The Synapse: Intercollegiate science magazine

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The Synapse

Oberlin College Science Magazine

Orientation '15 Edition

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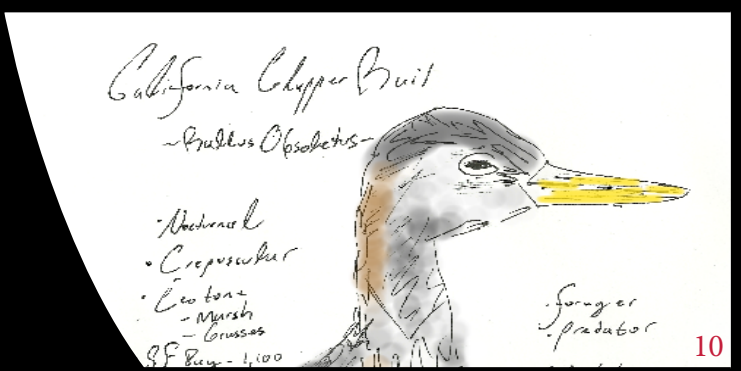

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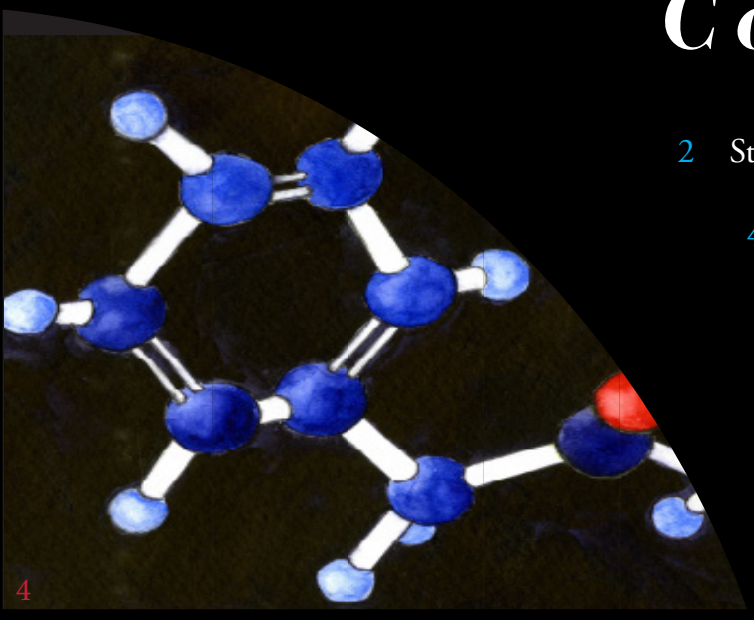

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Dear Reader,

The Synapse presents its '15 Orientation Edition, just in time for returning students to catch up on the latest scientific developments, acquaint themselves with the research of recent graduates, and familiarize themselves with science's pressing ethical considerations. If you are a first year, then this is likely your first perusal of an issue. Allow me to welcome you to Oberlin's realm of science journalism! Whether you read this magazine cover-to-cover or use the tabs to navigate by discipline, we promise that each article contained within was written with equal parts expertise, passion, and healthy skepticism. We hope you enjoy this collection of student-authored material.

Sincerely,
Gabe Hitchcock
Editor-in-Chief

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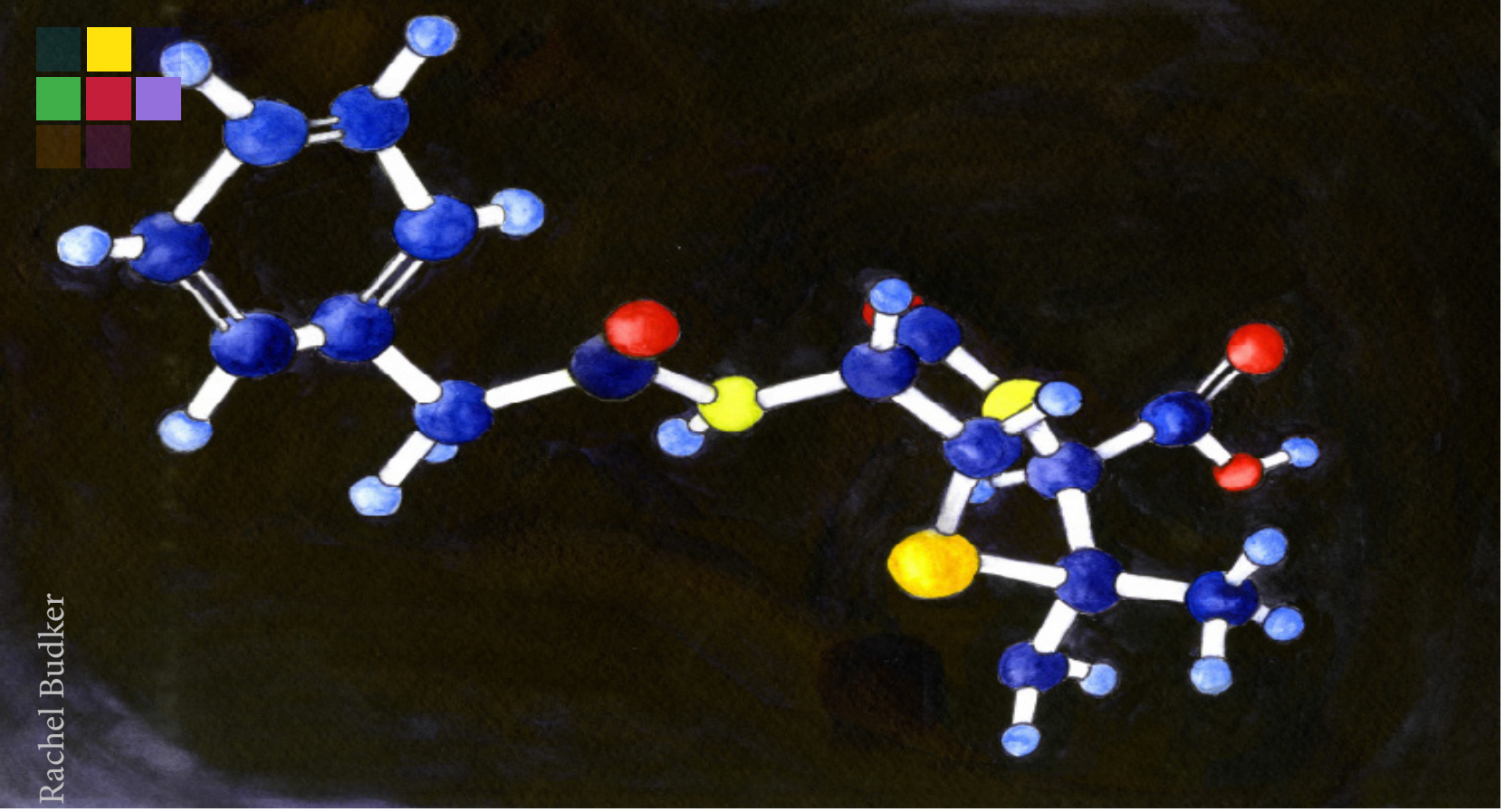
Physics Environmental Astronomy Policy



Rachel Budker

Oh Chemistry, Oh Chemistry

Rachel Budker

I went off to college declaring to my friends and high school teachers, and most importantly, my scientist parents that I was the "humanities person" in the family. And here I am in my final semester of college, an English major, and yet I'm in not one, but two organic chemistry classes. You might be wondering why, and frankly, so am I. While I ended up discovering an interest in science, and in particular medicine, there is still something that inexplicably draws me to orgo. Now bear with me here, because it's not that it's easy or that I want to become an organic chemist. There is something really alluring about the challenge of organic chemistry, but (as my editor will tell you) I can't quite find the words to explain it.

When you study chemistry, you spend a lot of time pushing electrons around, trying to uncover the secrets behind making and breaking chemical bonds. You are trying to understand what goes on between one atom and another atom. Do you know how small a scale that is!? Suppose you had a hundred dollar bill (or a piece of copy paper) and an awesome serrated breadknife. Now, suppose you took the bill and cut it like a bagel in half, separating the top and the bottom. Now, if you took the top half and cut that in half, and did that 20 more times, you would have an atom, or an average distance between two atoms—a unit of length called an angstrom (1 Å = 10-10 m = 10-8 cm = 10-4 μm). While particle physicists have to go down a few more powers of ten, this is still unfathomably small.

Naturally, this kind of scale requires you to work on a level of abstraction that, if you think about too hard too often, consistently causes your mind to be blown. And regularly, as Organic Chemistry Professor Albert Matlin tells me, in the beginning, people will say, "What the hell are these things?" when looking at molecules on the board . But, when you get into it, it's not just doodles in your notebook, but a system of visual representation that has an internal logic that is elegant and has predictive power: the pictures actually represent the theory, which represents our understanding of reality. When you draw an arrow

depicting a pair of electrons flowing from a negatively charged molecule to a positively charged atom, you aren't just adding a line on the page: you are showing our understanding of how the world actually works.

And by "world" I really mean the world—complex organic molecules are what make up all life. In fact, the designation "organic" originates from the belief that certain molecules extracted from living organisms had a "vitalism" that inorganic molecules did not . This distinction later became less clear and now organic chemistry simply means the study of carbon-containing compounds, encompassing molecules that compose life but also much more. Organic chemistry in particular, lies at the heart of industrial advancement and medicinal and pharmaceutical innovation. It is behind the synthesis of plastics and other structural materials, the invention of AZT, a treatment for HIV/AIDS, and other revolutionary antiviral medications. The future of organic chemistry lies within its applications in these industrial and biomedical fields, and in particular, the search for treatments for cancer and developing new antibiotics as bacteria develop more and more resistance to the ones we already have. Organic chemistry plays an essential role in developing greener solutions to industrial products and processes. For example, innovations in organic chemistry will be important in the face of declining oil supplies, and moreover, oil is the main feedstock of organic molecules .

While you can appreciate the vast and innumerable applications of chemistry and how everything is chemistry (similarly to how a philosopher would say all things are philosophy or how an economist might say that all things can be understood as economics), you have to learn to appreciate and validate the study of chemistry for its own sake, for its internal logic and beauty. Otherwise, it really is the dense and indecipherable forest of memorization that gives students nightmares and cold sweats. For someone not planning on continuing much further on, it has been a rewarding way of learning to think—challenging my conception of scale and reason. Practicing this sort of art or discipline has opened up a new worldview, when I might otherwise only be reading postmodern literary theory or writing papers on Renaissance poetry, not to mention that chemistry does give you moments of philosophy too. Last year, studying for my orgo final, I came across this passage regarding the formulation of mechanisms (schematics of how electrons move and molecules react) in our beloved 'Loudon' textbook:

" The mechanism of the reaction is modified or refined if required by subsequent experiments. ….[this] may seem disturbing because it means that a mechanism can be changed at a later time. Perhaps it seems that an "absolutely true" mechanism should exist for every reaction. However, a mechanism can never be proved; it can only be disproved. The value of a mechanism lies not in its absolute truth but rather in its validity as a conceptual framework, or theory, that generalizes the results of many experiments and predicts the outcome of others…. The evolution of mechanisms is no different from the evolution of science in general.

Knowledge is dynamic…."

I cannot say that I found the idea of science as open to revision to be "disturbing." Actually, I found it quite inspiring. Many people place science entirely in opposition to creative endeavors such as art or literature, seeing it as purely practical and empirical, solid and straightforward. And yet, I often find that the sciences, chemistry in particular, are the fields that are most readily open to self-revision, most aware of the impossibility of "absolute truth. " Organic chemistry is not just a science, but also an art of logic and experimentation. Within the rules and regulations that govern the chemical world, there is a lot of creativity, beauty and possibility. As someone who hopes to continue both as a humanist and a scientist, I am encouraged when I stumble upon evidence that the sciences and the humanities are often made of similar stuff. Through organic chemistry, I have learned to appreciate the challenge in the unfamiliar, and have learned that no matter what you do, your most important intellectual tools are creativity and rigor.

miRNAs and Spontaneity

Luke Gruenert

Back in November, my dad and I were eating lunch at this quaint Vietnamese restaurant just across the street from the lab. At this point I had been working in his lab for over a year. We were discussing the experiments I had been working on; I was trying to solve an issue with a Sickle Cell correction project.

In order to fully understand the problem with the project, it may be useful to understand the project itself. DNA is made up of four nucleotides, Adenine (A), Thymine (T), Cytosine (C), and Guanine (G). Mutations are essentially a disruption of the proper sequence of these nucleotides (i.e. when certain nucleotides replace others). Sickle Cell Anemia is what is known as an A>T transversion in the hemoglobin-beta gene in your blood. This means that a single Adenine is mutated into a Thymine, causing the hemoglobin-beta protein to be misfolded in such a way that it actually becomes hydrophilic, or "afraid" of water. So, rather than dissolving into the cytoplasm of the cell as it should, it precipitates under low-oxygen conditions. This causes the red blood cells to become rigid and sickled in morphology, leading to all sorts of issues.

So, the project I was working on consisted of turning that mutated "T" back into an "A" in sickle-patient derived Induced Pluripotent Stem Cells (iPSCs). For the correction, we used a gene editing technique my dad developed in the 1990s known as Small Fragment Homologous Replacement (SFHR). We essentially took the DNA from a healthy person, amplified a small section of it surrounding the Sickle Cell mutation a trillion times, and used this piece to replace the mutated DNA in the cells from the Sickle patient.

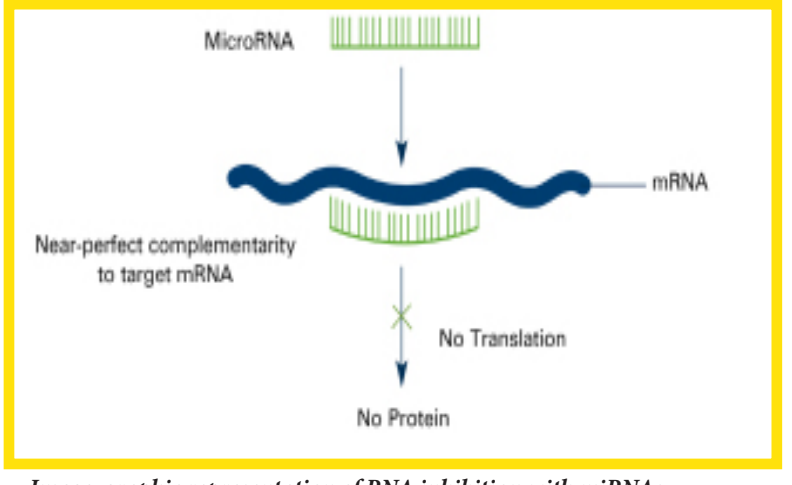


Image: graphic representation of RNA inhibition with miRNAs

Cells undergo something known as Homology-Directed Repair (HDR; formerly known as "Homologous Recombination") in order to correct breaks and mutations in their DNA. By introducing a DNA fragment with the corrected sequence, the idea is that the cells will recognize the correct sequence and swap out the mutated Sickle Cell Sequence with the corrected sequence using HDR.

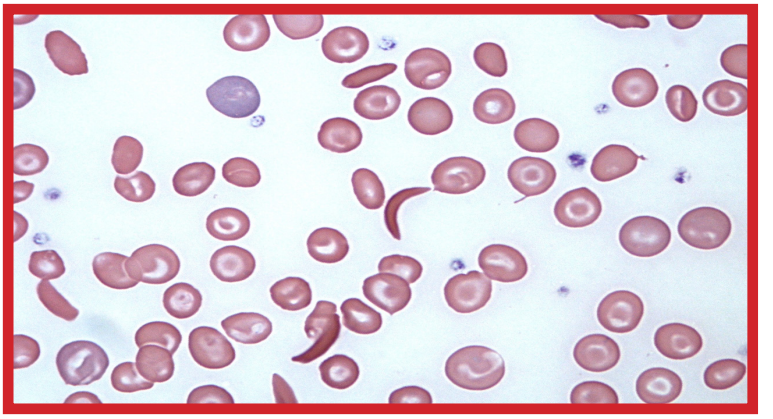


Image: sickled red blood cells amidst regular blood cells

The problem in the experiment lies around our ability to isolate the corrected cells from the uncorrected ones that are still mutated so as to grow up a pure population of only corrected cells in order for the treatment to be therapeutically viable. To help the cells facilitate this correction, an enzyme is also introduced that we designed to induce a break in the DNA near the mutation, making other repair enzymes in the cells notice and repair the break via HDR. This dramatically ups the correction frequency (by roughly 1000 times), but even with the higher frequency we still have to sort the corrected cells from the uncorrected ones. So the problem remains: how do we possibly differentiate the corrected cells from the uncorrected ones?

There is one method that exists that allows us to differentiate between corrected and uncorrected cells. This method is known as drug selection, and involves the introduction of specific sequences into the cell's DNA that make the cells resistant to deadly drugs. Because the drug-resistant sequence is added alongside the sequence correcting the mutation, the method is not what we call "footprint-free." Upon being corrected, the cells will actually incorporate the foreign DNA from the drug-resistant gene into their DNA, thus rendering the cells no

longer therapeutically viable—these cells will behave differently than the other cells in the patient's body due to the presence of this foreign DNA. Most notably, they could evoke an immune response upon being put back into the patient's body, something that we are trying to avoid. We could, theoretically, cut out the foreign sequence with an enzyme and leave just the corrected sequence in the cells, though that often leads to more mutations in the cell's DNA rendering the treatment nonviable.

So, the question remained: what method can we come up with that remains footprint-free but also allows us to differentiate between corrected and uncorrected cells? First, we needed to figure out a way to selectively kill any uncorrected cell. Well, kill genes kill cells… so what if we could put a kill gene into all of the uncorrected cells? Hmm that would work, but how could we possibly differentiate between the uncorrected and corrected cells and express the kill gene in only the uncorrected cells? And then it hit us: the answer lied within the power of noncoding RNA.

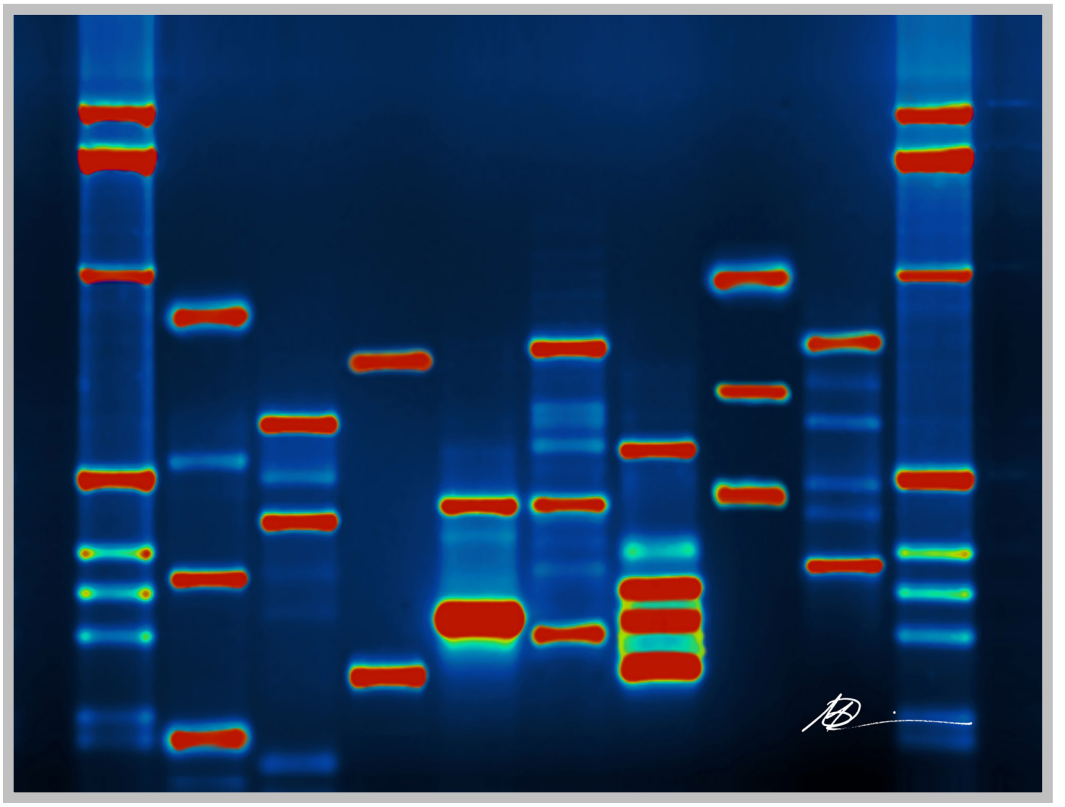


Image: a southern blot of electrophoresis -seperated human DNA

Our new method was simple: introduce what's known as an episomal plasmid (something that allows us to express any gene of our liking in a cell without leaving any foreign DNA permanently in the cell) containing a kill gene on it that could be inhibited by the presence of a micro RNA (miRNA--NOT to be confused with mRNA which denotes the messenger RNA that codes for a protein).

miRNAs are brilliant little things. They essentially work on the mRNA of a protein, binding to the mRNA and preventing it from being read and turned into a protein. So, the idea is that the plasmid codes for the messenger RNA (mRNA) for a kill gene, but if the corresponding miRNA is present, the translation of the kill gene protein will be prevented (miRNAs have shown to reduce protein production by up to 98%).

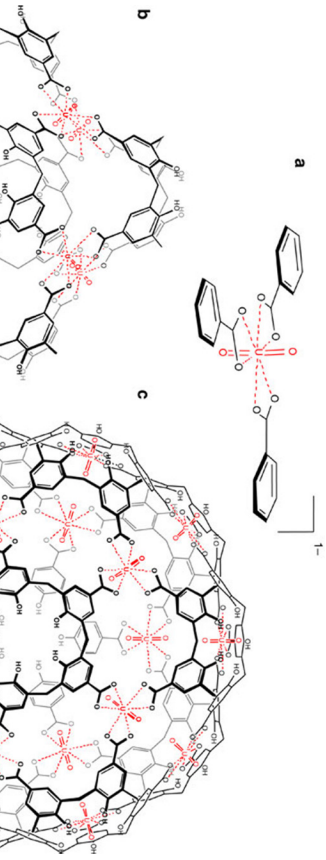
Our idea was that we would change the sequence of the correction fragment and tack a manually-designed, artificial miRNA sequence onto the end of it. This miRNA would have a complementary sequence to a section of the messenger RNA for the kill gene. The plan was to put the artificial miRNA sequence in the area of the fragment that corresponds with an intron (the portion of the gene that doesn't code for a protein), so that the foreign sequence would not actually have any bearing on the production of proteins. Also, the sequence of the miRNA would be unique to this fragment/mRNA pair, so it would not affect any other DNA sequence in the cell. Thus, any cell producing this specific miRNA would not die in the presence of the kill gene, as the miRNA would prevent expression of the gene. That said, however, any cell not producing the miRNA would die in the presence of the kill gene. So, after adding the correction fragment, we would treat with the kill gene a week later to kill off any uncorrected cells.

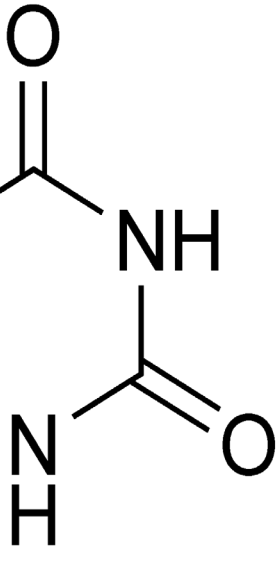
Now, this method was all fine and good as it was applied--it would allow us to speed up the process of isolating a corrected clone. But we soon realized it actually had many broader implications. If, for example, we could actually activate the kill gene in the presence of certain noncoding RNAs, we could potentially create very novel therapies. Any disease that is caused by the mutation of a noncoding RNA that leads to the upregulation of responsible genes (e.g. cancer) could be treated in this way.

So, naturally, we got very excited, ran back up to the lab (yes, we were still eating lunch), and formalized the idea into a project proposal that we have now submitted for funding. It's funny how science works—how one conversation can lead to a project proposal; how one lunch can lead to the next five years of your professional life being planned out. Spontaneity is a beautiful thing.

Genetic Discovery Improves Therapy Effectiveness

Carly Oddleifson





Recently, researchers for the Psychiatric Genomics Consortium discovered overlap in the genetic factors for several human psychological diseases. They analyzed many different research articles to identify strong links between genes and behavior. In other words, looking at a large number of individuals' records, they have found that schizophrenia, bipolar disorder, and major depressive disorder share genetic risk factors. The implication for improvements in therapy and psychiatric medicine is enormous.

Let me give an introduction to genes. During a process called meiosis, alleles, which are one of two or more alternative forms of a gene and are found at the same place on a chromosome, are rearranged. Each of us inherit an allele, one from our genetic mother and father. While alleles confer characteristics such as eye color or hair color, there are also other more subtle variations called single nucleotide polymorphisms (SNPs). SNPs are variations in a single base pair in a DNA sequence, the building blocks of genes.

Effective therapy arises from understanding the origin of a particular disorder. But we know that disorders often arise from both genetic and environmental input. Despite this research and previous knowledge, relatively little is known about the causes of certain psychiatric disorders.This 2013 study of SNPs, published in *Nature Genetics*, revealed considerable overlap of genetic risk factors among 5 diagnostic groups.

In an article published in the journal *Neuron* in 2010 describing genome-wide association studies, Patrick Sullivan, a member of Department of Genetics at the University of North Carolina wrote that "genetic risk factors are at the beginning of the causal chain that leads to disease." Sullivan goes on to say that"the synergy between genetics and biology will pave the path to true understanding of how genotype confers risk for phenotype and gives us the best chance of really understanding these disorders and paving the way for more effective therapies." To successfully treat individuals, psychologists and psychiatrists must have an understanding of potential genetic causes.

If schizophrenia, bipolar disorder, and major depressive disorder arise from similar combinations of many genes, maybe they require similar treatment. This research promises better therapy for psychiatric illness.

The number of people who stand to benefit from this research is considerable. According to the National Institute of Mental Health, bipolar disorder affects approximately 5.7 million American adults each year.

Discovering New Therapeutic Uses

Nate Bohm-Levine

Science has a history of serendipitous discovery. This is especially true in the history of drug development, where there are several examples of common medications that currently treat diseases or conditions that differ from the originally intended ones.

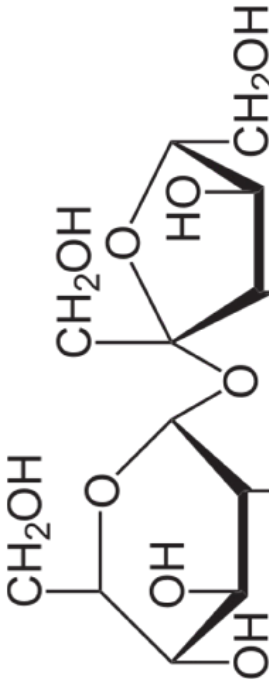
Lithium salts, now widely used to treat bipolar disorder, were originally utilized to treat the inflammatory disease gout. Furthermore, it was not until human trials that Viagra was found to be a terrible medication for hypertension and ischemic heart disease—but an incredible one for men with erectile dysfunction. While we have made remarkable progress in understanding human biology, our bodies are remarkably complex systems, and our predictions of a drug's effect miss the mark more often than not.

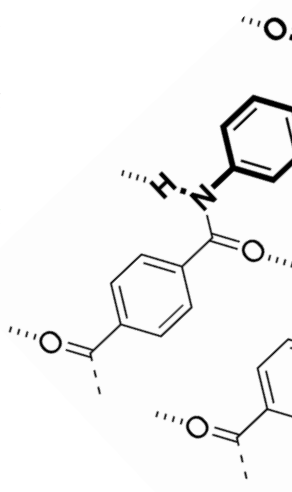
The National Institutes of Health's National Center for Advancing Translational Science (NCATS) has recognized this unpredictability. In May 2012, NCATS began the New Therapeutic Uses program, which creates partnerships between pharmaceutical companies and biomedical research labs to allow for faster drug development . With the aid of drug companies, the program has put together a library of not-fully-developed but relatively clinically safe drugs to save resources and speed up the development of therapeutic options for those in need.

The New Therapeutic Uses program has already seen promising results. In 2012, the pharmaceutical company AstraZeneca had spent several years developing the anti-tumor drug AZD05030, and began testing the drug on a larger group of human participants. Unfortunately, the drug failed at its principal goal decreasing tumor size—and it seemed as though all the time and effort put into development had been wasted. Recently, however, the New Therapeutic Uses program funded a lab from Yale University who was looking for potential drugs to treat Alzheimer's disease. In March, these researchers reported in Annals of Neurology that AZD05030, while in all respects a terrible cancer drug, happened to decrease the formation of amyloid beta plaques, a toxic protein buildup implicated in many of the symptoms associated with Alzheimer's disease. Their discovery in mouse brains plus all the safety data from AstraZeneca on AZD05030 led to the quick development of large-scale clinical trials on humans.

With these types of discoveries, this program has the potential to redefine drug development—currently a highly costly and time-consuming process. The average drug takes 14 years to develop and costs $2 billion in research and development. 95 percent of drugs fail to work as expected, wasting millions of dollars, and leaving many partially developed drugs, with potential therapeutic effects, sitting untouched.

With programs like New Therapeutic Uses, scientists will hopefully make some order out of the disorder that is the drug development industry. This might open the door for researchers to look towards "failed" drugs to find new, potentially life-changing clinical applications.





Contamination and Hatchability of the California Clapper Rail: A Review

Elisa C. Henderson

The California clapper rail (Rallus longirostris obsoletus) is a bird that is obligate to the salt marsh habitat of Northern California (Schwarzbach et al. 2006). The clapper rail diet consists of aquatic invertebrates and fish living in salt marsh wetlands (Casazza et al. 2014). The species is listed as endangered by the U.S. Fish and Wildlife Service (2015), and its range has been reduced to exclusively San Francisco Bay (Ackerman et al. 2011). Reasons for the declining populations include habitat loss, water contamination, and predation by invasive species (Ackerman et al. 2011, Foin et al. 1997, Lonzarich et al. 1992, Schwarzbach et al. 2006). Wetlands are extremely biodiverse and productive habitats and the functioning of these ecosystems is important for the maintenance of many fish and bird species (Davis et al. 2012, Eagles-Smith and Ackerman 2014). Efforts to restore the wetlands of San Francisco Bay and conserve the resident endangered species have been prominent in recent years (Ackerman et al. 2011, Foin et al. 1997, Harding et al. 2001, Marcus 2000). Is there a strategy that will affectively and reliably conserve this species along with its salt marsh habitat? In this paper I will review the research done on contamination of the salt marsh habitat and how this issue affects hatchability and reproductive success of the California clapper rail. I will address helpfulness of relevant research to the progress of conserving this species and its salt marsh habitat.

California clapper rail population size has decreased dramatically over the past century. Clapper rails are known to have existed historically throughout the California coast with numbers ranging in the tens of thousands, but by 1997, population size was estimated to be as low as 1,200 individuals restricted to the San Francisco Bay Area (Foin et al. 1995). A recent study has estimated population size at 1,040 to 1,264 (Schwarzbach 2006), similar to those estimated in 1997. Estimated hatchability (percentage of eggs incubated to term that hatch) of California clapper rails was 18.7% and 37.6% in 1980 and 1989 respectively. This contrasts dramatically with the proposed potential hatchability of California clapper rails, based on other closely related species, ranging from 87.3% to 92.3% (Schwarzbach et al. 2006). Research suggests that a major reduction in habitat has greatly contributed to the endangerment of the California clapper rail (Ackerman et al. 2011, Foin et al. 1997, Marcus 2000). In addition to habitat loss, contamination has become a problem for the success of populations. The San Francisco Bay Area salt marsh habitat has many harmful contaminants that originate from urban and industrial actions and developments (Davis et al. 2012, Lonzarich et al. 1992); historical organochlorine contamination from pesticides between 1950 and 1975 has caused the presence of polychlorinated biphenyls (PCBs) and mercury in the local salt marshes (Schwarzbach et al. 2001). The area is conducive of converting mercury into the highly toxic organic compound methylmercury, which in turn resides in the foraging grounds of California clapper rails (Casazza et al. 2014). The extensive use of chlorinated hydrocarbons from 1950 to 1975 led to high levels of contamination in the water that threatened the survival of piscivorous water bird species (Venkatesan et al. 1998). Studies assessing toxic chemical effects on avian eggs show a strong correlation between contaminants in avian habitats and reduced reproductive success. Contaminants found in the clapper rail habitat such as organochlorines, mercury, and PCBs, can decrease hatchability, and thus reproductive success, of the species (Casazza et al. 2014, Schwarzbach et al. 2006).

Photo by Max Max

Source of Contamination

There is strong evidence that industrialization has negatively affected the habitat quality of the San Francisco Bay Area salt marshes. According to Pyle et al. (1999), contamination by organochlorines is a result of agricultural runoff, dredge spills, and pollutants from a radioactive waste site near the Farallon Islands, causing high levels of PCBs and dichlorodiphenyltrichloroethane (DDT) in local fish. Sediments in the San Francisco Bay area may also be polluted with mercury as a result of historic gold mining (Casazza et al. 2014, Ackerman et al. 2011). In an attempt to assess the potential toxicity of contaminants to California clapper rail populations, Lonzarich et al. (1992) collected clapper rail eggs from four sites north of San Francisco and measured selenium, mercury, and organochlorine egg concentrations. They found the highest

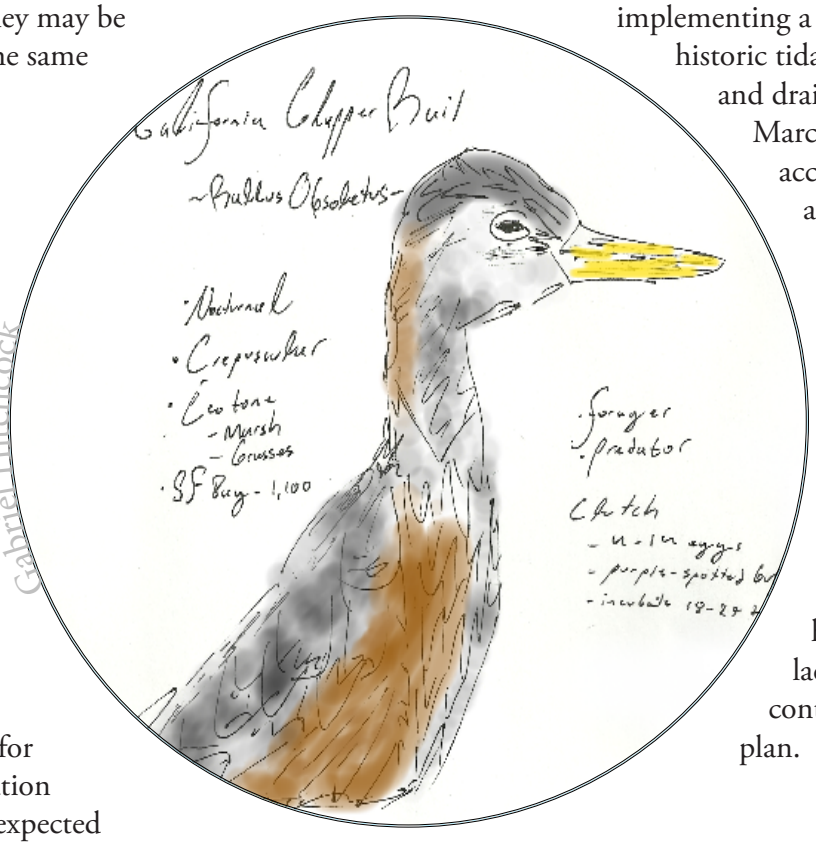
PCB concentrations in the Bay Area at Arrowhead Marsh, where high PBC concentrations have been found in the sediment. They also found high selenium concentrations close to the Chevron Richmond Oil Refinery and they suggest that oil refineries have a big impact on selenium pollution in the San Francisco Bay. Lonzarich et al. (1992) concluded that clapper rail populations are extremely vulnerable to pollutants in San Francisco Bay, specifically mercury and selenium. They suggest more research should be done regarding how harmful these pollutants are to the hatchability of clapper rails. This study provides early insight to the affects that water contamination has on clapper rails.

Risk of Contamination

Recent studies have provided evidence that high concentrations of contaminants in water and prey result in high concentrations in blood, eggs, and eggshells. Between 1989 and 1991, Hothem et al. (1995) collected night-heron and great egret eggs from five major sites in the San Francisco Bay and measured organochlorine, PCB, mercury, and selenium concentrations in eggs. They found that PCB levels were much higher in San Francisco Bay than in other California coastal regions and proposed that this is due to the highly urbanized environment. Schwarzbach et al. (2001) measured organochlorine and PCB levels in clapper rail eggs from four sites in South San Francisco Bay and compared these levels to those found by Goodbred et al. (1996) from light-footed clapper rails in Southern California. They found that PCB levels in eggs were much higher in California clapper rails of San Francisco Bay than those found in light-footed clapper rails of Southern California, suggesting that higher levels of water contamination cause higher levels of toxins in eggs of clapper rails. Mora et al (2011) collected eggshells from 20 avian species from various locations in California, Texas, Idaho, Kansas, and Michigan between 1985 and 2007. They measured chemical concentrations in the egg shells and found a strong correlation between concentration in egg shells and concentration in water for species that feed primarily on aquatic invertebrates. Prior to breeding seasons of 2009 and 2010, Casazza et al. (2014) collected aquatic invertebrate and fish taxa from four tidal marshes in South San Francisco Bay. They analyzed each of the 233 prey samples for mercury content and found that spatial patterns in mercury content matched the patterns of mercury content in blood samples of clapper rails observed by Ackerman et al. (2012). These studies provide important evidence that high water contamination is likely to cause high levels of contamination prey and in eggs of clapper rails.

With information that water contamination likely causes high contaminant concentrations in clapper rails, studies sought out to determine how this correlation affects body condition and reproductive success. Evidence that contaminants cause threats to other species of water birds has been found. Hothem et al. (1995) compared findings with those from Fox et al. (1993) and concluded that PCB concentrations in night-heron and great egret eggs were at levels that are thought to cause slow development and deformities in the embryonic stage. Because fish-eating birds that overlap ranges share similar diets, studies such as these may help us estimate harmful levels of contamination for the California clapper rail. This information can help us conclude that levels of mercury and other contaminants in fish in the San Francisco Bay Area may be the cause reproductive impairments in piscivorous bird species (Casazza et al. 2014, Eagles-Smith and Ackerman 2014, Lonzarich et al. 1992). After recognizing very low fecundity in California clapper rails in North and South San Francisco Bay, Schwarzbach et al. (2006) assessed embryo development of clapper rail eggs in nests at six intertidal salt marsh sites throughout the San Francisco Bay. They measured mercury and organochlorine content of assessed eggs that failed to hatch and found contamination to be negatively correlated with reproductive success of rails as exhibited by deformities, hatchability, clutch size, and embryo malposition. Schwarzbach et al. (2006) concluded that the proportion of young to fledge a nest is likely much less than 2.4 on average, primarily due to mercury contamination. They recognized that they may have obtained biased data by only collecting fail-to-hatch eggs, but they nevertheless suggest that water quality be of great importance when considering ways to increase reproductive success of clapper rails. Though they only collected eggs from abandoned nests, their findings of correlations between contaminant levels and body condition are important to recognize and useful for determining causes of reduced fitness. Between 2006 and 2010, Ackerman et al. (2012) collected adult clapper rails from four tidal marsh sites in the San Francisco Bay. They measured morphological characteristics of each individual and took blood samples from a subset of the birds. They also collected eggs from abandoned nests and measured mercury levels in blood, feathers, and eggs. They found that body mass of the California clapper rail is negatively correlated with high levels of feather and blood mercury and that levels of mercury in eggs found in 2007-2010 were similar to those found by Lonzarich et al (1992) in 1986-1987. This study is useful for determining a correlation with body condition and contamination and comparing

egg concentrations, but collecting eggs from abandoned nests may again cause slightly biased data. Reduced shell thickness may be another result of water contamination and may also contribute to population decline. In 1993, Pyle et al. (1999) collected eggs from several seabird species in two sites in central California. They measured shell thickness and organochlorine concentration. They found a correlation between concentration of organochlorines and shell thickness in eggs of seabirds and they noted that reproductive success has been found to be affected by eggshell thickness. This information can help us predict further problems for reproductive success in California clapper rails, as they may be affected in similar ways by the same contaminants.



Gabriel Hitchcock

Many studies have concluded that contamination in clapper rail habitat causes negative effects on hatching success, body condition, and overall fitness of individuals. However, little information has been concluded concerning the effect that contamination has on population size. Predicting future population decline that will result from water contamination is important for gaining support for conservation efforts. If we can model the expected rate of population decline of the California clapper rail, we may be able to explicitly show the outcome of contamination, in the theoretical case of no intervention. To determine how to increase population growth and decrease risk to eggs of California clapper rails, it is important to enhance our understanding of the population dynamics of California clapper rails and the role that contamination plays. I suggest more research should be done to predict the rate of population decline as a result of water contamination. There is likely already enough evidence to create a model that will allow us to predict not only how contamination affects individual fitness and nest success, but population outcome as a whole.

Based on the findings of studies reviewed in this article, efforts have been made to conserve the salt marsh habitat of San Francisco Bay Area, focused on increasing reproductive success of California clapper rails. Foin et al. (1997) summarize the effects of human actions on clapper rail populations and habitats and conclude that intense marsh restoration should be initiated. They outline strategies for clapper rail conservation involving expansion, restoration, and preservation of available habitat for clapper rails. However, they do not consider a resolution to water contamination. Marcus (2000) describes how human industrialization has reduced marsh habitat and outlines a concept plan for the restoration of marshlands in San Francisco Bay, California. The project was implemented in March, 2000 and consisted of designing and implementing a tidal marsh in the site of a historic tidal wetland that was diked and drained in 1900. However, Marcus (2000) did not take into account water contamination and did not implement a preventative strategy for contamination in the restored tidal wetland habitat. The fact that clapper rail hatching success remains very low may show that there has been less positive response in the environment than was hoped, possibly due the lack of consideration of water contamination in the recovery plan.

A New Approach

We have encountered and explored a problem that we desire to solve, but perhaps we are taking the wrong approach. Though more research should be done to determine the outcome of population decline, evidence strongly suggests that reproductive success of clapper rails is impaired as a result of water contamination in the San Francisco Bay. Efforts have been made to improve the quality of the salt marsh habitat, but water contamination remains a problem. Evidence shows that there is little use in trying to reduce mercury and contamination levels in the water in SF bay; regulations have been implemented, but with limited success (Davis et al. 2012). Overall, more research should be done to determine the best approach to improve clapper rail hatchability and minimize effects of water contamination.

Your Treatment on Trial

Kevin Ng

How do you know whether a medical treatment works or not? Well, there are a number of ways you could find out. You could try it out for yourself and see if you get better afterward, or you could see how a friend fares after your friend gives it a try. Unfortunately, there isn't a way to tell the difference between improvement due to the actual treatment, improvement due to the placebo effect, improvement due to the natural course of your symptoms, etc. It all feels the same to the person experiencing the improvement in condition. Another way you could find out is ask your physician. Unfortunately, physicians cannot distinguish between the different causes of improvement either; patient improvement is patient improvement, to the watchful doctor. Also, a doctor might prefer treatment A over treatment B, not because of superior evidence, but maybe because of tradition (think of bloodletting), or because the doctor's team of colleagues all have had good experiences with treatment A, or because the doctor is selectively remembering the times treatment A worked and unknowingly forgetting the patients for whom it didn't.

Small samples of patients, unconscious cognitive biases, inability to distinguish between different causes, etc. all get in the way of evaluating the true effectiveness and safety of a treatment. So now what? We all have only our own experiences to go off of; we can't go back in time, switch our treatment for a placebo at the last minute, and see if we get the same result. Without any comparison of experiences, there is no way to consider alternative explanations for an effect. Well, instead of looking at an individual experience with the treatment, we can collect a whole bunch of experiences; we can look at those bunches of experiences in the context of each other. When we randomly assign people to get different treatment experiences, we have a trial. In medicine, a trial compares a treatment against another treatment, or a placebo, or a wait-list control.

Why randomly assign? If researchers were allowed to pick who went in what group, they could, either consciously or unconsciously, assign people to the groups such that one group is different from the other in a way that biases the trial. If all the young, healthy people with fewer medical problems were in the treatment group, and all the old people who smoke and have multiple medical issues were in the control group, then you can make the treatment look really good since the people in the treatment group would be more likely to improve anyway. But suppose

people who exercise a lot are just as likely to get into the treatment group as the control group. Same for people who don't exercise. Moreover, people who recently started a fad diet are just as likely to get into the treatment group as the control group. Same for people who did not recently start a fad diet. The rate at which people get better on their own would also be about the same for both. Headaches come and they go, back pain feels like the worst thing in the world at some points in time and not so bad at others, and the severity of your stuffy nose isn't the same 24/7 throughout your week of cold. These fluctuations happen even if you don't do anything. The factors that affect the ebb and flow of your illness would be randomly distributed. The point is, random assignment assures that the groups are roughly the same in composition, dispersing the factors we don't want to influence the results, and isolating what we care about: the effects of being given the treatment.

A lot of the time, the control group is a placebo group. Basically, a placebo is a supposedly inert form of the treatment, and the placebo effect refers to therapeutic improvement brought about by one's beliefs and expectations. A lot of studies have been done on the placebo effect. It seems that there's a dose response; taking four sugar pills, with no active ingredient, is a more effective treatment for pain relief than taking two sugar pills. Likewise, a salt water injection brings about more relief than sugar pills. Sham surgery, sham acupuncture, and other sorts of "pretend" treatments have been shown to elicit a therapeutic response. Of course, these are average effects; the exact response will vary based on the particular patient's expectations.

Ideally, the trial is double-blinded, meaning neither the patients nor the physicians know who is in what group. This is to prevent biasing that would influence the outcome. If a patient knows he or she is in the placebo group, the patient will think, "Hey, I'm in the placebo group. This is a joke; I'm not getting anything – I'm not going to get better." If the patients in the treatment group know so, they'll think, "Wow, I'm getting the real deal here. I'm totally going to get better." Obviously, this would affect their expectations, enhancing the placebo component of the actual treatment response and downgrading the placebo group's placebo responses. And the doctors? If the doctor knows who is in what group, these expectations can change the doctor's conduct and tone of voice toward the patients in the different groups, unconsciously breaking the blinding. This means it might be unintentionally communicated to the placebo people that they are in the placebo group and to the treatment people that they are in the treatment group. Another effect of this knowledge is interpretation. Suppose you think that women draw better circles than men, and you run an experiment to find out by recruiting a bunch of men and women. Each person writes his or her name at the top of a sheet of paper and then draws a circle. You collect the stack of papers and judge the roundness of the circles on each sheet. Now, judging the roundness of a circle, like observing clinical features in a physical examination, is not a black-and-white endeavor. There is ambiguity, and subjective judgment calls must be made. The more subjectivity is involved, the more room there is for those unconscious biases to creep into your decision-making process. If you notice the name at the top of the paper looks female-typical, you might be more likely to rate the circle as being rounder than not; if the name looks male-typical, you might rate the circle as being less than perfect. All in all, your judgment calls would have been skewed by your knowledge and prior beliefs. It would have been better to conceal the names beforehand. You can imagine how knowing who is getting the placebo and who is not would play out on a doctor's expectations, and in turn the doctor's impression of who is getting better and who is not.

Once all is said and done, you look to see if more people in the treatment group got better than the control group, or if they got better faster, or if their side effects were not as bad, or if fewer people died, etc. Random assignment, the placebo effect, and double-blinding are essentially three uber important qualities of a well-done Randomized Clinical Trial, or RCT. There are other aspects that are important for how a RCT is conducted and analyzed, such as representativeness of patients, sample size, surrogate outcomes, taking account of dropouts, external validity, primary vs. secondary outcomes, etc. However, the basic skeleton of a quality RCT comprises these three elements. When one or more of these are missing, it detracts from the reliability of the RCT as a source of evidence for the efficacy of the treatment. And when you gather a bunch of RCTs in a systematic review to look at the big picture, those detractions add up and can make the review less than ideal. After all, junk in means junk out; synthesizing a bunch of flawed studies does not reduce the flaws.

What's not to like about RCTs? Well, RCTs cannot tell you anything about the mechanism of action. Maybe the treatment works by speeding up the work of particular enzymes; maybe the individualized nature of the treatment is part of the mechanism of its effectiveness; maybe it works through some yet to be discovered process or substance. When the first RCT was done on scurvy in ships on the sea, it was found that lemons did a really good

job at reducing scurvy related death. At the time, nobody knew about the existence of Vitamin C, or how Vitamin C deficiency caused scurvy, yet the results of the trial were astonishing. The treatment worked; sailors eating lemons fully recovered, compared to the sailors drinking vinegar or doing nothing, who were still suffering. The details about how it worked could be worked out later.

Of course, it helps to be able to conceive of a mechanism since it means there's plausibility. In fact, if a treatment's implied way of working violated the Second Law of Thermodynamics, the plausibility of the treatment would be so low that spending the resources to do an RCT and using up patients' time would be inappropriate. Even if a positive relationship were found, it should be met with skepticism since it would likely be a false positive, or chance occurrence resulting from random noise in the data. There is a reason why scientists are not taking the time to test the hypothesis that giving buttered toast to kittens gives them telekinetic powers, or if holding an anvil over your head as you jump out of a plane will reduce your likelihood of dying.

Other criticisms of RCTs have to do with medicine itself. Some think that group statistics do not apply to individuals, or that relying on RCTs instead of clinical experience will result in treating patients uniformly and coldly as numbers. The former is a misunderstanding; the unique characteristics that make each of us an individual do not necessarily undermine the effectiveness of an intervention. Those unique variables might be irrelevant to the underlying mechanism of the treatment. In other words, the unique attributes of each individual may not interact with the intervention, or they may be overcome by its main effects. Age, sex, ethnicity, other medical conditions, etc. may or may not affect the effectiveness or safety of the treatment. We would have to have done the RCTs to begin with and notice variation among subgroups, suggesting further research in particular groups of people. Here's an example: each person with melanoma is a unique individual – they vary in age, sex, hair color, diet, lifestyles, and who knows what else. But this doesn't change the fact that 90% or more of cases of this form of skin cancer are mostly curable with early surgery.

The second criticism is not so much of a problem if we put RCTs in context. RCTs play a role in clinical-decision making, and so do clinical judgment and patient values and preferences. They answer questions like "Is drug A better than drug B at reducing the risk of death from heart disease?" or "How does eating tofu affect your probability of recovering from stroke?" When we want to find out whether a treatment works or not, RCTs make up for the flaws of clinical judgment. Physicians are never blinded; they, like the rest of us humans, can exhibit cognitive errors that skew how they think; they might rely on what they learned decades ago; they might just be "going with the flow" by doing what's popular; they might be convinced by a pharmaceutical representative's spiel. They extrapolate from the results of previous clinical cases in order to figure out what to do with the next patient. The difference between that and the RCT database is that the research literature comprises a much larger sample of asthma patients, cancer patients, depression patients, etc. than what any particular clinician encounters in his or her clinical career.

Yet, clinical experience is valuable. In skill-based technical procedures, like surgery, experience is what fine tunes your abilities. Less tangibly, there are still many, many questions for which there has yet to be quality research done. Clinical expertise tells a doctor what to do in the absence of evidence, and this is where the art of medicine comes in. If a patient would forgo a more effective treatment in order to get fewer side effects, the doctor takes that into account. If a patient would prefer a treatment with more side effects if it's more effective, the doctor takes that into account. If a patient would prefer doing nothing, and seeing how he or she turns out, the doctor takes that into account. If the patient's cultural background limits what options are available, the doctor takes that into account. RCTs cannot tell the doctor what the patient ultimately wants – only the physician-patient relationship can. If RCTs are used as the final arbiter of clinical decisions, without listening to the patient, then this is cookbook medicine – it treats patients as numbers on a paper and not as suffering human beings who would like some care.

RCTs are not done for that purpose; they are a valuable source of evidence that plays a part in the clinical decision-making process. Efficacy and safety data do not, and cannot, replace a strong physician-patient relationship. The data can only inform, and RCT data should be put in the context of the other data – basic science lab studies, observational studies, case reports, etc. Each source of evidence has its pros and cons, and looking at any single category of evidence without context is useless. The whole body of evidence is what matters. RCTs are not perfect, but they are awesome enough; let's not overdo it and push them to do what they were not designed to do.

Sex Inequity and Medicine Side Effects

Sarah Page

Women are more likely to suffer from medicine side effects than men.[1] Moreover, there is a growing body of scientific evidence that many medicines are metabolized differently by men and women. Despite this, medical research groups still do not disclose how each sex is affected differently by medicine side effects. The practice of not publishing the sex specificity of medicine side effects must change to ensure women's health. I depend on this change; as a woman, a feminist, and a scientist, my personal stake in sex equity and my knowledge of the current inequity in medical research drives me to write this piece. I encourage all women to be knowledgeable about the side effects of the medicines they take. I also encourage women and allies to pressure the decision-making bodies of medical research to publish the sex specificity of medicine side effects.

By saying that medical researchers should publish the sex specificity of medicine side effects, I mean that the respective percentages of men and women who experience medicine side effects should be openly disclosed and addressed. Transparency includes publishing this data in scientific articles and in side effect pamphlets that are given out in conjunction with medicines or printed on medicine bottle labels. Providing this information to women is necessary for them to make informed decisions about their health. Decision-making bodies such as the National Institutes of Health (NIH) and its Office of Research on Women's Health (ORWH) can make this change happen.

The NIH is a major funding body of medical research in the United States. Because it is responsible for funding, it has weight in determining policy; people who do not obey the NIH will not have the funding to complete their research. The ORWH is an office within the NIH that advises the NIH director and the NIH general body about women's issues. It is almost entirely composed of women, so its members have first-hand knowledge of the gender disparities within the scientific community. The ORWH has successfully passed a mandate that clinical trials funded by the NIH must include women, and it has strongly encouraged people conducting animal trials to include female animals. The NIH, with pressure from the ORWH, has been and will continue to be a major force for correcting sex inequity in medical research.

The problems from not disclosing the sex specificity of medicine side effects are not just theoretical; many problems have already occurred. A 2001 study by the Government Accountability Office, an agency that investigates federal spending, found that 8 out of the 10 medicines withdrawn from the market in recent years posed greater health risks for women than for men. Similarly, a 2014 study found that daily low-dose Aspirin, taken to prevent heart attacks, poses a unique risk to women. Daily low-dose Aspirin has a common side effect of internal bleeding for women, which is extremely damaging and outweighs the benefit of heart attack prevention.

Furthemore, problems with the sleep-aid Ambien caused a critical and ground-breaking change in how the medical industry addressed medicine side effects. Women were getting into car crashes because they were unknowingly taking doses of Ambien that were too high for them (the doses were generally correct and safe for men). Lindsey Schweigert, a 31-year old defense contractor, nearly lost her life from sleep-driving while on Ambien. She took the recommended dose of Ambien as she went to bed, but

[1]For the purposes of this essay, the terms male/man and female/woman will refer to biologically male and biologically female sex, respectively.

she woke up in a police car instead of her bed. She had been in a car accident and was charged with a DUI. Out of pure luck, nobody was seriously injured from the accident. Lindsey's case is one of many equally disturbing cases that could have been prevented if the women who consumed of Ambien knew their heightened risk of side effects (and how to protect themselves, such as locking or hiding their car keys).

The effect of Ambien on driving, especially Ambien's effect on women, was only studied after many reports of car crashes where the driver had taken Ambien. The study revealed that women who took the recommended dose of Ambien late at night performed poorly on a driving simulation task early in the next morning, due to drowsiness. In response to this finding, the Food and Drug Administration (FDA) made an unprecedented move and created separate recommended doses for men and women. The situation with Ambien was a wake up call showing that women's lives depend on transparency about the sex specificity of medicine side effects. To achieve transparency, the NIH needs to mandate that medical researchers publish the sex specificity of medicine side effects. The ORWH and similar groups can pressure the NIH to make such a mandate.

"The situation with Ambien was a wake up call showing that women's lives depend on transparency about the sex specificity of medicine side effects"

These problems happened because of the medical industry's past neglect of women's health. It was only a little more than 20 years ago, in 1993, that it became legally required for women to be included in clinical trials. Before the 1990s, it was legal for medicines to be developed and sold to the general population without being tested on women. Even now, when women are included in clinical trials, there is no guarantee of an equal amount of men and women in the trials. Because clinical trials often include more men than women, the dosages that medical researchers determine often work for men but cause problems for women.

I fully admit self-interest in writing about this topic. As a woman, my health is directly affected by the NIH's past and present policies. I even took sleep medication (and drove the next morning!) for years. I have complex medical issues that require many medications, and those medications can only improve my quality of life if I know the correct dosages to use and have an understanding of the potential side effects. Additionally, as a feminist I find it essential to bring the lack of sex equity in medical research to light and to spark debate about it. Sex inequity in medical research is one of many issues related to sexism, especially in the sciences, that are not typically included in feminist dialogue yet greatly affect women's quality of life.

So, what can be done to ensure that the sex specificities of medicine side effects are published? The ORWH is a group that can affect change in this area. Through their connections with the NIH director and the NIH general body, they can persuade the NIH to adopt a policy where they will only fund medical researchers who intend to publish the sex specificity of the side effects in their results. As I already mentioned, medical researchers have an incentive to follow NIH mandates because they get their funding through the NIH. For the ORWH to know that this is something the American people want, women and their allies must let the ORWH and the NIH know that they want this change. This can be in the form of emails or phone calls, whatever people have the means to do.

Until that happens, there are protective measures women can take in regard to medicine side effects. Women can pay close attention to the potential side effects of the medicines they are taking, and closely monitor whether or not those side effects are occurring. If they are occurring, women can research how to cope with those side effects. This research can involve going online to see how other people are dealing with the side effects, and it can also involve asking a doctor. It is unfortunate that women can not do more to protect themselves at this time, which is why we need change in this area.

TAXONOMY QUIRKS

MCKENZIE SMITH

For most (paleontologists excluded), dinosaurs come in only a few varieties, made familiar by the childhood classic, "The Land Before Time." There are the giant terrifying ones (think Tyrannosaurus Rex/Chomper); the giant terrifying ones that we are told ate only plants, yet somehow that did not seem to negate their seeming penchant for destruction (these are Diplodocidae: Apatosaurus and Brontosaurus/Littlefoot); the short, fat ones with bizarre, spine like appendages (Triceratops/Cera, Stegosaurus/Spike); the flying ones with funny names (Pterodactyl, Arcahaeopteryx, Pteranodon/Petrie); and of course, the smaller ones that either ate meat and ran in packs (Theropoda); or did not and sort of resembled ducks (Hadrosaurids/Ducky). Of course, there are others, and any self-respecting paleontologist would be horrified at this butchering of what is, all things considered, a relatively intact phylogeny.

But, as neither an evolutionary biologist nor a smart aleck 7-year-old (any longer), the whole "what has happened to the Bronotosaurus that I definitely made a clay diorama of in 2nd grade and I'm pretty sure someone once told me could breathe through its skull?" question has periodically crossed my mind. By now, I'm sure we've all been made aware that the friendly, plant-eating dinosaur of our second grade classrooms: the Brontosaurus (fun fact: literally translates as "thunder lizard"), is no longer technically in existence, and the aptly named Apatosaurus ("deceit lizard") has usurped the position of the familiar and friendly giant.

To understand the origins of this emotionally riveting classification drama, we must journey back to the Wild West of paleontology – the era of The Bone Wars (or, for the less pugnacious: The Great Dinosaur Rush). This was a period of the late 19th century when two American paleontologists, Edward Drinker Cope and Othniel Charles Marsh, were engaged in a brutal, petty, and public battle for scientific recognition. Though both of these scientists were wealthy – and classically educated – white men, it is important to understand that Marsh was the slightly wealthier white man (his uncle was the wealthy financier George Peabody). This meant that Marsh could utilize his connections and money to greater advantage than Cope.

> The men fought over the naming of a number of lumbering giants unearthed in the plains of Colorado and Qyoming; *Stegosaurus*, *Allosaurus*, *Triceratops*.

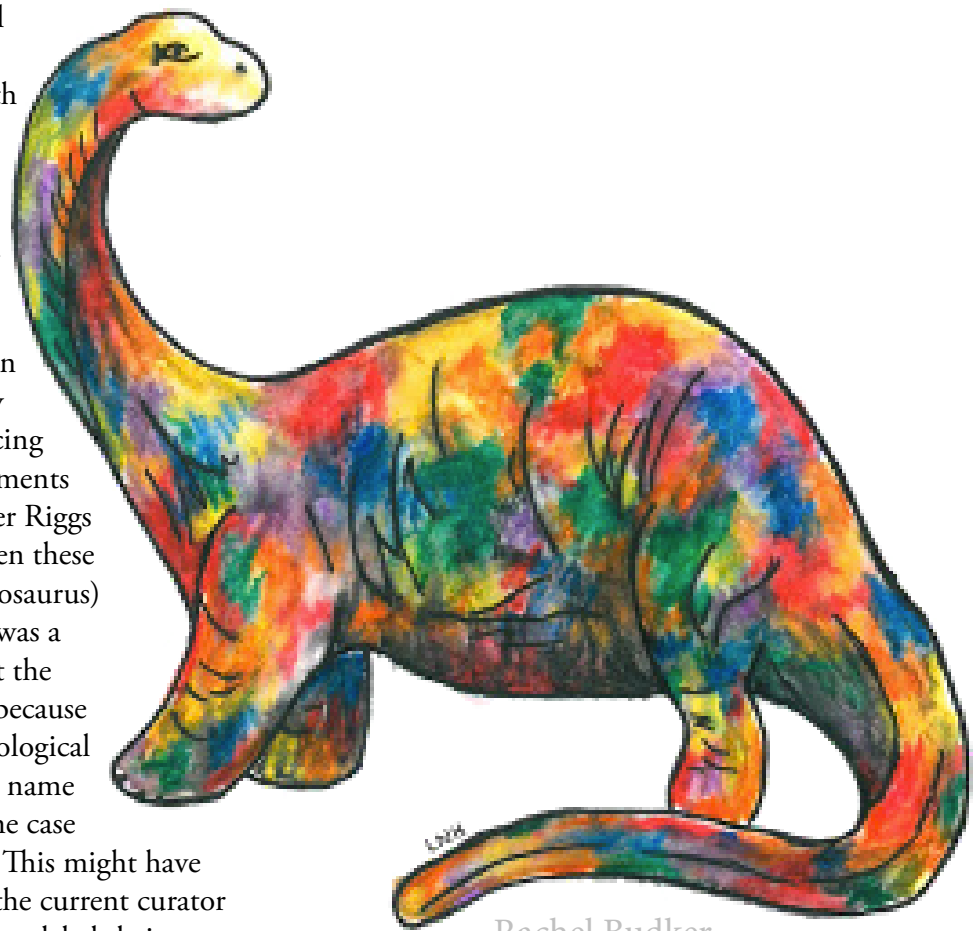
Before commencement of the Bone Wars feud, however, Marsh and Cope were quite cordial, even naming some of their early findings after one another (Ptyonius marshii and Mosasaurus copeanus). Their relationship soured publicly after Marsh suggested that Cope had attached the skull of a new creature Elasmosaurus platyurus, to the incorrect end of its body. Marsh's public treatment of the matter was a source of great humiliation for Cope.

As time went on, the rivalry between the two men grew more and more bitter. It reached a point where Marsh enlisted the academic equivalent of spies to report on Cope's doings, even developing a secretive, original codename for use when referring to Cope – "Jones." The relationship became progressively more bitter and tense over time, as the men fought over the naming of a number of lumbering giants unearthed in the plains of Colorado and Wyoming: Stegosaurus, Allosaurus, Triceratops, to name a few. This rivalry was marred by poor science on both parts; both men would rush to publish similar works, making careless mistakes and requiring several redactions in the process.

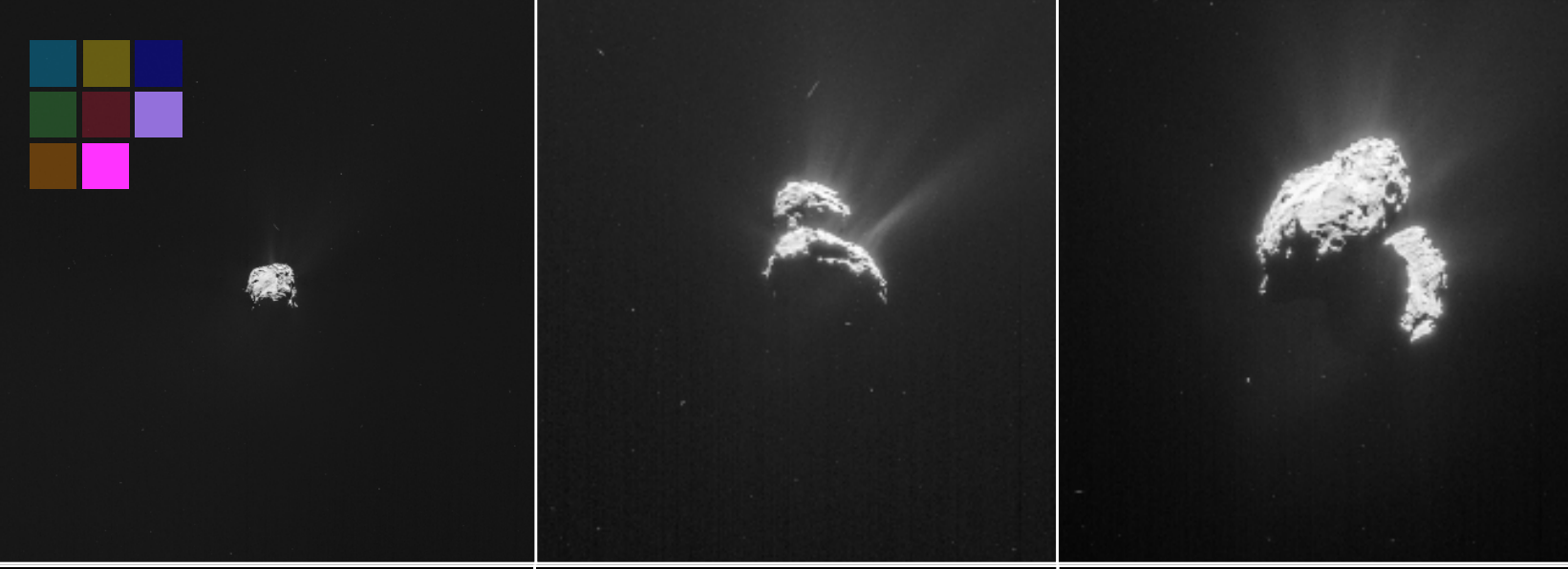
Somewhere along the line both Apatosaurus ajax (1877 – Colorado) and Brontosaurus excelsus[7] (1879 - Wyoming) were named by Marsh, who assigned them to separate genera on the basis of their scapular and vertebral characteristics. Now, Cope did not personally uncover the flaws in Marsh's research, but the men's rivalry arguably led to rushed and unconvincing science, making the next few developments possible. In 1903, a man named Elmer Riggs argued that the only difference between these two "genera" (Apatosaurus and Brontosaurus) might simply be that the Brontosaur was a younger Apatosaurus. This meant that the Apatosaurus moniker would be kept because the International Commission on Zoological Nomenclature mandates that the first name to be suggested ought to be used in the case synonymy (in this case Apatosaurus). This might have been the end of the controversy, had the current curator of Paleontology at the time not opted to label their Apatosaurus skeleton as a Brontosaur. This, combined with the already widespread public knowledge of the giant, gentle Brontosaur meant that Apatosaurus was not widely accepted as the correct term outside of the scientific community until the 1970s.

Which brings us to the present day – a recent article in the New York Times proclaimed the scientific return of the Brontosaurus after a century of disputation. This article was prompted by a new study suggesting the continued relevance of the Brontosaurus, following an analysis of 477 morphological characters. Specifically, this 300-page "paper" argues for the re-distinguishing of two genera and the reincarnation of the Brontosaurus type.

This re-classification is not definite by any means, but it illustrates the flux of evolutionary nomenclature and phylogeny (especially when these names are predicated on only a few, incomplete specimens). Furthermore, it demonstrates the ease with which patently unscientific concerns and interests can impact not only public perception, but professional dialogue as well. Mostly though, it suggests that even famous paleontologists can be petty and mistake-prone, but that when their mistakes or pettiness are pointed out, 7-year-olds the world over will be sure to notice.



Rachel Budker



226.5 km	198 km	118.5 km

ROSETTA MISSION

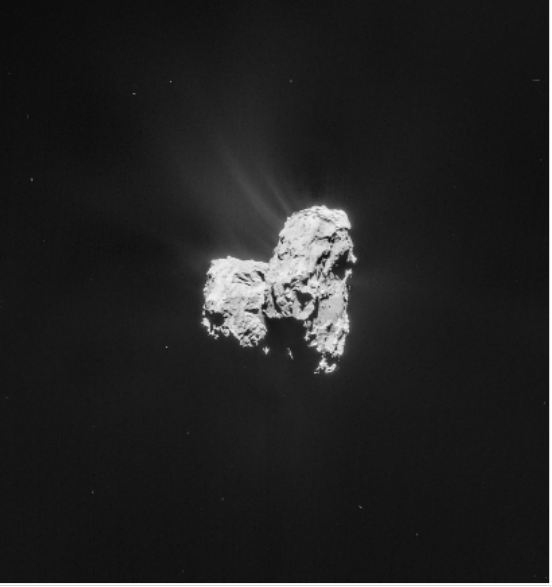
JACOB TURNER

To ancient civilizations, they were a sign of the coming fall of an empire. To us, they are chunks of ice and rock a few kilometers wide that formed just after the birth of our solar system. The vast majority of them orbit the sun at over 150 times the distance of Neptune, the outermost planet. It will take Voyager 1, the most distant human spacecraft to date, thousands of years to reach the halo-like cloud in which they reside. However, these objects are perhaps best known for the select few that are nudged in just the right way by the tidal forces of our galaxy and of passing stars. They are set on new orbital trajectories towards the inner solar system, and make beautiful tails of ice and dust tens of thousands of kilometers long when they get close to the sun. The objects I'm referring to, of course, are comets.

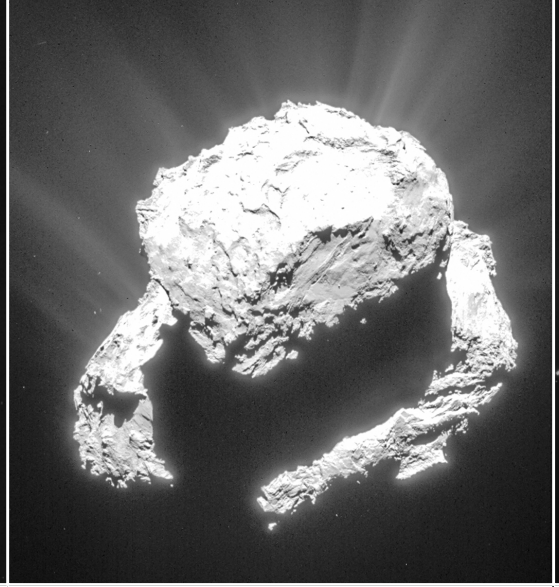
Comets are essential to understanding the history of our solar system in addition to providing spectacular viewing sessions during close approaches. Because they formed in the earliest years of our solar system and have remained in essentially the same state since, they can provide clues to the solar system's early composition, and perhaps to how Earth was able to harbor life in the first place. When our solar system was still only a few hundred thousand years old, it was a very violent place. It was filled with gas and dust that was accumulating into larger bodies such as planets and asteroids, so explosive collisions were very common. The Earth looked nothing like its present self. More closely resembling a giant ball of molten rock due to the constant bombardment of comets, it was not at all hospitable to life. During this time, many of the collisions with the Earth likely involved comets which, being partially composed of ice, may have provided much of the water that is now found on our planet. Taking this idea one step further, there has been speculation that comets may have seeded the Earth with organic molecules, and possibly even amino acids. Organic molecules are somewhat common in interstellar space and even more so in the disks of gas surrounding newly formed stars, so it's not inconceivable to think that comets may be partially composed of these molecules. If we could show that most of the water and/or organic molecules on Earth likely came from comets, it would support the hypothesis that comets are responsible for Earth's habitability.

Perhaps the most incredible possibility is a hypothesis known as panspermia, which suggests that comets may have been what brought life to Earth in the first place. We already know of microscopic creatures that can survive the harsh conditions of space, so life from other worlds could have lain dormant until they found suitable conditions to revive themselves.

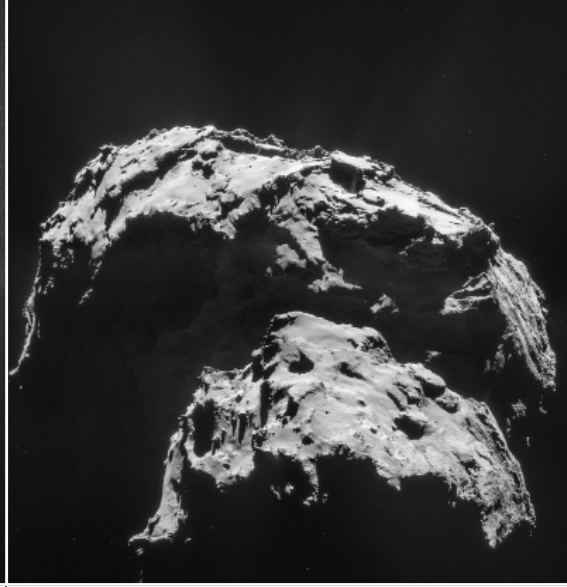
In 2004, in order to better understand comets and their potential influence on Earth's history, the European Space Agency launched its Rosetta spacecraft and Philae lander with the hopes of that they would become the first human objects to orbit and land on a comet, respectively.



94.3 km



71.9 km



27.9 km

After a 10 year journey, the two spacecraft finally caught up with comet 67p and began their orbit. After three months in orbit, the Philae lander was released from the probe and began its descent towards the comet. Due to the weak gravity of the comet (escape velocity is about 1 meter per second, a casual walking pace), the lander was designed with two thrusters that would guide its descent and two harpoons that would keep it anchored to the surface. Unfortunately, the harpoons did not fire, and the lander ended up bouncing twice before coming to a stop in an area of shade, which prevented necessary sunlight from reaching its solar panels. Without access to a direct energy source, the lander was only active for a little less than three days before entering into a hibernation state.

Fortunately, before beginning its temporary shutdown, Philae was able to discover two important facts about the comet. For starters, there was no change in the magnetic field measurements as the lander descended, meaning that no magnetic field exists on the comet, pointing to a likely lack of an iron core—a common feature among the planetary bodies in the solar system. Additionally, the lander was able to detect organic molecules that included elements like hydrogen and carbon, meaning that comets may have been at least partially responsible for some of the organic molecules found on Earth.

The Rosetta probe was also able to return some very important results regarding water composition. By analyzing the comet's water vapor, the probe discovered that the ratio of the deuterium, also known as heavy hydrogen (hydrogen with both a neutron and a proton in its nucleus), to regular hydrogen was about three times the ratio on earth, meaning that comets were likely not the source of water in Earth's early history.

Though only active for just a few days, the Philae lander was able to teach us much about comets and their role in the history of our solar system. Thankfully, that was not the last to be heard from Rosetta and Philae. On June 13th, Philae came out of hibernation and re-established contact with Earth. What's more, unlike traditional missions in which the orbiting probe crashes into the object's surface after its mission is completed, Rosetta is currently planned to orbit the comet indefinitely. And so, after a brief slumber, Philae has resumed data transmission and we once again await exciting new information from the comet 67p.

Peter Arden
Neuroscience
OC '15

Is the Use of Animals in Tea

Over the years, the use of animal experimentation in teaching labs has come under some scrutiny here at Oberlin. Though the use of animals in teaching labs is likely to continue, the issues raised do warrant a response. This article will not focus on the moral justification for animal research itself, as this topic has been discussed many times previously and is not raised as part of the current debate. This article will simply argue that the use of animals in teaching labs prepares our science students for the research world by ensuring they know what animal research involves and that they are aware of how to work with animals effectively and humanely.

The biological sciences at Oberlin College are well respected in the research world, as are our opportunities to do hands on research with animals throughout our undergraduate curriculum. Many colleges are unwilling or unable to allow students in teaching labs access to animals, and while this is far from the only differentiator in biological sciences at Oberlin, it does put our students at a distinct advantage. Students working in labs after Oberlin will be able to competently perform basic animal techniques, which can help our students get noticed, thus opening doors early in their career. Use of animals in introductory labs, such as the Neuroscience 211 lab, affords students this opportunity early on in their undergraduate careers. On a humanitarian level, learning animal research techniques in an environment that prioritizes proper animal treatment will lead to students who will treat research animals well for the rest of their lives. Animal research skills are taught under the close supervision of professional lab instructors who emphasize proper animal treatment. The alternative is real world lab technicians whose primary motive is in attaining results and evading animal ethics committees.

Oberlin not only provides students with the skills to do animal research, but also shows students exactly what animal research involves. Entering the research world already competent in the humane performance of laboratory techniques is a huge advantage Oberlin science students can enjoy. This early exposure also ensures students won't train for a career in animal research only to realize they're ultimately unwilling to take an animal's life. The theoretical sacrifice of animals for the purpose tends to be much more tolerable than the first hand act of performing said sacrifice. It's difficult to know how one will react to having to perform such acts without actually being exposed to them. It is an undeniable advantage to appreciate the intersection of one's practical and moral limits before entering an animal research-centered graduate program, as many are in the biological sciences. This awareness will save many a student from having to drop out of programs they have worked hard to get into, or worse force them into a career that they won't be comfortable with.

The use of animals in teaching labs is one of many elements that keep Oberlin's science departments strong and affords our students pre-professional exposure to animal research. It allows us to send competent and humane researchers out into the scientific community. Our graduates will be aware of what a career in animal research entails and be able to plan their futures accordingly. To end the use of animals in teaching labs would not only hurt the science program at Oberlin, but also hinder the progress of those students that believe it to be worthwhile. It would also likely lead to less humane treatment of animals in the greater research world, as Oberlin student tend to be more mindful of such matters. Such costs are surely not worth nixing animal research in our teaching labs, especially considering that any biological science major may complete their studies while abstaining from animal research. Eventually, every biological scientist must face the choice to do animal research or not, and Oberlin affords us the opportunity to make that decision from practical rather than theoretical knowledge. Animal research will continue to be a major aspect of the scientific world; by removing it from Oberlin we would simply remove our ability to guide such a system in a better direction.

SCIENCE SIDES

This section of *The Synapse* is dedicated to the discussion of an ethical question posed by scientific research. Authors are interested students from a STEM discipline affected by the issue. Have a stance? Visit *thesynapsemagazine.org* to join the discussion.

aching Laboratories Justified?

Sasha Mitts
Neuroscience & Philosophy
OC '15

The use of animals in scientific research is of undeniable value. Animals provide a means of rapidly testing hypotheses across many disciplines, and in service of many important questions. However, the moral justification for the use of animals, especially in non-research settings, deserves investigation. By using animals in teaching labs (non-research based labs associated with classes), we are assuming that students will quantifiably reduce suffering in the future in an amount greater than that which they cause the animals used, and that they otherwise would not have been able to do so. If this is not the case, then we as an institution are committed to the belief that there is a stark divide in terms of what kinds of vertebrate lives deserve freedom from captivity and pain. I will show that neither of these sets of assumptions is supportable, and thus that we have no moral justification for our use of vertebrate animals in teaching labs.

I will layout the first possibility more completely before evaluating it. In order to provide positive support for the use of animals that we know are capable of suffering, and are made to suffer (ignoring the additional weight of deprivation of freedom), an excess of good must result. More specifically, a greater amount of pain must be prevented than is caused, and that pain must not have been otherwise preventable. If a doctor would be just as well equipped to successfully operate on her patient, irrespective of work with vertebrates in teaching labs, her good work does not retroactively justify the pain those animals suffered. [1] Herein lies a significant problem with the rationale in support of using vertebrates. There is no way for moral justification to be backward-acting. An action must be morally justified, or not, at the time it is committed. Arguments from probability seem like they might be able to solve this problem. If you are fairly certain some desirable conclusion will follow from an action, you may be justified in expecting a certain outcome (epistemically justified), but that does not mean that you are morally justified in committing that action. Moral justification cannot operate on the same sorts of future contingencies as epistemic justification. The ends cannot justify the means. Take for example Billy, and his arch-nemesis Freddy. Freddy is awful to Billy, and makes his days at school less pleasant: taking his lunch money, calling him names, kicking him off the swing, etc. Now, Billy has a surefire way to get Freddy kicked out of school. Given his ability to have Freddy expelled and his past experiences with Freddy, Billy is justified in expecting that getting Freddy expelled would make his life better. However, Billy is not morally justified in doing this to Freddy. On a purely utilitarian reading, more pain would be caused than averted. On a slightly more common-sense reading, we don't tend to believe that we are morally justified in disposing of everyone who displeases us. The likelihood of desirable ends coming about might epistemically justify certain expectations given the use of certain means, but it does not grant the use of those means moral justification.

[1]The impossibility of proving a counterfactual further complicates this case, and compromises even our epistemic justification for using vertebrates in teaching labs.

There are two obvious responses to this. The first is that, yes more pain is averted, so we are justified. The second is that there are no good alternatives to using vertebrates in labs, so we must continue to do so. To the first response, I offer a reminder of the problem of taking future circumstances as moral justification for actions. Additionally, the burden of proof is on us to rigorously demonstrate that more (and otherwise unpreventable) suffering is being prevented before we willfully kill and torture vertebrates. The impossibility of proving counterfactuals is a serious problem for this route. The second retort is simply not an argument, and is an admission of our wrongdoing. The claim that there is nothing better seems that it should be more of a call to innovate, given our esteemed status as departments of the biological sciences, than an excuse for inaction.

I will now address the second possibility outlined in the introduction. If we are not preventing suffering, then somehow the suffering of the vertebrates we use must not have moral significance. The dilemma I pose is to find a meaningful difference in terms of mental faculties between humans with severe cognitive deficits, or human newborns, and healthy adult rats or mice. I'm not suggesting that infants and rats are equal in all ways, but that if we are uncomfortable experimenting on babies for ethical reasons, then those reasons must be because of some feature(s) newborns have. We can therefore either make the very weak argument that babies have moral rights because they are similar to us, or the more reasonable claim that they deserve protection in virtue of their mental faculties. If we accept this latter option, there is no moral excuse for the use of healthy adult mice and rats, given their cognitive capacities relative to newborns. Perhaps infants or the severely cognitively impaired would not provide ideal test subjects, but it is not for this reason that we have a visceral reaction to the notion of them being experimented on and held captive in labs. The conclusion that can be drawn from this is the lack of any morally rational foundation for condoning our use of vertebrates in lab testing, given our stark moral opposition to the use of highly cognitively disabled or newborn humans.

Given that neither of the two possibilities outlined above are morally supportable, we must realize that there is no adequate moral justification for the use of vertebrates in teaching labs. I will not put forth an opinion on the use of these animals in research labs, as I think the case is more ambiguous. This is all to say that the departments of the biological sciences here are excellent, but they have fallen short on their commitment to the spirit of science in abiding by its letter. If our goal is to improve the world through knowledge, the acquisition of knowledge ought not itself to sacrifice our ends. Certainly the pillars of research must be taught, and taught well. But if a hard contradiction arises between what is morally justified (and our purported goal), and what is actually being done, then change is needed. As an institution as well positioned academically and intellectually as we are, it is incumbent on us to at least seek to reform and improve these practices for which we lack moral justification.

Photo by John Seyfried

Jesse Rowsell

In Memoriam

Ren Wiscons

This past semester, the Oberlin community lost an esteemed colleague, teacher, and friend. Assistant Professor of Chemistry Jesse Rowsell passed away at age 37 on Jan. 30, while on a hiking trip in northern Ontario. A native of Cambridge, Ontario, Rowsell studied materials chemistry and its applicability for energy use and the environment at the University of Waterloo, the University of Michigan, and eventually Oberlin College. While at the University of Michigan, Rowsell won the Kasimir Fajans Award for best dissertation in chemistry, as well as both the Outstanding Graduate Student Researcher and Student Instructor Award. In total, Rowsell published 22 articles in peer reviewed journals, including four first-author publications that have been cited more than 1,000 times each. Scientific accomplishments aside, Rowsell was a beloved friend and mentor to six graduating, and three to be graduating, classes of scientists. The Synapse humbly presents this article by Ren Wiscons OC '15, a recent graduate of his tutelage.

Gabe Hitchcock, *Editor-in-Chief*

On April 4th 2015, chemists, crystallographers, friends, family, colleagues, and students congregated in Wright 201 to celebrate the life and work of Dr. Jesse L. C. Rowsell, who was lost to exposure while hiking in late January. Presentations navigated the audience through Rowsell's remarkable academic chronology, beginning with his undergraduate work on lithium-ion batteries at the University of Waterloo to cutting-edge research in hydrogen-storage. Rowsell was a materials chemist and a crystallographer, exploring both the design of microscopic architectures and the ways in which these highly geometric networks may be characterized and discussed in a systematic way.

> "Every question was genuine and unpolished, illustrating to students that accuracy is neither a indicator of an experiment's usefulness or a qualifier for intelligence."

Recent work in the Rowsell lab has deviated from the geometrical ideality achieved by inorganic and metal-organic architectures by focusing on small molecule-based materials, a relatively novel extension of gas-capture materials chemistry. In the same way that amino acids can link together and form incredibly elaborate architectures in the solution, larger scale assembly can be 'coded' into molecules. During the crystallization process, molecules are most stabilized by maximizing the number of favorable contacts and minimizing void space in the solid. These tenants can be used to design molecules with specific shapes and substituents that allow individual molecules to link up through the specified region on the molecule. The study of these intermolecular interactions is referred to as supramolecular chemistry.

Projects in the Rowsell lab focused on synthesizing new molecular building blocks, crystallizing functional materials, and fundamental explorations of the intermolecular interactions between molecular units. Students that worked with Rowsell on research projects received extensive training on X-ray diffraction instrumentation and a suite of techniques necessary to assess the structure and quality of materials. There was a certain degree of ridiculousness that seemed to surround the Rowsell lab. Rumors of late hours and danger shaped the

Photo by Ren Wiscons

way in which the lab was perceived. His mentality in lab was no different than that in lecture: he would ask students for the same attentiveness to detail to which he held himself.

There was a frustration inspired by the simplicity of his questions, for which the answer was almost always known, but the words to convey your understanding or perspective were difficult to arrange. As a student of his, I could sense myself becoming a better scientist simply by gaining the courage to ask about the obvious and answer questions beginning from the basics. But the lessons I learned in the lab made me a better person as well. There was a certain ease that crept into my everyday interactions that allowed me to think with greater clarity and speak with greater precision, unbridled by nerves. Professor Rowsell's dedication to his students was inspiring and his commitment to learning was unfaltering. Every question was genuine and unpolished, illustrating to students that accuracy is neither a indicator of an experiment's usefulness or a qualifier for intelligence. This mentality propagated through Professor Rowsell's students, challenging them to take risks and ask questions. He was venerated by all of his students and it is through them that his boundless curiosity will endure.

Publications

A Sampling of Prof. Rowsell's Work

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Honors Research

Erica Morelli, OC '15
Honors Student in Geology

From Pillars to Buttes: Formation of Hydrocarbon Seep Rock Through Time

Hydrocarbons stored deep below the Gulf of Mexico are a major target of petroleum exploration. The liquid petroleum and natural gas will naturally flow toward the seabed along faults and seep through modern sediments. When this happens, microbes take advantage of the hydrocarbons by oxidizing them as part of their chemosymbiotic metabolism. When microbes are active at seeps, they alter the sediment geochemistry which results in formation of carbonate rocks within the sediment. These microbial ecosystems linked to geologic formations creates a unique environment for the development of deep sea invertebrate communities. This study involves a comparison of samples of carbonate rock from deep-sea environments in the present day Gulf of Mexico with samples from the Tepee Butte rock formations of Colorado and confirms that the Cretaceous rock examples must have also formed through some association with hydrocarbon seepage on the seafloor. Through petrographic and Scanning Electron Microscope (SEM) analyses, samples from the Gulf of Mexico Pillar Rock and the Tepee Buttes were revealed to have similarities in siliciclastic content and iron signatures which suggests a subsurface mode of formation. Further isotopic analysis and comparison of the composition and fabric types of the Pillar Rock versus the Tepee Buttes reveals similarities in microbially mediated origins and continues to suggest that these two sites initially formed in a similar environment under the sediment-water interface. The Pillar Rock was later exhumed and has since begun to undergo diagenesis. Similarities in basic fabric types indicates that the Pillar Rock is a good proxy for early hydrocarbon seep rock formation in the Tepee Buttes and that the Pillar itself may continue to go through similar diagenetic processes.

Talia Greenberg, OC '15
Honors Student in Psychology

The Complicated Relationship Between Music and Foreign Language Learning: Nuanced Conditions Required for Cognitive Benefits Due to Music

Through a series of three experiments, my honors research in psychology explores whether music, in the background or as an active encoding device, has an effect on foreign language learning. The literature in the field has equivocal evidence: some researchers have shown that music may enhance performance on a cognitive task, and others report that music is distracting. I found no benefits due to music in my studies. However, my results point to the importance of difficulty of the learning task and familiarity of the music in determining whether music will help or hinder in performing a cognitive task.

Have an honors research project that you would like to tell people about? Then send your abstract to *synapse@oberlin.edu* and you could be featured in our next issue!

Laura Messman, OC '15
Honors Student in Biology

The Importance of Water Availability for Plant Community Structure in Restored Prairies

Lack of water kills plants and current climate change models predict a decrease in water availability in the central USA. To understand the effect of water availability on species richness, I measured the moisture content and the total water holding capacity of the soil in six Minnesota restored prairies. I found that older fields can hold less water but found no relationship between species richness and soil moisture or soil water holding capacity. Therefore, water availability may not be a major factor influencing species richness of prairies, suggesting positive outcomes for prairies in future drought scenarios.

Ren Wiscons, OC '15
Honors Student in Chemistry

Chiral Channels in Molecular Co-Crystals: Unexpected Structures that arise from the co-crystallization of 2,4,6-tris(4-X-phenyl)arenes

Diffraction of 2,4,6-tris(4-methylphenyl) pyridine and 2,4,6-tris(4-methylphenyl)pyrylium co-crystals revealed a pseudohexagonal columnar structure assembled from π-stacked helices that enclose channels containing disordered tetrafluoroborate counterions and solvent molecules. PXRD investigations suggest modification of the crystal structure as a result of interactions between the co-crystal and monovalent anions, indicating a possibility of ion exchange properties. The co-crystal structure is not shared with either of the end-members' crystal structures, though all three structures exhibit disorder, aperiodicity, and complex twinning patterns. To gain a better understanding of the unique structural properties that arise from co-crystallization, our group has synthesized the 2,4,6-tris(4-halophenyl)arenes and studied the subtleties of aromaticity, steric constraints, and halogen interactions on packing motifs. Preliminary results suggest the possibility of modifying solvent accessible volume in the tetrafluoroborate channels through ion exchange.

An interview with **Michael R. Loose**

by Gabriel Hitchcock

Michael Loose is a professor of neuroscience at Oberlin College. He began his life-long career as a student of the sciences at the USAF Academy, CO, from which he earned his Bachelor of Arts in 1975. After serving for five years, Prof. Loose went on to earn his PhD in neuroscience from the University of Wisconsin Madison in 1986. Since arriving at Oberlin, Prof. Loose has researched human decision making and neural circuitry, while also becoming a cherished instructor and mentor of Oberlin students. Over the years, Prof. Loose has made considerable contributions to the fields of neurophysiology and cognitive neuroscience, a legacy that he continues in his own lab with Oberlin student researchers.

I understand you attended the United States Air Force Academy. Could you tell me more about that experience?

It was an odd choice, in part, because it was during the Vietnam War. I had found high school to be not challenging, and I thought something like a military academy would be extremely challenging. It helps you to find out about yourself, find out how you to react under stress. So even though I knew it would not be a popular thing to do, I thought it would be worthwhile.

Did that inform your choice to study neuroscience?

Yes it did. There are weird stories in everyone's life. I was going to be a researcher after I graduated the academy. One owes 5 years of service minimum after attending an academy, and I was going to be getting into "psychological testing". In the sense that, when new people come into the air force, you try to get them into good positions that match their skills. That kind of testing. So I was going to do that. I had majored in life sciences, which was basically a pre-med major, and in psychology. That didn't happen. For very odd reasons, they decided that I would go into a combat related field. However, since my eyes are bad, the only combat related fields available for me were missiles or maintenance. So I "lucked" into being an aircraft carrier maintenance worker.

What was the field of neurophysiology like while you were working at Wisconsin?

In 1980 the society had only been around for 8 years. Although, to me as a new neuroscience person, it seemed like it had been around forever. I went to neuroscience meetings immediately, the first year I was there. What was it like? Well, I think that it was very similar to today, because in 1980 the classic papers in the field were still from the 40s and 50s. The people who had done the work did not call themselves neuroscientists, but they were doing neuroscience. It was very much a terminology issue for many years. It did not coalesce into a growing subfield for many years.

While you were researching at Madison, was there a moment at which you decided you wanted to teach?

That was something I knew going in, but it was reconfirmed. The road one travels is often very strange, and as a kid I had seen really dumb Disney movies, such as the Absent Minded Professor and I thought "that would be interesting." And so, when I went into college, I found that learning new information and discovering new stuff really did it for me. So then I went to grad school... and what do you do with that? You either work in a lab by yourself or you interact with a bunch of about-to-decide-what-to-go-into individuals. So I thought, I would like to be at a place like this [Oberlin]. Small, at least compared to a big research school. So no, teaching is not something I gained in grad school.

I read the review article about prenatal androgens in rhesus monkeys that you coauthored with Prof. Jan Thornton, and was wondering if it's a common thing for neuroscience professors to collaborate in their research?

In the field it is very common. Collaboration between

lab heads is very common these days, more so then it used to be, thinking of a historical perspective. We have so many disparate skills that it's hard for anyone to know everything. So it's very common to collaborate, as we're reaching a point when you need to, because no one person has all the answers. As far as Jan and I, that came out of Madison in a way. We both worked with primates at a primate center in Madison.

Could you tell me more about the current line of research you are pursuing?

Sure! *clap* Mhmm! It strikes me that most of us vertebrates, including humans, deals with a probabilistic future, alright? We can predict what will happen in the future with some probability. I am studying decision making and decision making is often not deductive, nor is it deductive syllogism, it's probabilistic. "What will probably happen?" "What that I do now will most likely be successful?" Jumping off from that, it's possible that these brain decision making circuits are basically designed to work with and deal in a probabilistic future. How does one make good decisions, given those circumstances?

So what do we do? We do very simple decision making tasks with students, with humans. We ask them to make repeated guesses as to what will happen in the near future because our tool, our technique, is to use the EEG [electro encephalogram] apparatus in order to see these very small neural deviations that are correlated with certain decision making processes. So we use our EEG, and we record from students' brains while they are making the simple decisions.

What do we study? It's arguable now, and it's an interesting point of time in the decision making world of research, that there's a feeling of consensus, a hypothesis out there that a lot of our reasoning is actually inferential and rather unconscious. So that's one of the things that we are studying. We are looking at influencers of guessing of what will happen in the future. The things [influencers, unconscious neural impulses] that have just happened a few seconds previous to when the decisions will be made, even though people are not aware of it, may influence their predictions. So we collect this EEG data, we collect their decisions, we collect their reaction times and we do some EEG correlations with those behavioral metrics, but we also do some computational modeling, asking if the brain is sort of probabilistically taking information and coming up with a decision each time. There are several models out there and we are looking at one of them.

Is there a particular field of academia, other than that in the biological sciences that you are especially interested in? And if you were to pick one, what would it be?

Right! oh! Pick one that's hard... hmm. Wow that's hard. Hmm. Ok. I find... I find two. Because I would be hard pressed to not give two. I find the economic argument now, the rational agent that the economists have been studying for a long time, and then [our] discovering that people aren't rational and [our] coming up with very interesting hypothesis about decision making, specifically economic decisions, to be quite useful! There have been a number of people in the field that have gone into, you know, Neuroeconomics. Glimcher is a famous person that has published good work. I believe that's a nice interaction point between neuroscience and another field.

I also like philosophy, as its very different from experimental science. I am an experimentalist at heart, but you do get some interesting perspectives from people that have thought about something in great detail, without looking at the details. Whereas I am detail oriented in some respects. But my favorite is late Roman History, which has nothing to do with neuroscience.

In the past Oberlin has received some criticism for their use of animals in teaching laboratories. Do you feel that this has waned in recent years and, if so, why?

It has waxed and waned ever since I've been here. Early on, we had some really heavy-duty discussions where we got together with students who had concerns. We even had a symposium at one point. So, in comparison to that waxing period, it might or might not be in a waning period right now. There's still a group on campus that has been involved in animal rights. Some few years ago we had some interactions and discussions with various groups. But nonetheless we have often, indeed, I would say always, never seen a point where students concerned about the issue have acted in a way that has prevented other students from being able to learn what they have wanted to learn. So there has been this interesting, respectful understanding that there are differences of opinions, which is really quite impressive because people get very strong emotions about this.

I would argue, without any data at all and mostly from discussions with students, that it is the students that take 211 [Intro to NSCI lab component] itself that make the difference. I think the word has gotten out that it's a really good experience, which may have influenced the interactions between the animal rights organizations and those who want to learn from studying animals. But no data.

If you could be any single eukaryotic cell, what would it be and why? Also, if you say a neuron please be specific.

laughter Huh. *long pause* I suppose, just because I talked about it in class today, I would pick one of the two swimming neurons in Clione [a small sea slug]. That is the simplest possible circuit that keeps that little animal alive. It's a two-neuron circuit that allows it to swim. So, I would be the motor neuron that makes the critical decision of how high in the water to swim.

If you could tell our prospective neuroscience major readers one piece of advice, what would it be?

One piece of advice: look for insight in all the courses you take. Stay broadly engaged. One can easily get a new idea of how the brain works from a different field that you never thought you would. Look for that everywhere.

An interview with **Marcello Vinces**

by Willa Kerkhoff

Marcelo Vinces is the director of the Center for Learning, Education, and Research (CLEAR) in the Sciences at Oberlin College. He grew up in New York City after moving with his family from Ecuador at the age of five. He attended Cornell University and earned a BA in Biology before earning at PhD in Molecular Biology at Tufts University. His interests range from science to art and languages, and he is responsible for encouraging interdisciplinary collaboration at Oberlin through the CLEAR Center.

Could you briefly describe what the CLEAR center does and some of the programs that you run here on campus?

Yeah! So the CLEAR office is now two years old, it'll be two years in March. It was founded on a grant from the Howard Hughes Medical Institute. The two big focuses of the grant and the reason for the center was to strengthen quantitative skills across the curriculum and to facilitate greater interdisciplinarity, both in student learning and in faculty teaching and research. You would think that at a school as small as Oberlin that the latter would happen naturally but it doesn't. I think that all of academia kind of happens in silos once you enter grad school, and yet twenty-first century science really demands greater communication between the disciplines. That was one of the things that HHMI was really excited about us doing.

In the quantitative skills part, there's a sense that students (at Oberlin) are graduating without enough of the quantitative skills that are necessary for everyday life, let alone for twenty-first century science. Even things like biology are becoming increasingly computational and quantitative in nature. So one of the missions of the center is to strengthen that. To that effect, we started up the quantitative skills drop-in center, which is downstairs in the science library, and it has parallel functions with the Writing Center, which has been at Oberlin for many years and is widely used. This is a center for quantitative type things, which is kind of an umbrella term for the kinds of things that students come in for. The most common things are for help with math if you're not in a math course…or maybe you're in a non-majors course for biology and you get an assignment that requires excel; you can drop in for that. The great thing about the tutors there is that they don't tell you the answer, because that's not really helping you. (when I went in) the tutor just basically asked me a lot of questions like "Oh, what did you mean by this x here in this code?", which led me to realize that I had labeled one of my variables incorrectly.

So that's the quantitative skills center. One of the other programs we operate for students is the OWLS program. That's for a selection of primarily introductory and intermediate courses in the natural sciences. Are you familiar with OWLS?

Yeah, many of the courses that I've taken in the last couple years have had OWLS instructors. It's been very useful, because it just helps to have a student in there who can talk about things in a more simple way.

Yeah, the goal was to provide an intermediate way of explaining and learning. So we also do some faculty development. Twice a year we have a workshop for faculty on a variety of topics, primarily focused on how to strengthen quantitative skills in your course. We've also given small curriculum-development funds for faculty from different departments to get together and co-teach or do a module shared between different departments. And this summer we're doing a quantitative skills workshop in conjunction with some other people who are doing a workshop of computational modeling, so that will be about a week long workshop. And there will be some outside participants for that.

So when you say interdisciplinary, do you mean between natural science departments, or is the CLEAR Center looking more around the college?

Both. I think that at a liberal arts college there's lots of opportunities for connections across lots of different disciplines, and in fact since the creation of the office we've been approached by a number of different programs on campus that have an interest in interacting with the natural sciences, but that connection just hadn't been there. So now that there's an office that interfaces with all of the natural science it's much easier to coordinate. I'll give you two examples.

One was the Allen Museum, which had a very small exhibit of photographs two years ago by an electrical engineer at MIT who had revolutionized fast-speed photography. They thought it would be a good opportunity to get the natural sciences involved if the faculty would write up little descriptions of each of the photos. So they got in touch with me, and I was able to get in touch with the people I know in the natural sciences who have an interest in art, like Katy Oertel (Catherine Oertel) in chemistry who does some research with the pipe organ metals, Bob Bosch in mathematics who does math art, and other people who I know that engage with the arts, and they put together a really fantastic brochure. So we invited natural sciences people to the opening of the exhibit, and I actually witnessed people meeting for the first time, people from computer science and physics meeting for the first time in the art museum. I think it's those kinds of opportunities that are really available at a small liberal arts college like Oberlin.

The director of Gender, Sexuality, and Feminist Studies approached us as well to see if we could do a collaboration and that's been really fulfilling. Last year we had a whole series called Roots and Stem, where the idea is to explore the societal context in which the natural sciences exist. We also collaborated with the MRC (Multicultural Resource Center) on this. Last year the focus was primarily on gender in the natural sciences so we had a couple of faculty panels and a guest speaker from Swarthmore who spoke on gender in the physical sciences. And that has actually led to some other things, there are some things happening this year; plans for a convocation speaker, possibly a course, but we're also really interested in facilitating more interdisciplinarity within the natural sciences.

Biology is just down the hall from Chemistry, in the same building as Neuroscience, but this doesn't necessarily mean that there's cohesion between the courses. Students will learn better if they can cement that the oxidation they're learning in chemistry has everything to do with respiration in biology, but those connections aren't always made on their own. Some better development between departments on how they teach their courses would really benefit everybody. That's what we're trying to facilitate better through curriculum development grants and workshops.

So I know that you have a background in the sciences. Could you talk a little bit about how your educational process led to you having this job that's in academia but is also kind of unconventional?

So my background is in molecular biology. I did a PhD in molecular microbiology studying pathogenic yeast, using a lot of what are considered conventional microbiology approaches. For my postdoc I then went on to study brewer's yeast, again very microbiology heavy but this time working in collaboration with a computational biologist. All along that time I was very interested in education, and during the first year of grad school they required us to do a certain amount of teaching. I found that I really enjoyed it and I was really good at it from the feedback, and so I continued to teach throughout my time in grad school. My idea very early on in grad school was "I'm gonna get this PhD, and I'm going to do research but really do a lot more teaching ". I went to a large research university so the teaching part wasn't a big component for professors there, so I started investigating schools like Oberlin, small liberal arts where people major in science to see how I would get to a place like that.

I had also heard about this science policy fellowship that happens in DC that is administered by the AAAS, the publishers of Science magazine. They have this fellowship for PhDs in science and engineering to work for the government for a year or two, and the idea is for sciences to lend their expertise to the federal government and at the same time get training in policy formulation. The reason I was interested in it was after hyperspecializing in this PhD program for so many years, I wanted to reconnect with the larger context that biology exists in and how it affects society. I thought that this fellowship would sort of broaden my scope and make me a better teacher. I applied, planning on just doing it for a year and then getting back on track applying for faculty jobs. While I was there I learned so much and I got really interested in more institutional work. One of the projects I had there was supporting research at primarily undergraduate institutions. My fellowship was at the National Science Foundation, and the NSF is very interested in supporting research at small schools. It was while I was there that I saw that Oberlin had a really disproportionate number of NSF grants and a really disproportionate number of students who went on to get PhDs in science and engineering. I had many colleagues in science and math who were from Oberlin and I thought, "Wow, it sounds like it's a science school." And now that I'm here I see why that is, because it's top notch, the kind of work that students get to do here. The courses they get to take, the professors they get to work with, and the interactions with the professors are key.

So while I was at this fellowship I became aware that in the sciences there are other jobs outside of the traditional track of researcher/professor. These administrative type jobs where they require you to have a good knowledge of the research but also do some more administrative stuff? That was new to me, and that's how I kind of started looking for jobs in the area, and when the job posting for this job came out in Science magazine I was excited. I thought it was a longshot but that I'd try, and here I am. It's really been a dream job.

/syn·apse/ n. the point at which a nervous impulse passes from one neuron to another

The Synapse is a relay point of science-related information with a threefold objective. First, we aim to stimulate campus interest in science by exposing students to its global relevance and contributions. Second, we work to bridge the gap between the scientific and artistic disciplines by offering students a medium through which to share their passions, creativity, and ideas. Third, we strive to facilitate collaboration between members of the Oberlin College community, especially within the natural science departments.

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