



# NUScience

Science by Students: Northeastern University

## The Creatures of Our World

Discover some of the fascinating animals that roam the planet, and what we can learn from each other.

### Also Inside:

- Happier rats will “say no” to drugs
- A roundup of this year’s Nobel Prize winners in science
- Immune system assistants that defend in disguise

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\*Jessica: Thanks for your time with the magazine, best of luck in your next endeavor!

### GET INVOLVED!

Are you looking for a creative way to showcase your work on campus? Do you want to boost your resume in a way that's creative, intellectual and fun? Become a part of NUScience! We publish two issues per semester on a variety of themes in science and technology and welcome our writers to explore any appropriate topic they find interesting.

We meet every **Thursday** at **8:15pm** in room **408 Ell Hall**. Come collaborate with us!

## Letter from the Editor

Dear reader,

ions, tigers, and bears, oh my! In our final issue of 2013, NUScience delves into the vast world of animal life inhabiting our planet. The number of animal species seems unquantifiable, with estimates reaching into the millions. A 2011 study approximated 8.7 million different species live on the planet. Take a look outside. With so much life on Earth, it's important to understand the world around you, but we here at NUScience are here to help.

In this issue, you'll explore everything from the controlled environment of the laboratory rat to the unknown depths of sea monsters' ocean habitats. We bring you to the rivers of North America, where otters still suffer exposure to chemical pesticides despite a pesticide ban several years ago; to cold climes of the north, where moose's survival rates are declining—possibly in relation to climate change; to the cluttered streets of cities, where fisher cats and other animals are adapting to rapid changes in the urban landscape.

On a more personal note, this issue wraps up my first semester as co-editor-in-chief of NUScience alongside Lauren Hitchings. It amazes me to look at our work this past semester, with the launch of our new blog at [www.nusciencemag.com](http://www.nusciencemag.com), the first issues designed in full color, and the explosion of interest and membership in the club. The magazine's evolution over the last few years makes me really proud. I want to thank, and furthermore congratulate, our writers, designers, and in particular the NUScience executive board on a job well done this year.

There may be 8.7 million species of animals on the planet, but a staggering 86 percent of existing species are yet to be discovered. The Earth's a big place, just waiting to be explored. What are you waiting for?

Jessica Melanson  
Co-Editor-in-Chief, Journalism, 2014

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The NUScience printed magazine only comes out twice a semester, but our blog is always rolling! To get your share of science content throughout the year, be sure to visit us online at [www.nusciencemag.com](http://www.nusciencemag.com).

Upcoming pieces include:

- Scientists break the record download speed from the moon using lasers
- Legendary marine biologist Fabien Cousteau's visit to Northeastern
- Fossilized mosquito found with a belly still full of blood
- The number of kids a man has can affect his testosterone levels
- Some people can't feel pain, but is it a benefit or a detriment?

*Correction: It has come to NUScience Magazine's attention that in the issue 16 article, "The Plastisphere: A New Frontier," it was reported that researchers observed 50 types of bacteria on small pieces of plastic. Erik Zettler, PhD, of the Sea Education Association, has informed us that researchers observed over 1,000 types of bacteria, not just 50.*

# Starfish Are Melting into Nothing

BY JORDYN HANOVER, BEHAVIORAL NEUROSCIENCE, 2017

Along the coast near Washington state and Canada, sea stars have begun melting. Since the summer months, the disease causing this phenomenon has rapidly progressed; in a matter of weeks, over half the population was infected with this near fatal disease, which relatively few sea stars recover from. In these instances, the flesh of the starfish deteriorates until the echinoderms can no longer hold themselves together. On the Pacific coast, the only species that has thus far been affected by this condition are the Sunflower and Morning Sunshine sea stars.

Jonathan Martin, of Simon Fraser University, who described the stars as deflating and then falling apart, has observed these "die-offs." He observed the areas where he dived as having arms, tube feet, and gills strewn across the floor near the fishing regions, some still moving. Speculation of potential causes has led to theories that the hundreds of tons of radioactive water being leaked from Fukushima, a power plant in Japan, is at fault. Additional tests of other species in areas where the starfish were found disintegrated have indicated that Cesium-137 levels were extremely high, indicating that fish in the surrounding population have radiation poisoning; the radiation levels also render the fish inedible.

Reports of a similar phenomenon have also turned up in New England. According to tracking reports of the sea stars, the population grew rapidly and unexpectedly until 2010 when unusually high numbers began dying—a process normal when a starfish population gets too large for the environment to sustain. Casualties of the observed magnitude, however, were highly unusual; in a matter of months, sea stars in the East Coast were reduced from large volumes to a sparse population. Also interesting was the fact that this disease seemed relatively isolated to the Asterias sea stars, which are in the same family of the Sunflower sea stars that had been affected by the disease in the West.

The progression of the death begins with a lesion on one arm of the star, followed by a white arm. At this point, the sea star sheds its arm. In healthy sea stars this process usually results in the growth of a new arm, but in the diseased organisms the internal organs begin to fall out and the body falls apart. When studied in laboratories at Brown University and University of Rhode Island, it was observed that the vast majority of stars in a tank with one diseased star would eventually catch the disease and die. According to these studies, the disease is contagious between sea star species, which could significantly impact the ecosystem.

Experts are still unsure of cause of this melting starfish syndrome. Along the West Coast, researchers believe that the radiation from Fukushima is what's causing the sea stars to die off, but others say that if the phenomenon is connected to the die-offs on the East Coast, there could be entirely different reasons behind the sea stars falling apart. In terms of the sea stars along the Atlantic, it seems illogical to assume that radiation poisoning is causing these stars to disintegrate, and so the professors studying the sea stars believe that a combination of environmental and pathogenic factors are at fault. They have speculated that a new disease was spread among the population, and that the sea stars were unable to combat the virus because of environmental changes, as global climate change has caused differences in the water temperature between seasons to become more pronounced.

Researchers in ecology and evolutionary biology have described this sea star syndrome as not uncommon, but rare to this degree. Pete Raimondi, of UC Santa Cruz, has seen this disease occur in starfish before when they become too dry or are severely wounded. He has said that even in these instances, the disease does not progress or infect as rapidly as it has among the population in this case, and that it also usually does not spread beyond minimal numbers, typically remaining isolated to a few sea stars or a small community. Additionally, Raimondi said that the speculation behind the cause is really still just that – this so-called "wasting syndrome" is essentially an umbrella for several different symptoms that result in the same problem. This also makes it much more difficult to determine what the connection across coasts for the stars melting is, if there is one.

At this time, it is still unclear as to whether the bicoastal sea star melting incidents are related or not. The disease appears to develop in similar ways, but it is not known whether the same virus is infecting the different groups of sea stars or if a combination of different factors is causing the problems on both coasts. Ecology and marine biology professors are devoting more attention towards this problem as it becomes more prevalent, but it could be months, or even years, before the true identity, cause, and depth of the disease is discovered. There are now websites available to divers to report any sightings of melting stars, but if the populations that have contracted the disease continue to grow, the effects on the ocean's ecosystem could be unlike anything that has ever been observed. ■



# Oreos: Not Only Milk's Favorite Cookie

BY KATIE HUDSON, MARINE BIOLOGY, 2017

If you have ever consumed an entire package of Oreos in a single sitting, don't worry, there may be help for you yet. At Connecticut College, faculty and student researchers recently announced that they found that the famous cream-cookie sandwiches can produce the same, if not stronger, effects on the brain as addictive drugs in rats.

Joseph Schroeder, an associate professor of psychology at Connecticut College, led a team of undergraduate student researchers within Connecticut College's Holleran Center for Community Action and Public Policy in this study. The study was designed to learn more about the addictive qualities of some foods—specifically foods high in fat and sugar.

To test this, Schroeder and his team made hungry rats run a maze. On one side of the maze, they fed rats Oreos, and on the other, rice cakes as a control. Afterwards, they gave rats the opportunity to spend time on both sides of the maze. This was then repeated with drugs, replacing Oreos with addictive drugs like cocaine and morphine, and the rice cakes with a saline solution. The team found that the Oreo-fed rats were spending as much time on the side of the maze where the Oreos were administered as the rats that were administered the addictive drugs.

This past summer, the team took the project a step further. Using immunohistochemistry, a process used to identify proteins in a tissue sample using the bonding of antibodies to their associated antigens, the team was able to measure the expression of proteins in the rat brains. They chose to focus on the protein c-Fos, which is a marker of neuronal activation present in the nucleus accumbens, or "pleasure center," of the brain. Schroeder chose this protein because, as he described, it tells "us how many cells were turned on in a specific region of the brain in response to the drugs or Oreos." From this, the team determined that Oreo consumption activated more neurons than exposure to addictive drugs.

While this study could focus on the effects of drug addiction, the student researchers have chosen a different focus: public health. Jamie Honohan, one of the two Connecticut College undergraduate students working with Schroeder on the project, said that these results may mean that "high-fat/high-sugar foods may present even more of a danger [than drugs like cocaine and morphine] because of their accessibility and affordability." Her research has led her to believe that these high-fat/high-sugar foods can be thought as more addictive than drugs, and that this may become a problem for the health of the general public as a result of their availability.

Honohan believes that this research "may explain why some people can't resist these foods despite the fact that they know they are bad for them." Honohan also took time to focus on the socioeconomic effects. She believes that low socioeconomic communities are the most at risk to becoming addicted to foods like Oreos that are high in fats and sugars because these products are affordable and highly marketed in these communities.

**“Oreo-fed rats were spending as much time on the side of the maze where the Oreos were administered as the rats that were administered the addictive drugs.”**

The findings of this study have only been announced briefly in a press release. The research is currently under review and has not undergone the peer-review process, yet the findings have caused more of a media frenzy than most peer-reviewed papers ever will. Once Schroeder released the preliminary results were released in mid-October, many news companies

broke the story. *TIME*, Fox News, *Forbes*, and CNN as well as many other news outlets covered the story; however, very few stated that what had been released was preliminary data.

Many news organizations did not waste any time in questioning the accuracy of this study. Jacob Sullum, a senior editor for *Reason* magazine covering the ongoing war on drugs, cited studies on addiction in rats and rhesus monkeys done in 1969 and 1985, noting that these organisms would constantly consume addictive substances like cocaine when deprived of stimuli.

"Research conducted in more naturalistic settings finds that monkeys and rats are much more apt to consume cocaine and morphine in moderation," Sullum wrote, attributing laboratory conditions as the source of the results. Sullum also questioned the conclusion that the rats were addicted to the Oreos. He argued that the strength of addiction does not depend on the amount of stimulus, but on the individual. Sullum stated that addiction is based on many factors within the individual and is, as a result, different for each individual.

It will be impossible to know if any of these factors were taken into account until the paper makes its way through the peer-review process and is published. Until then, you will just have to wonder if you finished that container of Oreos because you were addicted to them—or if your brain was just making you believe you were. ■



# The Mind's an Open Book

## Can classic literature help you read minds?

BY NAOMI STAPLETON, PSYCHOLOGY, 2016

Interviews, first dates, class presentations, arguments: all times when a healthy dose of mind reading would help us out. As humans, we do have a unique advantage: the ability to acknowledge, infer and empathically respond to the mental states of those around us. Recent research by David Comer Kidd and Emanuele Castano suggests that reading literary fiction (as opposed to nonfiction or popular fiction) hones this capacity, known as theory of mind, for social connection and empathy.

In their series of experiments, Kidd and Castano tested several different conditions in which participants read passages of literary fiction, popular fiction or nonfiction and then performed various theory of mind tasks, such as judging facially expressed emotions in photographs.

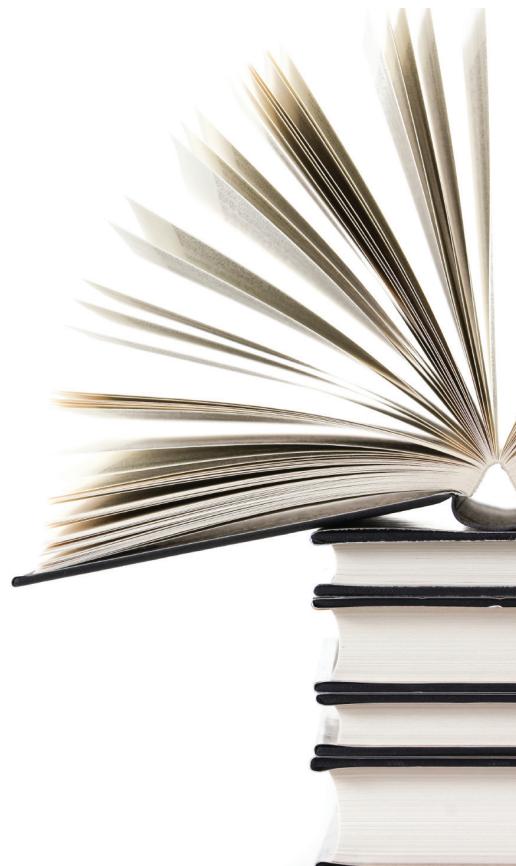
Operationally defining the three major genres proved difficult, Castano explained. The researchers identified popular fiction as having a much more obvious plot and meaning than literature. Events and descriptions in popular fiction focus almost entirely on efficient and predictable plot movement, rather than character development with great depth. Castano commented, "You open a book of what we call popular fiction and you know from the get-go who is going to be the good guy and the bad guy."

On the other hand, reading literature is a more mentally involved process that forces readers to analyze the motives of the characters and question their own beliefs. This mirrors the processes involved in social interactions.

Study participants who initially read passages of literary fiction scored better on tests in which they were asked to determine the facial expressions, emotions and beliefs of various characters. These results indicate the short-term impact of reading different genres and allude to the long-term effects of training one's social perception in this fashion.

Admittedly this uniquely human skill of social perception will not ever be fully mastered—as you wonder why your increasingly clingy texts to an uninterested suitor have gone unanswered—but humans do have a lot to thank theory of mind for: this capacity facilitates our complex relationships and communities. Being in tune with others' emotions, ideas and beliefs is crucial to successfully navigating the social world, from collaborating with coworkers to diffusing roommate disputes.

Castano and Kidd hope that their results provide support for the power of the arts and humanities in cognitive development. ■



## Ditch the Dirty Dozen

BY SUMAYAH RAHMAN, BIOLOGY, 2016

Hormones, the messenger molecules secreted by the endocrine system, regulate all bodily functions, from metabolism to growth to sleep. If something were to interfere with these hormones, these functions could be disturbed or altered, leading to dangerous or even deadly situations.

This is what is occurring in many people who are exposed to endocrine disruptors, such as Bisphenol A (BPA). BPA, which is commonly found in plastic bottles and metal cans, has been linked to cancer, obesity, diabetes, and heart problems. Recently, the Environmental Working Group (EWG) revealed that according to government tests, 93 percent of Americans have BPA in their bodies.

BPA is one of 12 hormone disruptors that

the EWG dubbed "the Dirty Dozen." You may already be aware of some members of the list, including lead, arsenic, and mercury, but there are others you may be less familiar with, such as dioxin, atrazine, and phthalates. The EWG list includes ways to avoid these chemicals, but realistically, it may be difficult for consumers to do so. For this reason, many doctors, scientists, and environmentalists are pushing for stricter regulation of endocrine disruptors, but they are facing opposition from those with financial stakes in the industry.

There is growing evidence that these chemicals should be tightly regulated. Hundreds of studies show that these chemicals, which are found in products that we use every day, are severely harming our bodies. The

most harm may occur in the critical windows of development of a growing fetus, when the fetus is extremely vulnerable to these hormone mimics. Furthermore, new studies with rats show that even future generations may be affected; there were high rates of obesity in rats three generations after exposure to the insecticide DDT.

As consumers, we can attempt to avoid products known to contain endocrine disruptors, and as citizens, we can write to our lawmakers urging them to support stricter regulations. By doing this, we will be making great strides toward a healthier and more sustainable future. ■

# ATTENTION JEDI:

## LIGHTSABERS MAY BE MORE REAL THAN YOU THINK

BY KRISTEN DRUMMEY, BEHAVIORAL NEUROSCIENCE, 2017



The *Star Wars* series is a classic saga about love, defiance, and intergalactic conquest—and lightsabers, of course. Avid fans and casual watchers alike have marveled at the glowing swords wielded by both Jedi and Sith, conveniently color coded for easy discrimination between good and evil. But like the light speed travel of the Millennium Falcon or the mammoth size of the Death Star, lightsabers are considered the stuff of science fiction. However, thanks to recent advances by Harvard and MIT scientists, lightsabers may soon become a reality.

The physics of light is complicated. In simple terms, light can act as both an electromagnetic wave and a particle. Particles of light are referred to as photons, a concept that first introduced by Max Planck in the early 20th century. Up to that point, it was widely accepted that light behaved only like a wave. Planck's concept that light came as small packages, or quanta, that behaved together as a wave became the basis of quantum physics. Although light can act as both a particle and a wave, it has never been known to act like a molecule. Photons are massless—in theory they could interact with each other under certain conditions, but in reality they are not known to interact at all.

Physics professors Mikhail Lukin, from Harvard, and Vladan Vuletic, from MIT, led a group that has managed to challenge the existing notions of light by molding photons in a new way. The team managed to change the typical nature of photons under a series of extreme conditions. Initially, the scientists filled a vacuum container with rubidium atoms, which they cooled to slightly above absolute zero. After the atoms cooled, the scientists used lasers to shoot single photons through the rubidium medium. When two photons entered the medium, they entered as single photons, but exited the medium behaving like a single molecule.

This molecule-like behavior of photons has never been seen in practice before, but has been described theoretically by the Rydberg blockade effect. Basically, the theory of the effect posits that when one atom is excited, the atoms next to it can't reach that same level of excitement.

The scientists in the study used the Rydberg effect to analyze their results. They posited that when a photon runs into an atom in the medium, the atom gets excited. The atom stays excited until the photon moves on, and during

that time none of the neighboring atoms can likewise reach that excited state. This creates an interaction between the first photon and the one following it, as the first photon “pulls” the second photon forward and the second “pushes” against the first so it can move on to the next atom, a kind of quantum tug-of-war. The result of all the pushing and pulling is the molecular behavior of massless particles of light, which produces light interactions that are astoundingly similar to lightsabers found in the movies.

Beyond the possibility of authentic lightsabers hitting the market, this new state of matter comes with exciting applications. Foremost among these is a possible method of quantum computing. Quantum computers have the potential to compute faster and more efficiently than the best computers available today. Computers operate on a binary system, which encodes information in strings of zeroes and ones. Modern computers can only process those two states, zero or one, only one at a time. Quantum computers are the focus of many scientists because they can process multiple states at once through superposition. The multiple states that quantum computers can simultaneously process are known as qubits.

Qubits, in the form of atoms and subatomic particles powering the computer, would need to be controlled in some manner, possibly through optic activity and optical traps. Optical traps could trap those particles and keep them under control. The work with photons by Lukin and Vuletic might provide the optical activity needed to create the first practical quantum computer. Quantum computers and their theoretically immense processing powers and speed could usher in an entirely new age in technology.

The results published by Lukin, Vuletic, and their colleagues provide only the first step towards realizing this novel technology, but this proof of concept signifies a huge advancement in the field. The behavior of photons observed in the study has bridged the gap between theory and reality and can provide a solid foundation for experiments in the future. Quantum computers and other practical applications may come about far sooner than expected, and stimulate rapid advances in the technology available. With these advances in technology and the new possibility of functional lightsabers, perhaps Earth can join the ranks of those planets in a galaxy far, far away. ■

# CHELYABINSK METEOR STRIKES RUSSIA,

## WITH THE THOUGHT OF MORE TO COME

BY JOSHUA COLLS, BIOLOGY, 2016

**O**n Feb. 15, 2013, an asteroid fell through the atmosphere and struck down in Lake Chebarkul, in Chelyabinsk Oblast, Russia, causing a detrimental explosion. Upon impact, the force of dissipation caused an explosion in equivalence to over 450,000 tons of TNT, provoking a shockwave that exerted the same force as 20 Hiroshima bombs, injuring near 1,600 people. The asteroid was gauged at pre-impact speed of 900 mph. Prior to the dispulsion of the asteroid particles, scientists estimated that the asteroid had been 62 feet long and weighed 12,000 tons. The fragments sunk to the bottom of the lake, making extraction

difficult for the prospective scientists due to the sheet of ice entirely covering the lake.

Oct. 16 was the first day divers were able to successfully locate and remove a piece of the asteroid. Upon weighing it, the foreign rock tipped the scale at upwards of 1,250 lbs. Directly following the impact, another asteroid brushed past Earth's atmosphere. Scientists attribute the reason for the sudden crash to a redirected near-earth-object from an intergalactic collision. A large interstellar clash could have resulted in many asteroid remnants flying off in unpredictable directions (possibly towards Earth).

Recent tests have shown that the number of larger asteroids hitting earth has increased in the last couple years. Scientists predicted that around every 25 years or so another asteroid, similar in size to Chelyabinsk, will hit Earth. However, taking into account the relatively large oceanic surface area of Earth leads to the assumption that many asteroids have been hitting the surface without witness. Correlation does not equal causation, but it appears likely that Earth may experience a fair share of meteor activity within the near future. ■

# NAIAD, THE PRODIGAL MOON OF NEPTUNE

BY SHANNON JONES, MARINE BIOLOGY, 2016

**N**eptune, the eighth planet from our sun, is currently known to have 13 moons, though until recently, one had been "lost" for more than 20 years. The moons of Neptune are notoriously difficult to track, considering the distance from the Earth and that there is rarely new information about the outer Solar System to be analyzed.

Naiad is the smallest and innermost of Neptune's moons. It was first seen in a flyby by Voyager 2, which managed to capture Naiad in a series of 25 frames over a course of 11 days in September of 1989. However, since that time, observers on Earth couldn't locate Naiad again. It's difficult to lose a moon – so where had it gone?

Neptune is very bright, and the brightness of the planet can be almost 2 million times that of Naiad. Naiad is also small, with an estimated diameter of roughly 54 km. (That's 33 miles, which is roughly the distance between Northeastern's main campus and Lowell, MA.) This is an approximation, as the moon is

irregular in shape, and may have been affected by internal geological processes since it formed from the fragments of a previous moon of Neptune, which was torn apart by the gravity of the surrounding moons. Naiad is only one arcsecond away from Neptune, meaning it is 1/3600th of a degree away from the planet's surface, when observed from Earth – basically, it is incredibly small and close to the planet's surface, which makes it difficult to track; it would be equivalent to observing a single hair from 50 feet away. Naiad orbits Neptune every seven hours and six minutes, but it is in a decaying orbit and may eventually deorbit and impact Neptune's surface.

Even though pictures were taken of Neptune and its surroundings in late 2004, Naiad was so difficult to find that it has taken until this fall to determine what happened to Naiad. New programs had to be developed in order to distinguish Naiad from the brilliance of Neptune, and when Naiad was relocated, it was found to be in a significantly different orbit

than was observed in 1989. The ephemeris, or predicted position of a celestial object, was far behind where the moon actually was in its orbit. This may have been caused by gravitational interactions with the planet or with Neptune's other moons. Further study of the moon's orbit will be needed to find out if Naiad is going to be torn apart or be pulled into Neptune's surface by gravity.

Coincidentally, the programs used to sharpen images and rediscover Naiad also discovered another tiny moon of Neptune, which is roughly 20 km (12 miles) across and is currently being called "S/2004 N 1." The return of Naiad and a possible new moon for Neptune demonstrate how much we still have to learn about space, even within our own solar system. As Dr. Showalter, the head researcher on the project said, "Naiad has been an elusive target.... it is always exciting to find new results in old data." ■

# Are Renewably-Powered Cities the Future?

BY CAYMAN SOMERVILLE, ENVIRONMENTAL SCIENCE, 2017

The global alternative energy industry is climbing and expected to overcome natural gas as the world's second largest source of electricity in the years to come, second only to coal. According to the International Energy Agency (IEA), "Renewables are now the fastest-growing power generation sector," and are anticipated to increase by 40 percent in the next five years. While 80 percent of the renewable power generated globally is hydropower, non-hydro sources such as wind, solar, geothermal, and bioenergy are rapidly growing and expected to double, supplying 8 percent of the world's energy before 2018.

This year, for the third consecutive year, Massachusetts was ranked nationally as the number-one leader in energy efficiency. Companies like Brightfields Development LLC are taking advantage of the newfound interest in renewable energy and constructing more and more solar, wind, and hydroelectric power plants to tackle global warming and pollution problems, as well as the rising power demand. Brightfields Development is responsible for the 3-megawatt (MW) solar farm that was just recently built, concealing Scituate, Mass.'s town-owned landfill.

Recently Scituate was dubbed the first town in the state of Massachusetts to get 100 percent of its power for municipal uses from renewable energy sources. By early 2012, the town had already completed their first renewable energy project—a 1.5 MW wind turbine. In 2011, Brightfields Development was awarded the contract to construct the solar farm and manage the solar parks on brownfield, or contaminated, property. Construction began earlier this year and concluded in late September, resulting in a fully functional solar facility atop of a capped pile of garbage. The solar farm consists of 10,560 photovoltaic (PV) panels, generating an estimated 3.75 million kWh of renewable energy annually. This is comparable to powering 331 average U.S. homes for an entire year. Brightfields Development deals with the details of designing solar facilities and feeding that electricity into the existing electrical grid. This project was focused on providing enough energy for all municipal needs such as schools, the fire department, and town hall.

Pete Pedersen, managing principal and founder of Brightfields, has talked at length about the pride the company takes in reutilizing dormant, contaminated properties as platforms for cultivating solar energy. According to Pedersen, solar utility regulations vary state by state in the northeast, leading Brightfields to be active in states similar to Massachusetts,



Photo courtesy of Brightfields Development LLC

which have a "significant amount of renewable portfolio standard incentives to help solar along." The company is active on closed municipal landfills, such as Scituate, and on industrial sites nationwide. They tackle significant environmental problems and help big industrial companies using a "solar energy fix," in which they place solar energy technology on top of contaminated properties. Initially, the "nasty contamination problem" is capped, and then solar panels are placed above as a more efficient way of using property that is otherwise unusable. After the solar park is constructed, minimal human involvement is required aside from monitoring and maintenance. It is for this reason that solar energy is often considered a more affordable option than other renewable energy sources.

Theresa DeLucia, an environmental science student at Northeastern University, is currently on co-op as a solar energy intern at Brightfields Development and has been actively engaged in the Scituate Project. Her internship responsibilities include, but are not limited to, visiting the site to evaluate its public image, leading a field trip for Scituate kids to explore the solar farm, and facilitating the incorporation of Brightfield's design into local public school curriculums. Theresa attributes her enthusiasm for the solar developmental work of Brightfields to their continuous engagement with the community, often long after construction has been completed, and their ability to turn a negative situation into a positive one.

Unlike other solar farms that are constructed

on uncontaminated or natural plots, the company develops on wasted land and transforms it into something that can generate electricity without further affecting the environment. Additionally, this particular landfill was made following regulations from Massachusetts's Department of Environmental Protection (MassDEP), and then Brightfields obtained a landfill reuse permit from MassDEP to ensure that the solar farm will continue to be safe. Similar to the wind turbine, the solar farm will hopefully be connected to a website that allows residents to monitor its energy production.

In the end, it's a hopeful story for the town of Scituate and the state of Massachusetts, recognizing Scituate to be among the first fully renewable communities. Not only does installing a solar park on a capped landfill create savings for the town, but the project promotes the advancement of the solar industry and the responsible usage of brownfield land.

Pete Pedersen spoke highly of the individuals who contributed to the project, stating, "Brightfields was very fortunate to work with a town that was as knowledgeable and cooperative as Scituate was. We learned a lot from their wind turbine experience ... and working together we were all able to bring this project to conclusion in spite of the twists and turns."

Theresa DeLucia, the Brightfields co-op, has asked that readers stay tuned for an upcoming presentation by Brightfields Development LLC, divulging more on the topic of clean energy and their role in Scituate's great success. ■



# “Thrifteting” Your Own Lab

BY KEVIN O'LEARY, COMPUTER SCIENCE & COGNITIVE PSYCHOLOGY, 2017

Scientific laboratories generally have high startup costs and are expensive to maintain. Consequently, many researchers across the world are unable to conduct any form of research unless they are able to acquire patrons or donors for equipment. To combat this issue, Lina Nilsson, a scientist at UC Berkeley, has begun an initiative to teach researchers and laypeople alike how to create their own lab gear from everyday items. In 2007, Lina received a grant to travel around the world, visiting labs in numerous countries. In the labs of Asia and South America especially, Lina was surprised by the lack of equipment. Upon returning home, she created a company called

Tekla labs, whose goal is to provide quality, low cost equipment to those who need it. Their website encourages users of all backgrounds to submit procedures for making their own laboratory equipment, such as magnetic stirrers or media rotators.

For instance, a member of Tekla Labs created a magnetic stirrer – a device that mixes components until they are a homogenous mixture – for \$30, whereas magnetic stirrers usually cost over \$250. This magnetic stirrer consisted of common parts such as a DC motor, an LED, and a circuit board. Without access to a magnetic stirrer, researchers’ results would be susceptible to contamination

and error, as stirring by hand can lead to inconsistent results. Other projects include centrifuges made from old kitchen blenders, and thermal cyclers – a device that amplifies DNA – made from just thermometers and light bulbs. There are many places worldwide, such underfunded high schools and research laboratories in Latin America, where the option to buy high-quality lab equipment does not exist. In those situations, Tekla seeks to offer new opportunities. As Lina has stated, “Great ideas are everywhere, but opportunity is not.” ■

# An Algorithm to Eliminate Traffic Jams

BY DEREK JONES, CHEMICAL ENGINEERING, 2016

We've all been there, driving on the highway when a traffic jam transpires causing an unwanted delay (Navigating into or through Boston is rarely a speedy process). After racing a snail on the side of the road for what feels like hours, you finally reach the source of the chaos. The kicker is that sometimes it's absolutely nothing! So what initiated the hindrance in traffic?

Berthold Horn, a professor at MIT, explained this phenomenon in an MIT news release: “Suppose that you introduce a perturbation by just braking really hard for a moment, then that will propagate upstream and increase in amplitude as it goes away from you.”

Since the 1930s, mathematicians have created several mathematical models that

describe these unexplained traffic jams. Horn is one of the first to develop an algorithm to prevent them.

The overly simplified idea is that if a car stays approximately midway between the cars in front of and behind it, then it won't have to adjust its speed as abruptly if the car in front slows down. In order to implement this “bilateral control,” vehicles must have a way to collect information on the speed of adjacent vehicles and the distances between them. Radar or laser rangefinders would be ideal for detecting other vehicles, but they can be expensive. A cheaper, less efficient, proposal was to use digital cameras to accomplish the detection; there's several possible solutions that could work.

One glaring problem with incorporating this algorithm into society is that almost every vehicle on the road would have to obey it to prevent problems from ensuing. The algorithm however would most likely continue to function accurately if the occasional vehicle wasn't properly equipped and didn't drive without regard for traffic laws.

Boston was rated the tenth worst city to for traffic in America, with the largest increase in congestion since last year. This increase is probably due to the below national average unemployment rates in the metropolitan area. The algorithm to alleviate some of the congestion could benefit not just Boston, but communities everywhere. ■

# Chimpanzee Friendships Are Defined By Their Personalities

BY JESSICA MCINTIRE, BEHAVIORAL NEUROSCIENCE, 2014

**T**hink back to the moment you bonded with your best friend. What made you like them? Why did you decide to spend more time with them? You probably didn't consider it at the time, but psychological studies have found that friendships are more likely to form between people that have similar personalities, an effect called "homophily." Human personality is often modeled with the Big Five personality characteristics: extraversion, agreeableness, conscientiousness, neuroticism, and openness. Of these, extraversion, agreeableness, and openness can predict friendships between adolescents and young adults.

By carrying out personality studies in humans' closest living relative, the chimpanzee, scientists can learn about human personality and friendship, and how these behaviors evolved. However, one hurdle they must overcome in the process is how to accurately characterize personality in animals. For years, the theory that animals had personalities was highly controversial, coming under criticism that the personality descriptions were more likely anthropomorphic projections of human character than true scientific observations.

Today, researchers have accepted that animals have personalities, defined as consistent differences in behavior between individuals, and have moved on to developing models that describe aspects of their temperaments. For example, some fallow deer are braver than others, exhibiting less predator-detection behavior and greater willingness to try new foods. In chimpanzees, most studies find that their personalities can be described using four to six personality domains. These domains usually have some resemblance to the human Big Five traits, frequently with categories corresponding to extraversion, agreeableness, and openness.

Moreover, chimpanzees, like humans, exhibit homophily. Chimpanzee friendships are exhibited as strong and long lasting preferences for certain individuals in the group. A study by Jorg Massen from the University of Vienna and Sonja Koski from the University of Zurich explored which personality

characteristics are predictive of chimpanzee friendships. As an indicator of relationship quality, they recorded how often individuals engaged in "contact sitting" with each of the other group members. Contact sitting is a behavior in which chimpanzees will sit with at least one body part in clear contact with another chimpanzee, often back to back or side to side. Additionally, the scientists took personality measurements of each chimp according to the qualities of sociability, positive affect, anxiety, grooming equity, exploration-persistence, and boldness.

What they found paralleled human relationships to a great extent: similarities between friends in sociability, boldness, and grooming equity were greater than between non-friends. Most striking is that sociability and boldness are highly reminiscent of the extraversion and agreeableness characteristics that are predictors of human friendships.

It's all very well to describe what kind of chimps become friends, but what does this explain about the evolutionary value of friendships? Building relationships takes an investment of time and energy that could otherwise be devoted to locating food, building shelters, or reproducing. Therefore, friendship must have an evolutionary benefit, especially if it is conserved between species.

Studies have shown that female-female friendship in chimpanzees increases survival, reproductive success, and infant survival. Male-male friendships and male-female friendships increase male success in reproduction, likely through the benefit of greater access to partners. There are also social benefits to friendship; chimpanzees show greater support for friends than non-friends in social conflicts, meaning chimpanzees with more friends are more likely to succeed in aggressive encounters between factions within a colony. It is not hard to draw parallels in human friendships: a woman calls her best friend to come babysit while she runs to the grocery store. A man brings his buddy to a bar as his wingman, or he asks his female friend to introduce him to her pretty roommate. The senior class president won't be the

kid who sits alone in the cafeteria.

Why is it important that friends have similar personalities? A clue lies in that homophily is not significantly observed in friendships between related chimpanzees. This makes sense considering the benefits of being able to predict others' behavior. Between related individuals, chimpanzees can learn the behavior of others over a long period, but between non-kin friends, the behavior of others is predictable because of similarity to themselves. One of the benefits of this ability to predict behavior is more successful cooperation, such as the exchange of grooming. Human friendships are partially characterized by decreased tracking of evenness in exchange of favors and tolerance of imbalances in reciprocity (a friend is fine spotting another friend for a coffee if he forgot his wallet, because he knows his friend would do the same for him). Researchers believe that this corresponds to similarity in grooming equity in chimpanzee friendships; a chimp need not worry whether the energy expended grooming his friend will be returned because his friend grooms others with similar frequency as himself.

This benefit applies in stressful situations as well, such as predator encounters. Successfully mobbing a predator requires attack by many chimpanzees at once, making it favorable for bolder chimpanzees (who are more likely to charge the predator) to associate with others that also exhibit bold behavior. A chimpanzee can reliably depend on his friends to support him in attacking a predator if he knows they are similarly bold.

This study is another amazing example of how our closest living relative, the chimpanzee, can help us to elucidate the evolutionary origins of complex human behaviors. Considering the similarities found here, it is likely that the more we come to understand chimpanzee personalities and relationships, the more we will find concerning humans through analyzing the analogous underlying bases of behavior. ■





Photo courtesy of Clark Howard, National Geographic

# Rare Oarfish Sightings Shake the Globe

BY CAYMAN SOMERVILLE, ENVIRONMENTAL SCIENCE, 2017

For centuries, myths have arisen telling tales of elusive sea monsters that roam the ocean's depths. The rare and strange creatures that recently washed ashore in California are likely the foundation for infamous sea serpent tales that told throughout the ages. Within the span of a week, two large *Regalecus glesne*, commonly known as oarfish, washed ashore in California 50 miles apart from one another. The larger 18-foot bony fish was found off Santa Catalina Island. The smaller 14-foot oarfish reportedly had 6-foot-long ovaries full of fertilized eggs. Coincidentally, in that same week, a rare saber-tooth whale was also found dead along Los Angeles' Venice Beach. The similar timing and locations of these rare sightings have baffled the world, reawakening superstitions and questions that not even scientists can fully address.

The mystique surrounding the oarfish can be somewhat attributed to the rarity of oarfish sightings. As oarfish prefer ocean depths up to 3,300 feet, marine biologists are more likely to read about them than actually study live or dead specimens in the laboratory. The long, ribbon-like body of an oarfish is known to reach lengths of over 50 feet and weigh as much as 600 lbs. *Regalecus glesne* is believed to be the world's longest living species of bony fish, and is characterized by a lack of scales and a red dorsal fin that runs the entire length of the body. Despite their terrifying appearance, oarfish feed on tiny plankton. They are not dangerous creatures, scientists posit, pointing to the oarfish's toothless jaws and parasites found within one of the beached oarfish's intestines. Tyson Roberts, who many consider the world's leading oarfish expert, claims that the species has no known natural predator, and when they are pushed up to the water's surface, there is likely a strong

current or other cause behind their behavior.

According to H.J. Walker, the marine biologist who extracted what he estimated to be "hundreds of thousands of eggs" from the female oarfish's ovaries, the 14-foot creature was nearly ready to spawn. However, when evaluating the cause of death of the deep-sea dwellers, the answer remained unclear. The male oarfish was missing a portion of its body thought to be its tail, and had wounds from cookie-cutter sharks, though they were not severe enough to be fatal. Walker believes that, more likely, the giant oarfish came too close to the surface and was knocked around by waves. Researchers found its stomach almost empty, leading Walker to theorize that a strong current carried both of the oarfish from their habitats.

Scientists have debated the possibility of elements of truth in ancient Japanese fishermen's myths that a "washed up oarfish [is] a sign of an impending earthquake," according to the *New York Times*. This theory was re-popularized after about 20 oarfish were found beached in Japan shortly after the 8.8-magnitude Chilean earthquake of 2010, and before Japan's own catastrophic 2011 earthquake. The Japanese call oarfish "messenger[s] from the Sea God's palace." The Japanese have interpreted these beachings as pre-quake warnings, and predict beached oarfish's locations would be near earthquake epicenters.

Milton Love, a marine biologist who evaluated the recent discoveries, claimed that there is no connection between the oarfish and earthquakes, as other fish in the environment would respond to tectonic movement similarly. Furthermore, Love pointed out, the discovery of the washed-up fish preceding the Japanese earthquake was not at a time near or during the natural disaster. His expert opinion about the

pair of oarfish on California's coast is that it was hardly a coincidence; he said he thinks that the same event led to both beachings. Supporting the theory that a strong current carried them into rough waters, the oarfish's vulnerable nature and inability to swim well likely contributed to their deaths. Love even suggested that additional oarfish may lay dead on the ocean floor.

On the other hand, according to *Japan Times*, even if scientists do not currently use fish behavior to predict seismic activity, there may be scientific basis to the myth. Ecological seismology specialist Kiyoshi Wadatsumi told the *Japan Times*, "Deep-sea fish living near the sea bottom are more sensitive to the movements of active faults than those near the surface of the sea." Quite a bit about the oarfish remains unknown, and these discoveries give scientists a rare opportunity to learn about the creature responsible for sea monster tales that have been passed down through generations.

The rare whale characterized for its dolphin-shaped head and saber-like teeth was also found dead in California, which is particularly odd considering its preferred habitat is in frigid subarctic waters typical off the shores of Alaska. The *Los Angeles Times* reported a 15-foot long female Stejneger's beaked whale washed ashore on Oct. 15, just two days after the first oarfish sighting. Rarely has this whale ever been seen in the wild, and it's even stranger for it to be found so far south. Despite fresh shark bites covering the mammal's body, the creature was just barely alive when it washed ashore. Like the other beached sea-creatures, the whale's death is also a mystery, and necropsies of these carcasses are truly the only way scientists can gather any further information about the organisms. ■

# CAGE VERSUS PARK

## The Issue of Environment in Engendering Drug Abuse

BY HEESU KIM, PHARMACY, 2018



In the question of substance abuse, empirical research suggests that addiction involves a complex interplay of genetics, environment, and development. The properties of certain substances have been implicated in severe physical and psychological dependence, threatening individual health, social relationships, and overall quality of life. Serialized in popular television programs as House M.D. and Breaking Bad, drug addiction has ascended as a topic of intense public scrutiny and debate. The perennial question of nature and nurture persists: how deeply does a toxic environment affect vulnerability to addiction?

In 1980, Canadian psychologist Bruce K. Alexander published the results of a study that linked social and physical environment to substance abuse. Alexander's study was borne of a series of 1960s rat trials, which were used to demonstrate that mere proximity to habit-forming drugs resulted in eventual dependence. In these trials, rats were contained in isolated cages and trained to self-inject psychoactive drugs at will. The results condemned self-control in the presence of freely available substances: the rats were observed to compulsively self-inject the drugs, in some cases to the point of death. The disturbing assumption was drawn that animals, and by extension, humans, have an innate affinity for addictive substances like opiates and would voluntarily inject them if offered the chance.

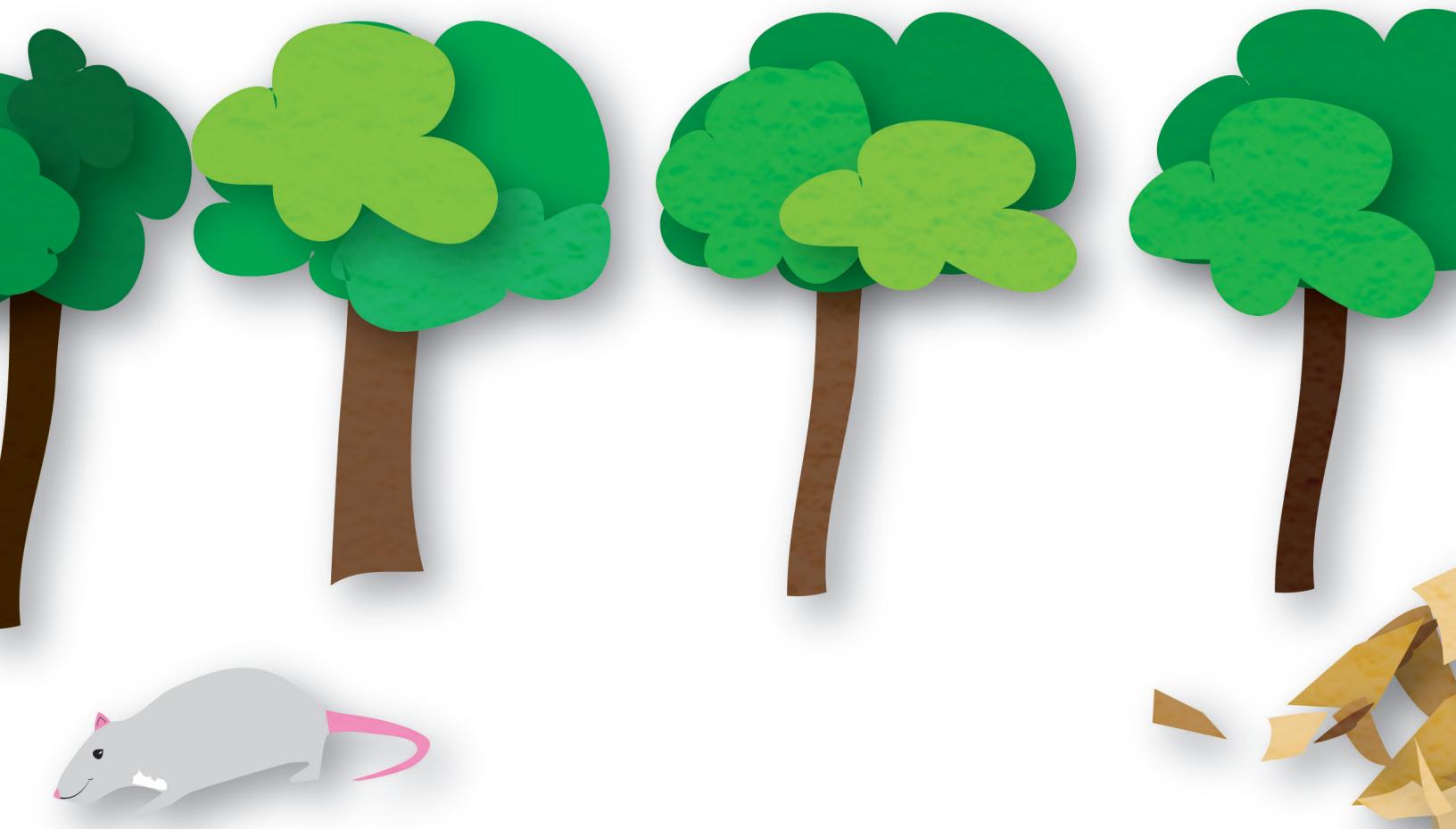
Criticizing the dubious experimental setup of the 1960s trials, Alexander has cautioned the public on overgeneralizing its results to the human experience.

"At first, the conclusion that was reached from this rat research made sense to me,"

Alexander wrote.

"But then I began to realize that it was a stretch .... First, the ancestors of laboratory rats in nature are highly social, sexual, and industrious creatures. Putting such a creature in solitary confinement would be the equivalent of doing the same thing to a human being. Solitary confinement drives people crazy; if prisoners in solitary have the chance to take mind-numbing drugs, they do. ... Second, taking drugs in a Skinner box where almost no effort is required and there is nothing else to do is nothing like human addiction, which always involves making choices between many possible alternatives. Third, rats are rats. How can we possibly reach conclusions about complex, perhaps spiritual experiences like human addiction and recovery by studying rats?"

Rejecting the notion that sheer exposure to drugs fosters addiction, Alexander hypothesized that the laboratory environment, not a natural proclivity for drugs or the drugs themselves, was the actual predictive factor for substance abuse in rats. To draw valid comparisons of environments, he constructed a plywood box and stocked it with materials for common rat behaviors, such as climbing platforms, spaces for nesting and hiding, and exercise wheels. The spacious box was filled with wood chips and painted with trees on its inner walls. A rat stationed in the so-called "Rat Park" was also allowed to play and interact with other rats of both sexes, resulting in a socially and physically welcoming environment. For the second environment, Alexander used standard 18 by 18 by 25 cm laboratory cages to confine certain rats in total isolation from other subjects. Compared to the 8.8 m<sup>2</sup> area of the plywood



box Rat Park, the cages were an estimated 200 times smaller in area. Sixteen rats each were randomly selected to live in the Rat Park colony or be contained in solitary isolation in the wire mesh cages.

In the early Rat Park experiments, researchers observed that both rat groups favored imbibing sugary fluids over bitter fluids. Using morphine hydrochloride, a relative of heroin, as the addictive substance, the researchers mixed the bad-tasting drug into sugar solutions in order to observe how rats would abide bitter taste for morphine's effects. The concentration of morphine was decreased over time, such that the solution tasted sweeter in the later phases of the project.

Initially, no rats drank from the intensely bitter mixture of morphine and sugar. However, as the scientists increased palatability of the solution, caged rats were observed drinking the morphine-sucrose solution earlier and in dramatically higher volumes than the colony rats. At the greatest point of difference in the trial, caged male rats were imbibing 19 times more morphine fluid than the Rat Park male rats. In contrast, Rat Park rats generally avoided the morphine solution in favor of the control fluid. Although their intake of morphine fluid slightly increased as the solutions became sweeter, morphine use remained at a considerably lower level than that of the isolated rats.

Alexander theorized that the environment of the Rat Park positively reinforced avoidance

of the morphine solution, causing those rats to drink less morphine than their isolated counterparts. In previous studies, morphine had been demonstrated to disrupt series-specific rat behaviors such as mating, playing, and nesting. Hence, Alexander suggested that morphine threatened the "social cohesion" present in the Rat Park, inhibiting essential series-specific behaviors in the colony rats. Caged rats, feeling no such social cohesion, imbibed morphine fluid in order to "[relieve] stress resulting from social and sensory isolation."

A later Rat Park study reversed the sequence of the original Rat Park experiment: instead of attempting to induce addiction in his subjects, Alexander pitted the effects of positive environment against physical dependence in already-addicted rats. His team habituated 32 rats to be dependent on morphine and randomly assigned them to the Rat Park colony or solitary isolation. These rats were mainly administered morphine-water solution, and then were taught to recognize that drinking more morphine-water would relieve symptoms of withdrawal. On "choice" days, rats were permitted access to both morphine-water and water to drink.

While rats in isolation actually increased morphine consumption on choice days, rats in the Rat Park colony were observed to very slightly decrease their morphine consumption, despite their established physical dependence on the drug. Those rats endured withdrawal symptoms like twitching in favor of drinking

water over morphine-water solution. Once again, the results were electrifying: caged, isolated rats fed their morphine addiction while contented Rat Park rats avoided it.

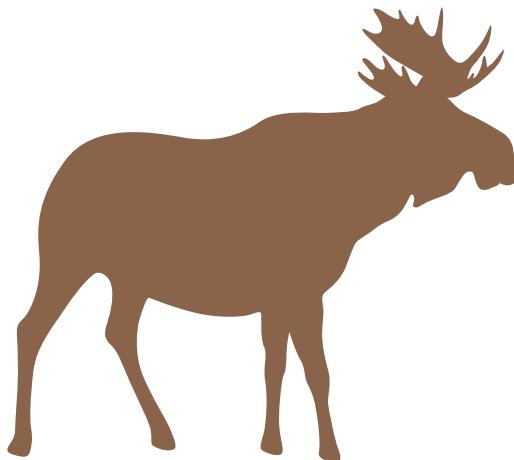
The results of the Rat Park study suggest that broader environmental factors influence rats' addiction to morphine. However, warns Alexander, "The Rat Park housing effect cannot be taken to be as robust as it originally appeared to be. Separating out the influences of type of narcotic, measurement system, and type of rat from that of environment in producing this effect may be a long process or even an impossible one. ... More important than the specific housing effect in these data may be some overriding results concerning the likelihood of rats consuming narcotics under all conditions."

Yet, if the Rat Park findings are valid, they demonstrate that the connection of environment to addiction can potentially outweigh physical factors of dependence, such as symptoms of withdrawal. Though rat addiction studies may not be generalizable to human populations, human trends in substance abuse also suggest that greater racial and socioeconomic factors are at play in determining vulnerability to addiction. Alexander's study teaches that deadly consequences can arise from poor living conditions, social interaction, and emotional health—implicating the global population in the chilling notion that where you live can decide how you live. ■

# The Last March of the Majestic Moose?

BY ANDREW BLOY, BIOLOGY, 2017

The moose: Mighty, majestic and ever enigmatic. Growing up to 7 feet tall, weighing in at three-quarters of a ton, the moose is the largest animal found in Massachusetts, and the second largest animal in the Americas and Europe (after the bison). All across North America, however, moose are dying off at an unprecedented rate. This sudden



decline in the population has baffled scientists from Maine to Alaska who are struggling to uncover a consistent explanation for the death of these creatures. There are a variety of theories explaining the moose population decline, but each has one thing in common: climate change.

Over the past few years, winters have become shorter and milder, leading to a rise in dangerous parasites such as winter ticks, pine bark beetles, brain worms, and liver flukes. All of these parasites tend to thrive when snowfall is limited and the weather is slightly warmer, so it is possible that a rise in parasites could increase their effect on the moose population. Another hypothesis is that the rise in temperature has put stress directly on moose, as evolution has provided them only with the tools required to survive cold, wet climates. With widespread brushfires, drought, and deforestation across the western portion of North America that moose live in, the moose's habitat is warmer and drier than ever. In the winter months, if the temperature reaches above the freezing, a moose will start to overheat. The process of cooling down requires a tremendous amount of energy and is very taxing. In many cases, this added stress can lead

to exhaustion, illness, and even death.

Climate change affecting large mammals may seem like a new phenomenon, but it is not. Around 10,000 to 12,000 years ago, a plethora of large land mammals called megafauna walked side by side with moose on North America. This included two species of mammoth, mastodons, cheetahs, lions, four species of giant ground sloths, two species of sabre-toothed cat, tapirs, camels, and dire wolves. Unfortunately for lovers of large, sometimes terrifying animals, all of these large mammals died out around the end of the last ice age; the culprit was climate change. Previously believed to have been the result of human big-game hunting, Australian scientist Stephen Wroe theorized that humans did not wipe out the large land mammals after the last Ice Age; rather, the various stresses natural changes to the animals' environment were to blame.

The moose is one of the last surviving large Ice Age mammals; however, climate change has once again put the mighty moose in jeopardy. If the moose's situation does not improve and global warming is not curtailed, we could see the moose vanish into the pages of history, alongside woolly mammoths and saber-toothed cats. ■

# Banned Chemical Pesticides Otter Be Gone By Now: Otters Still Experiencing Exposure

BY LAUREN HITCHINGS, BIOLOGY, 2014

In 1972, the U.S. banned the use of dichlorodiphenyltrichloroethane, better known as DDT, and several other harmful chemicals for use as agricultural pesticides. DDT and its later breakdown product, DDE, are incredibly toxic to the environment; they kill fish, shellfish, and other marine organisms, and can contribute to eggshell thinning in many species of bird. In humans and other mammals these chemicals can cause cancer and infertility, disrupt genes, and interfere with hormone function; they're particularly harmful to developing fetuses, which are vulnerable to low concentrations that don't impact adults. A recent study examining the concentrations of harmful chemicals in the livers of deceased otters revealed that while DDT has not been used commercially in over 40 years, the toxic chemical and its byproducts are by no means gone.

Researchers at the University of Illinois and the Illinois Natural History Survey conducted autopsies of 23 river otters that were incidentally killed by cars, fishing traps, or other hazards. They examined the concentrations of 20 compounds banned in the 1970s and '80s, and compared the results with data from studies from the same

time frame. The toxicological tests revealed that levels of many banned chemicals were just as high as in previous studies. One pesticide, dieldrin, was prevalent at levels higher than those measured when it was banned in 1987.

While researchers found banned chemicals in all of the otters, the contaminants' concentrations varied widely. These differences can likely be attributed to the small sample size, and the fact that otters were collected from many different counties across Illinois, indicating to scientists that some watersheds may be more contaminated than others.

"We don't have a good understanding of how much time [the otters] spend in a particular area, how long they stay there, how far they go or where they spend most of their time during the winter versus the summer," said wildlife veterinary epidemiologist Nohra Mateus-Pinilla, who worked on this study. "All of these can contribute to differences in exposure."

Scientists also observed that concentrations were far higher in male otters than in females. Some hypothesized that the concentration difference could be attributed to the fact that males are larger, or that they may travel further

and thus pick up more toxins along the way. It is also possible that the females transfer some of the harmful chemicals to their progeny through nursing.

River otters were used as biomonitoring for this study, representing more than just trouble for the otter population. Chemicals initially present in low concentrations become more concentrated as they rise up the food chain. Otters reign over the highest trophic level as top predators, so the presence and concentrations of chemicals in their systems carry implications for the state of the environment. It is probable that the high concentrations of banned chemical pesticides come from high concentrations in the fish the otters ate, including some species commonly consumed by humans.

Although the otters in this study did not die from toxin exposure, the fact that these chemicals are still present after having been banned decades ago is alarming. The half-lives of the chemicals researchers studied range from four to 25 years, so despite the government's response long ago, it is now clear that the damage was already done—we'll continue to see consequences for a long time. ■

# Wild Life for Urban Wildlife: Animal Adaptation to Urban Environments

BY GRACE SEVERANCE, BIOLOGY, 2018

**H**ave you ever heard a fisher cat scream? It's a bloodcurdling noise that sounds like it belongs more in a horror film than in a rural forest. However, people should get used to this vocal weasel because the fisher cat is one of many species of wildlife that have begun adapting to urban environments as humans encroach on their natural habitats. As urbanization sprawls out further and further from the concentrated epicenters of bustling cities, natural wildlife has been forced to either leave their habitats or adapt to their new bipedal neighbors. This leads to behavioral and physiological changes in many species as they try to acclimate to the unique human-related stressors imposed on them. Overall, the adaptation of wildlife in these situations has prompted biologists and conservationists to question if urban species and their rural counterparts truly express the same behavior or if we need to re-evaluate these urban creatures separately.

In my hometown, most people are accustomed to the smaller animals one would expect to see in the suburbs, the squirrels that scavenge for the winter and the sparrows that swoop past windows. An outsider would be quite surprised, and often delighted, to see white tailed deer eating tomato plants in the backyard. As Stephen S. Ditchkoff explains, "Once considered to be a suitable habitat for a small subset of wildlife species, urban ecosystems are now used by a wide array of wildlife that had previously been associated with rural landscapes or undeveloped wilderness." Ditchkoff of Auburn University has been studying such animals and recently released a research article explaining the various ways animal behavior has changed. One of the most persistent examples of animal adaptation to urban ecosystems is change in movement and activity. Large carnivorous predators are often forced to move their hunting hours to the nighttime as human activity disturbs them during the daylight hours. Aside from direct human activity, indirect human byproducts, like trash dumps and parks, provide huge sources of food for

animals. This impacts their natural distribution and density in a given area. "Raccoons in urban areas exhibit an aggregated distribution that is focused on communal feeding sites. ... Additionally, the high concentration of artificial food sources cause home ranges to be smaller and population densities to be greater in mesocarnivores that readily forage on artificial food resources." These unnaturally abundant food sources result in raccoons not scavenging as far away as they normally

**“Natural wildlife has been forced to either leave their habitats or adapt to their new bipedal neighbors.”**

would; consequently, raccoon densities are much higher around areas that give them easy access to nutrients.

Aside from predatory and foraging habits, the next most susceptible behavior to urban expansion is the reproductive habits of wildlife. Jays for instance, found in urban environments are more successful at finding food because of the availability of birdseed from humans. Ditchkoff postulates "that increased resource availability may serve as a perceptual clue for the appropriate timing of breeding... . Elevated food availability in the form of birdseed and other anthropogenic sources is thought to be the cause of these breeding shifts." This suggests that if humans didn't expand the natural dietary supply of wildlife, then their mating habits would be similar to those of non-urban creatures. Another avian species, cooper hawks, also struggle with proper reproductive habits in urban settings. Depending on mating calls to find suitable partners, these birds are disturbed by the day-to-day noises of a city and therefore

must vocalize to potential mates more often than native cooper hawks.

Finally, Ditchkoff noticed a particularly damaging effect of urbanization on wildlife: increased mortality rates. Despite what one would imagine with the increased food supply and lack of natural predators found in a city, many species have higher mortality rates than their rural counterparts. This is highly attributed to the presence of domesticated animals like cats and dogs. Wildlife that previously was not concerned with these predators must now find ways to survive alongside urban carnivores and often are unfamiliar with their predatory behavior. In addition to increased mortality rates due to domesticated predators, Ditchkoff explains that "mortality due to vehicular traffic may be greater in urban areas for many wildlife species because of elevated traffic and road densities." Vehicles are especially uncommon to most wildlife species and traffic accidents naturally result in high fatality rates for these species. It's quite difficult for animals to adapt to the crazy patterns of city traffic and thus far this issue has been one of the worst conflicts between animals and humans.

With growing human populations, urban expansion is inevitable. Many species are forced to adapt their natural behavior to industrialized habitats and biologists and conservationists are beginning to wonder if these behavioral changes need to be evaluated and compared to more natural behaviors. Such information would provide specific insight into how severely animals are disrupted by human action and would tell what changes might be helpful to create an environment where both wildlife and humans can cohabitate peacefully. ■





# EmTech

# 2013

PHOTOS AND TEXT BY JOSH  
TIMMONS, BIOLOGY, 2016

From Oct. 9 to 11, MIT hosted its annual EmTech Conference, a convergence of researchers, tech nerds, venture capitalists, and plug-in Porsches. The speakers discussed the state of their respective fields, with a few senior researchers talking about whatever they wanted. Some popular topics this year included internet currency, health care reform, video games for education, and climate change.

The days were split up between talks, info sessions, and networking. The "Innovators Under 35" session honored a group of 35 researchers and CEOs for their role in bringing change to their respective fields; especially notable among them was Eric Migicovsky, founder of the smartwatch company Pebble.

Other well-known speakers included Mary Lou Jepsen of Google[x]; Ben Milne, founder of Dwolla; and Tom Leighton, CEO of Akamai.

For more information, readers should go to [technologyreview.com/emtech/13/](http://technologyreview.com/emtech/13/). ■

# Nanoparticles Incognito: Innovation in Antivirulence Therapy

BY MICHAELA RAO, BIOLOGY, 2016

A team of researchers at the University of California, San Diego have discovered a way to disguise toxin-neutralizing nanoparticles as red blood cells in order to help the human body fight off anything from the MRSA virus to snake venom. In order to do their job, the nanoparticles have to be wrapped in the membrane of a red blood cell, which is composed of a unique set of lipids and proteins. This cloaking technique functions in two ways: it fools the pathogenic cell into attacking it, and it eludes the immune system by convincing it that it is a native cell.

Because these decoy cells are said to "absorb" pathogens, they were dubbed "nanospikes." When pathogens confuse a nanospike with a red blood cell, they attempt to create holes in its cell membrane. This would kill real red blood cells, but the decoy cell

instead absorbs the pathogens that attempt to puncture its membrane. Once the nanospikes cycle through the bloodstream and soak up the invasive agents, they make their way to the liver where they are safely broken down, causing no apparent damage.

Each nanospike is a package of tiny biodegradable polymers that is about 3,000 times smaller than a regular red blood cell. Despite their size, the nanospikes can take in great amounts of toxins, though absorption varies based on the pathogen. For example, the nanospikes are able to neutralize 10 times the amount of the toxic component in bee venom than that of MRSA; the toxin-to-nanospike ratio is around 70:1 for the MRSA toxin, and 700:1 for monomers of the bee venom component. In trials in which lethal doses of the MRSA toxin were administered to

mice, 89 percent of subjects survived if treated with nanospikes before infection and 44 percent survived when treated after infection, as reported by the UC San Diego team in *Nature Nanotechnology*. Though it is difficult to translate the survival of mice given lethal doses of MRSA, to applications in humans with varying amounts of the virus, the survival rates in this study are still very promising.

Unlike other treatments for pore-creating toxins, nanospikes do not have to be molecularly customized for each specific ailment. A single treatment can have a broad range of applications, which could someday make it a cheap and available option for patients. This innovation will likely be applied to a variety of antibiotic-resistant bacteria in the future. For now, the nanospikes will be appearing in clinical trials as antiviral treatment for MRSA. ■

## Wi-Fi in the Sky

### Google's Project Loon Aims to Make the Web Truly World Wide

BY CONNOR RUSSO, BUSINESS, 2017

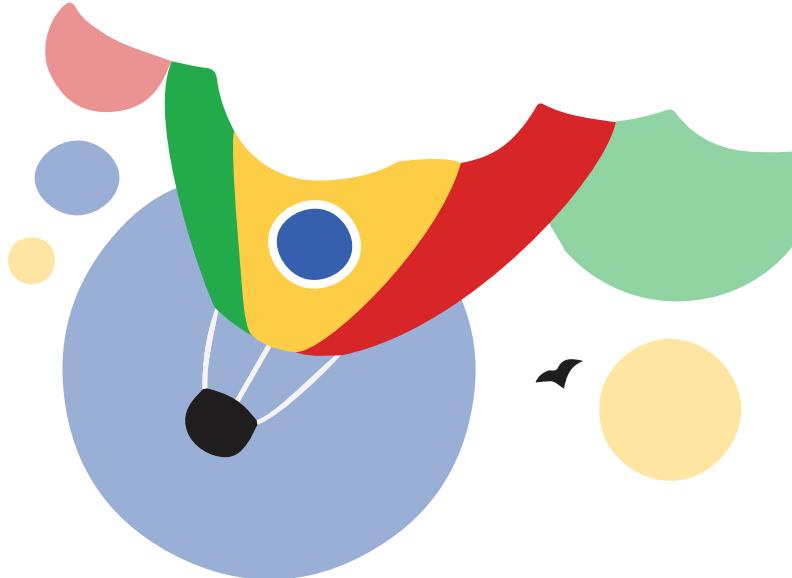
In what is often called the "Digital Age," approximately five out of seven people still don't have access to the internet. Google's Project Loon seeks to turn the internet into the ubiquitous service that many first-world citizens assume it already is. Wired infrastructure is difficult to establish in remote areas, while satellites remain too expensive to launch in such large scale. Engineers at Google have designed a new low-cost method to distribute Wi-Fi using balloons that circulate the earth's stratosphere carrying solar powered antennas.

Project Loon, as it's called, began as an experiment with duct-taped cardboard boxes, an antenna and modem from a local electronics store, and a trash bag balloon. In June, the

project launched 30 balloons over South Island, New Zealand. A small group of pilot testers had antennae attached to their houses to communicate with the balloons; they currently receive approximately 3G equivalent speeds from a network of balloons that float overhead and receive signals from a grounded internet service provider. At 20 km above sea level, the balloons avoid airplanes, weather, and about 99 percent of the air pressure experienced at sea level. With commands from the ground, Project Loon engineers can pump air in, or let air out to adjust the altitude of balloons. This process effectively acts as the steering mechanism for the balloons, which catch different directional wind currents as they fluctuate. Eventually, Google plans to launch

sensing balloons that can automatically adjust their positions in relation to one another.

The balloons can distribute Wi-Fi within a 40 km diameter on the ground and are moved so that another balloon can take the place of one shifting out of range without any lapse in connection. When they need to be repaired or replaced, the balloons can easily be brought down to collection sites. Every aspect of the project is currently being tested, adapted, and improved. Each part is made with a focus on lowering cost and easing scalability in the hopes that eventually, Google's balloons will provide Internet to everyone on Earth. ■



# Dear Evolutionary Theory, We Need to Talk.

BY CLAUDIA GEIB, JOURNALISM & ENVIRONMENTAL SCIENCE, 2015

In October, paleoanthropologists from the University of Zurich published a paper in the journal *Science* about an early hominid skull discovered in Dmanisi, Georgia that may change the way science looks at human evolution.

Up until now, the widely accepted theory of our species' evolution suggested that several different species of the *Homo* genus existed at the time that human ancestors began to migrate out of Africa, moving through the Caucasus region where Dmanisi lies as they went. This theory was supported by the previous unearthing of four other skulls in Dmanisi with separate, distinct characteristics, which led to the attribution of these fossils to separate species.

Yet according to the Zurich researchers, led by David Lordkipanidze of the Georgian National Museum, the variations between the five Dmanisi skulls showed no greater variation than might be found among five individual chimpanzees, or five modern humans. Their paper hypothesizes that the five Dmanisi individuals may therefore have all been members of the same species—*Homo erectus*—simply with different features.

The latest fossil, Skull 5, was discovered in 2005. Only recently, however, did scientists piece together how significant the find was.

Skull 5 is the best-preserved fossil of our early ancestors found to date. It has been described as having the largest face, the most massive jaw, and the smallest brain case of the Dmanisi group of fossils. However, the skull shares some of characteristics found in the previous four skulls, uniting features that had never been seen together. The skull's small brain and large teeth are similar to *Homo habilis* and *Homo rudolfensis*, respectively, which are earlier hominid species; yet its long face and the inner anatomy of its braincase most closely resembles the more recent *Homo erectus*.

The different ages and sexes of the five skulls found may have played a part in their dissimilarity and subsequent separation. The skulls have been attributed to an elderly toothless male, two mature adult males (one of which owned Skull 5), a young female, and an adolescent of unknown sex.

These five skulls come from individuals that all lived in the same place and all died approximately 1.8 million years ago, possibly within a hundred years of each other. In contrast, previous discoveries in Africa of hominid fossils have often been separated by geography and by time periods of at least 500,000 years.

This latest discovery may mean that some

of these early species found in Africa may also prove to be normal variants of the *H. erectus* species as well.

The paper and the conclusions it drew have attracted recent criticism from other scientists. Some have objected that the differences between *Homo* species do not come only from skull shape, which was the primary focus of the Zurich study. Attention has been drawn to other physiological differences that designate separate species, such as changes in the wrists, ankles and leg bones; length of arm bones; and inner anatomical features, like blood vessel openings in the skull or the bony anatomy of the braincase.

Despite the unavoidable debate that Skull 5 has caused in the field, this remarkable find has been widely recognized as a watershed discovery in the study of evolution. The authors of the *Science* article were quick to point out, however, that thinking of the early *Homo* species as individuals within a single, evolving line of *Homo erectus* would not completely overturn the understanding of human evolution, despite what recent headlines have suggested. The change in thinking about our ancestors "raises a classificatory, but not evolutionary, dilemma," the authors write. ■

# Neurons with Minds of Their Own

BY EMILY ASHBOLT, BIOMEDICAL PHYSICS, 2017

The human nervous system is a beautifully composed symphony of individual pieces playing in perfect order and harmony. Twenty-four hours a day, seven days a week, the brain receives an average of 2,000 bits of information a second that are transmitted to around 1 trillion neurons.

The neuron's job is a formidable one: turning random electrical impulses into things like images or feelings. They look very different from the average body cell, with a dense center containing their nucleus and long branching arms with tiny branching fingers at the end called dendrites. These dendrites are primarily responsible for making connections to surrounding cells and receiving environmental stimuli, which they then transmit as signals to the cell body. Or so it was thought.

Recent research from the Wolfson Institute

for Biomedical Research at University College of London, the MRC Laboratory for Molecular Biology in Cambridge, and the University of North Carolina at Chapel Hill is showing that the dendrites, which read impulses first, are not just merely messengers; they are actually adding their own input and breaking down some essential information before the signals ever reach the more complex networks of the brain. Researchers recorded electrical and optical signals directly from optical dendrites in mice, a finicky operation requiring a great deal of expertise and finesse due to the smallness of both subjects and signals. They found that different images caused different spikes of signals directly corresponding to the properties of the image.

When a person looks at an object, his brain automatically records its orientation in space. Previously, the consensus was that all of

observations of this nature were done deep in the neurons of the brain. However, it seems that at least this particular piece of visual stimulus, which is so important when attempting to climb a flight of stairs or read a clock, actually happens before these signals even get into the brain, within the dendrites.

A senior author of the paper on the study, Professor Michael Häusser, believes that this information is important because, more than anything else, it signals that there are likely other tiny computations happening outside the brain that scientists previously believed occurred within it. "This new property of dendrites adds an important new element to the 'toolkit' for computation in the brain," Häusser commented—raising dendrites from mere neurological "funnels" to tiny computers detecting and crunching essential data. ■

# Natural Armor

## Evolution Knows Best

BY MOLLY TANKERSLEY, ENVIRONMENTAL SCIENCE, 2016



Photo courtesy of Tropical Fish Forum Magazine

**I**t's a textbook prehistoric scene: deep in the waters of a swamp at night, the *Polypterus senegalus* slowly glides its snakelike body forward with serrated dorsal fins cutting through the murky water. It's carnivorous, hunts by smell, and has primitive lungs that allow it to survive on land for hours at a time. Protected from predator attacks by layers of bonelike scales, this fish does not betray its nickname: the "Dinosaur Eel." Except that it isn't an eel at all, and it can be found in lakes, rivers, floodplains, and swamps in Africa to this day.

Nearly the last surviving descendant of the ancient family Polypteridae from the Cretaceous period, the *P. senegalus*, or grey bichir fish, retains many of the primitive characteristics that have helped it survive for 96 million years. The key? Its dynamic scales offer fluid movement and shield-like protection that have captured the attention of scientist Christine Ortiz.

Ortiz, an associate professor in MIT's Department of Materials Science and Engineering, sees the future of body armor in these ancient fish's scales. She is the lead author of an article published in October that explores the complex interaction of layers that once allowed the bichir fish to fend off the pugnacious predators of the dinosaur age. Studying the mechanical characteristics of these scales could reinvent modern body armor—namely the Kevlar vest. Kevlar vests, the primary form of human body armor, protect the torso from bullets and shrapnel with a large ceramic or metal plate in a soft vest. Innovations in the heavily demanded

field of defensive armor are on the horizon as the lightweight and flexible properties of the grey bichir fish's natural armor are incorporated into current technology.

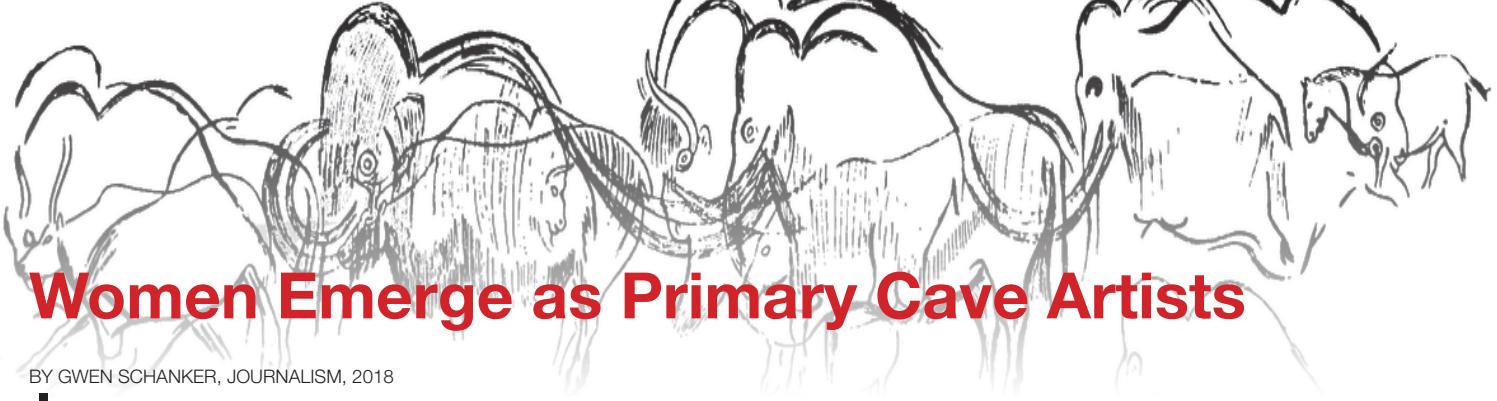
Using scales surgically extracted from an anesthetized grey bichir, Ortiz and her team utilized nanotechnology to research the mechanical properties of ancient fish armor in more depth and detail than ever before. They were able to distinguish four unique layers that make up each scale: ganoine (a type of enamel), dentine, isopodine, and a bone basal plate. The genius in the design shaped by evolution is how each layer has its own reinforcing purpose. The outermost layer, which is relatively thin and stiff, works in combination with the thicker layer below it to absorb and dissipate energy.

More importantly, they contain a revolutionary (or evolutionary, for that matter) failure mechanism: localized fracturing. When enough pressure is applied to the ceramic material in a Kevlar vest, it fractures outwards in radial cracks that threaten to shatter and destroy the structural integrity of the plate. Conversely, the structure of this layer promotes circumferential cracking, which circles the impact site rather than radiating outwards so that the structure remains intact and continues to function as protection. The two innermost layers also dissipate energy and localize fractures. The first of these inner layers serve as added defense and the final layer functions as a skeletal support structure. Combined, each layer fractures in a different pattern, keeping the overall structure of the scale

intact under tremendous amounts of pressure. Not to mention it's also 20 percent lighter than the single ceramic plates that line Kevlar vests.

The research into "natural armor" could inspire highly mobile body armor made of biomimetic structural materials specified to the certain threats like heat, impact, or toxins. Ortiz is expanding her study to include a number of other organisms with incredible defense systems made to face the scalding temperatures of deep-sea hydrothermal vents or endure biochemical toxins. The vast array of organisms with exoskeletons crafted by evolution to withstand and thrive in the harshest of environments may be an indication of the explosion of innovation biomimetic science could harness.

When this quad-layered design could be lighter, more flexible, and capable of handling impact on par with modern-day body armor with sophisticated failure mechanisms, the U.S. Army pays attention. They are funding research that has the potential to outfit firemen, policemen, soldiers, and even athletes, with lighter, more mobile gear best suited to the hazards they face. Blast protection technology from beetles that set off internal cannons to fend off attackers, or transparent armor from sea snails with clear exoskeletons—the applications are vast. Even self-healing armor is no longer too far-fetched, as Ortiz has a long-term goal of pursuing what she calls "living armor." For now, these super suits remain confined to the world of sci-fi and superheroes, but thanks to our hardy friend the dinosaur eel, they may not be far off. ■



## Women Emerge as Primary Cave Artists

BY GWEN SCHANKER, JOURNALISM, 2018

It has long been assumed that men created the Paleolithic art found on cave walls. This is mainly because cave paintings often depict animals or hunting scenes, the actions normally associated with males. Negative hand stencils or positive handprints of varying sizes often accompany these paintings. Previously, the smaller of these handprints were attributed to adolescent boys rather than women; however, research funded by *National Geographic* and conducted by Professor Dean Snow, an emeritus professor and archaeologist at Penn State University, has recently revealed that the majority of handprints found on cave walls may have been women's—a possible indicator that women were the primary cave artists in the Paleolithic era.

Snow was first inspired to conduct this research after talking with John Manning, a British biologist who has researched the use of various hand measurements (length of hand, digit ratio, etc.) to determine sex and other traits, such as sexual preference and susceptibility to heart disease. Following his conversation with Manning, Snow picked up a book on Upper Paleolithic art and examined some of the photographs of handprints inside.

He realized almost immediately that many of these handprints belonged to women, and set out to explore further. What followed was nearly a decade of research, during which Snow examined hundreds of handprints in caves mainly in Spain and southern France. Through extensive exploration, Snow was only able to gain usable data for about 32 handprints. He created algorithms to determine whether those handprints were male or female.

Snow's analysis, published in a recent issue of *American Antiquity*, found that 75 percent of the handprints (or 24 of the 32) belonged to women. Men left 10 percent of the prints, and the remaining 15 percent were found to belong to adolescent boys. To obtain these results, Snow used a two-stage analysis. The first stage was based solely on digit and hand lengths and was about 79 percent successful in determining gender, while the second stage examined ratios between digits and had a 60 percent success rate, namely in distinguishing the handprints of females from those of young boys. Snow's calculations were mainly possible because at the time that the paintings were created, the physical differences between men and women—known as sexual dimorphism—were much more

pronounced than they are today. The ratio of the index finger to the ring finger and the index finger to the little finger were both higher in women than in men, and on average male handprints were much larger than those of females—about 17 mm longer and 10 mm wider.

Snow is satisfied with the results he obtained, but believes that further research and more data could yield a higher success rate. It is also important to note that physical traits differ with geography, so Snow's research is not relevant in areas of the world other than southwestern Europe, and is still too limited even to make generalizations about that region. Nevertheless, his research has proven that it's possible to determine the sex of humans who left handprints in Paleolithic cave sites nearly 40,000 years ago—and, furthermore, his results have challenged the assumption that the majority of those handprints were made by men. While women may not necessarily have been hunting game themselves, they had plenty of interest in the outcome of the hunt, and as a consequence may have been significantly more involved in creating cave art than their male counterparts. ■

## NUScience Explains: Bug Repellents

BY JUSTINE BELINSKY, BIOLOGY, 2018

Have you ever wondered why spraying bug spray on your skin during the summer is the only way to keep bugs away? What is it about bug repellents that prevents mosquitoes, flies, and other insects from enjoying our delicious blood? Essentially, bug repellents interrupt the sensory cues that insects use to locate hosts to feed on. Insects are intensely attracted to lactic acid, carbon dioxide, and octenol, all of which human bodies emit continually via human breath and sweat, which both increase during the heat of the summer months. Basically, bug repellents work the same way as insecticides, in that they deter insects from finding and landing on a surface.

The most common active ingredient in bug repellents is DEET. Bug repellents can range from 4 percent to 100 percent concentration of DEET. Although the exact function of DEET is still unknown to scientists, they theorize that the chemical interrupts insects' reception of chemicals emitted by humans. Additionally, they posit that DEET may stifle the olfactory sensory neurons of insects' antennas, thereby inhibiting feeding. Thus, insects who have lost



Mosquito coils, made of insect-repelling incense, are commonly used in Asia, Africa, and South America. Photo courtesy of Haragayato.

their antenna seem to be unaffected by DEET.

DEET is effective even at low concentrations, and can, in fact, become harmful if the skin absorbs too much. Lotions, foams, and sticks that contain DEET or a similar insect-repelling compound are also useful, and applying bug repellents to clothing can be just as effective

as applying directly to skin. This mode of bug prevention can be much healthier than spraying directly on skin, because DEET has various associated health risks, such as eye irritation, eye pain, skin redness, dermal rash, nausea, and vomiting.

Repellents containing DEET are not the only type of bug repellent that can be effective. There are also some natural compounds that can be used as bug repellents, although they require more frequent application. Some natural herbs and ingredients that are used in natural repellents include lemon, eucalyptus, castor oil, peppermint, lavender, and clove. Homemade bug spray can be useful for people that live in areas with annoying, but ultimately harmless, insects. However, in areas where insects are more likely to carry diseases such as malaria or Lyme disease, DEET-based products are better to use.

Insects are attracted to chemicals humans emit most particularly during the summer. When June rolls around next year, don't forget to lather up—it may save you from pesky bites and, more importantly, exposure to insect-borne diseases. ■

# A Guide to the 2013 Nobel Prizes in Science

BY MATTHEW DEL MASTRO, BIOLOGY, 2017

**E**very year, the eyes of the world are fixed upon Stockholm, Sweden as the winners of the most prestigious awards in science, the Nobel Prizes, are revealed. The 2013 prizes recognize scientific advances in subjects ranging from microscopic cellular pathways to universe-spanning forces, but above all each achievement has facilitated a momentous development in our understanding of the world.

## Nobel Prize in Physics: François Englert and Peter W. Higgs

Although the media frenzy surrounding the Higgs particle began in 2012 after its discovery at the Large Hadron Collider, its history stretches back to 1964 when François Englert and Peter Higgs each independently proposed a groundbreaking concept. These two physicists were working in a dire time for the Standard Model of particle physics, a powerful theory that describes the matter and forces that govern the universe under a single unified model. The theory, however, possessed a glaring flaw: It was only viable if particles had no mass. Clearly this could not be, and such a weakness may have spelled death for the whole model had it not been for the efforts of this year's Nobel Laureates.

They theorized the existence of the Higgs field, an omnipresent force that particles interact with and derive their mass from. If such a field were to exist, its vibrations would manifest themselves in the form of a Higgs Boson particle. This presented a route for physicists to prove the field's existence: finding evidence of the Higgs Boson. Over 40 years later, researchers were finally able to do just that. The discovery set the stage for the two scientists who predicted the particle to earn the most prestigious award in physics. The Nobel Prize recognizes Higgs and Englert not only for correctly theorizing the existence of a new particle, but for providing one of the missing pieces in the explanation of the universe's existence.

## Nobel Prize in Chemistry: Martin Karplus, Arieh Warshel, and Michael Levitt

In recent years, the chemist's toolkit of beakers and Bunsen burners has been expanded to include data chips and processors. This year's Nobel Prize winners in chemistry have been at the forefront of this revolution. Before their work, scientists digitally modeling chemical structures were forced to choose between using a classical physics computer program or one based in quantum physics. Quantum programs had the powerful ability to simulate chemical reactions in action, but the enormous levels



of computing power they required left the analysis of larger structures beyond reach. Classical physics programs could model large molecules, but they were constrained to simulating the structures in a less informative inert state.

In the 1970s, the three Nobel honorees collaborated to bridge this gap. At the time, Martin Karplus was a chemist decidedly focused on quantum programming. However, when Arieh Warshel arrived at Karplus's lab fresh from developing a highly advanced classical physics program, Karplus saw a revolutionary opportunity. The pair built on Warshel's program, applying quantum mechanics to reactive parts of a large molecule while using classical physics to model the rest of the structure. The result was innovative but still restrictive in its capabilities. Arieh Warshel was eager to push the program further, setting his sights on modeling enzymes. He began collaborating with a colleague from his classical physics days, Michael Levitt. Warshel and Levitt spent years refining the program until at last it could model the large size and complex reactions of enzymes. Since then, the methods pioneered by these Laureates have been applied by scientists to understand and improve everything from alternative energy sources to medical treatments. The crucial contributions of these three chemists have earned them their field's highest honor.

## Nobel Prize in Physiology or Medicine: Randy W. Schekman, James E. Rothman, and Thomas C. Südhof

The organization of cellular transport puts even the best-planned railway system to shame. A plethora of products are constantly being shipped to different locations inside and outside the cell, and any misplaced or mistimed deliveries may have disastrous consequences. This year's Physiology/Medicine Nobel Prize honorees revealed how the cell keeps its transport mechanisms under control. Cellular components are transported inside small membranous orbs called vesicles, each of which knows precisely where and when to deliver its important cargo. To understand how, Randy Schekman began studying yeast with malfunctioning transport systems. Schekman identified mutated genes that caused the vesicles to go haywire and pile up in one region of the cell like a multi-lane car accident. The discovery of genes that keep the transport network flowing efficiently was a critical advance in understanding regulation of cellular transport, and it laid the foundation for the work of James Rothman.

Rothman noticed that vesicle target sites possessed specific proteins that were perfectly complementary to proteins on the outside of the vesicles, much like a lock and key. This explained how vesicles only dock exactly where their products are needed. The discovery that some of Schekman's genes coded for Rothman's proteins further demonstrated their vital function. Thomas Südhof elucidated the timing mechanisms for the precise deliveries described by Schekman and Rothman. Südhof worked extensively with neurons, where timing is especially crucial; neurons must release neurotransmitter vesicles only when they receive a signal from another cell. Südhof discovered that calcium ions trigger a cellular reaction culminating in the vesicle's ejection from the cell. This degree of precision is vital; when vesicle transport breaks down it can incite a wide range of defects including diabetes. Rothman, Schekman, and Südhof laid the groundwork for improved understanding and treatment of these diseases and thus earned the honor of a 2013 Nobel Prize. ■

# Professor Oyelaran on Malaria and the Search for a Cure

BY JOSH TIMMONS, BIOLOGY, 2016

**H**ow many single causes can you think of that kill nearly a million people per year?

There aren't many in the 21st century, but malaria is an outlier, and it's been plaguing humanity for 10,000 years. Despite a slew of treatments spanning back to 1820, it remains a mountainous obstacle in the way of global health.

Malaria is a protozoan parasite that infects humans through mosquito transmission. The majority of its victims are young children. Surviving the infection grants only partial immunity. In 2010, an estimated 220 million people were infected, and the economic costs have been put in the ballpark of \$12 billion a year. The flu-like symptoms leave its victims bedridden and unproductive; a country with a sizable portion of its population out of work, or at risk of death, suffers a direct blow to GDP, meaning less resources towards fighting the disease. To top off the list, malaria is a neglected disease. The world's largest pharmaceutical companies have little incentive to devote research dollars towards eradicating third-world diseases, when the next acid-reflux medication will have a greater return on investment.

Medicinal prescriptions have existed for over 100 years, but diseases are dynamic, and treatments need to be so as well. Quinine, the first chemically identified malaria treatment, was extracted from the bark of the cinchona tree in 1820. It was able to effectively treat malaria until the 1920s when newer drugs were created and more widely distributed. Chloroquine became the drug of choice in the '40s when strains of malaria began to exhibit resistance to earlier treatments. The malarial species resistant to Chloroquine went global by the '80s, meaning new forms of treatment had to be developed. Malaria treatments have been created, rendered ineffective by random mutation, and then pushed back by new medications. Within the last decade, strains of malaria have already begun showing resistance to today's drug of choice, Artemisinin. The cycle continues.

Professor Oyindasola Oyelaran here at Northeastern is working in collaboration with Professor Michael Pollastri to create a new drug effective against the particularly virulent and resistant strains of malaria currently thriving in sub-Saharan Africa and southeast Asia. Hanging the wall in Oyelaran's Hurtig office there is a whiteboard covered with organic chemistry, the sort that frightens most undergrads enough to avoid looking at it. The board shows the first stage in synthesis of molecules never before seen. What she and colleagues are trying to do is create a drug effective against *P. falciparum*, the strain currently most dangerous. Their short-term goal is to create a library of 10 to 20 compounds

to be sent away for biological analysis.

So what really underlies drug discovery? Partly intuition, analytics—and maybe some luck.

"The initial screens to find where to start, in coming up with a new drug, is usually just to *in vitro* screen," Oyelaran said. GlaxoSmithKline, the fourth largest pharmaceutical company in the world, published the structures and activity profile for over 13,000 compounds that were found to inhibit growth of the malaria parasite in a public format, with an open invitation for researchers to develop the compounds into drugs. Oyelaran and colleagues then selected one "scaffold," or class, from the published compounds. These potential drugs are far from being malarial cures; they're often poisonous to the body in addition to the parasite. Just a few of the concerns are size, toxicity, and lipophilicity. With drug creation, there are "certain characteristics of compounds that make them drug like, certain functional groups you look for—or make sure are not there," Oyelaran explained. With that being said, the ultimate goal is a working treatment: "In malaria research there is trend towards just finding something that works, and worrying about the mechanism, or how, later."

Oyelaran knows malaria better than most. Born in Nigeria, and having lived there through her high school years, she grew up in an environment where contracting malaria was "not that big of a deal. You get sick, it's not fun, and it's like getting the flu." When asked how many times she's had it, she responded, "You can't

count." While this sounds unheard of, the disease has grown more resistant in the last decade: "Chloroquine doesn't work anymore. Certain drugs that used to work doesn't work anymore. The attitude that I had, my family had, my friends had, doesn't work anymore."

Can she foresee a time in the future where the disease has been eradicated? "Malaria was in the US, but it's not here anymore," she said. "If it's been done here, that's supporting information ... I think prevention is the best tool against Malaria. Malaria has to be attacked from different perspectives. The bed nets are such an important strategy in combating malaria because if you cut transmission, if a mosquito can't find someone with malaria, it won't be transmitted. If you cut the numbers down enough, that's the way to go."

A reference to prevention seems odd coming from an organist chemist researching compounds for active infection, but the real goal is a world where half the population isn't at risk of contracting a deadly parasite. As Oyelaran puts it, the chemistry "is still on the board ... it's crucial to make use of all the tools and resources that are already available to work towards eradicating the disease." ■

*Students interested in learning more about the world of discovering drugs to fight diseases of poverty should look into "Medicinal Chemistry of Tropical Diseases," a course taught by Oyelaran herself.*

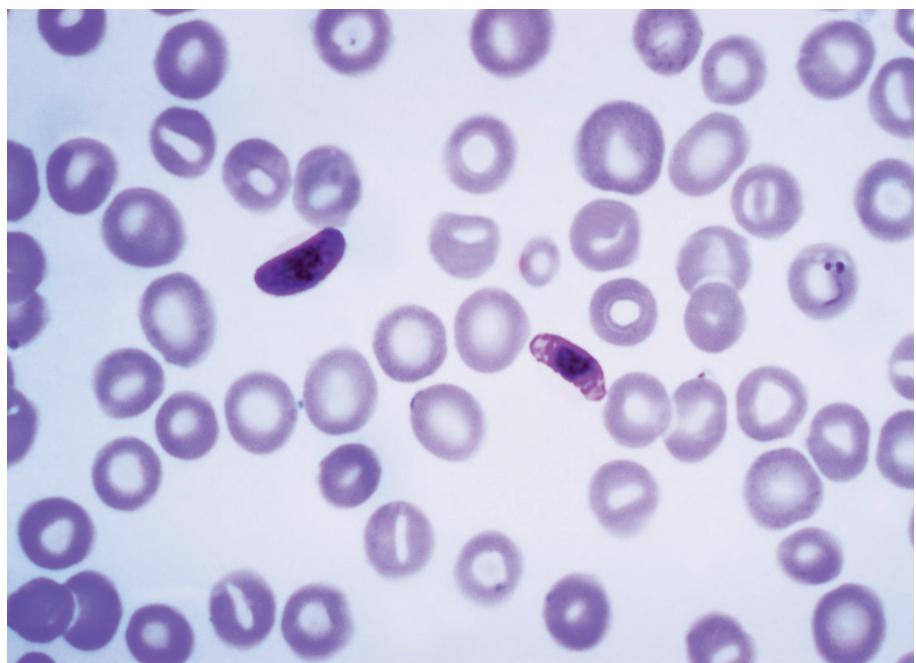


Photo courtesy of CDC/Dr. Mae Melvin.

# Rogue Planet in Our Galactic Neighborhood

BY MATTHEW TYLER, MARINE BIOLOGY & ENVIRONMENTAL SCIENCE, 2017

International astronomers at the University of Hawaii have discovered a free-floating planet in interstellar space that is not orbiting any star. Named PSO J318.5-22, the solitary planet is 80 light years away and not moving towards Earth. Unlike other planets, PSO J318.5-22 does not move in a patterned, consistent manner around a host star.

By happy accident, scientists discovered PSO J318.5-22 while originally searching for brown dwarf stars. Brown dwarf stars, or "failed stars," are celestial bodies with too little mass to fuse Hydrogen-1. In some cases, the distinction between a large gas giant and a

small brown dwarf is blurred, as both contain metallic compounds absent in other stars, and the hottest planets can be warmer than the coolest dwarf stars. These high temperatures, expressed in the form of infrared light, are what allowed PSO J318.5-22 to be detected in searches for brown dwarf stars.

The main basis for classifying a body as a dwarf star or gas giant lies in mass. Brown dwarf stars can fuse deuterium (Hydrogen-2) at 13 Jupiter masses or higher. At only six Jupiter masses, PSO J318.5-22 is not capable of doing so. Team member Dr. Michael Liu confirms that the body is in fact a planet, asserting that "it has

all the characteristics of young planets found around other stars." Testament to its youth, the planet is only 12 million years old—a junior age when viewed relative to the age of Earth. The birth of PSO J318.5-22 is, in fact, temporally closer to modern day. Due to its age and unusual distance from other stars, PSO J318.5-22 will be an exciting planet of study; said co-author Dr. Niall Deacon, it can "provide a wonderful view into the inner workings of gas-giant planets like Jupiter shortly after their birth." Who is to say what knowledge stands to be gained from this lonely planet? ■

# How Genes Shape Your Face

BY JORDYN HANOVER, BEHAVIORAL NEUROSCIENCE, 2017



There are two different types of DNA in the human body: coding and noncoding, or "junk," DNA. It has recently been discovered that junk DNA may help shape the face. Over 4,000 enhancers in mice were shown to be important to facial appearance, and a portion is specifically devoted to turning genes on and off. Scientists have developed techniques to look inside mouse embryos and see which gene-controlled areas develop when certain genes are active.

When these genes were deleted, even in small amounts, facial features of the mice changed significantly. Using CT scans to look at skull shapes, scientists were able to identify subtle differences in the faces of transgenic and unmodified mice, such as skull length and

narrowness of the face. While the differences in facial development were slight, they were a significant discovery. Professor Visel at the Lawrence Berkeley National Laboratory in California stated that the subtle gene switches were able to demonstrate that noncoding DNA is an important part of what the skull looks like. It is important to note that while enhancers were discovered to be important in facial sequences, it is not necessarily known exactly how each one impacts facial structure, but that the enhancers are a critical part of craniofacial development.

One of the main implications of this study was that these gene interaction studies could help scientists understand the genetics behind facial birth defects. The effects of facial birth defects, such as cleft lips or palates, are far-

reaching. Feeding, speech, and breathing are impacted, and extensive surgeries are necessary to change the face to improve the patient's quality of life. With the development of technologies determining which genes and DNA are involved in facial structure, it may be possible to identify some birth defects early. It will be many years before DNA will be used to predict appearance, or parents will be able to genetically alter the appearance of their child, but still, these enhancer genes have been proven to be more important than previously thought. Instead of simply being "junk DNA" they now have shown that they have subtle functions in human development. ■

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