Issue 4

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The last effects of the British Petroleum Oil Spill.

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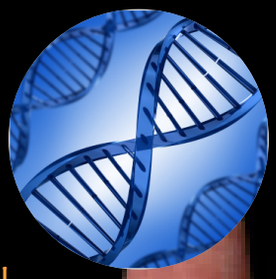


The Five Revolutions of Humanity

NUScience

Northeastern University's First Science Magazine

Letter from the Editor:

Hello Readers!

I'm excited to be writing to you as the first ever NU Science Editor in Chief. President Kristina has passed the torch to me to be in control of the content of the very magazine you hold in your hands. Thanks to the work of many, it is quite a magazine. I have to thank all my writers, who have put in the time and the research to create for the public a fantastic piece of science literature. Not to be denied, I need to thank you, the reader, for making this magazine reach more than just our printer. When I became the lead editor, I wanted to imbue one thing: science is discovery, journalism is discovery. The difference lies only in the end product. Science intends to explain how our universe works. Journalism intends to inform the public (you) of what is going on inside of it. In this magazine, the two align. Our five part feature holds scientists who transcended the scientific community to change the way we think. This is no coincidence that I chose this theme for the content of the first issue I was charged with. This is what I want to do: inform and enlighten. I don't only want to let you know about what happens in the field of science, I want it to effect and improve your view of the world.

Thank you, and enjoy,
James Peerless

WELCO

Whats been h

Hydrocarbons Everywhere!
What happens to oil when it enters the water column?

May 2010

Interview with Tom Szaky
CEO of TerraCycle

TERRACYCLE

A few corrections from our last issue...

- "Foer's Eating Animals Provides Unique Insight into the Concept of a Vegetarian Diet" was written by Sadie Lang
- Andrea Dedonato's piece on medical school admissions was meant to be labeled as "Op-Ed"

NUSci apologizes for any error or conflict arising therein.

Contributors to this months issue:

Charlotte Barker, Kristina Deak, Kyle Deerwester, Tara Dhingra, Taarika George, Elizabeth Gilbert, Jacqueline Lai, Brian Letourneau, Jake O'Neill, James Peerless, Emily Snead, Jen Tarnacki

Want to see your name on this list? Get involved! We meet Wednesdays at 7:30 in Room 20 IV. Email us at nusciencemag@gmail.com, check out our blog http://nusci.weebly.com and friend us on facebook!

The E-Board:

President
Kristina Deak

Editor-in-Chief
James Peerless

Secretary
Andrea Dedonato

COME BACK!

n happening while you were away...

The Mars Science Laboratory
An NU Student Co-Ops for NASA

Review of *Bad Science* by Ben Goldacre

September 2010

The 5 Revolutions of Humanity
The five ideas that revolutionized the way we think

Updates from NUScience

Dear Reader,

Welcome back! Ready or not, it's time for classes to begin again. Time to put away the sunscreen and pick up that orgo book. It's time for a fresh start and fresh faces, and here at NUSci, we're embracing it.

We've been working hard over the summer to revise our magazine and we're sure you'll enjoy the result. We strove to increase the intellectual integrity of our articles, without diminishing their accessibility. We edited out overall structure to make the content more relevant to the student scientist and to embody the innovate spirit of the Northeastern community. We also revamped our graphics to make our product both visually effective and intuitive.

Furthermore, we welcome James Peerless as our new Editor-in-Chief. He has been a dedicated editor for the past year and I have full confidence that he will help take our magazine to the next level.

I hope you'll look at our magazine as a great place to expand your knowledge and experience outside the classroom. As always, we welcome your suggestions and input. We are always looking for new ideas and new contributors, so stop by our meetings and get involved!

-Kristina Deak
President

Treasurer
Nicole Smith

Interviews and Reviews Editor
Elizabeth Gilbert

General Content Editors
Kyle Deerwester
Emily Snead

Design Team
Brad West (VP)
Simon Zelman
Taarika George

Hydrocarbons Everywhere!

What happens to oil when it enters the water column?

On April 20th, the Gulf of Mexico was changed forever. Millions of barrels of crude oil have infiltrated the ecosystem since that time as workers struggled to plug the well. But now that a solution appears to be in place, one must still ask, what about all the oil still out there? What happens to oil when it first hits the water, and how long is it going to stay around? Is this something that will contaminate the Gulf for decades, or will it be the matter of a rough season or two in the coming years? And of course, the common evil, are the chemical dispersants we use going to make things worse?

Black gold, black sheep

There is no denying America has a dangerous addiction with oil, an addiction that will lead to many more ruinous disasters, international arguments, and rapid price fluctuations before we are purged of it. But what exactly is this fluid that runs through the veins of industrialization?

Crude oil is a complex mix of thousands of varying chemical components, 95% of which are hydrocarbons. The three main classes of hydrocarbons present are alkanes, cylcoalkanes, and arenes, though their toxicity and potency range from light materials like propane to heavy compounds like asphaltenes and waxes. The remaining 5% of the substance is attributed to oxygen, nitrogen, sulfur, and traces of about fifty other elements. Before being distributed to consumers, crude oil is refined into light and heavy factions, which then become the end products of petrol, diesel fuel, etc.

Small concentrations (1-10 parts per billion) of background hydrocarbons are ubiquitous in the marine environment. Their sources include operational discharges from ships, land-based discharges from roads, sewer, and industrial sites, natural seeps, airborne combustion products, and from organisms themselves. However, the estimated 100 million gallons of oil spilled into the ocean in an average year elevates their destructive potential and overall toxicity of the environment.

Mother Nature at Work

As soon as oil touches water, a series of physical, chemical, and biological processes are initiated to destroy, metabolize, deposit, and transform the toxin into safer compounds. Collectively termed, "weathering," the efficiency of the group depends largely on the viscosity and persistency of the oil. Crude oil, like that discharged in the Gulf, is the most difficult for Mother Nature to handle on her own, and generally requires some sort of emergency clean-up response.

When oil is first spilled it will spread out along the ocean surface. In a recent article in Offshore Environment, it was calculated that a liquid ton of oil will disperse over a radius of 50 meters with a depth of 10 millimeters within 10 minutes. The thinner the oil can spread, the more effectively other mechanisms of weathering can work.

Within the first few days in a warm climate, evaporation can rid the water of the light and volatile components of the oil. These compounds can comprise up to 40% of the spill. Waves can cause the heavier components to disperse from the original slick into smaller droplets, which are then carried in the water column. Water-soluble components of the oil, such as benzene and toluene, may then be dissolved due to higher surface area exposure. 10-30% of the oil will sink to the sea floor and be absorbed by the sediment. Here, degradation can halt almost entirely due to hypoxic conditions, and the oil may persist for years.

Chemical oxidation occurs when oil reacts with oxygen and either degrades to soluble products or forms persistent tars. This is an incredibly slow process, and even with strong sunlight and perfect conditions only 0.1% will be deconstructed per day. The tar balls shown washed up on the coasts of Florida and Louisiana are the result of the oxidation and emulsification of crude oil.

Another important weapon in the ocean's arsenal is tiny microbes that can metabolize the oil. Luckily for us, the Gulf is a great breeding ground for them. A combination of warm water and the prevalence of oil from natural seeps and previous leaks have allowed a class of petroleum-loving bacteria to evolve. One such super-hero is Alcanivorax borkumensis, rod-shaped bacteria that dominates contaminated waterways. It has adopted novel mecha-

"..it was calculated that a liquid ton of oil will disperse over a radius of 50 meters with a depth of 10 millimeters within 10 minutes."

nisms to digest both organic and inorganic nitrogen, as well as the prevalent hydrocarbons. Recently, a group at the German Research Center for Biotechnology has deconstructed its genome into 3 million base pairs in an effort to understand how to harness the organism for future clean-ups.

You made the mess, now clean it up!

Despite its best efforts, every system has a cataclysmic tipping point beyond which it can no longer handle an influx. It is here that man must step in. Essentially, all human efforts are designed to compliment natural processes and to speed the effects of weathering. The longer the oil remains in the water, the greater chance for contamination of larvae, fish, and the entire ecosystem.

One of the most controversial and widespread methods we use to clean up spills is the application of chemical dispersants. Oil dispersants are complex blends of two components. The first is a mixture of surfactants that can emulsify or suspend the oil in the water. The second is a hydrocarbon-based solvent mixture that can break up the more viscous oil. In this way, the dispersants can help to break the oil slicks into smaller fragments that can then be weathered more effectively. While the logic is sound, the environmental implications can be troublesome.

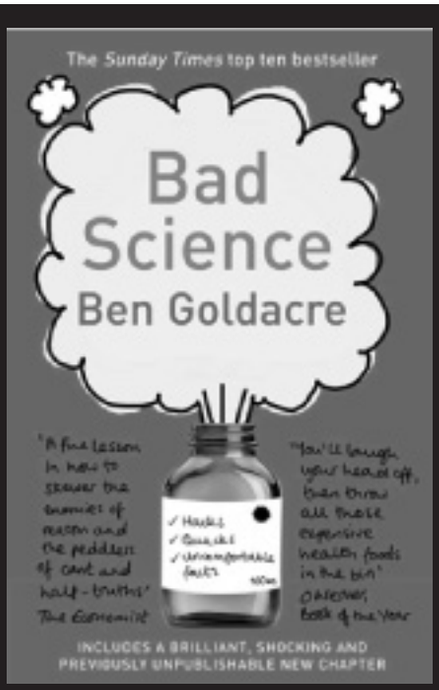
To date, up to 2 million gallons of dispersant has been released into the Gulf. The chemical used, Corexit 9500 was studied by the National Center for Computational Toxicology, a division of the EPA, in June. Although found to be below stated measures for toxicity and hormones, the testing did not occur in the open ocean. In addition, the substance hasn't been tested with high-pressure applications, for long-term effects, or for its effects on oceanic species. Current evidence suggests that dispersants can get trapped in between the shells of low-level members of the food chain as well as in larvae. As you move up the food chain, the consequences of this contamination could be compounded, similar to mercury poisoning.

It must be noted however, that this method is one of the most effective currently used at moving the oil from the immediate ecosystem. Chemical evidence exists that the presence of the dispersants is still better and more manageable than the presence of the crude oil. Thus, a theory of the lesser of evils can be employed.

Oil is a complex substance whose degradation can depend upon a variety of variables. Everything from the consistency of the compound released to the extent of rocky shoreline present can impact its dissipation rate. Its elimination can take anywhere from a few days to 30 years. In the process, hundreds of species of wildlife may be affected due to destruction of habitat, chemical poisoning, or consequent reproductive complications. Thus, even after the oil has been removed, it is impossible to say that the ecosystem could ever return to normal, optimal levels.

-Kristina Deak,
Biochemistry, Class of 2012

Interviews A



Ben Goldacre, MD, is a medical professional and writer famous for his keen sense of seeing through nonsensical, scientific-sounding fads presented to the population and exposing their inconsistencies. In his most recent work, Bad Science, Goldacre covers a wide array of seemingly science-based topics that prove undeniably erroneous. A personal favorite was the second chapter entitled "Brain Gym", a popular new method of supposed "brain-strengthening exercises" that are being used in elementary schools across the UK. Goldacre details certain breathing techniques that are used in this curriculum and explains how the suggested results are physiologically impossible to achieve. He describes an exercise that involves rubbing specific points on the body that supposedly activates "brain buttons". Goldacre negates this practice with a dry wit that captures his distaste for the scientific inconsistencies of the system, "Children can be disgusting, and often they can develop extraordinary talents, but I'm yet to meet any child who can stimulate his carotid arteries inside his ribcage. That's probably going to need the sharp scissors that only mummy can use." (14).

Another chapter sheds light on the optimistic claims made by the cosmetic industry in regard to the effectiveness of their products. Goldacre explains that this industry is much more resourceful in creating "bad science" than the creators of Brain Gym due to the heavy regulations placed on them by the government. Their advertising methods and scientific claims have to be a great deal more carefully worded. The author clarifies that the cosmetic companies attempt to sell you "extraordinary products" by placing ingredients such as RoC Retinol Correxion or Tenseur Peptidique Vegetal. Basically, strong chemicals such as alpha-hydroxy acids have proven effective in creating a more youthful appearance in high concentrations. However, such high concentrations of these chemicals can have detrimental effects to a person's health. Accordingly, they are closely regulated to ensure the safety of the consumer. Cosmetic companies continue to use these chemicals in small doses in their products in the hopes that the consumer will think they are effective, when they are actually relatively useless in such trace amounts.

The author goes on to address a wide range of discrepancies in the field of homeopathy, the pharmaceutical industry, and certain claims made by nutritionists. Goldacre's intelligent, humorous and relevant writing style is both captivating and informative. He questions the validity of these industries through the use of research and investigation into the claims, stressing to the reader that a scientific degree is not necessarily needed to sift through the verbose wording and technical vocabulary used by these industries. Rather, any consumer can distinguish "bad science" through the use of common sense and by consciously avoiding the flashy distraction of scientific vocabulary. This book is a must-read for scientists, consumers and anyone interested in learning how to determine the credibility of the claims made by various industries in today's market.

-Elizabeth Gilbert, Health Sciences 2012

Harvard Medical School Symposium on Aging

The 5th Annual Symposium on Aging was hosted by Harvard Medical School on June 21st, and featured speakers from across the country discussing a range of topics concerned with the biology of aging. In the past century alone, the average life expectancy in the United States has risen by 66.5%; from 47 to 78.24 years.. This drastic increase presents new problems for scientists and doctors to investigate. The increase can be primarily attributed to the reduction of infant deaths, which in turn means there is an aging population with an array of new medical issues. The most common cause of death in the U.S. in 1900—pneumonia—has since been replaced with heart disease. Other complications associated with aging such as diabetes, Alzheimer's, and ALS (Lou Gehrig's disease) have moved to forefront and are a driving force behind much of the research taking place today. All of these topics, among others, were covered over the course of the day and presented to an eager audience of scientists and students alike.

The symposium hosted a total of eight speakers, each one bringing a unique skill set and thorough research within their field. While the topics of each presentation were indeed different, there were some buzzwords that made their way into several of the pre-

s and Reviews

Science-Based Medicine Blog

The blog titled simply as Science-Based Medicine allows for a unique mix of physicians to review and post responses to new topics and discoveries in medicine. With categories ranging from acupuncture to cancer to pharmaceuticals, Science-Based Medicine is a varied and interesting source for current research. The blog is updated with a new post every weekday. The editorial staff of Science-Based Medicine is largely compiled of physicians who examine claims that they believe are unscientific or pseudoscientific. They discuss and respond to these claims from the viewpoint that medicine based on the evidence of hard science is far more credible when making scientific claims. The blog specifically targets the value of fields such as psychology, which they dub a "pseudoscience", and questions the "nonscientific evidence" that such fields accumulate. Many of the blog posts discuss recent news and research developments in the US, focusing around the topics of biotechnology, medicine and pharmaceuticals. It should be noted that the most interesting aspect of the blog is the response section of each entry. Many of the responders have viewpoints that differ from the authors of the blog entry, which inevitably leads to heated debates. Commentators discuss who is right and wrong, what should be done about the issue discussed and new ideas about the topic at hand, which sometimes seem to give more insight into the topic than the post did alone. While each article is definitely opinionated, there is no question of its legitimacy. Every blog post finishes with a clear source list for the reader to reference, with the assurance that the information quoted is accurate. In general, the blog, Science-Based Medicine, provides a good source for up-to-date news on the scientific side of medicine. However, readers should be forewarned that the editors have very strong opinions and are ready to debate the inexhaustible material.

http://www.sciencebasedmedicine.org/

-Charlotte Barker, Health Sciences 2012

sentations. Stem cell research, oxidative metabolism (free radical theory), and the human autophagy system were either featured or mentioned in multiple experiments, and corresponded nicely with Dr. Wendy Smith's Regulatory Cell Biology course at Northeastern. Some of the speakers were more engaging than others, and some topics seemed better suited for an undergraduate biology major such as myself. There were two presentations that particularly piqued my interest, and led me to seek out additional information.

Dr. Elaine Fuchs studied epithelial stem cells, focusing on hair follicles and hair loss during aging. She identified the two major signaling pathways that control stem cell activation—Wnt and Bmp—and how their regulation stimulates stem cell proliferation. Furthermore, she isolated the SOX9 biomarker as the critical component of these cell lines. In the absence of SOX9, lab mice were completely bald and were slower to repair epidermal damage. Her research is now at the point of determining how SOX9 can be manipulated in humans to prevent hair loss and promote healing to the epidermis. She concluded by stating the goal of her future research is to see if it is possible to induce SOX9 production to enhance stem cell proliferation during aging.

Alzheimer's disease, a devastating illness that affects millions of Americans, was the main focus of Dr. Li-Huei Tsai's study. Tsai examined HDAC2, a key protein involved in cognition, learning, and memory. HDAC2 binds to promoters of memory associated genes, and causes a loss of neuron connections. Tsai treated lab mice with sodium butyrate (an HDAC inhibitor), and observed an increased number of dendrites and synapses. When HDAC2 was inhibited, cognitive function was much higher, and overall neurodegeneration decreased. This finding can be crucial to future treatment of Alzheimer's, and is currently being tested to determine if it has a practical application.

Overall, the entire symposium was very informative and shed a light on a lot of the modern issues facing cell biologists. It is held annually in the spring and is highly recommended for anyone seeking to learn more about the science of aging and healthy lifestyle choices to prevent the effects of aging. For more information about this year's symposium and updates regarding next year's date, visit:
www.hms.harvard.edu/agingresearch/pages/glennsymposium.

- Jake O'Neill, Biology, Class of 2011

Upcycling is the new black.

Those new pretzel M&Ms- delicious, right? Chances are after devouring those chocolate treats, you probably (hopefully) threw the wrapper out in a garbage somewhere, never to be seen again. But where will this wrapper end up? Guess you didn't think about that.

TerraCycle, a company based out of Trenton, New Jersey can answer this one. Every year we produce billions and billions of tons of garbage that will eventually end up in landfills. Garbage is not going away, so what are we to do when our earth becomes covered in it? This is where TerraCycle comes in. Their main goal is to keep garbage out of landfills by taking trash and turning it into new products. One may consider this recycling, but it is actually a concept known as "upcycling". The difference is the way in which the products are reused. By recycling, the old product is broken down and made into a completely new product. As we know, many products cannot be recycled. Upcycling, on the other hand, can be tailored to a variety of other products, and keeps the waste material intact, using little to no additional energy.

The company was a result of Tom Szaky (see interview) and his encounter with the idea of organic fertilizer made out of worm poop. The worms were fed wasted food, and in turn their poop could be used as fertilizer. When looking for a way to market such a product, he turned to used soda bottles and sprayers as a way to package it. Doing just this, there was no waste – every component that went into such a process contributed to the end result. As he states on his website, "One system's garbage is just food for another system. We don't see garbage, we see valuable raw materials."

TerraCycle has now expanded to sell more than just worm poop. They have joined hands with companies like Stonyfield, Mars, Capri Sun and FritoLay, who agreed to fund and allow the waste from their products to be upcycled. They have also started programs in schools, encouraging children to start collecting waste, which then gets sent to TerraCycle, and is later upcycled into products such as backpacks, purses, and even kites.

The idea behind TerraCycle is so inspiring, and as you will read in our interview with Tom, has already kept 1.8 billion units of waste out of landfills in the United States. With such great success already, there is no doubt that with increased popularity, TerraCycle will have a very large impact on our world.

So why not get involved? As a plus, for some of the products, TerraCycle will even give you money back to go towards a charity of your choice just for collecting them. The next step is joining a brigade – each product has brigades, or groups all over the country, collecting certain wrappers. All you have to do is visit the website, Terracycle.net, find a brigade that relates to your trash habits, and start collecting. You can also buy some of the products they have to offer. Pretty soon everyone will be rockin' those Starburst messenger bags!

So the next time you go to throw out that bag of Lays Potato Chips, or that Clif bar you ate after sweatin' it out at the gym, stop, drop and upcycle!

-Tagrika George, Health Sciences, Class of 2013

One man's trash **IS** another man's treasure

This issue, we were lucky enough to be able to sit down with the CEO and creator of Terracycle, Tom Szaky, who was more than happy to "trash talk" with us.

NU Science: You started TerraCycle in college- what college did you attend, and what did you intend to major in?
Tom Szaky: I was studying behavioral economics at Princeton University.

NUS: What was your inspiration for the idea of TerraCycle?
TS: Friends were using worm poop on some plants and were having great results. I became fascinated with the worms which thrive by eating an amazing amount of household garbage. The combination of garbage, worms and worm poop fertilizer struck me as a revolutionary business model. We could take people's garbage (and get paid for it), feed it to worms, get great fertilizer and then sell it.

NUS: One of the first products you sold was worm poop, which is said to be the most organic usable fertilizer. How did you go about testing, collecting and eventually marketing such a product?
TS: As I mentioned, I had already seen worm poop work really well, so I needed to come up with a way to produce it on a large scale and market it. I learned about the composting business, bought a worm compost machine and worked with Princeton University to collect the leftover food waste from one of the dining halls. In summary, we eventuallylearned through our trials that liquefying the worm poop was more appealing to consumers; we used recycled soda bottles because they were less expensive than new ones, and we found overrun sprayers. We now had TerraCycle Plant Food.

NUS: Now, TerraCycle is based upon the idea of "upcycling" rather than recycling. Could you explain the difference?
TS: The term "upcycling" was coined by William McDonough and Michael Braungart in their 2002 book, Cradle to Cradle. According to them, upcycling is the practice of taking something that is disposable and transforming it into something of greater use and value. It's designing new products that are intended to be reused again and again without downgrading the original material or creating more pollution in the process.

According to the authors, recycling is actually an example of "cradle to grave" design, where recycled items are now turned into something unrecoverable. By turning items into products that were not the intent of their original production process (example: soda bottles into carpeting), they are effectively turned into something that requires as much energy or more to produce than the original item. When the life of the rug is over, it is still on its way to a landfill.

NUS: What kind of a process is involved in changing the trash to actual products?

TS: It depends on what we're making. Some packaging can be sewn together directly, while for others we use a heat press to fuse several levels of the wrappers together first before stitching together. Some items like soda bottles and yogurt cups can be directly reused by filling with a new item (like our world famous worm poop).

NUS: What was involved in acquiring companies to carry your product as well as getting companies to allow their wasted products to be upcycled?
TS: A lot of hard work and persistence. As I say in my book, Revolution in a Bottle, we had to have the steak and the sizzle in our presentation. We would keep calling and calling buyers and store owners to get them to meet with us. We made sure the prices were lower than products made with virgin materials and we were selling them a product that worked.

The collection of packaging waste started in 2007 with Seth Goldman, founder of Honest Tea. He was concerned about the juice pouches because they wouldn't be recyclable. He asked if TerraCycle could come up with a solution for the pouches. Shortly after that, I received a call from the CE-Yo of Stonyfield Farm, Gary Hirshberg, to come up with a solution for yogurt cups. By early 2008, Capri Sun was on board and we've continued to grow every year.

NUS: In this day and age, we are all becoming aware of how important it is to "go green". What kind of an impact has TerraCycle had on the amount of waste produced per year?
TS: Since late 2007, we've kept more than 1.8 billion units of waste from landfills in the U.S. and have more than ten million people signed up to collect waste. We're now international with programs in Brazil, Canada, Mexico and the United Kingdom. There will be several more international locations opening within the next year.

NUS: Do you have any advice for college students trying to start their own business?
TS: Don't debate - just start! What do you have to lose?

Spotlight on:

Aaron Gerry

Biology 2011
Co-founder/Chief Buy-ologist at Zazu

Ever imagine a coop with no boss? If entrepreneurship is your gig, it can be a reality. (As long as your coop coordinator approves.)

NU Science: What exactly does your coop entail as far as day-to-day responsibilities?

Aaron Gerry: My role is resident BUY-ologist which is fitting because I work on the marketing aspect of the company. What's nice about working for myself is that every day is a little bit different. I realized that I wanted to be an entrepreneur because I liked working for myself, I like making my own decisions and I like learning. I'm a constant learner. Honestly, being in this position, I'm learning more than I ever have in classes, which is really the intention of coop. But this is teaching me all aspects of it because I really have to make my own timeline. Basically everything is left to me. Ultimately I do all the market research, I figure out whose using our product, how big that market is, how fast that market is growing. Then I do customer interaction. This entails speaking to them: What do you like about the product? What is buggy about it? What would you like to see in it? Creating surveys, getting feedback, then telling Mark (Held,) our developer, that these are the things that we need to fix right now that are preventing people from using the app to its fullest. Then there's building social awareness, using social media, being on Twitter, Facebook, going out to events, really just evangelizing the product.

NUS: This is really a technologically based startup. In your future endeavors, do you always see yourself being close to technology?

AG: I'm not in love with marketing to be perfectly honest. I like the high tech business because technology evolves so quickly that you get to be on the cutting edge. That's what being in a startup is. You get to work with cutting edge technology that very few people get to have right now. I like working with people and I like building communities. I think my ultimate passion would be building an incubator program, where I would help other young entrepreneurs create their own companies. I'd like to impart my own knowledge to them, and I suppose learn from them as well.

NUS: Would you say that your current major of biology doesn't have much bearing on what you want to do in the future?

AG: Regrettably, probably not.

NUS: So if you could it all over again, what major would you choose?

AG: I wouldn't change a thing. My freshman year I was a business major. Then that summer came and I had an epiphany. I woke up one day and said "I'm going to change my major." For some reason I was under this impression that I couldn't do more than just live the typical life and climb the corporate ladder. Then I just woke up and said "I can do science". I got really excited about biotech because that's where all the innovation is happening in the pharmaceutical industry. They were startups basically. I really liked the idea that you were able to develop something from nothing. But it's still a corporate structure. I didn't like that aspect of it. I understand you have to pay your dues and everything, but it was too slow for me. I liked the technology but I don't like the speed of biotech.

NUS: Speed of career advancement or speed of technology?

AG: Both. Pharmaceutical technology is very slow. It takes an average of 15 years and $460 million to take a drug to market. But I learned things. I learned that I can do anything I want if I put my mind to it. I learned that I like building something from nothing. And that's really what sparked that entrepreneurial instinct.

NUS: What advice do you have for someone who was in your position?

AG: Anyone that comes to me I ask what are they passionate about. You can read people and tell with how they talk and how they move their hands. I guess for someone in my position I would've asked me "do you really want to be in biotech anymore?" It's hard to be honest with yourself but it's better to learn that now than later on. I'm

glad I did a coop and then realized that biotech was just not for me. I got started by just sending out an email to all the entrepreneurship professors on campus that just said "where do I start with entrepreneurship? What do I do?" From there I found a blog that I really liked called College Mogul about college entrepreneurs. I just emailed the editor and told him who I was and said I was interested in learning more about starting your own company. Ultimately, he brought me on as a writer and it grew from there. He actually ended up bringing me to my first event. From there I just kept going to different events, meeting people, getting comfortable with it. Just hearing different people's ideas helps spur your own ideas. It's really just letting your passion come through.

NUS: What about someone in engineering or science who is interested in start-ups, but not so much the business side of it? What is a good step for them?

AG: If you're an engineer or a technologist consider yourself lucky if you want to be a startup. Business people have the ideas more often than not, but they usually don't have the skills to execute. Engineers can make the product. Just go out to events, see what interests you, see what catches your eye.

NUS: What about resources at Northeastern?

AG: Go to the Entrepreneurs Club, join the Husky Innovation Challenge, and definitely check out IDEA. These are entrepreneurial based initiatives, but it's all about collaboration and bringing people together. We want the biologist to be working with the computer scientist to be working with the business student. All these people have different skills and different talents that we can bring together and why aren't we working together? A lot of people have ideas for companies, but they just don't know how to start or it's very scary or they just don't have the partners to get them there. And that's really what we're trying to break down.

NUS: How important were those partners for you starting Zazu?

AG: In a word, indispensible. Punit Shah is the CEO, and for him this was his third company. He was the president of the E-club until he graduated in May and had so many experiences to draw from that he was really the guiding light in the project. Marc Held is our developer, and won the national defense cyber competition last year as a Middler. He's been programming and interested in startups for eight years now and without his technical knowledge, none of this would've happened.

NUS: Switching gears here, what exactly is Zazu, besides "the best damn alarm clock"?

AG: Zazu is a mobile application on your phone. It wakes you up and tells you the information you need to get ready for the day. It tells you the news, the weather, your calendar and your email.

NUS: All audibly, correct?

AG: Yea, it reads it to you. Instead of sifting through newspaper looking for articles that you care about, it's customized so you can listen to CNN.com, World News or ESPN Boston. This specialization cuts down on that exploration time. It reads your emails; it can tell you your appointments on that day, and then the weather, as simple as how do you get ready for your day.

NUS: So what's the current state right now?

AG: We have a beta test out right now. We have 100 people using it, and we will soon release it to 70 more. We have roughly 800 people still signed up on the beta list that we will release to before we launch. So the beta right now is an alarm clock that works. First and foremost it has to wake you up. It reads you RSS feeds. You can put your calendar RSS feeds, or any custom RSS feed that you want. Eventually it will be more integrated with your calendar and your email. We're just looking for the minimum viable product right now, which is the product that works perfectly for the basic functions that we're trying to offer. Once we get that we're going to push it to market then iterate from there.

-James Peerless, Chemical Engineering, Class of 2011

The Mars Science Laboratory

An NU student co-ops for NASA

The success of NASA's Mars Exploration Rovers and advanced remote sensing data yields strong evidence that liquid water once flowed on the surface of Mars. With the intent to determine the current and past habitability for microbial life on Mars, NASA and the Jet Propulsion Laboratory in Pasadena, California are developing the largest and most expensive rover mission in history. Set to launch in the fall of 2011, the Mars Science Laboratory (MSL) rover is a $2.3 billion project with a notable 2,000-pound payload of scientific instruments including spectrometers, various sampling analysis suites, and multiple hi-definition cameras.

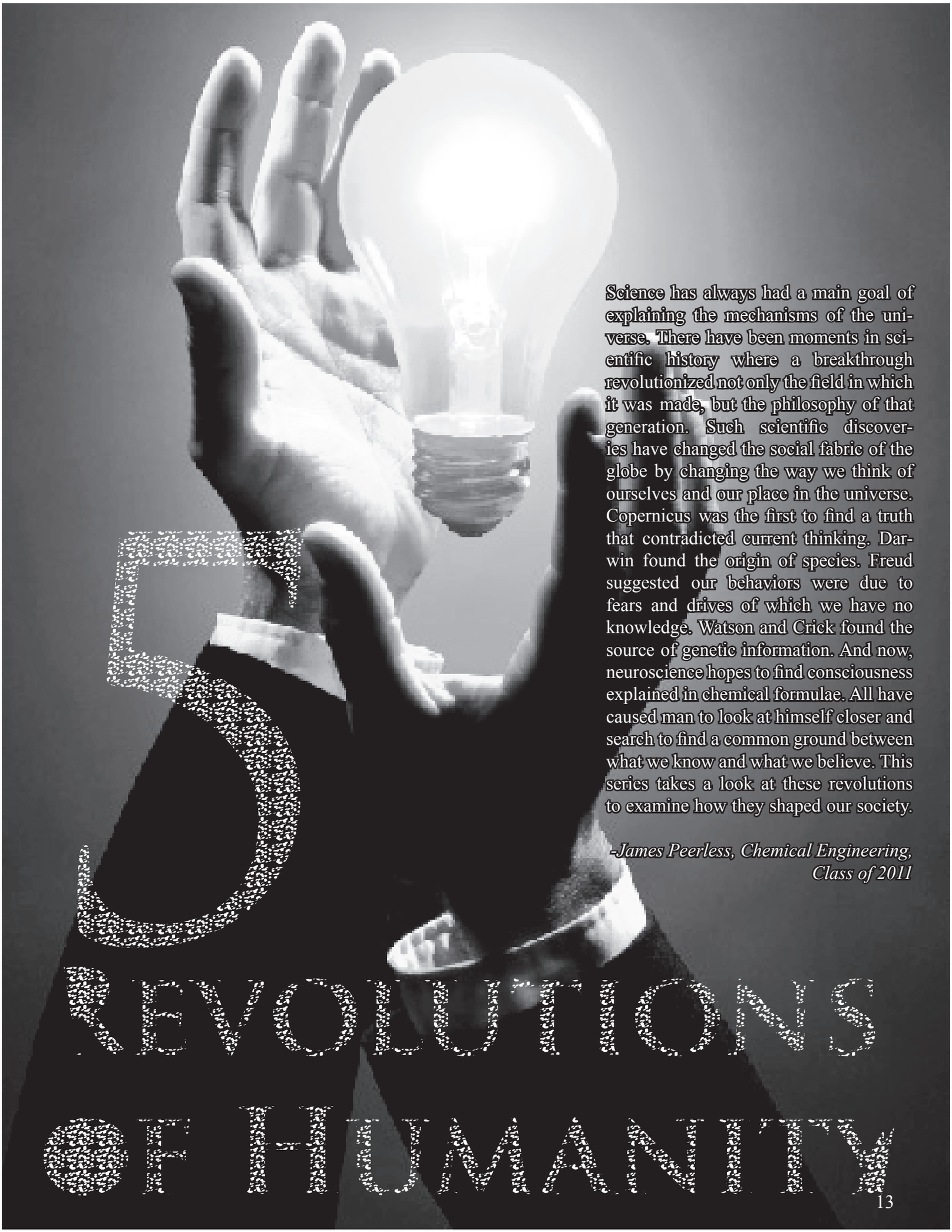
The MSL scientific objectives are to (1) assess the biological potential and capacity of at least one target environment on Mars, (2) to characterize the geology and geochemistry within the landing zone, (3) to study the processes of relevance to past habitability and the role of water, and (4) to characterize the broad spectrum of surface radiation. This noted, the MSL rover must land safely in an environment abundant in scientific potential – i.e., contains intriguing fluvial geomorphology and aquatic-based mineralogy characteristic of an environment suitable for the preservation of microorganisms – while operating within engineering constraints and thus avoiding regions with large rocks, massive aeolian bedforms, steep slopes, and rugged terrain.

Engineering and landing site constraints are defined based upon the initial design of the spacecraft, and the MSL rover faces similar restrictions as seen in previous Mars missions. Latitude greatly influences the range in which rovers may successfully land on Mars. The MSL mission is restricted to latitudes between45 ° N and 45°S. Low altitude winds and atmospheric turbulence must be minimal to ensure stability throughout rover descent. Elevation also must not exceed +1 km due to the necessity of a sufficient atmospheric density column during spacecraft entry and descent on a parachute. Upon landing, the rover belly pan may accommodate a rock up to 0.55m high. The landing site must exhibit a radar-reflective and load-bearing ground surface to ensure that the MSL will remain mobile. Fortunately, scientists can compare in situ data acquired by previous rover missions on Mars with remote sensing data acquired by the MRO satellite to determine the surface characteristics of any landing site from orbit. This comparison allows scientists to assess the surface composition and potential hazards in future landing sites on Mars without full dependency on in situ data.

Working within the Planetary Geophysics Department at the Jet Propulsion Laboratory this past spring of 2010 as a co-op student, I had the opportunity to assess surface hazards in two nominated landing ellipses for the MSL rover: Northeast Syrtis Major and East Margaritifer Terra. Utilizing THEMIS daytime infrared basemaps and data from the Mars Orbital Laser Altimeter (MOLA), morphology, elevation and slope were assessed in each newly proposed landing site. Additionally, stereo Context Imager (CTX) and HiRISE images (25cm per pixel) were acquired in each of the two landing ellipses and qualitative hazard analyses identifying ripple fields, rocks, and scarps were conducted. My qualitative and quantitative hazard assessment in these two potential landing sites allowed a panel of senior research scientists and engineers to determine the overall usability of the two sites on Mars. My research in regards to the overall safety of Northeast Syrtis Major and East Margaritifer Terra rendered them too dangerous for rover landing and traverse, and they required further development and exploration for future use.

A final landing site selection for the Mars Science Laboratory rover mission will occur in the late summer of 2011, and research scientists and engineers at the Jet Propulsion Laboratory diligently work to secure landing sites on Mars where both science potential and safety are high. The success of the MSL rover marks a turning point in all space and planetary exploration, and the potential for uncovering microbial life on extraterrestrial bodies within our solar system is soon to be within reach.

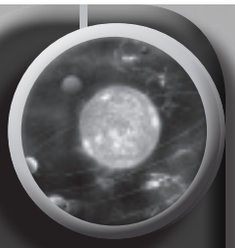
- Emily Snead, Environmental Science, Class of 2012



5 REVOLUTIONS OF HUMANITY

Science has always had a main goal of explaining the mechanisms of the universe. There have been moments in scientific history where a breakthrough revolutionized not only the field in which it was made, but the philosophy of that generation. Such scientific discoveries have changed the social fabric of the globe by changing the way we think of ourselves and our place in the universe. Copernicus was the first to find a truth that contradicted current thinking. Darwin found the origin of species. Freud suggested our behaviors were due to fears and drives of which we have no knowledge. Watson and Crick found the source of genetic information. And now, neuroscience hopes to find consciousness explained in chemical formulae. All have caused man to look at himself closer and search to find a common ground between what we know and what we believe. This series takes a look at these revolutions to examine how they shaped our society.

-James Peerless, Chemical Engineering, Class of 2011



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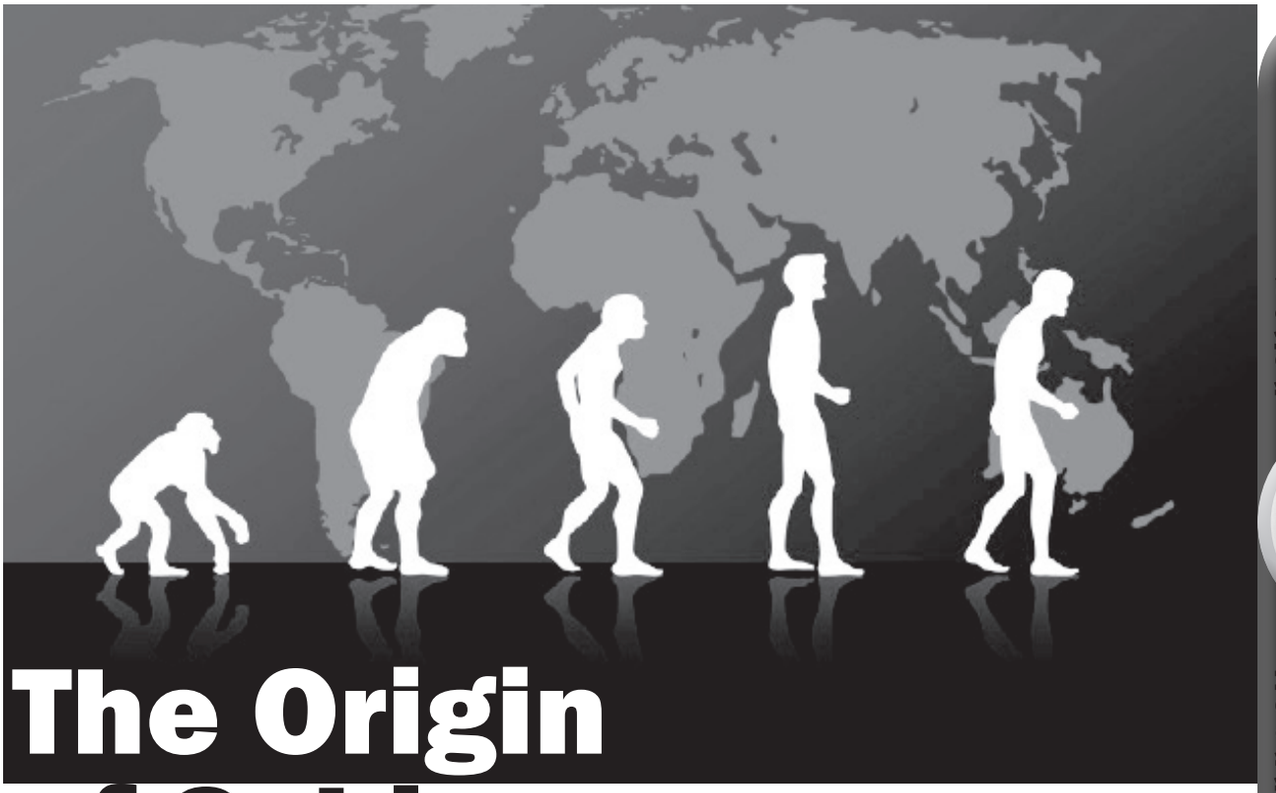
The Heavenly Spheres

It was a radical idea to proclaim that the Earth was not special. For centuries, it was assumed that we humans were located at the center of the universe. Our home was what we would measure all the rest of the heavens by. We were special. We had a special significance amongst the stars. It was with great trepidation, then, that Nicolaus Copernicus said that this was not so. Surely hundreds of years of philosophical and religious dogma could not be wrong! But the numbers didn't quite add up. The empirical evidence didn't fit. Many years of careful observation led Copernicus to believe that something was terribly wrong with the old geocentric model. He was right, and his theory would go on to have more profound consequences than he could ever have imagined. Copernicus' heliocentric model of the solar system would change the role of science forever.

The geocentric model of the universe (in particular, the Ptolemaic system), while never unanimously accepted, was the prevailing hypothesis for well over one thousand years. The Ptolemaic system postulated that the Earth sat in the middle of the universe with nine celestial spheres rotating around it. The view was not without some reasonable support. The distribution of stars above and below the horizon seemed to be even (roughly 50:50) and there was no observable parallax in observed constellations (stars closer to Earth should appear to move faster than stars farther away. This does, in fact, occur, but the differences are too small to be seen with the naked eye). Thus, it followed that the Earth had to reside at the center. However, there were many flaws to the geocentric model, such as an inability to adequately explain the retrograde (backward) motion of other planets and its inability to make precise predictions of celestial events consistently. However, the model was far more accurate than any of the previous hypotheses.

The geocentric model was not seriously questioned until the 1500s, partially due to a lack of technological advances in astronomy and partially due to the fact that geocentrism fit very well with religious scripture. The first true challenge came from Copernicus' postulation of a heliocentric system in De revolutionibus orbium coelestium (1543). In it, Copernicus presented the idea that the sun was the center of our solar system, and all of the planets revolved around it. Similar to the Ptolemaic system, however, Copernicus stayed true to the idea of celestial spheres and circular orbits. Reactions to this idea were mixed. Without the aid of advanced observation technology, such as the telescope, Copernicus was unable to gather enough direct evidence for his hypothesis to be widely accepted. Additionally, his heliocentric model did not result in more accurate calculations and predictions than the Ptolemaic model. Furthermore, the leading philosophers and religious officials of the day were opposed to the idea, as it stood as a blatant contradiction to the accepted philosophies and holy scriptures. De revolutionibus orbium coelestium was thus placed on the Index of Prohibited Books in 1616, and further printing of the book was suspended. However, this new idea of heliocentrism also posed many benefits, in particular an answer to the question of retrograde motion. Copernicus explained that the apparent backwards motion by planets in the night sky was, in fact, due to the Earth's own motion. This would spur further investigation, notably by Tycho Brahe, Galileo, and Johannes Kepler. It is not the hypothesis presented by Copernicus, then, that is truly important here. It is what the idea represented and its consequences that should be praised. Though he didn't have the advantages that Galileo, Kepler, Newton, and those that followed had, Copernicus' hypothesis was, in truth, very conservative. His model of the universe was overly concerned with preserving the philosophical "perfection" of the old models. In an attempt to stay true to the ideas of celestial spheres and perfect circular orbits, Copernicus had to add many mathematical corrections, such as extra epicycles (small circular orbits around a moving point in their larger orbits) not present in the Ptolemaic model. His model was no more predictive or mathematically accurate than Ptolemy's. What Copernicus' work did do, however, was trigger a break from religion's chokehold on science. In the years following his death, Galileo would point his telescope to the skies and describe the phases of Venus and Jupiter's moons providing direct evidence for a heliocentric solar system. Kepler would accurately predict transits of Mercury and Venus by applying elliptical orbits to planetary motion, shattering the philosophical "perfection" of a universe with circular orbits and celestial spheres. Newton would devise a law of universal gravitation. All of these discoveries would, in their own right, violate religious dogma. Copernicus's work may not have been the perfect model that astronomers were looking for, but its implications far outweighed its imperfections. With one publication, Copernicus was able to help push western society out of its dark age. With one publication, Copernicus was able to jumpstart the Scientific Revolution. Copernicus's heliocentric theory had much room for improvement, but it would prove to be the one of the first, and one of the bravest, steps towards modern science.

-Kyle Deerwester, Behavioral Neuroscience, 2013



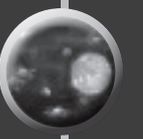
The Origin of Schism

How the Darwinian Revolution Polarized the World

Looking at Copernicus, we can clearly see that Charles Darwin was not the first scientist to publish findings that sparked controversy. However, when we think of controversy in culture regarding science, no subject comes clearer to mind than that of evolution. If Copernicus was a thorn in the sides of dogmatic conservatives, Darwin was a meat cleaver. Darwin's theory of evolution by natural selection opened a chasm between science and religious conservatives that has never been closed. This conflict aside, Darwin's work changed the western world like no other postulation has. His theories spawned philosophies, religions and political ideologies. His strategic, logical and modest explanation of evolution by natural selection in his work On the Origin of Species in 1859 changed the way people saw their place on the globe. Darwin is alone in that his discovery, though scientific in nature, has shaped western culture more than it did science.

This is not to say that Darwin's theory of evolution was not game changing in the field of biology. It most certainly is. However, Darwin was not the first naturalist in his age to postulate that species arose from adaptation of another. Notably, Charles Darwin's grandfather, Erasmus Darwin, and Jean Baptiste de Lamarck were early champions of evolution, though their theories were far from perfected. Although these theories were public, Darwin's true inspiration came from the work by Charles Lyell, a geologist/lawyer, titled Principles of Geology (1830-1833). Darwin read all three volumes of this work while on his voyage with the H.M.S. Beagle. The Beagle was an exploratory vessel meant for navigating the expanding trade routes across the globe. Darwin was the ship's naturalist, charged with finding biological specimens of interest and bringing them back to Britain. It was upon this voyage that Darwin's theories were conceived, spawned by Lyell's work. Lyell's focus was on geological formation. The current theory of the day, termed "catastrophic geology", was based around the idea that there was one catastrophic event which made the world into what it pretty much looks like today, with current changes being only minor. Lyell proposed that the tools to change the earth's formations are still active all around us; that volcanoes and rivers are constantly changing the face of the globe just as they always had. This theory, though seemingly benign, had huge implications. Here was the idea that no laws were broken in the formation of the earth as we today see it; the mechanisms that shaped the world we now see are still at work just as they always have been.

It seems that once Darwin made peace with this concept, and in fact embraced it, he began to question what shaped the large diversity in species we see today. Is it possible that the mechanism that created the diversity now present is still working? The long voyage of the Beagle began to shape his view. He was able to study what's termed biogeography, or the distribution of plants and animals in the globe. His most notable findings were found on the Galapagos Archipelago, a small grouping of islands in the mid-Pacific. What astonished Darwin first was the broad range of species found on the islands. He was then informed that each island had a different grouping of animals, even those hundreds of feet away from each other. Darwin could



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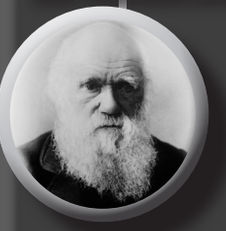

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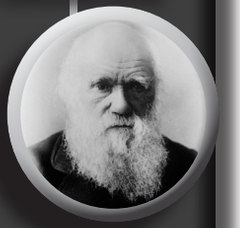

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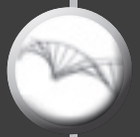

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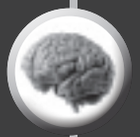

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not assume a creator had designed a different assortment of animals on each island. The animals must have come to the islands and changed once they were split. Evolution was Darwin's only answer.

It must be noted here that there are different parts of evolutionary theory. Evolution as a fact is the simple idea that older, less complex species change over time into new, more complex species. This was what Darwin knew and is most definitely accepted in this day and age. The path of evolution was still yet to be found. Evolutionary pathways refer to the actual process of one species becoming another one. The cause of evolution was the hardest question to ask: what makes this happen? This, Darwin had to work at. He studied adaptations of animals. He studied similarities between animals on different continents. He looked at fossils and compared them to the current animals in that same region. Darwin's answer, as outlined in On the Origin of Species, was natural selection.

Evolution by natural selection was logically presented with basic examples that we see every day. Firstly, diversity exists amongst species. Traits that arise from this diversity that are advantageous to survival allow the possessing animals to reproduce, and are then passed along to the next generation. Also, traits that help an animal attract a mate are also passed on more prolifically, thus these traits are seen in subsequent generations as well. Darwin's design for evolution looked somewhat like a tree, with each fork denoting a common ancestor. Each branch diverges due to changes in the environment or new predators and dangers that necessitate new adaptation.

With over a hundred years of history behind us, we see flaws in Darwin's theories, mainly due to his lack of knowledge of modern genetics. Still, with any shortcomings of the theory, On the Origin of Species turned everyone in Great Britain into an evolutionist practically overnight. After its publication in 1859, it was fashionable to be an evolutionist. When Darwin's ideas came into the limelight, they began to diffuse into other realms of thinking. His theory began to be boiled down to the over-simplified idea of "survival of the fittest", a term created by philosopher and biologist Herbert Spencer that was injected into later editions of Origin. Herbert Spencer than began to create the idea of "Social Darwinism", an idea that it is the duty of a society to weed out the weak and those unable to support themselves. This idea exploded all over the political map and changed international politics for the next one hundred years. It gave credence to capitalism. Its bastardization spurred fascists like Mussolini. It even found its way into the prime philosophy of the National Socialist Party in Germany. In the Nazi propaganda piece Mein Kampf, we find a most telling excerpt: "He who wants to live must fight, and he who does not want to fight in this world where eternal struggle is the law of life has no right to exist."

In a less bloody sense, Darwin revolutionized the philosophical and religious thinking until this point. Big names in classical philosophy, such as Aristotle and Plato, insisted that every being had a form that was conceived before the material representation. It followed that the material representation could not change gradually; the form had to be conceived first and the material had to be created anew. Philosophers, unlike the religious leaders of that time, saw this as an opportunity to improve the old theories rather than add a black eye to their profession. We then see the works of the pessimist Schopenhauer, the radical naturalist Friedrich Nietzsche, and the naturalistic humanist John Dewey all incorporate Darwinism into their philosophies.

Darwin's theories have seen no greater resistance in the western world than right here in the United States, regardless of the views of its founders. Around the end of the nineteenth century, concerns by conservative Christians over evolution began to rise. Darwinism was seen as the impetus behind the militarism that caused World War I and was soon beginning to find its way into the textbooks of every high school child in America. Here we find the Scopes monkey trial of 1925. In Dayton, Tennessee, John Thomas Scopes was put on trial for violating a state statute by teaching evolution to students in public school (this law prohibiting evolution education was overturned in 1960). The case had considerable public attention and the arguments between evangelical Christian prosecutor William Jennings Bryan and attorney Clarence Darrow were seen as fantastic entertainment. Although the prosecution won the trial, as Scopes was given a $100 fine that was later overturned on a technicality, the public saw the ridiculousness of fundamentalism in the context of science. As put by Michael Ruse, philosopher and author of The Evolution Wars, "The nation – the world – laughed at Tennessee and at the fundamentalists. Never again was right-wing Christianity to challenge science in such a way."

Nonetheless, the conflict was not resolved. The Cold War pushed the United States to scramble towards academic excellence in a sort of intellectual arms race. This meant writing new textbooks. Luckily for evangelist conservatives, John C. Whitcomb and Henry M. Morris arrived to give the textbook authors a scientific explanation of origins consistent with a near-literal interpretation of the bible: creation science. Creation science is not exactly unified into any one theory; however it is unified in the fact that it discredits evolution. It especially discredits Darwinian evolution. Most creation scientists put no trust in radioactive carbon dating to date the earth. They believe that the fossil record is the result of the catastrophic flood; the simplest creatures being drowned at the bottom while the most complex escaped to higher ground. Mainly, creation science was pushed in local school boards as an alternative to be taught in conjunction with Darwinian evolution.

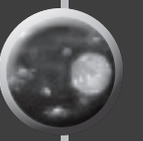
The education debate continued. In Arkansas and Louisiana in the early 80's, similar laws were passed that forced "balanced treatment" of both evolution and creation science was given in the classroom. Biology teachers were not pleased, as both spawned court cases. Finally, in 1987, the Supreme Court ruled that the Loui-

siana and Arkansas law of balanced treatment were considered unconstitutional, as they favored one particular religion (Christianity). In response to this ruling, creationists began to put their efforts into intelligent design, a vague theory that varies greatly upon interpretation. The main effect it has in the classroom is that it offers an alternative to Darwinian evolution without directly referring to God or the bible. The constitutionality of teaching intelligent design is still being debated and the balanced treatment mandate with regard to intelligent design varies by state.

Although we see specific cases of evolution coming to court in the arena of education, evolution has been deeply ingrained in the culture war of the United States since the 1960's. It is often seen as one of the fundamental differences between the conservative base and the liberal progressives. The implications of Darwin's theories have been blown to such a grotesque proportion that they have been wrongly infused in debates over abortion and in efforts to disprove God. However, both sides of the debate fail to see that there are scientists and theologians alike that see evolution and a deep religious faith completely compatible. Yet as the culture war rages on, so will the debate over evolution. As the social continuation of Darwin's theories was over blown and perverted one hundred years ago, so they shall continue to be. Nevertheless, it should be remembered that Darwin's theory was one of biology and not of philosophy or sociology.

Although Charles Darwin was by no means a man of self-aggrandizement, it would be hard for him to have any foresight into how much he changed our world 150 years after the Origin. In life, he always shied away from the religious debate surrounding his theories. He never would have wanted to create a social outlook or a culture-polarizing debate. He never could have imagined his theory being cited by the biggest despots in history or staunch atheists of our own day. Darwin's place in history is part scientist and part antagonist, however in life he was purely a scientist.

-James Peerless, Chemical Engineering, Class of 2011



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Anatomy is Destiny

The Theories and Impact of Dr. Sigmund Freud

Throughout the course of human history, there have been countless individuals who have influenced popular thought and challenged common assumptions. Found with the likes of Darwin and Copernicus is Sigmund Freud, perhaps the most well-recognized and controversial psychologist to ever enter the field. His development of psychoanalysis challenged the current notions of psychology, and his persistence in his theory earned him legions of followers and alienated him from anyone who doubted his work. Although he was initially considered a radical in the field of psychology, people soon began to accept psychoanalytic theory and Freud became recognized as a worldwide expert on the subject.

Before Freud's development of the theory of psychoanalysis, psychology had two main approaches to explaining mental issues and human behavior. The first approach was solely scientific and was based on the premise that the brain was controlled by the laws of chemistry and physics. The alternate view was known as common-sense psychology, which relied on common-sense explanations for human behaviors by using thoughts, feelings, and wishes to come up with cause and effect explanations. Taken separately, neither of these orientations could explain everything about human behavior and mental issues. Freud's theory aimed to remedy this situation. At its simplest, Freud's psychoanalytic theory assumed that people are unaware of the unconscious factors that guide their emotions and behavior. Freud divided the mind into two levels, the unconscious (which contains our drives and urges that are out of our awareness but still motivate our feelings and actions) and the conscious (which are any mental elements that are in our awareness at any point in time). Freud said that the unconscious contains the meanings of dreams, slips of the tongue, and the repression of memories. Freud also believed that unconscious processes can enter our consciousness, but first they are disguised or distorted as to prevent feelings of anxiety. For example, a person may hold unconscious feelings of eroticism or hostility, yet these feelings will be presented in the conscious as joking or teasing with other people. This enables the person to fulfill their desires, but it is in a more socially-acceptable manner than directly expressing hostility or eroticism. Freud believed that two drives guide all human emotion and behavior – sex (Eros) and aggression (Thanatos). Freud believed that these drives originate in a person's id (an unconscious region in the psyche that aims to reduce tension by fulfilling desires) but are able to enter a person's ego (a region of the mind that is in contact with reality and must balance the desires of the id and the demands of the superego). Freud believed that the existence of the sex and aggression drives could lead people to experience anxiety, which he described as an "unpleasant state accompanied by a physical sensation that warns the person against

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impending danger." To deal with a state of anxiety, Freud proposed that humans use a variety of defense mechanisms to avoid directly dealing with sexual and aggressive drives and thus avoid a state of anxiety. Freud proposed that a person's sex drive is one of the greatest forces in shaping a person's personality, and he even claimed that infants are driven by sexual impulses. One of the most controversial theories Freud had regarding sex was the male Oedipus complex. Freud stated that as an infant, boys identify with their father and want to be their father. However, this soon gives way to a sexual desire for their mother, and the boy views his father as a rival for the mother's love. Freud also put forth the idea of castration anxiety, in which a young boy fears of losing his penis. Eventually, the boy's Oedipus complex is resolved or repressed, and the boy abandons his incestuous desires toward his mother.

Similarly, Freud developed the idea of the female Oedipus complex, sometimes referred to as the Electra complex. The female Oedipus complex assumes that young girls develop "penis envy," and the young girl will hold her mother responsible for denying her the organ, and will turn her sexual energy toward having sex with her father. Freud believed that the female Oedipus complex is resolved once the girl gives up sexual pursuit of her father and identifies with her mother. These ideas were radical in the Victorian era, and caused Freud to lose some of his colleagues and patients. Some of Freud's followers and critics challenged Freud's views about the female Oedipus complex, and began to publicly criticize Freud as being sexist and negative towards women. Freud refused to recant his theory, but did state that the life of women is a "dark continent for psychology."

Besides simply developing the theory of psychoanalysis, Freud also created a therapeutic treatment of the same name, with the goal of increasing a person's self-awareness and helping them to understand the effects that past events have on their present behaviors. The two aspects most commonly associated with psychoanalytic treatment are free association and dream analysis. During free association, patients must tell the therapist every thought that comes to mind regarding particular stimuli and follow the trail of associations wherever it leads. Regarding dream analysis, Freud believed that dreams contain a manifest content, or surface meaning, and latent content, which is the dream's unconscious meaning. Freud believed that all dreams are wish fulfillments, whether or not the dreamer recognizes them as such.

Freud's theories and practices earned him a legion of followers, some of which eventually split from Freud to form their own psychological theories. The most well-known of these include Alfred Adler, who went on to create individual psychology, Carl Jung, who founded the field of analytical psychology, and Karen Horney, who went on to expand the idea of introspection. However, each of these new theories, and the subsequent theories they spawned, has some degree of Freudian influence.

Freud's psychoanalytic theory still pervades 21st century thought and culture. Most people have heard of the terms "ego" and "id," and many people still identify psychotherapy (talk therapy) with psychoanalysis. His work has been the inspiration for other works of art, literature, film, and popular culture. His theories have also clearly made a lasting impact on the field of psychology. His ideas were unprecedented and were followed by legions of fledgling psychologists and scientists of all fields. His works spurred other psychologists to challenge Freud's views and come up with their own theories. Psychology as a discipline received more attention due to the interest the public had in Freud and has since made significant advancements in its research and treatment of mental issues. Certainly, Freud's theories are not immune from criticism and further research, but it is clear that they have made a significant impact on psychology and society as a whole.

-Brian Letourneau, Psychology, Class of 2011

Heredity as Chemistry

The Discovery of DNA

In 1953, James Watson and Francis Crick discovered the double helix structure of DNA. This breakthrough ushered in a wave of genetic research and established DNA as the main form of hereditary. Watson and Crick proposed that two chains made of sugar phosphate bonds are connected via hydrogen bonds between pairs of bases: Adenine with Thymine and Guanine with Cytosine. This two chains twist to look like a spiral ladder. Watson and Crick's discovery has several implications for modern society.

Numerous advances and scientists conducting a vast amount of scientific research led to the uncovering of the DNA puzzle. Two other scientists were fundamental in the process but remain relatively unknown today: Maurice Wilkins and Rosalind Franklin. In 1962 Watson, Crick and Wilkins received the Nobel Prize in physiology or medicine. Though Rosalind Franklin was essential in the research, she passed away in1958, four years before the recognition. Despite the times Rosalind Franklin (b. 1920 in London) obtained a degree in Chemistry and became an expert in the new technology of X-ray crystallography. In X-ray crystallography, an

x-ray is shot at a protein to deduce its structure. Using this technique, scientists can visualize the structure of very small components in a cell, like DNA. Wilkins, a nuclear physicist also suggested using X-ray crystallography to study DNA. However, instead of cooperating, Franklin and Wilkins bumped heads frequently potentially slowing their progress. Already interested in genetics with a degree in zoology, Watson became involved in the project after hearing a lecture of Wilkins and seeing images of DNA. He soon moved to Cavendish Laboratory, a hot spot for x-ray crystallographic projects. Crick at the time was studying hemoglobin at the same location where he was recruited by Watson to develop a model of DNA structure. Using Franklin's photos, they published their work in Nature in 1953.

Besides X-ray Crystallography many other recent studies contributed to the model. Gregor Mendel through experimentation with peas observed that traits, today called genes, are inherited in certain patterns. The patterns correlate to factors, like shape and color that are located on the same gene. Two years later in 1868 Friedrich Miescher isolated nucleic acid from cells for the first time. It wasn't until 1944 that Oswald Avery connected the two discoveries while observing bacterial strains thus concluding that nucleic acids made up genes. Following this discovery the trend among scientists shifted from a view of proteins as the mode of hereditary to DNA as fundamental structure of life. In 1950, Erwin Chargaff's found that there are equal numbers of adenine and thymine and guanine and cytosine. The final piece of evidence was Linus Pauling's finding of proteins with helical shapes. In fact in the same year as Watson and Crick proposed a double helix model, Pauling published a paper suggesting a three-helical structure. By gathering all this information, Watson and Crick were able to develop the double helix model of DNA.

From medicine to agriculture the impact of Watson & Cricks discovery is profound. Manipulation of the genetic code can have profound effects on an organism: from balding to serious disorders like Down syndrome. Messing with the structure of DNA and alternating the genetic sequence can prevent or enhance certain traits ushering in a whole new way to treat diseases. Today, DNA fingerprinting is common in crime scene investigations and genetic manipulation is used to grow larger, pest resistant plants. Cloning is now essential in microbiological research and in 1996 Dolly the sheep became the first cloned mammal. However, much controversy and debate surrounds the genetic code today especially with respect to the ethics of cloning. From 1990 to 2003 the Human Genome Project led to the complete mapping of the human genome, a profound advance in genetics. Watson and Crick changed the way man approaches scientific research and opened up new fields of study. Without this breakthrough, man would still be ignorant of the mechanisms of heredity.

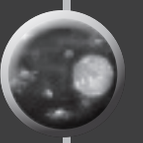
-Tara Dhingra, Biochemistry, Class of 2012

Neuroscience

The Revolution of Our Generation

Copernicus proved that the earth isn't the center of the universe, Darwin showed us we're all just clever chimpanzees, Freud told us we run on powerful subconscious desires, and lastly, the discovery of DNA. Francis Crick, after discovering the coiled double helix and thus revolutionizing the way we think about our genes and our history, famously said, "There is no scientific study more vital to man than the study of his own brain. Our entire view of the universe depends on it." The discoverer of DNA spent his later years convinced of the intrinsic importance of neuroscience, resolute that the study of the brain at the molecular level would discover the neural correlate of consciousness, and predicted that neuroscience would go through a molecular revolution comparable to the one he had led in biology.

For many, neuroscience is the natural end point for the most pressing and curious issues; it is the culmination of a variety of questions from an array of different subjects. From where does consciousness arise? What causes mental illness? How do we learn? How does memory work? It is a unifying field, it is here that all of the data we have collected and observations we have made from science, psychology, sociology, philosophy, even religion, will be coordinated into a whole picture. Everything from what makes us learn,



1543 - *De revolutionibus orbium coelestium* first printed in Nuremburg, Germany outlining Copernicus' heliocentric model

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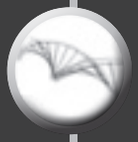

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to what makes us feel, to what makes us socialize; in short, what makes us human. There are dozens of places to look for answers, from research in molecular neuroscience, which now allows paralyzed people to move objects using their own neurons, to systems neuroscience, which is creating a new form of artificial intelligence using an electric nervous system as a model. We have so much data on the table from inside our brains, the majority of which is tantalizingly detailed yet still undecipherable. We can see patterns in its anatomy, but we still don't know what they mean. The complexity of the field is what makes it so promising, however it is also what makes it so difficult to grasp. The exquisitely complex action of the firing of a single neuron up to the way we learn to play the violin all happens in the brain. As Crick put it "Even our loftiest aspirations are byproducts of neural activity."

For some, science has no place answering deeply intricate humane issues like consciousness or empathy or our perception of reality. There is a knee jerk reaction that causes us to cry, "I'm a complex human being capable of higher order thought and building rocket ships and flambéing soufflé, I can't be explained away by chemical reactions!" In reality, understanding our biological processes in no way lessens what we experience. It is description, not explanation. The more we discover about the chemical, biological, and physical properties of our own brains, the more we realize how in the dark we are about the depth of complexity that comprises our minds, and the more inherently fascinating it all seems. In a strange way, unraveling the biological underpinnings of our brain intensifies the sense of mystery; it causes us to marvel at the incredible evolution that had to occur to make us human.

Have you ever noticed that someone was about to take a bad fall and flinched in response, momentarily feeling that person's pain? The reason for that could be found in something called mirror neurons. These were first identified at the University of Parma by Italian researcher Rizzolatti and his colleagues, who were testing motor neurons in the premotor cortical area of macaque monkeys. The premotor cortex is a part of the brain that separates sensory input and motor output; it is where actions are quickly rehearsed before being completed by the motor neurons. As often seems to be the case in science, it was not quite foresight but an accident that caused them to pause and notice something unusual. Rizzolatti and his colleagues were going about their business, eating ravioli, listening to opera and measuring their monkey's brain waves, when one of them noticed something odd-the same neurons in the premotor cortex that fired when the monkey himself picked up a peanut were also responding when the monkey saw a researcher pick up a peanut. The monkeys' premotor neurons were responding to the mere observation of an action. The researchers had stumbled upon something big. As Rizzolatti would later predict, "mirror neurons will do for psychology what DNA did for biology". What they found is a biological basis of imitative learning and culture acquisition. By observing another animal's actions, responding via mirror neurons, an animal could engage in imitative learning and possibly understand the intent behind the action. This shared knowledge could have allowed animals to evolve in tough environments, with one especially clever monkey's knowledge of tools being shared with all of the monkeys of his tribe. Mirror neurons were recently identified in human epilepsy patients in Dr. Itzhak Fried's lab at UCLA. They were found in more parts of the brain and even more highly developed than those found in the macaques. Our more sophisticated forms of mirror neurons mean we can engage in more complicated forms of imitation. Researchers hypothesize that the macaque monkey's premotor cortical area evolved its mirror neuron system as an area for high-level control of facial actions. If this proves to be analogous in humans, it could mean that mirror neurons and imitative learning are what led us from crude pantomime communication to the tongue movements of rudimentary language.

These neurons could also prove to be the biological basis for empathy, as research into the mirror neurons of both Autism patients and synesthetes shows. Experiments have shown that people with Autism may have deficiencies in the ability of their mirror neurons to function properly. The common signs of Autism, such as inability to meet others eyes, blank facial expression, lack of social reciprocity, lack of communication, etc., could be the effects of impaired mirror neurons. If they are unable to learn via imitation by mirror neurons, their interaction with others and their ability to communicate becomes impaired. Interestingly, on the flip side, people with the condition known as mirror touch synesthesia, unsurprisingly, have overactive mirror neurons. These are people who, when they see someone about to take a bad fall, not only flinch reflexively, but literally feel the injured person's pain. This is not just a perceived or imagined pain. It is a measured neurological response. Think about what this says about our unique perceptions of reality, and how arbitrary they can be. A better understanding of the mirror neuron system could elucidate the concept of empathy, which has more than just scientific implications: a deeper understanding of what it means to feel empathy could change the way we think about ourselves and our interactions with one another.

It is hypothesized that complex mirror neurons developed about five to ten thousand years ago, right around the start of civilization. It could be that mirror neurons are what allowed us to communicate with each other while feeling empathy for one another, enabling us to live in societies. Fifth revolution, perhaps?

-Jen Tarnacki, Neuroscience, Class of 2010

Did you know that...

The Life-Between-the-Sheets Theory

Helen Hansma of the University of California, Santa Barbara has a new theory on where the first cells originated from: mica sheets. That's right, from those flakey, glossy minerals we all pulled apart as gold. According to her hypothesis, known affectionately as "life between the sheets," the structured compartments formed between mica layers could have sheltered the molecular precursors to cells.

The building blocks of this theory rely on three reasons mica creates a great basin for cell creation. First, the compartments could have sufficiently protected and isolated the molecules from the harsh pre-historic environment. Second, the rich levels of potassium in mica sheets could correspond to the high levels found in human cells. Finally, exposure to ocean water would have allowed the sheets to push together, perhaps joining the molecules.

-Kristina Deak, Biochemistry, Class of 2012

The Furry Death: Oak Processionary Moth

Originally found in central and southern Europe, the oak processionary moth has been expanding its territory to London. In the past four years, the British government has been forced to take rigorous action to fight these sharp haired creatures. It has affected many areas in West London including the Royal Botanic Garden, Richmond Park, London Underground, and many other sporting and visitor attractions surrounded by oak trees.

The oak processionary moths begin to appear around July to early September in the form of an egg. Around April, the first larvae begin to appear, masked as harmless little caterpillars. From April to June, the larva enters their hazardous stage where they will develop about 620,000 long and short white hairs that cover the length of the body. The small hairs are covered with a histamine-liberating toxin (thaumetopoein), which can potentially be harmful to humans. According to Dr Brian McCloskey, director of the Health Protection Agency in Long, people exposed to the toxin may exhibit symptoms such as "itch patches of puffy skin, persistent itchy raised spots, irritant dermatitis, and itchy eyes." The oak processionary moth is particularly dangerous to asthma suffers because the hairs break off from the larvae, making the toxin airborne, and can ultimately trigger severe asthma attacks. Hairs that fall to the ground can maintain active for up to five years. The best way to tackle this problem is to terminate the creatures around May or June, before the larvae grows its hairs. The British government is currently using chemical and biological insecticides to manage and eradicate this health threat. However, larvae that are concealed and protected by nests will evade the insecticide, so the only option is to destroy the nests.

The pest, which damages tress and are harmful to humans, can be found most popularly in the English, Sessile, and Turkey oaks. This year, although the figures are lower, the moths have breached into one of the world's leading botanic gardens, the Royal Botanic Garden at Kew. Over two million people visit the Royal Botanic Garden at Kew every year, so it is critical that the oak processionary moths are under control. The British government is working closely with The Forestry Commission every year to eradicate these harmful pests before they become established in the UK. Hopefully, the measures taken now will help the UK be more oak processionary moth-free next year!

-Jacqueline Lai, Communications, Class of 2011

Global Warming Leads to More Sick Fish!

The list of consequences from an increased level of carbon dioxide in the atmosphere just keeps getting longer. According to a recent study at the Grice Marine Laboratory of the College of Charleston, the newest effect will be the increased susceptibility of coastal marine organisms to virus and diseases. As levels of CO2 rise in the air they are simultaneously accumulating in the ocean, dramatically skewing the ratio of oxygen to carbon dioxide. In these conditions the immune systems of fish, oysters, crabs, and shrimp, have difficulty in fighting off bacteria. According to their studies, it takes half as much bacteria to lethally harm the organisms.

When marine organisms are confronted with pathogens, their blood cells rush to the site of invasion. This typically causes a buildup around the gills, which can reduce the exchange rate of oxygen by 40%. Clearly, when there is a reduced level of the molecule in the water to start, this presents a dangerous scenario for the fish. Fortunately, the organisms appear to be able to adapt to the conditions after mild exposure since their usual ecosystems undergo a certain level of fluctuation of oxygen levels. If they will be able to adapt quickly and efficiently enough to more dramatic changes is anyone's guess.

-Kristina Deak, Biochemistry, Class of 2012

miRNA:

Tiny RNAs with a **Huge** Future

One of the most critical discoveries in molecular biology over the past decade has been the realization of a class of small (20-25 nucleotide) non-coding RNAs that can post-transcriptionally regulate genes. The fist microRNA (miRNA) was discovered as an endogenous regulator of developmental timing in C. Elegans in 1993. In 2000 there were only two known miRNA, however, with the completion of the human genome project and subsequent technological advances, over 10,000 have now been identified, 650 of these in humans.

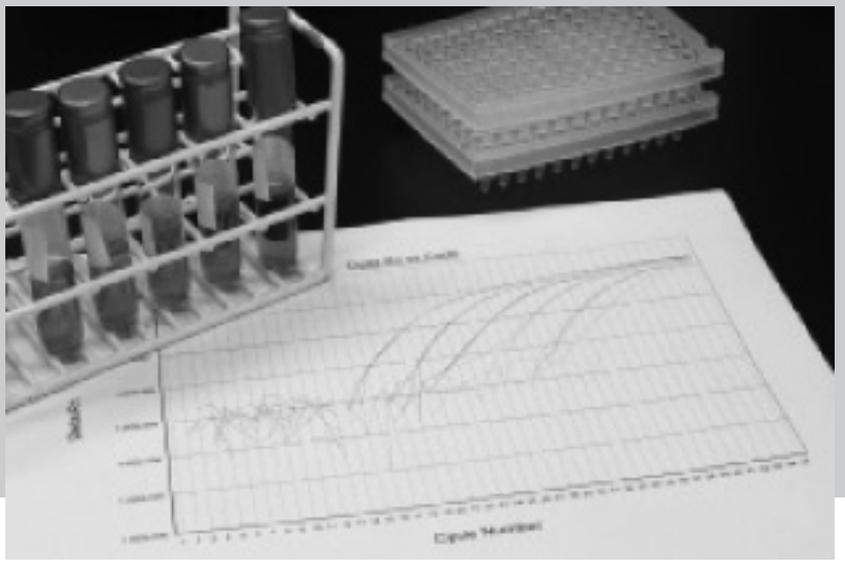
miRNAs are small, single-stranded RNA molecules that regulate amounts of proteins in cells by negatively affecting the synthesis of target mRNA for translation suppression or complete degradation. Their purpose is ultimately to help maintain homeostasis in the cell and they have impact on numerous processes from modification of chromatin structure to inception of apoptosis. While they only comprise about 1-2% of the eukaryotic genome, each miRNA can target up to 200 genes of diverse functions. Therefore, the molecules can control the expression of nearly a third of all human mRNA.

The abnormal expression of miRNA has been implicated as a factor in the development of several diseases including: cancer, muscular and cardiovascular disorders, schizophrenia, and inflammatory diseases. Thus, understanding more about how these molecules target genes and function in the eukaryotic system could hold the key to important pharmaceutical developments.

Biogenesis

miRNA biogenesis occurs in a step-wise fashion originating in the cytoplasm. First, the miRNA gene in DNA is transcribed by RNA Polymerase II to generate the long stem-loop structure primary transcript, known as pre-miRNA. This molecule is then processed by DGCR8, which determines the cleavage site of the pri-miRNA by measuring the distance from the dsRNA-ssRNA junction. Drosha, a ribonuclease, then asymmetrically cleaves the structure, releasing pre-miRNA with a 5' phosphate and 2-nt 3' overhang. This overhang is recognized by exportin-5, a transport protein that actively exports the molecule from the nucleus to the cytoplasm.

In the cytoplasm, pre-miRNA is cleaved by RNase Dicer III. This creates an asymmetric miRNA:miRNA* dupex, where miRNA is the coding strand and will mature and miRNA* is discarded. Next, the coding strand is loaded into an Ago protein and will become the core of the RNA-induced silencing complex (RISC). After association with additional proteins such as GW18, the mature ss-miRNA is loaded into RISC



and the entire complex heads to the 3'UTR of the target mRNA where subsequent mRNA translational suppression or degradation will occur.

Mechanism of Action

Mature miRNA interacts with mRNA based on typical Watson-Crick base-pair complementarity. The miRNA molecule contains a 7- to 8-nt long seed sequence, which is critical in the recognition of corresponding sequences in the 3'UTR of target mRNA. In the rare occurrence of perfect complimentarity between the two, complete degradation of the target mRNA will occur via enzymatic metabolism. More commonly, a partial complementarity will occur. In this instance the target mRNA is suppressed and will compress into destabilizing P-bodies.

Involvement in the Immune System

miRNA play critical roles in both innate and autoimmunity. In innate immunity, the presence bacterial ligands, viral ligands, or pro-inflammatory cytokines, can stimulate specific toll-like receptors, which in turn activate pathways can upregulate certain miRNAs. In adaptive immunity, miRNA can alter gene expression in T cells, generate T helper cells, and aid in B cell differentiation.

In recent years researchers have been able to identify specific miRNA associated with individual diseases. After stimulating cell lines with particular cytokines associated with a given disease, the researcher can isolate the cDNA, extract the RNA, and amplify it using reverse transcription and PCR technologies. After examining assays for differing expression levels, scientists are able to determine which miRNA are upregulated by the cytokines and can extrapolate disease connections. For example, in Rheumatoid Arthritis, it is known that the proinflammatory cytokines TNF-α and IL-1α can upregulate miR-155 expression in synovial fibroblasts.

Pharmaceutical Applications and Complications

So what practical application does this have? Scientists are currently working on technologies to use miRNA as biomarkers for disease. In addition, there is interest in modifying transcription and stimulation pathways such that some miRNAs that are constitutively upregulated in disease may be subdued. Such techniques would be invaluable as a "clean" solution to biological complications by targeting the direct genetic source of disorders rather than adding medicinal toxins with complicated side effects.

The road to pharmaceutical utilization is still a long one as several complications exist in the harnessing of this potent molecule. For one, the precise mechanisms of action of miRNA are still difficult to decipher among the thousands of other pathways occurring in the cell. In addition, precise target recognition of individual miRNA is a huge challenge due to limited application of novel technology. Today, several online databases exist where you can look up a miRNA and see its predicted targets. However, these sites rarely agree with one another. In one search for miR-140, one site implicated 12 targets, while another cited over 9,000. Clearly, a more concise bioinformatics approach must be sought.

In addition, there is concern with delivery of manufactured small molecules to the cell. As mentioned earlier, each miRNA can target several different genes. Thus, the unintentional ablation of a separate mRNA sequence is a real possibility when administering to the body system and a specified delivery mechanism must be created to avoid this. Currently encapsulation by cholesterol and lipids has been productive at limiting off-target effects, but much more research is needed.

miRNA are interesting molecules that have a significant impact on the regulation of various mechanisms in the eukaryotic biological system. While much still needs to be studied in regards to their precise mechanisms, modes of target recognition, and involvement in disease, they have tremendous potential in the pharmaceutical world.

-Kristina Deak, Biochemistry, 2012

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