

NUScience

Northeastern University's First Science Magazine

ISSUE 5

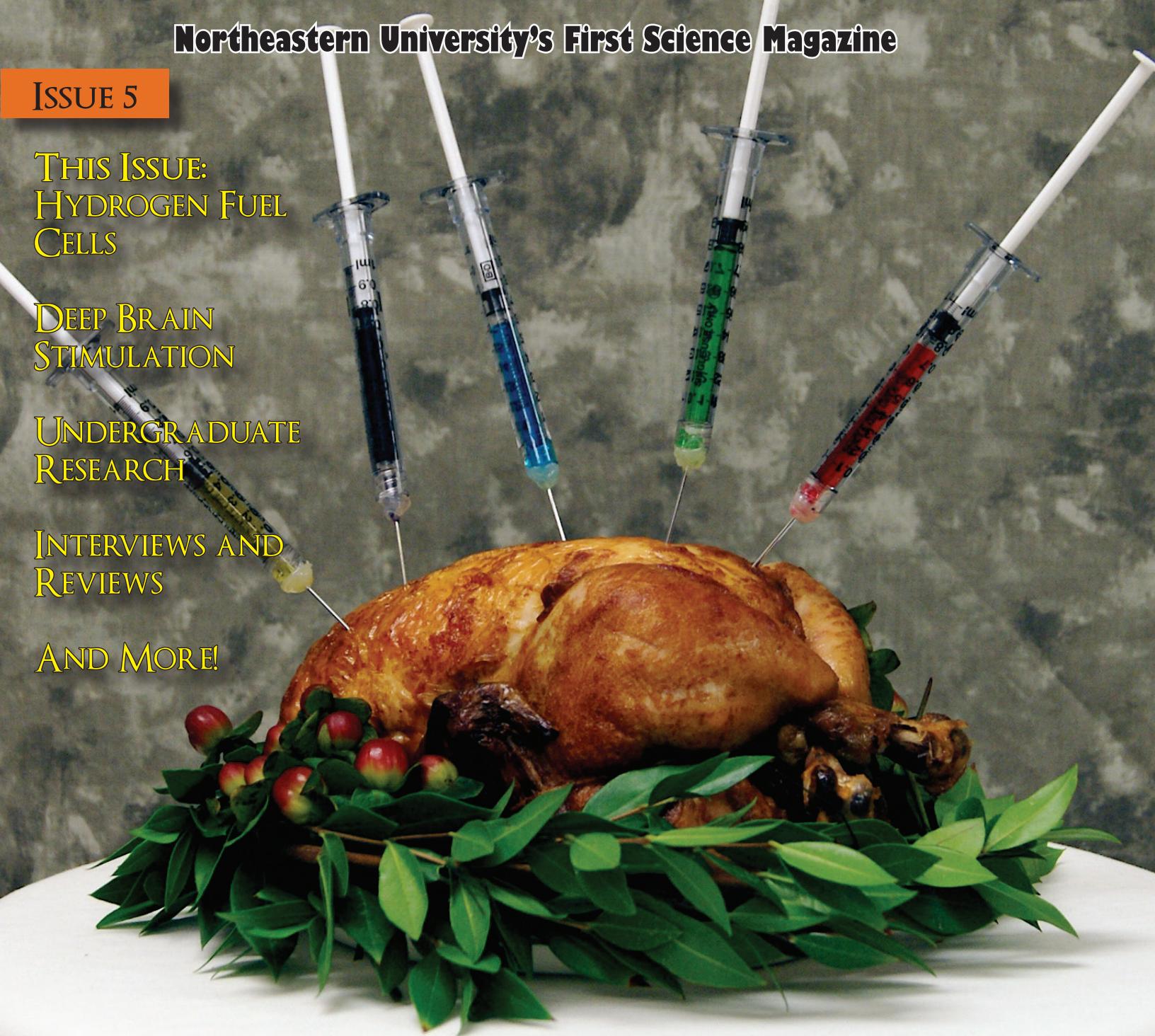
THIS ISSUE:
HYDROGEN FUEL
CELLS

DEEP BRAIN
STIMULATION

UNDERGRADUATE
RESEARCH

INTERVIEWS AND
REVIEWS

AND MORE!



GENETICALLY MODIFIED ORGANISMS:
WHAT'S IN THE FOOD WE EAT?

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Letter from the Editor

Hello Readers!

Welcome to our last issue of 2010! Here at NU Science we've been working ever harder to bring you, the ever-conscious students and faculty of Northeastern University, a magazine to broaden your scientific horizons. Our feature for this issue, focusing on genetically modified organisms, is a controversial and complex topic. We've attacked it from several angles: the current revolution in the first genetically modified animal for sale, the science behind the process of genetic modification, and one scientist's opinion on the ethics of this controversial topic. We hope that, at the very least, this feature allows our reader to think about this extremely complex and controversial subject and develop opinions on their own.

As always, we accept any opinions from our readers and articles of opposing viewpoints will be considered for submission. Science is always in a state of debate, so let us know your side of the argument! It's been only little over a year since our first ever issue, and we've come a long way. We have streamlined our system to provide you with news that's as current, as local, and as intriguing as possible. Our new academic advisor, Dr. Davies, has helped us tremendously to put us in touch with our faculty. We've done our best here at NU Sci, we still have a long way to go. If you see a change you'd like to see in the magazine, or believe a certain field is unrepresented, join us and let us know. As all scientists know, the more diverse the brain pool, the better the results.

Thank you, and enjoy,
James Peerless

Cover photo by Emily Snead

TURKEY AND TRYPTOPHAN: NOT THE ONLY CAUSES OF THE THANKSGIVING NAP

Food, football and a few z's, the three staples of the Thanksgiving holiday. The traditional post-meal nap has long been thought to be due to the tryptophan in turkey. Tryptophan is an amino acid that is involved in the production of serotonin, which helps with sleep. Even though Tryptophan is what causes drowsiness, excessive amounts are not coming from the turkey. Turkey meat contains the same level of tryptophan as other meats such as pork. The drowsiness we experience is from the consumption of lots of carbohydrates. Insulin production increases with the high level of carbohydrates and uses up other amino acids but leaves tryptophan in the blood. Since these other amino acids and tryptophan compete for receptors in the brain, the lack of competition allows for large amounts of serotonin to be produced causing a restful state. Another contributing factor could be the excessive blood flow to the stomach to help digest the large amount of food.

-Tara Dhingra, Biochemistry '12
This means less blood for the brain and less alertness. So don't avoid the turkey, just cut out the carbs!



UPDATE ON THE OIL SPILL IN THE GULF OF MEXICO

Efforts have begun to reverse the damage caused by the ruptured oil well in the Gulf of Mexico this past April. Recently, robotic devices, called autonomous underwater vehicles (AUV) have been deployed to aid in the efforts. These devices are released into the gulf and subsequently record and send data including measurements of ocean currents, measurements of the direction and speed of the oil, temperature, salinity, and optical density (indicates the presence of organic matter). The underwater vehicles operate from 30 to 200 meters below the surface and are driven by a buoyancy engine. In addition, there has been evidence that a new, rapidly evolving species of bacteria, related to Oceanospirillales, consumes hydrocarbons in the oil, aiding in the cleanup process. Chemicals called dispersants have also been used to reduce the surface tension of the oil slicks, so that they break up into small droplets and can be more easily consumed by the bacteria. However, although continuous efforts are being made, we are beginning to see what may just be the start of the detrimental effects. While the dispersants are there to break up the slicks, it has been found that the smaller droplets actually mixed with the water instead of sitting on its surface, making the oil much more toxic. Some of these hypotheses were validated when recently on November 2nd, 2010, scientists found a large area, 11 kilometers west of the spill, of dead and decaying coral and animals that was attributed to the toxins. This recent finding was a shock among the scientific community and cause for weary. However, the technological advances and effects of evolution can give us reason for optimism and hopefully will help to return the Gulf of Mexico to its former homeostatic state.

-Andrea DeDonato, Biology '11

Contributors to this Issue:

Andrea DeDonato, Tara Dhingra, Michael Lan, Brad West, Michael Murray, James Peerless, Sadie Lang, Kyle Deerwester, Emily Snead, Karissa A Sciacca, Jessica Melanson, Alexandra Sweeney, Sara McKecknie, John Jamieson, Corey Stepule, Kevin Hadar

Want to see your name on this list? Get involved! We meet Wednesdays at 7:30 in Room 14 IV. Email us at nusciencemag@gmail.com, check out our blog <http://nusci.weebly.com> and friend us on Facebook!

Meet the NEWEST addition to our NUScience team...

dr. geoffrey davies



Reviving the Earth:

Professor Davies talks about how dirt may be able to save us from climate change

How do you feel about your role as faculty advisor to NUScience?

I think it's wonderful. I really like how it educates many undergraduate students. I've worked with a lot of graduate students, but now I work exclusively with undergraduates. I enjoy teaching General Chemistry I; it's got something to do with seeing all these freshmen walking through the door, coming from all these different places, with some students who have never even seen a lab before, and bringing them together. The whole new experience is fascinating, isn't it?

What is your academic background?

Well, I was educated at Birmingham University- it's in England- starting in 1960, from a Bachelor of Science to a PhD, and all of them in chemistry, of course. I was at Brandeis and University of Kent for a little while. But the place I love most is Northeastern; I've taught at Northeastern since 1971, 39 years in fact.

Have you won any awards here?

I'm the only person here to have won four teaching awards, and the first to get a lifetime achievement award at Northeastern.

Can you talk about your research, such as on humic acids?

In the past, I've done research on alternative fuels, like liquefied coal, and on inorganic synthesis and kinetics- particularly on redox

reactions. Well, as of around 10 years or so, we established a group researching humic substances, specifically humic acids, which are these brownish polymers that are found in plants, coals, and soils. We have been figuring ways of extracting humic acids, trying to get them, as close as possible, in their most natural forms. To do this, we have to see how their structural components interact with various elements and compounds. For example, humic acids have this organic backbone with many functional groups, and these groups are very good at binding to things such as metals, nutrients, and water which make them very important for delivering nutrients to plants, and essentially (because we eat plants) ourselves. Now water has a very high specific heat, meaning that it's very hard to heat up. So humic acids 'absorb' all this water into the ground, and stabilize its temperature like a thermal sponge. Without them, you would just have dry land in some areas! So climate is controlled by humic acids, isn't it?

Can you elaborate more on humic acid's effects on climate change?

The main problem of climate change is that we are ruining the land, aren't we? Everyone is concerned about climate change, but we only focus on water and air, and we don't pay much attention to soil, don't we? When we erode the soil, through things like inorganic fertilizer and deforestation, the humic acids, which are soluble, are lost from the land, usually falling into the nearby

water. And since the humic acids have a high binding capacity towards metal toxins, all the toxins that fall with it poison the water, don't they? And the land, without the humic acids, has these huge temperature variations in different regions, which causes disasters like storms!

How can society use humic acids for its own benefits?

Most importantly, they can be reintroduced into eroded land as fertilizer and restore it with water- essentially giving life back to the environment. And landfills! All this junk is just dumped into nature, and their pollutants leak into many areas. So if you were an environmental engineer, you would establish a designated 'landfill' area, then dig a trench around that area, and you would put the humic acids (extracted from soft coal) inside of that trench. The humic acids would grab all the leached toxins into the trench, and protect the outside environment. It's wonderful, isn't it? Humic acids are also not carcinogenic, meaning that if they were delivered as a drug through the body, they wouldn't cause cancer. So they can bind to free radicals, these non-paired electron particles, which do cause cancer, and prevent them from harming the cells. But this is only very new research... I could go on forever about the uses of humic acids!

Northeastern University was the first to extract humic acids from a live plant, wasn't it?

Ah, yes, you've heard of Dr. Elham Ghabbour's work? Is she next door? [briefly calls Dr. Ghabbour over]. This is the person who was the 'catalyst' in my humic acid research, she's really quite wonderful. She was an important part in starting my research in this field.

So what does this purified humic acid look like?

First, we have the native sample, which is 98% water, with the rest being humic acid. Here the humic acid is like a sponge; it's soaked up water into these 'pores', or gaps in the humic acid, and all the water's surface tension is stretching the humic acid out! Like a brick, you see? Now there's this thing called an aerogel. It's this gel with very low density. So when you take the water out of the native substance, you're left with this aerogel, which IS the humic acid itself! Quite amazing, isn't it? The aerogel is like a backbone, and when we take water out of the original sample, we get the actual structure; all we did was to empty out the pores. If we had done it any other way, such as by directly heating the water, the whole thing would have collapsed.

And how exactly are humic acids extracted and isolated?

We want to replace the water in the pores with acetone, so the pores are full of acetone, and we put this sample in pressure, and then put it above the critical point of carbon dioxide. The pressure turns the carbon dioxide into this compressible superfluid, and this superfluid replaces acetone (which had replaced the water). Then as we lower the temperature, it evaporates... such that carbon dioxide becomes a gas, and since all the gas escapes and there's nothing to hold up the humic acid, then it's not a brick anymore, isn't it? It just slowly loosens into this gel, so what you end up with is this kind of jelly-like thing.

Do you have anything else to say to current undergraduates?

I highly encourage undergraduates to participate in research. And remember, next time you watch your step on soil, don't just call it 'dirt'.

-Michael Lan, Pharmacy '15

Hydrogen Fuel Cells: The Future Fuels of Automobiles?

Within the past 10 years the Department of Energy (DOE) has began focusing much of their attention on alternative fuels and the future of the automotive industry. Their goal is to be able to reduce dependency upon foreign oil, and to reduce greenhouse gas emissions. The Bush administration planned a 1.2 billion dollar project geared specifically toward researching hydrogen power and fuel cell technology as the future of the automotive industry. However, in 2009, the Obama administration cut funding of this program down to 68 million dollars, because battery electric cars seem to be a simpler solution. They are looking to fuel cells as a more long-term possibility in the future. Fuel cells are very promising because they are highly efficient and produce zero emissions; however the current lack of infrastructure is problematic for commercialization.

Fuel cells generate current through oxidation reduction reactions. A fuel is constantly fed through the anode (negative) side of the cell and an oxidant is fed through the cathode (positive) side of the cell. There are many different types of fuel cells that can be powered by a number of different oxidation reduction reac-

tions. However, hydrogen powered fuel cells are being pursued for the automotive application because oxygen is readily available in air, the only byproducts of the reaction are water and heat, and hydrogen is a very efficient fuel. The electrochemical half reactions for hydrogen fuel cells are relatively basic:

Anode Electrode Reaction:	$H_2 \rightarrow 2H^+ + 2e^-$
Cathode Electrode Reaction:	$\frac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow H_2O$
Overall Reaction:	$H_2 + \frac{1}{2}O_2 \rightarrow H_2O$

Hydrogen is oxidized on the anode side, oxygen is reduced on the cathode side, and water is produced as a product. This reaction is facilitated by the Membrane Exchange Apparatus (MEA), which is where both anode and cathode electrode come in contact with the ion conducting membrane. The type of membrane that is used depends upon the reaction that takes place. For hydrogen powered fuel cells, polymer electrolyte membranes or proton exchange membranes (PEM) are used. The electrode provides an electrical

connection to allow for the flow of electrons. Also located on the electrode is the catalyst where the reaction takes place. Typically this catalyst is platinum. The membrane facilitates the flow of hydrogen ions, H⁺, from the anode to the cathode side of the cell, and reacts with oxygen to form water. Aside from the MEA, another key component to fuel cell stacks is the bipolar plate. This plate has two main functions when stacking cells in series: to provide a connection for electrical flow through cells in series and to provide a barrier between gases of adjacent cells. The power capability of a fuel cell stack can widely vary as it depends upon the number of cells placed in series.

The Department of Energy has set several goals for fuel cells for in automotive industry. Durability, reliability, and cost are very key factors. In order to compete with the internal combustion engine, fuel cells need to be able to operate for 5,000 hours, which equates to about 150,000 miles under normal operating conditions, numerous start/stop cycles, and temperature cycling. The fuel cell stack also needs to be able to start up within a reasonable amount of time regardless of the external conditions. Freezing temperatures pose a problem when starting a fuel cell because the cell needs to heat up quickly and overcome the thermal mass of the entire stack so that the water produced does not form ice and cause the cells to freeze over and fail. The residual water left in the stack upon shutdown must be drained so that it does not freeze while the stack is not in use and upon startup the hydration state of the membrane must be restored before the cells can draw high current. Cost plays a major role in the commercialization of fuel cell technology because it needs to be comparable to the internal combustion engine. The Department of Energy estimated in 2009 the cost to produce an 80kW fuel cell stack to be \$61/kW for mass production and has set a goal of \$35/kW by 2015. Helping the cost of the fuel cell is its high fuel efficiency. On average, fuel cell vehicles are rated at approximately 58mpg and given the current cost of hydrogen, \$3.51/kg, it costs

6.1 cents per mile to operate this vehicle. This is cheaper than gasoline which is rated at 8.3 cents per mile for an automobile that gets 24mpg.

Currently, fuel cells also have a benefit over battery-electric cars because battery-electric cars have limited ranges. Fuel cells have an advantage largely due to the high-power-to-weight ratio of hydrogen gas. Fuel cell systems can provide power to a vehicle with 8 to 14 times less weight than would be needed with battery-electric cars. To increase the range of a fuel cell powered vehicle minimal weight is added to the system. However, this is not the case with battery-electric cars.

In battery-powered cars, more batteries would be needed to increase the car's range which increases the weight of the system.

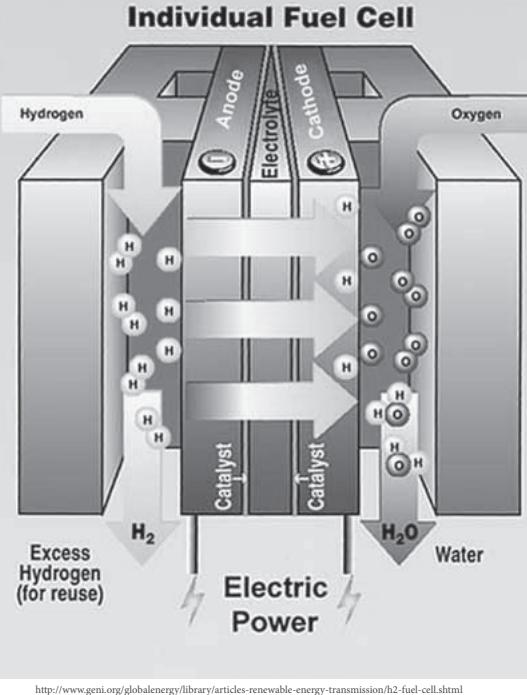
However, with the benefits of range and efficiency also comes a safety concern. In the presence of an oxidizer (oxygen in air), hydrogen gas burns very rapidly, and more easily than gasoline. It can also be highly explosive. Leaks in hydrogen storage tanks are a major concern and need to be monitored

by a hydrogen detector as the gas is colorless and odorless. Hydrogen gas produced from natural gasses can also be very expensive. Natural gas prices are currently rising due to dwindling reserves. Given the energy stored in gasoline at 115,000BTU per gallon, hydrogen production costs are almost double for an equivalent amount of energy.

Currently the infrastructure to support the commercialization of these technologies is not in place throughout the United States. The accessibility of hydrogen refueling stations will need to be greatly increased before these cars will become practical. However, broad scale commercialization within the next ten years is not unreasonable. Honda became one of the front runners in the industry with the release of their Clarity. The Clarity is powered by a fuel cell stack, a lithium-ion battery pack, and an electric motor. The Clarity was only released in the United Kingdom, Japan and only parts of southern California, due to a lack of hydrogen refueling stations elsewhere in the US.

It is still unclear if fuel cell technology will be the solution to the current energy crisis. However the outlook is promising and steps are already being taken toward commercialization of cleaner and more renewable sources of energy.

-Brad West, Chemical Engineering '13



Engineering Undergraduate Research: The Gordon-CenSSIS Program

Northeastern boasts a wide variety of organizations to connect undergraduate students with substantive research opportunities that meet their interests. For engineering majors, the Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems (Gordon-CenSSIS) provides an ideal environment for driven students to work on cutting-edge research.

Gordon-CenSSIS was founded in 2000 and devoted to studying the use of subsurface imaging technology, such as radar or X-ray, to solve real world problems. It currently serves as a National Science Foundation Engineering Research Center (NSF-ERC), working in conjunction with Boston University, Rensselaer Polytechnic Institute, and the University of Puerto Rico at Mayagüez, among others. The center receives millions of dollars annually in grant money from groups such as the National Science Foundation, the Gordon Foundation, and the Department of Homeland Security. Research at the center is focused on making progress in three “thrusts”: subsurface sensing and modeling, physics-based signal processing and understanding, and image and data information management.

Roughly a dozen undergraduates participate in research projects at Gordon-CenSSIS through the Gordon Scholars program. After an application process, accepted freshmen are introduced to the various projects, often being mentored by upperclassmen scholars. Gordon-CenSSIS Associate Director, Professor Carey Rappaport attributed the success of the Scholars program to the caliber of the students involved, commenting that “Undergraduates who seek out research tend to be curious, enthusiastic, show dedication, and tend to be pretty smart.” He also commented that, given the right circumstances, undergraduates have been able to make fundamental breakthroughs, due in part to their “basic, intuitive” approach to research.

Gordon scholars find themselves assisting a vast range of projects, from advances in radiology to pest control. Sophomore chemical engineer major Kassi Stein assisted with a microwave sensing system to detect pests in maple trees, working with Prof. Rappaport. Stein’s work included running computer simulations and modeling results with MATLAB. She stressed the connection she was able to make between her research and class work, saying “It was nice using programming skills that I’d learned in the classroom and applying it to real world problems. The whole research process helped me develop analytical skills which I can apply to any number of problems in a future career.”

Gordon-CenSSIS has two major off-shoots, Awareness and Localization of Explosive Related Threats (ALERT) and the Puerto Rico Testsite for Exploring Contamination Threats (PRO-

TECT). ALERT, a Department of Homeland Security Center of Excellence, allows students and faculty to apply sensing and imaging technology in new ways to help ensure the safety of others. To this end, Fernando Quivera, a middle electrical and computer engineer major recently worked with Prof. Rappaport and Prof. Jose Martinez-Lorenzo on an airplane-mounted radar system to detect underground tunnels. Theoretically, this development would help to prevent the transportation of explosives through tunnel systems. Quivera emphasized the positive

impact research has had on his studies, stating “It gave me motivation to study more. Now, I can’t wait to take classes and learn more! Research has also helped me to become more confident. I have felt like I can contribute to a current unsolved problem.” Students working with PROTECT seek to understand the effect of contaminants in the environment on human health, specifically preterm birth. Sophomore and civil engineer major Samantha Kendrick has worked for a number of months on a research project for PROTECT with Prof. Akram Alshawabkeh, studying the use of

iron electrolysis and other techniques to sanitize water sources.

The center also partners with Massachusetts General Hospital, allowing some undergraduate researchers to assist in the development of new biomedical technology. Melanie Jessel, a sophomore mechanical engineer major, does just this, helping to create a touch-free interface for devices used by radiologists. Said Jessel, “This research that I am doing doesn’t really have anything to do with my classes, which is something I like. It is exposing me to a type of engineering that I would not normally be exposed to since I am a mechanical engineer and I am working as a programmer. None of my classes really prepared for this.” On the subject of the practical applications of her research, she continued to say “Outside of what I do I know that there is the larger purpose of early detection of breast cancer screening so I am happy to be involved.”

Gordon-CenSSIS provides an invaluable resource for undergraduates looking to learn new skills with numerous applications. In the words of Prof. Rappaport, the center is “good for the undergraduates and good for the university. The best product is that undergraduates gain research experience and are able to contribute.”

For more information, visit <http://www.censis.neu.edu/>.

- Michael Murray, Computer Science/English '14

GMOs: What?

The Controversy Surrounding Genetically Modified Salmon

In 1996, genetically modified crops were approved for human consumption. Since then, the planted area dedicated to herbicide-tolerant soybeans, according to US department of agriculture, has increased from 7% in 1996 to 75% in 2002.

In fact, United States companies, unlike those in the European Union (EU) or Japan, do not even have to identify which agricultural products are genetically enhanced. Recently, AquaBounty Technologies submitted their AquAdvantage® Salmon (AAS) to the FDA for approval to sell as a food product. This has spurred more controversy, with concerns ranging from environmental impact to consumer awareness.

Salmon is the second most popular fish in America, and farmed fish makes up 50% of the salmon market. Today most salmon that we consume comes from farms. The consequence of farming salmon is the effect it has on the wild population. Biodiversity adaptability greatly decreases with the introduction of an altered genome. There are 48 times less wild salmon than farmed salmon today, and 30% of fish caught in the wild are actually farm escapees. Along with a threat to the environment, skeptics site socio-economic and ethical issues including sustainability (since it takes 1.5kg of food to produce 1kg of salmon). These critics argue that transgenesis will simply amplify the problems farming has introduced and continue to damage our environment. In essence, AquaBounty genetically engineered an Atlantic Salmon to grow twice as fast as a normal salmon by inserting a growth hormone gene from another species. In an interview with the company, AquaBounty argues that AAS “will provide compelling economic benefit to salmon farmers” and that “there will be less need for ocean pens.” They also address the issue of genetic contamination of wild species by

creating only female, sterile fish and using inland facilities that are far away from natural salmon habitats. In September of this year the FDA stated that there was no difference between the AAS and natural salmon including no increase in allergens, a large concern for many consumers. Besides consumption, fish can also be genetically modified as scientific models to study human diseases and pharmaceuticals, as “biosensors” to detect pollution, and to eliminate food allergies.

“Genetic modification is a complicated process that lacks precision. Even when utilizing the same protocol, there can be a many hits and misses with only some animals presenting the desired trait”

Despite the optimistic outlook, some still speculate about the safety of genetically altering animals for consumption. Genetic modification is a complicated process that lacks precision. Even when utilizing the same protocol, there can be a many hits and misses with only some animals presenting the desired trait. A growth hormone gene in one salmon species may have harmful or unknown effects in another species. Besides the unpredictability of making a GMS, certain health effects could arise if the desired gene also induces the production of a toxic substance or allergen. Another even more dangerous threat is the risk of horizontal gene transfer which can occur easily in an aquatic environment. Horizontal gene transfer occurs when genes pass from one species to another in the environment even if the organisms are not similar. For example, an antibiotic resistant plant may pass on the antibiotic resistance to bacteria in the soil. In this case, the transgenic salmon could pass on the growth enhancing hormone to other species that share the same habitat.

Although AAS are engineered to be unfit to live in the



For Dinner?

wild, if released they could add to the pressure on freshwater ecosystems which have already seen a 50% decrease in species populations since 1970. To combat this, engineers have utilized a strategy called induced triploidization, which results in three sets of chromosomes in the fish. The salmon will appear exactly the same to the consumer, but will not be able to reproduce. This, however, is not a fail-safe method in guaranteeing sterilization. Additionally, even though they cannot reproduce themselves, these larger salmon provide excess competition to wild salmon. The genetic flow of transgenic genes to the wild population over time could have detrimental effects. Three potential developments include: the complete removal of the modification from the population, the transgene becomes the wild type gene and eliminates the wild phenotype we see today, or the passing on of the trait through several generations leading to the extinction of the entire species. One critic estimated that "if 60 transgenic salmon were disseminated among 60,000 wild salmon, the natural population would be decimated in 40 generations."

Though many scientists focus on the environmental impact GMOs could have, there are many more facets to the issue. Biotechnology companies would have total control over manufacturing sterile salmon hurting farmers who would have to buy fish from them. Though it would drive down the price for consumers, small businesses and third world nations will suffer. But even with the lower price, would people choose GMS over non-GMS? A preliminary survey taken in 2002 assessed con-

sumer acceptance if a GMS came to market 68.9% of American consumers chose non-GMS over GMS and 53% were willing to pay a premium for non-GMS. However, a significant portion of the people screened were indifferent to the choices.

AquAdvantage Salmon is just the first of 30 aquatic species and some other farm animals, like pigs with less fatty meat, being engineered for the food market. Thus the FDA's decision will set a precedent for other companies producing these animals and to other countries that may import or export these goods. If the AquAdvantage Salmon is approved by the FDA for human consumption, it must be only with the strictest regulations and requirements to prevent the potential for a release into the wild. Protection should also be provided for small fish farmers who will become dependent on the companies that have the technology to make the cheaper, faster growing fish. Overall, this is a risky business that could affect the earth's ecosystems tremendously.

-Tara Dhingra, Biochemistry '12

The Science of Genetic Engineering

How Man Rewrites the Genome

The term genetic modification in our vernacular conjures up images of cutting edge science, automatic pipettes, microscopes, and Petri dishes. However, humans have been messing with the genetic makeup of organisms for millennia. One only has to look at the vast diversity of domesticated canine strains and orchid variations to see our handy work. Yet, advances in Gregor Mendel's experiments in the mid-19th century opened the door for our understanding of how the principles of genetics, already practiced in our history of selective breeding, actually work and can be predicted. Combined with the Watson and Crick discovery of the genetic molecule in the 1953 and the advances in technological equipment, we can bypass generations of selective breeding and literally insert the traits we desire in organisms of our choosing. Undoubtedly, these genetically modified organisms have taken part in our lives one way or another, but few of us actually realize how man can manipulate the basic building blocks of life to achieve our ends.

The entire genetic modification process starts with gene isolation. If one wants to create a banana

that tastes like a kiwi, one must first find what genetic sequence causes the kiwi to taste like it does. This particular example highlights one of the current limits of genetic engineering. The gene sequence that gives kiwis their taste is probably not a simple strand found on one chromosome acting independently of other cell processes. Complex traits such as taste are usually found on multiple chromosomes and are involved in a symphony of other cell processes of which taste would be a mere by-product. However, if the interest is in producing just one protein, say insulin or a protein that makes a plant resistant to herbicides, the specific sequence of nucleotides (Adenine, Thymine, Guanine and Cytosine) is commonly a linear progression found on a single chromosome. Although many genomes have been fully mapped, it is still unknown where in the genome the codes for many proteins lie. The first step is finding where the genetic material for the desired trait exists, and isolating it from the donor organism. Luckily, the gene can be captured from any donor organism's DNA, often humans, or can even be synthetically generated.

The next step is packaging the genetic material in a stable form for introduction to the host cell (the cell in which you want the gene ultimately expressed). The single DNA strand cannot be simply dropped in a beaker with host cells and be expected to enter the genetic code of the host. This usually involves adding extra genetic material known as promoters and terminators. These extra coding blocks regulate how much of the coded protein should be produced by starting and stopping gene transcription. The gene is

then inserted in a plasmid, a ring of genetic material found in bacteria, using gene opening and closing enzymes. The plasmids have a simple ring structure that does not require the complicated unfolding and unwinding of a normal chromosomal structure, making them perfect candidates for easy transfer of the genetic material.

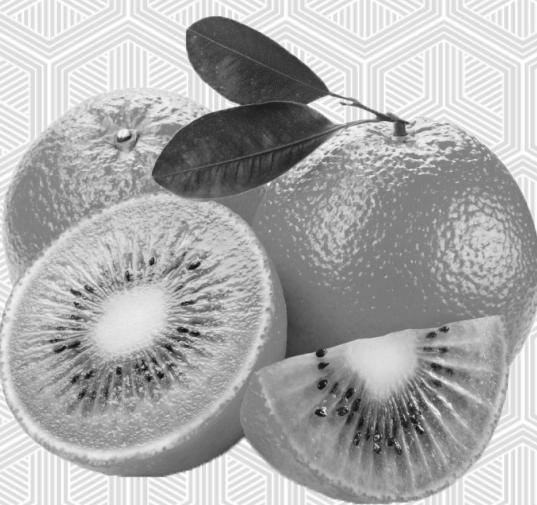
Now that the genetic material to be ultimately expressed is packaged in a stable form, it must be introduced to the host cell. Herein lies one of the more difficult parts of the process. Although the genetic material will be readily incorporated into the genome of the host by natural gene recombination processes, the genetic material in most cells is well contained in a variety of membranes (for good reason). The method for inserting the genetic material differs by cell type. Bacteria are generally the easiest, which is why the first genetically modified organisms were bacteria engineered to produce complex proteins used in pharmaceuticals. This is due to the fact that bacteria have no nuclear membrane guarding their genetic material; only the cell membrane of the bacteria needs to be breached. A few bacteria (about 1%)

have membranes that are naturally permeable to genetic material. For introducing foreign genes into other bacteria, microinjection, simply physically injecting the material through the membrane, can be used. Scientists also subject the host bacteria to heat or electric shock to make the membrane more permeable, but there are often considerations of harming the cell using these methods.

For the more complex animal cells, similar methods can be used, but they must be used on a much more delicate scale. Animal cells contain a nuclear envelope separating their genetic material from the rest of the cell. This means that microinjection techniques must penetrate this membrane as well as the cell membrane, and heat or electric shock methods must be more aggressive. Another method that has a much lower risk of harming the cell is using a viral construct. This method involves engineering a virus with the wanted genetic material inside of it. Viruses are naturally designed to invade the nucleus of a cell with its genetic material, and these synthetic viruses work very much the same way.

Plant cells are difficult because they have a rigid cell wall that would be destroyed by microinjection techniques. The method most commonly used is called Agrobacterium-mediated recombination. This utilizes the special naturally-occurring Agrobacterium which inserts a tumor-causing genetic material into plants causing crown gall disease. The method involves switching the natural tumor-inducing plasmid with the plasmid meant for gene expression.

Once the desired genetic material is inside the host cell, coding in the plasmid allows for incorporation in the host's genetic



Future of Genetic Engineering: Kiwi or Orange?

construct. Often, scientists will accelerate the process by adding gene splicing and replicating enzymes. Now that one host cell has incorporated the genetic code, the organism must be grown from the single modified cells. Bacteria simply replicate, while plants require a tissue culture to be formed. Animals have a very complex and regimented method of development, so embryonic stem cells must be used as a starting point. Once the cells naturally replicate, however, the formation of the final organism is completed naturally. This organism can then reproduce as normal adults of its species,

giving us insulin-producing bacteria, herbicide-resistant crops, and glow in the dark cats. Although the ethics debate over genetic modification will continue to be debated (as it should), the science has reached a state of maturity allowing its impact on our world.

-James Peerless, Chemical Engineering '12

Editorial

Genetically Modified Foods: The Ethics of it All

"While at one time a vigorous new religion could transfigure a continent in a few centuries, a vigorous new technology can now do the same to the entire world in a matter of decades" (Edwards 1999)

Science has led to many great discoveries but as stated it can have powerful effects on society. Taking a look at the subject of genetically modified (GM) foods (foods of whose heritable traits have been achieved through scientific manipulation), through the lenses of scientific, market, and cultural standpoints the science will be seen as having met many ethical dilemmas.

With the world population estimated to surpass 9 billion by 2050 (Associated Press, 2010) many see genetically modified foods as a hope to avoid projected widespread starvation. In recent news however GM crops have been seen as ineffectively addressing the issue of hunger (as tested in some third world countries such as Nigeria) but these crops have been seen as hurtful to such an effort. The pink bollworm (cotton plant pest) in India, for example, has mutated to resist one of the genes being used in cotton crops (NPR 2010).

In other cases as Marcel Montoya of Santa Fe writes, "[Genetically modified crops] are all completely chemically dependent and the fact that they are only grown in giant mono crop farms that basically destroy the soil they grow on within a matter of years, slowing soil degradation a little bit is by no means a solution" (NPR 2010).

Yet with effects such as these many supporters of GM crops argue that fears of this technology are similar to "concerns of microwave ovens" (NPR 2010). While this may not be the case there is a difference between the two subjects; for one the microwave was man made and so by altering it would fall under the justifications of its creator. Genetically modified foods, however, are a different story; people begin to become the creators of its own nature.

As philosopher Fred Edwards puts it, "with the capacity to massively change the external world of animals and plants to suite our desires, we relinquish another level of ties to the land and external nature. With the capacity to reshape ourselves, our family genetic heritage, and our communities, we divorce ourselves from many of the familial duties and social connections that once formed the basis of our behavior" (Edwards 1999).

Consequently the scientists and corporations behind GM products have to look at the different relationships and circumstances in order to conclude a variety of specific moral obligations. For example, in order for the FDA to state that a genetically modified salmon is safe under "reasonable certainty" it states:

- i. If something is deemed as safe, it can cause no harm.
- ii. GM salmon has been deemed as safe.
- iii. Therefore GM salmon can cause no harm.

The first premise of this argument falls under invalid reasoning; for if I deem a product as safe that does not necessarily lead to the conclusion that it cannot cause harm. And while this argument is unsound, it is arguably under similar reasoning the FDA has approved much of these GM products.

Genetically engineered foods must agree with the following three qualifications in order to be considered for mass production and marketing:

1. Is the inserted gene safe for the health of the [subject]? (NPR 2010)
2. Is the inserted gene and the growth hormone it's producing safe for humans to eat? (NPR 2010)
3. And third, will the [production of these GMOs] have any effects on the environment? (NPR 2010)

What is interesting is that the FDA does not require a GM product to be environmentally safe but that an "environmental assessment" of the product be studied instead (NPR 2010). Even if scientific research behind these products were done with greater depth, the research fails to touch upon other realms in which these products could effect, including psychosocial and cultural.

Psychosocial and Cultural Effects

Regardless whether a product has been deemed as safe, there is always risk. Risk in this case is seen by many social sci-



tists as subjective. That is to say, "risk is a social construct, meaning different things to different people and cannot be measured independent of our minds and cultures" (Finucane and Holup 2005).

With this in mind in 1992 the USDA allowed GM ingredients to market quickly in the US without labels. In contrast to the US, however, Europe was not so quick to give the ok in allowing GM ingredients to hit the market. Europe's caution in the matter may have been heightened due to the mad cow disease outbreak, leaving Europeans with a heightened perception of the risks involved in food production (Finucane and Holup 2005). While Europeans have quite a heightened perception of risk (as seen recently with student demonstrations banning GM potatoes) the US may be soon to follow as due to recent salmonella outbreaks in eggs.

Though the psychosocial and cultural issues surrounding GM products are great, the issue has not been studied thoroughly enough by the companies of which produce these products. Perhaps this is a lesson for all companies to embrace, that every cause has an effect.

Business Effects

Notably it is important to realize that in the end these crops and foods are products of a company and as such the ideals of business ethics must be looked at when discussing the realms of GM foods.

Firstly the issue of labeling is a heavily debatable one; should products be labeled as being genetically modified? Well nearly 60-70% of food products on grocery shelves contain GM products (National Institute of Nutrition, 2001). Inevitably the consumer has a right to know what is in their food. The dilemma in labeling these GM foods is that there is no unilateral set of laws that give obligations for these companies to label their products. Many times, however, the law and ethics share separate domains and in this case it would be ethically obligatory for corporations to come up with a unilateral system of labeling. This is in essence a company's initiative to act in good will and as such hold companies to act in sense of duty (Kantian Ethics).

Another dilemma lies within the shareholders of these companies. Many consumers would less likely purchase a product had they known it was genetically modified (MacDonald and Whellams 2007). In effect this would prove detrimental to the shareholders of these GM products.

The existence of these products, however, may prove just

as fatal to the shareholders of organic foods. In recent news the Ecological Society of America in Pittsburgh, showed that the vast majority of feral canola plants in the state contain artificial genes that make them resistant to herbicides, suggesting that GM canola seedlings have spread in the wild. (NPR 2010). In turn these organic farms could lose their license as well as being penalized by the USDA by falsifying their products as being organic. Therefore this argument for not labeling these GM products can be debunked as other shareholders are at risk regardless of their decision to label.

In essence the greater good in this case is the consumer. That is to say that the consumer maybe purchasing organic foods of which may not truly be organic; or in other cases, they may be unknowingly buying GM foods. As a result these products should be labeled and by doing so the consumer, not corporations, are given the leverage over the market.

The Ethics of it All

The creation and expansion of genetically modified foods is a debatable and controversial topic on many platforms. Such a conclusion has been reached after looking at the subject through a scientific, business and cultural perspective. Scientifically GM crops are done so by altering nature to our liking and consequently destroying the humanistic ties between man and nature. Through cultural perspectives the makers of GM products fail to establish an understanding of the cultural consequences of their products. Corporations of these products act in an egoistic manner by putting the result of an action (in this case profits and short term solutions to food shortage) over the character of which these actions are committed.

Overall the interests of which GM foods are made can either be debunked or seen as unethically accomplished. Jonas Salk, discoverer of the polio vaccine, once said, "If all the insects from the Earth disappeared, within 50 years all life on Earth would end. If all the human beings from the Earth disappeared, within 50 years all life on Earth would flourish." Thus it seems GM products are not the only subjects that should be brought into question. Before solutions are created, one should step back to see why these problems occurred in the first place; perhaps then much of these ethical dilemmas can be answered through the very actions of observation and questioning.

-Kevin Hadar, Biochemistry '13

Hypoallergenic Pets



62% of US households own a pet, according to the American Pet Products Association. Yet 15% of Americans suffer from pet allergies. Weekly immunotherapy shots can help relieve allergy symptoms, but science has come up with a much less painful method: genetically engineered hypoallergenic pets. Allerca Inc.'s "Lifestyle Pets" include cats and dogs that lack the specific glycoprotein that causes reactions in humans. According to Allerca's website, they target naturally occurring mutations in the genes that produce this protein (called Fel d 1 in cats and Can d 1 in dogs). By identifying and selectively breeding for these mutations, they claim to have created hypoallergenic pets. But does it really work? The Fel d 1 protein is only one of a few proteins that can cause allergens, and so far there have been no outside studies about the Allerca cats and if they are truly allergen-free. Want to see for yourself? Be prepared to pay at least \$10,000 and wait about a year to secure a cat or dog of your own!

-Sadie Lang, Environmental Science '12

Deep Brain Stimulation: the Next Careful Step in Neurological Treatment

We sing the body electric. We are ruled by action potentials. Waves of electricity pulse through our bodies. Every move you make, every thought you have, every personality quirk you show- all of it derives from electric currents coursing through your neurons. We are electric beings.

An interruption in our internal wiring, then, can have drastic consequences. Severing the motor neurons in one's spine can leave one completely paralyzed. Severing the connections in the fusiform gyrus can destroy one's ability to recognize the faces of his loved ones. Destroying the connections to one's hippocampus can eliminate one's ability to create new memories. Over activity of the same connections can result in crippling epilepsy. An incomprehensible number of neural connections exist in our bodies. Some of them are redundant, and thus, an interruption will have unnoticeable effects. Some of them are anything but, however, and an interruption here can completely change a person's very sense of self.

This presents an important question: if the electric impulses in a particular region of the brain can destroy a neurological function, can we restore that function by administering targeted electrical impulses to that region? This is the mechanism by which the neurosurgical procedure Deep Brain Stimulation works.

Deep Brain Stimulation (DBS) is by no means a trivial procedure. It is highly invasive, and potentially lethal complications can arise from the surgery. Thus, DBS is typically used only when all other options have failed. However, the effects observed in movement disorders have been absolutely remarkable, allowing people paralyzed by Parkinson's disease to walk again.

A DBS apparatus consists of three components. An Internal Pulse Generator (or IPG, similar to a pacemaker) is implanted under the skin below the clavicle. This IPG can be programmed and calibrated to an individual patient's needs by a neurologist. The second component of the apparatus is called the Extension. This is an insulated cord that runs from the IPG to the third component (called the Lead) by running up the neck, around the back of the ear, and up to the top of the skull. The lead goes through the

skull and terminates in four small electrodes that are implanted directly into the appropriate region of the brain as determined by MRI and CT scans (hence "Deep brain stimulation").

DBS as a treatment for psychiatric disorders is a controversial issue, however, as it is still highly experimental. To determine whether or not it is even a viable treatment, we must first determine whether DBS is a viable treatment for any neurological disorder. One of the pioneering studies for DBS measured the effects of "...high-frequency stimulation of the ventral intermediate nucleus (Vim)... in 26 patients with Parkinson's disease and 6 with essential tremor" (Benabid et al., 1991). Prior to this study, the primary method of surgical treatment of Parkinson's Disease was bilateral Vim thalamotomy, an extremely invasive procedure that could have drastic side effects. Additionally, thalamotomy was not

entirely effective, as it is a permanent, non-adjustable solution. DBS has the advantage of being adjustable, and thus, the optimum frequency range can be tuned to each individual patient without further surgeries. In an academic paper by Benabid et al., data shows a change in the physical structure of the brain post-operation- a factor that could not be controlled for in thalamotomy. However, because the IPG is adjustable, neurologists were able to change the administered pulses to match changes in the brain as it began to heal. Therefore, the procedure had a much higher success rate. The effects of the DBS are only present so long as the IPG is active, however, and so "Electrical stimulation will presumably have to be continued indefinitely..." (Benabid et al. 1991).

The paper goes on to suggest that new types of IPGs will need to be developed with more finely-tuned operative frequencies. However, the stage had been set by this paper. While the technology wasn't perfect, it showed that DBS is, in fact, a very promising procedure for motor disorders.

If neurological disorders can be treated via DBS, then, can psychiatric functions also be affected? If things such as mood and perception are truly mediated by neurological function, then it should follow that electrical stimulation of certain brain areas should also be able to change psychiatric properties of the patient. Definitive data proving this phenomenon came quite by accident



Deep brain stimulation electrodes placed in the subthalamic nucleus.

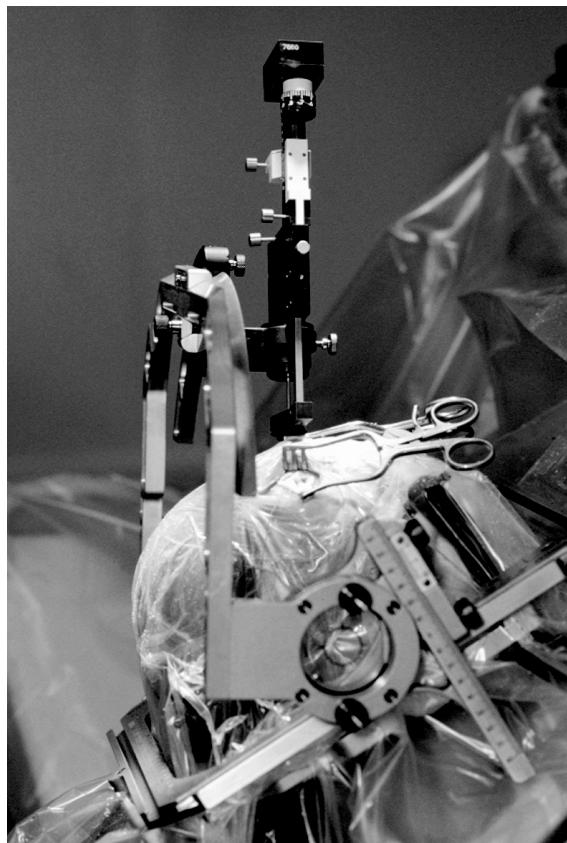
in a study published in the New England Journal of Medicine. In this study, a woman being treated for Parkinson's disease was given DBS surgery. One of the electrodes was placed in the substantia nigra, as opposed to the subthalamic nuclei, as was standard. This represents a 2mm shift in positioning. The effects were absolutely astounding.

During this postoperative evaluation, the patient's face expressed profound sadness within five seconds after a continuous voltage was delivered for seven minutes through contact 0 of the electrode implanted on the left. Although still alert, the patient leaned to the right, started to cry, and verbally communicated feelings of sadness, guilt, uselessness, and hopelessness, such as "I'm falling down in my head, I no longer wish to live, to see anything, hear anything, feel anything. . ." When asked why she was crying and if she felt pain, she responded: "No, I'm fed up with life, I've had enough. . . I don't want to live anymore, I'm disgusted with life. . . Everything is useless, always feeling worthless, I'm scared in this world." She had no hallucinations, nor were there any changes in her motor or cognitive symptoms of Parkinson's disease. The depression disappeared less than 90 seconds after stimulation was stopped. For the next five minutes the patient was in a slightly hypomanic state, and she laughed and joked with the examiner, playfully pulling his tie. She recalled the entire episode. Stimulation, performed at least twice, through the other contacts of each electrode did not elicit this psychiatric response. (Bejjani et al., 1999)

Stimulation of the other contacts in the left electrode (in addition to the right electrode in its entirety), mere millimeters away, resulted in cessation of Parkinsonian symptoms and left the patient's mood unchanged. However, stimulation of this one particular contact of the left electrode resulted in severe major depressive symptoms. The depressive symptoms appeared within seconds of the contact being activated and remained as long as it continued to administer pulses. However, within seconds of the contact being deactivated, the depressive symptoms completely disappeared, and the patient was back to her stable, baseline mood. This phenomenon was consistent throughout multiple trials and represented a very important discovery: DBS could induce certain psychiatric effects.

Now that we know we can cause a major depressive state in a patient via DBS, the next logical step would be to see if we can treat Major Depression through a more targeted application of DBS. We already knew of the efficacy of electroconvulsive therapy (ECT) for non-responsive depression, but it is very limited. One major shortcoming is that ECT is not a permanent solution. It must be re-administered consistently, as most patients will wind up relapsing within a few months of initial treatment. To make matters worse, there are many very concerning side effects associated with long-term use of ECT, including cognitive changes, amnesia, and even structural changes to brain tissue. For these reasons, it is very important that a safe, long-term treatment be found for unresponsive Major Depression. As of now, there is no general consensus that DBS is an effective way to treat Major Depression. However, there has been some extremely promising research to suggest that, with some fine tuning, it can be. A study by Mayberg et al. used DBS in the subgenual cingulate of six patients with unresponsive Major Depression. Four of the

patients showed statistically significant difference in their depression levels (as rated by the Hamilton Depression Rating Scale). By applying stimulation of 130Hz, 4.0V at intervals of 60 μ s (the mean as indicated in the results section of the paper) to the white matter of the subgenual cingulate, Brodmann Area 25 (Gg25WM), depression symptoms were dramatically reduced. However, upon pretending to apply the same electric pulses, the depression symptoms did not subside, meaning that the results were not due to the



Stereotactic frame for deep brain stimulation surgery

placebo effect, but to the actual DBS procedure. Unfortunately, this study has a very small sample size (only 6 patients), so even though the success rate is very high, this study cannot be accepted as conclusive evidence that DBS is an effective procedure for treatment resistant depression. However, this is a major step in the

right direction, and it is easy to see why one might extrapolate that we could see similar development in DBS as a Major Depression treatment as DBS for motor disorders.

"Stimulation of the other contacts in the left electrode ... resulted in cessation of Parkinsonian symptoms and left the patient's mood unchanged."

Having established that there is potential for DBS to work as an effective Major Depression treatment, the next logical step is to see if other psychiatric disorders can be affected by DBS. Another study published in the New England Journal of Medicine presented data suggesting that DBS could be used for the treatment of Obsessive-Compulsive Disorder (OCD). In this study, electrodes were placed in the subthalamic nucleus, only a few millimeters away from the location stimulated in treatment of Parkinson's disease. Stimulation was applied at 130Hz in intervals of 60 μ s, slowly being increased to 4.0V. The results, as the past three studies have shown, were very promising. This data shows that, after stimulation in the subthalamic nucleus, OCD symptoms subsided drastically. Stimulations were subsequently stopped, and in

Can Your Phone Make You Smarter?

Well, maybe if you've got the right one. Scientists and programmers are teaming up to produce iPhone and other smartphone apps to test and improve cognitive functions of the brain. Lumos Labs is a cognitive neuroscience research and development company that creates software to improve brain function and activity. Since its founding in 2005, Lumos Labs has developed numerous interactive "brain games" that improve memory, problem solving, critical thinking, attention, flexibility and speed. Backed by top-rated neuroscientists including Dr. Moirah Thomason, Dr. Cris Niell, and Dr. Michael Walker, Lumos Labs emerges as a leading software company invested in improving the daily brain activity and efficiency of its users.

To reach a broader audience, Lumos Labs has recently introduced an interactive iPhone app called Brain Trainer. The 30-day free trial includes nine games that challenge basic cognitive functions such as attention, memory, and sensory problem solving. At the conclusion of each brief three-game session, your overall BPI (Brain Performance Index) is calculated using a complex algorithm derived by Lumos Labs neuroscientists. Each individual training course is programmed based on scientific research and is presented in a creative, approachable manner. Combined, the nine games available on the Brain Trainer app have the ability to improve brain efficiency, attention span, memory function, critical thinking, and creativity.

To test the true effectiveness of Brain Trainer I downloaded the iPhone app to see what all the buzz was about. iPhone users have access to a 30-day free trial of the app, and I wasted no time to take full advantage of this offer. The games are fun, engaging, and exciting to complete. I quickly noticed an increase in reaction speed throughout my sessions.

doing so, the symptoms returned. This indicates that, once again, the reduction of symptoms is due to the DBS and not the placebo effect. Interestingly, Mallet notes that "There was no significant effect of the stimulation on measures of depression or anxiety, neuropsychological measures, or self-assessment of disability." The stimulation of the targeted regions in this study affected only the OCD-related symptoms. This indicates that there are, indeed, localized areas of the brain for various psychiatric disorders, and stimulation at targeted locations can relieve these symptoms, rather than having to resort to generalized ECT.

It appears, then, that there is serious merit to the idea of surgical methods being used to treat crippling psychiatric diseases. The hurdles that will need to be overcome are in identifying the proper locations to administer electric pulses to, and delivering the pulses in a less-invasive manner. Infection is one of the biggest

When my free trial expired, I signed up for a three-month period for \$4 (well worth it). Brain Trainer allows each individual user to track their BPI's in both overall and specific BPI's in categories including speed, memory, attention, flexibility and problem solving. In the past month and a half of use, my overall BPI has noticeably increased from a score of 850 to 1290 (on a scale ranging from 0 – 1700). The numerous memory and speed games in Brain Trainer helped me remember information on flashcards more efficiently for my midterms. Brain Trainer for the iPhone gradually re-trains its users' brains to be more efficient and effective in storing pertinent information, retaining attention, thinking creatively and solving problems.

Many outside researchers are now using the Brain Trainer games developed by Lumos Labs in various neurological studies. Dr. Maurice Finn of the University of South Wales currently tests the effects of Brain Trainer tools in older adults suffering

from mild cognitive impairment. Similarly, Dr. Adam Gazzaley, director of the Neuroscience Imaging Center at the University of California, San Francisco is using Lumos Labs tools to investigate age-related changes in memory function. To help returning soldiers recover from post-traumatic stress disorder and brain injury, Dr. Chris Johnson of the Naval Health Research Center at the University of California, San Diego is implementing the Brain Trainer games into his research and treatment.

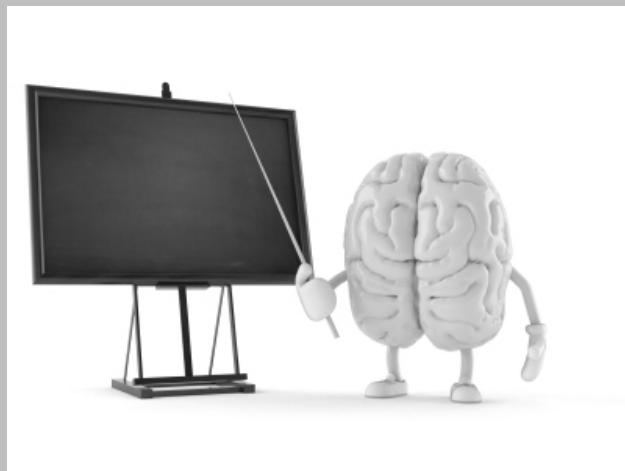
With final exams around the corner, it might be a good idea to download Lumos Lab's free trial of Brain Trainer - or log onto Lumosity.com – to boost your basic cognitive functions. Even if you don't find the interactive games useful, they're always fun outlets for taking study breaks!

-Emily Snead, Environmental Science '12

problems with DBS, as it necessitates the removal of the entire apparatus. By improving implantation techniques, or even creating less invasive apparatus, the risk of surgical complications can be drastically reduced, allowing more people to have access to treatment.

To see the effects of DBS on a patient with debilitating generalized dystonia, please watch the following two videos:
<http://www.youtube.com/watch?v=a-8LW5GAlbc> (before operation)
<http://www.youtube.com/watch?v=UAuxVwaRAKE> (3 months post operation)

-Kyle Deerwester, Behavioral Neuroscience '13



Doggone Shame: Herbicides Lead to Lymphoma in Dogs

Man's best friend and lawn keeper's best friend, as it turns out, are not friends of each other.

2,4-Dichlorophenoxyacetic acid (2,4-D), a common ingredient in many readily available weed killers, has been linked to lymphoma in dogs whose owners use 2,4-D herbicides on their lawns, according to recent scientific studies.

A dog is two times more likely to develop lymphoma if its owners treat their lawn with 2,4-D, a 1991 study, "Case-Control Study of Canine Malignant Lymphoma: Positive Association With Dog Owner's Use of 2,4-Dichlorophenoxyacetic Acid Herbicides," found.

"The findings in this study are consistent with occupational studies in humans, which have reported modest associations between agricultural exposure to 2,4-D and increased risk of non-Hodgkin's lymphoma, the histology and epidemiology of which are similar to those of canine malignant lymphoma," the study reported. "The present study suggests that human health implications of 2,4-D exposure in the home environment should receive further investigation."

According to the study, a dog can get 2,4-

D in its system by rolling around in or licking grass recently treated by a 2,4-D based herbicide.

According to a June 2005 Environmental Protection Agency (EPA) decision on the re-registration eligibility of 2,4-D, United States citizens collectively use 46 million pounds of 2,4-D a year. Homeowners treating their lawns with 2,4-D accounts for 18 percent of that number. An additional six percent comes from landscapers or contractors who treat residential lawns with the herbicide.

In addition, 660 agricultural and home use products contain 2,4-D, the EPA document reported.

A common weed killer, the Ortho-made Weed-B-Gon, has 2,4-D as an active ingredient. Anyone can purchase this herbicide at a hardware store. Home Depot, Ace Hardware, and Aubuchon Hardware all sell Weed-B-Gon.

Other products a person might find on the market include Ace Spot Weed Killer and Fertilome Weed Out Weed Killer. The herbicide can come in a variety of forms: As an acid, a sour substance with a pH lower than 7.0; as an amine, a derivative of ammonia; or as ester, a compound formed by condensing an acid with an alcohol.

2,4-D, according to the EPA, "is thought to increase cell-wall plasticity, biosynthesis of proteins, and the production of ethylene. The abnormal increases in these processes are thought to result in an uncontrolled cell division and growth which damages vascular tissue."

Cancer is an illness defined as an uncontrolled cell growth. 2,4-D, according to the EPA, produces an "uncontrolled... growth" effect in the weeds it is meant to exterminate – and possibly, as the 1991 study found, the same effect can be found in dogs.

A 1994 study published in *Cancer Epidemiology, Biomarkers, and Prevention*, entitled "Canine Exposure to Herbicide-

treated Lawns and Urinary Excretion of 2,4-D," attempted to evaluate the claims laid out in the 1991 study. This 1994 study found that dogs easily absorb and retain 2,4-D in their systems. Seventy-five percent of the experimental group, (the dogs exposed to 2,4-D), had moderate concentrations of 2,4-D in their urine. Thirty-nine percent of the experimental group had a high concentration of 2,4-D in their urine. Even of the control group, made up entirely of dogs unexposed to 2,4-D, four dogs still had traces of 2,4-D in their system.

Since four of the unexposed dogs inexplicably had 2,4-D in their urine, it is possible for dogs to get 2,4-D in their system from public places such as parks, the study explained. The study also found that dogs exposed to lawns treated with 2,4-D within a week were 50 times more likely to have a high concentration of 2,4-D than dogs exposed to lawns treated more than a week prior.

"These findings demonstrate that dogs living in and around residences with recent 2,4-D lawn treatment absorb measurable amounts of the herbicide for several days after the application and thus may constitute a useful animal model for evaluation of the effects of herbicides on the induction of lymphoid cancer," the study said.

A 1996 study published in *Fundamental and Applied Toxicology*, "Comparative Subchronic and Chronic Dietary Toxicity Studies on 2,4-Dichlorophenoxyacetic Acid, Amine, and Ester in the Dog," also responded to the initial 1991 study. The 1996 study contended that 2,4-D has no effect on the health of dogs. The study examines the effects on dogs who have been exposed to different forms of 2,4-D.

"The three test materials [2,4-D acid, amine, and ester] were relatively well tolerated at all dose levels," the study said. "There were no treatment-related deaths or illnesses...No treatment-related effects were noted in clinical signs, the ophthalmoscopic evaluations, hematologic parameters, or gross pathology."

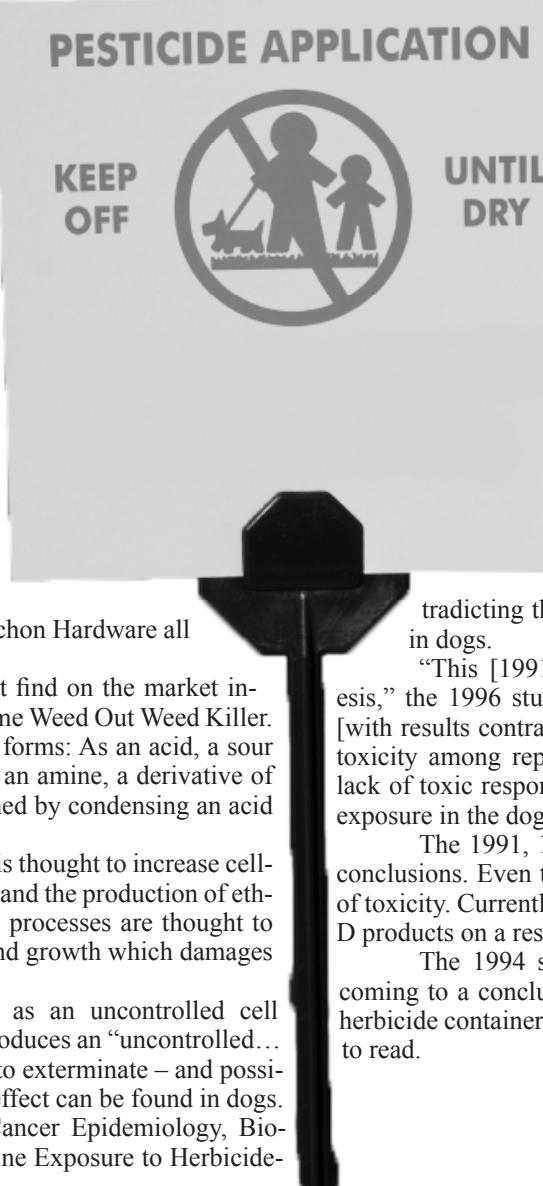
The 1996 study cited other studies contradicting the conclusion that 2,4-D can cause lymphoma in dogs.

"This [1991] report is unique in its lymphoma hypothesis," the 1996 study contended. "The findings of these studies [with results contradicting the 1991 study's] indicate comparable toxicity among representative forms of 2,4-D and their general lack of toxic response following sub-chronic and chronic dietary exposure in the dog."

The 1991, 1994, and 1996 studies all draw contradictory conclusions. Even today, scientists still disagree on 2,4-D's level of toxicity. Currently it is still legal in the United States to use 2,4-D products on a residential lawn.

The 1994 study advised further experimentation before coming to a conclusion. But just to be safe, read the back of an herbicide container before using it. It might be doggone important to read.

-Jessica Melanson, Journalism '14



NEW SHAMU? NEW TECHNOLOGY LEADS SCIENTISTS TO BELIEVE THERE ARE MORE SPECIES OF ORCA WHALES

Scientists have finally been able to confirm that there may be more species of killer whales, more commonly known as Orca whales, than have been previously discovered. For a long time researchers have observed physical differences in killer whales suggesting that there are different species, but more recently genetic evidence has been obtained to support this idea as well.

With the development of new mitochondrial DNA sequencing technology called highly parallel sequencing, scientists have sequenced the mitochondrial genome of over 100 whales to study their possible divergent speciation. Basically this means that scientists were able to look at all the little details that are described in the whale's genetics causing it to have its unique characteristics, such as its size, flipper length, and coloration patterns. As a result they could distinguish the different kinds of whale species that may have evolved over the years. This particular method is useful for species that have developed over a long period of time. Therefore, it is perfect for studying the development of these whale species because they began to diverge anywhere between 150,000 and 700,000 years ago.

Mapping out the genomes of the 100 plus whales suggested that all of the Orca whales are not the same. This may seem a little obvious, but in fact the whales are different enough to even be considered different ecotypes. This means that they are different species adapted to live in specific environments. According to an article by Morin et al. published in Genome Research studies "have revealed populations of sympatric 'ecotypes' with discrete prey preferences, morphology and behaviors." In other words, recent research has showed that there are two more types of Orca whale other than the standard type A whale that we have known for years. Genetic evidence has confirmed this and the speciation has been widely accepted by many scientists using varying levels of evidence.

Before all of the DNA data support, scientists were forming their conclusion of multiple species by several other important factors that should not go ignored. For example, the mere body size of a whale will differ from the "standard" type A whale, type B whales, and type C whales, as scientists have designated them. It is clear that the "standard" killer whale, the kind of killer whales you see in aquariums, is much larger in size than either type B or type C. In addition, their markings and coloration may also be slightly different. Generally, type B whales will be two-toned gray and have a larger eye patch while type C whales will have a narrower eye patch.

Another key characteristic that has been observed is prey specialization. Although the whales can eat all the same foods, they choose different primary sources of food. It has been noticed

that type B whales specialize in eating seals while type C whales focus more on fish.

So why is all this news about speciation important? This is because the only way to take care of the environment is by first understanding all the smaller parts that make up the environment as a whole. Orca whales are predators for different animals. The



Photo: Robert Pitman

number of Orca whales and what they eat will affect the number of those animals that exist. Knowing more about these whales may help us know more about the world's oceans and what to focus on to prevent the degradation of our earth's environment.

-Karissa A Sciacca, Biology '13

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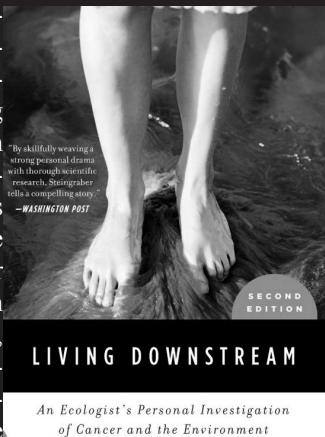
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Living Downstream Book Review

Written by ecologist Sandra Steingraber, Living Downstream is a compelling investigative research novel that explores several environmental links to cancer. At the age of twenty, Steingraber was diagnosed with a rare bladder cancer, one with direct correlations to toxic chemical exposure in the environment. As a result of the fact that only 2% of the 80,000+ synthetic chemicals in use by industries have been tested for carcinogenic effects, Steingraber publishes this revolutionary piece to unveil the fatal effects of anthropogenic pollutants in the environment.



The author chronicles numerous case studies and cites hundreds of research projects pertaining to the carcinogenic effects of incinerators, power plants, heavy metal industrial zones, water pollutants, pesticides and other residual pollutants produced by human activity. In one section, Steingraber uncovers the carcinogenic and biologically disruptive effects of incinerators. A potent toxin – dioxin – is released as a result of incineration, and is harmful at very low exposures. Multiple studies over the last decade indicate that dioxin is capable of disrupting biological processes at low concentrations of only a few parts per trillion. In 1994, the EPA released a 3,000+ page report that re-evaluated the threats of dioxin. In the report, the EPA identify that the incineration of both trash and medical waste are the leading sources of dioxin in the US, and that food consumption (primarily meat, dairy, and fish) accounts for 95% of the dioxin found in bodies of the general public. Humans not only absorb dioxin via respiration, but it invades and accumulates in the tissues of the plants and animals that are commonly consumed. This is merely one small example of the many carcinogenic pollutants we are exposed to on a daily basis, and Steingraber effectively unveils these hard truths.

What is most compelling about Steingraber's work is the 100+ pages of peer-reviewed scientific and governmental resources used to provide her research with an incredibly strong argument. Each case study presented in Living Downstream compellingly paints a true, and often grim, picture of pollution and its harmful effects on unsuspecting Americans. Living Downstream is a personal and accurate testament, and perhaps a much-needed wake-up call for people to be made aware of the adverse carcinogenic effects of the environments in which we live. If you are at all concerned with your health and the environment in which you live, I highly recommend this book.

-Emily Sneed, Environmental Science '12

Happy Accidents Book Review

From fungi to mustard gas, and everything in between, scientists find life saving drugs in the strangest of places. But luck is only half of the equation; it takes a keen eye and determination to turn a fortuitous finding into a billion dollar industry. This is the key lesson to be learned from Morton A. Meyer's Happy Accidents. Meyer lays out the serendipitous findings that paved the road for drug discovery. Whether it's Paul Erlich's cyanide cure for syphilis, or the unfortunate events at Bari that lead Cornelius Rhoads to conjure a treatment for Hodgkin's Lymphoma from mustard gas, history buffs and biochemical enthusiasts alike will find this a fascinating read.



You will learn about the blunders and misguided thinking that lead to the creation of the FDA as well as how the United States avoided medical catastrophes like the Thalidomide scourge that disrupted proper limb formation in thousands of babies across Europe. FDA reviewer Frances Oldham Kelsey refused to clear Thalidomide for sale due to the serious side effects in adults during clinical trials, which had been conducted after the drug's distribution throughout Europe as a tranquilizer and treatment for morning sickness for pregnant women. The comical side of patient trials is evident in the tale behind Viagra, one of the few drugs to have failed in two different clinical trials for angina and hypertension and subsequently be approved for a completely unrelated function. The compound was found to have the interesting side effect of inducing erections, an effect that only came to light after many male participants refused to return their medication at the conclusion of the experiments.

The theme recurring throughout these accounts indicates that some of the most advantageous discoveries in the course of drug history have been chance events. While science is often depicted as a rigorous set of studies in the pursuit of a single perfect molecule, often the best remedies come from a fungus spore and a dirty Petri dish full of bacteria. In the pursuit of knowledge, the answer may come in many forms; but when it's an answer to a question that wasn't asked, only those with an open mind and a sharp eye will be able to turn an interesting finding into a drug.

-Alexandra Sweeney, Biochemistry '11

Lecture

Embracing Yin and Yang – The Art of Acupuncture

Review of Professor Bernstein's Lecture on Acupuncture

When most people catch a cold, develop respiratory problems, experience anxiety, or have general pain in specific areas, they are quick to visit a doctor and get a prescription to begin the healing process. However, some people turn to the less conventional method of acupuncture. Acupuncture involves inserting needles into the body at specific points for certain lengths of time in order to achieve results. The practice has long been used as a course of treatment for numerous physiological conditions in countries such as China. In recent years, acupuncture has become increasingly prevalent as an alternative therapy in the United States, due to its effectiveness in alleviating conditions.

On October 15th, 2010, Doctor Eugene Bernstein presented a lecture on alternative medicine and provided an acupuncture demonstration. Professor Bernstein specializes in physiology and alternative medicine. In fact, in the Fall of 1997, he introduced the "Alternative Medicine" course to Northeastern University. In 1999, he became a licensed acupuncturist after studying at the New England School of Acupuncture. Though Dr. Bernstein now only performs acupuncture part-time, he instills his passion for alternative medicine within his students.

To determine which region of the body to insert needles, the patient must first be determined as having "Yin excess" or "Yang excess". If the patient is normally cold, has a slow pulse, pale face, or a weak voice, they are considered to be Yin. Needles will then be inserted to general regions of the organs

ruled by the Yin – such as the heart, liver, lungs, spleen or kidneys. Conversely, characteristics such as being very warm, having a rapid pulse, a red face, or a loud voice determine the patient to be Yang. Organs ruled by the Yang include the small and large intestine, gall bladder, stomach, and bladder. Overall, acupuncture is an art, and a sense of intuitiveness is vital in determining the correct positioning for needle placement.

At the conclusion of his lecture, Dr. Ber-



nstein did a demonstration on two students. On the female student, he inserted one needle into each leg near the ankles. He explained that in his experience, a majority of women tend to experience pain in this area. Needles typically remain inserted for 20 to 40 minutes and are rotated periodically.

Dr. Bernstein has effectively improved symptoms of schizophrenia, infertility and many other cases during his ten years as a licensed acupuncturist. Overall, he stresses that acupuncture is completely safe because it can be performed regardless of any medications that the patient may be on, unlike other practices in alternative medicine, where extreme caution must be exercised in order to avoid negative interactions.

-Sara McKechnie, Pharmacy '14

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Finding the Answers: How Technology is Accelerating the Scientific Process

It is commonly held that the field of science is based on concrete laws or facts from repeated observations. Naturally, the majority of science is therefore experimental. Another key component of science is to develop the hypotheses, or concepts, that one can test in these experiments. This is what we refer to as the theoretical. Scientists must make use of imagination and creativity in order to challenge preexisting norms and conventional wisdom. Take for example, Louis Pasteur, who in the 20th century disproved the thought that spontaneous generation was the basis of life. This aspect of science, then, isn't actually based on concrete laws, but instead on presumptions that eventually form theories. These theories are then subjected to validation through experimental observation. This theoretical approach can therefore be seen as the driving force behind what is collectively known today as science.

In recent years, theoretical methodology has yielded a tremendous amount of progress in the world of bioinformatics and genomics. Structural genomics seeks to determine the structure of thousands of proteins from the genome of various species. The structures of millions of other proteins are being predicted through theoretical modeling. Functional genomics, which seeks to predict the biochemical function of these proteins, bases a lot of its advancements on theoretical and computational methods. Many of these computational methods act as tools to perform sequence and structure analyses and predictions. Online databases are available that contain thousands of protein profiles, allowing the structural biology community to exploit and share information. Through these methods, it is

possible to successfully determine the entire 3D model of a protein, or even predict where ligands will dock on an enzyme! These techniques can also be used to validate more traditional, experimental methods and eventually to create new strategic hypothesis. Research in the functional genomics field not only teaches us about the mechanisms of these proteins, but also provides framework for novel targets for the medical field.

As an undergraduate student, I have recently become aware of the important implications that theoretical and computational methods have in the science world. The concept is almost mind-boggling. It is amazing, really, that this is all done by the click of a mouse and based on theoretical computations. It praises the field of technology, but also the collaboration between many different, even dissimilar fields. Functional genomics provides us with a glimpse into the future of biology and technology. Science, in itself, is evolving!

Northeastern has already aided in the progress. Professor Mary Jo Ondrechen and her research group are actively involved in cutting edge research that is able to predict protein function from structure. Interested students may contact Professor Mary Jo Ondrechen (M.Ondrechen@neu.edu) for more information.

-Andrea DeDonato, Biology '11

Picture: Courtesy of Matt Howard, http://commons.wikimedia.org/wiki/File:Argonne%27s_Midwest_Center_for_Structural_Genomics_deposits_1000h_protein_structure.jpg

THE STATE OF NASA

Ever since July 20, 1969, the day of the first manned landing on the surface of the moon, NASA has been the world leader in space exploration. But the role of NASA is about to change. On October 11, 2010, President Obama passed the National Aeronautics and Space Administration Act of 2010, which sets NASA's budget at \$58.4 billion over the next three years and outlines the projects that NASA will be working on for the next few decades.

It's true—the current US space shuttle program is ending, and all three of our shuttles—the Atlantis, the Discovery, and the Endeavor—will be retired. But this does not mark the end of US space exploration; it is a time of transition. From here on out, more and more space expeditions are going to be carried out by private corporations. US astronauts will be taken up to low earth orbit destinations like the International Space Station (ISS) by non-governmental companies who compete through bidding on the launches, leaving NASA to focus more on deep-space exploration and on the potential for a Mars landing sometime in the mid 2030s if all goes to plan.

However, this system of private shuttle flights will take some time to develop, so the act does allow for one last mission on the Endeavor during which it will bring certain hardware up to the ISS in early 2011. Also, over the next few years NASA will rely on Russian, European and Japanese space craft for its space station cargo and crew transportation needs.

Some critics feel that this "piggyback" kind of approach is symbolic of the US forfeiting its leadership position in space. Others, however, point out the country's national debt and feel that the cost of continuing our own shuttle operation is just too high, when other areas of our nation are falling behind.

Former Apollo astronauts Neil Armstrong, Gene Cernan, and Gene Lovell have expressed concern over allowing private industry to transport astronauts, saying that some companies might not be as knowledgeable or experienced with space exploration as NASA, which could put people's lives in danger. But other astronauts have come out in support of the president's plan, such as Buzz Aldrin. "This program will allow us to again be pushing the boundaries to achieve new and challeng-

ing things beyond Earth," Aldrin said in his official statement.

One of the major points of the NASA Authorization Act is the cancellation the Constellation program, which was a plan signed by President Bush to put a man back on the moon by 2020. This program was determined to be highly under-funded and behind schedule by the Augustine Panel, a group of space experts assembled by President Obama to assess NASA's situation. Constellation's cancellation sits alright though with Florida Democrat Ben Nelson, who flew aboard the shuttle Columbia in 1986 and who played a key role in winning approval for a modified version of the president's original request. "The goal is not the moon," Nelson said. "We were there 40 years ago. The goal is Mars by a flexible path. The president has stated that goal ... and this legislation which he is signing into law will now set us on that course."

Sally Ride, the first woman in space, was a member of the Augustine Panel and strongly agrees that "[the act] is an excellent bill that will move NASA forward." The soonest project that is mentioned in the act is the development of a state-of-the-art heavy lift rocket, capable of launching loads of up to 50,000 kg or more. About \$11.5 billion over the next six years will

go directly towards this project, in addition to the \$9 billion that already went into similar research on the Constellation project.

In addition, the act extends the International Space Station operations funding until at least 2020. The president also said that he would like to see NASA successfully land on an asteroid by 2025, but some experts have already said that this goal may be unrealistic with expected funding levels. Nelson added that even though the act was passed, there is still a long road ahead. The budget authorization now must go through the appropriations process, which determines exactly how and where the money will be spent.

Regardless of the present change in NASA's goals, the organization continues to hold its unique position at the forefront of the space industry, developing new technologies and innovations for mankind.

- John Jamieson, Chemical Engineering '15

GLIESE 581G AND JAMES WEBB SPACE TELESCOPE



The discovery of habitable planets outside of the solar system could happen sooner than you think. In September, astronomers revealed the discovery of Gliese 581g, the first planet to meet the strict requirements to potentially support life. It possesses adequate mass to maintain an atmosphere and orbits its star at a distance that makes liquid water on its surface a possibility. However, Gliese 581g is tidally locked to its sun. Consequently, one side receives constant daylight, causing temperatures to rise dramatically, while the other hemisphere is permanently shrouded in darkness, resulting in extremely low temperatures. This effect leaves only a thin strip of potentially habitable land between the two sides.

The true significance of this discovery is not the planet itself, but instead the speed with which it was found. The fairly quick discovery leads many scientists to hypothesize that potentially hospitable planets are much more common than previously believed. They expect the number of known extra-solar planets that can support life to increase dramatically in the coming years.

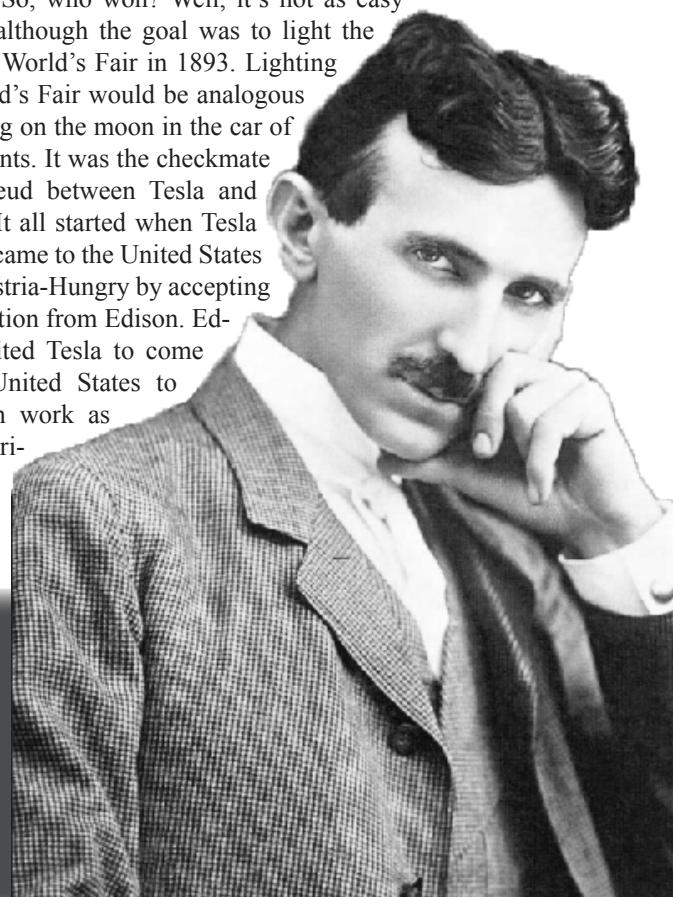
Soon to be at the forefront of space discovery is a new space telescope designed to replace the Hubble Telescope. This device, the James Webb Space Telescope will allow scientists previously impossible insights into the nature and origins of the universe. While manned space programs may be on the decline, humanity's ability to learn from the universe around us certainly is not.

-Michael Murray, Computer Science/English '14

WAR OF

Many of you have heard of Thomas Edison. He was the inventor of the light bulb, and numerous other original inventions and pivotal discoveries in the fields of electrical engineering. Many of you have also heard of Nikolai Tesla, an additional contributor of innovations and inventions concerning electricity. Tesla originally applied his knowledge of magnetic rotation in order to create the induction motor. Both Tesla and Edison exhibited huge amounts of knowledge in electricity and were significant assets to industry and capitalism during the Industrial Revolution. You may think that these two powerful men would come together and create a duo that would be comparable to Batman and Robin. If you thought this you would be wrong, very wrong. Why would they do this if there were huge amounts of money and investments to be made? Edison and Tesla both held strong positions on which approach of commercial electricity would be more efficient, and this standoff lasted for several years. Tesla pressed for the use of alternating currents while Edison disputed with his direct currents. The war of the currents was AC vs. DC. Nonetheless, the argument had incredible stakes: the future of the nation's electrical dispersal.

So, who won? Well, it's not as easy as that, although the goal was to light the Chicago World's Fair in 1893. Lighting the World's Fair would be analogous to landing on the moon in the car of the currents. It was the checkmate in the feud between Tesla and Edison. It all started when Tesla humbly came to the United States from Austria-Hungary by accepting an invitation from Edison. Edison invited Tesla to come to the United States to help him work as an electri-



THE CURRENTS

cal engineer to aid in the development of Edison's dynamos, or electrical generators. Edison had already established an electric kingdom all based on DC currents. Tesla's task was to work with and improve Edison's dynamos. However, all of Tesla's innovations were patented in Edison's name. It is here that Tesla left Edison's company to file patents for his own generators, transformers, transmission lines, motors, lighting; basically everything Edison already had. But Tesla's AC currents were used rather than Edison's DC. Tesla underestimated the true value of

"[Edison] vigorously advertised his DC currents and made many efforts to defame Tesla and Westinghouse for promoting their alternating [DC currents]. At one point Edison even electrocuted an elephant to show the dangers of alternating currents."

these patents, and George Westinghouse purchased them with the intent to fully commercialize Tesla's inventions. Westinghouse gave Tesla over \$60,000, which included \$5,000 in cash and 150 shares of stock in the Westinghouse Corporation. Not only that, but he had agreed to give \$2.50 per horsepower of electrical energy sold. With the money, Tesla built his own lab to continue his inventing. Soon Edison became very wary of his new opponent, thus beginning of the war of the currents.

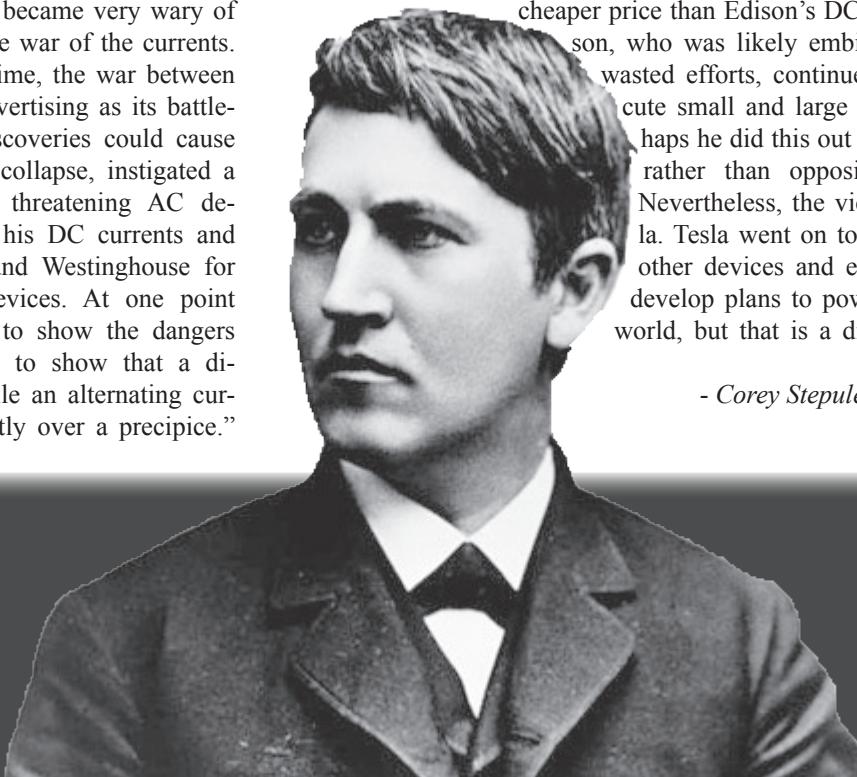
Heralded as wizards of their time, the war between Edison and Tesla took the world of advertising as its battlefield. Edison, knowing that Tesla's discoveries could cause his already established DC empire to collapse, instigated a propaganda campaign against Tesla's threatening AC developments. He vigorously advertised his DC currents and made many efforts to defame Tesla and Westinghouse for promoting their alternating current devices. At one point Edison even electrocuted an elephant to show the dangers of alternating currents. Edison fought to show that a direct current was peaceful and safe while an alternating current was "like a torrent rushing violently over a precipice."

Why was Edison so defensive? How are AC currents better than DC? Simple. The currents in an AC are alternating and the direction of the current reverses many times per second. A DC current only goes in one direction at all times. The benefit of AC currents is the fact that the voltage can be changed. This is very important for commercial use because power plants can convert the electrical current to very high voltages so they can travel greater distances. Edison's direct current could only travel two miles, so a power station had to be positioned in two-mile intervals. Conversely, DC current shows few advantages over AC. Direct currents are not beneficial for long-distance distribution and industrial uses of electricity. Edison was fighting a war that he could not win. His efforts could not surpass the practicality of the AC current. Tesla let alternating currents fend for themselves. Edison was simply attempting to save his investments in his own DC Empire.

While Edison fought and slandered AC currents, the World's Fair in Chicago was approaching. Originally the Fair was going to use DC currents for the cost of \$544,000. Alternately, Westinghouse proposed the fair run on Tesla's AC current for the lower price of \$399,000. The World's Fair of 1893 was lit by more than 200,000 electric light bulbs all run on the AC current. Tesla had essentially landed on the moon. He had won the war of the currents by simply proposing a

cheaper price than Edison's DC system. Edison, who was likely embittered by his wasted efforts, continued to electrocute small and large animals. Perhaps he did this out of pure anger rather than opposition to AC. Nevertheless, the victor was Tesla. Tesla went on to invent many other devices and even began to develop plans to power the entire world, but that is a different story.

- Corey Stepule, Biology '15



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