

# NUSCI



Time

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# Letter From the Editor

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A college student's most direct relationship with time is the constant worry that they don't have enough of it. With finals just around the corner, students are feeling the stress of limited time to cram for their exams or finish their assignments. Lack of time can be limiting in a number of ways: it prevents students from getting enough sleep, it makes it difficult to be punctual, and it caused me to overlook a couple of crucial typos in the last issue of NUSci.

Other times in the semester, time can feel like it is dragging on – the lead-up to Thanksgiving break feels particularly long. And still other times, like during summer vacation, the days rush along much faster than desired. Through all of that, the weeks and months continue at a constant rate, and important moments happen. But it's not always obvious what those important moments are until there's time to stop and look back.

In the 26th issue of NUSci, we tackle the concept of time at one of the busiest points in the semester. This theme provides several opportunities. It allows us to acknowledge our writers who set hours aside to contribute each semester, both to our print publication and to our website, by writing about topics that matter to them. In this issue, you'll find a description of how stigma against mental illness has evolved; a discussion of the emerging profession of genetic counseling; and an analysis of nomophobia, or the fear of being without a cell phone, which many students can likely relate to. You can also explore a thought-provoking piece on the concept of time itself and an entertaining discussion of the predictive accuracy of *Back to the Future Part II*.

This issue also examines how NUSci itself has changed over time, with a special feature that revisits topics analyzed by our writers in earlier issues. Personalized medicine is discussed from a modern perspective. The clean water crisis is addressed from the point of view of students involved in Northeastern's chapter of GlobeMed, a nationwide organization looking to fight the clean water crisis in Uganda. This feature article not only demonstrates the progress that's been made in these areas of innovation over the years, but also demonstrates the progress NUSci itself has made without ever straying far from our roots.

Whether you did so to procrastinate, to inspire or to fight off boredom, thank you for picking up the newest issue of NUSci Magazine. I hope the reading experience is enjoyable, educational, or in some other way worth your time.

Sincerely,

Gwendolyn Schanker  
Editor in Chief



## Northeastern University's Student Science Magazine

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PHOTOGRAPHY BY NAOMI STAPLETON

# Scientific Breakthroughs:

## a 2015 summary

BY GWENDOLYN SCHANKER, JOURNALISM AND BIOLOGY, 2018

JAN

Physicists present the first evidence of quantum entanglement – the state in which multiple particles act in uniform – on a silicon chip, potentially allowing for more powerful encryption technology.

FEB

Researchers successfully map the epigenome, which controls when certain cells turn on and off in the human body and which may help scientists better understand individuals' risk of disease.

MAR

The Medical Research Council in the U.K. announces a clinical trial that will use genetically modified bone marrow stem cells to treat lung cancer. The trial will enroll 56 patients and is slated to begin in early 2016.

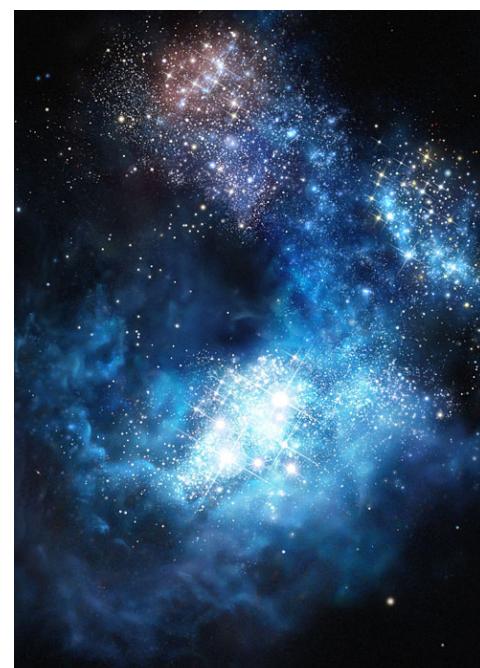
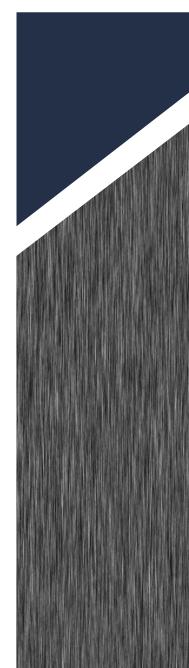
APR

A group of Chinese scientists from Sun Yat-sen University report the world's first genetic modification of a human embryo using CRISPR/Cas9 technology, sparking controversy and ethical debate between scientists around the globe.

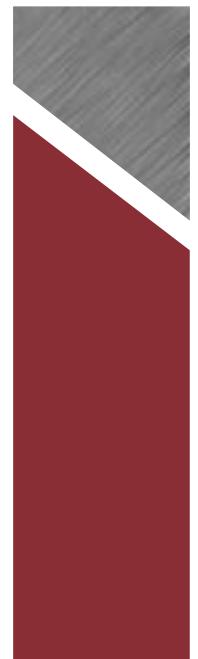
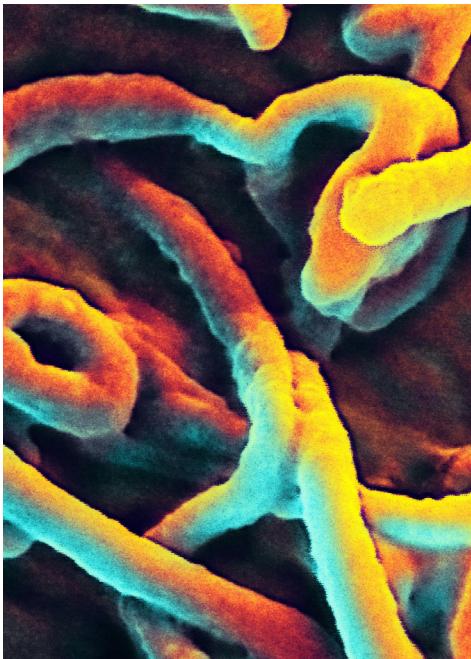
JUN

Astronomers discover evidence of the first generation of stars using the European Southern Observatory's Very Large Telescope. The study also identified the brightest galaxy observed in history, which the researchers labeled CR7.

MAY



PHOTOGRAPHY FROM FLICKR CREATIVE COMMONS, WIKIMEDIA, AND NAOMI STAPLETON



**JUL** An experimental Ebola vaccine shows encouraging results in an initial clinical trial in Guinea. The study was led through a partnership between groups including the World Health Organization and Doctors Without Borders.

**AUG** A research team at the Mayo Clinic in Florida discovers a method of allowing cancer cells to be converted back to benign cells through the restoration of normal levels of microRNA, triggering production of the PLEKHA7 protein.

**SEP** A research team in Sweden creates artificial neurons that can mimic cell-to-cell communication in human brain cells using an enzyme-based biosensor, creating potential for such technology to be used to restore damaged nerve cells.

**NOV** A research team at MIT uses electrically driven shockwaves to desalinate water and make it usable, a new process referred to as shock electrodialysis that does not require a membrane to separate salt particles.

**OCT** Researchers from Flinders University develop a polymer that is capable of removing mercury from contaminated water. The polymer is made from sulfur and limonene, a product found mainly in orange peels.

**DEC** A new study published in *Nature* suggests that rates of global carbon dioxide emission slowed in 2014 and are expected to decline in 2015, due in large part to slowed growth in China.

FROM THE HORIZONS OF  
**EDEN**  
TO THE DEPTHS OF  
**ATLANTIS**

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

**Time.** A word deeply rooted in philosophy, linguistics, physics, biology, and mathematics. The classical view of time consists of three parts: past, present, and future. The past being all events that have happened, the future being all events that will happen, and the present being all events that are happening now. But what is now? Since the past has always just happened, and the present is always just about to happen, the present must be very small. Trying to pinpoint the present requires the smallest measurement we can think of – the infinitesimal.

In order for something to be considered infinitesimal, it needs to be small enough that it cannot be measured by any means. And since our reality is entirely conceived by the perceptions we create off of our sensations, the means must be ourselves. Now ask yourself...what are you currently experiencing? A fragment of thought may have been created in that brief moment, but you certainly did not view it as discrete. You viewed it as continuous. If humans fail to perceive the present, how does categorizing time into three distinct groups actually help determine the fundamental nature of time? For example, take Newtonian physics. If it weren't for this framework, our buildings and bridges would collapse. However, Newtonian physics falls apart when you reach the extremes of both the infinite and the infinitesimal. This is where General Relativity comes in. Even though Newtonian Physics is incredibly pragmatic, it is not inherently true at a fundamental level.

Imagine a trillion little pixels projected onto a dome. All of them are white. You're in the center of the dome and you have your hand on what appears to be a joystick. Out of the corner of your eye you see a flash of blue. Your instincts cause you to swivel the chair to the blue with a flick of your wrist. After it recedes, a geometric line is formed across a group of the pixels. It transforms into a circle and divides one million times over. On the opposite side of the dome a deep red starts rippling outwards. It eventually touches the circles, which start billowing and forming new shapes. The shapes start rippling themselves, spewing colors of the rainbow in sporadic fashion.

Soon the dome is enveloped in new shapes and colors in patterns you don't understand. You try to understand everything going on around you...but there is just noise. The pattern repeats itself. Again. And again. And again. Eventually you start to create patterns off of this data, patterns that are predictable. These patterns are events. Every new formation of stimuli causes you to be aware of these formations. But there's too many events and you can't keep track of the everything you are sensing. You start to lose focus.

You've shortcircuited yourself. But let's think this through. Currently, all of your processing has been done at one level. What happens when we add another level of processing? With this extra level, patterns that occur frequently can be calculated while our energy is simultaneously spent on identifying newer, novel patterns. The extra level communicates with the original level, allowing us to create more abstract representations – or perceptions – of the pixels in the dome. Suddenly you regain focus.

It appears that nothing has changed. A more complex object is created in front of your eyes. The ground rumbles. You make out two sharp objects connected to a larger object. The object grows larger. You are reminded of the scar on your right abdomen, created after a fight with a similar looking object. You swivel the chair away from danger. Soon, new more complex objects start arising. You need more levels.

So what have these levels of processing done? They have allowed you – as a living organism – to prioritize events that are the most important to you at any given point in time. If your brain is filtering stimuli optimally, it will ignore inconsequential patterns at the lowest of these levels. They will never reach the upper echelon of processing. So what are the implications?

Some theories in modern neuroscience and cognition state that the brain is a very complex filtering algorithm. A simple example of this lies in Gestalt

principles, a psychological framework that attempts to group visual stimuli through patterns like movement and similar color. When our brain abstracts over a group of stimuli and deems it unimportant, it may never reach what humans refer to as "consciousness." If our brain acts like a ginormous tree structure, taking an infinite amount of stimuli and filtering it down to more abstract, understandable forms, then our current notions and preconceptions of time fall by the wayside. Since our reality is purely comprised of these events, or abstract forms of arbitrary sensations, the structure of time is entirely contingent upon how our brain creates and uses these abstract forms, and nothing else.

A simple deep sea creature survives by staying in the dark and feeding off of bacteria in these waters. If it is in an area with too much light, it will not be able to feed off of these bacteria and it will risk death by being seen by predators. Due to these variables, it has developed a very simple circuit that detects light. If the light passes a certain threshold, the circuit triggers, sending the creature 180 degrees. What is time to a creature like this?

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## Co-op Spotlight

# Navy Marine Mammal Program

BY MEGAN PINAIRE, PSYCHOLOGY, 2018

This summer, I did a four-month co-op with the United States Navy Marine Mammal program. I worked at the Navy base in Point Loma, California. Just across the bay from scenic Coronado island are the ocean water pens where I worked with some of the most intelligent animals that inhabit our oceans: dolphins and sea lions.

Most of the time, when I tell people I worked with the Navy sea lions and dolphins, they respond with something along the lines of, "those are the animals the Navy sends to disable mines right?" or the even more shocking, "those are the animals the Navy sends to plant mines right?"

Needless to say, this is not what Navy dolphins and sea lions are used for. In fact, one commonly used system is a sea lion system called MK 5 object recovery. This is the Navy system that is completely declassified. These sea lions are trained to dive to depths up to and exceeding 800 feet to find and mark debris from Navy machinery tests that occur over the ocean. Debris falls into the ocean, and the MK 5 sea lions mark it so that it can be retrieved.

The process is completely harmless to the sea lions. In fact, they seem to enjoy the work they do. First, the trainer will send the sea lion into the water to search for the target, and when the sea lion finds the target, it will return and signal a positive by touching a paddle on the side of the boat with its nose. The trainer will proceed to hold out a contraption called a bite plate. This bite plate is a neoprene-covered device that the sea lion holds in its mouth. The sea lion will swim down, using its exquisite low-light vision to re-find the target, and forcefully attach the bite plate to the target. The sea lion will tug back on the bite plate to ensure that it is secured on the target before swimming back to the boat for a fish reward. After the target is marked, trainers and Navy personnel can pull the target up onto the boat, and the mission is accomplished.

A normal day for me on co-op began at 6:00 a.m. on the Space and Naval Warfare Systems Command base (SPAWAR) where I would prepare the diets of each animal on the crew I was on for that rotation. My crew for the first half of the summer was made up of the breeding dolphins, including pregnant females and new moms

and calves. My crew for the second half of the summer was made up of sea lion pups. These are the young sea lions who are learning their manners, how to go into open water, and the beginnings of how their future systems will work. After diet preparation, I would drive to the Naval Mine and Anti-Submarine Warfare Command Complex (NMAWC), where the dolphin and sea lion pens were located. For the next five hours or so, I would interact with the trainers and animals on the crew I was assigned to. I would always get to watch training sessions, and I often participated and interacted with the animals myself. I was on the water all day, since the pens were floating ocean pens. Often, when I worked with sea lions, I was on a boat in the bay for much of this time as well.

While as an intern I was someone who did much of the grunt work around the Navy bases, I gained so much actual training knowledge and experience. The opportunity to actually participate in and, at times, run a training session was invaluable and inspiring. Moreover, I developed personal relationships with the trainers I worked with, learned all of their

stories and asked any questions I could possibly think of about the animals, the training, etc.

The way the Navy and other training facilities such as SeaWorld train their animals is through operant conditioning, specifically positive reinforcement. Under this process, the animals are rewarded (reinforced) for performing a behavior correctly. However, if the behavior is not performed or is performed incorrectly, there is no punishment. Instead, there is simply no reinforcement. Through this, the animal learns what it gets reinforced for, and thus the reinforced behaviors become more frequent.

Of course, training a dolphin calf or a sea lion pup is not as simple as it sounds. Trainers need a lot of experience and teamwork to train a successful systems animal for the Navy. Between the trainer and the animal, there must be respect, understanding, and patience.

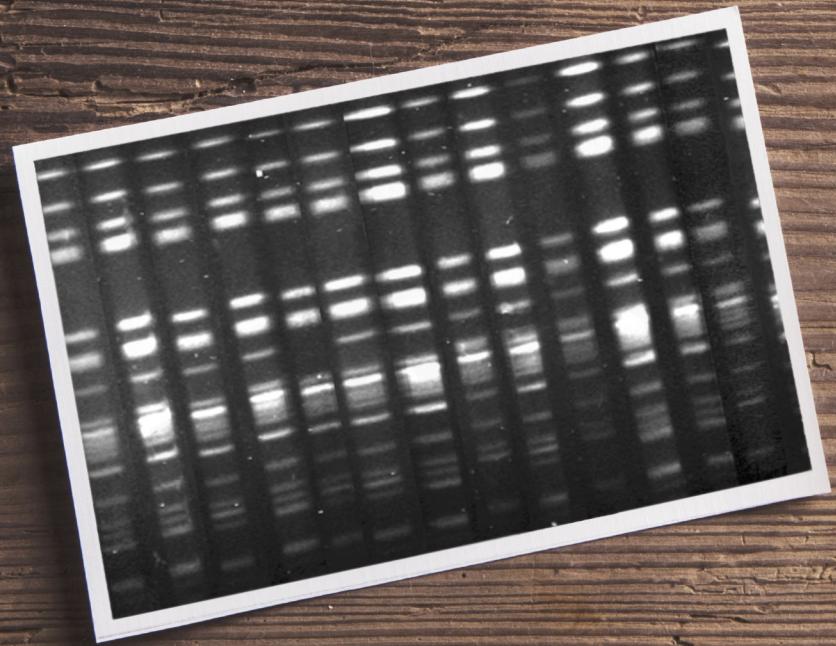
The trainers at the Navy Marine Mammal Program taught me all about operant conditioning in addition to the process of beginning the training of a dolphin calf or

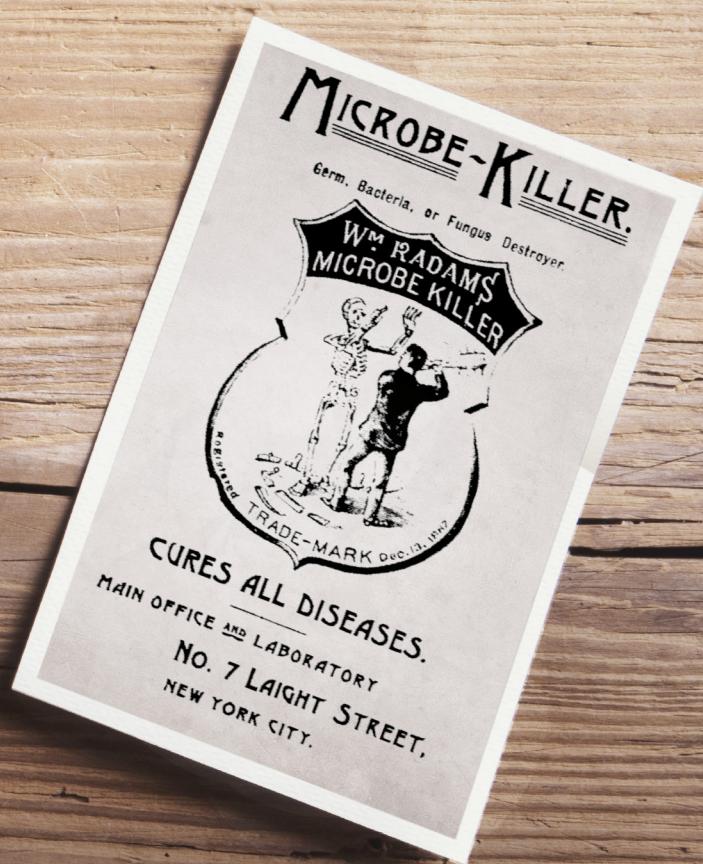
sea lion pup all the way through training for complex behaviors needed for the Navy work that they do.

Living in California for the whole summer also made this co-op that much cooler. I lived an easy fifteen-minute drive west to the beach, SeaWorld, Old Town San Diego, and a short drive east to great hiking mountains. I jumped off an ocean cliff with my fellow interns and watched the sunset on many occasions over the ocean from the view of these cliffs, appropriately named Sunset Cliffs.

I brought so much home with me from my co-op in San Diego. I left California with more knowledge about marine mammals and the process of training than I thought I could learn in one summer. I met one of my best friends during the internship, someone I never would have met had I not taken the chance on a co-op in a state I had never been to, let alone lived in for an extended period of time. All in all, it was an experience that I never imagined I would have before coming to Northeastern. The opportunity to create my own co-op made my first co-op experience one that I will never forget.







# Throwback

# Quenching the Need for Clean Water

In the spring of 2013, an article was published in *NUSci* Issue 14 explaining how Northeastern's very own chapter of GlobeMed was helping to fight the clean water crisis in Uganda. A lot has happened since then, and the work done by the students of GlobeMed, as well as by other organizations and social enterprises, has made a palpable impact on those that lack clean water sources.

BY STEPHANIE WASIUK, BIOLOGY, 2017

The clean water crisis isn't news to anyone – about 1 in 9 people on the planet find themselves without access to a clean water source. They must drink water that potentially contains bacteria that can cause major health issues or even death. An estimated 3.4 million people die each year due to a contaminated-water-related health problem.

GlobeMed is a nationwide organization which pairs each of its chapters with a grassroots cause in a developing country. Northeastern's chapter is paired with Kitovu Mobile Ltd., which is an organization out of Uganda that provides education to people in villages on why clean water is so important to overall health as well as ways to access clean water and maintain good hygiene.

Every summer, Northeastern's chapter sends a team of four students on a month-long Grassroots Onsite Work (GROW) trip. The students chosen to go on this trip travel to the Kyanamukaaka sub county in Uganda and conduct field research projects to survey and interview those who have been touched by Kitovu. The students measure how well-equipped the villagers are to practice good hygiene and get clean water, as well as the impact Kitovu has had on their village over time.

GlobeMed works to raise \$7,000 every year through fundraising efforts around campus and grant writing. After the students on the GROW trip conduct their research in the villages, they decide where to allocate these funds based on the level of need in the villages and what resources they will benefit from the most. Examples of projects funded by this money include shallow wells, pit latrines, and tip taps, which are water jugs that help conserve water by limiting the flow for activities like hand washing.

Two students, Chris Lin, a third-year biochemistry major, and Sam Lovett-Perkins, a third-year nursing major, were part of the GROW trip last summer. While reflecting on his experiences, Lin expressed the importance of the work's education aspect. He felt that there was some degree of resistance from those in the villages because they were being taught by foreigners about clean water practices that had never been a part of their lives before. He remembered that the women would say their husbands were stubborn and that is why they could not adopt these practices. Lin believed this was an excellent opportunity for the GlobeMed team to explain why these practices are so important to overall health.

Lovett-Perkins described how one woman from the village told the GlobeMed team that five to six children used to die each month, but now that they had access to clean water and better hygiene methods, only one child maximum might die in a month. He thought that the most important aspect of the program was that the GROW students were surveying those in the villages about what they wanted, not what the organization thought would be best for them. This project is really a grassroots effort and "more of a response, rather than a mission," described Lovett-Perkins.

Lin remembered one village that was located three hours away from the nearest clean water source. The time spent traveling to far away sources such as this reduces time that can be allotted to other work, such as food gathering or preparation, and can also be dangerous for women and children, who are often the ones collecting water. Lin hopes that GlobeMed can assist Kitovu in their efforts to support these villagers and that eventually there will be enough resources for Kitovu to operate independently.

Another approach to the clean water initiative is through social enterprises like Jibu. Jibu is run by a father-son pair out of Colorado, and uses a franchising method to bring a "business-in-a-box" to areas that need both clean water and opportunities for income generating activities. Those who participate in the franchise model are given filtering systems, which allow them to bottle water, and retail space in which to sell the purified water. Jibu also gives the franchise owners support if there are problems down the road.

The father-son pair realize that the continuing support given to those who operate the franchises is part of what makes Jibu different than organizations whose sole purpose is to give aid. Over \$1 billion in aid was wasted over the past 20 years because water projects failed or because aid money was used to donate a certain product, but not to help maintain or repair it. This is why Jibu has a business model approach to help sustain the initiative.

The water crisis is unfortunately still a major problem that requires much more work and innovation. If you are interested in getting involved, GlobeMed holds fundraising events on campus throughout the year and meets every Monday night from 7-8 pm in 104 West Village G. The GlobeMed team can be contacted at [northeastern@globemed.org](mailto:northeastern@globemed.org). To learn more about Jibu, visit [www.jibuco.com](http://www.jibuco.com).



# Mystery Killer to Sea Star Wasting Disease: Found

In Issue 17, *NUSci* reported on sea star wasting disease, stating that sea stars along the Pacific rocky intertidal zone were dying en masse due to an unknown killer. When the issue was first published in 2013, much about the disease was still unknown. Scientists were unsure as to how far the disease would continue to spread, how many organisms it would impact, and what effects lowered populations of sea stars would have on intertidal ecosystems.

BY REBECCA LYNKEY, ENVIRONMENTAL SCIENCE, 2019

In my senior year of high school when outbreaks of the disease were first occurring, I conducted a research project to develop monitoring methods for the spread of the disease in *Pisaster ochraceus* species. Now, three years later, the topic has once again become relevant. Scientists have identified the mystery killer and are now observing dramatic shifts in community ecology due to rapid declines in sea star populations.

In 2014, researchers at the University of Nebraska published a paper linking sea star wasting syndrome to a pathogen known as densovirus. This pathogen is from the same group that causes gastrointestinal problems in unvaccinated dogs. The researchers present evidence that the “cause of the disease is transmissible from disease-affected animals to apparently healthy individuals, that the disease-causing agent is a virus-sized microorganism, and that the best candidate viral taxon, the sea star-associated densovirus (SSaDV), is in greater abundance in diseased than in healthy sea stars.”

Scientists have also linked the rapid succession of the sea star wasting disease to climate change. Seasonal increases in water temperatures place stress on marine organisms, making them more susceptible to diseases transmitted through the water column.

Total population loss has been devastating along the west coast. Species including *Solaster dawsoni* (morning sun star), *Pisaster ochraceus* (ochre/purple star), and *Pycnopodia helianthoides* (sunflower star) have the highest mortality rates associated with the disease. Thus far, sea star wasting disease has affected a total of 19 species from British Columbia to Baja California, and some areas have seen local population declines as great as 90 percent. These massive population losses are caused primarily from the rapid progression of the disease. Symptoms are first observed when a sea star experiences lesions in one arm. Once the lesions turn white, the sea star will shed the diseased arm. Under normal circumstances, a healthy sea star could simply regrow the lost arm, but a sea star infected with this disease does not have the energy or capacity to do so. Instead, sea star wasting disease will eventually kill affected organisms as their bodies become more and more fragmented from disintegration.



When the disease first hit in early 2013, researchers placed most of their focus on identifying the pathogen causing it and documenting its scope. But now that the pace of decline has slowed and the pathogen causing the disease has been discovered, scientists have switched their attention. “We’re more focused on assessing the [ecological] consequences and looking at signs of recovery,” says Pete Raimondi, a marine ecologist at the University of California, Santa Cruz, in an interview with National Geographic.

Sea stars are keystone predators – meaning that they have a disproportionately large effect on the environment in which they live in relative to their overall abundance. As a result, the magnitude of death in sea star populations along the North American Pacific coastline has caused a massive shift in community ecology. Urchins and mussels are becoming more dominant without the presence of sea stars to keep their numbers in check. If their population remains in decline, scientists are unsure of how dramatic the effects will be on intertidal communities along the West Coast of North America.

However, hope remains for sea stars. Ben Miner of Washington State University and his team do not expect to see local extinctions of sea star populations. Miner explains to National Geographic that, “if a population is doing well in one location, it has the potential to produce millions of offspring, which can be dispersed widely.” Although it will take a few years to discern whether or not the young sea stars will contribute to salvaging populations, there is huge potential for recovery in local populations of sea stars.

*PNAS* (2014). DOI: 10.1073/pnas.1416625111.



# How Close Are We to Personalized Medicine?

In 2012, current *NUSci* editor Andrew Bloy wrote an article exploring the readiness of the United States' current healthcare system for future advances in personalized medical technology. Three years later, *NUSci* writer Margaret Downs provides an update on how far we have come.

BY MARGARET DOWNS, BIOLOGY, 2019

What if we were able to tailor medical care to each individual, using data gathered from genomic sequences? Not very long ago, this seemed like something out of science fiction. Societal, technological, and practical hindrances made the idea of personalized medicine a distant one. While some of these hindrances still exist, we may be closer to making personalized medicine a reality, and a widely available one at that.

Many people were concerned that the arrival of personalized medicine could adversely affect people's ability to have health insurance, which in turn would impact the industry as a whole. If patients (and by extension, their insurance companies) were aware that they were genetically predisposed to a certain condition, the insurance companies could deny coverage. A major change has happened in this regard in the form of the Affordable Care Act; as of January 2014, insurance companies can no longer deny patients coverage based on preexisting conditions. This concern, then, has been all but eliminated.

Genome sequencing technology has also come a long way. Next-generation sequencing (NGS) technologies first appeared about ten years ago. While old methods allowed the sequencing of the human genome to take place, researchers quickly realized that they were neither time- nor cost-efficient. In 2004, the National Human Genome Resource Institute began a program to lower the cost of sequencing a genome to \$1000 within the decade. Development of standard procedure is still required, but costs are dropping rapidly and sequencing processes are becoming far more efficient. Another practice that has only recently become available is that of genome editing using CRISPR technology. Scientists have applied this practice to mice, removing defective genes and curing individuals of genetic disorders, and in 2014 two Japanese researchers predicted that doctors would be able to alter the genomes of human embryos using CRISPR "in the immediate future." The combination of

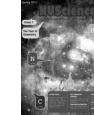
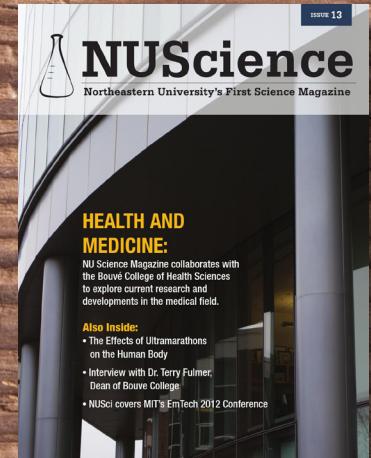
genome sequencing and genome editing technology could take personalized medicine in a previously unanticipated direction.

Currently, the major barrier to the practicality of personalized medicine is an insufficient number of genetic counselors. Based on projections by the Bureau of Labor Statistics, there will likely be about 3,000 genetic counselors employed in the United States by 2022. While the job is experiencing growth at a significantly greater rate than most other occupations, this still leaves too few genetic counselors for the U.S. The job currently requires a master's degree in genetic counseling, for which there are only 34 accredited programs in the country. It is possible that general practitioners could be trained as genetic counselors, but this would need to occur while still ensuring that the physicians were able to provide the level of care necessary for patients. Modified training can take time to become the norm, and while it is not impossible, we cannot guarantee that it will happen quickly.

Personalized medicine may not be exactly around the corner, but we are certainly more technologically equipped to make it a reality than we ever have been. Some barriers to it still exist, while we have all but dispensed with others. In all areas, though, we have made progress, making the future of personalized medicine a bright one.

*Reproductive Biology and Endocrinology* (2014).

DOI: 10.1186/1477-7827-12-108.



# Looking for a Cure: Using Gene Therapy to Treat Blindness

*Blindness can be caused by a multitude of factors including infection, injury, chemical poisoning, vitamin deficiencies, various diseases, and inherited conditions. Of these inherited conditions, there are hundreds of different genetic defects that can lead to blindness in humans. With all of these factors, treating blindness is a complicated and daunting task for researchers, but some studies have suggested that hope lies in the field of gene therapy.*

BY JUSTINE BELINSKY, BEHAVIORAL NEUROSCIENCE, 2018

In Issue 18 of NUSci, Gwen Schanker wrote about a trial gene therapy study that treated patients with choroideremia, which causes degeneration of retinal cells that are involved in light-sensing activity. Gene therapy involves correcting dysfunctional proteins that lead to disease by introducing DNA into the body that contains genes for these proteins of interest. The DNA is delivered to the body using a virus that has been modified to contain the gene. Once the virus has entered the mammal host cell, it inserts its genetic material into the cell, which can begin to produce the proteins that the genes encode. In this way, scientists can replace malfunctioning proteins that cause disease.

The process of viral delivery is easier in the eye than other parts of the body for two reasons. First, the eye is not connected to the body's immune system as completely as other organs, reducing the chance of an immune attack on the foreign virus. Additionally, the eye is extremely easy to access for surgeons since it is located external to any body cavities. Various studies have shown progress in gene therapy for preventing blindness, including recent work from a collaboration between the University of Pennsylvania and the University of Florida.

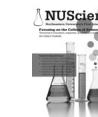
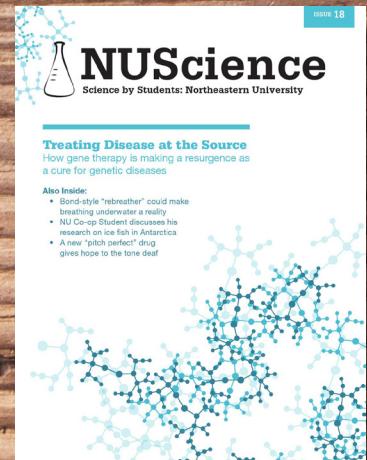
The research from these investigators focused on a common genetic disease that causes degeneration of the retina, called retinitis pigmentosa, which starts to be seen within the first ten years of life. The researchers used a canine model for this disease, and found that by augmenting the mutant RPGR gene responsible for disease by viral gene delivery into the eye, they could stop the progress of retinal degeneration, even at mid- and late-stage disease stages. Importantly, their work differed from previous experiments which typically injected DNA into animals before the disease onset occurred. These recent findings have more clinical significance since most gene therapy on humans would be implemented after the disease onset.

There are also many research groups that have even tested gene therapy on human subjects who have vision impairments caused by genetic diseases. The choroideremia study mentioned earlier is one of such studies. People with choroideremia experience vision problems starting as teenagers, and eventually can become blind by middle age. The researchers found that they were able to improve the vision of all six patients, and had initiated a second trial on three more patients. Since then, another team has initiated a study at the University of Alberta in Canada. This study, led by Dr. Ian MacDonald, was also conducted on six people who have choroideremia.

Performing gene therapy procedures is no small feat. The procedure involves detaching the retina and injecting the viral vector using a very thin needle into the back of the eye. One of the six participants of the Canadian study, Ken Ross, reported to News Medical that he is pleased with the improvement he has experienced since his surgery. Before the surgery, he had only five percent vision, but now is able to distinguish shapes and colors much more easily.

The researchers from all of these studies hope that their work will be able to extend to other vision degenerative diseases besides retinitis pigmentosa and choroideremia. However, the challenge lies in identifying the exact protein dysfunction and the mutant genes that underlie each condition. Despite these obstacles, for people like Ken Ross who have experienced progressive vision loss their whole life, gene therapy may be the only light they can see for their future.

PNAS (2015). DOI: 10.1073/pnas.1509914112.



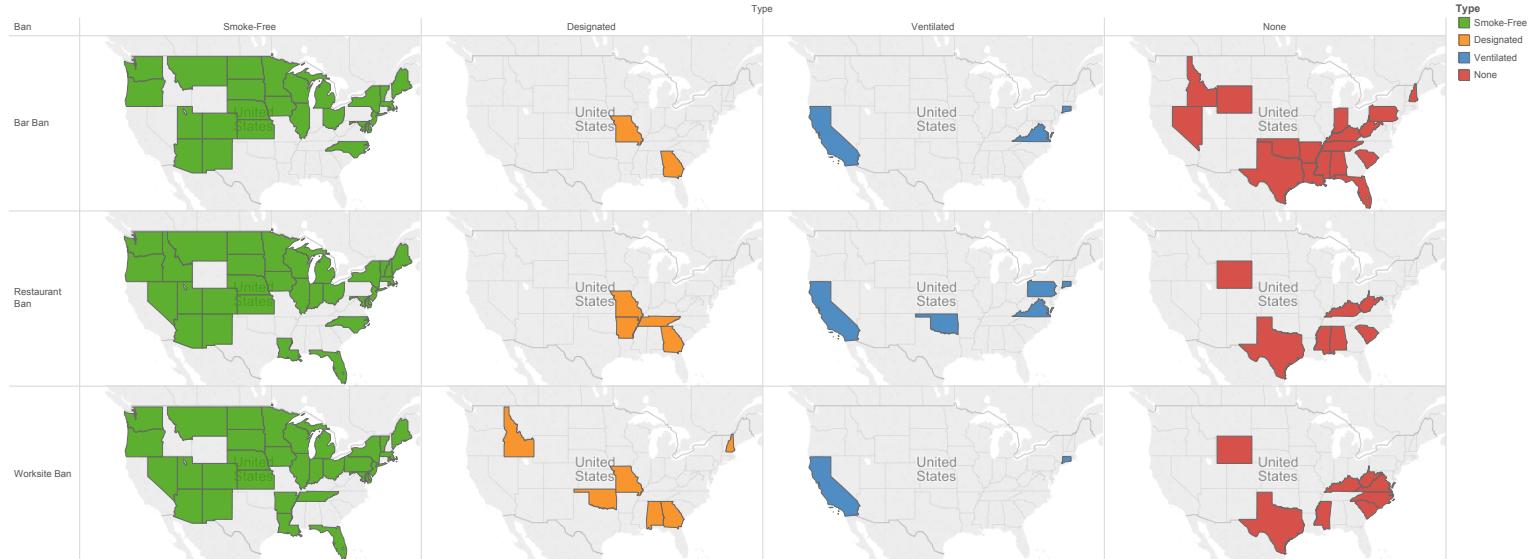
# A Positive Trend

DATA AND VIZUALIZATION BY DIANA MOREL

With ever-present social media and 24 hour news, there aren't many large, slow-moving trends that will reach public awareness. Two weeks of following the presidential race will show just how short our collective attention span is. One day it's ISIS, the next it's Donald Trump mocking a reporter's disability. And when trends are discussed it's usually a trend that we wish didn't exist, like global warming or growing obesity. This Numbers section is about a positive trend: declines in smoking rates.

## STATE BY STATE

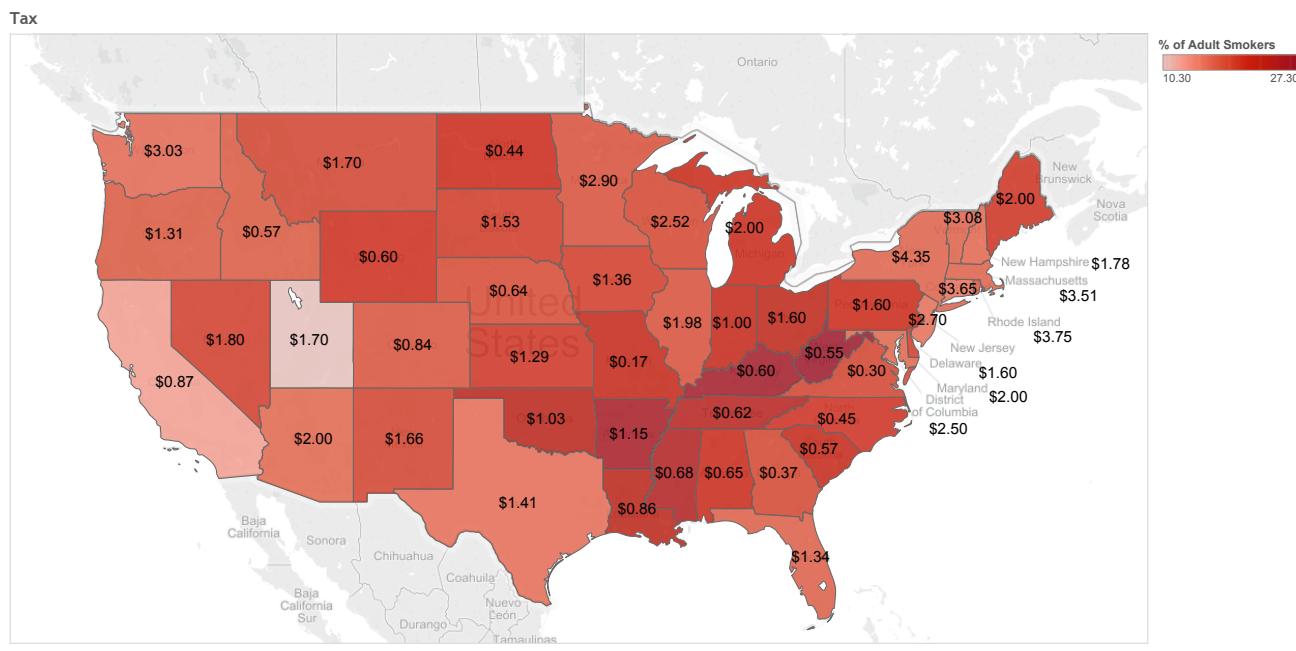
Prevalence of Smoking Bans



Map based on Longitude (generated) and Latitude (generated) broken down by Type vs. Ban. Color shows details about Type. Details are shown for State.

The success in America's declining smoking rate is attributed by many experts to "universal interventions," or policies that affect everyone, rather than a select group. Per pack taxes are one such example. Smoking bans are another.

# NATIONAL

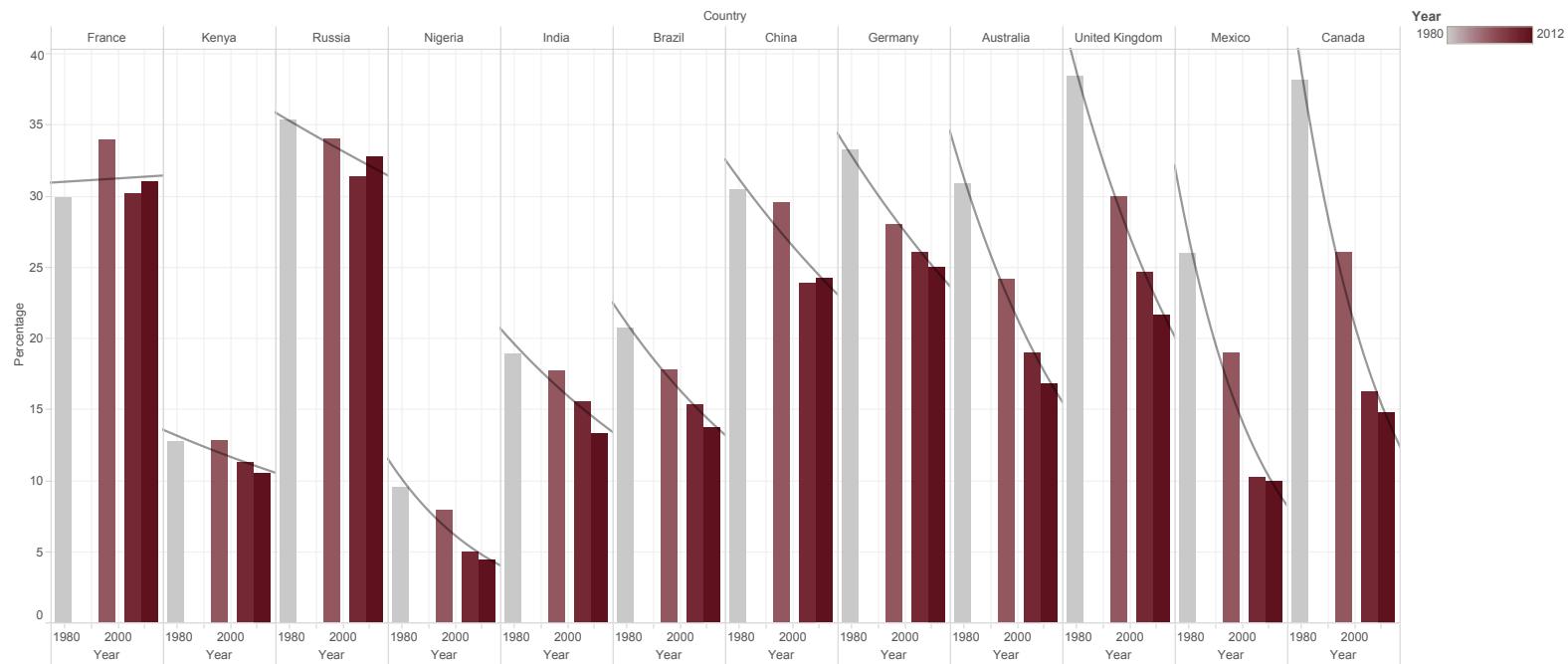


Map based on Longitude (generated) and Latitude (generated). Color shows sum of Adult Smoking Rate. The marks are labeled by sum of Cigarette Tax per Pack. Details are shown for State.

Smoking is nearly half as prevalent among our generation as it was just one generation ago. The decline in youth smoking prevalence stands out the most among across the board drops. Whether the trend will continue is unknown but a growing number of university campus smoking bans, like the one Northeastern adopted in 2013, may continue to drive a decline. Interestingly, it's been suggested that further declines in cigarette smoking will be due to increased use of e-cigs, considered a safer alternative to combustable cigarettes.

# INTERNATIONAL

International Trends - Least Progressive



The plot of sum of Value for Year broken down by Country. Color shows details about Year.

The smoking rate in most countries has also declined. Bars above show percentage of country citizens that smoke in the years 1980, 1996, 2006, 2012. While several countries like France and Russia have seen relatively little decline in their smoking rates, other countries like Mexico and Canada have managed to cut their rates in half. Countries are arranged from least decline to greatest.

*Building with*



# With humankind's insatiable drive to engineer, it's inevitable that synthetic biology will grow.

BY JOSHUA TIMMONS, BIOLOGY, 2017

There's a frizzy-haired architect hunched over his keyboard at a workstation diagonal from my own in Snell. He has a colorful program open with a map of a city in two dimensions; streets, buildings, and decorations are represented by a pallet of orthogonal shapes, a gridwork of architectural complexity. To a human 100 years ago, this architectural plan would look like nonsense, but to the architect, it's a plan. It's a design. It's a mental projection into the future, a careful theoretical arrangement of matter to benefit other humans. It's engineering. It might never be, but regardless, this undergraduate has the power to come to the library one afternoon and effortlessly construct a giant theoretical arrangement of atoms so others might theoretically benefit.

The second floor was designed this way. A design firm drew up a mock for how the floor could be transformed from its original banal space—that fewer and fewer will remember—into its present creative space. Outside the library the Interdisciplinary Science & Engineering Complex has emerged and is being mounted with windows that researchers will one day look through between experiments. The atrium's staircase was designed to "maximize serendipitous meetings." The atrium's floor space was made to double as a dinner space for 200. What was once a desolate black-tar parking lot was transformed with ingenuity and capital into a usable and functional space for other humans to benefit from.

From our buildings with their unnatural climates to our phones with planet-wide connectivity, everything we interact with is the byproduct of human invention and engineering. Look around and try to find something that wasn't engineered for human existence. It won't be easy. Surprisingly, in this world full of objects designed with intention, planning, and purpose, we've made ourselves the outliers. For now.

## Concentric Circles

What separates 2015 from 1985, a time when many of our parents were the age we are today? Computers are the most obvious. Pocket-sized computers with screens connect us and let us call other people to come and drive us around or buy us groceries. Thirty years ago information was distributed through a hierarchical system of newspapers, radio, and TV channels. Today, we are each wirelessly connected to one another by cell phone in an invisible nervous system. Our experiences and thoughts are more easily transmittable than ever before, and this reality is owed entirely to the research and development of electrical engineering and software engineering that made these tools possible.

It's a generalized view that works for all emergent, widespread technologies—and therefore history. There was the Bronze Age, the Iron Age and much later the industrial revolution. The microcomputer revolution defined the last generation.

**“So is it worthwhile to wonder what might define our generation and the next?”**

One way to look at technology is by the increasing level of complexity required for its engineering. There's a reason the Bronze Age came before the Iron Age. Iron is more difficult to extract from ore, and required a more technical and nuanced approach to smelt. Bronze could be melted in a pot over fire, while iron required a special furnace. The Iron Age was first built on the metallurgy knowledge from the Bronze Age.

Chemistry was, until relatively recently, strictly a science. In the mid-nineteenth century chemistry moved beyond its original vitalism—the theory that all organic chemicals must come from a living organism—with the creation of urea from inorganic compounds. The idea and realization that organic molecules can be made, rather than isolated, spread like wildfire, leading to the creation of synthetic chemicals never before seen in nature. Not unlike the architect with his programmatic design of a city layout, chemists learned to design.

Synthetic organic chemistry, with its emphasis on systematically interacting molecules, led to a greater understanding of chemical principles and laid the groundwork for the rich ability to produce novel chemicals and pathways

that humans have today. It's notable that scientists were creating new reactions and molecules years before a holistic understanding of chemistry existed. It was the side by side existence of goal oriented synthetic chemistry with analytical chemistry that advanced the entire field.

An abstraction level higher... biology is chemistry. Biology is the sum product of an inconceivable number of chemical interactions through time. Membranes, enzymes, receptors, and all the other constituents of a cell—life—are defined by their chemical structures.

The newly emerging field, the theorized concentric circle of our century, is synthetic biology. Synthetic biology allows scientists to take an applied approach to biology with purpose, and design organisms to fulfill novel applications in all the areas that old approaches have thus far failed. Rather than simply providing something to observe and analyze, synthetic biology aims to engineer cells, bringing life into the circle of useful substrates.

## This Century's Circle

Physicist Freeman Dyson made the unabashed prediction in his essay, “Our Biotech Future,” that “the domestication of biotechnology will dominate our lives during the next fifty years at least as much as the domestication of computers dominated our lives during the previous fifty years.”

Imagine a future in which diabetics no longer need to inject themselves with insulin. Bacteria with recombinant DNA for insulin produce the drug they must inject. It's only one step further to engineer a strain that lives in the microbiome of the gut and intelligently produces insulin after induction with external UV light. Similarly, it might be possible to create gut bacteria that sense high levels of interferon or other inflammatory signaling molecules, like those elevated in patients with Crohn's disease, and then mount an adaptive response by internally induced drug production. If this seems far-fetched, consider that cells are already doing it continuously. Life for bacteria, like humans, is a series of internal responses to external stimuli.

It's not just the insides of humans that might be augmented. Cells themselves might receive upgrades as engineers realize how to harness their metabolic activity. One emergent area of research is looking at hijacking the machinery of cells, like yeast used in breweries, to make pharmaceuticals. Long and complex (or infeasible) chemical syntheses could be exported to the genomes of yeast. The entire multi-step production

processes, that today requires multimillion dollar facilities, could be written out in DNA and put into yeast, effectively making them small and self-replicating drug factories. Already, Dr. Christina Smolke and her team at Stanford have managed to recreate the entire metabolic pathway for opioid synthesis in yeast by the introduction of 23 non-native enzymes.

## "A pharmacy is a modern day shire for the religion of synthetic organic chemistry."

It's predicted that synthetic biology will leave no industry untouched. When Dr. George Church, a Harvard professor of genetics, appeared on The Colbert Report to promote his new book Regenesis, he brought along a tiny piece of paper in his front pocket. Bringing it out he explained, to the skeptical host, that he had over 70 billion copies of his book, written in the genomic converted binary, all on a space less than the size of a period. Despite meaning it as a one-off joke, several companies immediately reached out to Church about using DNA as a storage system; his lab is now working to scale the approach.

## iGEM

In the middle of this emerging field is international Genetically Engineered Machine (iGEM), an undergraduate synthetic biology competition where university teams compete to build their own organism. By the novel arrangement of genomic parts, teams construct organisms that have never existed before for purposes that lack adequate existing solutions. These projects, like the synthetic biology itself, have covered a range of topics. Cells that recognize, bind to, and selectively destroy cancer cells (Penn, 2012). Peptides that attract insects to reduce their harm of food crops (NCTU Formosa, 2014). Bacteria with altered properties that would survive on Venus (Stanford, 2012). Because of newly affordable synthesizable DNA, many of these iGEM projects are completely novel.

In the same way that inorganic molecular precursors in synthetic chemistry can be combined to create complex natural or synthetic molecules for application, synthetic biology will be comprised of well-understood genomic components. It's these parts that iGEM teams compete to create and then submit. Gene promoters, coding

sequences, and terminators all make up the growing molecular toolbox available to synthetic biologists.

Last year was Northeastern's first with an iGEM team. We went all out trying to demonstrate the production capabilities by making a therapeutic antibody in the nucleus on microalgae (Northeastern, 2015). Inspired by the Ebola Outbreak of 2014, and the unavailability of a life-saving antibody cocktail, ZMapp, we envisioned using microalgae as a relatively cheap and rapidly scalable production platform. While we did not produce an antibody within the summer timeframe, we submitted parts that might make antibody production possible. We also attended the competition in the Hynes Convention Center and met other undergraduates from the world over, all of whom are working towards making synthetic biology's long-term potential future a near-term reality.

Whether Dyson's prediction holds true is to be determined. Regardless, it only takes one look around to realize humankind's propensity to engineer. It might be foolhardy to underestimate humankind's ingenuity.

*Science* (2015). DOI: 10.1126/science.aac9373.



# GENETIC COUNSELING:

## When Sci-Fi Doesn't Feel Like Fiction Anymore

BY JEN OBRIGEWITCH, BIOLOGY, 2017

**"It's in my genes"** is a phrase that is commonly used to describe physical and personality traits that a child shares with his or her parents. But for the general public, there was no proof of which genes were actually present in the genomes of both the child and parent until recently. No human genome in its entirety was even mapped until the conclusion of the Human Genome Project, a task 13 years in the making that concluded in April 2003.

After the project's completion, rapid advances in the field of genomics led to the identification of many genes that contribute to common diseases such as cancer and diabetes. But even after the completion of the first human genome, each new human genome that was sequenced cost \$10 million, a price few could afford.

In 2004, a program was created to award grants to scientists and companies that brought down the price of human sequencing to \$10,000. Once the next generation of sequencing technology entered the market in 2007, the price plummeted even more drastically and now sits below \$5,000 for a detailed, fully sequenced genome. The goal is to reach \$1,000, a number scientists are very close to reaching.

What does this mean for everyday folks who just want to know what their genetic code says about their risk of developing diabetes like Grandma did? Well, for \$199 and a test tube full of your saliva, a company called 23andMe will analyze your DNA and output data such as your ancestral lineage, a wellness report about how your DNA affects things such as caffeine consumption effects and lactose intolerance, whether you carry genetic variants for certain diseases, and the likelihood of you and your child having certain physical traits such as brown eyes or curly hair.

But with every new scientific discovery comes hesitation about how having this information might affect your choices. If you find out that you're a carrier for sickle cell anemia, do you still want children who might develop the disease? If your genetic code says that you're highly likely to develop cancer, are you going to stop doing anything that might further increase your risk? How do you handle having this information?

A whole new profession has also come out of the new availability of genetic testing: genetic counselors, people whose job it is to walk you through the process of sequencing your genome and interpreting the results. There is even a national society of genetic counselors has been established to supply the increasing demand for such support. Some counselors have medical

degrees and transfer from practicing medicine to interpreting genetic results, but recently most active genetic counselors have obtained a Master of Science in genetic counseling from an accredited university program. The counselors are a great resource for helping those electing to have their genome sequenced decide what to do with the information they've gained, and how to cope with its implications. The counselor will even help you decide which test results you'd like to see and which you choose to keep veiled. As more tests become commonplace for diseases such as Huntington's and Alzheimer's, these counselors are trained on how to handle explaining these test results and ensuring they are understood correctly.



**“for \$199 and a test tube full of your saliva, a company called 23andMe will analyze your DNA...”**

The development of full human genome sequencing and its increasing availability to common people has also led to ethical debates about whether it is right for knowledge of your or your fetus's genetic code to alter your lifestyle decisions. If you were planning on having children until you found out that there was a chance that child would develop Huntington's disease, would you still have children? If in the early stages of pregnancy you found out there was a high chance of your child being born with a physical or mental defect, would you choose to abort the fetus? Should parents be able to select what eye or hair color their children will likely have, as if it were a science fiction movie? Knowledge comes with responsibility, and when new areas of knowledge are being exposed, lines can seem blurry. With the steadily increasing knowledge and accessibility of genetic counselors, the interpretation of the new information can be monitored so that a situation similar to the plot of a science fiction movie does not become reality.

**Cost of DNA Sequencing**  
The Full Human Genome





# Stepping Through Stigma

Despite modern understanding & advances, a strong stigma remains for depression & other mental illnesses.

BY NAOMI STAPLETON, PSYCHOLOGY, 2016

**Over centuries, there has been progress** in mental health both strikingly forwards and shockingly backwards. Depression (or as it was known in ancient times, melancholia) has a particularly turbulent history of treatment and perception.

Melancholia was initially attributed to demonic possession in many civilizations. Hippocrates, hailed as “The Father of Modern Medicine,” was the first to consider both mental and physical illness as medically treatable, but even he attributed melancholia to an imbalance of the “humors,” particularly an excess of black bile. Later, Roman and Greek doctors interpreted the disorder as both biological and psychological, but sought to cure it with such methods as donkey milk, gymnastics, massage and baths. Surprisingly, the Age of Enlightenment brought even more misunderstanding and mistreatment to depression; thinkers during the 18th century saw melancholia as a permanent and irreversible weakness, which yielded mass ostracization and imprisonment of the mentally ill. The depressed were left to devastating squalor at best.

The introduction of neurology in the late 18th century framed a dramatic reinterpretation of melancholia as an affective disorder. William

Cullen attempted to find a neurological cause, describing melancholia as “partial insanity” caused by inactivity in the nervous system. Alternatively, Sigmund Freud cited psychological imbalances and unconscious conflicts as the underlying factors of depression, facilitating the still ongoing debate of the merits of psychodynamic versus cognitive and biological approaches to mental illness.

This scientific debate about the nature of depression has fueled years of productive psychological and pharmaceutical research. In the last hundred years, great strides have been made in the treatment of depression. Patients now have access to effective and personalized combinations of medication, psychotherapy, transcranial magnetic stimulation, cognitive behavioral therapy, and electric shock treatment (ECT). Contrary to popular understanding, ECT is an effective and humane last-resort treatment. First introduced in 1937, the approach yields a rapid remission of symptoms in more than 80 percent of patients, though there is a minor risk of confusion and memory loss.

Specialized medicine along with targeted treatment plans are becoming widely accessible, with 80 percent of patients showing an improvement within four to six weeks. If the rate of recent research continues, treatment methods for depression will continue to become more and more refined for the approximately 14 million American adults who suffer from depression each year (6.7 percent of the US population). Depression is highly comorbid with other disorders and diseases, like cancer (25 percent of cancer patients have depression), strokes (10-27 percent), and HIV (33 percent). More than two-thirds of the 30,000 suicides committed in the U.S. each year are attributed to depression. Despite these distressing statistics, only a third of the 14 million sufferers in the U.S. seek treatment. This isn’t a depression-specific problem: a quarter of the world’s population have a mental illness, yet as many as 75 percent of those people do not receive treatment.



Many cite stigma around mental illness as the main reason for this major discrepancy. A recent cross-cultural study review from King's College London explained, “When seeking help for mental disorders, people reported feeling not only stigmatized by society but branded by their own hand, with a deep sense of personal shame.”

Other barriers to treatment included a fear of public disclosure as well as that classic self-diagnosis: not crazy.”

According to Dr. Ramin Mojtabai’s 2007 study, the American public has relatively positive attitudes regarding seeking treatment for mental health issues. The study shows that between 1990 and 2003 there were improvements in willingness and comfort to seek help. However, our perception of the effectiveness of treatment hasn’t changed: “In [1990 and 2003], the public estimated that more than half of people with an emotional problem who see a professional are helped and that less than half of those who do not obtain professional help recover,” says Mojtabai. The situation is clearly the reverse: not enough people are being helped even though successful treatment is highly likely. We are lucky to be living in a time where we can more comfortably acknowledge and discuss these issues, but there is still work to be done in terms of awareness and education. The stigma around mental illness must catch up with science.

# High Protein Electronics

## Students make biological nanowires

BY DAVID ROSENBERG, CHEMICAL ENGINEERING, 2020

**This summer, a team of students** at the University of Kent in England developed a method for fabricating nanowires using bacteria. The project, presented at the International Genetically Engineered Machines Jamboree this September, aims to increase sustainability in nanowire manufacturing. It was inspired by recent research in functional amyloid, a class of self-assembling protein structures.

Amyloid proteins contain beta sheets, zigzagging amino acid chains linked in a grid by hydrogen bonds, and can be stacked in a column or spiral to form strongly bound fibers. When a free amyloid unit comes into contact with a fiber, it can alter its shape and join the stack. This structure is physically and chemically very stable, making amyloid an attractive material because of its strength and ability to self-assemble.

Kent students combined DNA from a yeast amyloid protein, a peptide signal, and a cytochrome protein. The yeast DNA encodes the self-polymerizing portion of a protein involved in transcription which deactivates itself by combining into strands. The peptide signal is part of *E. coli*'s own amyloid synthesis and causes the cell to assemble the amyloid on its surface before releasing it. A cytochrome from the electron transport chain attached to the amyloid protein attracts a current conducting heme molecule. The resulting strands could potentially replace expensive and less sustainable metal wires in electronics and research.

Typically, a nanowire is a material with two dimensions approaching the wavelength of its electrons. At this scale, quantum effects that have very little impact on larger wires become predominant. Combined with a very high surface area to volume ratio, this gives nanowires unique properties and challenges. Various types of nanowires have been prepared for efficient energy storage, molecule detection, and research. They have also been prepared to carry electricity in nanoscale circuits for computer chips, disk drives, and biological implants or transparent, flexible circuits and solar cells.

The wires developed at Kent are 5-10 nanometers in diameter and can resist temperatures up to 98°C, overcoming a major drawback of silver nanowires, although the ability of the wires to conduct electricity remains uncertain. The biological nature of the wires gives them unique advantages. "If you use the bacterial systems, then you can imagine that you can feed the bacteria with a waste product . . . and also the nanowire you are producing is a protein-based nanowire," said Dr. Wei-Feng Xue, an advisor on the project and a chemical biology professor at the University of Kent.

Nanowire-forming microbes could also potentially be used in living circuits and modified to export electricity generated through normal respiration, creating self-assembling, self-repairing electronics that generate their own power from the environment. In the nearer future, they could be used in a biological battery known as a microbial fuel cell (MFC).

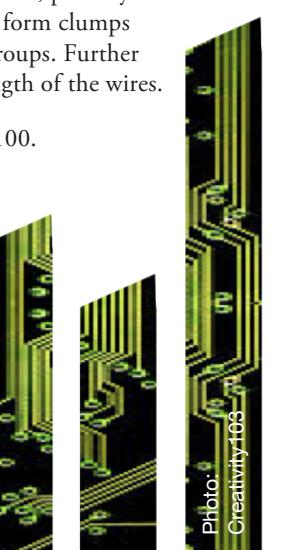
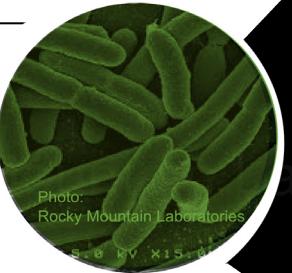
'Conventional' nanowire manufacturing includes a wide array of techniques adapted to different wire shapes and compositions. Lithography and templating typically involve depositing molten or gaseous material on a polymer which is later removed. Alternately, wires can be chemically synthesized. A catalyst can be used to draw dissolved ions out of solution or to attract gaseous particles. Electrodeposition builds wires directly from an electrolyte solution by applying a current that converts ions to solid metal on microscopic anodes.

Microbial synthesis would replace unsustainable polymers used in lithographic techniques and templating with organic molecules and without the high economic and environmental expense of depositing gaseous metals, which requires operation in a vacuum at temperatures close to 500 °C. It would also replace expensive and often toxic materials used as catalysts or solvents.

This development builds on work published in the *Proceedings of the National Academy of Sciences* in which the same protein fragment was modified to bind gold nanoparticles and produced in *E. coli*. Amyloid fibers assembled outside the cell from small fragments were coated with gold and silver. The paper mentions a simultaneous study of metal-plated DNA wires, which are less stable but easy to modify and adapt. The method developed at Kent eliminates the need for outside modification and expensive nanoparticles while generating much thinner wires.

Purely organic wires won't be ready for production any time soon, however. Resistance measured over cultures of the modified bacteria was highly erratic and much greater than that of purely metallic or metal-coated nanowires, possibly in part due to a tendency of released fibers to form clumps that kept electrons from reaching the heme groups. Further research will also be needed to control the length of the wires.

*PNAS* (2003). DOI: 10.1073/pnas.0431081100.



# Great Scott!

## How accurately *Back to the Future Part II* Predicted the World we Live In

BY KATIE HUDSON, MARINE BIOLOGY, 2017

**On Wednesday October 21, 2015,** Marty McFly arrived from the distant past of 1985 to a world of flying cars, hoverboards, cyborgs, and dehydrated Pizza Hut pizza. The film Back to the Future Part II was released in 1989 as a sequel to the 1985 film, Back to the Future, and starred Michael J. Fox and Christopher Lloyd as a pair of time-travelers who are constantly trying to undo their actions that catastrophically alter past, future, and alternate timelines.

When the movie was being produced, writer and producer Bob Gale and director Robert Zemecki did not try to accurately predict the future. Instead, they strove to create a future that “audiences would want to visit.” While they missed iPhones, other smartphones, and social media, both Gale and Zemecki were still able to get some things right despite this approach to creating the film.

True hoverboards do not exist like the one that McFly sports throughout the film, but hoverboards with wheels have become an increasingly popular method of transportation, especially in cities and on college campuses. These hoverboards, or more accurately, balance boards, are manufactured by major companies like Segway and have become so popular in such a short time that cities and campuses have been scrambling to regulate them.

The Future McFly house was home to many of these future technologies that were either spot-on or total flops. Among these technologies, Skype makes an appearance in the scene in which Future McFly is led into a scam that eventually results in him being fired by his boss in his living room moments later. There is a shout-out to the NSA in the same moment when it is revealed that Future McFly’s boss has been

monitoring the call. Email, texting, and Facebook message replaced the multitude of fax machines scattered throughout the house as today’s fax machines are few and far between. In addition, Gale and Zemecki predicted the rise of phone/internet/cable mogul AT&T within the same scene.

The filmmakers also predicted the existence of Google Glass. The actual product, however, was not as popular or essential to future life as the movie made it out to be. Smart televisions were also present – Marty McFly Jr. used a voice-activated television similar to many of today’s smart televisions to watch nine programs at once – although whether it was connected to the internet (if the internet even existed in this alternate 2015 world), is still unknown.

To mark the anniversary of McFly’s trip to the future, not only did film fanatics take to social media, but corporations also took advantage of the event. Nike revealed that it has a patent pending on a self-lacing shoe, like those seen in the film. Several Kickstarter campaigns went live promising real, hovering hoverboards like those used in the film. Pepsi released a limited batch of Pepsi Perfect, a drink seen in the film costing close to \$50 a bottle. The limited edition bottles, which originally went for \$20.15, sold out within minutes. Bottles like those used in the film can now go for as much as \$300.

Despite the filmmakers’ desires to create a world they would like to see instead of one based on 1989 technology like polaroid cameras and the first Mac computer, Gale and Zemecki were able to accurately predict some variations of today’s technology. Now if only they were right about the Chicago Cubs sweeping this year’s World Series...

# Separation Anxiety:

## PHONE EDITION

BY HEATHER OFFERMANN, BEHAVIORAL NEUROSCIENCE, 2018

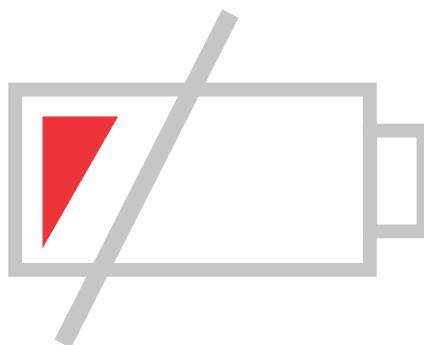
**In a generation accustomed to frequent technological advances** and expanding media networks, smartphones appear to be becoming more essential than our basic human necessities. We are beyond the point of returning to the days of conducting research from those big, bulky encyclopedias, and making payphone calls using the spare change in our pockets. Phones are everywhere, primarily stuck in our hands as we are walking the streets, or even at social gatherings.

Our psychological dependence on smartphones has become quite overwhelming to some, as more researchers are studying the emotional connection formed with our handheld devices. From this connection, it's safe to assume that most of us have acquired nomophobia, which is the fear of being without a mobile phone. It sounds ludicrous, but anxieties can develop from damaging a phone, losing a phone, or even thinking of being without a phone. Understanding nomophobia is an up-and-coming topic among psychologists, though most of the research conducted has been qualitative data based on surveys and observations.

Not surprisingly, roughly 83 percent of smartphone users are between the ages of 18 and 29. This statistic represents the staggering climb of dependence formed between young adults (primarily college students) and their phones. In July of 2015, researchers at Iowa State University conducted a study on nomophobia by extensively interviewing nine carefully selected college students aged 19-24 about their phone use and dependence.

It's easy to see why this research is relevant to our generation, but why is it important? Understanding the dependencies on technology allows us to better adopt the integration of phones into educational settings, and to become aware of an issue that society tends to sweep under the rug and see as an accepted part of everyday life. Nomophobia is an international phenomenon that merits further research. Technology has evolved to the point that, as the researchers state, "not having a smartphone is an aberration from the norm."

To draw relevant and accurate conclusions from the study, the researchers only interviewed respondents who met the following criteria: (1) the student owned a smartphone for more than a year, (2) they were able to readily access the internet through the smartphone, (3) they spent more than an hour using the smartphone, and (4) they had a higher phone



dependence score compared to other students who were surveyed, based on the Test of Mobile Phone Dependence questionnaire.

Through a series of detailed interviews, the students were asked questions such as, "For what purposes do you usually use your smartphone?" and "How would you feel if you left your smartphone at home and had to spend the day without it?" Their individual responses were recorded verbatim, and were categorized into common themes occurring among the nine students. The findings were not mind-blowingly significant, but they provide insight into the multiple dimensions of nomophobia and the reasons why we rely so heavily on our phones. The first finding was that people were afraid of not being able to communicate, which included the feelings of anxiety related to not being able to be contacted by other people. The students were also afraid of losing connectedness with the world, including feeling disconnected from one's identity and "second life" on social media. Additionally, not being able to access information was stress inducing, seeing that Googling information is a form of instant gratification for many. And lastly, nomophobia is defined by giving up the convenience of searching the web, or even the accessibility of taking out your phone during awkward situations to appear occupied.

The participants also related to how ensured they felt when checking their smartphone for notifications.

Humans have begun to be satisfied by the strangest of events, such as the screen lighting up with a notification or a fully charged phone battery. Relationships have not only formed between people and their social media accounts, but also with their phone as an object.

Although we have the knowledge of the world at our fingertips, we mustn't confuse this privilege by moving towards complete dependence. Our phones contain all of the information accumulated from our daily lives: pictures, notes, Google searches, and most importantly, messages from our friends and family. It's no wonder that we have formed a connection with our phones; they tend to identify with who we are, while conveniently keeping a record of our personal information. Even though nomophobia isn't a life threatening or serious condition, shining light on the phenomenon can help us become more aware of phone dependence during the ever-changing interrelations between humans and technology.

# REVOLUTIONIZING HIV



BY OLOLADE AKINGBADE, BEHAVIORAL NEUROSCIENCE, 2018

**One of the largest public health crises** facing our nation is HIV/AIDS. HIV, Human immunodeficiency virus, is characterized by a progressive failure of the immune system, and can lead to acquired immunodeficiency syndrome, or AIDS. There is no current effective cure. As a global pandemic, 35.3 million people live with HIV globally, with 68 percent of these cases in Sub-Saharan Africa. Domestically, the United States served as the center of the 1980s AIDS epidemic, first observed in young metropolitan LGBTQ populations. Currently 1.2 million people in the United States live with HIV, and 1 in 8 are unaware of their infection. Rates of diagnosis are higher in Black Americans, consisting of 43 percent of all cases in the U.S.

HIV's profound social implications and prevalence are underscored by complex biological characteristics. The disease spreads by lentivirus transmission, when a single-stranded RNA virus is reverse transcribed into double-stranded DNA and integrated into a cell's nucleus. HIV transmits between parties through bodily fluids and affects white blood cells in the immune system, specifically CD4+ T cells.

Pathologically, HIV begins with an acute infection characterized by flu-like symptoms. As the disease transitions into clinical latency, HIV reproduces at low levels, often presenting itself asymptotically. Proper treatment in this stage is definitive in determining disease progression: with proper HIV treatment, latency can continue for decades to limited ill effect, while without treatment, the disease progresses. AIDS develops once CD4 immune cell count is low - fewer than 200 cells/mm<sup>3</sup> - and opportunistic infections thrive.

Although HIV is more easily diagnosable and treatable than it was in decades past, its chronic nature calls for costly disease management. Today's drugs work by

reducing viral load, the amount of HIV in the blood. Antiretroviral Therapy (ART), prevent growth of the HIV disease, usually through reverse transcriptase inhibition or inhibition of various steps in the HIV life cycle. Viral load daily treatments are hard to keep routinely and get access to, especially for low income. Long-acting HIV management shots are more easily administered than daily pills, allowing for consistency in treatment regime. Such regime could change healthcare for patients with HIV.

**"it's chronic  
nature calls for  
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management."**

A study conducted by ViiV Healthcare in collaboration with Johnson and Johnson, GSK, and Pfizer, entitled the Long-Acting Antiretroviral Treatment Enabling study, shows promise in the area of long-acting HIV treatment. A shot once every 1 to 2 months was found to be as effective as daily pill treatment for HIV. Now injection of two drugs that suppress HIV and AIDS every 4 and 8 weeks works just as well as 3- a-day pill treatment. As a Phase 2b study, these findings are pivotal to treatment efficacy and are crucial in defining dose range for patients.

The trial's monthly treatments centered on the drugs Cabotegravir and Rilpivirine, created by Viiv and Johnson and Johnson respectively. Rilpivirine blocks the reverse transcription process and can be administered via injection. Cabotegravir works against infection, blocking integrase, an HIV enzyme that integrates viral DNA

into human cell DNA. As these treatment options progress into phase 3 testing on larger patient groups, John Pottage, the chief medical officer for ViiV, expects U.S Food and Drug Administration approval soon after. As of now, ViiV has found the long-term treatment to be as effective as daily pills, achieving a 94 percent and 95 percent viral suppression rate successfully.

"When you think about people with HIV, you're going to treat them for a lifetime, and you have to treat them with a combination of drugs," Pottage said in an interview with Newsweek. "Monotherapy is not enough. There are patients who get tired of taking daily pills, or have lifestyles that don't lend themselves to that."

Apart from the time and convenience benefit of long-term drug treatment, this new regime could also lessen the financial challenges of HIV maintenance. Lifetime cost of care can total hundreds of thousands, averaging \$14,000-20,000 per year. Close to 30 percent of those living with HIV and AIDS in the US have the disease under control through a medical treatment plan. More than 50 percent of those living with HIV/AIDS have costs covered by Medicaid and Medicare, but often times is not covered unless an individual has AIDS or is disabled by HIV.

"Going from many pills a day – like 10, 20 pills a day – to now one pill, to now one injection every two months is I think a huge medical technical achievement," said Johnson & Johnson Pharmaceutical Chairman Paul Stoffels in an interview with Bloomberg News. "Long-acting injectable drug formulations may offer another option for HIV maintenance therapy." The developers are looking to bring long-lasting injection treatment to the market by 2019, which could positively change health outcomes and the economic issues behind effective HIV treatment.

# HIV, AIDS, and How PrEP Can Help

BY SHANNON JONES, MARINE BIOLOGY, 2016

**In Issue 12**, Hessu Kim reported on a new method for the prevention of HIV/AIDS. Since 2011, the method discussed has come into general practice. For our retrospective issue, all of us at NUSci thought that updating this article would be worthwhile.

Human Immunodeficiency Virus, or HIV, is a virus that gradually affect the T cells in the body. Normally, T cells perform many functions: helping to make antibodies, recruiting white blood cells, defending against microbial, inflammatory and infectious activity, and coordinating the overall immune responses. When HIV is present in a person's system, the immune system progressively loses the ability to fight diseases and infections. Over time, this leads to a point where so many T cells have been destroyed that the person is diagnosed with Acquired Immunodeficiency Syndrome, or AIDS. Meanwhile, massive research efforts are being poured into prevention, delaying disease progression, and curing the disease altogether.

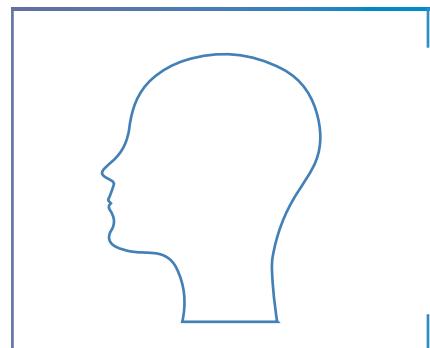
Though there is no cure for AIDS, a person can stall the progression from HIV to AIDS. After the initial infection, a person experiences mild symptoms, if any, as the virus remains dormant for a period of time, with low amounts of virus present in the blood. Many researchers consider stalling during this "undetectable" period the best way to delay the progression into AIDS.

In 2011, NUSci reported on a study that suggested that antiretroviral drugs, or ARVs, could be used as a way to prevent the transmission of HIV. In 2012, this method of prevention of HIV transmission was approved by the FDA. PrEP, or Pre-Exposure Prophylaxis, is a once-daily ARV pill for people who are at

high risk for HIV that can greatly reduce the likelihood of HIV infection when a person is exposed. Similar ARVs are used in PEP, or Post-Exposure Prophylaxis, which can be used immediately after exposure to a HIV-positive individual to reduce the chance of positive HIV infection. Between the two, many individuals can be protected from HIV infection.

When PrEP was first introduced, many people who were using it were older and more frequently female. However, male usage has increased recently, as has usage in the younger population.

Though this is good news for people who are at high risk for HIV infection, several concerns remain. Right now, PrEP is available by prescription, but few people are taking advantage of it. This may be due to a stigma – people who are on PrEP are sometimes seen as more promiscuous or less careful than those who are not taking PrEP. Critics of PrEP are concerned that it could lead to people becoming less circumspect in their partners, or less vigilant in asking about a partner's HIV status. Condoms are intended to be used in conjunction with PrEP, but critics are concerned that there will be decreased usage of condoms when an individual is protected from both HIV and pregnancy (naturally, by gender, or artificially, by birth control). In addition, PrEP has to be taken daily, and has not been proven as effective below a 90 percent adherence rate – in other words, researchers worry that people won't take their pills on time, which reducing the effectiveness dramatically. Researchers are working to expand the forms of PrEP to vaginal gels and injectable forms, but as of right now, the once-daily pill is the only option. Critics are even more concerned about the use of a

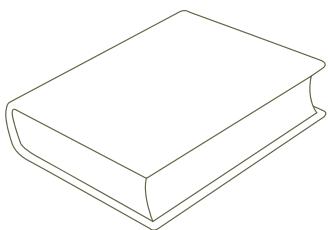


preventative drug in a non-infected patient – the effects on the patients taking daily PrEP are still being studied. Critics worry that PrEP will have an effect on uninfected individuals, and that PrEP usage might create a drug-resistant form of HIV.

However, perhaps the most prohibitive aspect of PrEP is the cost of the drug. PrEP can cost up to \$14,000 a year depending on health insurance coverage. People must also go to the doctor every three months to refill the prescription and to get regularly tested, ensuring that they remain HIV negative. Recently, Kaiser Permanente, the makers of the major PrEP medication Truvada, changed from a co-pay system, where the consumer pays a small fixed amount, to a system where the consumer pays a percentage of the total. This raised the price for the consumer dramatically. After backlash from users, advocates, and politicians, prices were dropped and costs were refunded to some consumers. However, this move has only served to grow the black market for PrEP medication. Taking PrEP from a non-recognized source means taking it without the support and quarterly monitoring that benefits legal users. This leads to a higher risk – how can people confirm the drugs they receive are effective? How can they confirm their continued health on them?

Overall, PrEP could be a highly effective way to combat HIV. However, many concerns remain, preventing PrEP from being used universally to treat HIV patients.

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# Mountains Beyond Mountains

BY EMILY ASHBOLT, BIOMEDICAL PHYSICS, 2017

**If you are seeking to be both inspired and incredibly humbled** by your insignificance, there are a lot of things you can do, but few in my experience accomplish this as well as Tracy Kidder does with his book *Mountains Beyond Mountains*. The book is a spectacular telling of the life and work of Paul Farmer, who, with an intimate group of equally amazing people, set up the non-profit organization Partners in Health.

Published in 2003, this is by no means a new book. I was gifted this amazing, brightly colored book during a mini-revival of the book this past summer. I was amazed by how quickly it became a mainstay in my bag, considering it only took four days for me to devour it.

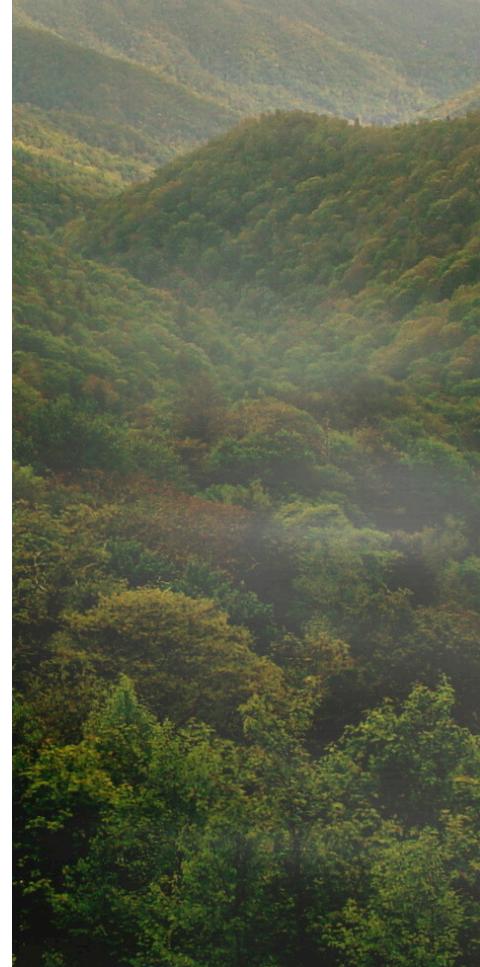
Pulitzer-prize winning author Tracy Kidder has a knack for non-fiction, spinning captivating stories by leaving no stone unturned in his research. Following a figure as non-stop and multidimensional as Paul Farmer could not have been an easy task. Kidder shows that without being self-pitying, inserting himself

in the story just enough to remind you that it is in fact a true story.

And what a story it is.

From his underserved upbringing in Florida to his journeys through Duke University and Harvard Medical School, Farmer built a healthcare empire using his immense anthropological knowledge and skills as a physician. Devoted to the most extreme use of the term, Farmer would never avoid helping one person, even if on paper it might seem more economical or efficient for him to use his time elsewhere. From the streets of Boston to the slums of Haiti to the forests of Peru to the prisons of Russia, Farmer and his partners stop at nothing to bring the best care to the most desperate patients.

At the risk of getting overexcited, I won't give many more details: you will have to read the book. But if you are looking for a book that will simultaneously inspire you and make you feel like you will never achieve anything in your life, I could not recommend this book more highly.



# O&A With Toyoko Orimoto



Toyoko Orimoto is an assistant professor in Northeastern's physics department, and is one of four faculty members who contribute to the Compact Muon Solenoid (CMS) collaboration at the Large Hadron Collider (LHC) in Geneva, Switzerland. Orimoto spends much of her time conducting research at Northeastern but collaborates daily with her colleagues at the European Organization for Nuclear Research (CERN). NUSci contributor Gwen Schanker first spoke to Orimoto in 2013 about her role in the discovery of the Higgs boson, which completed physicists' understanding of the standard model of particle physics. Two years later, Orimoto discussed what's been happening since the LHC underwent a two-year shutdown and energy boost, and also shared some personal anecdotes.

BY GWENDOLYN SCHANKER, JOURNALISM AND BIOLOGY, 2018

## How did you become interested in particle physics?

I got interested in particle physics in high school. For me, the idea that all of nature could be explained by a handful of elementary particles – that was really incredible and beautiful, and I've been hooked on that idea ever since. I knew when I went to college that I wanted to major in physics and I wanted to study particle physics, and then I got really interested in CERN. CERN is an epicenter for particle physics. I was really excited to go there and made my first trip through the Northeastern REU [Research Experience for Undergraduates] program with the National Science Foundation. Ever since then, I had my eyes set on going back.

## What are the main questions being explored at CERN right now?

The Higgs boson was the last piece of the standard model that had not yet been discovered. However, we know the standard model still has some tensions in it, and we think those tensions are potentially indicative of physics beyond the standard model. There are a lot of outstanding questions that such new physics could address. For instance, we don't understand why the electromagnetism and the nuclear interactions are so much stronger than the force of gravity. Another big mystery is the fact that we don't understand what dark matter or dark energy is. In particle physics, there's this feeling of discovery in the air. Not only is the energy boost potentially helping us to discover something new, but the more and more data we get, the more possibility for discovery that we have.

## What is your particular research interest?

What I'm most interested in is using the Higgs boson as a window into new physics. We know that the Higgs boson is how the elementary particles obtain the masses that they have, and so anything that has mass can potentially interact with the Higgs. You can measure the different properties of the Higgs to see if there are any deviations from what you expect. Any such deviations can be an indication of new physics.

## Can you explain what happened during the shutdown period?

Every few years, we have really long shutdown periods to upgrade and maintain the detectors and accelerating complex. Although the detectors are generally built to be radiation-

resistant, the LHC is a very high-radiation environment, so there will be parts of the detectors that will have to be replaced with time. Analysis of the data is still ongoing during the shutdown period. There are a lot of places that new physics can possibly be discovered, and we want to make sure that we look everywhere. We don't want it to be that we accidentally missed some part of the parameter space, so we're trying really hard to constrain everything and look in as many places as possible.

## What's the benefit of pursuing a co-op opportunity at CERN?

I am currently working with a co-op student named Alexander Coda based at CERN right now. He's my first co-op student, and I can already see how valuable the co-op program is. He basically spent the first month or so getting his bearings, and from there he's become very productive to the point that he has more work than he can potentially do before he comes back. He's an expert at what he's doing now, and he's producing important and impactful results. Being at the lab is a very special experience. It's not only a really interesting and stimulating environment – it also is very efficient to be able to talk to [physicists] one-on-one.

## What's the best part of your job as a professor?

I really enjoy working with younger people. One of the best things about being a professor for me is being able to advise graduate students and co-op students. They always surpass my expectations.

## What about your job as a researcher?

I feel very lucky that my work is, first of all, something that I dreamed of doing as a teenager, and also second of all, that my work is pure scientific research, aimed at answering very deep and fundamental questions. I really like that sense of questioning and discovery. That was something that as a high school student I didn't really get a feeling for as much. One thing I discovered as an undergrad is that science is not set in stone. It's a constant quest for answers, and when you find one answer, you ask another question.



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