

NUScience

Northeastern University's First Science Magazine

The Continuing Digital Revolution:

From Google's driverless cars to a possible restructuring of the internet, NU Science discusses the profound impact computers and the internet have on our lives.

Also Inside:

Confronting Mycophobia and the Lack of Fungal Research

A Northeastern Student Saves Animals in the Amazon

New Personal Health Informatics Program Explores an Exciting Field of Study

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Become a part of NU Science! 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 **7:30pm** in room **408 EII Hall**.

Come collaborate with us!

Letter from the President

Dear Readers,

It is my pleasure to present to you the 14th issue of *NU Science*, an investigation and celebration of the science of the internet. It's easy to forget – or ignore – how human ingenuity has been our shepherd into this world of instantaneous, global connectivity. For this issue, we chose to focus on the technology that brings people together.

When the first trans-Atlantic telegraph was sent in 1858, a massive parade was thrown in New York City, complete with fireworks. Telephones followed soon after, and since then communication technologies have grown exponentially, ushering us into the modern age of chatting distractedly in the sidebar with a friend across the world. Everyone with an internet connection has access at the touch of a button to a mind-boggling repository of knowledge, art, funny cat videos, and, above all, the opportunity to connect with billions of other minds. We as a species are utterly flawed. Yet I can't help but be amazed at what we have achieved, and wildly excited for the road ahead.

I hope the articles in this issue will give you the same sense of wonder I feel every day. As editor, contributor and president of this magazine, I have had the privilege of drinking from a fire-hose of science twice a semester for three years. I'm graduating this spring, so in case I don't get another chance to say this: thank you to everyone, staff and readers alike, for making my experience at this magazine so wonderful. I'm tearing up a little, so I'll stop here. Go read and enjoy.

Cat Ferguson

President, Behavioral Neuroscience, 2013



#OverlyHonestMethods

Have you ever wondered what really goes on in a research laboratory? Scientists share their experiences on Twitter, using the trending hashtag #OverlyHonestMethods.

**We used this method because the buffers don't need to be pH-ed.
#overlyhonestmethods**

"Experiment was repeated until we had three statistically significant similar results and could discard the outliers" #overlyhonestmethods

The eppendorf tubes were "shaken like a polaroid picture" until that part of the song ended #overlyhonestmethods

Samples were prepared by our collaborators at MIT. We assumed no contamination because, well...they're MIT #overlyhonestmethods

Incubation lasted three days because this is how long the undergrad forgot the experiment in the fridge #overlyhonestmethods

Blood samples were spun at 1500rpm because the centrifuge made a scary noise at higher speeds. #overlyhonestmethods

The sample was stirred with a spoon of sugar then sipped once before I realised it wasn't my coffee. #overlyhonestmethods

500 kW laser pulses were employed BECAUSE LASERS. Pew pew.
#overlyhonestmethods

COOL CO-OP:

Wildlife Rescue and Conservation in Peru

An interview with Anthony Denice

BY LAUREN HITCHINGS, BIOLOGY, 2014



UScience had the pleasure of interviewing Anthony Denice, a student whose unique co-op experience allowed him the opportunity to work in conservation and animal welfare in the Amazon rainforest.

Where did you do your most recent co-op?

My most recent co-op was with the Taricaya Rescue Center, which is linked with the Amazon Planet-Eco-lodge where I did my last co-op. They're neighbors with one another in the Southeast corner of Peru, in the Amazon rainforest. I did work in conservation, and got the chance to work with animals such as peccaries, jungle cats, tapirs, and exotic birds, and many different types of monkeys.

How did you find out about this opportunity?

I found out about Amazon Planet from another Northeastern student who had been working on a project doing research on fungi down there. I ended up doing my first co-op with them and through that experience I worked closely with the Taricaya Rescue Center and decided I wanted to work with them directly for my second co-op.

What kind of work or projects did you do there, and what were some of your regular responsibilities?

The work we did at Taricaya mostly had to do with ongoing conservation. We did a lot with local agriculture, and would often go to local farms and to vaccinate their animals against a variety of zoonotic diseases. At the actual rescue center we did a lot of work with the rescued animals, such as feeding at least once a day, and providing veterinary care, training, and enrichment. We had to make sure the animals were active enough, so

we would make different kinds of toys for them, and move things around the enclosures so they wouldn't get too bored with how things were set up. Sometimes we worked on constructing new enclosures entirely. I also supervised a lot of the volunteers who came through and worked on different projects.

Were there any safety concerns you had while working with wild animals?

We had a safety plan for pretty much every possible situation so I was never particularly worried about safety issues. The main thing you have to remember is that they are WILD animals; you don't know what they're thinking, so you always need to be prepared in case anything were to happen.

What was your living situation like in the rainforest?

Loud. The sleeping quarters were open-air bungalows with just netting around them, so you could hear all of the sounds of the rainforest at night: the insects, the howler monkeys, everything. It was also hot and humid just about every day and there was not much you could do to escape it.

What was the best experience for you on this co-op?

I had a lot of really great experiences, but one that really stands out was getting to track a group of monkeys that we had released into the wild. When they arrived they were only babies and we took care of them and watched them grow, and then when we released them, BOOM! They were wild animals. Seeing them go out and be eating and playing and forming communities on their own was just really cool.

What was your worst experience?

My worst experience was definitely having to spend five days in a hospital in a developing country. I was bit in the leg by a monkey while distributing food one day, and the medical care there is not quite the same as at is here, I didn't expect to have to stay for so long.

Do you feel that you've walked away from this experience with any valuable skills?

Oh absolutely. It combined two of the things I'm most interested in pursuing: animal welfare and conservation; this was a great way for me to break into the field. I got a lot of experience working with different kinds of animals, and good management skills working with volunteers. I picked up a lot of other little skills too: things like Spanish, some really good cooking, and using a machete.

Would you recommend this co-op to others?

Yes and no. For me it was a yes because the experiences I had will have a lot to do with the things that I want to pursue in the future. I'd recommend that everyone visit the Amazon at some point, because it's incredible, but I don't think living there for a full co-op term is for everyone. It's far from home, it's hot, it's humid, and it's loud. Seriously, it's way louder than any city street you'll find in Boston. It's not an easy place to live day-to-day, so I'd only recommend it to people who really have a passion for it. If you have the passion and the dedication, and you think you can take it, then absolutely do it, because there's nothing else like it. . n

Astronomical Discovery Challenges Current Perceptions of the Universe

BY LAUREN OLEAN, ENGLISH, 2014

A recent astronomical discovery may force scientists to reconsider our current understanding of cosmology. Led by scholars from the University of Central Lancashire, an international team of astronomers have discovered the largest known structure in the universe to date. At 4 billion light-years across, the sheer immensity of the structure challenges the Cosmological Principle that underpins contemporary astronomy.

The structure is a clump of quasars that form a large quasar group (LQG). A quasar (or quasi-stellar radio source) is the highly energetic nuclei of distant galaxies that surround a central, supermassive black hole. Quasars are the brightest objects in the universe, radiating massive amounts of energy, with the most powerful quasars able to emit energy at a rate equal to that of two trillion suns. Quasars glow red, from which we can infer that they are very distant. This is because red is the longest wavelength in the visible light spectrum; as the quasar moves further away from the earth (as the universe continues to expand), the lightwave lengthens and appears proportionally more red, otherwise known as "redshift". This distance allows us to assume we are observing young galaxies undergoing brief periods of extreme luminosity from early in the history of the universe. The brevity of these periods is relative, of course, lasting from 10 to 100 millions years. Quasars are powered by gravitational pull (or accretion) of matter into the black hole that they surround.

A large quasar group is a collection of quasars that have clumped together. The recent discovery is comprised of seventy-three quasars with a diameter ranging from 1.4 billion to 4 billion light-years. A structure of this size was believed to be theoretically impossible. For perspective, the Milky Way is a mere 100,000 light years across. This LQG is 1600 times larger than the distance between the Milky Way and Andromeda, the nearest galaxy.

The discovery violates the cosmological principle that assumes the universe is homogenous for all observers when viewed from a sufficiently large scale. This presumed consistency (which extends to the physical laws that rule the universe) has informed all current astronomical theories including Einstein's theory of relativity, and was first articulated by Newton. In simple terms, the cosmological principle claims that there is no "special place" in the universe; that our observations on earth are a fair sample of the universe as a whole. Scientists were thoroughly unprepared for this discovery, which runs counter to all current understandings of how the universe operates. In the words of astronomer William Keel, the discovery challenges the assumption that "the universe is knowable and playing fair with scientists." It is safe to say that in some cases, the more you learn, the less you know. n



Experiments Everlasting

BY SUMAYAH RAHMAN, BIOLOGY, 2016

As any student researcher would tell you, repetitive experiments that last for months on end can get to be a little tiresome. But what about experiments that last not for months or for years, but for decades?

Richard Lenski, evolutionary biologist at Michigan State University, began an experiment in 1988 and it is still going strong. He started with 12 flasks of the same strain of *E. coli*, and watched as they evolved. He wanted to see if they would all change in the same way or diverge in different directions due to random mutations. In the beginning, it seemed that all 12 flasks were evolving similarly, but 15 years and 30,000 generations later, one of the flasks underwent a striking change: the bacteria in this flask could now consume citrate, a chemical that had always been present, demonstrating the vast effect that random mutations can have on a population. Lenski plans to retire in 10 years, but he thinks that the benefits in continuing this experiment for many more years would be extraordinary for the field of evolutionary biology, and seeks a young scientist to continue his work.

Lenski's *E. coli* study is not the only experiment that has lasted for decades. Another researcher at Michigan State, Frank Telewski, is continuing a study

that was started by botanist William J. Beal in 1879. Intending to discover the length of time that seeds would stay dormant yet still viable, Beal buried 20 bottles of plant seeds with the plan to remove one bottle every five years. Beal removed six bottles before his death, and the project was passed onto another scientist. Then another. And then another. Telewski is the fifth in this chain of scientists, and he, too, plans to pass it on when he retires. Only two of the plant species in the most recent bottle were viable, but Telewski wonders if a plant that hasn't germinated in a while will surprise us when the next bottle is pulled out. The scientist who inherits this study will be continuing an awe-inspiring legacy that illustrates that there are some questions only answerable with time.

However, some long-lasting experiments end with the experimenter. When Donald L. Unger was a child, his mother told him that knuckle cracking would lead to arthritis. He tested this theory by cracking only the knuckles on his left hand for over 60 years. Neither hand became arthritic, and he eventually published his findings in the journal *Arthritis and Rheumatism*, for which he received the Ig Nobel Prize (a parody of the Nobel Prize which recognizes unusual or amusing discoveries in science).

It is a great feeling to see an experiment proceed successfully, which can be difficult to accomplish when the time span is so large. Sometimes, nature intervenes. The basement rooms of Smilow Research Center at New York University (NYU), home to thousands of genetically-altered rats and mice, were completely flooded when Hurricane Sandy hit, and all 10,000 animals drowned. The rodents had been modified to contain genetic mutations that cause human diseases including cancer and heart disease, in a study that NYU scientists had been working on for the past decade. Despite the devastating setback, these researchers will attempt to rebuild their collection of lab rats so that they may plow on in the quest for medical advancement and scientific discovery.

Researchers frequently go to great lengths to find an answer to their question of interest, but it is especially impressive when they push through daunting obstacles such as time, nature, and even their own deaths in order to make contributions to science and to society. Without a doubt, it is people like these who exemplify the passion that it takes for a good scientist to be a great one. n

Spacecraft Messenger Reveals Water on Planet Mercury

BY JORDYN HANOVER, BEHAVIORAL NEUROSCIENCE, 2017



For almost four decades, scientists have searched for evidence of water, and possibly life, on other planets. On November 29, 2012, the spacecraft Messenger, equipped with X-ray spectrometry, a magnetometer, and a topography-measuring laser altimeter found water, ice, and possible evidence of large organic molecules (molecules essential to but not necessarily indicative of life, made up of hydrocarbons that can be made from simple chemical reactions). Using the altimeter, several deposits were found on the planet's poles, and in construction of a heat map of Mercury, bright areas indicated surface ice while dark areas contained material distinctive to the planet. These deposits, in conjunction with the heat map, analyzed that the hydrogen content of the imaged craters is almost exactly the same as ice water.

Because Mercury is the closest planet to the sun, at less than 40 million miles in comparison to Earth's almost 93 million miles, in theory it should be too hot for any ice to form. The surface temperatures can reach over 400°C, far too hot for any ice to be present. However, the tilt of the planet's rotational axis, at less than one degree, keeps various pockets on the planet's surface entirely shielded from sunlight at extremely negative temperatures – these temperatures can

fall below -170°C. Using neutron spectroscopy at patches of bright radar detection (consistent with the heat map provided by the altimeter), Messenger was able to measure the average hydrogen concentration, and then compare those measurements with that of water ice. Messenger's data also found that there were some slightly warmer areas of the planet, which provided evidence of ice insulated under an unknown dark material. Scientists say that the notion that this material is composed of organic substances is "the only thing that makes sense."

This evidence of life potential is supported by three main, independent facts: excess hydrogen levels measured at the North Pole are consistent to those of water, polar deposit reflectance measurements are at near infrared wavelengths, and images of the surface and near surface temperatures using the actual topography of Mercury all indicate that water ice is a large component of the planet. However, it is important to note that the existence of water and organic molecules doesn't necessarily mean that there is life on Mercury; just that such life is possible. It is also crucial to mention that, while water ice appears to have been discovered, there was no evidence provided that liquid water was present on the planet.

Messenger was launched in August of 2004, and first flew around Earth and Venus before it could finally begin to circle Mercury, over five years after the mission was initially launched. These circles around Earth and Venus were used as trajectory correction maneuvers, necessary to get close to Mercury. Because Mercury moves quickly through its' orbit, Messenger had to circle the planet three times before it could successfully enter the orbit. Moving at over 140,000 miles per hour, the spacecraft was able to provide the first new data concerning Mercury in over 30 years.

There are several new questions that have been raised by Messenger's findings, such as the composition of the dark material covering and insulating the ice. Sean Solomon of Columbia University says that, "Messenger has now supplied a unanimous affirmative verdict [that Mercury contains abundant water ice in its polar regions]... the new observations have also raised new questions." The images and radiation maps provided by Messenger demonstrate that space exploration can provide valuable information about the geologic composition of other planets in comparison to earth, and that life as we know it is possible on other planets. □

Felix Earns his Wings: Exploring the World's Most Extreme Skydive

BY EMILY ASHBOLT, BIOMEDICAL PHYSICS, 2017



Felix Baumgartner has long been famous for his adrenaline pumping stunts, including the shortest B.A.S.E jump ever and the first skydive across the English Channel. On October 14th, however, the Austrian thrill-seeker outdid himself, falling nearly 40,000 meters from the outer atmosphere back to earth in the world's longest, highest, and fastest skydive ever. The distance he leapt from (39,045 meters, or about 24 miles) is about equivalent to the distance between NEU and Brockton. He spent 4 minutes and 20 seconds in free-fall.

Baumgartner's media-frothing stunt, which has been in the making for the last 5 years, was not actually the longest free-fall of all time. That accolade goes to Baumgartner's mentor Joseph Kittinger, who fell for a full 17 seconds longer in 1960. But Baumgartner was the first human outside a vehicle to break the sound barrier.

Surprisingly, the speed of sound is affected less by the medium the sound wave is propagating in and more by the temperature of that medium. Because of this, the speed of sound steadily decreases as altitude increases. This pattern holds up until 11 KM above the ground, after which air temperatures begin to heat up through the upper

stratosphere and thermosphere. Baumgartner had a top speed of 834mph (just under 372m/s), which is faster than sound as measured from anywhere on Earth. Interestingly, he broke the sound barrier several times during his fall as the speed of sound changed around him.

When asked what such a milestone felt like, Baumgartner reported that it was "hard to describe", because he could not actually tell. "When you're in a dead pressure suit [with no reference points] you don't feel anything," he elaborated.

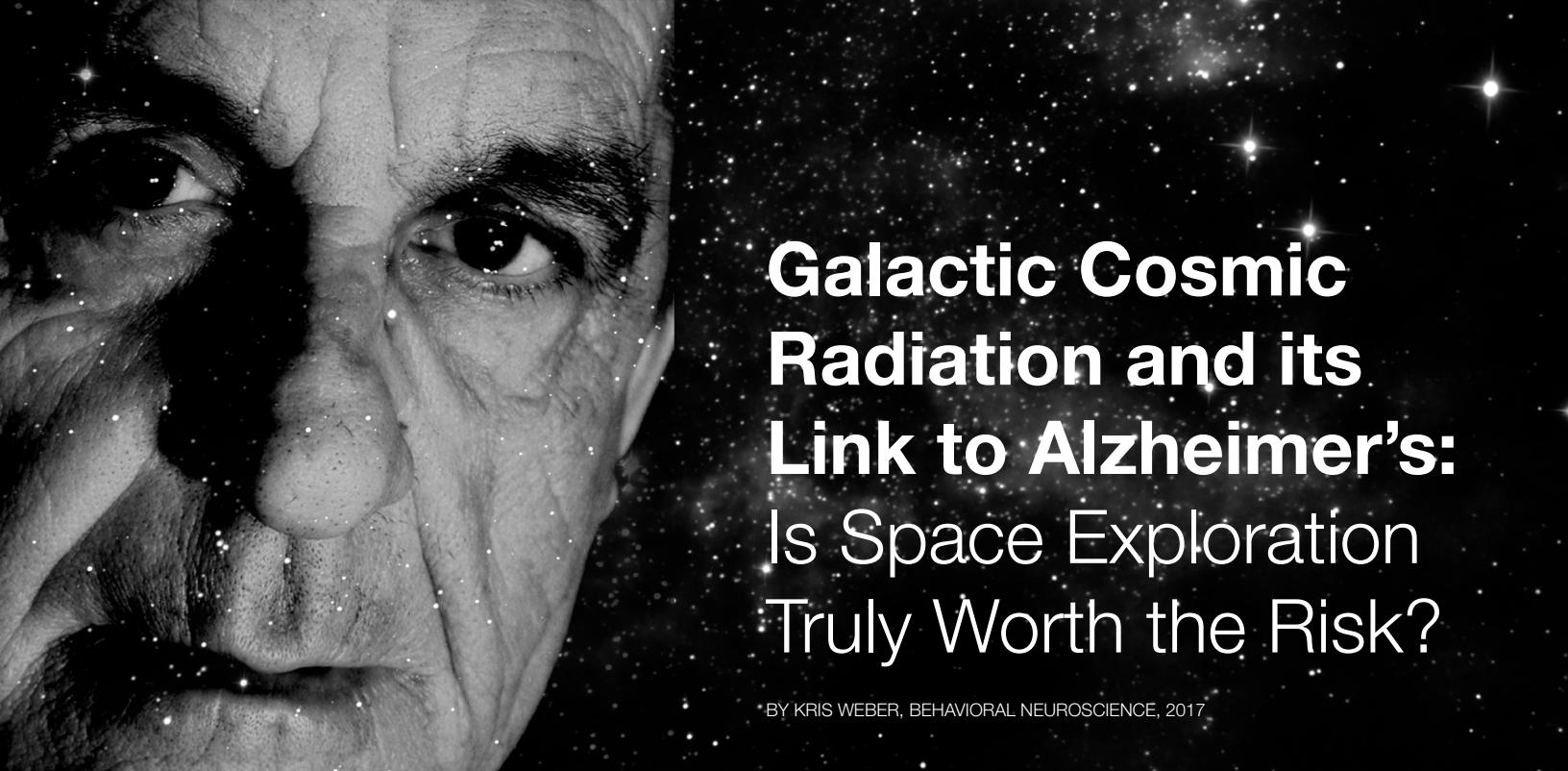
He was glad for that suit, though. One of the biggest threats to Baumgartner's wellbeing was not his speed at all, but the nature of space. At altitudes upwards of 20,000 meters, ebullism can occur. This is a dangerous form of pressure sickness in which the body's fluids actually begin to boil due to the lower pressure. Along with this, there is also the possibility of decompression sickness, also known as the bends, which deep-sea-divers sometimes suffer from if they are not careful when ascending.

Keeping a (reasonably) constant pressure in the air around Baumgartner was key to his avoiding unconsciousness or even death due to the pressure change. Designed by space-suit specialists at

David Clark Company, Baumgartner's four-layer outfit was made to withstand extreme high and low temperatures. Red Bull covered the (undoubtedly immense) price of its manufacturing, which was never actually released. While Baumgartner initially suffered from claustrophobia caused by his technological cocoon, he managed to overcome it.

There was a moment of drama during the drop when Baumgartner entered into an uncontrolled spin for about 35 seconds. "If you are in that situation and it spins you around like hell, and you do not know if you can get out of that spin or not. Of course that is terrifying," reflected Baumgartner on that particular part of the experience, which, if not handled properly, could have resulted in most of his blood rapidly exiting his body through his eyeballs. Despite immense force, however, Baumgartner recovered from his spiral to stabilize in the stratosphere, finishing his jump with little incident.

What was Baumgartner's motivation for his incredible feat? "Sometimes you have to go up really high to understand how small you really are." □



Galactic Cosmic Radiation and its Link to Alzheimer's: Is Space Exploration Truly Worth the Risk?

BY KRIS WEBER, BEHAVIORAL NEUROSCIENCE, 2017

Space: the final frontier." Anyone living in the United States over the last 60 years can attest to the country's longstanding obsession with exploring the mysterious void of space, truly the last uncharted region known to man. Beginning in the late 1950s with the Soviet Union's launch of Sputnik 1—the first artificial satellite to orbit Earth—America fell headfirst into the Space Age, with TV series such as "Star Trek" and movies like "2001: A Space Odyssey" capturing the imagination of the country. Americans brimmed with excitement as the newly formed National Aeronautics and Space Administration (NASA) launched program after program to further the United States' foothold in space and edge out the USSR in the Space Race; even now, over 40 years after the successful moon landing of Apollo 11 in 1969, outer space still seems to elicit a sort of romantic fascination for many. However, recent research studying the effects of galactic cosmic radiation on neurodegeneration has called our decades-old obsession into question—is space exploration truly worth the physiological price that may be paid by our astronauts?

It has long been known that space is filled with radioactive particles of varied compositions and characteristics. Earth's magnetic field normally provides a layer of protection from this damaging radiation, but once an astronaut leaves the safety of orbit, he or she is immediately exposed to massive amounts of galactic cosmic radiation (GCR) containing high-energy, high-charged (HZE) particles. One type of HZE particle, ^{56}Fe , is of particular concern; due to their relatively large masses and high travel speeds; these iron-based particles are capable of penetrating solid objects like a spacecraft. According to M. Kerry O'Banion, M.D., Ph.D, Professor of Neurobiology

at the University of Rochester Medical Center and senior author of the study in question, "One would have to essentially wrap a spacecraft in a six-foot block of lead or concrete" to prevent ^{56}Fe particles from entering. Clearly, this level of protection is not realistic, so scientists must weigh the possible risks of exposure to such radiation with the potential benefits of manned space missions. Previous studies have focused on the link between these particles and cancer as well as cardiovascular diseases, but O'Banion's is the first to concentrate on damage to the brain.

At NASA's Space Radiation Laboratory on Long Island, researchers utilized special particle accelerators to recreate the levels of radioactive ^{56}Fe present in space. After mice were exposed to several different intensities of radiation, they were then tested in two domains—fear conditioning, which focused on the ability of the mice to remember certain locations associated with a painful shock, and object recognition, which tested their ability to recognize particular objects. It was observed that mice exposed to HZE radiation performed markedly worse on these tests than the controls, even when the levels of radiation were relatively low. The reason? An increase in the accumulation of amyloid beta (A) plaque in the brains of the mice—a hallmark of Alzheimer's disease.

In a healthy individual, amyloid beta (a peptide) functions in the brain to regulate cholesterol transport and enzyme activation. The level of A is normally kept steady by the vascular system, but in an Alzheimer's patient, A begins to accumulate and form harmful deposits of plaque in neural tissue. This buildup initiates a damaging cycle of neuroinflammation and impaired transport of A out of the brain, leading to a decline in cognitive ability. Many factors

have been shown to lead to this buildup, but one factor in particular stands out in the context of this study: radiation.

The researchers found evidence implicating the radiation emitted from ^{56}Fe particles and other types of HZE in the deterioration of the blood-brain barrier (BBB), a semi-permeable membranous system that functions as a layer of protection between the brain and substances traveling through the vascular system. Reduce the effectiveness of the BBB, and the nervous system's delicate chemistry is thrown off balance. Removal of excess amyloid beta may be compromised and result in the aforementioned buildup of plaque and increased neuroinflammation, which prevent the activation of necessary enzymes and glucose uptake by neurons. Cognitive decline ensues; thus, high levels of amyloid beta are strongly linked with accelerating both the onset and progression of Alzheimer's.

Currently, NASA is working to send the first manned spaceflight to Mars in 2035, a round-trip mission that could take up to three years. The opportunities for exploration and study afforded by this mission would be unparalleled—but are they truly worth the potential health risks stemming from such an extended period of radiation exposure? Is an increased likelihood of Alzheimer's for American astronauts simply a price that must be paid for scientific advancement? For the chance to "explore strange new worlds, to seek out new life and new civilizations, [and] to boldly go where no man has gone before"? n

Exciting Applications of 3D Printers

BY DEREK JONES, CHEMISTRY, 2016

Wouldn't it be cool if you could print out a new case for your phone, a piece of jewelry, or a model of the Eiffel Tower as easily as your latest essay? With a 3D printer, these tasks are quite possible. A 3D printer is similar to a regular printer in the sense that it brings to life a design created on the computer, but the two are very different. While 2D printing simply layers ink onto paper, 3D printing goes through a more sophisticated process to produce the desired product. 3D printing relies on additive manufacturing, a process that adds material until the product is complete.

Before 3D printing, using subtractive processes was the standard way of manufacturing things. In this method, material is removed from the whole. For example, the artist who envisions a sculpture in the block of marble will have to remove the excess to release the masterpiece within. In addition to leaving scraps behind, subtractive processes have their limitations (especially with certain hollow or complicated objects).

Charles Hull invented stereolithography in 1984. This is the process that allows the design from the computer to be created in real life. With this invention came the creation of 3D printing. The first 3D printers were very large and had limited capabilities. Fused deposition modeling (FDM) was established in the late 1980's. FDM is most commonly used for making prototypes to see if the product will work. It also allows more than one material to be used at once.

After 3D printing came nearer to perfection, more advanced objects began to be produced. In 1999, scientists began trying to design and print out organs. In 2002, they succeeded in printing out a small kidney that was capable of filtering a small animal's blood and producing urine. A group of scientists found a way for a 3D printer to make edible food in 2006. For this specific machine, a paste or other food of that consistency is used as the starting material, and the printer will use this paste to create the design on the computer. In 2008, a self-replicating 3D printer was made; this is a printer that has the capabilities of printing most of its own parts. This allows users "to make more printers for their friends." Working blood vessels were printed in 2009. This was a huge breakthrough; utilizing this technology could save more lives at a cheaper cost.

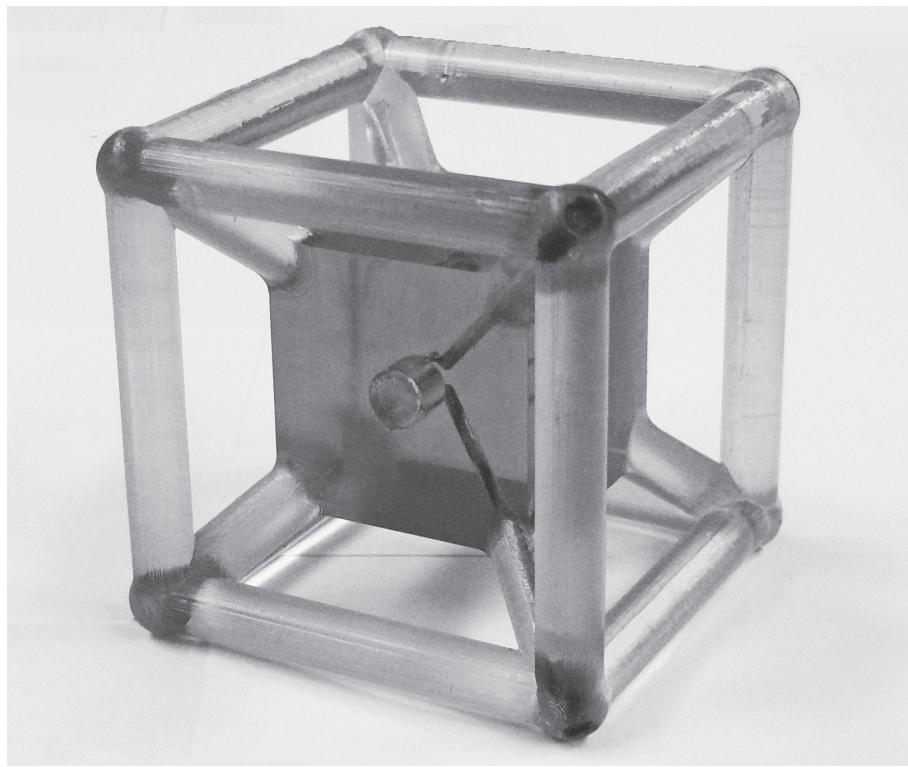
The past few years have brought along even

more advanced and impressive innovations to this technology. 2010 was a big year for 3D printing; new developments include printing a robotic airplane, a car, and printing with silver and gold. The robotic plane was designed with a normally very expensive feature, elliptical wings, that allow for a more efficient flight. By using a 3D printer, the cost to produce this feature is comparatively less expensive. With 3D printing, it requires only \$8000 and a one-week period to make one of these planes. In addition, the recently developed car is very modern looking and gets excellent gas mileage (200 mpg on the highway and 100 mpg in the city) because it is also an electric car. If these cars become available for the average consumer, the price will most likely range from \$10,000 to \$50,000. Being able to print with silver and gold could be revolutionary to how jewelry is made; 3D printing is more precise, less expensive, and more efficient.

So how can the average person gain access to one of these printers? The price for a top-tier

one can easily be over a million dollars, but there are small ones with limited capabilities available for a more affordable price, ranging from less than one thousand to several thousand dollars. If purchasing one doesn't sound like an attractive option, there are companies such as Shapeways, Kraftwurx, and Freedom of Creation that can print something for a customer.

The future of 3D printing looks very bright. First of all, processes have recently been refined to allow rapid production. Rapid production will open the doors that lead to 3D printing into mass production. This means it will be possible to produce products with quality in quantity. Research for printing chemical compounds is currently taking place. Also, research is being gathered to see if it is possible to print chemical compounds and have them react. It has already been proven that this technology is capable of producing new compounds. Once more research is done in this area, it could lead to an amazing number of possibilities. n



3D printed built in circuit with LED light. Produced at Northeastern University in Professor Mavroidis' Biomedical Mechatronics Lab.

“Look Ma, No Hands!”

The Future of Automobile Technology

BY THOMAS HANLON, HEALTH SCIENCES, 2017



Is the headache of driving a thing of the past? Google may think so. Back in 2010, they announced their goal to improve the safety, enjoyment, and efficiency of driving by creating a car operated entirely by artificial intelligence. This project is led by Google engineer, and director of Stanford's Artificial Intelligence Laboratory, Sebastian Thrun. Thrun is noted for having co-invented Google Street View.

The Google car contains the latest robotic and sensory technology. One of the most essential pieces of the automated car is the Velodyne 64-beam laser, which is mounted on the roof and creates a 3D map of the surrounding area. The Velodyne Lidar uses a collection of lasers to produce a 3D point cloud of data points covering a 360-degree horizontal field of view and a 26.8 degree vertical field of view. It is capable of spinning at tremendous speeds with each of the lasers shooting out at about 4,000 times per revolution. The lasers project out of a side lens, hit a nearby object, and travel back through a central lens where the information is processed. This results in an intricate 3D map of the surrounding area that gives the automated car its “eyes”. The car uses this complex laser radar along with HD maps to produce different data models, which allow the car to drive itself. It is also equipped with 4 radars on the front and rear bumpers to detect other cars, a camera near the rear view mirror to process traffic lights, a GPS navigation system, inertial measurement unit, and wheel encoder.

The fleet of 10 self-driving cars undergoing road testing includes 6 Toyota Prii, 1 Audi TT,

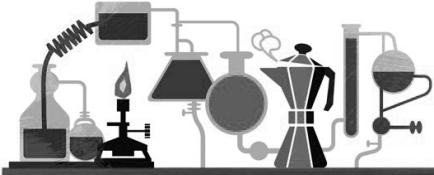
and 3 Lexus RX450hs. Each self-driving car costs roughly \$300,000. While on the road, the automated car contains a person in the driver's seat and a Google engineer in the passenger's seat. The car contains an override feature which can be activated by the person in the driver's seat by turning the wheel or stepping on the break. As a safety precaution, Google engineers manually drive the route of the driverless car beforehand in order to acquire data for the car's intricate sensory system. This helps the car differentiate between pedestrians and inanimate objects. The car has the speed limit of the road it is traveling along with a GPS map stored in the computer's memory.

There has been much controversy and skepticism surrounding the idea of a self-driving car. As of 2012, a number of Google's driverless cars drove for a combined 300,000 miles with only a couple of hiccups. That's the equivalent of driving around the equator more than 12 times! There were two reports of Google's cars being involved in accidents over these 300,000 miles. One occurred when the Google car was stopped at a red light and got rear-ended by another driver. The second was the fault of the Google car, however, Google claims that a Google engineer was manually driving the car at the time of the accident. Despite these bumps in the road for the cars, Nevada, Florida, and California have passed laws allowing the use of driverless cars.

Sebastian Thrun has claimed three impressive statistics that would result if everyone in the U.S used a driverless car: the number of traffic

accidents, the amount of time spent commuting, and the number of cars on the road would each be reduced by 90%. In 2009, there was a reported 5.5 million motor vehicle accidents in the U.S. alone. These accidents resulted in the deaths of 33,808 people and injured millions more. Across the entire U.S., the United States Census Bureau reports that there is an estimated \$450 billion in total cost due to car accidents. By using Thrun's claim, the Google car would reduce the number of accidents by 4.95 million, save 30,000 lives per year, save \$400 billion in accident-related costs, and eliminate 4.8 billion commuting hours. It would also reduce fuel consumption by 1.9 billion gallons, which would save \$101 billion dollars in lost productivity and costs. These estimated savings are indicative only of the U.S. The worldwide social and economic benefits of the Google driverless car could conceivably total to trillions of dollars per year.

While the idea of a computer taking people from point A to point B may be a compelling concept, the Google driverless car is still in the early stages of its creation. Further down the road, Google needs to find a way to lessen the cost of its masterpiece to make it accessible to a wider range of consumers. Google also needs to convince the car's doubters that it is a much safer alternative than people driving themselves. This project could be revolutionary, paving the way to a new technological era in which everyday tasks, such as driving, may be replaced by a computer. n



NU Science Explains: Google

BY HANNAH BIALIC, BIOCHEMISTRY, 2016

What is a kumquat? How many licks would it take to get to the center of a tootsie pop? Where in the world is Timbuktu? You may be asking yourself what all of these questions have in common, and the answer is: Google. To find the answer to any one of these obscure questions we might turn to our good friend the search engine, often Google.

The average person probably uses Google, or some type of search engine, at least five times a day. You ask and Google answers. But how does this website work? How can one small word be enough to filter through millions of sites, words, pictures, and documents to find you numerous matches to your search?

The answer is actually quite complicated. According to "Learn How Google Works: In Gory Detail," Google dispenses technological "Google bots" that scour the web and index every site, tweet, post, or picture depending on its level of authority and visitation. It is from within that index that Google operates, though that index is constantly being updated. So, for example, if you tweet: "Man I hate waiting at On The Go #NortheasternUniversityProblems" and the link to your tweet doesn't contain any "nofollow" tags, then it is indexed both in an index used for obscure searches and an index used for broad and competitive sources. Your tweet would be assigned authority depending on how many links it can be connected to.

Next comes the grunt work. Each page, post, or tweet that is added to the World Wide Web and tagged by Google is then checked against editorial policies, copyrights, and laws. Penalties are applied to potentially unwanted pages to aid users in their searches. All of this takes place before we enter a single search term.

When we type in our question, Google does a lot more than we think. First Google suggests keywords that would make the search easier and runs the search using multiple synonyms of what was typed to expand the search. The initial result set has been created. But that is not the set the user sees; the results are ranked and duplicate sites removed by means of PageRank, which rank the pages in order of authority and usefulness. Next, Google applies their filters that add in multimedia to the search results, personalizes the results to the user's website preferences, and puts a high authority on "trending pages." And finally, your results are displayed. And this all occurs in under one second. If you don't believe me, Google it. □



Photos courtesy of Google.

Google Fiber: Another Internet Revolution

BY EVANGELINE FACHON, BIOLOGY, 2017

Anyone who has ever downloaded a large file knows the frustration of waiting for the progress bar to fill. As the meter slowly crawls towards a hundred percent, there might be time to get a meal, take a shower, or even just go to sleep and check it again in the morning. Yet through Google's latest business venture, Google Fiber, internet users can eliminate the excruciating waiting periods that come with large files and enjoy an overall faster internet experience. Google Fiber is an internet service that boasts speeds of one gigabit per second—one hundred times faster than the average connection speed in America. As the chief financial officer of Google, Patrick Pichette, said during the announcement of the new program, "there's no need for slow."

Google Fiber is currently only available in Kansas City, and the company has been unclear on whether or not they plan to expand to nationwide service. Installations in Kansas City started in the fall and won't be complete for some time, but the Huffington Post reports that the faster connection is already igniting the city's startup scene. In the meantime, other cities are making bids to be the next on the list for Google Fiber.

A secondary feature of Google Fiber is a new TV service that features high definition channels and advanced DVR. With Google TV, users can record up to five hundred hours of television. Currently, HBO, ESPN, and several other prominent channels are not included in this

package, which costs \$120 per month. Google is in negotiations now to get a more complete list of channels.

Google employee Milo Medin explained how these new speeds and capabilities will serve to make America more internationally competitive. Right now, Americans pay more per megabit and receive slower service than most other members of major countries. Meanwhile, increased internet speed has been linked to significant improvements in national GDP, meaning that Google Fiber, once fully implemented, should have great economic benefits.

Some people might ask why faster internet is so exciting, when the service that we already have is adequate for the everyday tasks. Historically, faster internet has proved to be a catalyst for new developments. As Medin explains, when dial-up was the standard mode of internet connection, many companies refused to invest in broadband because they believed that the faster internet would be superfluous in the everyday lives of their consumers. Once broadband came into use, however, new innovations such as streaming movies and software downloads were developed. All of these are services that someone using the old dial-up method could never have access to. While the faster Google Fiber speeds may be convenient for day-to-day use now, the truly exciting part is all of the further technological possibilities that it is sure to inspire. □

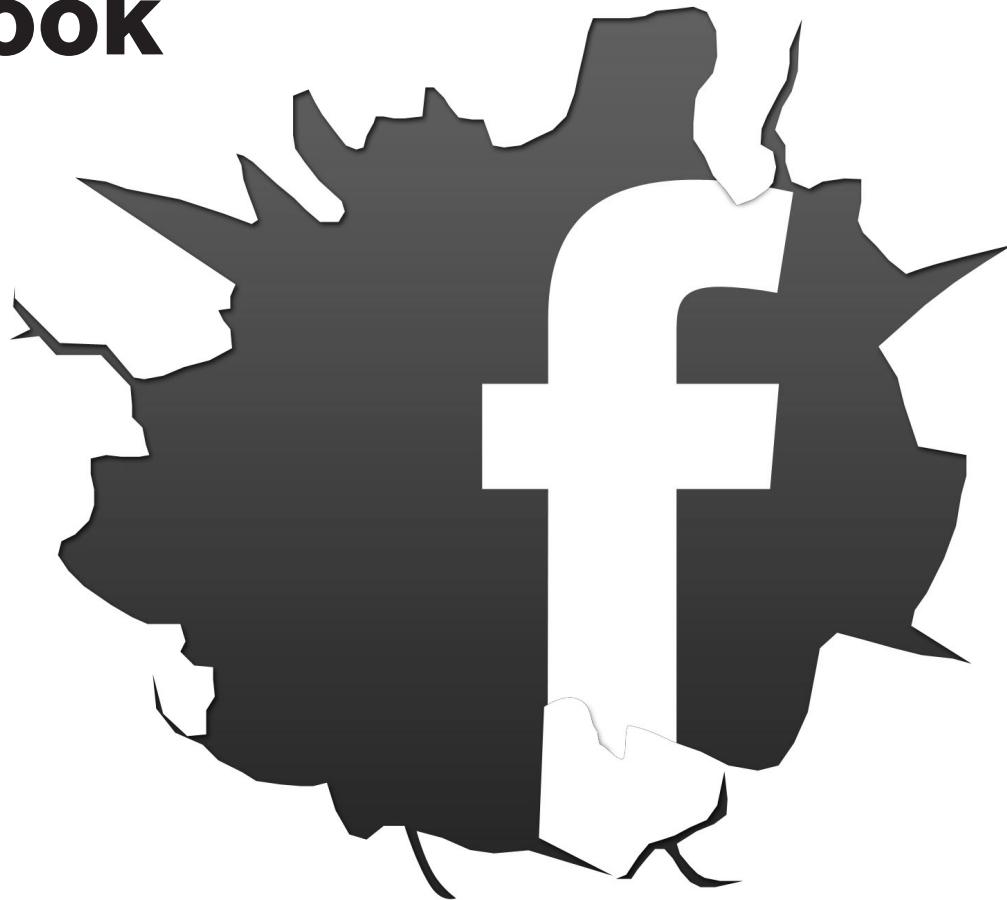
The Implications of Facebook

BY MONIQUE COELHO, BIOCHEMISTRY, 2015

H ave you updated your Facebook status today? According to an article by e! Science News, people can remember Facebook statuses better than they can remember a person's appearance or something they have read elsewhere. The article explains that Dr. Laura Mickes from the University of Warwick and Professors Christine Harris and Nicholas Christenfeld from UC San Diego have researched how much retention someone actually has when it comes to a Facebook status update. According to their research, people see the differences of how people live their daily lives when they read dozens of statuses daily, and because of the spontaneous nature, it makes statuses much easier to memorize compared to other writings that are more precise and edited.

Smart phones and other devices have made relationships partly based in media. Everywhere you walk down the street, someone is texting, talking on the phone or simply checking their Facebook. A documentary by CNBC called "Facebook Obsession" examines just how much society has gotten addicted Facebook. The website is now used in politics, business and even police searches for fugitives. How serious is this obsession? The Facebook obsession could bring about positive results: Anyone can search for a person they met so they can build up a relationship. But there can also be a downside when a person's privacy is in question.

The documentary spoke of people getting into trouble because of things they wrote in their statuses. In one example, a school teacher wrote a status venting her frustrations about her students on Facebook. The school found out, and the teacher lost her job. This brings about the misconception that when someone posts a status or a picture, he believes it is safe online as long as he blocks his page. Yet companies still seem to find a connection in order to find the information that they want about Facebook users. Facebook has turned into a place to connect with other people, transforming into a public journal where everyone posts things they are doing, where they are located, and exactly what they are thinking. This can be dangerous since anyone can access it, so not only is there a safety concern about posting your location, but also people can now judge other individuals based on what they post to Facebook.



According to DoSomething.org's list of 11 facts about cyber bullying, cyber bullying is as common as the more well-known face to face bullying. One of the most shocking facts said that "81% of young people believe that bullying online is easier than bullying in person." Another said, "Only 1 in 10 victims will inform a parent or trusted adult of their abuse." Think about the last couple of status updates that an individual might have posted insulting someone else. How about those Facebook groups that post pictures of individuals with the phrase "1 Like equals 1 Slap"? Facebook has made it much simpler to get in contact and reach out to other people, but it also has made it much easier for someone to be more judgmental and bully others.

Facebook of course has the upside of enabling people to find a long lost friend or even a birth mother. The documentary "Facebook Obsession" showed one woman who wanted to find her birth mother. She put up a Facebook group page and thousands of people began to follow her. One woman in particular specialized

in reconnecting families and was able to find the birth mother's Facebook page. There was a happy reunion in the end. This is one of the amazing advantages of the social media. Before these inventions, everyone had to go through papers, letters, or neighbors' doors to find information. Now everything can be found within a few seconds of searching online.

Facebook has grown extremely popular in the world, reaching almost 1 billion users, according to BeginGroup.com. Like everything else that was invented, it can be used for unsavory purposes like bullying or stalking. It can also be used for good reasons like having a way to get closer to a potential significant other or finding an old friend. The way it is used is completely up to society, and the hope is that everyone can put it to use for constructive reasons. □

Content-Centric Networking Offers a Different Kind of Internet

BY MICHAEL MURRAY, COMPUTER SCIENCE/ENGLISH, 2014



The internet may be the single most unifying piece of technology today. The potential for instantaneous and global distribution of information brings more and more people together all the time, often in ways never before possible. There are currently 5 billion internet-connected devices, a figure that the MIT Technical Review expects to triple by 2015. This massive increase represents a mix of a greater number of connected people and more devices per person. While the social impact of higher internet usage might be overwhelmingly positive, the technical implications are worrisome for the current implementation of the internet.

The internet today operates on an end-to-end model. Generally, each request you make goes all the way to whatever server holds the data before returning that information back to you. A helpful image is a telephone call (which is particularly apt, as some readers might remember connecting to the internet through dial-up). Every request requires your computer to "call" the appropriate server to complete it. Each one is defined first by the IP address where the data you want is stored; location of data is the primary focus in the current implementation. Location-centric architecture has been in place since the

first days of the internet, and new requirements have been satisfied by ad hoc improvements rather than any massive overhauls. Challenges such as network security and mobile devices, neither of which were anticipated originally, required inventive solutions and changes to some underlying protocol, but left the basic model of the internet in place.

It's easy to see how 15 billion devices making constant end-to-end calls could overwhelm servers, which can only process a finite number of requests at any time. However, what other options exist? While many labs have offered proposals for replacement architectures, those involving "content-centric networking" (CCN) are among the most widely discussed. This design shifts attention to a globally unique identifier for the data itself instead of its location. Rather than sending a request to a specific address, users broadcast an "Interest packet" specifying the information they want. This packet is routed towards a data source, much like it is today, but with one crucial difference: at each stop along the way, nodes check to see if they already have the requested data stored. If they don't, the Interest packet continues on its way, leaving behind a record of where it came from. Should

any node have the data stored, the request goes no further and the information is sent back along the path from which it came. Additionally, each stop along the way back to the user's computer caches the data for some period of time. If some other user's request for the same data comes across any of these, the cached version will be returned to them. This architecture massively reduces the load on host servers and overall network traffic by cutting down on the number of requests that become end-to-end calls.

CCN stands to be an ideal solution for an internet with ever-increasing traffic. While gains in network speed and efficiency could be seen in today's number of users, the reduction in traffic increases along with the amount of internet use. The more people making requests, the more likely it is that a request will be found early. There are numerous other benefits, as well. Implementations of CCN could allow for greater security, placing trust in digitally signed content, rather than hosts. CCN's decreased interest in geographical location reflects our increasingly mobile internet usage.

Of course, CCN is far from perfect, and it isn't the only option. This architecture would place significantly more burden on routers within the network. Analysis by researchers at Bell Labs suggests that both the hardware and software of today aren't up to the task of supporting an internet-scale deployment of CCN. And while MIT's Named Data Networking Project (NDN), which uses the content-centric approach, garners frequent discussion and funding from the National Science Foundation (NSF), it isn't unique in that sense. The NSF currently funds a number of diverse research projects studying internet architecture. They began the Future Internet Architecture Program in 2010 to investigate possible options. One alternative is the expressive Internet architecture (XIS) program, based out of Carnegie Mellon University. Compared with the NDN Project, it remains relatively near to current architecture while incorporating necessary advancements in a natural way.

No simple answer exists when it comes to the future of the internet. Dramatic restructuring of the internet's most basic architecture, such as the switch to CCN, would be the most fundamental change in its entire history. Regardless of the specifics, challenges arising from the current architecture will be met with creative and innovative solutions. n

The Root Mycelium of the Problem:

How mycophobia inhibits innovation

BY SAMUEL BOSCH, BIOLOGY, 2017

Paul Stamets is a fun guy. As one of the most vocal and prominent mycologists of our time, he has plenty of reasons to bring up mushrooms in everyday conversation. However, when he does so, most people "immediately think Portobellos or magic mushrooms, their eyes glaze over," and they may think he is a tad bit crazy. So before we get in too deep, let's get some facts straight about the fungus among us.

The Kingdom Fungi encompasses the largest range of sizes of all living organisms, from single-celled yeasts to the largest organism known to man, a fungus residing in Oregon that spans nearly four square miles (Take that, blue whale!). Kingdom Fungi also includes organisms that can reproduce sexually or asexually- most can even do both! Finally, they are heterotrophic, meaning they use complex organic molecules as their energy source.

Despite the amazing diversity of this Kingdom, fungi are some of the least studied organism. There are an estimated 1.5-5 million species on the earth, yet only 100,000 have been taxonomically classified. The average person isn't likely to know much about fungi either. Stamets believes this results in a phenomenon he calls "mycophobia". Not necessarily an irrational fear of fungi, but rather, "an irrational fear of the unknown, when it comes to fungi." Why have so few taken a lichen (yes, I'm aware a lichen is the product of a symbiotic relationship between a fungus and a plant) to fungi? While Stamets may be one of the most outspoken "fungi activists," many other scientists have attempted to tackle mycophobia by showcasing the wide breadth of innovations that can be derived from studying this kingdom.

Fungi have been proposed as possible solutions to a number of environmental problems. One such proposal is letting fungi be the sole proprietors of the activated-sludge process in water treatment. As early as 1970, an experiment published in the Ohio Journal of Science showed that fungi can run the activated-sludge process as efficiently as the traditional mix of bacteria and protozoa. More recent experiments based out of Iowa State University not only concluded with similar findings, but also stated that the bacterial biomass that piled up due to the bacterial treatment could not be used in many applications, and was thus energy inefficient and wasteful. The use of fungi, they suggested, would produce fungal biomass, which could be used as both "animal feed and potentially in human diets."

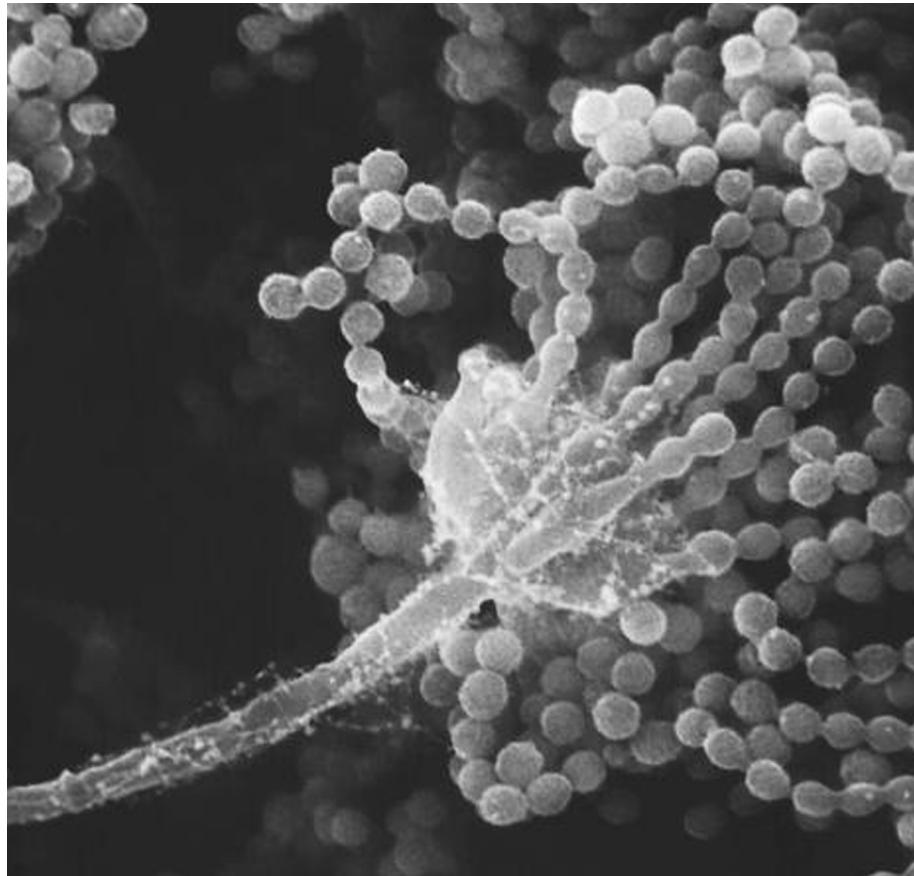


Photo courtesy of CDC/Robert Simmons

Stamets and his team have been utilizing fungi to clean up common human messes. In particular, they have tested the efficiency of fungi in cleaning up petroleum and diesel waste. In Stamets' experiment, petroleum was subjected to some mushroom mycelia; when given six weeks, the fungi completely soaked up the petroleum and seemed to be living healthily. Explaining this is rather simple; mushroom mycelia can break down hydrocarbons and convert them into carbohydrates, which the fungi use as food (being a heterotroph, and all). More amazingly, his work determined that the fungi, when put in this situation, began to create their own little habitats, as Stamets explained "They sporulated, the spores attract insects, the insects laid eggs, eggs became larvae. Birds then came, bringing in seeds, and our pile became an oasis of life." The fungi were able to change what was before

a dark cesspool of human waste into a habitat capable of housing a wide variety of life.

And that is not all that fungi can do: their uses have been studied across a wide variety of fields, some of which are rather unexpected. Computer network engineers have studied mycelia networks, which work in ways similar to the Internet, civil engineers use fungi to prevent roadside erosion, and medical practitioners have turned to fungi for treatments for illnesses. Stamets himself has been researching the healing powers of a certain fungus (*Fomitopsis officinalis*) on small pox, with largely successful results. So, you say you have a problem in need of fixing? There's a fungus for that. n

Aaron Swartz- Internet Hero

BY JOSHUA TIMMONS, BIOLOGY, 2016



Photo courtesy of www.forbes.com

Aaron Swartz committed suicide on January 11th, 2013, at the age of 26. Though he died at an extremely young age, he will be remembered for his internet activism and vehement protection of information access. With a complete resume too long to include, his fledgling career involved all parts of the internet. In 2005, at just 19, he was a co-founder of Reddit, a widely used social media site. While the buyout of Reddit in 2006 guaranteed Aaron a hefty paycheck and financial security, internet freedom was his great passion. A philosophy major at heart, Aaron became so obsessed with the idea

of universal and unrestricted access to information that he wrote an official declaration of his views: the Guerilla Open Access Manifesto.

His stand for internet freedom took on many forms throughout his young life. In 2006 he downloaded the entire bibliographical section of the Library of Congress and posted it on Open Library, a site of his own creation. In 2008 he posted 20% of the PACER archives, a government archive of court records, online to public.access.org, a non-profit that fights for the free availability of court records. While PACER records were always available for a nominal sum, Aaron stood fundamentally opposed to the idea of charging fees for access to public information.

When the Stop Online Piracy Act (SOPA) was introduced to augment the US government's regulatory role online, Aaron was one of the loudest opponents. It would have created a list of websites deemed harmful to copyright law and shut them down entirely, something Aaron saw as a limitation of freedom of speech. In a country with widespread use of copyrights, Aaron feared an internet at the total mercy of censorship. To counter SOPA, Aaron created Demand Progress, an online petition platform that was deemed critical in the defeat of SOPA. Today Demand Progress has over one million members.

Before his death, the Massachusetts state government was prosecuting Aaron for his illegal mass download of scientific journals from the database JSTOR. Despite the fact that Aaron didn't publish the journals online, and JSTOR asked to drop the case, Aaron was still being charged under the Computer Fraud and Abuse Act. In its current form, the legal system doesn't distinguish between hackers stealing sensitive personal or financial data, and those like Aaron who break rules as insignificant as terms of use contracts. Aaron was facing 35 years in prison and a million dollar fine. But ultimately, the battle he lost was the one with depression.

Whatever role legal troubles played in the decision to end his life, Aaron's death has sparked outrage on the part of all those who knew him. It has also called into question a slew of factors, from the prosecution's handling of the case to the motives of MIT. Even the laws that govern the internet are being challenged as Aaron's family, friends, and co-workers speak out against the case. It stands to be seen how the ripple effects of his death will impact the political, legal, and academic environment. Despite his early passing, Aaron's impact will transcend his short life and influence the internet far into the future. n

Implicitly Explicit

BY JOSHUA COLLS, BIOLOGY, 2016

Society exhibits prejudice without realizing so, via the subconscious categorization of individuals. This mental tendency has come to be known as implicit bias: an individual's innate feelings about groups of people without their conscious knowledge. Studying this phenomenon, scientists published a website that examines individuals' partiality to certain groups, implicating not only race, but also age, gender, sexuality, weight, and religion as factors. The scientists behind the Implicit Bias Association are well-renowned doctoral professors Brian Nosek, Mahzarin Banaji, and Tony Greenwald.

Individuals may be unaware of their implicit biases as a result of social norms. For example, discrimination toward segments of the population is discouraged by society, and may result in the suppression of a person's prejudices. As a result, the implicit bias association attempts to look beyond conscious denial of prejudice in order to discover individuals' inner stances on specific issues. Thus, in order to avoid the introduction of conscious thought into the assessment, individuals are asked to complete tasks as quickly as possible. These rapid-fire responses express the inner, instinctive thoughts of a particular person—slow, thought-out responses skew the results, preventing the test from accurately depicting the subject's innate associations.

Sigmund Freud was the first to touch upon the idea of the adaptive unconscious in social

psychology. The adaptive unconscious, or the intuitive thought processes that allow people to adapt to the environment, influences the processes that take place during the implicit bias association. To examine these intuitive processes, the association exam is engineered to occur in a certain chronological order. In the implicit association race study, for example, the participant is asked to sort pictures of people into categories of African American and European American based on the color of their skin. Afterward, the subject is requested to sort certain phrases like love, joy, happy, awful, evil, and nasty into classifications of 'good' and 'bad'. Finally, the subject is asked to categorize the pictures and phrases at the same time—for example, sorting both African American faces and 'bad' words to the left, and European American faces and 'good' words to the right. Once this portion of the exam is completed, the terms switch sides and the test is repeated in a different configuration—from the previous example, African American faces and 'good' words would now be sorted to the same side. Incidentally, this is the junction where the subject characteristically makes the majority of his or her mistakes, not only for the race association, but also for every association examination offered.

When the test has been completed, results are determined by the amount of mistakes made, the time taken to choose each association, and the modus of

each mistake or correct answer. The strength of the association is based on these factors—for example, faster speed in sorting African American faces with 'bad' words suggests a stronger bias against that racial category. In the case of the race study, results range from little to none, slight, moderate, or strong bias, in favor of either European Americans or African Americans. As of February 14, 2013, 70 percent of people express bias against African Americans. This is a comparatively high number to the proportion of people who freely admit stigmas against African Americans, demonstrating the efficacy of the implicit bias association in revealing hidden or unconscious prejudices.

Understandably, the outcomes of the implicit bias test may not be well received by the subject. In terms of prejudicial suppression, participants are often unaware that they hold partial viewpoints. As a result, when test-takers are informed of their implicit biases, some subjects express denial and judge the test to be too controversial. Indeed, results may not be entirely accurate if a person consciously tailors his or her answers to reflect what may be considered ideal. However, the consistent results point to a societal proneness for hidden biases that are, in spite of ourselves, all too prejudicial and partial. n

Northeastern's New Ph.D Program Changes How We Look at Healthcare Technology

BY CLAUDIA GEIB, JOURNALISM, 2015

As technology continues to play a growing role in people's lives and well-being, Northeastern University is helping revolutionize the way the world looks at health with their new Ph.D program in Personal Health Informatics. The program, in its second year, trains students for a growing field that marries health and technology to transform the way patients receive care.

"Personal health informatics is person-centered or patient-basing sources of interfaces," explained Professor Stephen Intille, one of the founders of the program. "It's technology designed for the person in the healthcare system, or for wellness before you enter the healthcare system."

Northeastern students in the new program, often abbreviated PHI, are trained to design these technologies. The program combines the studies of computer-human interface technology and health sciences with research and hands-on experience from one or more of Boston's many medical institutions.

Intille believes that personal health informatics will soon become standard in the healthcare system. But what exactly does personal health informatics do? In a hospital setting, PHI technology might help put a patient at ease by providing them with information about what's going on around them. After leaving the hospital, the same technology might remind a patient when to take medication or when to see doctors, and might keep them updated on how their condition should be progressing. Even outside of an illness-related use, PHI technology can help individuals maintain wellness by logging their health-related goals or helping them to keep track of diet and exercise decisions.

According to Intille, after graduation PHI students could serve in a number of different fields: as faculty in schools of public health or computer science, as researchers at tech companies that make PHI devices, as science advisors at companies, or even as entrepreneurs of their own businesses.

The university kicked off the program last September in response to general interest in personal health informatics. Northeastern already has a successful health informatics master's program, and many of health sciences professors have been working on personal health informatics research projects.



"The goals of the program are to accept a handful of new students each year and grow up the program to have a network of Ph.D. students," said Intille. "But we also hope to extend it so that at the masters level and the undergraduate level there are students doing research in this area. We hope to build a community of people interested in this topic and really doing top-notch work."

Stephen Flaherty, one of the students accepted to the PHI program last year, entered the program after years of searching for one that suited his interests. He worked as an MRI technologist at Beth Israel Deaconess Medical Center before entering the Northeastern program.

"I had been looking for the right program for a number of years but nothing seemed to have the health centered focus I was looking for ... until I found the PHI program," Flaherty said. "I've worked in healthcare for many years, and there is a surprising lack of efficiency and usability in our computer systems. I want to design and improve the tools available for both patients and providers to make better use of the health data we have."

So far, Flaherty's experience has been a good one. He said that great professors who are experts in their fields motivate him and the other students to "push harder." The diversity of fields from which the PHI professors come, Flaherty said, add depth to the program, and the course

mix is both challenging and flexible, allowing students to choose electives according to their own interests.

Upon graduation, Flaherty hopes to work as a researcher in PHI technology, either in an academic setting or for a healthcare technology company.

"I want to constantly seek better ways to do the critical tasks that come up every day in healthcare," he said.

As for Intille, the prospect of a new year and another new group of students is an exciting one. The field of personal health informatics is a new way of looking at healthcare, he says, and one he hopes he and his students can expand to help people worldwide.

"If you look at most medical informatics ... they're typically creating systems for physicians and hospital staff. They're not thinking directly of the individual's experience as they travel through that system," Intille said. "We think that this is a very unique focus. We're confident that this will be a big part of the United States healthcare system and the global healthcare system in the future. And we hope to be at the forefront of that."

The program is currently accepting applications for the fall of 2013. For more information, visit <http://phi.ccs.neu.edu/>. □

The Skinny on a Junk Food Diet

BY HEESU KIM, PHARMACY, 2018

Does it really matter what types of calories are consumed by the body? Or is it quantity, not quality, of calories that causes the body to gain weight?

In August 2010, Kansas State University nutrition professor Mark Haub challenged the popular concept of dieting, using the now infamous "Twinkie diet" to prove that calorie deficits, not nutritional value, are the true secret to weight loss.

Slightly overweight with a body mass index (BMI) of 28.8, Haub restricted his caloric intake from his previous 2,600 calories to 1,800 calories a day. For a period of two months, two thirds of Haub's diet consisted of junk food items, including Twinkies, Oreos, and Doritos, consumed every three hours. He supplemented this daily diet with a multivitamin pill, a protein shake, and a few vegetables.

By the end of his experiment, Haub had reduced his weight by a stunning 27 pounds and his BMI to a normal 24.9. Additionally, his LDL "bad" cholesterol levels decreased by 20%, while his body fat percentage dropped from 33.4% to 24.9%. Haub's diet was a conclusive success, and what began as a classroom demonstration became a media flurry that spellbound dieters across the nation.

But was Haub's weight loss feat truly a surprise? For the scientific community, not so. In fact, Haub's experiment was another piece of evidence in the long line of support for a known, rudimentary principle of nutrition science.

In plainest terms, the kilocalorie, abbreviated as "Calorie," is a unit of energy. The energy of a Calorie, whether from a vegetable or a Twinkie, supplies an identical quantity of 4,184 joules. Thus, from a purely weight loss perspective, the source of the calorie is irrelevant to the amount of energy metabolized by the body. As long as a calorie deficit is maintained, in which the body consumes fewer calories than burned, body mass will decrease.

Furthermore, according to Dawn Jackson Blatner, spokeswoman for the American Dietetic Association, being overweight is itself a causative factor of several health issues, including high blood pressure and cholesterol. As a result, losing excess body fat naturally leads to improved insulin, lipid, and cholesterol levels, independent of the means by which the body achieved its weight loss.

In contrast, long-term health implications of a primarily junk food diet are less positive. The

Twinkie diet, severely deficient in fruits, meats, and whole grains, fails to provide the body with vitamins and nutrients essential to healthy functioning. Instead, it replaces these necessary reserves with processed sugars and fats, which result in low satiety and insufficient nourishment. Moreover, said Blatner, the continued following of a diet similar to Haub's regimen may potentially affect future risk for cancer and other illnesses.

These consequences allude to a major theme in nutritional health, which has been distorted and misunderstood by contemporary diet culture: weight loss is not synonymous with physical health. Dr. David Katz of the Huffington Post points out that in addition to dieting, steep weight loss may also result from drug abuse, chemotherapy, and cholera. In short, a slimmer figure is not automatically reflective of a healthy body.

Ultimately, fruits, vegetables, and whole grains remain the standing pillars of healthy weight loss. While scientists have consistently shown that weight loss is principally a matter of calorie deficits, the quality of foods is important to consider when looking beyond a coveted waistline to the body's internal health. Lower in fats and nutritionally more complete than junk food, whole grains and produce provide natural sources of energy for the body's processes. Their physical benefits are many and long-lasting,



including feeling fuller for longer, providing vital nutrients like fiber and folic acid, and promoting a balanced digestive system. Unlike junk food items, these benefits provide a healthier fuel for the whole body, to promote more lasting health and weight loss.

So while we Americans vow in this New Year to drop those stubborn pounds from the holiday season, consider this bottom line: losing weight truly does come down to eating fewer calories than the body expends. And as Haub has shown, it is completely feasible to lose significant body mass on a diet of processed junk food and empty calories.

Realistically, a regimen such as the Twinkie diet is void of essential nutrients and vitamins, and potentially increases risk of severe health issues in the future. In this respect, old-school diets ring true: junk food, consumed in moderation, is an enjoyable and occasional indulgence. But healthy, more permanent weight loss may only be achieved through the responsible and conscientious adherence to a balanced diet. And the Twinkie diet, nutritionally incomplete and grounded in instant gratification, is certainly no way to go about it. □

Evolution at Your Fingertips

BY ANDREW BLOY, BIOLOGY, 2016



When the word evolution is mentioned to any science major, the images of fish crawling out of water, or apes that progressively appear more human comes to mind. These are the more well recognized examples of evolution, however, evolution can account for almost every quirk, strange behavior or interesting adaption in living things. Everything from lactose tolerance to why we dream can be explained by evolution. From our ancient origins up to today, there are numerous unusual examples of human evolution worth examining.

When you take a step back and think about why and how humans are able to drink cow's milk, it is an evolutionary miracle that we are able to drink it. All mammals, during their juvenile years, drink their mother's milk for nourishment and the immune support they get from the antibodies in breast milk. In order to digest milk, most mammals produce an enzyme called lactase to break down the lactose sugar found in milk. Once maturity is reached, however, almost all mammals stop producing this enzyme, stripping them of their ability to digest milk. One special exception to this is humans, who can drink and digest milk for their entire lives. Being able to digest milk well into adulthood is called "lactose tolerance". This trait first arose around ten-thousand years ago, when animals were first domesticated. One of the most important animals

to be domesticated was the cow, whose milk provided additional nourishment, so the ability to digest this cows milk into adulthood became an important evolutionary advantage. However, since humans were already spread across the globe, this adaptation only affected populations that domesticated cattle (Europeans, Arabs and some Africans). Some earlier civilizations that did not domesticate cows, such as Asians and Native Americans have a much harder time digesting lactose than Europeans, Arabs and Africans.

While the process of digesting lactose is not visible to the naked eye, some evolutionary adaptations, such as fingers wrinkling in water, are clearly visible. For example, there was a time in childhood when every kid spent too long in a bathtub, the ocean, or a swimming pool and their fingers wrinkled up. Physiologically, fingers wrinkle when blood vessels in the dermis (the deeper layer of the skin) on the fingers and toes constrict and pull the surface of the skin in, forming wrinkles. While this has traditionally believed to be the result of saturation of the epidermis (the outermost layer of the skin), researchers at the University of Newcastle in northern England, have theorized that the fact that the epidermis on the fingers and toes becomes saturated and wrinkled is to improve grip on wet surfaces and objects. Studies have

shown that wrinkled fingers are more effective at picking up wet and slippery objects.

Evolutionary adaptations are not limited to physical traits; they have also shaped the way the human mind works, namely by developing dreams. Antti Revonsuo, a cognitive scientist from Finland has theorized that dreams are evolutionary adaptations that allows human beings to practice their reactions to certain stressful situations, all within the safety of the mind. The support for this theory comes from the fact that the regions of the brain that coordinate fight or flight responses, and plan our motor functions for such responses, are heavily engaged during the REM sleep cycle compared to other stages of sleep, despite the fact that the dreamer is typically lying completely still during this part of the sleep cycle.

Evolution, over millions and millions of years, has shaped every portion of our lives. There is much more to human evolution than walking upright and having opposable thumbs. Everything from what we eat to how we dream is a result of millions of years of evolutionary brilliance. Perhaps one day, humans will illuminate their entire evolutionary pathway, but until then there is still plenty for young Northeastern science students to uncover. n

A Noble Cause: Gripping with the Helium Crisis

BY ISAIAH THOMAS, BIOLOGY, 2017

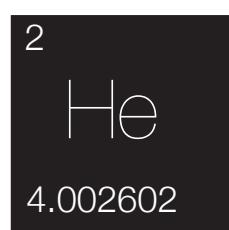
The days of carelessly popping balloons and inhaling helium may be over. The shortage of this gas approaches a crisis, despite helium being one of the most common elements in the universe. According to a report from *CBC News*, the shortage may be due to reckless sales practices in the U.S., particularly the 1996 Helium Privatization Act which sought to have most helium reserves sold off by 2015 as a budgetary measure. Because the market was flooded with cheap helium, oil companies didn't take the time to capture the helium released while drilling for natural gas. Capturing helium at that time could have potentially prevented this shortage. Furthermore, many of the new production plants both in and outside of the U.S. have stalled out or even shut down, according to *Physics Today*.

According to a report from *CBS News*, most helium used commercially comes from the Federal Helium Reserve, outside of Amarillo, Texas. This reserve provides half of the U.S. helium supply and one third of the world's supply, with two billion cubic feet of helium put up for sale every year. The reserve is currently working at maximum capacity to remove helium from beneath the surface of the Earth, but with private oil companies having little incentive to capture it, keeping up with escalating demands for

helium is proving to be increasingly difficult.

In the first half of the twentieth century, helium was used by the U.S. in airships which protected convoys crossing the Atlantic Ocean. Because helium had become so important for national defense by the 1960s, the U.S. government passed a law that called for the purchased one-hundred years' worth of the gas. Helium quickly lost its value in terms of national security, and by 1996, the government tried to extricate itself from the helium industry and give control back to private companies with the Helium Privatization Act.

The helium shortage may seem to many people to only affect the party-supply industry or the Macy's Thanksgiving Day Parade. However, the shortage has many implications beyond these commonplace applications. The crisis is of particular weight in the medical field because magnetoencephalography, or MEG, scanners, which are similar to MRI scanners, require liquid helium to function. These scanners detect brain activity and have been used in research related to perceptual and cognitive processes and the functionality of different parts of the brain. They also can be used for pinpointing pathologies in the brain, such as the source of seizures, before surgical removal. According to a report from *The Independent*, many university facilities using these



scanners have been forced to shut down periodically or cancel bookings for scanner use due to the shortage.

Helium even has a place in rocket science. According to the Bureau of Land Management, when the liquid hydrogen and oxygen fuel is burned to launch a rocket, hydrogen and oxygen become hot gas. If the hot gas were to mix with the cool liquid fuel, the results could be explosive, and not in a good way. To prevent them from mixing, helium is used to clean the cavity that separates the substances. Because helium is the most stable element, it will not react with either of the substances.

Access to this important resource is dwindling, a reality which may have grave implications for research, technology, and birthday clowns around the world. However, the new production plants are forecasted to become operational in the next year, so hopefully birthday parties will not have to forgo helium balloons for too long. n

GlobalMed: Clean Water Saves Lives

BY KRISTEN MINISH, COMMUNICATIONS, 2013



In the Masaka District of Uganda there are more people living with HIV than there are people with toilets. A group of Northeastern University students is working to address this shocking issue.

In May 2012, four students from Northeastern traveled to Uganda to work with Kitovu Mobile AIDS Organisation. Kitovu Mobile was founded in 1987 in response to the large number of people living with HIV/AIDS in the poor and rural Masaka District of Uganda. The organization provides outreach to individuals in the surrounding communities who are

"infected and affected" by HIV/AIDS through direct patient care, as well as patient and family counseling.

During their four-week internship, students met with patients both at their homes and in community health centers. While some patients had just begun their antiretroviral therapy (ART), others had been on ART for several weeks and were being monitored for adverse effects. A few patients had even just stopped by because they had heard the Kitovu Mobile staff was going to be in town. From writing prescriptions to attending support groups, students were able to experience the comprehensive HIV/AIDS education and care that Kitovu Mobile provides to the community.

One of the most important insights that the students had during their trip was the lack of awareness and prevention in the area. For a population with an estimated 1.2 million people living with a preventable disease, this is a critical need. By providing community members with the proper education and resources, many preventable diseases – especially those caused by poor hygiene and water sanitation – can be avoided. Students worked closely with village health teams to create and disseminate a survey to evaluate the existing hygiene and water sanitation practices of community members.

Currently, these surveys are being analyzed so that both the students and the health workers at Kitovu Mobile will be able to understand what the

current practices are and how they can be improved. This type of research also helps Kitovu Mobile create programs such as a women's self-help groups to empower women to become health promoters in their communities. The women learn hand washing and water boiling techniques that they are encouraged to share with their neighbors to foster good hygiene practices and proper household care.

You might ask, how did these four students end up in Uganda? Well, the answer is GlobeMed. GlobeMed is a student-run nonprofit organization that strives to relieve health disparities around the world for people living in poverty. The Northeastern chapter has been partnered with Kitovu Mobile AIDS Organisation since 2009. Since then, GlobeMed at Northeastern has raised over \$22,000 dollars to aid Kitovu Mobile's projects, including the women's self-help groups and the construction of pit latrines, tippy taps and water tanks. Improved hygiene and access to clean drinking water are essential to achieving better health overall in the Masaka region.

Each year, GlobeMed sends a few members of the organization on its Grassroots Onsite Work (GROW) trip. This trip allows students to see the direct impact that fundraising back home has for GlobeMed's partner organization on the ground in Uganda. If you are interested in joining GlobeMed, e-mail northeastern@globemed.org or stop by the meetings on Tuesdays at 7:30 PM in 311 Ell Hall. n

Have We Considered How Global Climate Change Will Impact Humans?

BY CAYMAN SOMERVILLE, ENVIRONMENTAL SCIENCE, 2017

When thinking of global climate change, people often envision the disappearance of the Arctic sea ice or the shrinking of glaciers. The amount of evidence for climate change is immense. The mechanisms behind earth's climate system, in addition to human-induced alterations of the natural world, arguably display the causes for abrupt global warming. However, few people consider the direct implications global climate change poses to humans. There may be a difference in how various regions of the world will experience it. For example, the cooler parts of the world will most likely feel positive effects economically, whereas the warmer parts will experience negative consequences. Coincidentally, the richer nations of the world tend to be in these cooler areas, whereas the poorer nations in the warmer locations.

As climate change becomes increasingly dramatic, the negative impacts on the environment are considerable, however it is also important to take into account the potential consequences to the nations of the world. As global warming continues, there are grave issues that both individuals and societies might experience. A few significant considerations are the increased chance of being affected by vector-borne diseases (VBDs), the increase in the frequency and intensity of extreme weather events, health issues, and even threats to the poor as well as national security.

According to the Center for Climate and Energy Solutions, VBDs are "diseases that result from an infection transmitted to humans and other animals by blood-feeding arthropods, such as mosquitoes, ticks, and fleas." The geographic ranges of these vector species are affected by weather, particularly temperature and humidity. Recently, researchers have begun to consider how global climate change will affect the distribution of VBDs. Typically, vector species are found in warmer and wetter climates, and as global warming and extreme weather events like droughts and heat waves continue, it is expected that the zone of potential transmission for many VBDs will also expand. Not only will new human populations be affected by VBDs, but the vector species populations will increase, infecting more and more people.

One of the most common examples of VBDs is malaria, transmitted from mosquitoes, which are creatures from hot, wet climates. In addition, due to an expansion in their geographic ranges, infection rates will increase, especially as temperatures rise and rainfall increases. As numbers of mosquitoes grow, potential for malaria exposure swells. The fact that there will be more mosquitoes, eating more often, in more places may not be a death sentence. However, the increase of mosquitoes does often lead to a period of incapacitation (sometimes for up to 3 weeks), which can cause major problems for people who must feed their families or tend to their farms.

Unfortunately, the increased chance of exposure to disease is not the only problem.

Many of the negative impacts of climate change are not simply going to happen in the far-off future; they are already happening now. A prime example is the increased occurrence of extreme weather events. Hot days have been hotter, rainfall and flooding heavier, hurricanes stronger, and droughts more severe. According to the American Red Cross, lately "excessive heat has caused more deaths than all other weather events, including floods." Typically, the most vulnerable people to heat-related illness are city dwellers, the sick, the young, and the old.

According to Dr. Amanda Staud, a National Wildlife Federation climate scientist,

"Global warming is bringing more frequent and severe heat waves, and the result will be serious" for the 30 largest cities around the world, and climate models indicate that negative impacts will only get more severe. As a result, health officials are urging the public to realize that global climate change is a health issue rather than just an environmental problem. Physicians are concerned because of the various studies that have found a significant correlation between global warming and the increased likelihood of heat waves. A report by the Intergovernmental Panel of Climate Change assessing weather extremes pointed out that in addition to an increased magnitude of these events, "heat waves that now occur once every 20 years will be occurring every two years by the end of the century."

As urbanization has swept Western and Eastern societies, cities are constantly expanding and becoming increasingly dense. Scientists predict that heat waves will become more common, longer lasting and more intense, especially in urban areas. According to the National Wildlife Federation, cities will experience as much as 10°F excess heat due to the surrounding "asphalt, concrete, and other structures [that] absorb and re-radiate heat." Researchers have pointed out that the most obvious risk from a warming world is killer heat, and already it has struck populations.

In 1995, a deadly heat wave hit Chicago, killing around 750 individuals and alerting people to the disastrous impact of continued high temperatures. George Luber, from the Centers for Disease Control and Prevention, pointed out that what happened in Chicago was nothing compared to the European heat wave of 2003; officials calculated over 70,000 deaths to be heat-wave related. Heat waves have demonstrated how unprepared society is for potential future extreme weather events.

At the societal level, there are four areas that are most vulnerable to the negative impacts of climate change, including, but not limited to, the Arctic, sub-Saharan Africa, low-lying Islands, and mega deltas.

These climate change hotspots are places where either the most climate change will occur or where the adaptive capacity (of the inhabitants) is lowest. The Arctic is a fragile ecosystem that displays the effects of climate change. Melting ice caps can increase the sea level and cause habitats for unique animals to shrink. This decrease in animal populations can greatly diminish the food source of people native to the region. Eskimos that live around the Arctic Circle still practice subsistence hunting. Also, melting permafrost will manifest both physical and ecological effects, such as shoreline erosion.

Africa has a low adaptive capacity from years of poverty, struggles, and a lack of governance, foreshadowing what the suffering subsistence farmers will experience when VBDs and desertification strike. Low-lying islands and major cities may be washed away as sea levels rise. Some of the world's most important ports are surrounded by heavily populated cities. Lastly, flooding, changes to rivers, and an increased chance of powerful hurricanes can result from rising sea levels.

Humanitarians and politicians have also taken notice of the detrimental effects of global climate change on humans. Global Humanitarian Forum, a non-governmental organization, published a report in 2009 recognizing the responsibility of developed countries for the high levels of green house gas emissions. They also demanded "climate justice" regarding the developed countries, since the poor experience the majority of these adverse effects. The President of the Forum voiced her concern, stating, "It is the poorest countries and poorest people who are, and will, suffer most... [but] none of us is immune to its impact. Everyone, and every country, has a responsibility."

It is for this reason that officials have called for binding emissions agreements. In addition to the environmental impact, governments have begun to consider global climate change as a threat to national security. According a New York Times article, "Climate-induced crises could topple governments, feed terrorist movements or destabilize entire regions," like the vulnerable region of sub-Saharan Africa. It is these concerns that display the complex dynamics behind scientists' concerns and negativity towards our rapidly warming Earth. For those interested in learning more about the topic, Professor Daniel Douglas teaches a course on Global Climate Change at Northeastern. □

Turritopsis nutricula: The Real Life Benjamin Button

BY KATHERINE HUDSON, MARINE BIOLOGY , 2017

Humans have long known about organisms that can live for centuries, such as tortoises and redwood trees. As a result, researchers have often attempted to discover ways to extend the human life span with the ultimate goal of finding a means for humans to live indefinitely. In the past twenty-five years, however, scientists have discovered an organism that has beat humanity to discovering this "Fountain of Youth." *Turritopsis nutricula*, in the class Hydrozoa, is a species of jellyfish that grows to be no larger than the human pinkie nail. It is more commonly known as the immortal jellyfish, due to its ability to return to the immature polyp life stage after reaching sexual maturity.

“It is believed that the hydrozoan genome has the potential keys to unlocking not only immortality but cures for cancers as well. **”**

The life cycles of Hydrozoa are complex. The animals begin as larvae, and then settle to form polyps. After these polyps develop, they reproduce asexually by budding, forming the medusae. This portion of the Hydrozoa life cycle is the one that beach-goers are most familiar with. They float with their bells on the surface, tentacles dragging behind to catch prey such as small fish. When the jellyfish reaches sexual maturity, it reproduces sexually by releasing sperm and eggs into the water. Normally, after this occurs, the animal dies. The immortal jellyfish, however, is able to revert to its polyp state by settling on the seafloor, absorbing its tentacles, and beginning its life cycle anew. Potentially, it could live forever, unless it is eaten or exposed to extreme stressors.

The exact mechanism of this immortality is unknown. However, scientists have discovered that the jellyfish's cells are able to transdifferentiate, changing from one type to another, a process common in human stem cells.

An example of this is a nerve cell changing into a muscle cell. This is likely how the cells change their function when the organism reverts to its polyp life stage, essentially "reversing" the age of the animal. Although this phenomenon has never been observed in the field, scientists believe it occurs when the individuals are placed under environmental stress, physically harmed, or become diseased.

In 1996, Stefano Piraino, Ferdinando Boero, Brigitte Aeschbach, and Volker Schmid, scientists from Italy and Switzerland, attempted to explain how the immortal jellyfish is able to reverse its life cycle in a paper titled "Reversing the Life Cycle: Medusae Transforming Polyps and Cell Transdifferentiation in *Turritopsis nutricula* (Cnidaria, Hydrozoa)." The paper was not, however, able to provide any concrete observations of *Turritopsis nutricula* regenerating in its environment or provide an exact mechanism for this phenomenon, due to the difficulty of inducing hydrozoan reproduction in a laboratory setting.

According to James Carlton, a marine sciences professor at Williams College, Hydrozoa research is not only held back by the challenges of studying them. It also lags because so many members of the scientific community find them relatively uninteresting. Carlton calls

this the Small's Rule, which states that "small-bodied organisms are poorly studied relative to larger-bodied organisms." As a result, there are very few scientists that specialize in Hydrozoa research.

However, interest in studying the jellyfish's potential immortality is growing. Scientists have begun using genetic technologies that did not exist when "Reversing the Life Cycle" was published. Advances include insight into what influences human stem cells to differentiate, such as the activation of biological molecules called microRNA. According to Kevin J. Peterson, who studies miRNAs at Dartmouth College, this activity may cause the cell to differentiate. He believes that if the miRNA are deactivated, the cell "loses its identity," allowing it to differentiate again. To help build the understanding of the role miRNA molecules play in cell differentiation and transdifferentiation, Peterson suggests studying them in hydrozoans since "miRNA are crucial to their biological development." Excitingly, recent DNA sequencing shows that humans and jellyfish are more genetically similar than previously believed. If miRNA are, in fact, crucial to the process of transdifferentiation and the immortal life cycle of *Turritopsis nutricula*, then this research will bring the human race one step closer to the Fountain of Youth. n

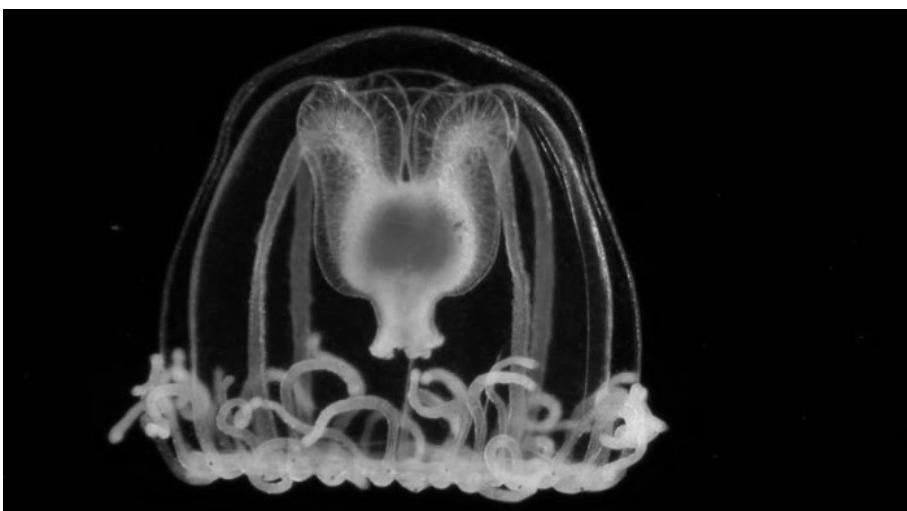


Photo courtesy of Alvaro E. Migotto

The Science Behind Emotional Pain

BY CAT FERGUSON, BEHAVIORAL NEUROSCIENCE, 2013



Anyone who has lost a loved one knows how badly it can hurt. An empty dresser drawer, a favorite corner of a coffee shop unfilled: every blank seems to frame a ghost. It's agonizing.

According to an Institute of Medicine study, "I can't stand the pain any longer" is among the most common phrases used in suicide notes. In 1984, a researcher asked thirty depressed patients with history of physical trauma which was worse, the psychic or physical pain. Twenty-eight of them said no physical pain they'd experienced was worse than their depression. A broken bone is sharp, tangible pain. A broken heart is diffuse, and all the more excruciating for it. It may be no accident that metaphors for emotional trauma frequently recall physical pain; there is growing evidence that hurt feelings and broken bones activate some shared pathways in the brain.

In a study on the pain of social exclusion, fMRIs were recorded of subjects who played a simulated ball game with two other players. After a few rounds, the other players stopped throwing to the subject. A part of the brain called the anterior cingulate cortex (ACC) lit up on the

scan. Another study showed the ACC is active in the brains of women looking at pictures of a dead loved one (perhaps the most solid scientific evidence on the dangers of Facebook).

In one study, when mother rats had their ACCs ablated, they stopped responding to distress cries from their pups. Only 12% of pups survived. In addition, squirrel monkeys with ACC lesions don't cry with distress when alone. Evidence points strongly to this sliver of brain in maintaining social behavior in mammals.

The ACC is a relatively old part of the brain, associated with many autonomic functions such as blood pressure and heart rate, as well as higher-order processes, including the experience of physical pain. In humans and great apes, the ACC is dense with spindle cells, an evolutionarily young type of neuron found only in humans, great apes, elephants, and some whales. In studies that subject many people to the same uncomfortable stimuli, those who report more pain have greater ACC activation. This suggests that the cingulate is responsible for the unpleasantness of pain, rather than the physical sensation. FMRI studies of chronic pain patients show strong ACC activity. Indeed, some

surgeons have used cingulotomy, the lesioning of the ACC (similar to a lobotomy), to mediate the effects of chronic pain. People who have undergone the surgery report that they can still feel the pain. It just doesn't bother them much anymore.

This self-report mirrors those from a recent study on the effect of acetaminophen, an over-the-counter analgesic, on the pain of social exclusion. After three weeks of taking the drugs twice a day, daily self-reports of social pain decreased. The subjects knew they were being excluded, but they didn't care as much as the placebo group did. A separate group of subjects also took a three-week dose of acetaminophen and then, while an fMRI was being recorded, played the simulated ball game described earlier. Again, they reported being aware of being excluded, but their ACC activity was reduced compared to a control group.

The more severe the emotional pain, the nearer it might come to physical pain. A 2011 study recorded fMRIs of 40 participants who had just undergone an unwanted breakup of a long-term relationship. When showed pictures of their exes, areas of the brain associated with the sensory processing of physical pain, including the secondary somatosensory cortex (S2), were activated much more strongly than when they were shown a picture of a friend. The response difference was about the same as when the subjects' forearms were touched by a warm object versus a painfully hot object. The S2 is known to activate during most physical sensations, from light touch to intense pain.

Nathan DeWall, an author of the acetaminophen study, told *Harvard Business Review*, "Probably what happened over the course of human evolution is that as we came to rely more on social inclusion for survival, the body's physical-pain system became the basis for a social-pain system designed to ensure we weren't fending for ourselves in a hostile world."

Stronger community ties correlate with better treatment outcomes for everything from cancer to chronic pain. Rats in groups respond less strongly to shock training than rats on their own. So next time you're hurting, surround yourself with friends. It will keep you strong out there on the electrified grid. □

NU Science Interview with NU Professor Albert-László Barabási

BY KEVIN FRANCIOTTI, BEHAVIORAL NEUROSCIENCE, 2013

Albert-László Barabási has found quite a niche for himself here in Boston. A distinguished professor at Northeastern and the founding Director of the Center for Complex Network Research (CCNR), he boasts perhaps one of the most enviable pieces of real estate the campus has to offer. Located on the top floor of the Dana Research center, the Barabási Lab is a stimulating hub of innovative, cutting edge research. Comprised of an interdisciplinary team of mathematicians, physicists, and computer scientists, the CCNR plays a leading role in the burgeoning field of network science, with the potential for exciting developments in medicine, understanding human behavior, and complex living networks. NU Science had the pleasure of sitting down with Barabási for an intriguing conversation about his work.

Barabási's first book, *Linked: How Everything is Connected to Everything Else*, compiled over a decade's worth of discoveries made through his own research along with fundamental theories proposed by his predecessors that helped shape what modern network science has become today. In sociological experiments, researchers relied primarily on questionnaires they had to collect individually from each participant. While this enabled them to ask very specific and pointed questions, the surveys came with inherent limitations that affected the objectivity and thus the scientific rigor of the data. What he terms the "game changer" is that people are making information about them available on their own. "What the internet has done to us is that it really created the means to record [information], and not that we record it, but people kind of self-report it."

One of the fundamental impacts the internet has made on network science is to provide researchers with access to a tremendous wealth of data on everything from trends on Twitter to YouTube hit counts. On the morning of our interview, the YouTube sensation and Korean pop star PSY became the fastest person ever to reach the top viewed video on the popular video sharing site. So what can we learn from the "Gangnam Style" YouTube phenomenon? Other than giving bad dancers a confidence boost, in the language of networks the concept of ranking is something Barabási says he is very interested in. "It completely set a different standard of what it means to be number one." For him, there



Photo courtesy of Cambridge Nights

are many questions worth asking, "What's the difference between #1 and #2? How do certain things in a self-organized matter run ahead and become in the top or stay behind? And at what point is it meaningful to talk about if one is better than the other one?" For many scientists whose goal is for their work to reach the level of Einstein or Darwin in terms of prestige, the dilemma presents a similar problem. It may take decades to build up the respect and reputation that is reserved for only the most brilliant minds. Though to truly reach the top, Barabási clarifies, "You become #1 not when you say you are #1, but because we all say you are #1!"

As our conversation shifts from the internet to medicine, there is a noticeable enthusiasm in Barabási as he discusses the promise of network science. "Right now we can tell you that there's a mutation in your genes, but we cannot tell you what the consequences are of that, partly because we don't have the map. We got the parts of the car but we don't have the blueprint on how to put it together." He outlines the necessity of taking the next steps towards personalized medicine which began with the mapping of the human genome sequence. "Eventually we will get to the day when you go to the Doctor's office and he or she will have your genome sequence," he says, noting that the world genomic movement will be wasted if medical research does not take the next step in understanding the network aspects of the cell. As it turns out, Barabási is

“ You become #1 not when you say you are #1, but because we all say you are #1. ”

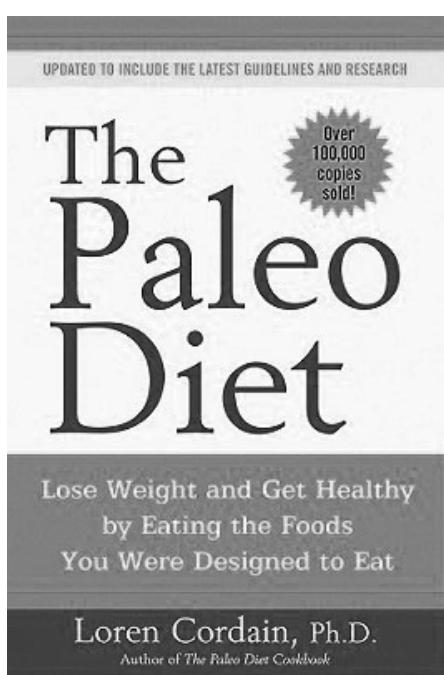
helping to put together Harvard Medical School's latest initiative to develop the new discipline of Network Medicine.

Despite having access to an unprecedented amount of information, Barabási is not satisfied. "If I could get access to your mobile phone data, knowing where you've been in the last five years, I can tell you a lot about your lifestyle, and I can start codifying that information." Due to the various legal controls companies have over access to personal data of their customers, he will have to remain patient, but he has hope for the future. When asked if he could envision a device or technology that would be as revolutionary to researching networks as the internet and mobile phones, he is more cautious. "Scientists are very bad prognosticators, we're not good at that, so don't listen to us." □

“The Paleo Diet” by Loren Cordain

A Book Review

BY JULIETTE KASSAS, BIOCHEMISTRY, 2015



At the start of every calendar year, we are always bombarded with advertisements about nutrition, gym memberships, exercise techniques, and diet plans – “Drop those holiday pounds” and “It’s a new year and a new you” are phrases everyone has heard frequently. Typically, I’m not the person to go out of my way to experiment with different dieting plans. I am a firm believer in eating clean and training dirty; that’s the only real way to achieve noticeable body change. Nothing happens over night, it takes a great deal of time and patience to see any type of results. At the beginning of this year, however, I came across a diet I had never heard of, The Paleolithic Diet, often abbreviated “Paleo.”

Over winter break, I stumbled upon “The Paleo Diet” written by Loren Cordain on the table reserved for popular reads at Barnes and Noble. I originally disregarded it and thought of it as another fad diet, but eventually came back to it. I learned that the diet is based off of the eating habits of our hunter-gatherer ancestors who lived during the Paleolithic era, hence the name. To put it simply, they didn’t have access to dairy products, processed foods, cereal grains, alcohol, or legumes. My eyes widened as I thought, “That’s more than half of my diet right there... How can people do this and be satisfied?” The diet restricts consumption of anything other than lean meats, seafood, fruits, and vegetables. I almost put the book down at that point, but then the author went into scientific detail about how these foods enhance the process of muscle growth and development.

The author takes the reader through a four-step explanation of the Paleo Diet and muscle development. She states in the first step that the diet is undoubtedly high in animal protein, which implies that it is rich in branched-chain amino acids (BCAA). This includes valine, leucine, and isoleucine, whose structures include isopropyl, butyl, and isobutyl R groups, respectively. I began to draw the structures out and I concluded that they were all non-polar, making them fatty, rich energy sources. The author states that these amino acids play a key role during the muscle growth and repair process after exercise. As we know, exercise is a physically draining activity. It demands a person to expend quite a bit of energy to recover afterwards. This speaks to the fact that the molecules involved in the repair process are rich energy sources, which the author deliberately highlights.

Her second point explains that when food is being digested, the contents are reported to the kidneys and they are rated as being acidic or basic. Muscle protein breakdown is promoted by a lower blood pH; this means that the more acidic the blood, the more likely it is to induce the reaction. The reason it does this is because the breakdown of muscle protein helps to neutralize the acidity of the blood. She goes on to describe that the typical “American diet” consists of salty, processed foods, which all promote blood acidosis. In contrast, fruits, vegetables, and lean meats are rated as basic when they reach the kidneys, so they reverse the muscle protein breakdown process.

The third point is very brief and states the importance of trace nutrients in a person’s diet. High quantities of antioxidant vitamins, minerals, and phytochemicals are found exclusively in fruits and vegetables. This implies that the “American diet,” loaded with refined grains, oils, sugars, and processed foods, does not suffice the body’s nutritional demands. These components are crucial for suppressing the affects of illness and aiding in the maintenance of a strong immune system. For the final point, the author explores the effects of the Paleo Diet on glycogen storage. It’s a common belief that loading up on sugars and carbohydrates are the ultimate way to store energy before long exercise sessions. She disproves this by again, bringing up the structure of the BCAA found in lean proteins. By breaking down the energy-rich bonds in these structures, exercise performance remains the same and the subject does not encounter the risk of storing any excess fat from the carbohydrates or sugars.

The book also provides the reader with multiple recipes to try, which helps them ease into this major lifestyle change. I found it a very intriguing and informative read, and I’ve attempted to start the diet within the past couple of weeks. One thing is for sure though: it’s going to take me awhile to adjust to a life without coffee, frozen yogurt, and the occasional trip to Qdoba. n



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