working with the chimpanzees, she watched them build lasting family relationships, experience human emotions, and engage in basic warfare. Dr. Goodall formed trusting relationships with many of the chimpanzees she worked with, which led to her passion for primate conservation and educating others about their impact on nature.

Dr. Goodall is best known for her time spent studying chimpanzees in the Gombe forest, but she is also a large proponent of environmental activism, an expert in behavioral sciences, and an author for audiences of all ages. Her revolutionary work with chimpanzees in the Gombe forest of Tanzania has earned her more than 100 prestigious awards and over 50 honorary doctoral degrees from various institutions and nations worldwide. Among her commendations, Goodall has received the title of Dame of the British Empire, the French Legion of Honor, and United Nations Messenger of Peace. She is also credited with carving the path for women interested in primatology; today's leading primate researchers are predominantly female. She has written autobiographies, detailed research publications, and has even published children's books encouraging youth to do their part in conserving the environment and learning more about chimpanzees.

Goodall has also founded two nonprofits, The Jane Goodall Institute, and Roots & Shoots, both aimed at teaching society about its role in protecting the forests.

The role of Dr. Jane Goodall in promoting conservation and educating the world about the many similarities between humans and primates is unquestionable. Today, Dr. Goodall spends her time traveling to schools, community groups, and institutions of leadership around the globe. She gives lectures to students, activists, and policy makers around the world, sharing her wealth of knowledge. She plans to spend her final years maintaining her impact on primatology; she still visits her research establishment, the Gombe Stream Research Centre, and contributes to training new scientists in ethical primate research. As a leader of the field of primatology, Goodall is a fantastic role model for children, women, and humans in general. Her legacy is well-established, but she's not done yet!





Rosalind Franklin



Nettie Stevens



Henrietta Leavitt



Lise Meitner



Chien-Shiung Wu

The Matilda Effect:

How history has silenced some of the greatest scientists

BY ALEXANDRA JACULLO, BEHAVIORAL NEUROSCIENCE, 2021

DESIGN BY KATIE GREEN, BIOENGINEERING, 2021

It is hard to imagine that a field as objective as science could ever fall victim to the subjective and flagrantly outrageous whims of sexism. Presumably, everyone would like to believe that the global community of scientists painstakingly pursuing universal truths are the most honorable people and have been throughout history. While that reputation holds true in many cases, the unfortunate reality is that in just as many cases it does not.

The Matilda Effect, a term coined by Margaret W. Rossiter in her 1993 publication *The Matthew Matilda Effect in Science*, captures the systemic phenomenon in which female scientists are subjected to widespread disregard and lack of recognition, with their work often being faultily credited to men.

Infamous enough to warrant its own moniker, the Matilda Effect has plagued countless women in their scientific careers. Consequently, it seems there is no better time than the present to shed a bit of well-deserved light on some of the most influential women in science who have been wronged in this historically male-dominated arena.

Currently, climate change is one of the most relevant scientific problems. The discovery of the greenhouse effect, a main contributor to global warming in which emissions of gases like carbon dioxide trap heat in the atmosphere, has historically been credited to John Tyndall. However, in 1856, three years before Tyndall's work was published, the diligent work of Eunice Foote precisely demonstrating the greenhouse effect was presented by Professor Joseph Henry of the Smithsonian Institution at the American Association for the Advancement of Science. Due to being a woman, Foote was prevented from presenting her own work at the conference.

Austrian scientist Lise Meitner established the theory behind nuclear fission, a phenomenon where the nucleus of a single atom splits apart. Her collaborator, Otto Hans, published their discoveries but left Meitner's name out of the publication. Hans went on to win the Nobel Prize in Chemistry in 1944 while Meitner failed to receive credit for her crucial work.

The 1957 Nobel Prize in Physics was awarded to Tsung-Dao Lee and Chen Ning Yang for disproving the law of parity, a principle widely accepted at

the time that stated two physical systems that were mirror images of each other must behave in identical fashion. Except Lee and Yang weren't the ones who played the biggest role in this discovery: Chinese-born physicist Chien-Shiung Wu conducted the pivotal experiments that refuted the law of parity, but her indispensable role was not acknowledged.

A name that may be more familiar is Rosalind Franklin, the chemist who determined the structure of DNA through her work with x-ray crystallography. Franklin was overlooked for the discovery she made, with the credit and 1962 Nobel Prize in Physiology or Medicine going to Maurice Wilkins, James Watson, and Francis Crick.

Similar manifestations of the Matilda Effect persist, from Nettie Stevens who established the principle of chromosomal sex determination, to Henrietta Levitt who revealed the period-luminosity relationship in astronomy, to Esther Lederberg who discovered the lambda bacteriophage in 1951, to many more groundbreaking female scientists.

It is important to remember the societal contexts in which these women were slighted; history often has not been kind to intelligent and determined women. Misogyny was a pervasive social norm that exerted undue influence on the many female scientists who have been disregarded for their discoveries.

It is tempting to think that the scientific community has long since outgrown the baseless predilections of the Matilda Effect. However, if these harmful mentalities have truly been eradicated in present day, then it might be worth questioning why only this past October was Dr. Donna Strickland the first woman in 55 years to be awarded the Nobel Prize in Physics and Dr. Frances H. Arnold the fifth woman ever to be awarded the Nobel Prize in Chemistry.

These historic instances only just begun to scratch the surface of the injustices against female scientists, perhaps most apparently against women of color in particular. Although these pioneering women were originally denied the recognition they deserve, it is never too late for the scientific community to make the effort to honor their accomplishments today. After lifetimes of silence, it is time to give these scientists back their voices.

Social Studies of Science (1993). DOI: 10.1177/030631293023002004

PHOTOS BY FLICKR AND WIKIMEDIA

The Chumash: An ancient coastal people

BY TAYLOR MANNES, MARINE BIOLOGY, 2020

DESIGN BY KAI GRAVEL-PUCILLO, ENVIRONMENTAL SCIENCE, 2021

The Chumash tribe of Santa Ynez, California, were the original inhabitants of coastal California. Their territory stretched from modern day Malibu all the way to Paso Robles, almost 200 miles. The name Chumash can either mean “bread maker” or “seashell people.” They cultivated the natural resources of their land, using willow branches and whale bones to build their homes. Unlike other native tribes, the Chumash did not rely on farming. Instead, they fished and gathered naturally growing plants. The sea and land provided a wealth of supplies for them to live on, and they prospered because of this. Their coastal caves became locations of religious ceremonies and worship. Chumash cave paintings, often vibrant scenes of yellow and red, still exist today in Santa Barbara and Malibu. The tribe says these paintings represent the relationship the people have with their environment. There were over 150 original Chumash villages, all with distinct qualities and traditions. Despite their differences, they all shared a reverence for the ocean and their environment. Many tribal members refer to the Pacific Ocean as their first home.

Resources from the ocean are part of every aspect of Chumash life. Their food consists of shellfish; their clothes were once made from seal pelts. Their houses were decorated with abalone shells, and musical shakers were formed from kelp bulbs. The Chumash origin story details their sacred relationship to dolphins; many members consider dolphins their ancestors. Even today, the tribe regards dolphins with reverence and admiration. Canoes enabled the Chumash to gather resources from the ocean and trade with other villages. These canoes, called tomols, were made from redwood trees and took months to construct. They were often decorated with abalone shell, and patterns were burned into the wood.

When the Spanish arrived in California in the 18th century, five missions were established in Chumash territory. This caused a major decline in the native population. Of the 20,000 or so original Chumash, there were around 1,000 left in the mid 1800s. The settlement of the coastal areas and

exploitation by Spanish settlers decimated the Chumash tribe. The last person to speak the original Chumash language died in 1965.

In the 1990s, however, there was a “renaissance” of Chumash culture; members of the tribe spent enormous effort to revive their lost traditions. They relearned their ancient basketry techniques and dances through local museums and Chumash experts. Many members also participated in programs put on by the National Park Service. Through these programs, modern Chumash members finally were able to feel connected to their history.

Today, the Santa Ynez band of Chumash is the only federally recognized Chumash tribe. Its members number several thousand. The tribe has established its own environmental office to advance sustainability and serve the Chumash people. They are working to make the implementation of governmental Marine Protected Areas (MPAs) include co-management by the Chumash tribe. The tribe has lived sustainably with the ocean for thousands of years, and they want to continue to do so. The Chumash are also becoming more financially independent through the establishment of casinos.

The income from these casinos is used to preserve the reservation and Chumash culture. So, they are still fighting to keep their history, culture, language, and traditions alive.



We can learn a lot from the Chumash tribe. These people lived sustainably for thousands of years. Their reverence and appreciation for their environment should be admired and emulated. As we continue to exploit the ocean, the Chumash still fight to preserve it. They not only fight to preserve the ocean for themselves, but for everyone. They realized long ago that without a healthy ecosystem we cannot hope to survive. The only way that man can persist, they say, is to learn to live in a sustainable way. The world will continue for centuries more, as it always has, but man cannot if we do not appreciate and protect the resources we have.

Blink twice if you see it

Pupil shapes across the animal kingdom

BY ARCHANA APTE, ENVIRONMENTAL STUDIES, 2021

DESIGN BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

Ever wonder why a cat's eyes are vertical slits, while people have circular pupils? What about the strange w-shaped pupils of a cuttlefish? These differences are a window into how vision works across the animal kingdom. A 2015 Science Advances study found strong correlations between pupil shape and species lifestyle. An animal's habitat and place in the food chain help determine what the animal should focus on in its environment, which in turn influences pupil shape for its survival and fitness.

Horizontal Pupils

Been on a farm lately? Many grazing animals, such as sheep and goats, have horizontal pupils. It turns out that this pupil shape best suits these creatures in a variety of ways. The horizontal shape reduces blur for objects seen on the horizontal plane, enhancing the animal's view at ground level. This feature is most useful for prey animals, as most predators would advance from the ground and not from the air. Horizontal pupils also improve image quality for objects in front of or behind these animals, useful for evading predators while maintaining a view of the terrain ahead of them. To maintain the ability to monitor the horizontal ground surface, many of these animals rotate their eyes to ensure their pupils are always parallel to the ground when eating, looking up, or otherwise tilting their heads. This unusual behavior can be seen in many animals, including horses and goats.

Vertical Pupils

Cats, snakes, and foxes all have a similar vertical pupil shape. These animals are ambush predators who hunt their prey from a distance, so vertical pupils

suit this lifestyle in a variety of ways. Vertical pupils can dilate and contract to greater extremes than other pupil shapes due to this shape's larger number of eye muscles. An increased dilation range allows animals to hunt effectively at night without being blinded by sunlight during the day.

Judging distance is also very important for predation. There are three main strategies for depth perception: motion parallax, where close objects move back and forth faster across a field of vision than objects far away; stereopsis, the combination of images from both eyes to judge depth; and blur, where objects' visual sharpness

"These differences are a window into how vision works across the animal kingdom."

varies with distance. The researchers in the Scientific Advances paper ruled out parallax as useful for predators, as the necessary head movement would give their position away. They found that vertical pupils assist in stereopsis and blur. Stereopsis requires sharp images along the vertical plane, which vertical pupils maximize for objects above ground level. This pupil shape enables depth perception using blur for objects located along the ground. Most objects are blurrier at a distance and sharper when closer to the eyes. This variation is called the blur gradient. A vertical pupil shape lets animals use this effect to judge depth for objects at ground level. Thus, creatures with vertical pupils can use stereopsis and blur cues to accurately judge distance without moving their bodies. This effect is exacerbated for animals with

front-facing eyes, which is why many predators with vertical pupils also have front-facing eyes.

That said, vertical pupils are most advantageous for shorter predators, because the blur gradient is larger for shorter animals than for taller ones. To illustrate this, lie on the ground and look straight ahead. The ground farther away is much blurrier than the ground in front of your face, and this disparity lessens as you stand. True to this trend, vertical pupils are most common in shorter ambush predators such as snakes and foxes; taller predators or predators who do not hunt on the ground, including birds and humans, typically lack vertical pupils.

Round Pupils

Humans, big cats, birds, and dogs have round pupil shapes. This shape does not offer enhanced nighttime vision or depth perception; instead it is suited for daytime hunting involving prey pursuit over long distances. The researchers also found that animals over 16 inches tend to have round pupils, as these animals do not need to see well along the ground the way sheep and deer do.

Other Pupil Shapes

Other creatures have unique pupil shapes. The cuttlefish's distinctive w-shaped pupil helps balance vertical light and increase contrast in dark scenes, useful for creatures living in water lacking sunlight from above. Geckos have vertical pupils with pinholes along them, allowing for precise depth perception in bright conditions.

Photos (left to right): bush viper, human, cat, cuttlefish, sheep.



AS WATER NEEDS INCREASE, IS DESALINATION A GOOD IDEA?

BY WILLEM BUSSINK, CHEMISTRY AND INTERNATIONAL AFFAIRS, 2021

California is entering its third year of drought this fall. A combination of low rainfall and increased water consumption is drying up the Central Valley aquifer. This aquifer has provided drinking water for people and irrigation to farms in California for hundreds of years.

These same difficulties are being seen everywhere water is scarce. In the Middle East, a region that contains many of the water poorest countries in the world including Jordan, Kuwait, and Saudi Arabia, aquifers and rivers are becoming dangerously overused. Researchers are even saying that the Nile River is in danger of drying up. Given such water scarcity, governments have turned towards the only source of water they have left: the sea. Israel and Saudi Arabia have pioneered the process of desalination, however even cities in the United States are turning towards the technology. A brand-new desalination facility was just completed in Carlsbad, California, that will provide 50 million gallons of clean drinking water to San Diego County.

Desalination plants generally use two different techniques to treat their water. The first and simplest technique is distillation. This process requires the seawater to be evaporated and then re-condensed leaving the salt and other contaminants behind. While simple, distillation requires a huge amount of energy in the form of heat often provided by burning fossil fuels.

The second technique, which has been implemented in the newest desalination plants, is known as reverse osmosis. In these facilities, water is forced at high pressure through membranes that contain perforations small enough to allow water molecules through, but not dissolved ions. Osmosis is the tendency of a liquid to flow towards a more concentrated solution. To filter seawater, the desalination plants must combat reverse natural osmotic pressure of water, hence the name "reverse osmosis." In a typical reverse osmosis process, seawater is placed under enormous pressures ranging from 800 - 1000 psi.

In recent years the membrane quality employed in these plants has improved drastically. By improving the water permeability of the membranes while increasing their lifetimes, prices have been driven down drastically.

“This technology could be implemented all over the southwestern United States, where a supply of water that does not depend on rainfall or a dwindling groundwater supply would be of incredible value.”

DESIGN BY EMMA ESTBERG, COMPUTER SCIENCE AND DESIGN, 2023

Researchers at the Massachusetts Institute of Technology have even proven that atom thick graphene sheets could be used for water desalination. Graphene membranes provide the same separation that conventional ones do while also allowing more water throughput. If production costs can be lowered, they will likely be the next generation in desalination membranes.

In 2013, Israel completed a state-of-the-art desalination facility known as the Sorek Plant just south of Tel Aviv. This plant utilizes reverse osmosis technology to produce 627,000 cubic meters of clean drinking water each day. However, the most revolutionary aspect of the facility is not the amount of water produced, but the relatively inexpensive cost for families that rely on it. This has been the main problem with desalination in the past. Water in Israel now costs under 100 dollars a month for a family of four, less than many U.S. cities. This technology could be implemented all over the southwestern United States, where a supply of water that does not depend on rainfall or a dwindling groundwater supply would be incredibly valuable.

Unfortunately, the environmental impacts of large-scale desalination projects are not fully understood. The waste from the plants comes in the form of highly concentrated brine which is generally piped directly back into the sea. While the effects of this waste can be mitigated by diluting the waste water before it reaches the sea, higher salinity levels in the surrounding ocean may affect marine life. Even more worrisome is the extremely high carbon footprint of desalination plants that contributes significantly to global warming, which cyclically causes the droughts that created the need for desalination plants in the first place.

These findings call into question the long-term effectiveness of desalination as a water solution for growing populations around the world. Unless energy can be produced in a sustainable way, desalination appears to be a stop-gap measure as droughts get worse and populations increase.

Nano Letters (2012) DOI: 10.1021/nl3012853
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Climate change and respiratory health: How a warming climate is projected to worsen air pollution

BY ROXANNE LEE, ENVIRONMENTAL SCIENCE AND POLICY, 2019

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

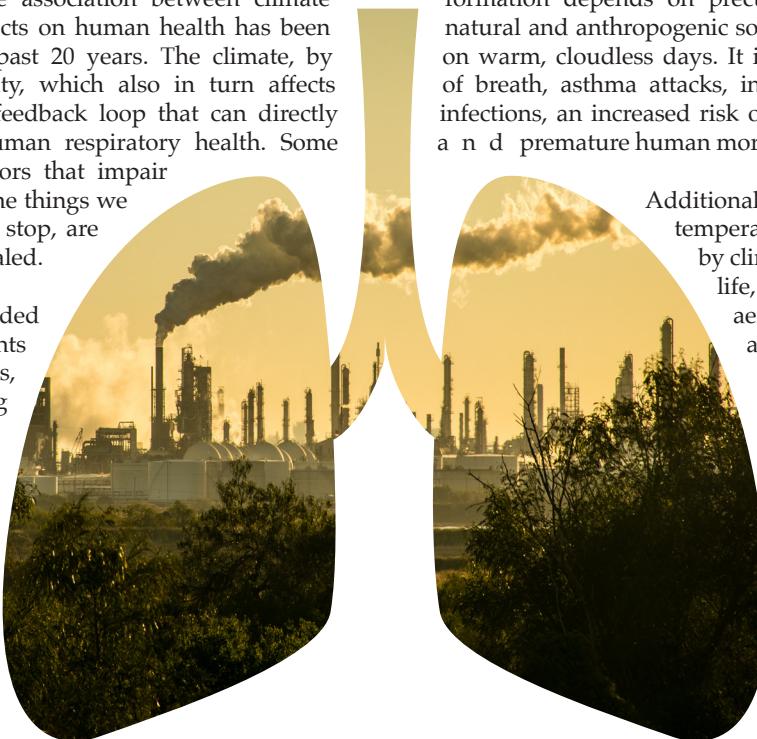
Climate change is a pervasive phenomenon. It will, and in many cases already is, affecting every part of our lives: from where we live, to what we eat, to the air we breathe.

Climate change is the long-term change in climates and weather that persists for multiple decades or more, and evidence supporting the association between climate change and adverse effects on human health has been accumulating over the past 20 years. The climate, by nature, affects air quality, which also in turn affects the climate, creating a feedback loop that can directly and indirectly affect human respiratory health. Some of the most urgent factors that impair respiratory health, and the things we have the most power to stop, are materials that can be inhaled.

Air pollution, further divided into primary pollutants and secondary pollutants, is already a pressing public health issue that will only worsen due to climate change. Primary pollutants are made of material like soot and other forms of particulate matter, which is tiny solid or liquid particles in the air that can be inhaled and have various negative effects on lung health; these effects include links to increased mortality

in infants and young children and increased severity of and increased hospitalization for asthma attacks in children. Particulate matter often forms from gaseous pollutants like power plant emissions. These emissions usually increase during heat waves, which climate change will only make more frequent.

High concentrations of primary pollutants from anthropogenic sources, in addition to harming human health on their own, can also alter the climate even further. For example, climate change increases the frequency of forest fires due to increased occurrences of drought. Increased forest fires mean more soot and other particulate matter are sent into the air, and thus breathing conditions for those near the fires are worsened. In addition to impairing human health, it's a step in the feedback loop – soot absorbs heat, which increases local temperatures, which both worsens breathing conditions and increases the odds of another fire starting.



Secondary pollutants, on the other hand, are pollutants that are not directly emitted, but are formed when other primary pollutants react in the atmosphere. One of the most common types is ground level ozone, a gas that forms just above Earth's surface. It is created when the two primary pollutants nitrogen oxides (NO_x) and volatile organic compounds (VOCs) react in sunlight and stagnant air. Ground level ozone formation depends on precursor emissions from both natural and anthropogenic sources, and is more common on warm, cloudless days. It is associated with shortness of breath, asthma attacks, increased risk of respiratory infections, an increased risk of pulmonary inflammation, and premature human mortality.

Additionally, the changes in average temperatures and humidity incurred by climate change will affect plant life, common producers of aeroallergens. Aeroallergens are any airborne substance that can cause an allergic reaction, like pollen or mold spores. Climate change both increases aeroallergen production and changes the timing and duration of pollen seasons. Allergies and asthma cost the US an estimated \$32 billion or more annually in both direct health care costs and lost productivity. With an increase in the frequency and severity of allergies and asthma due to the climate predictions discussed above, the amount could rise.

Climate change poses a danger to human health by facilitating conditions that create respiratory disease and illness, as well as by acting with air pollutants in a feedback loop. These effects on respiratory health will incur monetary costs, as more people will need medical care. Conditions will be especially pressing to already disadvantaged communities, like those already sick, the elderly, disabled, and those who do not have healthcare.

The situation is not totally beyond hope; a decrease in pollutant emissions would mitigate some of the negative effects. To protect human health, regulatory intervention will be necessary. In terms of pollen, spores, and other aeroallergens, curbing urban pollution, restricting the planting of pollen-producing species, and supporting further research into the connection between climate change and pollen production could all help minimize the potential impacts.

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DREAMS AND DREAM THERAPY

BY RACHEL GRIEP, BIOLOGY, 2022

DESIGN BY YASMINE MYFTIJA, BIOLOGY, 2021

It's the same dream every time: your old high school math teacher hands you the exam, and you don't know how to answer a single question.

Dreams are universal; everyone has them, though they may not always remember them. On average, a person spends approximately two hours each night in REM (rapid-eye movement) sleep, the stage of sleep in which most dreaming occurs. Most people have up to four or five dreams per night, however, people typically only remember one or two dreams per week. Some dreams are recurring, like the one described above. But the dreams people most often remember are the last dreams of the night, when they are emerging from sleep or sleeping lightly, or dreams which evoke a deep or powerful emotional response, like fear.

Psychologists have long been developing theories to explain why and how dreams occur. Sigmund Freud, an early pioneer of dream theory, developed the "wish-fulfillment" theory for dreaming, based on the presumption that dreams are a means of expressing repressed sexual conflicts and desires. Other psychologists took a more scientific approach. A theory of dreaming developed by Crick and Mitchison discusses the physiological function of sleep. They believed that REM sleep was used as a means to preserve and prune neural pathways. Two other psychologists, Hobson and McCarley, believed in an activation synthesis dream theory that REM sleep causes neural firings that the brain shapes into stories. However, both of these theories do not explain the personal reported meanings of dreams.

Though there are many theories for the functions of dreams, most psychologists agree that dreams reflect people's waking experiences. Studies have shown that dreams

“Most psychologists agree that dreams reflect people's waking experiences.”

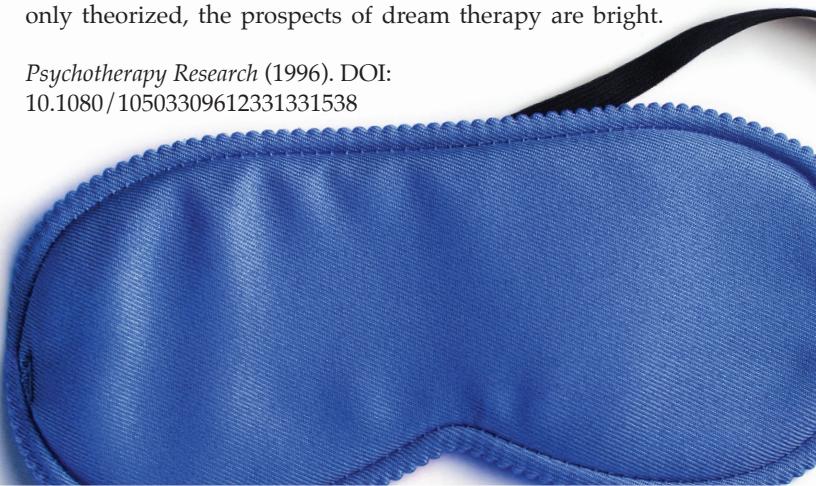
are often autobiographical in nature, and commonly focus on people who the dreamer has a strong, emotional attachment to, or people who the dreamer is currently in conflict with. According to a study conducted by J.Allan Hobson et al. at Harvard Medical School, 48 percent of people that inhabit a person's dreams are identifiable by name, and another 35 percent are identifiable by a social or professional role. Only 16 percent are unidentifiable. Additionally, the setting of dreams is typically commonplace or familiar to the dreamer, such as a school or workplace. Not only are most dreams autobiographical, but a majority of

them evoke emotions or events which could be characterized as negative, according to dream researcher Antonio Zadra. For example, many recurring dreams, such as the one previously described, often involve the fear of being unprepared, chased, or attacked, and often reflect traumatic events or longstanding unresolved problems. These dreams are more common than one may think. In a 2015 meta-analysis conducted by Zadra et al., between 60 and 75 percent of adults reported having had at least one recurrent dream in their lives.

Dream content can reflect a wide variety of topics such as gender, socioeconomic status, and marital status. Moreover, dream content also varies amongst people with different mental disorders. For example, depressed people often have dreams filled with masochism, dependency needs, and self-defeating ideas, while schizophrenics' dreams often include loneliness, bizarre imagery, danger, morbidity, and a sense of emergency. Nightmares are a characteristic feature of post-traumatic stress disorder (PTSD), often vividly replaying the actual traumatic event over and over again, making sleep a challenge. For victims of PTSD, extensive discussions of their recurring nightmares in a supportive environment can help them reorder their memories of their experience, and their nightmares tend to dissipate.

The autobiographical nature of dreams, the apparent linkage of dreams to deep seated fears and emotional events, and the well-documented scientific theory that dreaming and waking recall utilize the same sections of the brain, suggest that a focus on dreaming can enhance several forms of therapy. Most of what psychologists know about the success of dream therapy comes from clinical evidence. Dream interpretation plays an important role in long-term therapy because it allows psychologists to chart changes in dream content over time, often reflecting changes in mental state. However, dream therapy arguably plays an even more impactful role in short-term therapy. Through the analysis of a particular dream, the patient will often openly express content that otherwise would have taken much longer for the patient to share. Additionally, it is often difficult for patients to articulate what is truly bothering them, whereas dream analysis has the potential to make underlying conflicts clear. Though the true physiological function of dreaming is still only theorized, the prospects of dream therapy are bright.

Psychotherapy Research (1996). DOI:
10.1080/10503309612331331538



Old habits, who dis?

NU Sci explains learning and forgetfulness

BY RAFI RAZZAQUE, ENVIRONMENTAL SCIENCE, 2019

DESIGN BY EMMA ESTBERG, COMPUTER SCIENCE AND DESIGN, 2023

Muscle memory' is a funny concept; ever try and use a familiar skill for the first time in forever? Perhaps driving stick for the first time since your European study abroad, or forgetting how to tie a bowline knot?

You're far from alone. Even the most routinely practiced activities and actions fade away from us if enough time passes. There's a science behind our experiences and our abilities—or, lack thereof—in recalling past experiences for present-day use. What then, leads to this proficiency decline, and is there hope for those who have lost out on skills that were once second nature?

To understand the challenges in retaining and recalling familiar skills, it is worth looking into the way we learn and compartmentalize these activities in the first place. Our brain is capable of perceiving information from one of the five main senses, as well as other senses such as balance, temperature, or pain. Our brain is also compatible with a wide variety of learning activities, such as active learning, associative/non-associative learning, play learning, and rote learning.

Activity-based learning, also known as procedural memory, is encoded in the brain and involves object use and movement. Acquiring a skill requires more than menial repetition. Rather, it requires a degree of learning where a performed behavior changes over time, such as improved outcomes in throwing clay on a wheel, or improving swimming strokes. By breaking down the skill to be learned in smaller parts, an individual can potentially improve the acquisition process of their skill. From there, practice makes perfect, as the old cliché says. Actions become increasingly automated, where mistakes are curbed. We also recognize certain data and feedback from our tasks to hint us towards flawlessness; grinding gears while learning to drive stick-shift hints us to use more clutch, for example. After a while, we ignore unimportant stimuli in performing our tasks and gain the mental capacity to handle new challenges in our activity, such as ignoring small roadside bumps while biking to work in rush hour.

“With practice vital to improving and retaining said skills, a lack of practice leads to decreased tactile sense, and one may struggle distinguishing unimportant stimuli while performing said activity.”

What happens when we lose our proficiency in our hard-earned skill set? For one, with practice vital to improving and retaining said skills, a lack of practice leads to decreased tactile sense, and one may struggle distinguishing unimportant stimuli while performing said activity. Conversely, one may fail to act appropriately to important stimuli, such as pitch correcting poor intonation during a musical performance. Additionally, for tasks that require physical strength, such as correctly pitching a baseball and climbing a tree, raw strength and muscle development can deteriorate over time, making it difficult to practice and execute a skill.

This corresponding loss of proficiency can be graphed, with information plotted over time. This is known as a forgetting curve, or an Ebbinghaus curve. Hermann Ebbinghaus predicted a drop-off in memory abilities over time, and today, the exponential drop of information over time bears his name. To retain this information and lessen the heavy drop-off of information over time, repeat (practice) your learned skill! In particular, practicing the learned skill at specific intervals limits how much we forget whilst giving us a chance to practice and retain information that could otherwise be lost. Practicing this learned skill engages synapses between neurons, and lengthens spines that grow off dendrites. A 2015 study from the University of California Santa Cruz found that manipulating dendritic spine formation to shrink caused mice to forget particular learned tasks. Thus, practice also reinforces biological connections that facilitate a learned skill.

Learning new skills is a daunting task, but the thought of relearning them is even more time and effort! Making the effort to occasionally practice your hard-learned activities gives your brain and body a chance to recognize acceptable and unimportant feedback to perfect the execution of your tasks. Take it from yours truly; it's not a nice feeling when something as familiar as playing a violin starts to feel as foreign as a bad handshake. Even the activities we already practice often can use some attention; performing them at an automated level means there's the mental capacity to do them better, faster, or more accurately! After all, we should never stop learning and trying to better ourselves.

BRAIN-TO-BRAIN INTERFACE

BY HANNI WILSON, BIOENGINEERING, 2022

While there are many aspects of our reality are not yet fully understood, the human brain is among the most intriguing components. Over the last several decades, advancements in neuroscience research have led to new findings concerning brain structure and function, and even more questions to be posed by researchers. While most neuroscience research has focused solely on the single brain and the seemingly infinite web of neuronal connections, many researchers have begun to explore how the intricacies of the brain interact outside of the skull with other entities such as computers and other humans.

In attempting to understand how the mind processes input and produces output information, many researchers are analyzing the neuronal workings behind communication, or how we exchange ideas, thoughts, and memories with each other. Uri Hasson, a professor of psychology and neuroscience at Princeton University, is one of the first researchers to analyze the neurological principles behind basic communication and what it can tell us about the underlying circuitry of the brain. In a feature with Princeton Alumni Weekly, Hasson described communication as “a single act performed by two brains”, indicating that communication itself is an orchestrated process that two separate entities must engage in *together*.

Neurologically, the verbal communication chain consists of the speaker’s brain waves, produced by the synchronized electrical pulses of neuron masses, which generate a sound wave. This sound wave, better known as speech, is then received by the listener’s brain and is interpreted in a way that creates meaning for the listener. This cognitive simplification of verbal communication explored by Hasson is termed *brain coupling*. The alignment of brainwaves of two conversing people indicates a level of mutual understanding that is essential in effective communication. Hasson’s work has shown that the stronger the coupling of two peoples’ brainwaves, the better the mutual understanding between them. This principal has led to explanations of why friends often share commonalities in neurological data. People who are friends are often *cognitively homophilous*, sharing similar brain wavelengths.

Furthermore, neuroscience research on verbal communication has led to interesting findings for how our brains may be able to communicate through other means. While natural telepathy is certainly out of the realm of what we know to be possible, neurological research conducted within the last decade has explored alternative ways to

communicate through brain-to-brain interfaces (BBIs). The conversation surrounding this topic began in 2015 at the Center for Sensorimotor Neural Engineering at the University of Washington when the first instance of actual brain-to-brain communication was observed while subjects played Space Invaders. With an electroencephalogram (EEG) cap and stimulatory electrodes, information between the two subjects was transmitted via a computer that could compute the electrical signals produced by the first subject and send them to the second subject in a decoded electrical form that the brain could interpret.

The same team of researchers have further shown how we may be able to couple electrical and computer power with neurological function to forge a new connection between people. In September of 2018, they created a multi-person, non-invasive direct brain-to-brain interface called BrainNet. Utilizing EEG electrodes and transcranial magnetic stimulation (TMS), the team was able to orchestrate the exchange of thoughts between two people who were guiding a third person in a game of Tetris. While this study was designed to complete a fairly simple task, its implications for the field of neuroscience and BBIs is monumental. The concept of BrainNet promises a future in which we may be able to connect many minds into an intricate biological web, changing the way we approach and tackle the world’s most pressing problems.

Even in its early stages, this technology can create a new dimension of communication: direct transmission of information. This form of communication could help those suffering from neurological disorders with impaired cognition, or even enhance the capabilities of the military pertaining to the transmission of covert information. Even beyond these applications, the implications of new interfaces like BrainNet are immense. Connecting the minds of millions of people could hold the key to some of our biggest global questions, such as how to achieve effective environmental conservation, or how we may step foot on Mars. Inversely, while focused outwardly towards elevating humanity to another level of cognitive excellence, the concept of BBI may also hold answers to some of our most inwardly focused questions concerning how our brains function. Through evaluation of these extremes, we may one day form a more complete picture of the brain both inside and out.

DESIGN BY YECHANG YANG, PSYCHOLOGY AND CHEMISTRY, 2022
PHOTO BY PIXABAY

ARE YOU CAPABLE OF EVIL?

The Stanford Prison Experiment

BY YASMINE MYFTIJA, BIOLOGY, 2021

In the early hours of August 14, 1970, 12 college students in Palo Alto were arrested in their homes and charged with armed robbery. They were stripped, searched, deloused, and transported to a makeshift prison in a Stanford University basement – all because they had answered an advertisement for a soon-to-be famous study known as the Stanford Prison Experiment. These 12 people served as “prisoners” while their counterparts served as “guards” in a simulation of the effects of power in American prisons. They were given strict roles and put under surveillance by Stanford Professor of Psychology Philip Zimbardo.

In the experiment, guards were only under limited surveillance and faced few repercussions for hostile actions taken against the prisoners. Instances of psychological abuse broke out. Guards dehumanized prisoners by referring to them only as numbers, forcing them into exercise-based punishments, removing their mattresses, putting them into simulated solitary confinement, and making them stand naked for prolonged periods of time. Participants who had seemed psychologically normal by Dr.

Zimbardo’s standards showed increasingly sadistic tendencies.

While the personalities of each guard may have played a part in how they adapted to and carried out their role as a figure of authority, Dr. Zimbardo argues that it is even more likely that the situation the guards were placed in allowed them to behave aggressively. Prisons have a notoriously rigid power structure, and people placed in such positions will conform to these roles. If given too much power, Zimbardo concluded, regular people can morph into oppressors with no regard for the wellbeing of others.

Fifty years later, the implications of Zimbardo’s studies are still ever-present in other systems of power. Perhaps the most recent example involves the American military and prisons in the Middle East, such as Abu Ghraib in Iraq, where prisoners have been abused and tortured. Such studies suggest that deeply-ingrained power structures, rather than a few bad people, are to blame when atrocities occur. They force us to ask: are we also capable of evil?

A computer can recognize you anytime, anywhere

BY DREW BODMER, PHYSICS AND COMPUTER SCIENCE, 2022

Many new laptops will display a message upon startup that says something like, “Looking for You.” This may seem a strange message for a computer to display, but it is one of the most significant products of machine learning: facial recognition. Over time, computers have become better at accurately recognizing faces, in some cases even better than humans. This technology can have a massive range of applications, from personal computer security to assisting police in searching for missing persons or fugitives.

In the late 1960s Woodrow Wilson Bledsoe created the first facial recognition software, a system that could recognize faces based on manually-set markers on each picture. This data could be put into a database, and then when a new photograph was given to the system, it would find the face in its database that most closely resembled the new face. This system was not truly a facial recognition program, however, as each face had to have features manually marked, and the computer simply calculated the distance between features.

More recently, machine learning has been applied to facial recognition, with promising results. Researchers succeeded in creating facial recognition AI that has less than one percent error in deciding

gender based on faces. Machine learning works by having an algorithm make a decision about a face (male or female) and then checking it against the correct answer, which is manually marked by a programmer. Whether or not it was right, it updates its algorithm based on the data it has acquired.

Recently, facial recognition has become extremely common. It appears in technologies like the iPhone X, which uses facial recognition to open the phone, and even in Snapchat, which uses facial recognition to create effects that

follow a user’s face. Facebook also has a feature that recognizes faces in uploaded photos and allows users to automatically tag people. The NSA, FBI, and regional police have all begun adopting commercial facial recognition software to find suspects and persons of interest. In the future, this technology could make it nearly impossible for criminals to hide, but false positives in the software might cause problems. Innocent people may be unnecessarily brought in for questioning.

Ultimately, facial recognition is only a tool, and is not inherently a good or evil thing, but its prospective applications have the potential to completely change the way our society works, from locating criminals to how we unlock our phones.

DESIGN BY MARISSA KEESEY,
ELECTRICAL ENGINEERING, 2022

PHOTO BY MICHAEL GREENE, FLICKR



Unpacking the psychopath

BY BEIYU (PAM) LIN, BIOLOGY, 2021
DESIGN BY IAN PROULX, BIOENGINEERING, 2022

Perhaps the best way to define it would be with words from presumed psychopath and notorious serial killer Ted Bundy himself: "I don't feel guilty for anything. I feel sorry for people who feel guilt." Bundy was confirmed to have murdered 36 women in cold blood, with experts believing that the actual number could be more than 100. He still remains a societal enigma to this day, with his exact mental diagnosis disputed amongst psychologists. However, despite the lack of a conclusive diagnosis prior to his execution by the electric chair, the term 'psychopath' seems to be repeated in expert opinions.

Defined by many experts as a mental disorder, psychopathy is typically hallmarked by antisocial behavior, lack of empathy, and egocentrism. It is thought to be a severe form of antisocial personality disorder (ASPD) and is usually diagnosed using the Psychopathy Checklist-Revised test, a behavioral

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Psychopaths are often riddled with superficial charm, pathological lying, and an inflamed sense of self worth.”

assessment for individuals that may exhibit psychopathic tendencies. Psychopaths are often riddled with superficial charm, pathological lying, and an inflamed sense of self-worth; many of these characteristics were exuded by Bundy, helping him to be an especially alluring killer. It is difficult to make a definitive diagnosis of psychopathy, likely due to the many obstacles that researchers must face when studying individuals with severe emotional detachment; they are often unreadable and excruciatingly hard to truly understand.

A recent study of Connecticut inmates who exhibited psychopathic tendencies showed experts that individuals with these characteristics can empathize with others if they

deliberately choose to do so, although it's not an automatic response for them as it would be for the average person. This inability to naturally empathize helps to explain why psychopaths often behave with severe selfishness and are three times more likely to commit violent crimes. Even with this general knowledge, the spectrum for the disorder is large, and each individual that exhibits the typical markers has nuanced traits that makes each of them incredibly unique.

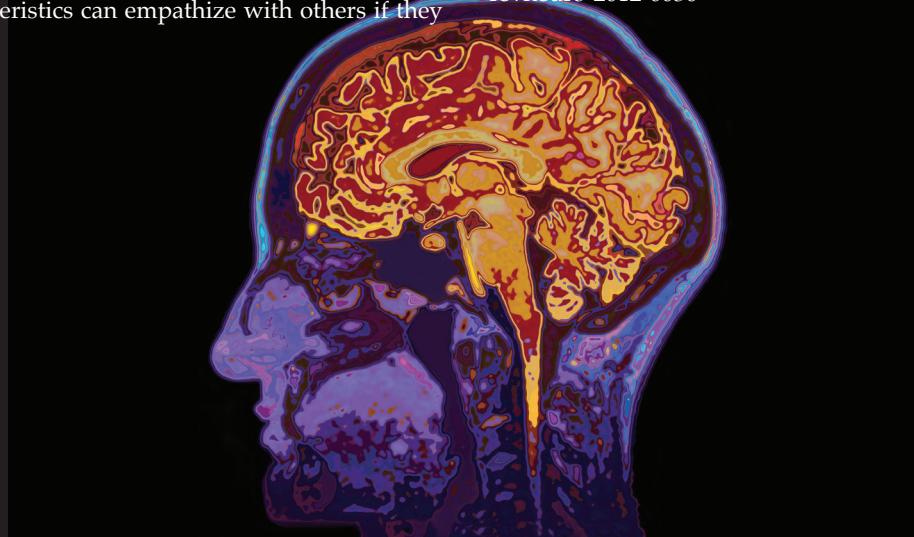
Going beyond simply behavioral aspects of psychopathy, brain scans for those diagnosed with the disorder also show alarming differences from those of non-psychopaths. When studying the brain images of prisoners, researchers at the University of Wisconsin-Madison found that those diagnosed as psychopaths showed less connections between the ventromedial prefrontal cortex (vmPFC) and the amygdala than those who did not exhibit psychopathic tendencies. These findings suggest that psychopaths seem to be missing links between the area of the brain that controls feelings of empathy and guilt, the vmPFC, and the area that controls feelings of anxiety and fear, the amygdala. The scientific backing of disconnect between emotional and social behavior in these individuals may help scientists better understand the roots of criminal psychopathy and ways to treat and prevent the volatile behavior often exhibited by psychopaths.

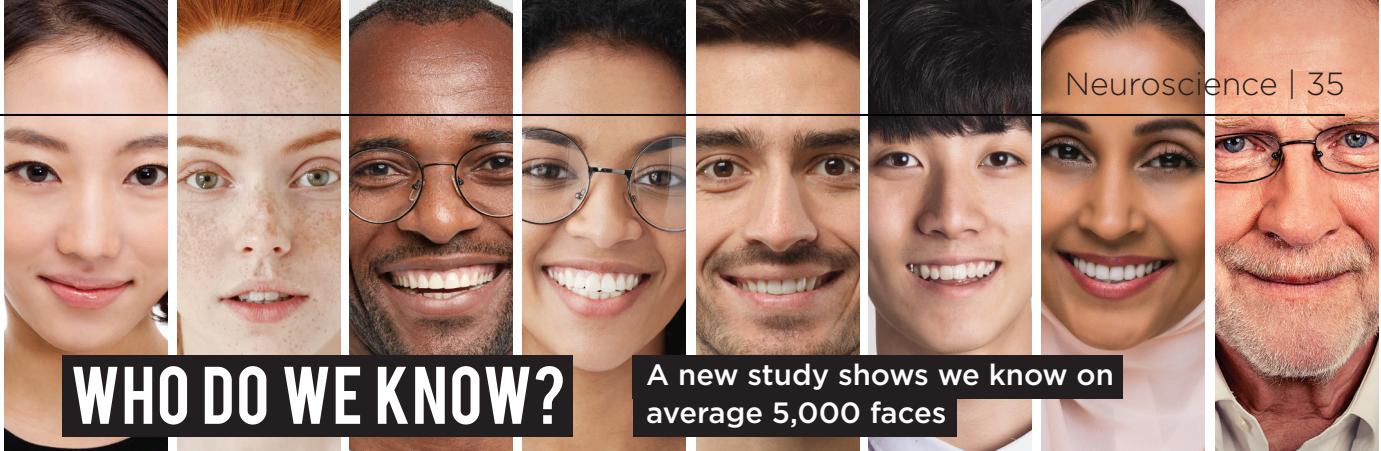
Psychopathy is a topic that remains intriguing to many, which is evident by how heavily highlighted it is in the media. While many serial killers, such as Ted Bundy and John Wayne Gacy, were ultimately presumed to be psychopathic, there are many more that actually live in plain sight. Approximately one percent of the population is presumed to be psychopathic, a statistic that forces people to realize that not all psychopaths are murderous or manipulative. In fact, the majority are nonviolent, functioning members of society. Research at University College London is currently being conducted on children, with results suggesting that approximately one in 100 of them exhibit antisocial behavior indicative of the disorder. The study of these nonviolent, productive members of society can even help shed light onto what exactly turns some individuals towards a life of crime versus a normal life, allowing society to view psychopathy as less of an enigma and as more of an illness. Until then, the pure fascination with psychopathic criminals will likely remain untouched.

Forensic Research & Criminology International Journal (2016).

DOI:10.15406/frcij.2016.02.00046

Reviews in the Neurosciences (2012). DOI:10.1515/revneuro-2012-0036





BY ALYSHA EBRAHIM, CHEMISTRY, 2022

You are walking down the street, you see someone you know. You can't figure out their name, but you recognize their face.

A new study published in *Proceedings of the Royal Society B* found that the average person knows up to 5000 faces. It is very likely a person will recognize seeming strangers on the street because they have seen that face before.

This study was conducted using subjects ages 21 to 25 looking for a ratio of how many people each of the participants recognized out of a certain amount, using pictures of people. This ratio was then converted to how many people we would recognize versus the total population. The study tested recognition for famous people and personally-known people separately. These results were slightly different, but overall the study concluded that the process to remember a regular face and a famous face is the same. Additionally, this study is based on the amount of faces we actually know, not how many the brain can handle. There have not been tests yet to see how many faces we would be able to recognize because of memory capacity.

Though it is now said that we can recognize 5000 faces, there are also studies that say that humans as a species are

A new study shows we know on average 5,000 faces

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

not good at "unfamiliar face matching." According to the *Oxford Handbook of Face Perception*, this means that in the presence of people with similar features, people are not likely to recognize one person over another. One reason is that today many of the faces we see are on a screen. With faces on a screen and real-life faces, many people see slight differences and are not able to pick out someone they saw in a picture, in real life. In a 2006 study published in *Memory & Cognition*, with the chance to pick between 10 people with similar features and only one person being seen before, participants chose the wrong person 10 percent of the time. This could be because of the lighting or angles. People find it difficult to recognize a person when the lighting is different or if the person is in a different position.

Ultimately, it seems that we humans have the capacity to memorize many different types of faces. But when it comes to recognizing them in everyday situations, the environment we see them in has a significant impact on our ability to recognize them.

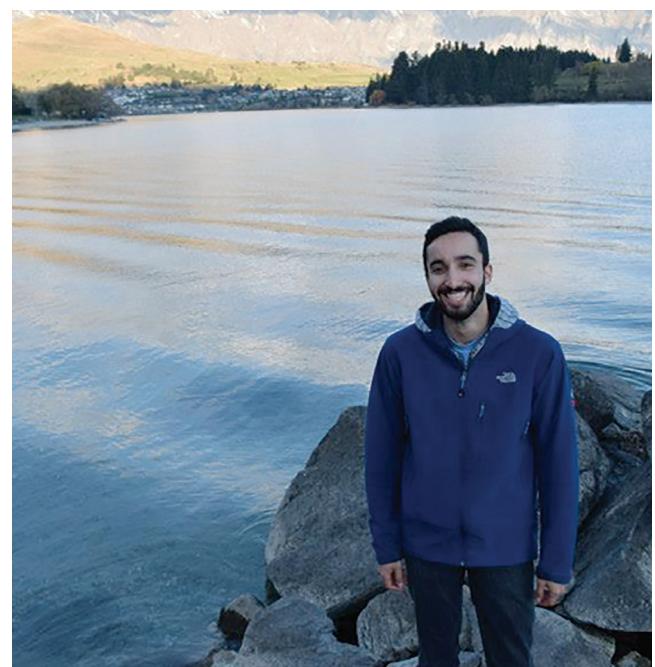
Proceedings of the Royal Society B (2018). DOI: 10.1098/rspb.2018.1319

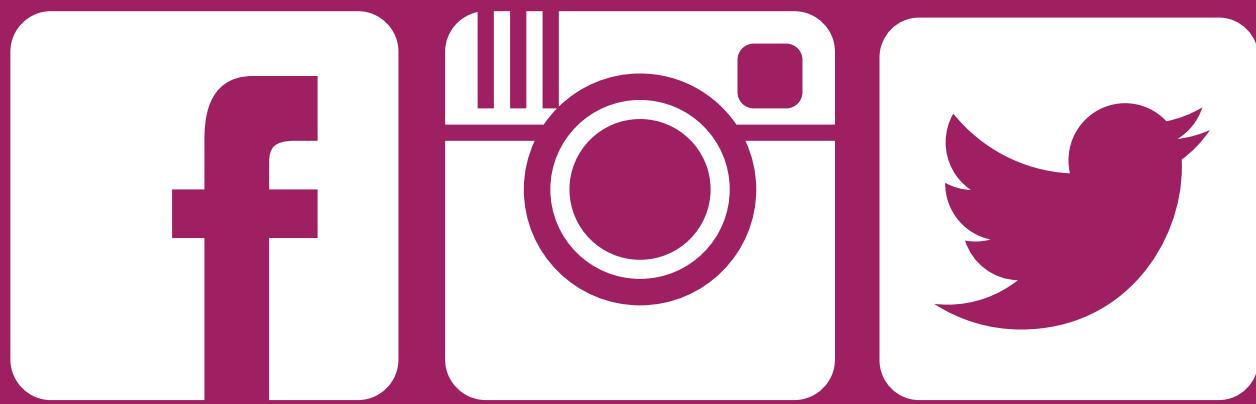
Memory & Cognition (2006). DOI: 10.3758/BF03193433

Congratulations and best wishes from NU Sci!

This December, we'll be sad to lose one of our great editors, Lucas, but can't wait to see what he does next!

Lucas Cohen, biology major, has been writing for NU Sci since spring 2016, and has filled the role of editor since fall 2016. His favorite articles include "Interview with Professor Tarik Gouhier: Statistics, Modeling, and Climate Change," "Earthly Extraterrestrials: Life in the Vacuum of Space," and "When the Mussel Doesn't Stick: Slippery Liquid-Infused Porous Surfaces Versus Marine Biofoulers." For Lucas, NU Sci was a way to merge dual passions for writing and science. He hopes that writing about science will remain a part of his life as he explores opportunities to gain additional experience before graduate school.





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