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NU SCI



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Letter from the Editor



For the past few months, we've been exposed to constant coverage of one of the most contentious election seasons in decades. The two candidates are divided on almost every subject – turn to page 10 of this magazine if you want to find out just how much.

It's been exhausting for everyone involved, but has also brought up a lot of important issues that our society remains divided on. In Issue 29 of NUSci, we tackle the concept of rivalry from multiple perspectives, from history to biology to social science. Take a look if you're interested in reading about the historic battle for light between Thomas Edison and Nikola Tesla, the subtle rivalry between Doctors of Medicine and Doctors of Osteopathy, or the ongoing tug-of-war between humans and nature. Whether you'd prefer to read about the chemical defenses of plants or the ongoing Epipen debacle, this issue has something for you.

Though the majority of articles in this issue cover topics of contention, many of them also emphasize the importance, as one writer puts it, of "collaboration over competition." Rivalry is essential to progress, and to achieve that progress, there is an ultimate need for rival groups to work together to achieve a common goal. That's true for everything from the polio vaccine to the space race, and is also a relevant sentiment for the NUSci team. This semester, we have a great group of editors, marketers, and designers from different majors – many of whom are just starting out in their respective positions – who have all collaborated to create a final product that is attractive, accurate, and of course, enjoyable to read.

Even though rivalry is the theme of this issue, collaboration is the key to success. After flipping through the next 30 pages, I hope you'll feel the same way.

Gwendolyn Schanker
Editor-in-Chief

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TRENDING SCIENCE



BY ZOË BOWERS, BIOLOGY, 2020

N. AMERICA

CHILDBIRTH ADVANCEMENTS

In multiple centers across the United States, a study was performed to test whether azithromycin (an antibiotic used to treat infections caused by bacteria), along with standard antibiotics, could prevent infection at the incision after Cesarean delivery (C-section). Even though Cesarean delivery is one of the most popular surgeries today, it still brings a high risk of infection at the site of delivery. Results showed that the addition of azithromycin lowered the occurrence of infection while also lowering other aftereffects like postpartum fever, need for readmission, or treatment with antibiotics. The women who had azithromycin also had a shorter hospital stay, which reduced hospital costs.

S. AMERICA

DISEASE SPREADS TO CHILE

On Chiloé Island in southern Chile, scrub typhus has infected three patients in late 2015 and early 2016. Scrub typhus is a zoonosis (disease spread between animals and humans) that is transmitted by chiggers - mite larvae. Originally found in the Eastern Hemisphere, specifically Asia, Australia, and the Middle East, the discovery of the disease in patients in Chile shows that the pathogen is spreading across the world. The common symptoms among the Chilean patients were severe rash, high grade fever, muscle aches, and headaches. All three patients came in contact with wood, which was the cause of chigger bites in Asia. Scrub typhus is a life threatening disease, but if discovered, it is easy to treat with antibiotics.

ANTARCTICA

RECEDING SEA ICE

Sea ice in Antarctica is getting close to an all-time low, which would have severe consequences for all. On August 28, 2016, the sea ice measured a total of 18.5 million square kilometers, much lower than the 20 million measured in 2014. Sea ice is vital for marine life, such as seals, penguins, and krill. With less sea ice, there is also less regulation of the Earth's climate through sun rays. Furthermore, receding shorelines make it more difficult for research centers to fly to bases with heavy equipment. Though we're already seeing numerous consequences, the potential downstream ecological, biological, and sociological consequences of receding sea ice are almost unfathomable.

ASIA

WILDLIFE CONSERVATION

In the Western Ghats, a mountain range along the coast of India, indigenous tribes are hunting protected wildlife to keep with their tradition of consuming wild meat. The Western Ghats is rich in biodiversity, but these tribes pose a huge threat to many animals, like deer, wild boar, and junglefowl. Through research done by the Conservation Research Group at St. Albert's College in India, scientists developed strategies to help the indigenous tribes keep their traditions while also protecting the diverse wildlife. These include creating "no-take areas" where hunting would not be allowed and making domestic meats cheaper and more accessible for the tribes.

EUROPE

PHYSICAL ACTIVITY IN CHILDREN

In The Netherlands and Finland, where many three-year-olds spend time in childcare, a study was performed testing the physical activity levels of children in childcare centers as well as how these centers affected the levels as the children grew up. Researchers from the University of Jyväskylä in Finland and Maastricht University in The Netherlands found that childcare centers should increase outdoor time and allow children to come up with their own activities. Encouragement by teachers and other staff members also increased physical activity levels. This study mentioned that consistent physical activity during childhood helped maintain physical activity into adulthood.

AFRICA

SAVING THE TREES

Elephants in South Africa are destroying trees, which is causing harm to other species that rely on the trees. Since elephants are herbivores, they eat the leaves, bark, and roots of the tree by breaking branches, stripping bark, and breaking the main stems. However, these trees are very valuable to the ecosystem around them, so in order to protect the living things that rely on the trees, the trees need protection from the elephants. To fix this, researchers from the University of South Africa and Western Kentucky University wrapped some trees with wire fencing and left some trees without it. They checked on the trees several years after wrapping them and noticed the wire fencing protected the trees against bark stripping, mainstem breaking, and uprooting. It didn't really protect against branch breaking, but it did decrease the impact of the elephants.

AUSTRALIA

INDIGENOUS RETROVIRUS

Researchers from Alice Springs Hospital in Alice Springs, Northern Territory, Australia conducted a study on one remote indigenous tribe from that region to determine the prevalence of the Human T-lymphotropic virus type 1 (HTLV-1) among tribes. Human T-lymphotropic virus type 1 is a retrovirus (an RNA virus that makes DNA from RNA using an enzyme called reverse transcriptase) that affects the T lymphocytes. Results showed that there were high rates of HTLV-1 infection among adults. It also showed that horizontal transmission occurred, which can result from exposure to infected lymphocytes through blood, intercourse, or breastfeeding. Currently, there's nothing to stop the transmission of this infection among indigenous communities, mainly due to the lack of data.

NUSci Explains... Drug Names

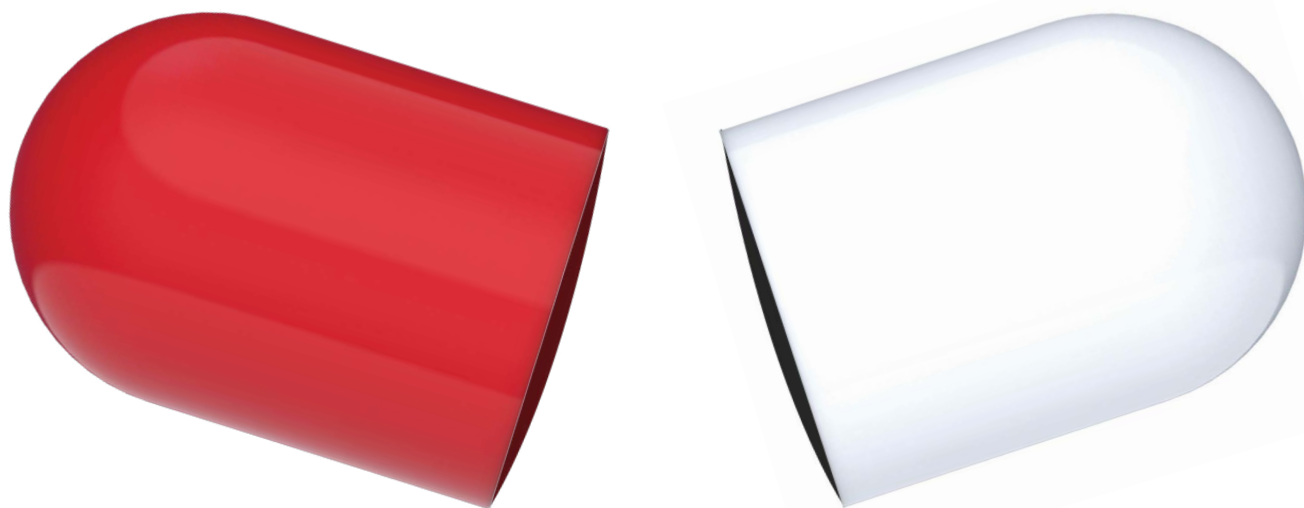
BY JORDYN HANOVER, BEHAVIORAL NEUROSCIENCE, 2017

DESIGN BY ALEX GUSHULAK, CIV ENG, 2021

What's in a name? A rose by another name would smell as sweet. In the instance of drug labeling, there are three names to consider when answering that question. A drug's chemical name is determined from the chemical structure of the molecule. The two other designations every drug receives are a generic and a brand name.

generic drugs are often less expensive.

So why go through the trouble of introducing brand-name drugs into the market? A brand name identifies a drug as belonging to the particular company where it was developed. For example, the drug Lunesta nods at the moon to imply its use in treating insomnia. Brand names are usually developed during the first two phases



The generic name of a drug is often used to describe a less expensive but equally effective version of the compound, whereas the brand name is typically the moniker commonly affiliated with the drug. For example, mild pain reliever Tylenol is a brand name of acetaminophen, which has the chemical name N-(4-hydroxyphenyl) acetamide.

Tylenol

Acetaminophen

**N-(4-hydroxyphenyl)
acetamide**

of a human study, and are submitted with the proposal to the Food and Drug Administration (FDA) for an investigational new drug. The name of the drug is usually abstractly associated with the drug's purpose to appeal to physicians and patients. Brand names often circulate internally before review to avoid trademark disputes.

Generic compounds face specific naming constraints. Name stems, or portions of a drug name, exist to label drugs belonging to a specific category. Drugs that act as agonists to a specific class of serotonin receptors are required to have the suffix "-triptan" in their name, such as antidepressant Serotonin, a form of oxitriptan.

Dozens of these name stems exist to classify a drug's mechanisms. The United States Adopted Name (USAN) Council, selects names for compounds by drug potential. When naming a new drug, the USAN Council has strict regulations: the name of a new chemical should be easy to pronounce, internationally usable, and cannot be associated with any implications of effectiveness. Because of the patent protection involved in producing brand-name drugs,

After passing company and consultant review, potential names are then sent to U.S. and European patent offices in a year-long process coordinated between both offices. The brand name (like the generic name) cannot imply dosage, efficacy or sound too similar to the generic version of the drug and other patented drugs.

Overall, drug naming is a complicated, multifaceted process that can take years and hundreds of thousands of dollars to get approved. Though a drug can be identified by different names, the brand name (or names) chosen by a company has the potential to dominate a drug sector based on name recognition alone. After all, is it Advil, ibuprofen or Motrin you reach for when you've caught a cold? Whatever name you prefer, they're all one and the same.

So Much to Come

Rivalry and Revolution in the Stem Cell Field

BY GWENDOLYN SCHANKER, JOURNALISM AND BIOLOGY, 2018

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2020

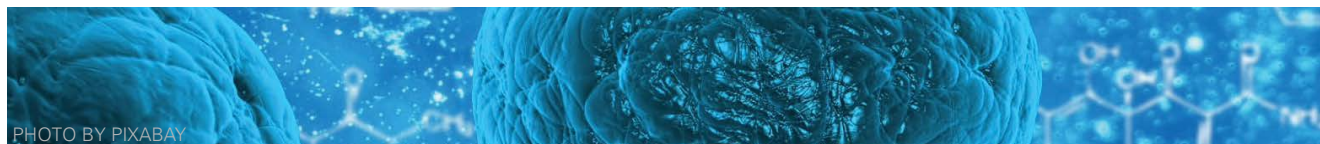


PHOTO BY PIXABAY

Stem cells and regeneration are consistently evolving sectors of biomedical research. Like any other area of science, they are marked by a few important milestones: for example, the first mammalian cloning of Dolly the sheep by Ian Wilmut and his colleagues at the Roslin Institute in Edinburgh, Scotland, and Shinya Yamanaka's discovery of induced pluripotent stem cells (iPSC), adult cells that can be reverted back to their undifferentiated state simply by activating a few transcription factors.

Statistics dictate that the majority of researchers who enter the stem cell field aren't likely to make a life-changing discovery, instead contributing to the field in their own small way. However, because stem cell therapies are such a transformative prospect for humans, the pressure to make those few life-changing discoveries is unusually high.

James Monaghan, assistant professor and regenerative biologist at Northeastern University, studies the regenerative abilities of axolotl salamanders. Axolotls can regenerate large parts of their limbs – containing bone, muscle, nerves, and skin – as well as their tail, heart, and spinal cord. By studying how the salamanders regenerate, the researchers hope to enhance understanding of future regenerative medicine therapies in humans.

"As a new lab, our success is based on new, exciting discoveries," Monaghan said. "There are hundreds of stem cell labs all trying to come up with the next therapeutic, so the competition is intense."

A very limited number of scientists who graduate with a Ph.D. in a scientific field end up running their own lab. In the biomedical field in particular, there's a lot of pressure to build on that success and make a new discovery that will ultimately leave a lasting legacy. Sometimes this pressure leads to an unfavorable outcome. For example, in January 2014, a paper was published in *Nature* describing stimulus-triggered acquisition of pluripotency (STAP) cells. The paper suggested that it was possible to induce cells back to their pluripotent state – where they were capable of becoming any type of cell in the human body – simply by subjecting them to some kind of stress, like submersing them in a weak acid. The story understandably generated a great deal of media buzz, and the supposedly revolutionary STAP cells were even covered in an issue of *NU Sci*.

However, as other scientists tried to replicate the data over the next few months, it became clear that the STAP cell method didn't work. In fact, postdoctoral researcher Haruko Obokata, who did most of the legwork on the project, had manipulated several images in the paper. In

July, coauthor and respected stem cell researcher Yoshiki Sasai hanged himself, presumably due to anguish at having to retract the paper.

Looking across biomedicine, this type of fabrication of data is not unique to stem cell research. "It's not more prevalent than other fields – it's that the stem cell field self-polices by trying to replicate the research," Monaghan said. "Furthermore, because stem cells are such a sci-fi, futuristic potential towards regenerative medicine, it gets more press than many other fields."

In such a prominent field of research, fraud isn't the only concern. There's also a great deal of contention over who gets the credit when big discoveries do happen. One example of this is the current debate over the patent for the discovery of the revolutionary genome-editing method, CRISPR-Cas9. The CRISPR method builds on a number of past biological discoveries, but takes a monumental step forward in its ability to easily edit the genomes of organisms up to and including humans. The institution that walks away with the patent – either the Broad Institute of MIT and Harvard or the University of California Berkeley – not only retains bragging rights but also ensures a great deal of future funding.

"There's so much monetary potential in the stem cell field," Monaghan said. "Even though all new findings build upon what's previously found, there are some major leaps and CRISPR-Cas9 is one of them."

The CRISPR patent debate is ongoing as lawyers review lab notebooks and email threads to determine who came up with the idea first. Though this has created rivalry between the two petitioners, the CRISPR technique itself is a testament to just how far the biomedical field has come. "Cells are more amenable to manipulation than what we've ever thought, even in vivo," Monaghan said. "We can see it on the horizon that we're going to be able to treat defects and injuries through the use of stem cells or by inducing regeneration. I don't think I would have said that a decade ago."

Monaghan added that the collective sense of moving forward fosters collaboration over contention, especially as all of the different aspects of the field – developmental biology, regeneration, and stem cells – continue to build on one another. "The goal is in sight," he said. "The community sees that coming. It's easier to collaborate than to close your doors and work in a bubble."

Selective Storytelling of Adverse Effects: *A Potential Danger to Medical Research*

BY RACHEL SON, CELLULAR & MOLECULAR BIOLOGY, 2020

DESIGN BY HEATHER OFFERMANN, BEHAVIORAL NEUROSCIENCE, 2018

We've all done it before. When someone meets a stranger, they usually introduce themselves. They share fun facts and exciting stories about their weird trip or cool friend. Selective storytelling is the most efficient way of letting someone else get to know the most remarkable parts of a new friend's life without giving a lengthy and dull autobiography. Who wants to share all the sleepless nights they spent studying or the time they cleaned their apartment all day when they can pick and choose interesting stories?

However, when people select what information is publicized, they are also obscuring the reality of the larger picture. The time they went abroad may be more fascinating to hear, but it does not accurately reflect their daily life.

This can have catastrophic results on research. Publication bias results from the tendency to publish the data people find significant while ignoring seemingly less significant data. This then only rewards researchers who report significant data even though nonsignificant results are just as valuable for advancing scientific knowledge. A view affected by publication bias will almost certainly lead to incorrect conclusions in the future.

The issue of publication bias is prevalent in all types of research, including clinical trials, which can have a very real and direct impact on patients.

A study published in September 2016 in *PLOS Medicine* by Golder et. al conducted a systematic review of reports of adverse events in both published and unpublished studies of healthcare interventions. After examining 28 key studies, the researchers found that adverse events - described as any unexpected and detrimental effects of a medical treatment like skin irritation, seizures, and death - from clinical trials seem to be better reported in unpublished documents than in published documents. Adverse events were reported in 95 percent of unpublished reports but only 43 percent of the publications that resulted from these reports. In 11 of the 28 studies, 18 out of 24 adverse events described in both published and unpublished reports are listed more frequently in the unpublished reports.

The authors explicitly recognize publication bias as a possible factor that results in this discrepancy between published and unpublished adverse effects data, and also name it as one of many "very serious threats to the validity of systematic reviews and meta-analyses of

harms." They recommend that researchers make more an effort to consider unpublished data, and also suggest that pharmaceutical companies should increase accessibility to unpublished data in order to be more ethical.

In one paper Golder and her colleagues examined, researchers conducted a clinical study examining the efficacy of two previously tested antidepressants for adolescents: paroxetine and imipramine. The researchers discovered that these antidepressants are just as effective as a placebo and may actually increase adolescents' risk of adverse events like suicidal thoughts.

It is currently impossible to establish a precise depiction of the risks involved with medical treatments while major issues like publication bias still exist, and therefore these biases negatively influence the value of findings from scientific research.

“ Publication bias results from the tendency to publish the results people find significant while ignoring seemingly less significant results.

The scientific community has fortunately recognized the need to minimize the effects of publication bias to help researchers better understand the potential adverse effects of medical treatments. An open-source academic journal called *BMC Psychology* recently declared its intention to pilot the first "results free" approach to selecting manuscripts for

publication. Liz Bal, the Associate Publisher at BioMed Central and the publisher of *BMC Psychology*, stated that "We believe that this could help reduce publication bias by basing the decision to publish purely on the scientific rigor of the study design." The ten manuscripts in the initial trial will only be judged for publication by their content, methodology, and adherence of the discussion to the objective of the study rather than the research results.

The occasional remarkable research findings and individual crazy adventures may be fun to hear about, but they do not illustrate the whole story of medical treatments and people's lives. The importance of giving medical professionals and patients the data they need to make informed and rational choices cannot be discounted. The idea that patients and physicians may decide on a medical treatment based on false research findings due to publication bias is terrifying, but unfortunately realistic. As a result, any previously tested medical treatments are likely ineffective and may even be harmful.

PLOS Medicine (2016). DOI: 10.1371/journal.pmed.1002127.

PHOTO BY ALEJANDRO ESCAMILLA



Belief in scientific views polarizes political parties

ARTICLE & DESIGN BY ANNA LI, BEHAVIORAL NEUROSCIENCE, 2019

The authority of science has been consistently divisive for the political spectrum. Both major political parties have criticized the other for being more anti-science on issues like evolution, climate change, vaccination, genetically modified organisms, stem cell research ethics, and more.

Joshua Rosenau, Program and Policy Director for the National Center for Science Education, suggested in a 2012 article that those who hold beliefs disputed by scientists do not question the credibility of the scientific process, but rather the credibility of scientists who present evidence against their beliefs. "Science denial often emerges when a scientific idea becomes linked to the identity of a social group," Rosenau wrote.

For example, conservatives are more likely to deny evolution, which is antithetical to creationism, because Christian religion is a fundamental part of conservative political identity. Instead of rejecting science completely, conservatives are more likely to support the work of a scientist who shares their views.

A 2015 study by the nonpartisan Pew Research Center showed that political ideologies are most polarized by climate issues — 64 percent of conservatives favored more offshore drilling compared to 24 percent of liberals. Additionally, only 29 percent of conservatives said that they believe the earth is warming due to human activity, while an overwhelming 76 percent of liberals do.

In fact, many of the Republican members of Congress cite science as a reason to believe human activity does not contribute to global warming. Some, like Rep. Gary Palmer, say that science has not shown a temperature increase for nearly two decades. Rep. Tom McClintock accepts that the planet has been warming, but places the blame on normal global temperature fluctuations. Others, such as Rep. Tim Griffin, have suggested that research has shown "shenanigans going on with the data" that supports man-made climate change.

By the same token, the anti-vaccination movement has been often criticized as being part of the liberal agenda. An early 2015 measles outbreak at Disneyland in California shed light on

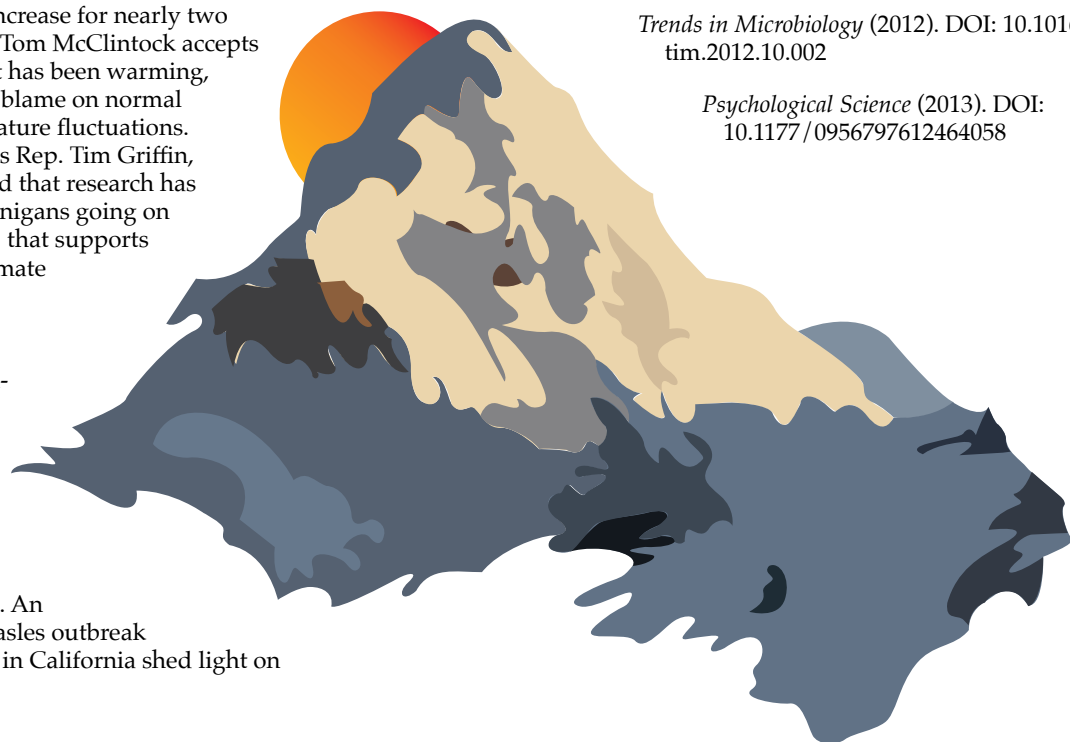
certain counties with rates of unvaccinated children as high as 10 percent. California state law requires children to be vaccinated for measles, mumps and rubella. Before this July, when California lawmakers passed a stricter vaccine law, parents could legally waive the requirement if they claimed personal belief that vaccines are harmful. The Pew survey shows that similar numbers of Democrats and Republicans believe that children should be required to receive vaccinations, but the counties in question — East Bay, Marin and north San Francisco, to name a few — are staggeringly affluent and liberal.

Perhaps, then, it is not just the political ideologies themselves that are either for or against beliefs supported by most scientists. Parents in Marin who share similar socioeconomic status and political leanings and hold anti-vaccine beliefs cluster together, perhaps bolstering their ideas. One 2013 study showed that political extremism occurred when closely-knit communities became more confident in their faulty explanations — in this case, the insufficient evidence that vaccines were harmful. These people also tended to look specifically for information that supported their beliefs, and interpret new information in a way that fits their ideas.

"The messengers most likely to break through will be those who share a social identity with the science-denying audience," Rosenau said. "Their mere existence undercuts the belief that an individual cannot belong to this group and accept the science. When they discuss how they accommodate their scientific understanding and their social identity, they offer the audience a possible roadmap towards acceptance of the science."

Trends in Microbiology (2012). DOI: 10.1016/j.tim.2012.10.002

Psychological Science (2013). DOI: 10.1177/0956797612464058



WHERE THE CANDIDATES

BY CAYMAN SOMERVILLE, ENVIRONMENTAL SCIENCE, 2016
RAFI RAZZAQUE, ENVIRONMENTAL SCIENCE, 2019

DESIGN BY KYRA PERZ, CHEMISTRY, 2020

★★★★ HEALTHCARE ★★★★★

TRUMP

Trump has repeatedly signaled his intentions to dismantle Obamacare, labeling it as “expensive”, a “fraud,” and a “disaster.” Trump touts health savings accounts instead—a form of investment accounts—as a viable replacement to the current healthcare system. In addition, Trump believes allowing for competition among healthcare providers will help reduce spiraling healthcare costs.

As of 2017, a fifth of Obamacare enrollees won’t have a choice in their health care company - up from only two percent of enrollees in 2016 - due to decreased competition. As a whole, competition is shrinking as premiums continue to rise in the healthcare industry. To increase competition and lower premiums, Trump envisions buying insurance across state lines as a cheaper alternative to the current system.

CONSENSUS

The cost of healthcare and medication has skyrocketed despite America’s widespread enrollment in health insurance. Of the two candidates, the choices are to either build on the controversial Obamacare or to dismantle it and start anew. Both arguments have their merit, but the discussion on health spending is far from over and will continue to be an expensive part of our GDP.

CLINTON

Hillary Clinton has defended Obama’s Affordable Care Act (ACA), noting that though premiums, co-pays, and deductibles have increased, health care coverage across the United States is over 90 percent. Because over 20 million people have found coverage since the institution of Obamacare, Clinton believes turning back will be detrimental. By bringing down costs, Clinton believes she can increase health care coverage to 100 percent across the United States whilst “keep[ing] quality up.”

In addition, Clinton has highlighted specific terms of the ACA as successes that should not be rolled back. In the October debate, Clinton mentioned a few of them: the clause preventing insurance companies from denying coverage because of pre-existing conditions, as well as preventing companies from charging women more than men. Clinton also brought up the fact that adults up to the age of 26 can be covered under their parent’s insurance under the new terms of the Affordable Care Act. Because of these clauses and the vast coverage Obamacare has already established within the United States, Clinton wants to expand and fix health care, rather than start over with a new system. According to Clinton, “Reigning in the costs... has to be the highest priority for the next president.” She also stated in a recent debate, that we should “fix what’s broken, but let’s not just throw it away.”

★★★★ EDUCATION ★★★★★

TRUMP

Donald Trump’s education reform centers around giving families a choice in schools, a traditional piece of the Republican platform. Trump plans on diverting \$20 billion in federal spending towards “providing school choice to every American child living in poverty.” When families choose the schools where they wish to send their children, Trump will give block grants to states, allowing states to disperse money to the schools families choose to enroll in.

With regards to the controversial Common Core educational standards, Trump has promised to dismantle it, citing that “Common Core is a total disaster...we cannot let it continue.” Instead, Trump envisions empowering individual states to set their own STEM-rich curriculum to enrich future economies.

CONSENSUS

September 2016 marks the permanent passing of the 400 parts per million threshold of atmospheric carbon levels, which was set during the Paris Climate Conference to minimize global warming to 2 degrees Celsius above pre-industrial levels. With this in mind, it is imperative that the next president is focused on global climate change.

CLINTON

Though Secretary Clinton’s educational reforms focus mostly on reducing debt for college students, Clinton has promised to fund computer science education for every student in America. According to Clinton, school districts and states will be issued money to encourage computer science competency.

For college students, Clinton has promised a three month moratorium, or grace period, for all federal loan borrowers. Clinton has also envisioned free community college for all, and free tuition at in-state public colleges and universities for families that make less than \$85,000 a year. Clinton hopes that evolving education reforms will eventually allow families that make under \$125,000 a year to attend in-state schools without paying tuition.

In addition to her tuition reforms, Clinton has also pledged \$25 billion to historically minority-serving colleges and universities in order to better serve underprivileged groups.

STAND ON SCIENCE

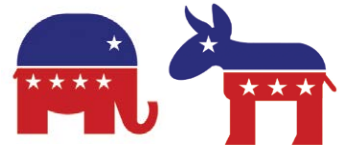


PHOTO BY DONKEYHOTTEY

★★★★ GLOBAL CLIMATE CHANGE & FOSSIL FUELS ★★★★★

TRUMP It's no secret that Donald Trump does not believe the scientific evidence behind global climate change. Following President Obama's reelection, Trump famously tweeted: "The concept of global warming was created by and for the Chinese in order to make U.S. manufacturing non-competitive." In the years following this tweet, he continued to publicly discredit global warming, calling it an "expensive hoax." Within the first fifteen minutes of the September debate, when Clinton criticized his stance, Trump denied this position.

Yet, the Republican nominee pledged to eliminate the Environmental Protection Agency (EPA) in order to balance his proposed budget, believing that "the [EPA] is killing energy companies." Trump plans to reverse recent Executive Orders and EPA regulations, such as Obama's Climate Action Plan, and promising to bring back coal plants and tap into \$50 trillion worth of fossil fuel reserves.

CLINTON Hillary Clinton intends on maintaining the Paris Agreement, signed by President Barack Obama in early 2016, in her fight against climate change. The Paris Agreement stipulates signing countries reduce greenhouse gas emissions by 30 percent by 2030, and 80 percent by 2050. In addition, signing countries promise to help maintain global temperatures at 2 degrees Celsius above pre-industrial levels, with a long-term goal to limit global temperature rise to only 1.5 degrees Celsius.

CONSENSUS September 2016 marks the permanent passing of the 400 parts per million threshold of atmospheric carbon levels, which was set during the Paris Climate Conference to minimize global warming to 2 degrees Celsius above pre-industrial levels. With this in mind, it is imperative that the next president is focused on global climate change.

★★★★ NUCLEAR ENERGY & ALTERNATIVE ENERGY ★★★★★

TRUMP Donald Trump has issued conflicting statements on his support of alternative energy. His statements in the first debate affirm he is "a great believer in all kinds of energy." By investing into energy, Trump believes "bring[ing] our energy companies back...will pay back our national debt."

On the other hand, Trump claims he invested and "lost heavily" in solar energy, while simultaneously disapproving of the EPA's renewable energy standards. In addition, Trump stated "the EPA is so restrictive that they are putting our energy companies out of business."

As part of his energy initiative, Trump aims to tap into a claimed 50 billion dollars worth of shale, oil, natural gas reserves and over 100 years worth of coal reserves available in the United States. Trump has asserted Clinton wants "to put miners out of business."

In order to stimulate the coal industry, Donald Trump must overturn several EPA measures that shut down numerous coal plants, which he claims will bring back more jobs. On the other hand, Trump has encouraged ethanol production, a biofuel that is often mixed in with gasoline.

During the primary, Trump strongly backed nuclear energy and downplayed concerns of a meltdown. On the topic of natural gas—an alternative fuel, but still carbon-emitting—Trump declared his support in a 2012 tweet when he stated, "Fracking will lead to American energy independence."

CLINTON One of Hillary Clinton's largest campaign commitments is her \$60 billion Clean Energy Challenge, which aims to encourage states, cities and rural towns to lower emissions and to promote clean energy usage. In addition, Clinton has laid out short-term and long-term goals towards securing a green future and increasing the clean energy workforce. By 2020, Clinton wants to install half a billion solar panels—enough to cover 25 million homes. Clinton envisions a clean energy future with enough renewable energy generation to power every American home, with America becoming an energy "superpower" and producing more jobs. In addition, given the current level of strife in the Middle East, Clinton has suggested natural gas is a viable, local replacement to fossil fuels that can increase jobs and economic activity.

With regards to nuclear energy, the former Secretary of State has flip-flopped on energy issues as far back as her first presidential campaign. Though her current campaign has not specifically addressed nuclear energy, her campaign has noted she leans towards "advanced nuclear" energy, favoring "successful" nuclear efforts while believing in the closure of nuclear initiatives "that fail to deliver results."

CONSENSUS In order to maintain international agreements and mitigate global climate change effects, the next executive leader must promote clean energy innovation and investment. America's energy independence and clean energy commitments have a global impact in addition to local impacts, both of which our next leader will need to successfully manage.

In Polls We Trust Scrutinize With a Healthy Dose of Skepticism

BY ANH PHAM, BIOLOGY, 2020

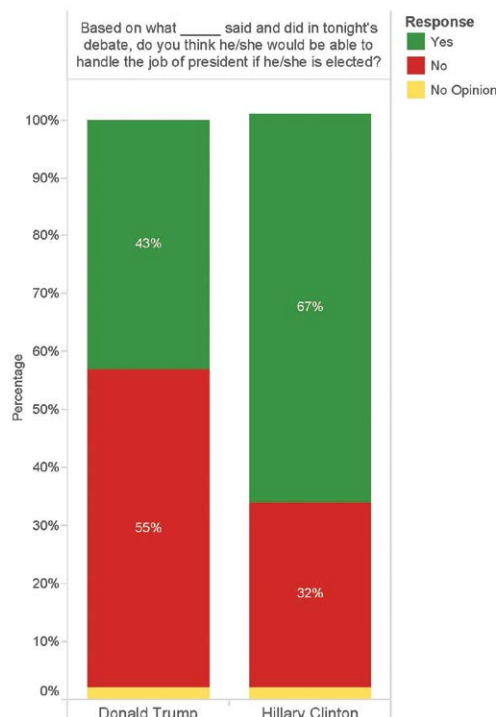
DATA VISUALIZATION BY DIANA MOREL, MATHEMATICS AND FINANCE, 2017

With statistics being repeatedly referenced by every major cable network during this nerve-wracking election, at some point most people have probably questioned the origin and the scientific integrity of these polls (or alternatively, have Googled how to become a Canadian citizen). The results of the public opinion polls that Americans see everyday on TV are often bought from consulting companies such as *Gallup*, *Politico*, or *RealClearPolitics*. These private companies have a long-proven record of gauging what millions of people think about a specific issue. However, some major news anchors also conduct their own polls, often in affiliation with market-research agencies. Such is the case with *CNN/ORC International*, *Fox News*, and *CBS*.

Take an example from the first presidential debate of the 2016 election. Besides covering and moderating, *CNN/ORC International* also interviewed 1501 adults—751 via landline and 750 via cell phones—who previously indicated they would be watching the debate and were willing to be interviewed before and after the debate. The pollster first “got to know” the interviewee by asking about their party affiliations, gender, age group, ethnicity, and economic situation (Are they in college? If not, what is their monthly income?). To obtain an honest answer, interviewers have to really narrow down the scope of what is asked. A sample question would be “Regardless of which candidate you happen to support, who do you think did the best job in the debate – Hillary Clinton or Donald Trump?” and the responses must cover all possible answers: “Hillary Clinton,” “Donald Trump,” “Both,” “Neither” and “No opinion.” Each response is weighted within a specific demographic group. That’s why a polling result among, say, Hispanic voters tends to be more reliable than just a general polling result.

There are many barriers that a poll has to overcome to have some practical value. The wording of the question must not have a potential for bias, such as “federal intervention” and “help for the poor.” The sample size also needs to be large enough and above all, random. Past statistical research has shown that a sample size of about 1,000 to 2,000 people, if done correctly, can reflect the opinion of 187 million

Americans with less than 3 percent error. Above the 1,000 mark, there is very little accuracy gained from polling more individuals. For example, a poll with a sample size of 2,000 is accurate within plus or minus 2 percent, and 1 percent more accurate than one with a 1,000 sampling size, but at twice the cost. Such a small number of people can represent the entire population if all members have an equal probability of being selected.



Moreover, the sample size doesn’t compensate for the lack of random selection. In 1936, *The Literary Digest* predicted that Alfred Landon, the Republican nominee, would defeat Franklin D. Roosevelt, the Democrat. They polled 2 million of their readers on who would win the election, without taking into account that most of them were more affluent (i.e. able to afford a newspaper subscription during the Depression) and more likely to be Republican. However, the majority of voters, the middle and lower classes, welcomed Roosevelt with open arms.

With so many variables, how do pollsters keep those margins of error small enough for polls to accurately reflect a trend? The key for an accurate prediction to collect as much data as possible. *Gallup*, for example, has been predicting election results since the time of Roosevelt. Their computers and technicians have the advantage of more time and data to perfect the art of weighing. They also fund experiments to improve their methods and find ways to eliminate bias. One of the questions that is historically proven to be unbiased is *Gallup*’s question on presidential performance: “Do you approve or disapprove of the job (blank) is doing as president?” That wording, once it has proven to elicit a true reflection of what the general population thinks, will stay the same for decades.

What about something that is new and has no data to confirm its effectiveness? Recent elections have seen the emergence of Internet polls. They are promising for their convenience, but they have a small audience that excludes most of the people who show up to actually cast ballots. Internet polls also do not have a safeguard against bias, so they are a pretty terrible indication of public opinion. Our first response should be caution when we hear about them, but then again, shouldn’t that be our reaction to all polls?

D.O. or DON'T?

Doctors of Osteopathy: The underdogs of the medical world

ARTICLE AND DESIGN BY HEATHER OFFERMANN, BEHAVIORAL NEUROSCIENCE, 2018

Since the beginning of time humans have quarreled about how our bodies should be examined and treated, and rightfully so, as the human body is particularly personal and sacred to each individual. Every doctor has their own beliefs about how they like to practice medicine while treating their patients. The overarching philosophy typically stems from the education they received in medical school.

Competition is one of the driving forces of today's medical students. Feuding for becoming the "best doctor" leads students into a whirlwind of biased attitudes towards medical remedies that differ from their personal preference, and this unfortunately creates a clashing of fields. Many undergraduates aspiring to become a doctor may not yet know about the two different, yet strikingly similar, medical degrees that are offered at medical schools. Many are already familiar with the traditional, allopathic Doctor of Medicine (MD) that most connect with at their family practice, but another important degree to consider is the Doctor of Osteopathic Medicine (DO), the unique underdog of the medical world.

There's a subtle rivalry between MDs and DOs. Many MDs will say that osteopathic doctors "aren't real doctors," and that a DO is a degree to fall back on instead of one

“Competition is one of the driving forces of today's medical students.

to strive for. Where did these assumptions come about? Let's define each type of doctor. An MD student attends a typical, four-year medical school and studies the practice of medicine in order to access and diagnose patients, prescribe medicine, and, under certified training, perform surgeries. They have the freedom to specialize in a variety of fields, but all students graduate medical school with an MD. A DO student follows the same educational pathway in medical school, and can apply for the same residencies and fellowships as MD students. In the end, both types of licensed doctors are allowed to practice medicine and surgery in all fifty states.

So why is one of these two licenses so criticized over the other? DOs are trained to take on a more holistic approach while diagnosing and treating patients, and are constantly reminded of the powerfully underestimated mind-body

connection. For this reason, DOs are often nicknamed "hippy doctors," and practitioners of "pseudoscience," which is defined by a collection of beliefs that are presented as legitimate but have no scientific evidence. One 2010 Forbes article by Steven Salzberg questions the legitimacy of osteopathic physicians, suggesting that colleges of osteopathic medicine do not fit the bill due to the lack of science in DO training. However, a 2015 article for

GreenMedInfo from Dr. Larry Malerba defends osteopaths, stating that "homeopathy tailors its treatment to each individual with doses that are far smaller and, therefore, far safer."



DOs require all of the same schooling and training as MDs, with the addition of a program of special training for Osteopathic Manipulative Treatment (OMT), which educates students about the "interconnected system of nerves, muscles, and bones," allowing for the promotion of overall health, mobility, and prevention of pain and diseases. Prescriptions are still given by DOs, and surgeries are still performed, but the OMT is meant to supplement medical technology. During a typical examination, DOs take into consideration the lifestyle and environmental conditions of their patients instead of just focusing on symptoms.

Another important component of the battle between these two types of physicians happens long before students receive their licenses. The rivalry can be traced back to the application process for getting into these medical schools. Overall, students are accepted into DO programs with lower MCAT scores and GPAs than MD applicants, and there are currently only 33 osteopathic medical schools in the country. These facts give rise to the belief that obtaining a DO degree is easy, and that the osteopathic program only attracts people who couldn't get into traditional medical school. Students who strive for DO school are often questioned for their choice, which provides an opportunity for the person posing the question, "Why DO?" to become more educated about the degree.

Whether or not you believe in the holistic philosophy of osteopathic doctors, it's important to remember that it's just another path, one that more than 20 percent of medical students currently choose to follow. Both degrees have their benefits, disadvantages, and preference among patients. The number of students pursuing DOs is expected to grow through appreciation and popularity over the next ten years. However, the feud is not likely to dissipate until the misunderstood world of DOs can be respected for its differences.

How Zika Might Be Contained by Genetically Modified Mosquitoes



BY LINH "DENNY" TRUONG, CHEMISTRY, 2020

DESIGN BY HEATHER OFFERMANN, BEHAVIORAL NEUROSCIENCE, 2018

The most recent Zika outbreak has been one of the hottest headlines throughout every news channel. Although healthy adults have little to no symptoms or effects from Zika, the virus can have devastating impacts on fetuses inside pregnant women. According to Dr. Amilcar Tanuri of the Federal University of Rio de Janeiro, not only can Zika increase the chance of microcephaly, a condition that results in the abnormal development of the brain, but studies also find a connection to neurological abnormalities. Since there is currently no vaccine, the best way to prevent the spread of Zika is to target the mosquito population. For this reason, Oxitec, a biotechnology company based in Oxford, has proposed the release of genetically modified mosquitoes into the environment to reduce and control the mosquito population.

Since only female mosquitoes bite, Oxitec designed a male genetically modified mosquito—known as OX513A—that is the species that carries the Zika virus—the *Aedes aegypti*—with altered DNA. Essentially, this modified DNA ensures that the male's offspring will die before reaching adulthood. While this solution seems reasonable and optimal to reduce mosquito populations and limit transmission of the virus, it nonetheless is a controversial approach, due to doubts about its effectiveness and safety. Although governments of countries such as Brazil, the Cayman Islands, and Panama have encouraged clinical testing by releasing OX513A into a controlled environment and tracking the changes in the mosquito population, the public still opposes this potential solution. The United States Food and Drug Administration (FDA) approval for the local release of OX513A in Key Haven, Florida this past August only sparked more controversy.

Oxitec's solution allows Zika to be contained due to the lack of vectors that carry the virus. Recent studies indicate the advantage of using modified mosquitoes to reduce the vector's population. Oxitec has established programs and experiments in countries that support testing, and the results are encouraging. It is confirmed by the company that the OX513A mosquitoes can reduce up to 80-90 of the mosquito population in affected areas.

"We have seen 90% suppression of *A. aegypti* in every field trial we've run. If you're going to use insecticide, the best you get is 50% suppression," said Simon Warner, Chief Scientific Officer of Oxitec, in a 2016 report for The BMJ. Not only is the rate of reduction higher than any other methods, genetically modified mosquitoes are a cheaper and timesaving solution as opposed to developing a cure or vaccine for Zika. Nature acknowledges that although a

vaccine is several years away, the world cannot wait that long to contain the Zika outbreak.

Although Oxitec has guaranteed safety to humans, animals, and the environment, there are still skeptics who oppose the solution. Though OX513A has been approved in Key Haven, citizens are still hesitant to allow Oxitec to release it into their environment. There are a number of reasons for this widespread concern, including the age-old argument that it is wrong for humans to alter genetics in nature. Most of the data from the project has been provided by Oxitec, raising the concern of credibility.

According to one paper in *Nature*, people are also concerned about how OX513A will perform on a larger scale instead of just in small, controlled territories. There is also currently no direct evidence that links the reduction of vectors to the decrease in Zika infection, although logically that result would be reasonable. Furthermore, mutations could occur to either the OX513A or its offspring, which might give rise to another species that could harm both humans and the ecosystem.

While researchers and the government are both pushing hard to find a fast and safe way to contain the Zika outbreak, it is important to be cautious with genetic modified organisms. Given the risks, some might question the decision to release modified mosquitoes into the wild. However, considering the reward is the reduction of Zika-carrying-vectors and other diseases such as malaria and dengue fever, clinical and field experiments are the logical step to take, both for now and in the future.

JAMA Neurol (2016). DOI: 10.1001/jamaneurol.2016.3720.

Nature Biotechnology (2016). DOI: 10.1038/NBT0316-221.

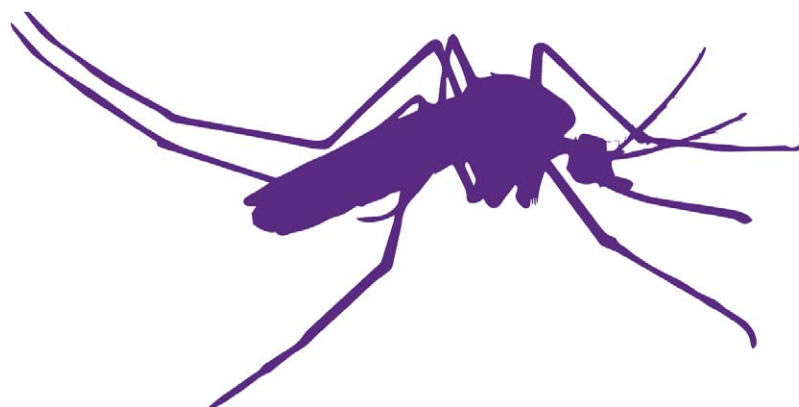


PHOTO BY CYNTHIA GOLDSMITH

Public Outreach: It Benefits Us All

PHOTO BY RICHARD HOPKINS

BY ADRIANNA GRAZIANO, BIOLOGY, 2019

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2020

As scientists, public outreach is a part of our responsibility to increase knowledge in the surrounding communities, pass effective policy, and acquire government funding. However, over the past few years, the general public has expressed growing distrust of the scientific community. A poll conducted by the Pew Research Center in 2014 found that 15 percent of U.S. adults believe that science has made life more difficult for most people, a figure that increased from 10 percent since 2009.

It's easy to blame the educational system or misinformed politicians for this knowledge gap. However, lack of community outreach in science degree programs may also be the culprit. As students and professionals become more specialized, the focus is on communicating research between colleagues and collaborators. Community outreach is left on the back burner, with many not knowing who should be responsible for educating the public and whether or not this education is even necessary for research.

The poll conducted by Pew Research Center shows us that public outreach is necessary for science to progress. If the public distrusts scientists, it creates two separate communities: us and them. Science shouldn't be combatting public thought; rather, it should be molding and guiding public thinking along with scientific developments. Thus, all scientists should feel responsible to make their research relevant to the public, who can show researchers what to focus on and where the need is, especially on issues of public health.

Dr. Gail Begley, teaching professor at Northeastern University, suggests that "students and scientists at all levels should work on articulating science and 'putting it into words.' It is our privilege, and therefore our duty, to educate the public." Begley helps her students learn this skill by enrolling them in the Service-Learning program at Northeastern, where they communicate science to various groups of people within the Boston community, from young students to Spanish-speaking mothers. This program is effective in reducing this environment of distrust because it allows people to learn about relevant topics and ask questions of the scientific community directly. It also gives more formal training and experience to young scientists, who can then communicate what they're learning to different audiences.

At the end of the day, we need to provide a means for students at all levels to gain experience and to understand the importance of public outreach. For science to progress, it is our job to make it relevant. By implementing and engaging in programs such as Service-Learning, we can learn how to effectively communicate science to change the public's perspective on how they view science and its teachings.

Companies Unwilling to Take a Hit With Zika Vaccine

BY HUGH SHIRLEY, BIOCHEMISTRY, 2019

In the past year in South America, a record number of babies were born with microcephaly, a typically rare congenital disease that causes a small head and other developmental problems. Research shows that there is an undeniable link between microcephaly and the ongoing Zika epidemic. Now more than ever, people are turning to pharmaceutical companies to create vaccines that will curb the danger that infection presents to pregnant women and their unborn children. Zika is spread by *Aedes aegypti* and *Aedes albopictus* mosquitoes, both of which are found in the U.S. Primates act as a reservoir for the virus.

Unfortunately, those that need the vaccine the most are the ones least able to afford it. Poor slum residents in South American cities are at high risk of infection. Drug companies hope that travelers from wealthier countries who need a Zika vaccine will be able to subsidize the cost, allowing cheaper prices for the poor.

While multiple drugs are in development by different companies, they will all be slow to come. Furthermore, the

recent global history of epidemics like Ebola, SARS, H1N1, and West Nile Virus has left pharmaceutical companies reluctant to dip their toes into the Zika pool. Few know this better than Dr. John Heinrichs, the head of the Zika project for Sanofi Pasteur. In an interview with STAT, he explained how drug companies invest large sums of money to quickly push vaccines forward just to see the epidemic coming under control. Vaccine production is a long, expensive process, from synthesis to testing, approval, production, and distribution. Companies that can't guarantee that they will earn back their expenses are less likely to take a risk.

These problems prevent the needed vaccines from being produced. It would be unfair to blame the pharmaceutical companies; instead, it's a matter of economics. Dr. Rip Ballou of GSK Global Vaccines explained in the same STAT article how past epidemics have influenced production. "As a consequence of our experiences with pandemic flu, with ebola.... we cannot continue to do business like this in the future. It's too disruptive. There has to be a better way of doing it." Our next step then, is finding that better way and making a change.

Hawking's Hairy Black Holes

BY JAMESON O'REILLY, PHYSICS AND MATH, 2019

DESIGN BY CATU BERRETTA, COMPUTER SCIENCE 2016

One thing that Stephen Hawking has in common with your local sage is that they both believe that everything happens for a reason. For scientists, Professor Hawking included, this is less religious or karmic and more to do with simply preserving the notion of cause and effect. Everything that happens must have been caused by what was happening before it and the laws of Nature. Over time, the cosmos and every part of it goes from state to state by way of logical chains of events governed by both known and unknown principles. This belief is known as causal determinism.

In theory, one should be able to take the current state of the universe, frozen in time, and trace it back to find out what happened before. In other words, all of the information about the past must be encoded in the present. This is the foundation of much of scientific thought and research, so it was a big shock when, in 1976, Stephen Hawking explained a process through which information could be permanently destroyed.

The key to this process is the idea from particle physics that "empty" space is not really empty at all. Every particle has an antiparticle, such as the electron and positron, and pairs of one particle and one antiparticle each can pop into existence and pop back out almost instantaneously anytime, anywhere, even in the cold emptiness of space right on the edge of a black hole. These are called virtual particles and have essentially no energy. If a pair happens to pop up such that one is inside the edge of the black hole and the other is outside, the one inside will be sucked into the hole and the pair will be unable to annihilate each other like usual. Instead, the free particle is forced to become real, which it does by taking energy away from the black hole and flying away.

These new particles are what is known as "Hawking radiation," and the energy that they take from the black hole causes it to shrink over time due to the equivalence of mass and energy expressed in Einstein's famous $E=mc^2$. Eventually, this process will cause the black hole to lose all of its mass, in which case it will disappear. The information about what was sucked into the black hole will be lost along with it. While the information was in the black hole, it was still technically in existence as part of the universe, so causal determinism is not violated. Once the black hole

completely evaporates, however, the information inside of it is irreversibly lost, or at least so Hawking thought then.

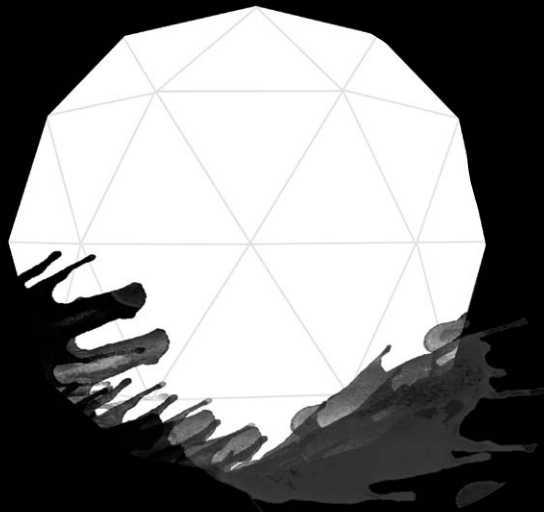
This violation of causal determinism has unsettled scientists for decades and, unfortunately, every attempt to solve it has come at the expense of some other, even more important physical axiom. Thankfully, earlier this year, the man who initially pointed out this paradox began the process of resolving it with the help of Andrew Strominger, a physics professor at Harvard. In the first of what will likely be a series of papers, Hawking and Strominger

described how the information that falls into the black hole and is later destroyed is actually encoded in what they call the "soft hair" of the hole.

This "soft hair" is basically collections of very low energy photons and gravitons that surround the black hole. This hair interacts with the particles that get sucked into and fly away from the black hole. These interactions save the information that otherwise would just be destroyed when the black hole fully evaporated from Hawking radiation.

It still exists in the same way that the information contained in a book still exists when it is burned. Any different configuration of ink on paper will burn slightly differently, so every book will have a different "signature" than any other book. In that sense, one could theoretically determine what the burned book said if they knew everything about the smoke particles. Practically, this information is much too complex and jumbled to ever actually reconstruct, and it is the same thing for the information being encoded outside of the black hole. It still exists in principle, which is the key for preserving causal determinism.

Hawking and Strominger thus far have only shown that this can work for electromagnetism, meaning that the charge entering the black hole is encoded in the soft photon surrounding the black hole. The analogous calculation for gravity is promising but not yet completed. If it does work out, the information paradox will be resolved and astronomers will be able to rest easy once again.



rocket rivalry

BY SAMANTHA GLASSNER, MECHANICAL ENGINEERING, 2020

DESIGN BY ANNA LI, BEHAVIORAL NEUROSCIENCE, 2019

“ We have set a clear goal vital to the next chapter of America's story in space: sending humans to Mars by the 2030s and returning them safely to Earth, with the ultimate ambition to one day remain there for an extended time.

PRESIDENT BARACK OBAMA

President Obama's recent declaration solidifies our country's goal to reach the next plateau of space exploration: sending humans to a celestial body outside of our orbit. Obama echoes the ethos of John F. Kennedy's brazen claim in 1961 that the nation would land a man on the moon before the decade was out. Today we have no Cold War face-off to motivate the government to intensify support to the National Aeronautics and Space Administration (NASA). Instead, Space Race 2.0 contestants are privatized space exploration companies vying for NASA project contracts.

"Getting to Mars will require continued cooperation between government and private innovators, and we're already well on our way." – Barack Obama

Currently, SpaceX and Orbital ATK are the major private companies involved in space transportation. They are part of the International Space Station's (ISS) Commercial Resupply Service to replenish their supplies and remove trash. Along with their current efforts, SpaceX has successfully completed secondary missions to utilize reusable rockets.

In addition to supply runs, NASA's Commercial Crew Program is looking for companies to create a launch vehicle to shuttle astronauts to the ISS. Such a launch vehicle would free NASA from depending on European or Russian space agencies to transport american astronauts. Allocating basic resupply projects at private companies allows NASA to shift its efforts elsewhere, like to future deep space and Mars missions.

The fierce competition has pushed private space companies to differentiate themselves through groundbreaking technology. Boeing claimed the contract to build the Space Launch System that NASA is planning to use in

their journey to Mars - with a goal of sending humans to the Red Planet during the 2030s - while SpaceX's plan is self-funded and independent of government projects. Elon Musk, SpaceX CEO, has pitched his company's plan to get humans to Mars before 2030 and create the transportation foundation for a colony on Mars. In a recent interview with AtlanticLIVE, Boeing CEO Dennis Muilenburg retorted, "The first person to step foot on Mars will arrive...on a Boeing rocket."⁷

Private companies are chasing the boundaries of space exploration with grandiose aspirations and ambitious timelines. Not only does NASA benefit from this technological competition, but the ongoing rivalry is inspiring a new generation of scientists and engineers to make dreams of space travel a reality.

Northeastern's Race for Space!

This new age Space Race frenzy is so ingrained that rocket rivalry has also broken out at the university level - including right here in Boston. Project Karman, part of Northeastern's chapter of the American Institute of Aeronautics and Astronautics (AIAA), is hoping to make Northeastern the first university to launch a rocket into space. They aim to surpass the Karman Line, which marks the shift between earth's atmosphere and space 100 kilometers above earth's surface. Project Karman, as well as the numerous other groups that are currently working towards reaching the final frontier, are proof that space travel will always provide opportunities to advance scientific knowledge through healthy competition.

PHOTOS BY WIKIMEDIA COMMONS



From Seagulls to Penguins: My Co-op at SANCCOB



BY SHEINA RAJKUMAR, BIOLOGY, 2017

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2020

In the fall of 2016, I decided to trade in my Northeastern sweatshirt for oilskins and crocs while working 8a.m.-6p.m. and treating various injured seabirds. I got the chance to travel back home to Cape Town, South Africa, where I spent three unforgettable months working with the SANCCOB, the Southern African Foundation for the Conservation of Coastal Birds.

This non-profit organization was established in 1968 with the goal of rescuing, rehabilitating and releasing injured, ill, abandoned or oiled coastal birds. They are especially dedicated to oil-spill response and reversing the decline of various seabird species.

Currently, SANCCOB has saved 95,000 seabirds, treated 24 different avian species, reared 2,407 chicks and aided in an overall 19 percent increase in the African penguin population. I spent three months as a seabird rehabilitation intern, where I was taught hands-on rehabilitation techniques and became familiarized with numerous areas of the rehabilitation center to treat various seabirds, such as seagulls, cormorants, gannets, pelicans, and African penguins. SANCCOB put a lot of trust in my abilities, and they were willing to train me even though I lacked prior experience.

As an intern, my responsibilities ranged from documenting and admitting new birds into the rehab center to releasing birds I had worked with over the previous weeks. The beginning of my training was particularly difficult, as I was thrust into the flying birds' pen. My first task was to catch flying seagulls and place them in crates to be carried to the medical center for check-ups.

It wasn't about to get easier. Next, I learned to document, hold, weigh, feed, hydrate, conduct physical therapy on, and medicate birds, as well as sanitize the entire center and prepare their food. However, my hard work certainly paid off. At the end of my time at SANCCOB, I had the ability to run the center as a leader without any supervision, and I could work in the intensive care unit (ICU) of the hospital treating the high-risk birds.

One of the most valuable aspects of my time at SANCCOB was the relationships that I built. In the scientific field, it is extremely difficult to encounter mentors who are willing to take an immense amount of time to teach the valuable skills

needed to eventually take charge. While I was building these skills on co-op, I worked with various international and local volunteers and interns who have become some of my closest friends.

It was very challenging learning to treat animals, since unlike humans, they cannot explain their symptoms or ask for help. However, it was also extremely rewarding. My proudest moment was releasing 11 African penguins I had worked with intensely for three weeks at Boulders Beach, a beach known for its amazing wildlife conservation

efforts and a prime spot for African penguins. Knowing that my hard work gave the penguins the strength to return to their natural habitat and boost their declining population made everything worthwhile. By working with SANCCOB, I was able to discover a passion for wildlife conservation. I highly

recommend this experience to anyone who is looking for animal handling experience and has a love for animals and learning.

“Knowing that my hard work gave the penguins the strength to return to their natural habitat and boost their declining population made everything worthwhile.”

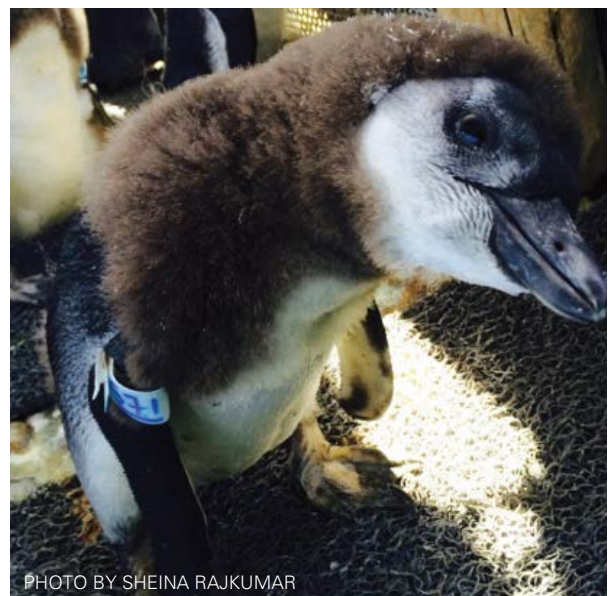


PHOTO BY SHEINA RAJKUMAR

Graduate Students and Unionization

BY ZIFISO NYONI, CHEMISTRY, 2020

DESIGN BY ALEX GUSHULAK, CIV ENG, 2021



For nearly as long as the university system has been around, graduate students in schools across the country have partaken in a system that involves learning, research, and the development of a thesis or dissertation in pursuit of an advanced degree. On top of these commitments, graduate students work as teaching and research assistants. On August 23, 2016, the National Labor Relations Board (NLRB) issued a 3-1 decision in Columbia University that student assistants working at private colleges and universities are statutory employees covered by the National Labor Relations Act.

This decision grants any student performing research or teaching in a private institution the right to be represented by a union, as they are considered school employees in the eyes of the NLRB. The ruling has led to the quick formation of graduate student unions at universities across the country and, perhaps more importantly, the legitimization of already-existing unions.

The coalescing of students in this manner is important because unionized students have the power of collective bargaining, a process by which they can negotiate contracts to determine their terms of employment including pay, benefits, hours, and job health and safety policies.

Many proponents of unionization contend that universities have increased their dependence on doctoral students instead of full-time professors to teach. Approximately 91 percent of undergraduate laboratory sections at research institutions are taught by graduate teaching assistants, according to one 2012 study. As the work they do is a component of their education, graduate students have struggled to attain benefits that reflect this increased responsibility without unions.

In addition, many graduate research assistants are on the frontiers of their respective projects with principal investigators. Many graduate students in the sciences log 60 to 80 hours of research work in a week in pursuit of completing their thesis or dissertation. The services graduate students provide with seemingly little return are done despite the fact that many of them have families and other significant financial obligations that undergraduates do not. The mean annual wage for graduate student teaching assistants is \$32,510, with variations based on field of study and university, according to the Bureau of Labor Statistics. Some believe that this is not adequate for a sustainable livelihood for many students.

Places where collective graduate student presence is already strong have witnessed schools being more responsive to graduate workers' needs by increasing stipends, extending paid family leave, and providing childcare subsidies. Unionization, however, has faced its fair share of opposition, especially from academic institutions. Officials argue that the academic relationship students share with faculty members and departments as part of their studies is not equivalent to that of an employer and employee, making unions unfit for the situation.

Philip Miscimarra, the lone dissenting vote in the August NLRB 3-1 decision, deemed managing student-faculty relationships like an employer-employee relationship a detriment to the educational process. The students'

“ Many graduate research assistants are on the frontiers of their respective projects.

“successful completion of degree requirements results from the combined commitment of faculty, administrators, and the students' own academic efforts,” he declared. The potential threat of either

faction - graduate students or the institution - using economic weapons to injure one another, a process that is often involved in collective bargaining, could deter the educational process, Miscimarra says.

“The ‘business’ of a university is education, and students are not the means of production – they are the ‘product.’” With those words, Miscimarra voices the opinions of the majority of academic institutions. This definition of students as the product of the institutions' ‘business’ operations delegitimizes any right graduate students have in unionizing and employing collective bargaining. However, those in favor of student unionization assert that although students are completing course requirements in pursuit of an advanced degree at the hands of the academic institution they attend, the services they provide while completing these requirements warrant the rights and capabilities of other laborers in more traditional labor-management models.

So what exactly are graduate students? Are they exactly what the name implies, students that are simply doing the things needed to receive their desired higher degree? Or are they laborers, providing their academic institutions with low-cost teaching and research services? Perhaps the modern-day graduate student occupies a space in between these definitions. With new developments granting graduate students newfound leverage and power, their role may experience an unprecedented evolution.

The Epic EpiPen Debacle

A review of the recent EpiPen price increase

BY BIRUK ABREHA, CHEMISTRY, 2019

Millions of Americans suffer from some type of allergy. For some, exposure to an allergen can result in a mild rash or, in severe cases, anaphylaxis, a reaction which may cause a large drop in blood pressure and blockage of the airways due to swelling. This potentially life-threatening allergic reaction requires immediate medical attention. There are more than 200,000 cases of anaphylaxis per year in the U.S. Luckily, there exists an acute treatment: epinephrine. It can be instantly administered in the proper dosage via an auto-injector. The most common type of auto-injector is the EpiPen.

The company that markets the injector, Mylan, acquired the EpiPen in 2007, and in 2009, the price of two injectors was \$103. Last May, the price for two auto-injectors increased to \$608. The epinephrine in the injector is worth just a few dollars. This begs the question - how can a single auto-injector cost more than \$300? This injector can mean the difference between life and death for many allergy sufferers, so the price increases have left many feeling outraged, especially those whose health insurance does not cover the cost of the injectors. The fact that Mylan CEO Heather Bresch earned \$18.9 million in 2015—a 671% increase from her 2007 earnings—only fuels the outrage.

In September, Bresch was brought in front of a congressional committee to explain the hefty increases in the price of the injector. In the middle of a particularly divisive election season, the CEO managed to receive scrutiny from democrats and republicans alike. She brought with her a poster, outlining the costs associated with the EpiPen. Bresch said that since there are numerous middlemen involved in the manufacture and sale of the EpiPen, Mylan only receives \$274 for each two-pack of the injector. According to the numbers presented to the House Oversight Committee, the two-pack costs about \$105 in addition to overhead costs, which brings Mylan's net profit for each EpiPen two-pack to \$100. Bresch's testimony was vague at times. Representative Elijah Cummings said he was unimpressed by the company's "simple but corrupt business model." Furthermore, it turns out that the profit estimates presented included a 37.5% corporate tax reduction; in reality, Mylan had an overall 7.4% tax rate in 2015. This means their actual profits are closer to \$166 per two-pack. Nevertheless, the steep price of the EpiPen has led many to search for alternatives.

DESIGN BY HEATHER OFFERMANN, BEHAVIORAL NEUROSCIENCE, 2018

Mylan has responded by launching a generic EpiPen that is identical to the current EpiPen, but sold at a 50% discount. This immediate response to public outcry suggests that the company was already capable yet unwilling to lower, if not stagnate, the price of the EpiPen. It also disputes the narrative presented by Bresch to the congressional committee. Besides the recently introduced generic EpiPen, there are currently no FDA-approved generics. Teva Pharmaceuticals had a generic auto-injector under review by the FDA, but the administration cited "major deficiencies" in the injector, delaying the product's release until at least 2017. Though the FDA cannot disclose the information, the administration likely has other generic auto-injectors under review.



PHOTO BY GREG FRIESE

This recent case of the EpiPen brings attention toward the much broader issue of pharmaceutical companies charging exorbitant amounts for their drugs. Many might hesitate to trust "Big Pharma" especially after Bresch deceived the public regarding Mylan's actual profit margins. A particularly unique case of apparent price gouging by pharmaceutical companies is that of Sovaldi, a drug developed by Gilead Sciences to treat hepatitis C. A single pill costs \$1,000 and must be taken daily for 12 weeks. Some may wonder how it's possible that a drug could cost so much. In many cases of expensive drugs, the high cost is intended to make up for the money invested in the research and development of the drug. A single drug can cost billions of dollars to develop from start to finish. However, this doesn't apply to the EpiPen because epinephrine is incredibly cheap to make, and the technology in the auto-injectors is fairly mature. Northeastern University Professor Robert Hanson suggests that, "Prices are likely to be driven by market forces," or what companies can charge before there is pushback.

One possible solution is to increase government regulation in the pricing of drugs and medical devices. In some European countries, prices related to drugs and medical treatment are set by the government and are thus free from market forces and monopolization. The same EpiPen two-pack which costs \$600 in the United States can be purchased for \$117 in the United Kingdom or \$105 in the Netherlands, the location of Mylan's corporate headquarters. Would such a system be effective in the U.S.? According to Professor Hanson, "One needs a technologically informed public to provide informed legislative [and] regulatory oversight in this area. Currently, we do not have this."

Humans vs. Nature

The Anthropogenic Impacts of Humans on Earth

BY CAYMAN SOMERVILLE, ENVIRONMENTAL SCIENCE, 2016

DESIGN BY ANNIE LEE, GRAPHIC DESIGN, 2019

In the years to come, historians will likely recall September 2016 as the time global climate change passed the point of no return. In order to have even a chance of maintaining a global average temperature rise of 2°C or less above preindustrial levels, atmospheric carbon dioxide (CO₂) levels would need to stay below 450 parts per million (ppm). These emission and temperature rise limits were internationally agreed on at the Paris climate conference, citing the dramatic impacts of such a warming on humans and other species worldwide. Additionally, the Intergovernmental Panel on Climate Change (IPCC) had called for drastic remediation to prevent the prevent us from reaching the “tipping point” of 400 ppm, stating that in order to maintain the 450 ppm limit, nearly 80 percent of fossil fuel reserves would need to remain untouched. While atmospheric carbon levels are typically lowest in August and September, CO₂ remained above the “symbolic threshold” of 400 ppm during the seasonal change, alerting scientists worldwide that we had passed the point of no return.

Global climate change has had extremely severe impacts on aquatic organisms, as seen in the devastating damage to coral reefs due to changes in ocean chemistry. However, land use also dramatically affects animals. In the early 1900s, when hydroelectricity first became popular in the U.S., dam constructions increased significantly. Today, many detrimental effects of dams have been identified, including the restriction of flow, shifting of sediment, relocation of organisms, biodiversity loss, altering of water temperatures, and impact on water quality. These upstream and downstream hydrology, geomorphology, and habitat changes have led to many threatened and endangered species. However, some of these effects can be reversed, evidenced by the river herring’s return following dam removals.

Today, dam removals are common in river restoration projects. There are over 3,000 dams in Massachusetts and only 250 are used for flood control, hydropower, or water supply. The rest were originally utilized for textiles and milling, and are now recreational or kept because of aesthetic or nostalgic purposes. By removing dams, environmental planners eliminate barriers to fish passage and sediment transport. When the 200-year-old Hopewell Mills Dam was taken out of the Mills River, the Nature Conservancy reported that over 1,000 river herring (alewife native to New England) returned for migration

the following year. Herring travel from saltwater to freshwater to spawn—a custom essential to their continued survival. As part of a commitment to opening up passage to the Atlantic Ocean, this project is the first of three dam removals.

River systems are connected, so urban growth has detrimentally impacted numerous ecosystems. Urbanization has disturbed ecosystem services, caused unusual stream discharges, and has also impacted hydrology—disrupting both the timing and magnitude

of river flows. Many studies have found that urbanizing areas has accelerated the warming of Earth and CO₂ emissions, while the full effects on the climate system have yet to be understood. Furthermore, studies have found a linkage between global climate change and the increase of both the frequency and magnitude of flood risks. This is particularly problematic when we build on floodplains, which are likely to collapse during severe flood events because natural water channels have been altered.

Converting Earth’s surface to urban landscape is, according to one 2011 study, “one of the most irreversible human impacts on the global biosphere.” In addition to altering the climate, this anthropogenic force alters hydrologic and biogeochemical cycles, impacts resources, causes habitat

fragmentation, and reduces biodiversity. These effects are particularly relevant during unique natural disasters, such as Hurricane Matthew, which caused extensive property and environmental damage—especially when human impacts have already weakened the ecosystem.

The creation of monocultures in our industrialized agriculture system causes sediment to be highly packed, resulting in a lack of infiltration and runoff carrying high amounts of nutrients. This runoff has been found to accelerate pollution of our water bodies, further impacting sensitive ecosystems. Freshwater watersheds provide essential ecosystem services, such as spawning habitat, water retention, raw materials, biodiversity, and erosion control. It is imperative that humans understand their influence on organisms and ecosystems, and take the necessary steps to mitigate these impacts before more species go extinct.

PLOS ONE (2011). DOI: 10.1371/journal.pone.0023777.



The Fight For Light

Tesla, Edison, and the Battle to Power the Future

BY MATT DEL MASTRO, BIOLOGY, 2017

DESIGN BY ALEX GUSHULAK, CIVIL ENGINEERING, 2021

It's hard to know exactly what spectators in the crowd were thinking as engineer Harold Brown prepared to discharge 1000 volts of electricity onto a frightened pet dog. Some desperately tried to halt the demonstration, while others fled in horror. Perhaps some asked: what could drive a man of science, trained in the practices of calculated logic and dispassionate reasoning, to such destructive madness? The answer lies in the story of a clash of principles between scientists, infused with large egos and even larger sums of money, until it was transformed into one of the most notorious rivalries in scientific history.

The war of the currents originated with the conflicting ideas of two brilliant, if diametrically opposite, inventors. By 1886, Thomas Edison had worked hard to establish a direct current (DC) electrical grid to power New York's homes and public buildings. The hard-headed Edison always had as much of an eye for business as he did for invention. Science was a way to fill a market gap and make big profits, and all he had to do was put in the man hours: "one percent inspiration, and ninety-nine percent perspiration." The great flaw of DC – its inability to change between the high voltage necessary for long distance travel and the low

switching between high and low voltage, an AC generator could provide power over much greater distances than DC. Thus, instead of building power stations everywhere electricity was needed, the power could be brought in from remote energy sources such as waterfalls. Tesla was developing a motor to work with AC, and he was eager to bring Edison into the fold on his pet project. However, his new boss had already made vast investments in DC infrastructure and was not receptive to change. "Spare me that nonsense" was his sharp dismissal. Yet any animosity was soon put aside as Tesla made a name for himself as Edison's most talented and hardest working employee. Even the boss himself couldn't deny that the new immigrant was "a damn good man."

Despite the tumult of moving to a new country and working around the clock work for Edison, Tesla couldn't stop new inventions from springing forth in his mind. He soon returned to Edison with a new plan to overhaul the Edison Company generators to maximize profits while remaining within the confines of DC. Edison was enticed by the financial benefits, but didn't believe that Tesla could accomplish such an enormous feat. He sardonically

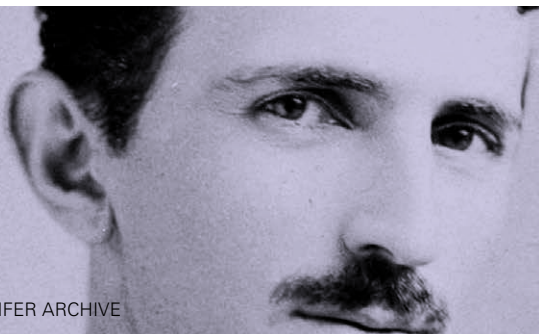


PHOTO BY MARC SEIFER ARCHIVE

“Tesla stormed out of the Edison Company, leaving in his path an unbridgeable chasm between the two men.

voltage needed to power lamps – was not going to stand in the way of his electrical empire. However, Edison's plans would soon be thrown awry by his company's newly hired engineer from Serbia: Nikola Tesla.

The whimsical and eccentric Tesla was Edison's perfect foil; when he wasn't applying his penetrating intellect to troubleshooting Edison's machines, he was dreaming up new devices and building them in his mind's eye. These engineering solutions, which over the years included flying machines and underwater mail tubes, were often imaginative to the point of fantastical. Above all, his greatest fixation was with alternating current (AC). By

declared: "There's fifty thousand dollars in it for you – if you can do it." Perhaps Edison saw the outlandish offer as the end of the matter, but Tesla was just getting started. He labored for a year to implement the renovation; at last, he was ready to claim his prize. Edison quickly recovered from the shock of the request and brushed off his young employee by picking on his immigrant roots. He chided, "Tesla, you don't understand our American humor." Whether this was a gross about-face by Edison or a pitiable misunderstanding by the socially awkward Serb is a matter for debate. Indeed, some Edison supporters question whether such an offer was made at all. All that can be known with complete certainty is that Tesla stormed out of



PHOTO BY CALEB RIENIGK

the Edison Company, leaving in his path an unbridgeable chasm between the two men.

Tesla soon found a more receptive partner in George Westinghouse, a new electricity magnate for whom Tesla's motors were the final piece in the puzzle for the AC power network he had already been assembling. Westinghouse was a titan of industry who had made his name in the railroad business. While his quiet nature didn't lend him the mass appeal of Edison, who the media had by this point elevated to something of a celebrity, he had a good reputation with employees and associates for benevolence in an age when most industrialists were out to get rich on the backs of their laborers. Rather, the romantic Westinghouse was firm in his desire to use his corporation to improve lives with technology and provide decent jobs for Americans. Westinghouse quickly began receiving commissions. Rather than building DC power stations every mile, customers could now buy one AC generator to light up a whole town: a revolution was on the way.

The gauntlet had been thrown down, and Edison quickly responded with a cavalcade of publications branding the AC power system as a menace to society. Westinghouse instituted a public AC education campaign that he figured would dispel the hysteria, but he underestimated the lengths Edison would go to preserve DC's advantage. Edison joined forces with Harold Brown, a disgruntled engineer who had already been publishing his own propaganda on the dangers of AC. Nobody knows what sparked the previously unknown Brown to transform himself into the most rabid anti-AC apostle, but he was soon to plunge the campaign to sordid new lows.

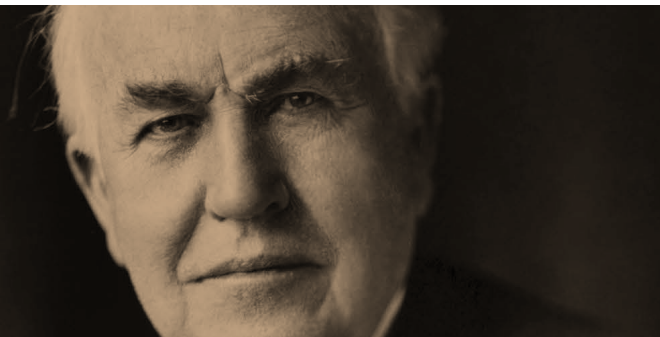
Brown accrued a collection of family pets (purchased from enterprising school boys at a rate of 25 cents each) for a morbid demonstration. By publicly electrocuting the

unsuspecting dogs and cats with AC current, he hoped to make the name "AC" synonymous with death. Brown must have thought it effective, as he soon surreptitiously licensed Tesla's patents in order to electrocute (or "to Westinghouse," as he and Edison were now publicly referring to it) a condemned prisoner with AC current. Brown's team, practiced only with executing the much smaller household pets, botched the job and subjected the man to a prolonged and tortuous death.

Although their names were being run through the mud, Westinghouse and Tesla held firm. Scientists began to see through the propaganda and rally behind their cause, and in 1896 Westinghouse was offered the opportunity to generate power from Niagara Falls. This prestigious contract was coveted by both sides, and marked the beginning of the global domination of AC current. In the end, rationality prevailed over fear mongering, but Edison's shortsightedness and cruelty in the race to defeat his rivals has left a lasting stain on his great achievements.

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Rather than building DC power stations every mile, customers could now buy one AC generator to light up a whole town: a revolution was on the way.



TAKING IT TO THE BIG SCREEN:

Superbug research gets mega sized

BY DAVID ROSENBERG, CHEMICAL ENGINEERING, 2020

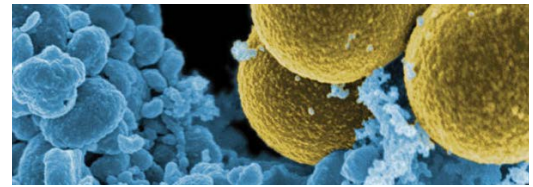
Seeing has always been believing in microbiology, where despite concerning objects far too small to observe with the naked eye, visual data often predominates. This summer, researchers from Harvard Medical School and Technion-Israel Institute of Technology brought visualization to a whole new level in a study on antibiotic resistant microbes.

Scientists constructed a two-by-four foot petri dish to make a massive scale-up of a classic study of bacterial growth. Researchers placed normal *Escherichia coli* cells on either ends of a slab of gel filled with nutrients and microbe-killing drugs in blocks of decreasing concentration from center to edge. A two-week time lapse captured the growth of thousands of generations of cells as they made their way across the plate. While antibiotics initially confined bacteria to the edges, individual cells overcame them and started lineages that pushed towards the center. Eventually, microbes were growing in 1000 times as much drug as stymied their ancestors as time and time again the dish, deemed the Microbial Evolution, and Growth Arena (MEGA) Plate, became covered in a solid mass of colonies.

The experiment puts vital concepts of evolution and antibiotic resistance in a concrete, visual, and accessible form. Thanks to the rapid duplication of *E. coli* and time lapse photography, a viewer can *see* a mutation develop in the population that opens the door to new resources as cells fan out like water bursting from a crack in a dam. In an interview with the *Harvard Gazette*, senior study investigator Roy Kishony noted, “Our MEGA plate takes complex, often obscure, concepts in evolution, such as mutation selection, lineages, parallel evolution, and clonal interference, and provides a visual, seeing-is-believing demonstration of these otherwise vague ideas.” The plate also provides novel insights into the movement and evolution of bacteria in space through changing conditions, allowing phenomena typically excluded by the miniscule scale of most experiments.

Antibiotic resistance is both an easy selection tool for observation and a sobering presentation. Perfectly ordinary, antibiotic-susceptible bacteria invariably give rise to colonies which thrive in chemicals used to control them within days on the plate, replicating the rise of superbugs – drug resistant disease-causing bacteria now ubiquitous in hospitals.

Since the discovery of penicillin in 1928, antibiotics have been the most common, often the only, cure for microbial



DESIGN BY CATU BERRETTA, COMPUTER SCIENCE, 2021

infections. However, as the MEGA plate demonstrates, natural selection will create bugs that can ignore any toxin under the right conditions. Thanks to copious and often careless use, as well as bacteria's ability to transfer such handy genes between strains, antibiotics are rapidly becoming ineffective. Some have predicted that humanity is approaching a 'post-antibiotic era' in which successful treatment is the exception instead of the norm. A 2013 CDC study found 98 cases of tuberculosis resistant to 10 antibiotics each from a sample of 651 TB patients in South Africa. Similarly hardy strains have been reported in Iran. From 1992 to 2002, the prevalence of methicillin resistance in *Staphylococcus aureus* rose from near zero to 28 percent in the U.S. and 70 percent in Japan.

The fight against antibiotic resistance begins with smarter use of existing drugs. Taking too little of a treatment allows bacteria with partial resistance to survive and decrease the population's susceptibility, while prescribing antibiotics too liberally needlessly adds to the resistant population. Doctors and hospitals have already taken steps to lessen these risks with education and more careful prescriptions. Meanwhile, research centers around the globe continue to seek out a greater variety of antibiotics and other treatments. To improve the search, researchers at the Webster Nanomedicine Lab at Northeastern have packaged existing antibiotics in a polymer delivery system embedded with silver particles that penetrate the outer covering of bacteria to circumvent common resistance mechanisms. More specific treatments are also gaining traction. Some new antibiotics target specific pathogens or even eliminate disease-causing factors without killing cells, while probiotics encourage the growth of harmless microbial species that compete with disease-causing ones.

The MEGA plate not only makes all this more accessible to the public but provides a tool to make sense of some of the more complex mechanisms at play in the medical arms race. Researchers hope to determine whether a standard strategy of giving patients multiple drugs at once to avoid resistance works as intended or if the different rates at which they spread through the body cause them to act as distinct treatments, promoting multiple resistance. The plate can also examine the behavior of mixed species, more closely resembling the body.

Science (2016). DOI: 10.1126/science.aah5641.

Microbiology and Molecular Biology Reviews (2010). DOI: 10.1128/MMBR.00016-10

PHOTO BY FLICKRY NIAID



Two is Better Than One

How rival vaccines work together to eradicate polio

BY ERICA YEE, INFORMATION SCIENCE AND JOURNALISM, 2020

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2020

Polio could be the next eradicated human disease after smallpox, thanks to two scientists who created two very different vaccines.

The highly infectious poliomyelitis virus invades the nervous system through person-to-person transmission. Fear of polio consumed the U.S. during the first half of the twentieth century. At first, symptoms include fever, fatigue and vomiting. Then, according to the World Health Organization, 1 in 200 infections can lead to irreversible paralysis.

No cure has been discovered, but a vaccine given multiple times can prevent onset in children. Although polio has been eradicated in the U.S., young children still receive four polio vaccinations. Due to immunization, the number of cases worldwide has decreased by over 99 percent, from an estimated 350,000 cases in 1988 to 74 reported cases in 2015, the WHO reports.

President Franklin D. Roosevelt founded the National Foundation for Infantile Paralysis (now March of Dimes) in 1938 after his own polio diagnosis. The foundation funded two researchers who used contrasting approaches to reach the same goal of creating a polio vaccine.

Dr. Jonas Salk, known as the “father of biophilosophy,” created the first inactivated polio vaccine (IPV) in 1953 using killed viruses. The IPV produces antibodies in the blood to prevent the virus from spreading to the central nervous system. By 1961, this vaccine had helped decrease the incidence of paralytic polio in the U.S. from 13.9 to 0.9 cases per 100,000 people, according to World Virology Journal.

Despite its efficacy, not all polio researchers agreed with Salk’s approach. Dr. Albert Sabin, a virologist originally from Poland, thought long-term immunity was only possible using live, weakened viruses. He began testing an oral polio vaccine (OPV) created this way in 1957. The viruses in the OPV replicate in the intestines, but are much weaker than the wild virus, allowing the body to generate an effective immune response.

The Salk vaccine was used so widely in the U.S. that Sabin had to run clinical trials in the Soviet Union; fortunately, the fear of polio overcame Cold War political rivalry. Yet enmity remained between the scientists. Sabin belittled Salk, calling him a “kitchen chemist.” Ironically, Salk did some early testing in-home, vaccinating himself and his family. Salk’s son told The San Diego Union-Tribune, “He gave us the shots in our kitchen. My father boiled the needles and syringes on the stove top, then lined us up.” One dose of OPV today costs \$0.12 to \$0.18. There is no need for a health professional or equipment to administer,

making it useful for mass immunization. Though extremely safe and effective, in rare cases (around 1 in every 2.7 million first doses), the OPV can cause vaccine-associated paralytic polio (VAPP) because of its live virus, according to the Global Polio Eradication Initiative (GPEI).

By contrast, a trained health worker must inject the IPV using sterile procedures, and one dose costs over five times more than the OPV. But there is no evidence the IPV causes any serious reactions.

Use of Sabin’s OPV mostly replaced Salk’s IPV until 2000, when more polio-free countries started using the IPV for routine vaccinations because of VAPP. The IPV does not stop virus transmission as the OPV does, so the latter is still used to contain outbreaks. When polio is eradicated, however, OPV use will have to end to prevent new vaccine-derived polio.

After a year of no reported cases, the WHO removed Nigeria from the list of countries with endemic (native) transmission in September 2015. The country’s polio-free status meant the disease had been eradicated from Africa, leaving only Pakistan and Afghanistan affected by endemic transmission.

However, last summer, polio cases detected in the Nigerian state of Borno were linked to 2011 cases, indicating the strain had been circulating since then. This caused the WHO to retract Nigeria’s polio-free status.

A June article from African Health Sciences explained how Boko Haram aggression in Nigeria includes “violence against polio workers, disruption of polio immunization campaigns, with consequent reduced access to health care and immunization.” All children in Borno must be vaccinated, but militant control in some areas makes the process difficult.

According to its website, the GPEI constantly assesses the optimal use of different vaccines to stop polio transmission. Neither Salk nor Sabin patented his vaccine, choosing instead to gift it to the public. “The people [own it],” Salk said in 1955. “Could you patent the sun?”

Together, Salk and Sabin’s contributions have been essential to the global eradication effort. Soon, hopefully, the world will ultimately thank them by no longer needing what they gave.

African Health Sciences (2016). DOI: 10.4314/ahs.v16i2.28

World Journal of Virology (2012). DOI: 10.5501/wjv.v1.i4.108



Bacteria are Hitting the Airwaves

BY ARIA ELAHI, BIOLOGY, 2017

As the scientific community vigorously strives to keep up with the ever-changing nature of bacteria, PhD student Violetta Medik is at the forefront of research that could help us understand the perplexing inner workings of bacterial species. Her work takes place right here at Northeastern University in Professor Slava Epstein's lab, where she is ambitiously pushing the borders of bacterial research while studying hard to complete her degree.

Most scientists in this field are fairly confident that bacteria have the ability to communicate with one another. This theory has been expanded by the idea that bacteria can communicate through diffusible compounds when they come into contact with one another. Medik believes that the extent of bacterial communication doesn't stop there and that their conversations may be exchanged in only the air.

"There are ten times as many bacterial cells than human cells in the body," Medik said in an interview with NU Sci. "By neglecting some of these interactions that are going on, we are possibly neglecting the effect bacteria are having on humans."

Medik routinely compared two strains of oral isolates of *Streptococcus*, a genus of spherical Gram-positive bacteria, through a technique known as mass spectroscopy. This method allowed Medik to see what kinds of molecules are the acting messengers between two separated strains. By giving one strain antibiotic resistance, she could also see whether interactions are actually occurring.

Each strain secreted approximately thirty types of organic molecules that can be characterized as small, volatile, and hydrophobic. More importantly, these molecules have a low boiling point and a high melting point. To Medik, this could only mean one thing – the molecules are evaporating and interacting with the other strain via air. She also observed that the antibiotic resistance passed from one strain to the other. This indicates that the interaction between the two strains is almost undeniably occurring – and it's all due to the molecules being secreted into the air.

These findings provide a tremendous clue towards solving the puzzle that is bacterial interaction.

"There is more and more research that bacteria may have an effect on diabetes, behavior, mood, cancer, autoimmune diseases, anything, since they vastly outnumber human cells," Medik said.

This kind of research can profoundly change the how the scientific and medical communities perceive the human body, as bacteria seems to be just as integral to the body as human cells.

DESIGN BY KYRA PERZ, CHEMISTRY, 2020

Medik thinks the bacteria are not only communicating with one another, but also with human cells, which also come into contact with the bacterial molecules secreted into the air.

"If we are able to determine more about how they are able to interact, it may lead to future discoveries on how we can shift the composition of bacteria in the human body without the use of antibiotics," she said.

The idea that bacteria are considered merely residents of the human body has passed its expiration date. Instead, Medik describes the body as a delicate ecosystem where good, bad, and neutral bacteria coexist with human cells. She hopes that with greater understanding, it may be possible to shift the composition of bacteria in the human body in favor of the good bacteria over the harmful ones.

“ By neglecting some of these interactions that are going on, we are possibly neglecting the effect bacteria are having on humans.

Medik also pointed out that most antibiotics are becoming obsolete as more and more bacteria become immune. If it is true that bacteria can pass on antibiotic-resistance to other strains without coming into direct contact, then it seems that immunity is inevitable. Will we have to coming up with new antibiotics forever? If so, will we reach a point where bacteria will be nearly immune to everything? Is there actually a way to prevent bacteria from passing on immunity altogether? These are questions that must be asked in the face of these discoveries.

For Medik, to learn about bacteria is to learn about humanity itself, as they influence our survival with all the good and harm they can do. Although these new discoveries shine some light on these microbes that are so irrevocably tied to our existence, there is still a great deal of mystery. Scientists do not know precisely how these molecules interact with the target bacteria or what receptors and transcriptional factors are involved, and Medik thinks they may only be scratching the surface of what can be discovered.

When asked what motivates her to continue this research, Medik quickly replied, "Because it's awesome!"

Strangely enough, when facing endless uncertainty there is at least one thing a scientist can always be certain of.

It's Getting Hot in Here, So Take Off Your Zooxanthellae

BY CHRISTINA WEBER, CELL AND MOLECULAR BIOLOGY, 2020

DESIGN BY CATU BERRETTA, COMPUTER SCIENCE, 2021

Global warming and efforts to minimize it are present all around the globe. People are made well aware of how it will affect them, but sometimes fail to consider other species involved. Corals remain a valuable part of the aquatic biome, and are essentially the tropical rainforests of the ocean. These tropical sights provide quite a view, but if nothing changes, that view won't exist for much longer.

These rainforests are full of diversity and color; they are filled with life. Corals contribute greatly to the rainforests' overall beauty and ability to play home to multiple organisms. Corals build skeletons of calcium carbonate. When the coral polyp dies, this carbonate skeleton remains and becomes a part of the reef, which is the attraction many organisms enjoy. Many of these corals get their miraculous colors from their symbiotic friends: zooxanthellae. “ Zooxanthellae are marine algae that live inside the tissues of corals that help corals with their energy needs, which enables them to survive. Corals show vibrant colors when they are still in contact with zooxanthellae, but they become a sickly white color without them as their skeleton begins to show - a process known as bleaching. Without the algae they are essentially being starved to death.

The mass destruction of reefs causes corals to be cut off from their food source through the process of bleaching. This is not comparable to stereotypical Clorox bleaching, though. Coral bleaching is a result of calefaction, which is the warming or increase in temperature of, in this case, the ocean. Corals experience increased hyperthermal pressure due to global warming. When this occurs, the symbiotic relationship between coral and algae breaks down. The coral begins to swell, up to about 340 percent, which can be catastrophic. When this occurs, the zooxanthellae are expelled from the coral body. During this expulsion process, those beautiful pigments are also removed, causing the corals' deathly white appearance.

Corals are being eliminated at an alarming rate. There is looming extinction as this process of bleaching repeats itself on various corals. As sea temperatures rise, sea levels rise along with it. This factor can contribute to the death of coral through the suppression of growth, poor lighting, or even drowning. This starvation can be prevented if conditions return to their normal state. Nevertheless,

high temperatures are damaging as they decrease the corals' reproductive and growth rates while also increasing their susceptibility to disease. If oceans continue to warm, there is less of a chance that they will be able to recover without significant effects. An increase in temperature is not the only threat to corals; bleaching is also triggered by low salinity, pollutant runoff, sub-aerial exposure, and solar irradiance.

If global warming can do this to corals, the destruction it can cause to other organisms may be equally terrifying. There could be an induced chain reaction that slowly wipes out all living organisms. In 1988, there was a bleaching event on the Great Barrier Reef that bleached fifty percent of the reef. Much of the reef was able to recover, but the Great

Barrier Reef is currently suffering from one of the worst bleaching events in history. Calefaction also affects other organisms including plankton, seagrass, seabirds, marine turtles, and fish. All of these organisms make up the aquatic biome that is such an important part of our world.

Major resilience actions are still being taken to counteract this dreaded fight for life on the battlefield of corals versus

calefaction. People are trying to reverse the damage that global warming is causing. One program, the Reef Health Incident Response System, has a Coral Bleaching Response Plan for detecting and responding to coral bleaching in places like the Great Barrier Reef. This includes programs like the Reef Water Quality Protection Plan, which plans to improve water quality and reduce pollution to keep the water livable for these organisms, and The Great Barrier Reef Marine Park Zoning Plan, which is responsible for conserving and managing the reef. These actions, among others, are being taken to protect one of the most biodiverse areas on our planet. So who will win? Corals or calefaction? The world will find out soon enough.

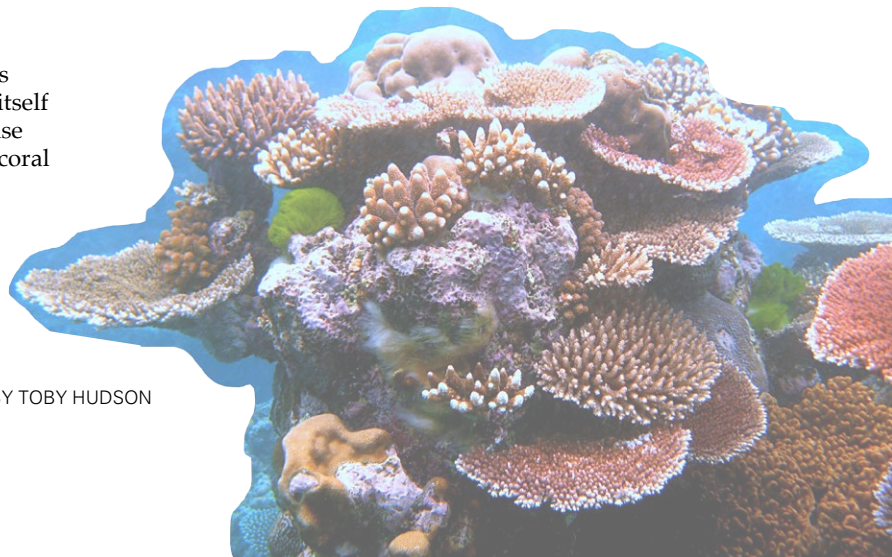


PHOTO BY WIKIPEDIA BY TOBY HUDSON

Collaboration *over* Competition

BY CICELY KREBILL, BIOLOGY, 2019

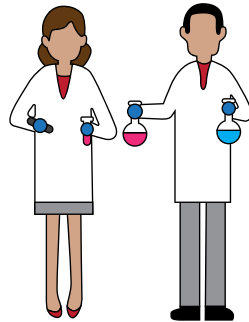
DESIGN BY JULIETTE PAIGE, MECHANICAL ENGINEERING, 2020

With funding for academic institutions continuing to fall, and the ever present competition in industry increasing, the two sides of research are looking to strengthen their relationship with a previous rival: each other. Both parties' individual problems are only growing with academia losing funding while industry is becoming even more competitive. Currently, only about 0.4 percent of the federal budget accounts for scientific research, a large decrease since its peak of 5.5 percent in the 1960s. Of that, less than 20 percent of grant applications are successful. On the industry side, companies are declining in both productivity and profit potential. Adding to their problems, pharmaceutical and biotechnology companies are also competing with new generics that are being developed as drugs and other technology come off patent. Because of these afflictions, both sides are coming together to fulfill the other's needs.

These resulting partnerships are nothing new. The start of industry-academic partnerships can be largely attributed to the Bayh-Doyle Act of 1980, which gave universities ownership of any patents that arose from research grants. Prior to this legislation, the patent of any invention created using any federal money would belong to the federal government. This largely discouraged companies from working alongside academia for fear of losing the rights to their invention. However, with the passage of this act, there was a rapid increase in industry-academic partnerships that is continuing to change the culture of collaboration today.

One program, Bench-to-Bedside, is trying to use joint industry-academic efforts to accelerate innovation to solve unmet clinical needs. Bench-to-Bedside is a competition held at the University of Utah where multidisciplinary teams of students, surgery residents, and clinical faculty are paired with an industry mentor. The program's ultimate goal is to create a prototype to solve a problem introduced by that industry partner using less than \$500, demonstrating that this partnership not only creates innovative solutions, but is cost effective as well.

Last year the program focused on the surgical field, a field where the majority of this innovation is developed in medical centers that lack the capability to create marketable technology. Bench-to-Bedside is trying to remedy this disconnect. The teams competed to



develop a technology aimed at global cervical cancer prevention and the result exemplified the possibility of what could come out of a great partnership. In just 72 days, the winning team created a prototype aimed at treating precancerous cervical lesions with the cost of development coming in under the \$500 cap. This prototype is a handheld, battery-powered device that can be used in resource-poor areas. Their industry partner, Cure Medical LLC, then took the prototype and presented it to the World Health Organization (WHO). Recognizing the technology's potential impact in countries with poor health infrastructures, the WHO applied and received a \$2.4 million grant from the National Institutes of Health to do a four year clinical study in Zambia.

The Bench-to-Bedside program is one of the many partnerships that illustrate a more ideal model of joint endeavors. Their successful partnership was a result of both parties relying on their respective strengths in order to advance the health of society. Although the Bench-to-Bedside program creates short term partnerships, long lasting multimillion dollar contracts with pharmaceutical and biotechnology companies alongside academic institutions, including top companies like GlaxoSmith

Kline, also exist. Partnerships like these give the pharmaceutical companies access to novel compounds studied by academics earlier so that they can accelerate further research and development using their large budgets. It also provides access for academics to do extended research on drugs that are currently under patent by these companies. Furthermore, academics can use the increased knowledge of these patented drugs to encourage further innovation.

With traditional funding from government agencies decreasing and companies focusing efforts on more complex problems, the necessity for collaboration continues to grow as each side has what the other lacks. Academia gains access to necessary finances and technology that would be otherwise unavailable to their labs, while industry receives scientific expertise in their field of interest. Although critics of these affiliations frequently voice concern over the threat to the integrity of academia, the innovation that is coming out of their collaboration is becoming more necessary if both academic labs and companies want to keep their competitive edge.

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This Nest Ain't Big Enough for Two of Us

BY SAGE WESENBERG, BIOCHEMISTRY AND JOURNALISM, 2019

DESIGN BY ANNIE LEE, GRAPHIC AND INFORMATION DESIGN, 2019

"Survival of the fittest" is a term that has been used by evolutionary biologists since the 1800s.

It refers to natural selection, the way generations of species adapt to a changing environment by passing on certain genes and traits that are then passed on to their offspring. This phrase has become essential in understanding evolution, biology, and cohabitation across species in the plant and animal kingdom.

Among and between many different animal species, we see competition arise as a result of traits that give them advantages over others, which can lead to dominance of one species over another. Through interspecific competition, animals of different species may compete for resources like food and territory. On the other hand, intraspecific competition occurs between animals of the same species,



the firstborn determines the death of younger chicks, no matter what. Many cases have been studied where the eagle chicks are observed pecking the younger sibling over 1,000 times within the first three days of their life. One study conducted in 1988 found that out of 200 Black Eagle nests, there was only one nest where both chicks survived.

This is a brutal form of intraspecific competition, but it isn't entirely unique to the

Black Eagle. Other bird species like the Osprey, *Pandion haliaetus*, have adapted to perform facultative siblicide, in which younger chicks may only be killed if environmental conditions are harsh. Many different environmental variables have caused several bird species to evolve these siblicidal behaviors. These variables include resource competition, confined nest space, limited food provided to nestlings, and weaponry. These factors prevent both chicks from easily surviving together, therefore making extreme aggression and siblicide an evolutionary necessity.

Parents also play a large role in the likelihood of siblicide. In cases where resources are limited, parents might allow more siblicides because they know not all chicks will survive anyway. In this case, it makes evolutionary sense that the stronger chicks should survive over their weaker siblings. This also conserves energy for parents who then have fewer mouths to feed.

While this seems harsh, siblicide often helps increase the reproductive success of future generations. The younger siblings' death ensures that the older sibling will have a better chance of surviving to maturity, which overall benefits the species' reproductive success. Indeed, this phenomenon is seen in non-avian animal species such as the spotted hyena, *Crocuta crocuta*, in which siblicide rates escalate if the growth rates of young hyenas begin to decrease. After siblicide occurs, the surviving cub will exhibit an increased growth rate. These hyenas also often commit siblicide to gain more parental care. However, this evolutionary technique is still mainly apparent in birds like the Black Eagle and Ospreys, as well as the Blue Footed Booby (*Sula nebouxii*) and some egrets. Whether it's to increase genetic viability of the overall species or to directly help the dominant sibling, avian siblicide has developed through evolution and the Black Eagle chick will always have a nest to itself.

“ One study conducted in 1988 found that out of 200 Black Eagle nests, there was only one nest where both chicks survived.

which must compete for limited resources that may impact their abilities to survive or reproduce. Intraspecific competition is often seen in avian species, when birds use techniques like avian siblicide in order to maximize their ability to obtain resources and thus ensure their survival.

The Black Eagle, *Ictinaetus malayensis*, is a bird that inhabits the mountains of northeast Africa through the Middle East. It is almost entirely black with yellow feet and a yellowish-grey beak. Adults are over two feet in length as adults and have a five-to-six-foot wingspan. They eat many small mammals like squirrels, bats, and other birds – sometimes including a whole nest of chicks and eggs.

Black Eagles build their nests on ledges and lay two eggs each year. Once the first chick hatches, it is almost guaranteed that it will be the only chick to survive. Immediately after their younger sibling hatches, the firstborn will begin attacking it, performing obligate siblicide. In obligate siblicide – which also happens in some other bird species, like pelicans and other eagles –

When Salads Fight Back



BY LUCAS COHEN, MARINE BIOLOGY, 2019

DESIGN BY KYRA PERZ, CHEMISTRY, 2020

Plants are far from defenseless.

Some, like the Umbrella Thorn Acacia, *Vachellia tortilis*, have evolved conspicuous mechanical defenses. In the case of the acacia, these are long spines that discourage large herbivores from grazing on tender new leaves. Tobacco plants, chiefly *Nicotiana tabacum*, on the other hand, are infamous for targeted chemical warfare and high concentrations of nicotine. In humans, small doses of nicotine act as a stimulant; in insects, however, nicotine is a potent neurotoxin.

Of course, deadly toxins are not the only chemical defense in plants' molecular repertoire. Tannins are another class of compound common in both angiosperms and gymnosperms – from large oak trees to blueberries – and are responsible for some plants' tendency to be incompletely digested by some herbivores, as well as a general lack of palatability. Tannins work by binding together, and thus precipitating, various proteins, which produces a bitter, unpleasant taste – known as astringency – that deters eager browsers.

Plants manufacture tannins in response to a variety of environmental stressors. In the case of herbivory, this not only includes defense against insects, but also larger organisms. In one recent study, scientists at the University of Leipzig and Max Planck Institute for Chemical Ecology described a phenomenon occurring in the saplings of

maple and beech tree in which tannins are found in higher concentrations in response to herbivory by roe deer. The deer's saliva triggers an alarm of sorts, prompting the tree to produce chemical deterrents.

In many cases, the chemical response of plants to herbivory doesn't only concern individuals: plants may work together to survive. Volatile organic compounds (VOCs) are yet another important class of chemicals produced by plants that almost defy belief. Both the role of VOCs in plant communication and the subject of plant communication in general have been the target of controversy. David Rhoades, the author of an early 1983 study detailing the apparent ability of willow trees to exhibit changes in foliage in response to attacks by caterpillars in neighboring trees, was among the first to hint at the existence of biogenic VOCs in plants. Hints of their presence are everywhere, from the smell of freshly cut grass to the intensity with which conifers burn.

Now, evidence implicating VOCs in plant communication abounds, particularly in response to herbivory between one, VOC-releasing individual and neighboring individuals. Overall, the near-invisible war between plants and their predators is wonderfully complex, and scientists are still working to uncover this hidden world.

A Protective Protein: Tardigrade Protein Increases Radiotolerance

BY AMANDA BRETTI, CHEMICAL ENGINEERING, 2019

Many people know tardigrades as the cute, microscopic animals that can survive in open space, nicknamed "water bears." Now, a recent study suggests that tardigrades have another feature to boast about: they contain a protein that could protect human cells from radiation.

Tardigrades are able to enter anhydrobiosis, a dehydrated state that allows them to withstand high temperatures, pressures, and irradiation. Looking to discover the genomic reason for the tardigrade's high environmental tolerance, a team of researchers in Tokyo analyzed the tardigrade genome and the animal's gene expression under dehydrated and hydrated conditions. They hypothesized that tardigrades contain a protein that associates with DNA to protect it from irradiation. Using mass spectrometry, a technique that sorts components of a sample by mass, they were able to identify a protein near the nuclear DNA. They named this protein Damage suppressor, or Dsup.

The researchers then created a human cell line that expressed Dsup. When they exposed these human cells to X-ray irradiation, their DNA exhibited less single-strand and double-strand breaks. Furthermore, more cells survived following the irradiation. These results indicate that the researchers' hypothesis was correct, and that Dsup increases radiotolerance not only in tardigrade cells, but also in human cells.

Dsup may be the first protein discovered that associates with DNA to protect it from irradiation. Its ability to protect human cells means that it has many potential applications, from helping lessen the damage of radiation therapies to protecting workers in nuclear facilities. Further research may develop these applications or lead to discoveries of even more benefits that tardigrades can offer.

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The Battle Against Invasive Species in the U.S.

What Can You Do to Help?

BY LUCAS PRINCIPE, ENVIRONMENTAL SCIENCE, 2020

In the United States, we have a ubiquitous problem with invasive species. Depending on where you hail from, when you hear the words “invasive species” you are bound to think of organisms such as the zebra mussel, Asian carp, European starling, or Kudzu vine. In our modern interconnected world, invasive species are now a global problem. The amount of damage these invaders can cause, both financially and biologically, is shocking. Researchers estimate that 50,000 invasive species have been introduced to the United States throughout its history, and cost approximately \$120 billion a year. In 2011, the Department of the Interior spent over \$100 million on invasive species prevention, management and research. We’ve all heard the story of how these organisms are running wild through our ecosystems, but never about the organizations in the trenches fighting this war, the weapons at their disposal, and what the everyday citizen can do to help.

A wide variety of government agencies contribute to conservation and the eradication of invasive species, including the EPA, US Forest Service, U.S. Fish and Wildlife, Department of Agriculture, U.S. Customs and Border Protection, and even the Department of Defense. Non-governmental organizations include The Sierra Club, National Wildlife Federation, and various others. These organizations spend time removing species, researching, and educating the public in order to help stop the spread of these invaders. Without them we would most definitely see a rise in pest numbers and effects on our ecosystems.

When considering an invasion, the most important concept to grasp is the difficulty of eradication and the reality of containment. While some invasive species aren’t too difficult to completely eradicate, due to size, abundance, and success of colonization, others are near impossible. For example, when feral pigs invaded California’s Santa Cruz Island, the removal of these creatures was achievable due in part to their relatively small population size. Conversely, when the Mimosa weed invaded Australia, the only method of dealing with the invasive species was containment. At over \$500,000 a year, the Australian government has been able to curb any other outbreaks of the weed. You may be surprised to learn that many pest management projects rely on the principle of controlling invasive species rather than eradicating them. Many times when a species successfully colonizes a new area, they’re there to stay.

Various methods are used to fight these invasive outbreaks including manual, biological and chemical control. Manual control, the most basic, includes hunting, digging out, flooding, or burning invasive plant or animal species. When biological control is thoroughly calculated and tested, it can be an effective tool.

DESIGN BY ANNIE LEE, GRAPHIC AND INFORMATION DESIGN, 2019

For example, the aquatic plant species Hydrilla, an invasive species in Florida, has had its numbers cut through a variety of biological control measures including using sterilized Chinese grass carp to control the population.



SOUTH AMERICAN CANE TOAD PHOTO BY SAM FRASER-SMITH

However, biological control methods can be disastrous if implemented without enough prior research. In 1930, a few thousand South American cane toads were introduced to Australia in order to eradicate the beetles eating local Queensland sugarcane crops. The toads never accomplished this goal, but they did manage to successfully colonize most of Northeast Australia. Their numbers are now in the millions, and they cause irreversible damage in every ecosystem they invade. What’s more, they’re also highly venomous, causing injury or even death to any other species that decides to prey on them. Clearly, this method is a high-risk, high-reward gamble. Chemical control is also a viable option when battling invasive species. Many invasive plant species have had their populations controlled and even eradicated through the use of herbicide in the past. However, herbicide can also have adverse effects on human and wildlife health, and can pollute soil, water and non-target vegetation (USDA, 2002). As a result, many conservationists have called for herbicide to be used sparingly and not as a first response measure.

It’s easy to forget that when it comes to invasive species management, the most important method in stopping the spread of pests is having an informed citizenry committed to protecting our ecosystems. There are many things you can do in order to decrease the rate of invasion in the United States. For starters, never release non-native pets into the wild, whether they be terrestrial or aquatic. Additionally, always be sure to thoroughly clean your hiking boots if you’re traveling to different foreign ecosystems, and your boat if you’re transporting it between different bodies of water. And finally, volunteer! Environmental organizations are always looking for eager volunteers to stop the spread of invasive species in our ecosystems.

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