ISSUE 15

NUScience

Northeastern University's First Science Magazine

The Path to Sustainability

Investigating the ways we can reduce our environmental footprint

Also inside:

- Stopping deforestation with cell phones
- An exploration of off-shore wind farms
- How Big Data analyzes our online presence
- NuSci Explains: Fracking

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Are you looking for a creative way to showcase your work on campus? Do you want to boost your resume in a way that's creative, intellectual and fun? Become a part of 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 Ell Hall**. Come collaborate with us!

Letter from the Editor

Dear Readers,

As you can tell from the opposite page, we've got a large number of senior e-board members graduating this semester. Three of them have been with us since the magazine was founded and all of them have been absolutely essential to making this club what it is.

We're moving (begrudgingly) into a new, founder-less era in NUScience's history, but we don't mean to stop improving now. I've thought that each issue we produced this year was our best yet, and this one is no exception. Take another look at the cover. That is a good-looking cover. But more importantly, it calls to mind a key point: positive environmental change requires not just more efficient technology, but a shift away from some convenient, established systems to which we're all accustomed. It sounds obvious, but when you're trying to plan a magazine full of interesting topics, it's easy to overlook.

When we sat down to plan Issue 15, we talked a lot about emerging technologies with positive environmental implications, things like mycodiesel and new approaches to solar energy. However, we soon realized the need to expand the scope of our topics, calling attention to potentially dangerous issues as well. To this end, you'll find discussions about hydrofracking and saving the rainforest alongside innovations in green energy.

The contrast between the cover's green, natural footprint and its polluted counterpart invite numerous interpretations. Personally, I view it as a reminder of the need not only to develop new alternatives, but also to increase awareness of unsustainable options and move away from them. As new technology becomes feasible, we need to step towards more environmentally neutral replacements and leave behind the kind of energy sources that make Captain Planet sad.

Left foot, right foot. Left foot, right foot…

Michael Murray
Editor-In-Chief, Computer Science/English, 2014

NUScience Calendar of Scientific Events

Temporary Exhibit in the Art and Science Gallery
Ocean Stories: A Synergy of Art and Science
Museum of Science: Boston, MA
Currently On Display
A collaboration of artists and scientists working together to create an exhibit on the topic of oceanography

Blue Discoveries Family Day: Earth Day Celebration
New England Aquarium: Boston, MA
Sunday, April 21st, 2013
Additional activities related to Earth Day are available throughout the aquarium

Annual Riser Lecture
Northeastern University Marine Science Center: Nahant, MA
Friday, April 26th, 2013
The Marine Science Center will host a lecture by Dr. Paul Dayton entitled, Bottoms Beneath the ICE: Reflections on 100 Years of Benthic Ecology at McMurdo Sound, Antarctica

Goodbye to our graduating seniors

In 2009, there came upon this campus a great magazine - a magazine for science. With it came laughter, tears, scientific inquiry, questioning young minds, and of course, editors. Our senior editors will be leaving us as of May, but before they go, let's look at who they are, where they came from, and where they're going…

Bradley West
President, 2011-2012
First Headline - "College Night" at the Museum of Science Popular Among Students in the Area

Brad is going to be working towards getting his PhD in Electrical Engineering at Arizona State University. He will be researching defects in thin film solar cells, and then hopefully saving the world after that. Over the summer before school starts he plans to go skydiving and to do lots of yoga.

Elizabeth Gilbert
Co-Editor-in-Chief
First Headline - "The Newly Established College of Science's Dean Demonstrates Interest in Pursuing Innovative Technologies as well as a Commitment to Experiential Education"

Lizzy will be working towards her Master's Degree in Global Health and Public Policy at the University of Edinburgh. She hopes to work in international health policy, particularly in matters relevant to sub-Saharan Africa. After completing her master's degree, she plans to attend law school. Before that, her plan is to spend most of this summer in Cape Cod, hanging out with her mom and wheaten terrier... and taking a lot of naps. She's not sure if that's news-worthy, though.

Cat Ferguson
Current President
First Headline - PICTURE THIS: The Emerging Science of Mind-Reading

Cat Ferguson plans to flee the Northeast with her dog immediately after graduation. She is excited to be leaving behind the snow and sleet of our winters for UC Santa Cruz and their science journalism program. Though she'll obviously miss us all, we'll miss her more. You know, because there are collectively more members of the science magazine than there are Cat Fergusons.

Taarika George
Treasurer

After graduation, Taarika is going to be attending physical therapy school at MGH Institute of Health Professions.

Alyssa Sullivan
VP of Design

Alyssa is currently looking for a graphic design job with a design studio in the Boston area. Her experience is in print design, so she's hoping to work on brochures, publications, advertisements, annual reports, and anything else she can get her hands on.

The World's Smartest Calculator

BY JOSHUA TIMMONS, BIOLOGY, 2016

You know Google. It's the site with all the answers. While some might try searching with Bing, most people know Google on a personal level. It's the 10 seconds of research between a person with a computer and any lapse in human knowledge. It's knowing DiMaggio's on base percentage in 1938 compared to 1949: .387 to .459. It's the greatest index in recorded history, with a catchy mission statement: "To organize the world's information and make it universally accessible and useful." But if Google is the greatest librarian in the world, then Wolfram Alpha may be the greatest calculator. It can solve any inquiry you throw at it.

Google is a search engine. Type in "Joe DiMaggio Stats" and it spits out 400,000 results, all linking to existing web pages somehow related to the input words. On the other hand, Wolfram Alpha actually solves problems. Using structured data, the site solves any inquiry using math. Its data sets span everything from historical figures to colors, and other external sites continually augment its wealth of information. It's officially labeled a "computational knowledge engine," which is a jargon term for a program that uses internal knowledge to create results.

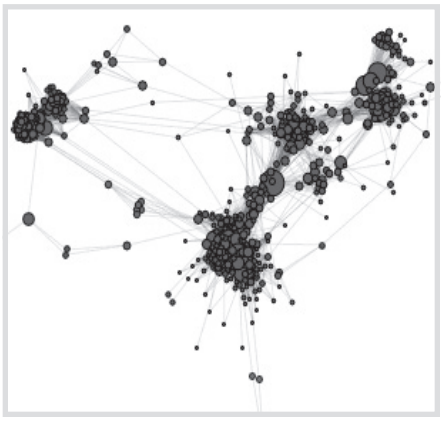
With basic keyword searches, Wolfram Alpha excels at getting to the pertinent information and cutting out the fat. A search for "dasatinib" yields a single page with the essentials: protein kinase inhibitor, 488.01 g/mol, PubChem numbers and an image of the complete molecular structure. Its easy display for organic molecules makes skimming Wikipedia or searching the tables of chemistry textbooks seem both arcane and arduous.

When applied to mathematical functions, its utility becomes even more indispensable. Almost any formula can be crunched down and spit out by Wolfram's intuitive graphs and detailed explanations. Punching in "0.00057x^2-0.000072x-2.5" results in the derivative, the integral, four alternative forms of the function, and step by step instructions for finding each of those functions, all in addition to interactive graphs. Setting the function equal to zero yields the two answers in seconds. A similar task on a T89 would take 10 times as long and be a tenth as informative.

But Wolfram Alpha is capable of doing more than physics homework. It can find all known organisms that give off cyan light. It can compare historical stats between any two football teams. It can find out the number of unique words in any given Shakespeare play. It can make a random password or let you know if you're drunk. It can track the occurrence and use of any name over the past 400 years: Joshua is 14th most common male name in the U.S. and experienced a spike in popularity during the mid 80's.

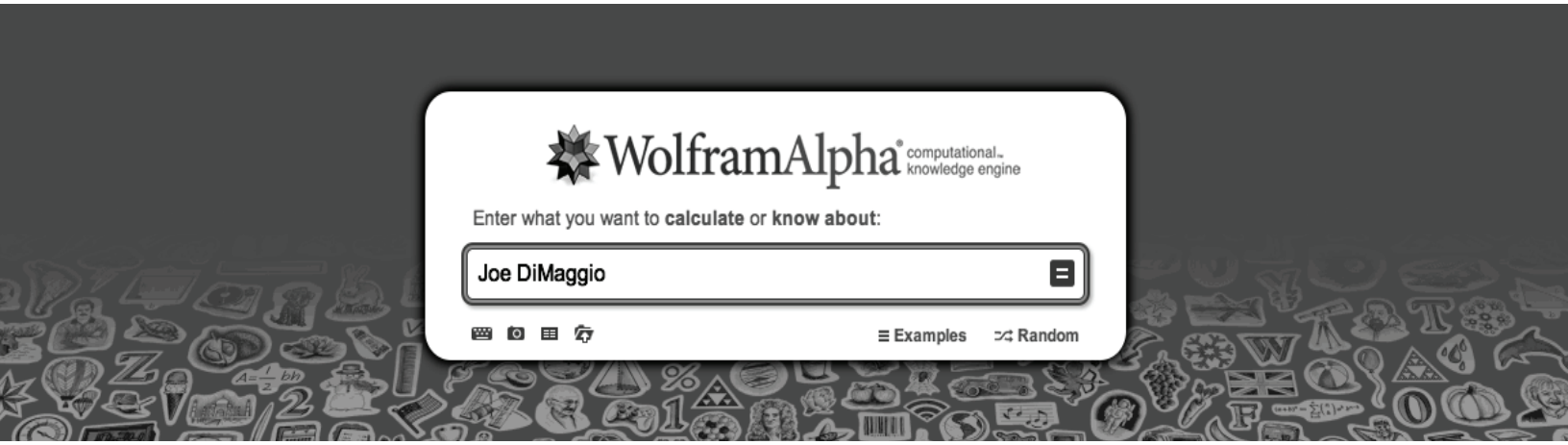
The program itself is based on Mathematica, a dense program with six million lines of code. It runs on over 10,000 CPUs with a couple supercomputers to boot. When first launched, Wolfram Alpha had over 10 trillion individual chunks of data. Some of this data is constant, such as historical weather patterns in Nicaragua. Other data is being updated real-time - think stocks and sports.

Wolfram Alpha has received extra attention lately for its new tool, Facebook Analytics. Allowing it access to your friends list creates an enormous page with the typical lists of data all related to a user's Facebook interactions. Some seem narcissistic: "most liked photo" and "friends with the most friends." Others are humorous: My oldest friend is 115, for example.



It's the Friend Network map, however, that's the most profound. It uses mutual friend stats to track your place in a social network. With each dot representing a different friend, the scatter plot puts you in a web surrounded by your friends and peers. College, high school and family friends all branch into their respective groups; it looks like your entire social network displayed in a succinct colored graph. It's the real utilization of online interactions to map our external reality. Perhaps it's this connection that led 400,000 people to get their report within the first few weeks of the release.

If you're ever bored, and Internet cats aren't quite so amusing, try Wolframing a word or a date. Or better yet, try pressing "random" and going to whatever comes up. The breadth of Wolfram Alpha is staggering and the possibilities are quite literally infinite. Take a break from Google, and give the world's smartest calculator a shot. n



Photos courtesy of www.wolframalpha.com

Big Data: It's a **Big** Deal

BY JOHN JAMIESON, CHEMICAL ENGINEERING, 2015

Ever notice how oddly specific certain online ads are? One day you send an email about math tutoring, and the next day every single ad in your Gmail account is about tutors or math? Or you are shopping for new sneakers on Amazon, and suddenly ads on Pandora are trying to sell you sneakers?

Time Magazine ranked "Big Data" the number two buzzword for 2012. So, exactly what is it?

Big Data refers to the ability to collect and analyze massive quantities of information in real time. Generating data is only the first step. The real power of Big Data is in the analytical techniques used by data scientists to spot relationships and create correlations.

Advances in large-scale data analytics will revolutionize health care in particular. Implantable and wearable biosensors that monitor patients' hearts, implants, blood glucose levels, and tumor growth or that track drug delivery already exist, and are becoming less invasive, less expensive, and smarter in their functionality and ability to communicate results.

These sensors can automatically alert a patient's doctor the instant an irregularity occurs. In many cases, doctors can pair sensors with other devices that respond appropriately, by releasing more insulin to the bloodstream or by defibrillating a patient's heart. Continuous, reliable monitoring of patients from their homes could significantly reduce the length of hospital stays and the number of patients requiring hospitalization.

OUR CARS. OUR BODIES. OUR HOMES. EVERYTHING IS STARTING TO GENERATE DATA.

Rick Smolan, Author of
"The Human Face of Big Data"

Sensor-based health care applications will begin primarily with the elderly. Consider a wearable accelerometer that detects when an elderly person falls and then automatically signals for help. Or a smart pillbox, which can provide an alert if the contained pills were not taken on time. Is it possible that 20 to 30 years from now, everyone, even the young and healthy, could have small sensors continuously monitoring their EKGs?

Medicine can also become more personalized. Genetic screening could determine a drug's possible effectiveness for certain patients. For example, Herception, a breast cancer treatment drug, is successful for patients with the HER2 gene, but that only accounts for 20 to 30 percent of cases. A pre-treatment screening would determine if a person has the gene and if Herceptin should therefore be administered.

The computing power of IBM's WATSON proved its effectiveness in data analysis for answering "Jeopardy!" questions. Doctors could use that technology in a similar device loaded with research papers and clinical trial data to recommend treatment given an individual's age, gender and other health factors. Applications of data are abundant in other fields as well: Smart phones have provided people with incredible convenience and function, from built-in GPS to the ability to ask Siri anything the heart desires.

However, the conveniences of Big Data are only made possible by a dramatic increase in the collection of data from individuals. Consider how every time you download an app, it notifies you of the list of information that it will access. You usually click "Agree" without any concern that the app may access contacts, calendars, GPS locations, Facebook posts and other personal information. This could be a concern in regard to your privacy. Anytime you make a purchase, visit a website, or even use your phone, you generate data about yourself without even thinking.

Additionally, websites sell your clickstream to advertisers to help target ads. Your browser history, while insignificant to you, is extremely valuable to a company trying to sell you a product. As any business knows, having real-time knowledge of consumers' needs provides a huge competitive advantage. Understanding the behavioral patterns of groups and detecting deviations from these patterns is the key to Big Data.

Credit card companies' profits rely on their ability to accurately assess a customer's risk level. By analyzing the purchases you make, companies can learn a frightening amount about your life, such as if you may be headed for a divorce and if you are therefore a higher credit risk. Believe it or not, companies have developed a "divorce algorithm" listing approximately 40 things, and if you start to match up with too many, they will mark you as a higher credit risk. They look for things like sending flowers to an address that isn't your own, staying in a hotel in your home city, frequenting singles bars, having your teeth whitened or even joining a gym.

Insurance companies also assess risk. Many car insurers push customers to install a sensor on their cars that tracks their driving habits in return for a slight discount.

Even more dangerous is the chance that increased use of genetic screenings in health care could lead to personal genetic information finding its way into the hands of health insurers, who could then charge customers differently based on genetic predispositions. Even your web browsing history would be valuable for an insurer looking to determine your risk.

The amount of data will only continue to grow. Who owns this data, and what are they allowed or forbidden to do with it? How much control do we really have over what data we share and with whom we share it? This is a conversation that needs to start now before it's too late so that people can be in control of their personal data, what is done with it and who profits from it.

Every tweet you tweet, photo you Instagram, Youtube video you watch and every question you ask Siri is stored in a massive database somewhere. It is a data tattoo–absolutely permanent. n

Salt of the Earth

BY EMILY ASHBOLT, PHYSICS, 2017

There is a science to the pressure needed to bite though a potato chip. There is a science to the color of soda, the way crackers feel in one's mouth, the pattern on the cookie bag. Any food product that is being pulled out of a package to be consumed has been perfectly formulated through long processes of trial and error to be the most appealing it can be.

Unfortunately, this system does too much for the consumer; by delivering exactly what their taste buds want. This is great news for the companies, which now have an inconceivably massive arsenal of ways to make their products more desirable. However, it can wreak havoc on the consumer. As Pulitzer-Prize-Winning Journalist Michael Moss elaborates in his latest book, *Salt Sugar Fat: How the Food Giants Hooked Us*, published this past March, what makes processed food more desirable to humans are three things that humans, particularly in America, could really do with a little less.

Salt, sugar and fat.

All three of these nutrients are vital to living a healthy life. Throughout all of human history, mankind has had to eat foods featuring these components or face terrible consequences. These can include being unable to absorb vitamins, regulate the body's water pressure and balances, or transmit nerve impulses that allow muscles to move and contract, among many other things.

However, in excess, these food components cause severe problems such as raised blood pressure, heart disease, diabetes and obesity- and they are certainly in excess in the current market's processed foods.

The human body is extremely susceptible to being tricked by the high availability of processed foods containing these components. Not only are these foods "tasty" and encourage a social recall of pleasant experiences, but from a biological standpoint, since finding foods like this was rare when humans roamed the plains, the body wants to consume as much as possible while it is available.

There is nowhere this is more evident than with salt.

Companies mass-producing processed foods were quick to catch on to the idea that salt made their foods taste better and made people want to buy more. At this point in time, salt is in high quantities of almost anything from a package, and woe betide it go missing: Moss, while researching for his book, took a trip to Kellogg headquarters, where they made for him salt-less versions of their most famous snacks. Cheeze-its, understandably salty, were to Moss "a god-awful experience", but even foods one might imagine being low in salt or with salt having little effect were drastically twisted by removing it- frozen waffles " tasted like straw" and "the real moment came in tasting a cereal – I think it was Corn Flakes – which tasted hugely, awfully metallic." Salt balances out flavors, preserves, and it actually makes people want more.

In 1985, it was calculated that salted foods made up as much as 40% of the total energy consumed when salt is readily available- and such a statistic is likely to only have increased since then. The craving can even be rooted in one's genes: Rats fed junk-food during pregnancy have offspring that prefer processed and salted food, and as such are far more likely to develop obesity. A study done at the University of Florida in 2008 even revealed neuropsychiatric evidence that salted foods can act like mild opiates, and that consumers can very easily become addicted to them, leading to a downward spiral of overeating and the following health problems.

There is hope, however. Frito-lay may have a team of nearly 500 chemists and psychologists working to find more weird and wonderful ways to keep the world snacking, yet they cannot overcome the sheer power of human biology. The more one consumes such salty, processed foods, the more one craves them. However, the opposite is also true. One can actually train oneself to no longer desire such food products by cutting extreme sodium out of one's diet. It takes, on average, less than two weeks for the taste buds to readjust and not even have cravings for whatever is missing.

While the lengths at which companies will go to keep themselves in the black is sometimes horrifying, there is another positive- many big food processing facilities are seeing the problem of obesity facing the US, seeing the way the public is reacting to some of their products, and are taking a new root. There is talk of a breakthrough in the works for a sodium substitute- something that could provide a similar flavor with less of the negative health benefits. Perhaps it seems pie in the sky, but one should never underestimate the drive these businesses have to stay ahead of the curve- or the funds they have and are willing to use to get them there.

Though food scientists may be experimenting in every way possible to get you to try their latest flavors, in the end, only you can decide exactly what you put in your mouth. n

The Neuroscience of Partisanship:

Do Differences in Brain Activity and Anatomy Relate to Political Party Preference?

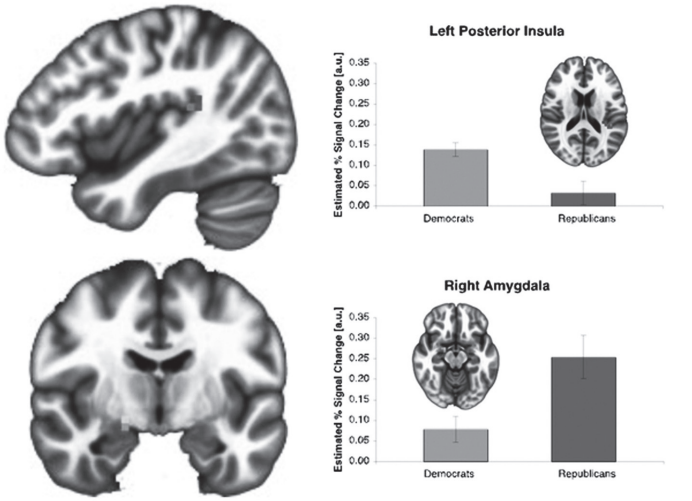
BY KRIS WEBER, BEHAVIORAL NEUROSCIENCE, 2017

Jon Stewart versus Sean Hannity, the Occupy movement versus the Tea Party, MSNBC versus FOX News; it doesn't take an expert to appreciate the vast ideological split in our society's political structure. From abortion to gun control, how is it possible for one country to be so polarized in its beliefs? As a recent study at the University of California, San Diego suggests, biology may actually underlie such extreme differences in opinion.

Darren Schreiber, Ph.D is a 'neuropolitical' researcher at the University of California, Los Angeles and the University of Exeter. Along with a team of UCSD researchers, he conducted a study to determine how American liberals and conservatives differ in neural processing. Participants took part in a gambling game in which they were presented with three numbers (20, 40, and 80) for one second each. During the display of the number, subjects were to decide whether or not to press a button. Pressing the button during the display of '20' would result in a gain of 20 cents; pressing it during the display of '40' or '80' would result in either gaining or losing that respective number of cents. Thus, while pressing the button during higher numbers offered a chance to win more money, it also carried with it the risk of loss. During this simulation, brain activity was measured using a functional MRI (fMRI), and results were compared with self-reported political affiliation.

There was no difference in behavior observed between Democrats and Republicans during this risk-taking simulation; however, there were significant differences in brain activity. When assessing risk, subjects who identified as Democrat displayed more activity in the left insular cortex, while those who identified as Republican showed more activity in the amygdala. (It must be taken into account that the sample group consisted of 60 Democrats but only 22 Republicans. It is unclear whether or not the greater proportion of Democrats skewed the results.) The left insular cortex has been associated in previous studies with both empathy and "theory of mind," or the awareness of other's and one's own internal drives and states. The amygdala, on the other hand, is associated with emotion and fear processing, as well as one's sensitivity to potential threats.

In addition to such differences in cognitive processing, the neural anatomy of liberals and conservatives may differ as well. A 2011 study of students at the University College London found that the amygdala occupied more space in the brains of conservatives, while the anterior cingulate cortex–an area associated with one's ability to deal with uncertainty–was larger in liberals. (Again, the sample must be taken into account. When rating themselves on a scale of 1-5–very liberal to very conservative–no participants rated themselves as a '5.' Thus, the experimental model was shifted to a scale of 1-4.)



Volume	x	y	z	Side	Area	t	p
Dem>Rep							
384	-36	-40	18	Left	Insula	3.153	0.002
Rep>Dem							
448	20	-6	-10	Right	Amygdala	3.774	<0.001

Graphic courtesy of www.plosone.org

These findings from UCL reinforce the conclusions drawn by Schreiber's team. Essentially, Democrats seem better able to deal with the uncertainty of a risky decision, and more willing to make such a decision if the potential outcome holds promise for improving the situations of themselves and others. Republicans seem to have a greater sensitivity to possible threats, due to the amygdala's role in the 'fight or flight' response. They tend to be cautious and wary of uncertainty, more likely to stick with tried-and-true methods. This dichotomy is clearly illustrated by the ongoing conflict over the Patient Protection and Affordable Care Act ('Obamacare'), a bill which essentially proposes a revamp of the country's healthcare system. During the Senate's 2009 vote, all Republicans voted against the bill, while all Democrats voted for it.

Ultimately, analysis of neural activity during risk assessment remains the most accurate predictor of political orientation. Researchers correctly identified party preference 82.9% of the time when analyzing activity in the insula and amygdala, as opposed to 71.6% when basing predictions on relative grey matter volume, and 69.5% when using political preferences of the subject's parents (a well-established predictor). Indeed, some researchers believe that these differences in cognitive processing may actually lead to changes in brain structure. It is not that liberals and conservatives are born with completely different brain anatomy; rather, their different methods of assessing decisions direct more bloodflow to certain areas over others, eventually resulting in anatomical differences.

Unfortunately, no definitive answer has been found for the basis of such differences in neural processing between Democrats and Republicans. As research for more specific underlying factors continues, it is important for both groups to acknowledge that regardless of biology or belief, we are all human. In an age filled with political polarization and sensationalist propaganda, we would do well to remember this fact. n

Advances in Nanotechnology: A Sobering Report

BY SUMAYAH RAHMAN, BIOLOGY, 2016

Charles Darwin famously said, "an American monkey, after getting drunk on brandy, would never touch it again, and thus is much wiser than most men." Although most drinkers are fully aware that alcohol is toxic in large quantities, excessive consumption is a major problem and causes 80,000 deaths per year in the United States according to the Centers for Disease Control and Prevention. However, a groundbreaking study by a team of researchers at the University of California, Los Angeles, reveals that it may be possible to lower blood alcohol content (BAC) and reduce liver damage simply by taking a single pill.

Two enzymes, alcohol oxidase, which converts alcohol to the toxic substance peroxide, and catalase, which converts peroxide to water and oxygen, were encapsulated in a polymer shell. This enzyme nanocomplex, a stable structure of enzymes that function together, was named n(AOx-Cat). n(AOx-Cat) was fed to intoxicated mice, which reduced BAC by 10% at 45 minutes, 32% at 90 minutes, and 37% at 180 minutes. Additionally, mice treated with n(AOx-Cat) had significantly lower levels of alanine transaminase, a biomarker for liver damage. Dr. Yunfeng Lu, the scientist that led the team, stated, "with further research, this discovery could be used as a preventative measure or antidote for alcohol intoxication."

Enzyme complexes are ubiquitous in nature and are necessary for many standard biological processes, but constructing stable clusters of enzymes in the laboratory is extremely difficult. For this reason, the creation of n(AOx-Cat) marks a great achievement in nanotechnology and sets the stage for the development of other enzyme nanocomplexes that can be used for many different applications. For example, the possibility of creating an enzyme nanocomplex to prevent hair loss is currently being explored.

Although the development of a "sober pill" is still in the very early stages, it is clear that the existence of such a pill would have profound effects. With an accessible remedy to alcohol overdose, lives may be saved and liver damage may be prevented. However, would having this remedy available cause drinkers to be even more reckless with their consumption? This remains to be determined, but it is clear that the most obvious solution to the negative health effects of alcohol would be to prevent overconsumption in the first place. n

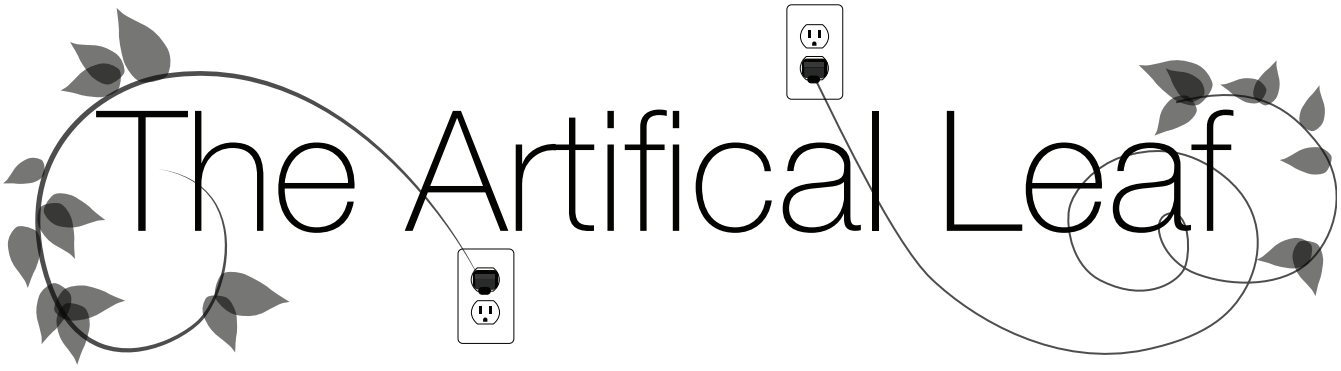
BY SAMUEL BOSCH, BIOLOGY, 2017

In 2008, microbe hunter Gary A. Strobel and his team published a paper on the fungus *Gliocladium roseum*, which holds potential as an alternative energy source. *Gliocladium* is an endophyte, a fungus that is part of an endosymbiotic relationship with a plant. Its host is the Ulmo tree (*Eucryphia cordifolia*), native to Patagonia. Inside this tree, the fungus produces a wide variety of volatile organic compounds (VOCs), some of which can be siphoned off to create crude oil. Strobel grew the fungus on cellulose medium, where it still produced VOCs. Cellulose is the most common organic compound on Earth, leading to exciting possibilities for alternative fuel sources.

Two years later, Strobel's son, Scott, released his own findings that tested the VOC production of a similar genus of fungus (*Ascocoryne*). The fungi produced over 100 distinct VOCs, several of which are promising candidates for biofuel. Gary Strobel returned with another paper in 2012, testing yet another genus (*Hypoxylon*) that gave off many VOCs. This time, the types of VOCs differed per individual. He and his team pointed to the epigenetic modulation of the fungus by the host plant (basically, the tree changed the gene expression of the individual fungus so it produced different chemicals than other fungi of the same genus). This leads to interesting questions and potential research opportunities for those studying gene modification.

Using fungi as fuel, which Gary Strobel calls "mycodiesel", would have innumerable positive effects. If crude oil can be made from a fungi that reproduces easily in a laboratory setting, that will mean inexpensive and relatively easy production of carbon fuel. One of the primary concerns about other biofuels is their impact on the global food market, such as growing corn for ethanol. If these fungi are able to produce fuel directly from cellulose, we can use non-food, fibrous plants as the medium, and not have to worry about creating food just to destroy it. Growing corn also uses a great deal of carbon fuel, limiting the net gain of energy. Producing cellulose uses much less.

To "cap" it all off, the Strobels are looking into the genes that allow for the production of such VOCs. Using the information gathered from this research could allow for faster implementation and production, and even lower costs. It's possible that if interest in this source of alternative energy increases, we could be pumping fungi fuel into our gas tanks in the near future. n



The Artifical Leaf

BY LAUREN HITCHINGS, BIOLOGY, 2014

A new innovation in solar technology, known as the "artificial leaf" is currently taking the next big step towards becoming a commercially available product for affordable green energy. A team of researchers at MIT, led by professor Daniel Nocera, developed this new technology to mimic the photosynthetic process that plants use to harness energy. Unlike the common model for solar technology, which harnesses energy from light and stores it as electricity, the artificial leaf uses the energy from sunlight to split water molecules. The resulting gaseous products can be harnessed and stored as a chemical fuel to be used as an energy source later on.

The artificial leaf is made of a thin layer of silicon and is very similar to an ordinary solar cell in structure, but the difference lies in the catalytic materials bonded to each side of the silicon. On one side is a layer of cobalt-based catalyst that releases oxygen, and on the other is a coat of nickel-molybdenum-zinc alloy, which releases the hydrogen atoms from water. When placed in a container of water and exposed to sunlight, the device immediately begins to generate streams of oxygen and hydrogen bubbles from the respective sides. If a barrier is placed to segregate the streams from the two sides, then the gases can be collected and stored for later use. They could potentially be combined once again into water by another type of fuel cell in order to produce an electric current.

While other devices have been made to split water using sunlight, most have required the use of harsh corrosive solutions, or expensive, rare materials such as platinum. The artificial leaf is a much more realistic option to be put into commercial use in energy production because it is made mostly of silicon, nickel, cobalt, and other earth-abundant, inexpensive materials, and it works in ordinary water. It is also very portable and lightweight, and requires very little additional equipment to maintain. The hope is that eventually this eco-friendly technology will become an inexpensive and efficient way to provide people with electricity, particularly in developing countries where it is not widely available otherwise.

While the "proof of concept" paper, published in 2011, showed that this technology was possible, little research had been done in optimizing efficiency. Researchers at MIT just recently published a new paper, which analyzed in detail many of the possible challenges and limitations on the efficiency of this device, and laid out a plan for improving the model enough so a practical and commercially viable prototype could be produced. By pointing out the challenges that lie ahead, researchers hope to be able to address and solve each one experimentally.

The artificial "leaf" created in 2011 had a very low efficiency, and was only able to harness about 4.7% of the total available energy. With the implementation of new methods, researchers now hope to raise that value significantly. By using single-bandgap semiconductors, like crystalline silicon, the team working on the project expects the efficiency to reach 16% or higher. They also hope to test different solar cell and catalyst combinations in order to determine the best possible components to include.

A major goal the team has been to increase the voltage produced by a standard silicon solar-cell, which ordinarily produces a voltage of 0.7 volts. By pairing cells in a series, the researchers hope to increase the voltage to a level high enough to power the water-splitting reaction; a feat that requires at least 1.2 volts. While the scientists know this will lead to some losses at the interface between cells, they are still are optimistic that this approach will yield higher efficiencies overall.

Another limitation on the efficiency lies in the inherent inefficiency of water. Electrons must travel through water to complete a circuit, but that water is resistant to the electrons. A possible way of improving efficiency of water is to lower its resistance, which can be done by reducing the distance the ions must travel through the water to complete the electrical circuit. In the case of the artificial leaf, using interleaved plates may be a solution for decreasing the distance between the two sides of the reaction.

While it may seem like a pessimistic process for researchers to write an entire paper dedicated to describing the obstacles that lie ahead for this technology, it is in fact an important jumping-off point for the future of this product. As Tonio Buonassisi, associate professor of mechanical engineering, and one of the contributing authors to the paper explains: "We don't always get it right, [but this type of analysis] lays a roadmap for development and identifies a few 'levers' that can be worked on." By laying out the challenges in a clear, well-analyzed manner, they will be much easier to face as the researchers at MIT move forward.

Some of the predicted limits of solar-cell efficiency have already been exceeded, and by acknowledging and pushing these limits, the team responsible for the development of the artificial leaf may soon be able to break into the commercial world with a revolutionary new product. While the limits of the artificial leaf as an energy source are becoming more defined and narrow, the impact an energy source like this may have on human society is entirely unbound. n

NUSci Explains...

FRACKING

(and Why It Makes People So Mad)

BY CLAUDIA GEIB, JOURNALISM/ENVIRONMENTAL SCIENCE, 2015

Jason and Debby Kline didn't think much of it when their water started fizzing. The Ohio parents knew that a company had begun drilling into underground shale nearby for natural gas using the controversial practice known as fracking. Yet they didn't think that the site had anything to do with their bubbly water, or that it could pose any threat to their family. That is until Debby placed a candle next to a running sink, and the air from the tap to the ceiling lit on fire.

The explosion was linked to the escape of methane gas, which occurs naturally in shale formations, from the Kline's water. Prior to fracking began nearby, the Kline's water had a methane level of 9 milligrams per liter, which is considered safe for use. A few months later, the water was tested and measured at a level of 22 mg/L. While methane doesn't pose a danger dissolved in drinking water, when it escapes into the air, it's both extremely flammable and can act as an asphyxiate by displacing oxygen in the air, much like carbon monoxide.

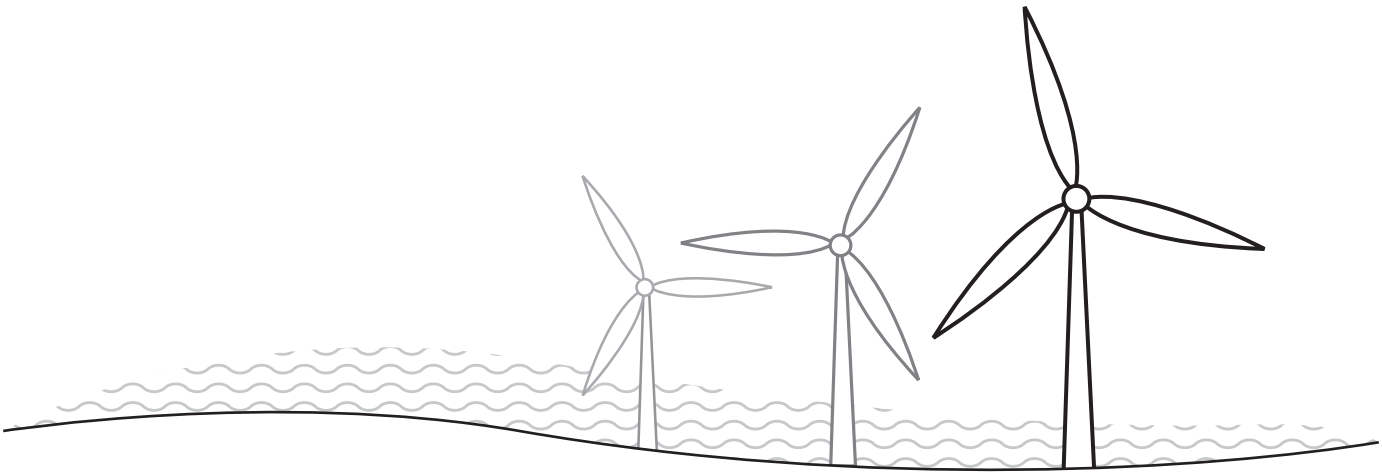
This has become the new reality for American families. As hydraulic fracturing begins nationwide, the side effects of drilling have many people asking about what's happening in their backyards.

Hydraulic fracturing, or "fracking," is used to withdraw valuable substances like petroleum and natural gas from reservoirs deep within the earth. At the depths that these substances lie, the rocks surrounding them may not be permeable enough, or pressure may not be great enough, to allow oil or gas to flow into a well for extraction without help from the surface. Fracking provides this extra push. After drilling vertically to the desired depth, workers then drill a well horizontally into the rock where oil or gas lies. They propel a mixture of water, sand and chemicals through the horizontal well at high pressures, which causes the surrounding rock to fracture. Oil or gas can then flow easily through the new fractures into the well and be pumped to the surface.

Vertical fracking has been used to stimulate wells slowing in production since 1949. The recent nationwide boom in fracking comes from new technology that uses horizontal drilling as well as higher pressures and volumes of water than used previously. These advances allow companies to drill into shale, a hard, impermeable and previously untappable rock which can contain oil and natural gas. The possibility of shale for fuel production means that drilling can now expand into areas previously untouched by the oil and gas industry, such as the northeast United States, where the enormous Marcellus and Utica shale deposits below New York, Pennsylvania, West Virginia and Ohio contain the potential for trillions of cubic feet of natural gas.

Fracking has the capacity to bring billions of dollars into the economy and drastically cut U.S. dependence on foreign oil. Yet stories about pollution of drinking water aquifers by the chemicals used in fracking have made many wary about expanding the industry nationally. The gas and oil industry maintains that there has never been a proven case of water contamination caused by hydraulic fracturing, and that fracking occurs too far below aquifers to pose a threat. Yet there was an instance discovered as early as 1984 of fracking fluids contaminating a West Virginia home; stories like the Klines' continue to roll in.

Gas and oil companies are lobbying against bills in Congress that would force the natural gas industry to comply with the Safe Drinking Water Act, under which they would be required to disclose chemicals used in fracking. Abroad, companies are preparing to tap shale gas reserves beneath Europe and China, which combined could produce twice the amount of natural gas as the United States. Meanwhile, filmmakers like Josh Fox, director of "Gasland", and celebrities such as Yoko Ono, Scarlett Johansson, Mark Ruffalo and Alec Baldwin have taken a public stand against the drilling, supported by a grassroots movement of impassioned "fracktivists." With fracking underway in 31 states and beginning to spread across the globe, the debate over this practice is far from over–in fact, its players are just getting oiled up. n



Offshore Wind Farms:
Coming Soon to a Coastline Near You

BY KATHERINE HUDSON, MARINE BIOLOGY, 2017

For centuries, wind power has been relied on as a source of mechanical energy for farmers and other rural areas. In recent years, technology has been developed to turn that same mechanical energy into usable electricity. As this technology becomes increasingly efficient, many countries are looking to wind power as a new and exciting renewable energy source.

The structures used to transfer the kinetic energy of the wind into mechanical energy and finally into electrical energy are known as wind turbines. Depending on wind densities and turbine size, wind turbines have the capability of producing from as little as 100 kilowatts of electricity to as much as several megawatts. Putting these figures into perspective, turbines producing below 100 kilowatts of electricity can be used to power individual homes. Those producing over 100 kilowatts and up to several megawatts of energy can be used to power entire communities and towns. These typically large turbines are most efficient and cost effective when arranged in wind farms, arrays of wind turbines capable of producing large quantities of energy.

However, complicating their usage, wind farms are only able to fulfill their energy potential when placed in areas of high wind density. These areas, unfortunately, are often hard to find or unavailable for use. As a result, many wind farms have been placed offshore, where wind density is higher. Europe has taken the lead with this initiative, constructing wind farms off the coasts of Denmark, the United Kingdom, Ireland, Sweden, and the Netherlands by the end of 2006. Currently, more than 1,600 turbines operate off the shores of Europe.

In the United States, steps are being made toward implementing a wind farm in the Massachusetts area. This project, called Cape Wind, is the first of its kind in the United States and is planned to begin construction by the end of 2013 off the Nantucket coast. The 130-turbine wind farm will cover 25 square miles, with each individual turbine standing at approximately 260 feet above the ocean. For comparison, at their highest rotation, these turbines would be nearly 60 feet higher than the Statue of Liberty. The turbines are to be anchored to the seabed and the electricity would be carried to shore via undersea cables. The Cape Wind group has estimated that this wind farm could supply Cape Cod and the nearby islands of Nantucket and Martha's Vineyard with a massive 75 percent of their electricity needs.

A controversial alternative energy endeavor, Cape Wind has been met with much criticism and opposition. The project was only able to finish the approval process at both the state and federal levels by the end of 2012, 11 full years after the project began. The exhaustive legal battles that the project has endured to work through 17 now completed approval processes have inspired a documentary titled "Cape Spin," termed by the New York Times as a "'tragicomic' look at one of the nation's most protracted energy infrastructure battles." Many journalists and authors have also published their opinions on the painstakingly long approval process, naming it a disgrace of the American political system.

Among the reasons for this lengthy approval process was the opposition's belief that the project would negatively affect marine life– incidentally one of their strongest arguments against the project. However, the current body of research is not extensive enough to support or negate their claim at this time. Additional research is currently being conducted on European-based wind farms to determine their effects on the proximate environment.

While studies in 2005 and 2006 suggested that bird species and harbor porpoises avoid wind farms after their construction, the displacement has not been shown to significantly affect local population density overall. Other issues implicating marine life, including the disruption of bottom habitats, have been dismissed as having negligible or minor direct effects.

Further challenging its criticisms, the Cape Wind project has many positive aspects that have allowed it to persevere through the approval process. The project would provide a clean, reliable energy source to Cape Cod and the surrounding islands with little to no carbon dioxide production– a factor that will become increasingly important as global climate change becomes a more pressing issue. The wind farm would also help boost the economy, through providing construction and maintenance jobs for residents of the area as well as an educational diversion for schools and ecotourists. Cape Wind also promises that the wind farm will not interfere with commercial shipping lanes, nor cause problems for recreational boaters. It even claims that the presence of the wind turbines may create habitats for commercially valued fish and increase fishery catches and revenue.

Despite its setbacks, the Cape Wind project is a promising one that will help propel the United States toward an end goal of sustainability and energy independence. The project has already paved the way by being the first to face the problems of current government restrictions head-on. Cape Wind has opened up many possibilities that all renewable energy industries can take advantage of to help the nation take the initial, necessary steps toward sustainability. n

The New Frontier of Speed: An Alternative to Air Travel

BY ANDREW BLOY, BIOLOGY, 2016

No one likes flying. Checking bags and waiting in long lines for the inconvenience of customs make air travel highly unpleasant. In addition, burning jet fuel is expensive and contributes significantly to atmospheric pollution. With an energy crisis looming, there is a significant market for an alternative to jet-powered travel.

There may be a solution on the way. Vactrains are trains that use the power of magnetic levitation inside a vacuum tube to achieve speeds around 2,500 mph using nothing but green alternative energy. Speeds like this would not only offer a viable alternative for air travel, they would seriously undercut current travel times offered by airplanes. At that speed, a trip from Boston to Chicago would take about a half hour. Boston to Los Angeles would take slightly under an hour.

This may seem like science fiction, but all of the technology required to build Vactrains is currently in use commercially. The mind-blowing speeds could potentially be achieved using maglev trains and vacuum tube technology. Maglev trains, short for magnetic levitation, use powerful electromagnets embedded in the track to hover about a centimeter off the track, eliminating the friction experienced by traditional trains. Maglev trains can attain speeds over 350 mph on test tracks. The electromagnets in the track can be switched on and off as needed, allowing sections to be powered on while supporting a train and powered off while dormant, drastically cutting energy consumption. Maglev trains also make use of regenerative braking, meaning that a significant portion of the energy used to accelerate the train can be reclaimed while the train is slowing down. A study conducted by Massachusetts's own Worcester Polytechnic Institute found that over the same distance, Maglev trains only consume 25% of the energy expended by aircraft.

In addition to being more energetically efficient, maglev trains are also quieter and more environmentally friendly than conventional trains or air travel. They are also much better at climbing hills. Maglev trains can climb grades of up to 20% with negligible speed loss. Traditional trains can only perform this feat on a maximum 3% incline. Therefore, maglev technology could reduce the need for expensive tunnel building in mountainous regions. Because the trains never come in contact with the track, the wear and tear associated with conventional trains is negligible, drastically reducing the cost of maintenance.

A 19-mile Maglev system links Shanghai airport with the city of Shanghai. Regularly operating at speeds in excess of 250 mph, the train makes the 19-mile trip in around 7 minutes. Over greater distances the efficiency increases, because the train can spend more time at top speed instead of accelerating and decelerating. Three Maglev systems currently serve the public around the world, with one more under construction. They have been proposed in numerous countries, ranging from the United States to Indonesia.

However, to unleash the true potential of the Maglev train, it must be placed inside a vacuum. Most of the energy Maglev trains consume is used to overcome air resistance. Once this factor is eliminated, the potential speed of the trains skyrockets. Without friction or air drag, the train could travel as fast as the magnets could carry it (about 5,000 mph). The technology needed to remove the air from these tubes can be found at most drive-thru banks across the United States. To create this vacuum, all that is required is an airlock at either end of the tube, and pumps to remove air. The entire system could be powered without the use of fossil fuels.

As with most groundbreaking technologies, the vactrain is not without problems. They have never been tested on a large scale, leaving questions about feasibility. The cost of creating the track is also a deterrent. The 19-mile system in Shanghai cost $1.2 billion dollars to construct. Even at the ideal future cost of $28 million per mile, a Maglev track would still be much more expensive than conventional rail. These costs are only for the track. It would cost more to create a sustained vacuum for the trains to operate inside.

Vactrains may seem far-fetched today, but it would be naive to ignore their potential going forward. Perhaps one day, Northeastern students will be able to hop on a train at South Station after breakfast and make it to Los Angeles in time for lunch. n

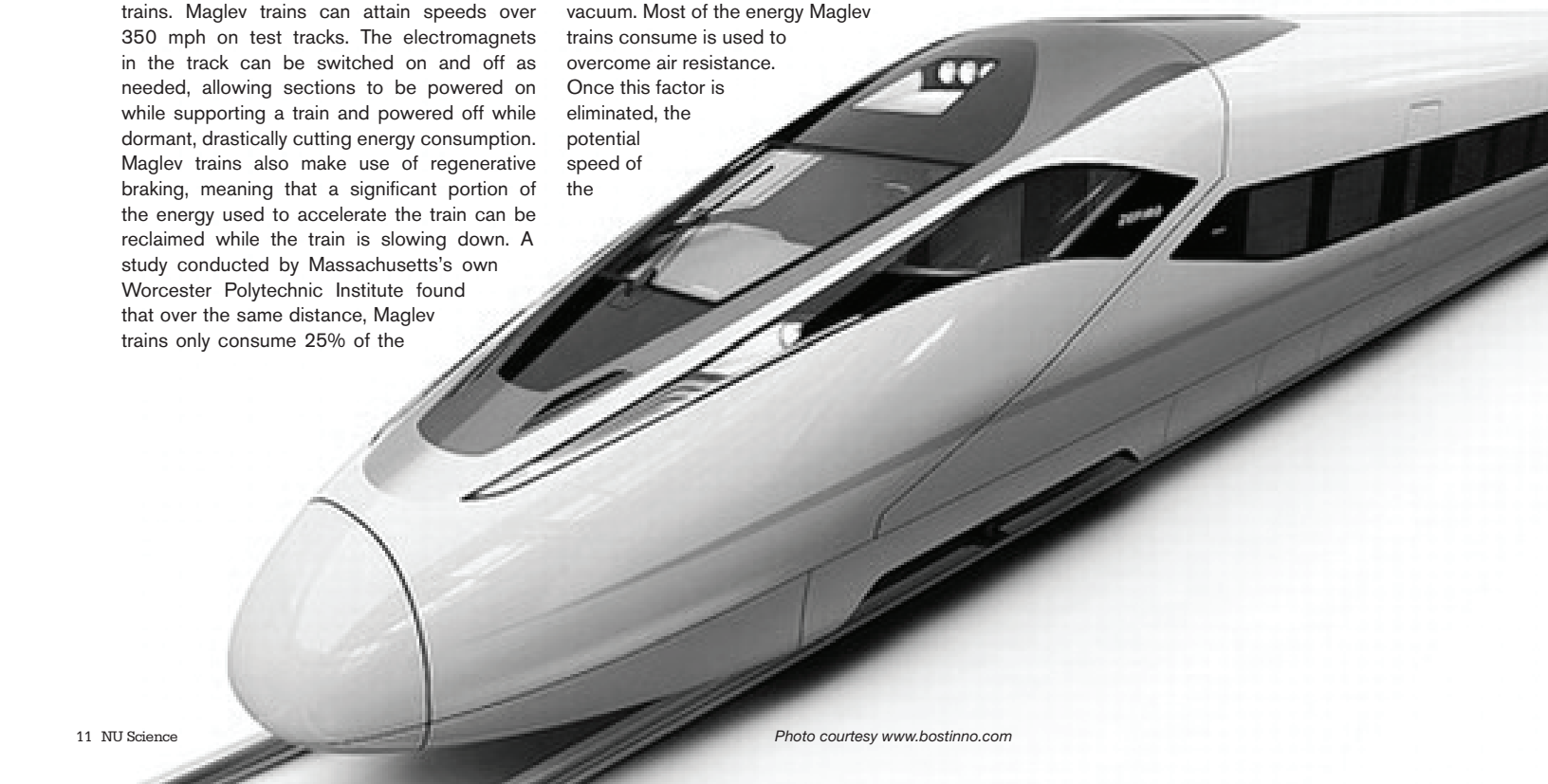


Photo courtesy www.bostinno.com

INTERVIEW WITH

Rainforest Conservationist Topher White

BY CAT FERGUSON, BEHAVIORAL NEUROSCIENCE, 2013

Photo courtesy of U.S. Geological Survey, photo by Greg Winters

Can you save the rain forest with a cell phone? Topher White, founder of Rainforest Connection, believes you can. Using cheap cellphones and near-ubiquitous network coverage, his organization will record sound and other data from the rain forest and broadcast it freely on the web. White plans to identify the sounds of chainsaws in real time, allowing locals to respond more quickly to the destruction; other organizations, in both science and tech, will likely find further uses for the information.

White has an infectious enthusiasm, paired with barely-contained energy. During infrequent pauses he raps his knuckles on the table in quick staccato; that restlessness is reflected in his resume. His last job was CTO and lead programmer of Enthuse, a start-up in San Francisco. Before that, he spent four years directing web communication at ITER, an experimental nuclear fusion reactor in Cadarache, France. (He also spent a few months after college building Rube Goldberg-style sculptures at Dennis Hopper's studio in New Mexico.) Besides programming, he brings to Rainforest Connection a background in physics, with a bachelor's from Kenyon College and work at the SLAC National Accelerator Lab at Stanford.

He first became involved with rainforest conservation through a man named Chanee, who founded Kalaweit, an organization dedicated to protecting gibbons and their habitat in Indonesia. Kalawait's reserves, including 64,000 acres on the island of Sumatra and 13,000 acres on Borneo, are under constant attack from illegal poachers, loggers, and those who clear cut rain forests to make room for palm oil plantations. Kalaweit employs a few guards to patrol the reserves, but the scale makes it impossible to prevent human encroachment that way. White's solution? Place recording devices throughout the forest, to identify where and when chainsaws are being used.

All of the recording, processing, and transmission is done by the cell phone itself. Solar panels will power the devices, but there is little light under the canopy of the rain forest. A series of clever hacks allow the phones to draw as little power as possible, lowering the power requirements to the level panels can provide. Most of them involve tweaks to the operating system. The code can be found at https://github.com/rfcx; so far, everything is open source, including the design of the devices.

To monitor power generation, the solar panels are connected to an LCD inside the otherwise dark container, which varies in brightness depending on the energy input. A phone's proximity sensor works by monitoring light levels: when it's against your ear, the lack of light triggers a simple on/off switch for the screen. With a little reprogramming, that light sensor can read how bright the LCD in container is. The phone tracks this data, adjusting its own performance accordingly to ensure it never uses more power than it will be able to generate. Between these modifications and a (mostly) water-tight container full of desiccants, White estimates the life of each device to be about a year.

White is not the only one using modern technology to stop deforestation. Current efforts focus mainly on ground patrols, difficult in such immense areas, and comparison of satellite images over time, which can have up to two weeks of lag between each photo. The World Resources Institute is about to launch Global Forest Watch 2.0, an effort to apply advanced computing to satellite images, allowing for faster updates and higher spatial resolution. They also intend to use input from people in the field with smart phones to monitor forest conditions. However, in reference to satellite techniques, White says "we need to close the gap between knowledge and intervention." The Rainforest Connection devices could provide direct, immediate data which could be used to quickly stop loggers and would-be palm farmers.

This summer, White is traveling to Indonesia to install the first devices in the field. He hopes that some day soon, it will be simple for locals protecting their rain forests to plug a phone into a box, nail it to a tree, and begin collecting data that can help them track and prevent illegal logging. "We'll give [the devices] away for free, because we ultimately rely upon locals to intervene when an 'event' is detected. Making it simple, effective and accessible for them is our first priority."

Raising money to launch Rainforest Connection is an ongoing challenge, involving corporate sponsorship and an impending Kickstarter campaign, but White is optimistic. "At the consumer level, there is a profound untapped enthusiasm for saving the rainforest amongst many who care but who would not contribute financially. If we can harness that energy, we can change the world." n

From Dust to Dust:
The Industry of Natural Burials

BY ISAIAH THOMAS, BIOLOGY, 2017

Imagine your corpse, buried in the ground, lying in a hermetically sealed box for eternity. Now imagine your body decomposing naturally and reentering the earth's nutrient cycle to foster future life. The U.K.-based company ARKA Ecopod, essentially the founder of the natural funeral industry, has made this dream a reality. An Ecopod is a biodegradable coffin made from recycled paper and can be cremated or buried in cemeteries or woodland sites. According to the Ecopod website, "The Ecopod is a beautiful design of coffin that brings together artisan skills with style, elegance and a respect for the environment."

Like many green movements, natural burials seek to promote both environmental and economic sustainability. The Oregon-based Natural Burial Company specializes in importing, marketing, and distributing natural burial products and acts as Ecopod's North American distributor. The company's woven fiber coffins decompose more rapidly than wood and do not require trees to be cut down for production. In general, the company only uses materials that are biodegradable, non-synthetic, and procured from renewable resources. They pledge to meet or exceed fair labor standards, to minimize pollution, and to support artisanship and handicrafts.

Natural burials also minimize the negative effects of traditional burials. According to Scientific American, the production of wooden caskets consumes about 9.1 million meters of wood each year, and the wood used is often mahogany and other tropical hardwoods. Planet Green reports that huge amounts of steel (enough to build another Golden Gate Bridge) and concrete are used each year in traditional burials for caskets and vaults, and their transportation expends additional energy. It can take years for wooden caskets to decompose in soil, leaving the space unavailable for extended periods of time. Formaldehyde is often used in the embalming process in traditional funerals; the chemical, which is classified as a "known human carcinogen" by the 12th Report on Carcinogens by the U.S. Department of Health and Human Services National Toxicology Program, can pose a threat to funeral home workers by exposure, and to the environment by contamination.

A natural burial is not just about what you do to your body, it is also concerned with where the body is laid to rest. The Green Burial Council (GBC) certifies three types of burial grounds: hybrid burial grounds which are traditional cemeteries that allow for burial without vaults, natural burial grounds which prohibit the use of vaults, toxic embalming chemicals, and coffins made of non-natural materials, and conservation burial grounds which meet all the criteria of a natural burial ground while also being legally recognized conservation land. This last option, honored with a Three Leaf Rating by the GBC, does not usually have large memorial markers, but instead may use a native tree or engraved flattened stone. These burial grounds symbolize the stewardship of the environment that drives the movement and at the same time the belief in returning to the earth from whence we came. n

Tying Knots of Air

BY DEREK JONES, CHEMISTRY, 2016

Have you ever seen someone blow a ring of smoke? Your first thought probably wasn't, "Wow, look at that vortex ring!" Vortex rings occur commonly in liquids and gases; they are just hard to see unless other particles are there to reveal them. Just as one cannot physically see the wind, one cannot see a vortex ring unless an alternate substance, such as the smoke, occupies it.

A vortex ring consists of a fluid and, as the name would suggest, is shaped like a ring. It is a phenomenon that occurs everyday. The fluid spins around an imaginary ring-shaped axis. Other examples of vortex rings include bubble rings underwater, mushroom clouds, and currents of air resulting from a fired gun or cannon.

Imagine if someone asked you to knot a smoke ring. This is an extremely difficult task; how could one begin to fathom tying air in a knot? William Irvine thought colliding two vortex loops could cause the currents to interfere with each other and tie the rings together. Unsuccessful with his postdoctoral research at New York University, he went to Chicago to team up with Dustin Kleckner, a postdoctoral scientist with the James Franck Institute at the University of Chicago. All of their initial attempts "failed catastrophically," as Irvine put it. Watching videos of dolphins blow their own bubble rings and play around with them further inspired Irvine and convinced him knotting vortex rings was possible.

They revised their approach by hydrofoils, akin to wings used in water, with a 3D printer. Many intricate shapes were designed for these trials; they tried about thirty different shapes before one finally worked. This shape consisted of a closed loop with an open knot in it.

The experiment took place in a water tank where a "beautiful technique" could be invoked to view the vortices using bubbles. It would be easier to observe because the ring would last longer due to the higher viscosity of water. Instead of using a bubble ring consisting of one big bubble, it was much simpler to use a multitude of micro bubbles. First, a hydrofoil is fastened to a frame designed to pull it downward rapidly. Next, micro bubbles are produced, and a thin layer catches onto the bottom of the hydrofoil. As the frame accelerates downward, taking the hydrofoil with it, the bubbles are released. They then become a vortex ring and are observed with a high-speed camera. Using certain shapes, the vortex ring comes off the hydrofoil already knotted, successfully forming a vortex ring of micro bubbles into a vortex loop.

Why is this important? Understanding this marvel can help us understand other phenomena such as turbulent flows in regular fluids and turbulent plasmas (like in the sun). Irvine agrees: "If confirmed, this would deepen our understanding of the dynamics and connections between many disparate physical fields." With more investigations, this could eventually lead to new processes, technologies, and innovations that would benefit our lives. n

The Environmental Impacts of Anti-Drug Eradication: Plan Colombia

BY KEVIN FRANCIOTTI, BEHAVIORAL NEUROSCIENCE, 2013

Economists have long known that where there is a demand for a certain product, supply is there to meet the rates of consumption. In a free market society, the basic principles inherent to capitalism support this relationship in almost all areas – technology, healthcare, food industry, etc. When it comes to drugs of abuse these same forces are at play, but as an outlawed market, the underground drug trade presents a problem for governments around the world. Intoxicating substances have always been in demand, and though it was not until recently that modern societies have prohibited their use, attempts to eradicate the illicit supply of certain dangerous drugs have not been met without challenges.

While it seems the main focus of the war on drugs has been a criminal justice and social policy response to address consumer demand and interdict the importation of supply, the environmental impact of government sponsored eradication has been the topic of widespread controversy for its use in numerous countries. Coca production in South America has long been a target of international campaigns to wipe out the source amongst the very farmers growing the crops. In 2000, under President George W. Bush, a project called "Plan Colombia" involved the aerial spraying of herbicide over many parts of rural Colombia, affecting almost 3 million acres of land over an eight year period. The program has been met with controversy since its inception, and although experimental evidence seems to indicate that the herbicides used have few adverse effects on the environment, there has not been much success at lowering supply despite the billions of dollars spent on continuing efforts.

As with any environmental impact research, the difficulty of proving causality leads many studies to be deemed inconclusive, or conflicting evidence from repeated experiments pits one group of scientists against another. Another challenge for researchers lies in accurately simulating experiments under controlled conditions that are also representative of the natural environment they are studying. In 2009, the Journal of Toxicology and Environmental Health published research by Keith Solomon out of the University of Guelph in Ontario, Canada, which showed minimal toxic effects due to herbicides on several amphibious species (animals that are prime indicators for the overall health of an ecosystem) as well as over 2,500 pregnant women with no significant detriments observed in the developing fetus. These findings contradicted prior research that showed significant in vitro cell death of human umbilical, embryonic, and placental cells.

While the uncertainty of harmful toxic effects in humans is prevalent, indirect environmental impacts of herbicides have been well documented by a variety of organizations. The Interamerican Association for Environmental Defense (AIDA) has fought aerial spraying since the start of Plan Colombia. In a memo sent to the US Congress in January, 2007, the AIDA stated that, "[t]he spraying impacts human health and well-being, destroying food crops and contaminating water bodies that people living in impacted areas depend on for cooking, drinking and bathing. Routing destruction and contamination of food crops, as well as harm to livestock." Many rural farmers who fall victim to the pressures set by herbicide spraying live in areas where coca production is especially problematic. Many have been forced to convert their farms under duress from the local drug cartels. Others are simply helpless against the immense profit available to them at low production cost compared to the unpredictable cost effectiveness of growing crops and caring for animals.

The practicality of large-scale aerial herbicide spraying has had its share of operational setbacks as well. Like traditional markets, drug production has adapted by changing trafficking routes after the fields are destroyed or the government attempts to intervene. Despite the lack of substantial effect from attempts at destroying the source of international drug production prior to its importation into the US, the policy continues under the Obama administration, with pilots from multiple branches of the military tallying over 46,000 hours of flight time spent on anti-drug missions. Whereas the evidence today emphasizes the sheer magnitude of the financial and administrative cost of the global war on drugs, the initial investigations predicted the obstacles from the war's onset.

In 1973, Richard Nixon commissioned a committee charged with assessing the potential effectiveness of the US anti-drug strategy. At the time this strategy was gaining enforcement priority for little more than a decade, though it had been building up for years prior. One of the most important conclusions the commission warned was, "Perhaps the major consequence of [anti-drug legislating]…has been the creation, at the federal, state and community levels, of a vested interest in the perpetuation of the problem among those dispensing and receiving funds." n

Why Haven't We Converted to Renewable Energy Yet?

BY CAYMAN SOMERVILLE, ENVIRONMENTAL SCIENCE, 2017

The debate over the dangers associated with fossil fuels has been exhausted and concluded. It is clear that as a society, the United States is heavily dependent upon fossil fuels as a major energy source. According to the Annual Energy Review 2011, fossil fuels, coal, petroleum, and natural gas, are responsible for about 82% of US primary energy consumption. In comparison to this, renewable energy has risen to share about 9% of the total energy consumption. Renewable energy is praised for its natural replenishment, unlike fossil fuels, which means we will never run out of the energy source. This includes power acquired from running water, biomass, geothermal, solar, and wind sources. 1 However, few have considered the topics of why we have not fully converted to alternative energy, the problems associated with the mechanisms behind alternative energy sources, and the energy efficient measures we can take instead. Recently, Professor Daniel Douglass, whose areas of expertise include earth and environmental sciences, sat down with NUScience and addressed these issues.

THE UNITED STATES AND ITS BELOVED FOSSIL FUELS

The total energy consumption of the US is clearly dominated by fossil fuels. The reliance is so significant that Professor Douglass claimed "Realistically, given some of the technical issues related to the alternative technologies, it's probably going to be many more years before that number comes down significantly." Of the three main types of fossil fuels, coal is undoubtedly the worst. Coal produces an immense amount of carbon dioxide in relation to the amount of energy you get out of it. In addition to the obvious effects of excess carbon dioxide in the atmosphere, coal produces acid rain pollution. Fortunately, the statistics display the use of coal decreasing (to 20%), while natural gas rises (to 26%). 1 Dr. Douglass explains that it is easy to convert a coal-fired power plant into one that runs on natural gas. Though it would be more ideal to fully replace all fossil fuel reliance with alternative energy, replacing coal with natural gas is a step in the right direction.

PROBLEMS ASSOCIATED WITH ALTERNATIVE ENERGY SOURCES

Nuclear electrical power is an independent category from the renewable sources, making up about 8% of our primary energy usage. In addition, it supplies "19% of the Nation's electrical output." However, nuclear power plants have their own issues as well. A major one is the issue of reactor-safety, though Dr. Douglass claims that globally, there have been very few reactor issues. After producing nuclear waste, all we can do is contain it, as it will remain for thousands of years. The waste must be continually examined, ensuring that its containment system is properly functioning and that the box it is contained in is still structurally intact. This procedure of regulation and containment is very expensive, but essential when establishing its safety. All of the alternative energy sources are currently more expensive than the fossil fuels that they would replace.

The proposition of wind and solar panels as a replacement for the dominant source of energy is an attractive idea. Unfortunately, there are crucial technical and financial challenges associated with these options that many people involved cannot overlook. First, both wind mills and solar panels are what Douglass calls "intermittent energy sources." Intermittent production is any source of energy that is not continuously available due to some uncontrollable factor; solar panels do not make electricity during the nighttime or when it is cloudy and wind turbines cannot produce energy when the wind is calm. Professor Douglass views this issue as a scientist and as a family man, emphasizing that "Most American customers are not willing to have an electrical system where you want to turn your lights on and they don't come on. That's not workable for [the] average person." In order for these sources to become central, electrical storage systems need to store excess power during the time in which these systems are not functioning. However, electricity is very difficult and expensive to store. Second, after subsidies, traditional electrical solar panels come out to be about 4 times more expensive than producing electricity from coal. This means that in addition to your electrical bill quadrupling, all of the products the average consumer owns that require energy to create (like a car) will be more expensive to manufacture and thus to purchase. On the other hand, there are efforts to make these options more cost-effective, and it is our hope that the technology can be better developed and utilized.

BEST-PROPOSED ALTERNATIVE ENERGY REPLACEMENT

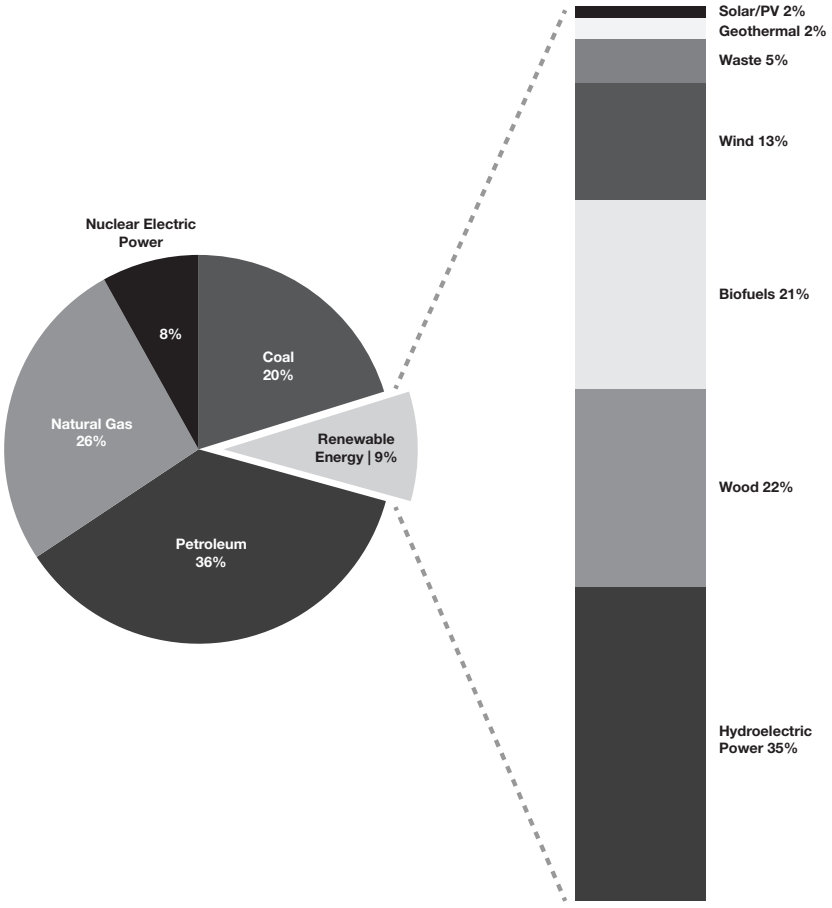
When asking Professor Douglass which technology has the best chance of working, he responded saying, "Based on what I have read and what's out there, that doesn't mean that someone doesn't come up with some great invention tomorrow, the best [alternative to fossil fuels] that I have seen is what's called solar thermal." Solar thermals use mirrors to concentrate sunlight from solar panels into something that boils water and produces steam. Then that steam is used to produce electricity in the same way that a coal fire power plant produces electricity. On a cloudy day or during the night you can supplement the solar panels with some other heat source like coal or natural gas, so that you can still produce the electricity that we need. This alternative both gets around the intermittency issue and can potentially be cost effective. Though it is still experimental, it is estimated that the more of these systems that are built, the cheaper it will be to build them.

BIOFUELS

Currently, the creation of corn-based ethanol through first generation biofuel technology transform about one third of the corn we grow into ethanol. The United States is heavily reliant on corn as a food source, export, and as the primary component behind everyday products we need and use. In fact, according to the US Department of Agriculture, the United States is the world's largest producer and exporter of corn, making up about 60% of the world corn exports. During biofuel production, after harvesting the corn, a small amount of sugar is extracted from the corncob and fermented into ethanol. That ethanol is then mixed in with gasoline. The same procedure occurs in Brazil using sugarcane, which has a higher sugar concentration and thus more sugar per stock to be fermented. This sugar is also mixed with gasoline and is slightly more efficient than corn-based production. Since there's more sugar in sugarcanes, more of the biomass is converted into an actual fuel source. In corn, there is a lot of cellulose in the stock that cannot ferment and ends up wasted. Dr. Douglass points out, "One of the consequences of corn-based ethanol is that we've taken a significant amount of the food supply and now put it in our gas tanks." This means that less food is available to be put on the table, and food has gotten substantially more expensive. He also emphasizes that these rising food prices are detrimental for people living below the poverty line or struggling to make ends meet financially. This has led to a movement towards second generation biofuels.

Unlike first generation biofuels, second generation biofuels use all parts of the plant and its waste products. A bacterium has been fabricated in the laboratory that can convert cellulose, the sugar in the cell wall of the plant that makes up most of the plant tissue, into something that looks like diesel. This can be mixed with regular diesel or gasoline and then burned into most people's engines. This new technology allows us to gather grass clippings, stocks of corn, or even sewage sludge and send them into a factory to be converted to fuel source. Instead of using a high value food substance, we are using a low value waste product. There is also a crop called switch grass that is capable of growing on landscapes where regular crops could never be grown. Switch grass has no food value and thus could be harvested as a fuel source without subtracting from the food supply. Overall, second generation biofuel production is more efficient and less cost intensive, but the technology is scaling up slowly. The amount of ethanol and diesel-like substance produced each year has so far been unable to compete with the amount of gasoline that gets burnt in this country on an annual basis. Professor Douglas remarks that "We are trying to figure out how to go from getting it to work in the beaker-scale in the laboratory… then turning it into a factory-size thing to feed America's car fleet. Those are two different things." Though this is a fixable issue, it means more research and development needs to be carried out in the future.

"In order for [alternative energy] sources to become central, electrical storage systems need to store excess power during the time in which these systems are not functioning."

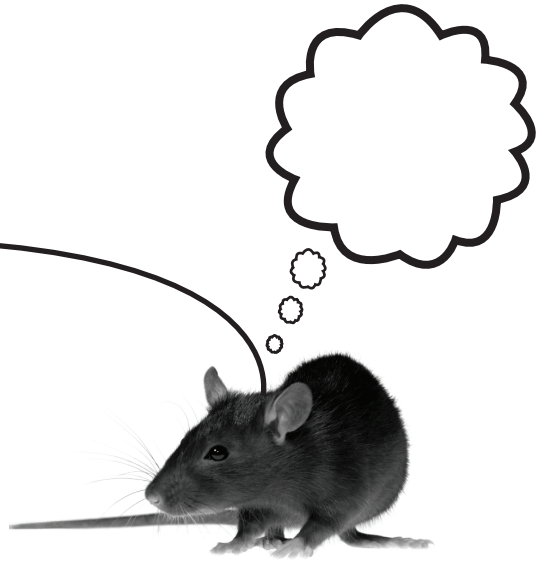


WHAT'S NEXT?

As energy and electricity becomes more expensive, it becomes more important that we take energy efficient measures to reduce financial burdens. We should collectively take measures like insulating buildings, adapting to compact fluorescent light bulbs or LED light bulbs, and minimizing transportation. The next decade should focus on finding the technology required to minimize the usage of fossil fuels and transform to the primary consumption of renewable energy. Fortunately, President Obama just proposed using the $2 billion from federal oil and gas fees over the next decade to pay for research on alternative fuel cars.4 This notion brings much glee to the environmentally conscious portion of our nation and brings hope that this is a significant step in the right direction. n

New Study Reveals Rats are Able to Communicate Through Wires

BY JORDYN HANOVER, BEHAVIORAL NEUROSCIENCE, 2017



In February, scientists at the Duke University Medical Center discovered that rats connected to each other through various wires and cables were able to directly communicate. In some instances, the rats were able to complete the mind-link from hundreds of miles apart. Using positive reinforcement, researchers were able to discover that animals have the capability of communicating mentally with each other – both sending and receiving messages with clear instructions: pull the proper lever and be rewarded with water.

In this experiment, two rats were put in separate cages with two levers and hooked up to an electronic cable. One rat would receive an electrical stimulation to push the lever, obtaining water as a reward. The rat would then send a cue through the wire to the brain of the second rat, essentially encouraging the second rat to pull the lever and obtain a water reward as well. About 70% of the time, the second rat (after extensive training) was able to correctly interpret the signal it received and pull the correct lever, thus prompting an additional reward for the first rat and encouraging a stronger mental cue through the wire in the future.

According to the study, there was a strong correlation between the lever the first rat selected and the lever the second rat selected of the two levers presented. This implies that the first rat was able to communicate to the second rat via the cables connecting their brains which lever to pull in order to obtain the reward – approximately 69% of the responses of rat one matched rat two. In another portion of the experiment, it was discovered that the rats were using the whisker length to determine the appropriate response for a reward; the rats could determine whether a compartment was wide or narrow using their whiskers. The researchers were also able to associate both tactile and visual stimuli with brain responses associated to the whiskers.

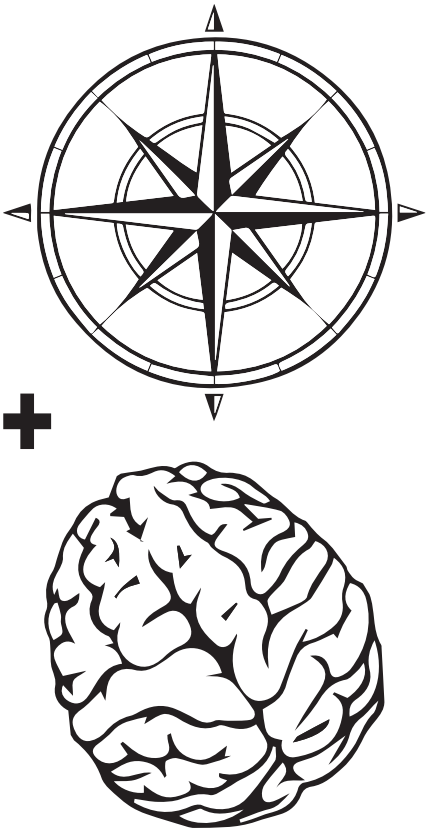
Professor Miguel Nicolelis, who led the study, believes that this technology can be used on other animals, including humans, “We will have a way to exchange information across millions of people without using keyboards or voice recognition devices or the type of interfaces that we normally use today.” However, the only technology that currently exists is extremely invasive, something which would have to be remedied in order for such ”mind-links” to be useful to humans. Professor Christopher James uses only noninvasive procedures in his research, and admitted that currently, there is no way to non-invasively feed information into the brain through the scalp.

Other professionals have raised the question of whether this experiment actually proves anything, citing that a limited number of levers in the cage allowed the rats a large chance of randomly selecting the right level. Previous experiments have been done to allow monkeys and humans to obtain control of robotic limbs and, using only their brain, perform actions that they could not have before. And others have debated whether the potential for future use in humans is ethical – essentially allowing multiple people to share information with each other simply by thinking it. Does this give some people an unfair advantage? How would people control exactly what was sent? What other sorts of access would people have to the brains – memories? Perceptions?

This research provides a step for direct connection between human brains; if rats can communicate directly with only a wire in between them, there is a definite possibility that in the future, not only will humans be able to do the same but also they may be able to do so better and more efficiently. As technology continues to develop, one day we could communicate like the layout of a Facebook page: hundreds of friends and family members with their own unique pages able to interact with each other – except with our brains. n

Obama Orders a Map of the Brain

BY JORDYN HANOVER, BEHAVIORAL NEUROSCIENCE, 2017



In his State of the Union address, President Barack Obama outlined a plan to map the activity of the human brain within the next ten years. Beginning in 2013, teams of scientists in several different fields, from various foundations and organizations, will start working to sequence every neuron and synapse in the brain. Scientists believe that such a brain map could hold the key to exploring, understanding, and eventually eliminating mental illnesses.

The Brain Activity Map project could change the trajectory of scientific development. Its implications span from pharmaceuticals to artificial intelligence. A greater understanding of how the brain works could result in more comprehensive and effective drug development. New technologies could be developed in order to quickly discover problems in the brain that could potentially lead to diseases like Alzheimer's and Parkinson's. The program, however, will not be enacted without cost.

The human genome project cost almost 3 million dollars per year for ten years and returned over two hundred times its cost within twenty years of its initiation, according to a government conducted study. Mapping the human brain is a project of comparable size. President Obama is confident that financing the Brain Activity Map project will have a positive return on the economy. With advancements in brain mapping and understanding brain-based diseases, new drugs can be developed that counter negative effects of diseases. Obama believes that these investments will create many jobs in the science fields.

The size of the project also presents several issues: whose brain should be mapped, how should the brain be mapped? Scientists have several ideas for how to go about it. One proposition is to build a sensor-based machine to measure and store brain activity by tracking all the synapses. Another is to use synthetic DNA to store information. Scientists believe they can develop technology to map the brain without having to perform any invasive procedures.

Currently, there are several brain projects already in progress, most notably one being run out of the National Institute of Health to map a static brain. However, Obama's new project would focus on mapping the synapses within an active human brain. It is not yet known exactly whose brain should be used for this massive project, or if multiple brains should be used. Once one person's brain had been mapped as a baseline, brains with developing diseases- like Alzheimer's and Parkinson's- can be studied to a greater extent.

The brain project could lead to some of the most important scientific advancements of this generation. It could result in advancements in both drug testing and development. The possibilities for the future are endless, and the benefits of the project's completion will be reaped for years to come. n

Language's Beginnings

BY SHANNON JONES, MARINE BIOLOGY, 2016

The first language spoken by a person is sometimes called his "mother tongue", and this colloquial expression may be more accurate than originally thought.

According to a study done by a team of Swedish and American scientists, language experienced by a fetus in utero affects the way that a child expresses and perceives vowels. The study worked with a group of newborns between seven and 75 hours old, of both Swedish and American nationality. Each newborn was given a pacifier that monitored when it was being sucked on. As a newborn generally sucks in rhythmic bursts, the study theorized that if an infant was interested in the sounds he was hearing, the child's suckling would increase as he responded to the sound. When a newborn sucked twice in quick succession, vowel sounds from both the English and Swedish languages were played into the child's ears. The vowel sounds chosen were unique in their pronunciation to each language. In this way, it could be seen if the infants were more likely to respond to an unfamiliar language, one that the newborns had not been exposed to in utero.

The study found that each newborn was more likely to continue their suckling if their native language's vowel sounds were being played, and suck equally during each sound, which researchers theorize means that they were aware that the vowel sounds are similar to each other.

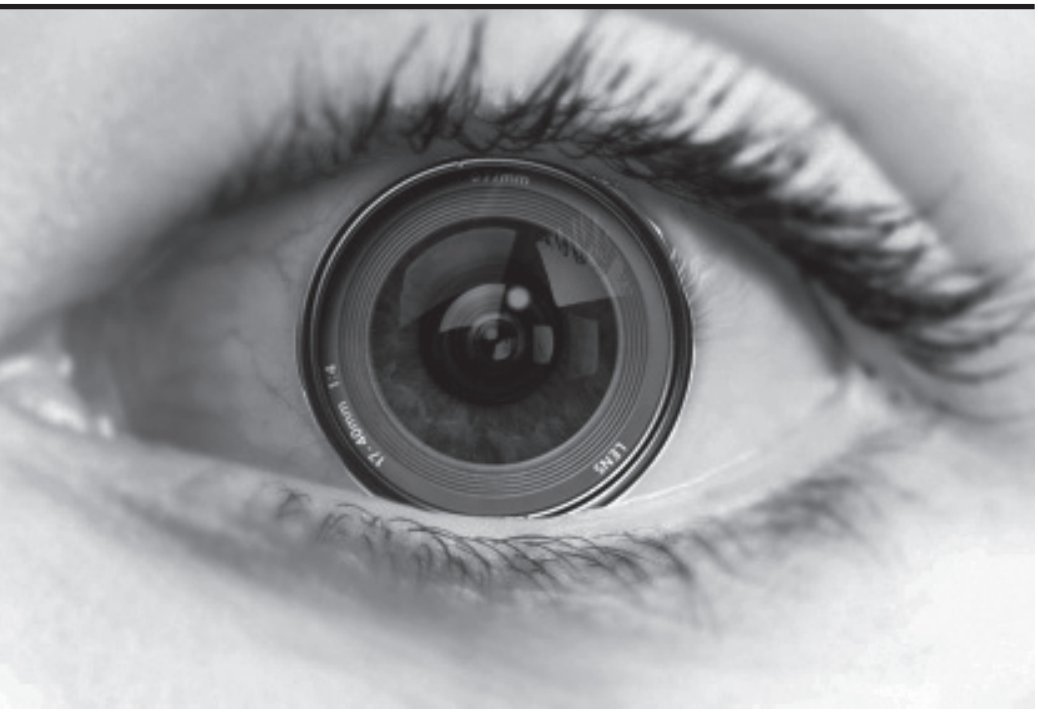
However, if a clearly pronounced vowel sound from a novel language was played, the newborns reacted differently. Instead of continuing to suck in a similar pattern, the vowel sound that they were not familiar with elicited a different, more frequent, suck pattern.

This knowledge of intonation patterns of the language children hear in the womb may even carry over into the way they cry, according to another study done on French and German infants. The intonation of the cries of newborns have been found to follow a similar pattern of rising and falling that takes after the intonations of their parent's language. For example, German inflection generally deepens at the end of a sentence, and newborn German children's cries begin high and get lower in pitch as they progress.

More research remains to be done in examining the way we communicate and learn language, but what scientists have found so far seems to suggest that language learning and imitation begins sooner than previously anticipated. n

Restoring Vision Through Prosthetic Eyes

BY KRISTEN DRUMEY, BEHAVIORAL NEUROSCIENCE, 2017



Vision is arguably the most important sense humans have. It's hard to imagine going to class, trying to catch the green line, and navigating through the daily commotion of life without being able to see. However, for people who have lost their vision, this is everyday life. Over the years, different methods of coping with blindness, such as braille and seeing eye dogs, have been developed to aid those who are unable to see. Unfortunately these methods are only able to help those who are blind cope with their disability, and few efforts have successfully restored vision to any degree. Recent technology, however, has brought an exciting breakthrough to the field of retinal prosthetics, and gives new hope for medical restoration of vision.

Our ability to see is the sum of many complex processes; vision begins when light enters the eye through the pupil. Light particles pass through the inner chamber of the eye until they hit the tissue covering the back of the eye, called the retina. The retina contains photoreceptors, like rods and cones, which pick up the particles of light and transduce them into electrochemical energy. The electrochemical signals can be used by neurons, which come together from the eye to form the optic nerve. The optic nerve proceeds from the eye into the brain, where the visual signals go through higher level processing. These levels of processing, from basic to complex, culminate in our ability to see.

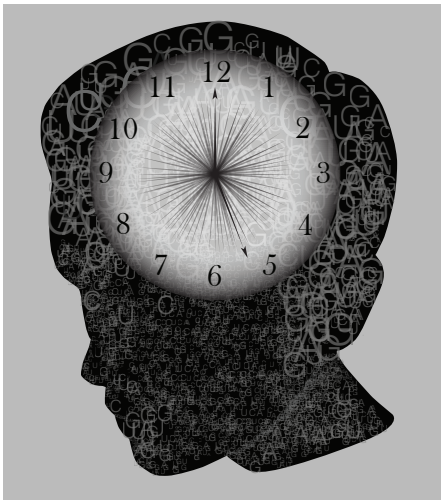
A disruption at any step of this system can lead to blindness. Retinitis pigmentosa (RP) is a genetic disease that affects vision at the photoreceptor level. RP is a degenerative disease that gradually breaks down photoreceptors on the retina. Rods, the photoreceptors dealing with night vision and peripheral vision, are the first to degenerate, causing tunnel vision in those with the disease. As the disease progresses, vision becomes worse and worse until eventually it is reduced to almost nothing. About 100,000 people in the U.S. are affected by RP.

This past February brought exciting news to those who suffer from retinitis pigmentosa. On February 14th, the FDA approved Second Sight's Argus II Retinal Prosthesis System for use. The Argus II, backed up with 20 years of research, is a revolutionary method of restoring vision. According to the president of Second Sight, the Argus II is "the only FDA-approved long-term therapy for people suffering from advanced RP". There have been sparing cases of people getting their vision restored through different surgeries, but the Argus II is one of the first devices of its kind. The system is comprised of a small video camera, an artificial retina implanted on the eye, a video processing unit, and a pair of eyeglasses fitted with a transmitter. Images from the environment are recorded by the video camera, which are then converted into electrical signals using the video processing unit. The electrical signals are then sent to the artificial retina and up to the brain.

Argus II is designed specifically for adults with advanced retinitis pigmentosa. The surgically implanted artificial retina serves to replace the photoreceptors that were degenerated because of the disease. Rather than restoring vision to a nearly perfect state, Argus II allows the user to see patterns of light and dark in his or her environment. Although "patterns of light and dark" seems less than impressive, clinical trials have shown that Argus II has profound effects for the person using it. The people tested were able to detect direction of motion and street curbs, both of which are vital for crossing a street. They were also able to recognize large letters and words and even match black, gray, and white socks. The device should be available in the U.S. later this year.

Argus II could have profound implications for helping people suffering from RP and may open the door into new and broader methods for restoring sight in the future. Says CEO of Second Sight, Robert Greenburg: "This is a game changer in sight-affecting diseases, that represents a huge step forward for the field and for these patients who were without any available treatment options until now." Argus II is a specialized prosthesis designated for adults with retinitis pigmentosa, but its basic concept and technology could possibly be applied to create more effective and generalized visual prosthetics. The field of visual prosthetics is only beginning, but it holds exciting prospects for restoring vision in the future. n

Organisms Use Codon Degeneracy to Adjust Biorhythms



BY MICHAELA RAO, BIOLOGY, 2016

Recent studies have revealed that codon degeneracy, or redundancy, may be a tool used by organisms to adjust their biological clocks in response to changes in their environment. Vanderbilt University researchers Carl Johnson and Antonis Rokas showed how organisms can, in a manner of speaking, hit the snooze button on their circadian clocks, allowing them to adjust to changes in the environment. The organisms that are able to temporarily adjust their clocks can actually change the period of their biorhythms, which helps them to function better in relatively normal, yet not quite ideal, conditions, such as slightly heightened temperature. To understand the mechanism needed to modify the clock via degenerate codons, one must first grasp several key points pertaining to mRNA, translation, and codon redundancy.

The genetic code of mRNA consists of four bases that can be abbreviated by the letters A, U, C, and G. When a strand of mRNA is translated into a protein, its sequence is read three letters at a time. A group of three letters, such as ACG, is called a codon, and each codes for an amino acid- the building block of a protein. There is no ambiguity in codon translation, meaning that each codon only codes for one amino acid. However, there is redundancy in translation, which means that one amino acid can be called for by several different codons. For example; GUC, GUU, GUA, and GUG all code for the amino acid Leucine, and only Leucine. It was previously thought that these redundant codons- those that code for the same amino acid- were interchangeable. In light of recent research, it is now known that this is not the case.

The aforementioned study from Vanderbilt University reported that different redundant codons are translated at varying speeds, since some are easier for cells to assemble into proteins. Researchers dubbed the codon that was translated the fastest for a particular amino acid an "optimal codon." These optimals are most often found in mRNA that codes for proteins of great functional importance, as they can be synthesized rapidly when needed. One may ask why, through the history of evolution, have non-optimal codons persisted in the genome? Wouldn't it be more efficient for DNA to be translated as fast as possible? Surprisingly, the answer is no!

The study showed that utilizing codons of varying translational speeds allows genes to adjust how quickly proteins are produced. This is possible because a strand of mRNA containing many optimals will produce its protein in less time than a strand containing few. Having a grip on the throttle of protein output allows genes to actually adjust the normal oscillations of protein expression that lead to an organism's circadian rhythms.

The word circadian derives from a Latin phrase, meaning "about a day." Circadian rhythms, therefore, refer to any biological processes that oscillate on a period of approximately 24 hours. These processes are dependent on varying protein expression, which is basically how much of each protein is being synthesized at a given time in the 24-hour cycle. In almost all organisms, the circadian clock is vital in the regulation of hormones, cell regeneration, brain activity, core body temperature, and patterns of eating and sleeping.

Organisms such as cyanobacteria and the bread mold Neurospora crassa have been prime subjects of optimization studies. The Vanderbilt study and a study concurrently published by Yi Liu of the University of Texas Southwestern Medical Center (UTSMC) experimentally optimized the codons of these organisms and observed diverse, yet equally profound effects.

The former observed that cyanobacteria operated on an adjusted period of 30 hours, instead of 24, when optimized. Additionally, those cells were able to perform better in lower temperatures that would typically impair cell function. An adjusted period likely led to changes in the bacteria's daily functioning that allowed for such an adaptation to a cooler temperature. This demonstrated that preference for optimal codons can help an organism adjust to temperatures that are not ideal.

On the other hand, Dr. Liu of UTSMC studied the fungus Neurospora, which has a more complex biological clock than Vanderbilt's cyanobacteria. Researchers were shocked to find that optimization completely knocked out protein oscillations in Neurospora! This state of arrhythmicity occurs when the amount of protein being produced is static, and the organism cannot function normally. The fungus contains a protein called FREQUENCY (FRQ) that is produced by its gene counterpart frq. Frq was one of the proteins focused on in the study due to its importance in rhythm regulation. When the gene's many non-optimal codons were replaced with optimals, there was no longer oscillation in the expression of the FRQ protein. It was concluded that the increased speed of FRQ synthesis, due to codon optimization, prevented the protein from configuring correctly. It also impaired feedback loops that are critical to the biological clock mechanism, among other adverse effects. Of course, FRQ was just one protein focused on by the team, so this phenomenon cannot yet be generalized for all proteins. However, it can be said that complete optimization is not certainly advantageous, as it can knock out rhythms by preventing proper protein conformation.

The results of the Vanderbilt study show that the ability to employ optimal codons when needed can lead to greater environmental adaptability. Though, sole use of optimal codons in a genome can be detrimental to biorhythms, as seen in UTSMC's results. It can be concluded that it is necessary for organisms to employ a mix of optimal and non-optimal codons, as it allows genes to properly tailor the amount of expression that will lead to more advantageous rhythms for present conditions. This method of gene regulation has been previously underestimated, and it is clear that we still do not know the extent of its use in the genome. However, what knowledge we have elicited thus far has many potential applications in biotechnology, in areas such as gene therapy and biofuel production. n

The Science of Hangovers: New Explanation for Old Woes

BY BILL FLEMING, CHEMICAL ENGINEERING, 2016

Anyone who is close to an alcoholic knows how challenging it can be for them to quit, both mentally and physically. Why is it so hard for them to stop drinking? This is not an easy question to answer. Alcohol metabolism is a very complex process, and ethanol, the active ingredient in liquor, interacts with the brain in many different ways. A common explanation for mental addiction to different substances is their effect on dopamine in the brain. But this is a quick and easy answer that does not account for many of the physical withdrawal symptoms from alcohol.

When the body metabolizes ethanol, it creates a by-product called acetate. Acetate, also called acetic acid, is the main acid in vinegar. Acetate levels are much higher in the bloodstream of heavy drinkers than light drinkers. Graeme Mason of Yale University recently co-authored a study regarding the brain's ability to use acetate as a source of energy. The study found that the brains of heavy drinkers are extremely efficient at utilizing acetate for energy, transporting the chemical into the brain and burning it at twice the rate of light or non-drinkers. For many years, scientists have thought that the brain gets energy exclusively from sugar, but it is turning out to be more adaptable than that. Mason believes that added energy and caloric intake might be part of what causes the withdrawal when heavy drinkers stop imbibing. Mason and his colleagues intend to follow this line of research, investigating whether an acetate supplement could ease the withdrawal symptoms of recovering alcoholics.

Drinking alcohol decreases the brain's ability to utilize glucose, so it's not hard to imagine that cutting off another major energy source would cause physical symptoms. Our brains are constantly delivering messages to our bodies using sensory or physical means, such as sensations of hunger or muscle pain after exercise. It makes sense that withdrawal symptoms may be similar in nature, the physical manifestation of the brain's reaction to low acetate levels. If this is the case, then an acetate supplement would be able to help a recovering alcoholic in the same way that a nicotine patch helps an individual attempting to give up smoking.

There have been many other attempts to create a drug that would allow an alcoholic to have an easy recovery. One such example is Antabuse. This drug binds to acetaldehyde dehydrogenase, the enzyme that allows the body to metabolize acetaldehyde, a waste product produced by the metabolism of alcohol and one of the main causes of hangover symptoms. Binding these enzymes prevents the body from metabolizing acetaldehyde. If the person taking Antabuse drinks, large quantities of acetaldehyde build up, causing nausea, vomiting, heart palpitations and a variety of other symptoms. Theoretically this might condition drinkers to avoid alcohol. Antabuse can be very useful, but it can be dangerous. It also relies on alcoholics' willingness to continue taking a drug that causes intensely unpleasant side effects when combined with alcohol, instead of helping ease withdrawal symptoms.

Continuing advances like those of Graeme Mason may one day offer people suffering from addiction an easier way to cope with recovery. Many people go back to using a substance because the physical withdrawal symptoms are too much for them to handle. This new research may lead to treatments to ease the discomfort and pain of withdrawal, which might bolster the success of social support programs such as Alcoholics Anonymous or Narcotics Anonymous. n

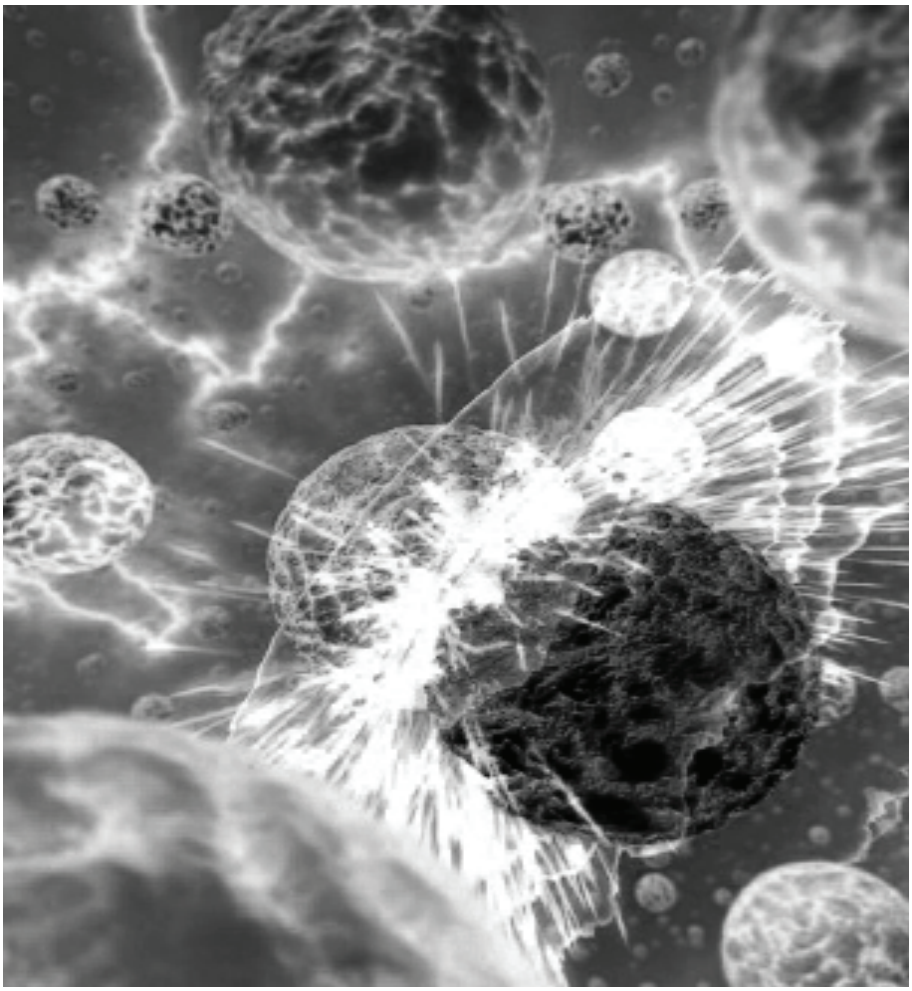
LHC **Long** Shutdown

BY ANDREW CLARK, PHYSICS, 2016

September 27, 2008 was a milestone date in the European Organization for Nuclear Research's (CERN) history as it opened the world's largest particle accelerator, the Large Hadron Collider (LHC). First envisioned in 1998, this 17 mile long ring of superconducting magnets and detectors has run from 2008 up until February 24, 2013. In this time the LHC has had its successes and failures, most notably the discovery of a particle by two teams working at separate detectors on July 4, 2012, that is consistent with the theoretical properties of the elusive Higgs boson (Leon Lederman's so-called "God-Particle"). This was the main proposed purpose of the LHC and after 4 years of collisions, it was finally discovered.

On February 24, 2013 the accelerator was shut down after colliding the last proton beam into a lead nucleus. However, this shutdown is not like the inadvertent shutdown in 2009 when a superconducting magnet caused a rapid expansion of the liquid helium coolant, resulting in a minor explosion that contaminated the beam tube. This shutdown is, in fact, right on schedule, according to CERN's timetable for the LHC. CERN plans on reopening the LHC in 2015, at full its full energy potential of 7 teraelectronvolts (TeV) per beam. Right up until the shutdown, the average particle beam energy was 1.5 TeV.

Why is CERN shutting down now, and why was the LHC not operating at full energy potential? The main reason is to perform routine maintenance on the accelerator and to consolidate the interconnection splices in the magnet rings themselves. The magnets are supposed to receive a current of 14 kilo amps (kA). With the current setup, the magnets cannot withstand that kind of current and if the full current were to pass through them, they would overload, causing a similar situation to the 2009 disruption. Over the past three years of operation, the physicists at the LHC have been working on how to properly apply this level of current to the magnets without causing problems. The plan currently being put into action involves placing copper shunts next to the existing current carrying cables to dissipate the heat produced by such a large current. These shunts must have an 8 mm gap between their joints in order to maximize the heat transfer, and in order to be effective, they must be placed along the entirety of the ring, which is why the shutdown will last for three years. In addition to these shunts being placed all the way along the ring, the existing Niobium Titanium superconducting splices must



be redone in order to provide this continuous current. It is these splices that the copper shunts will be soldered to. CERN estimates that only 15% of these splices will need to be consolidated.

So the engineers and maintenance staff will have their hands full in these next three years, but what about the physicists themselves? They also have a long three years of analysis ahead of them. At the LHC, data concerning a beam collision is recorded using the units of inverse femtobarns (where a barn is a measure of the cross section of a particle or particle beam). Over the past three years the LHC has produced roughly 30 inverse femtobarns of data. According to CERN the Higgs Boson was found after "analyzing 12 inverse femtobarns of data." So the scientists at the LHC still have a lot of data to sift through. Who knows, they may even have found newer and more exotic particles while looking for the Higgs.

The LHC will not be colliding any new particle beams for at least another two years. However, we can still look forward to news from CERN from their other particle accelerators as well as the data they are currently analyzing from the LHC. The next two years look to be just as exciting as the past three years of the LHC's operation! n

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