The Synapse: Intercollegiate science magazine

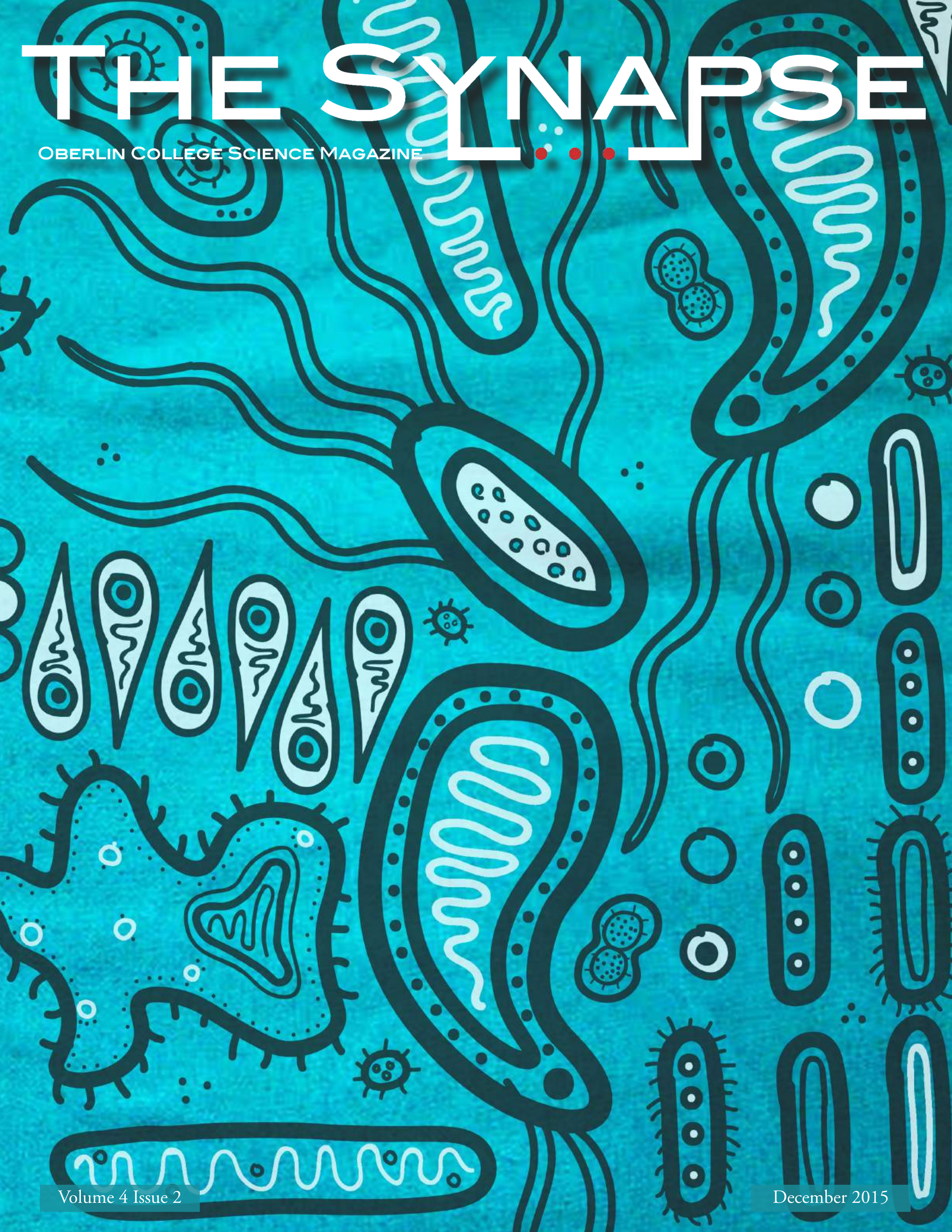
Volume 7 | Issue 1 Article 1

2015

Issue 7

THE SYNAPSE

OBERLIN COLLEGE SCIENCE MAGAZINE



Volume 4 Issue 2

December 2015

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In the fall semester, as part of the Oberlin Convocation Series, author and science journalist Sonia Shah visited our campus to promote her book The Fever: How Malaria Has Ruled Humankind for 500,000 Years. While Shah was on campus, we were able to sit down with her and discuss one of the primary goals of our publication: bridging the gap between the scientific and nonscientific communities.

Shah told us that the journalist's role was to "challenge the myths that each side has of each other" and to remind readers that "science is a human enterprise made up actual people, not magical beings."

Whether influenced by Shah's message or not, this issue contains several articles that explore this notion of a rift between the scientific community and the general public. First is Paulus van Horne, whose article moves from personal anecdotes to national politics. Second is Brooke Oertel, whose piece focuses on the insights of some of our professors on both sides of the debate. Taken in sum, this issue has a very clear theme.

And yet it would not be *The Synapse* without some entirely unrelated but no less fascinating science content. Solar sails, Tinder, and space elevators each make an appearance in this issue, as do comics about moody planets and terrifying cockroaches.

We hope that Beatrix Parola's invitation to explore the microbial world caught your eye and that, so caught, you now discover something new, possibly bizarre, but no less fascinating within these pages.

Enjoy.

Gabriel Hitchcock
Editor in Chief

Featured Contributors

and their advice for the aspiring scientist

Luke Gruenert is a sophomore, biology major from Mill Valley, California. Luke has worked as a writer, editor, and more recently admin for the magazine. This semester, Luke has led our intercollegiate committee, a group of eight students that works to take *The Synapse* beyond Oberlin to other undergraduate institutions. Luke, a dedicated researcher, hopes to continue the research he has done these past three years to develop and improve cancer therapies. Luke currently works in Prof. Whelan's chemistry lab to this end. To the aspiring scientist: Stay creative. From my experience, creativity is the cog that keeps the wheel of progress in motion. It's especially important in science, and will set you apart in the field.

Willa Kerkhoff is a junior, neuroscience major from Mt. Vernon, Ohio. She has worked as an interviewer for The Synapse since Spring, 2015, more recently becoming our interview coordinator. In addition to her work with the magazine, Willa is also a writing associate, a researcher with Prof. L. Kwakye, and a tour guide. After graduation, Willa intends to pursue a Ph.D. in neuroscience with a concentration in systems neuroscience and computational/cognitive modeling. Every person, no matter how many times they've been interviewed before, can still be taken by surprise. So find a question that you don't think your interviewee has ever been asked; it makes for better journalism.

Théa Klement is a senior, double major in Biology and Peace and Conflict Studies major, plus minors in both religion and politics. Théa was one of two layout editors who simultaneously learned the ropes and designed V3I1. If not for her contributions, it is very unlikely that the magazine would be in circulation today. Currently finishing up her studies in Marseille, France, Théa intends to take several years off following graduation to travel and do research, eventually ending in medical school to obtain a masters in divinity or psychological anthropology. Your interests and studies find ways of fitting together in the end. This is the time to explore!

Jacob Turner is a junior, Physics major with a concentration in Astrophysics from Chicago, Illinois. Jacob has written for The Synapse since his freshmen year, making him one of our longest running contributors to date. In addition to being our physics journalism guru, Jacob is also the treasurer of the Astronomy Club and a research assistant in the Physics and Astronomy Department. After graduation, Jacob intends to pursue a Ph.D. in astrophysics with the goal of becoming a full-time researcher. Check out his article Solar Sail in this issue! For aspiring physics majors: Don't be afraid to ask for help when you need it.

Contents

No, I Don't Care About Molecular Spin

A Call to Action for Better Communication

By Paulus Van Horn
Illustration by Sydney Bernal

What does my housemate Jeffrey Levy do in the biochemistry lab all day? Jeff is the only natural sciences major in our four person house – the rest of us are musicians and computer scientists. All I know is that his work involves synthesizing chemicals and something to do with Alzheimer's…or is it Parkinson's? This obliviousness is a systemic problem throughout the Oberlin community. Neither the sciences nor their audience currently make a sufficient effort to understand one another.

I often hear well-meaning scientists ask, "How do we get more people interested in the sciences?" But this question is redundant; natural science is inherently interesting– in the outside world, in the human body, in the laws and mechanics of the universe. Science enables us to express and explore this interest, as the scientific method, for better or worse, is our most rigorous approach to gathering knowledge about our universe. It may seem myopic and slow-moving to the outside world, but it builds our understanding of the mechanics of life on every timescale imaginable. We do not need elaborate programs to foster curiosity about the questions science addresses, as the field touches on almost all subjects of natural curiosity. Instead, part of a scientist's job should be to demonstrate how science, as a particularly effective method of investigation, allows them to satisfy and further explore their curiosity about the world. The same spirit of inquiry that brings humanities students to critical theory and literature brings scientists to the lab, huddled over testing equipment.

wThere is no shortage of curiosity, but a shortage of translators. Scientists must retrieve the deeply human fascination with the world, too often buried in scientific language, and bring it back to the public sphere. These translators must be both intelligent and articulate, and liberal arts institutions with commitment to the sciences are well-situated to provide this education. This is a call to practice science in public, with curiosity on full display.

Post-college, you might find yourself at a bar, where some fine individual asks, "so what do you do, again?" As much as you might like to reach for a napkin and start drawing molecules in an ill-fated attempt to explain gas chromatography, a succinct easy-to-understand description will serve you much better. The "non-scientist" public not only includes your acquaintances and peers, but important decision-makers and public officials. Only 10 percent of the last Congress was made up of people with STEM backgrounds. One out of fourteen members in the Senate Committee on Commerce Science and Transportation represented a STEM field. The House Committee on Space Science and Technology was just over 40 percent STEM specialists. And yet, the congressionally-funded National Science Foundation provides "24 percent of all federally supported basic research conducted by America's colleges and universities." The congressionally-funded National Institute of Health "invests nearly $30.1 billion annually in medical research for the American people." With the amount of money appropriated for scientific research by non-STEM experts, it should be clear that scientists must present their work to the so-called 'court of public opinion.' Of course, NIH and NSF portion out their allocation through rigorous application processes, lead by experts in the field. However, the specter of Congress cutting funding is ever-present. If you cannot translate your research into language for a lay audience, your prospects at the bar and on the congressional floor might very well dry up!

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If it is so vital, why is this translation of scientific research often neglected? Scientific research builds on years of previous studies and shared knowledge within the field. Translation always involves loss, and the desire to explain the minutiae of scientific work runs counter to this fact. However, one must prepare for the inevitability of translation. Scientists will have to learn to live with slight inaccuracy in service of more understandable explanations, suspending for a moment their belief that years of research and education are necessary to understand what they do. Using metaphors and familiar concepts in your explanations will help clarify the importance of the research. Explaining every detail of the sampling method or computer software involved in your research is not particularly informative to a lay audience. If someone explains the framework of their research well, it will spark the natural curiosity in the listener to ask about the details that were left out. If you can sell your research in the larger context of wonder and amazement at the mechanics of our universe, the rest becomes much easier.

What is the responsibility of science educators to prepare students for the real-world in this sense? I believe there is a tremendous onus on natural science professors at Oberlin to teach their students how to navigate the professional and non-professional world. Take Professor Rebecca Whelan in Biochemistry, for example. For the last year, she has led Socializing with Scientists on Friday afternoons. "Socializing" is a weekly (pizza-fueled) meeting of curious minds in the sciences and humanities in the Science Center's Love Lounge. Students come ready to discuss research and current science news in a non-technical manner. There are even buzzers that you can ring if someone is using jargon! This event moves scientific discussion in the right direction. As Professor Whelan puts it, "I am committed to the sharing and dissemination of knowledge, not simply knowledge construction. I encourage people to view their education they get here as a tremendous gift, not to hold onto it selfishly but to think about how it can be shared." Socializing with Scientists is surely one of the many ways Oberlin can prepare science students to communicate with us lay people.

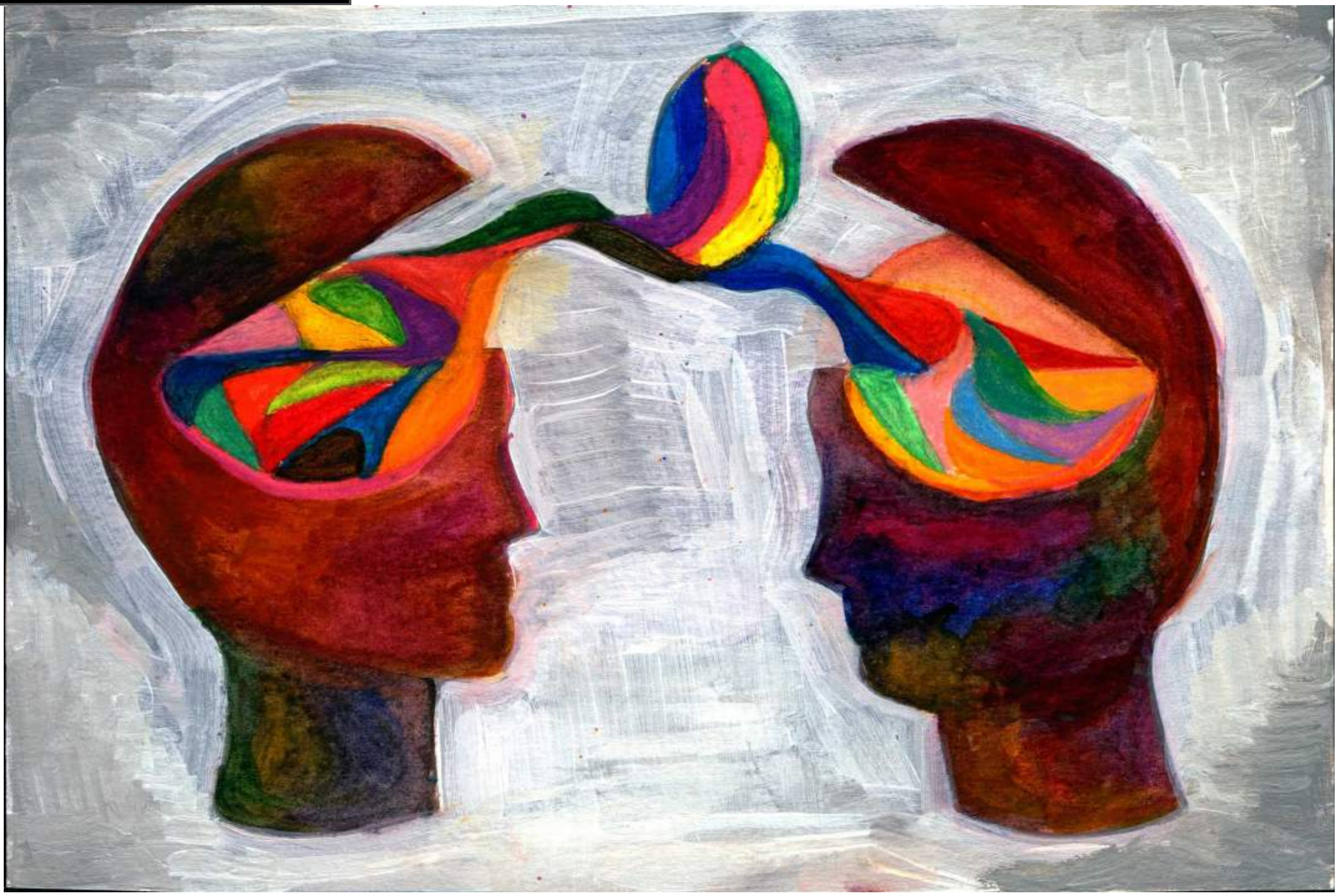
However, there should be a call for more science classes to directly relate daily life and scientific learning. Geology professor Karla Hubbard, who teaches the class Earth's Environments, says, "Most students in a 100-level course like Geo 120 are not going to end up taking multiple geology courses…I tend to think of them as the 'lay' audience. I hope that what I teach them equips them to catch when science is being presented well or poorly by the media or in conversations with others after graduation. I am not convinced that a single course in a science discipline will be enough to prepare students to translate the outcome of pure research coming out of labs and published in journal articles. I would hope that a science major could do that."

Think about the climate into which you are about to enter. NIH and NSF both suffer from wildly fluctuating budget allocations due to congressional bickering. Climate change denialism is healthy and abundant outside the confines of Oberlin. Even major news coverage of scientific breakthroughs often misrepresent or refute scientific research. It would be shortsighted to claim this as only a problem of translation. Obviously, there are many political and ideological hurdles to jump in order to remedy these problems. However, scientific translators are needed for the public! Maybe if lay audiences trusted climate science, having access to it in a form that didn't involve equations and jargon, such denialist politicians would not be elected.

Now, if anyone has access to the eyes and the ears of the public, it is the media! If the media deems your research newsworthy, you may be called for comment; if you can't explain your research well, the media will do it for you. If you cannot bear the lack of precision required for a non-technical description of the work or lack the skills to create one, the media will do the translating for you, inevitably representing your work more inaccurately than you would. Again, this is why I advocate for technical and non-technical language to be taught in science classes at Oberlin. I believe classes should sponsor spin-offs of Socializing with Scientists, requiring students to explain their work to non-experts. Even better, science majors should produce presentations to the public, involving Oberlin city residents. Efforts such as STEM nights for local schools are another great start. I encourage science majors to participate in these types events, both for the benefit of local children just discovering science, and for yourself as translation practice. No group is more curious, yet less interested in the technical nitty-gritty, than children.

> As much as you might like to reach for a napkin and start drawing molecules in an ill-fated attempt to explain gas chromatography, a succinct easy-to-understand description will serve you much better.

Recently, I sat down with Jeff Levy and asked him to explain his work one last time. It began as a struggle. I saw carboxyl groups and he started talking about "molecular spin" and my eyes glazed over. I reached nervously for the bowl of Dum-Dums on our living room table, crunching one between my molars. I reached out for anything that I could make sense of. He mentioned eumelanin. "Eumelanin… that sounds familiar, it's a skin pigment right?" Jeff nodded, and started to describe how these molecules link up to form "sticky" networks, potentially useful in cheap water filtration. The conversation was not easy. We stopped several times to get rid of the last bit of jargon but I understand his work now. As students, I think both sides of the "scientific divide" should try to have this kind of conversation more. These conversations not only bring us together cross-disciplinarily as scholars, but contribute to a larger discourse that affects the future of scientific research and public policy.



There's No Debate

How Do We Close the Gap Between Science and the Popular Press

By Brooke Ortel
Illustration by Ava Field

Despite the flood of information available online today, accessible with a few keystrokes, there remains a divide between the research of the scientific community and the general public. Research findings published in the scientific community belong to a body of literature that, for the most part, does not overlap with mainstream media. And when mainstream media attempts to cover scientific topics, its translation does not always accurately communicate research findings or their potential implications.

In light of the environmental issues we face today, it is important to consider the disconnect between the scientific community and the rest of society and to think critically about the role that science journalism can play in bridging this gap. To understand how the world is changing and why, the public, not just scientists, needs to gain some understanding of the science behind overwhelmingly complex issues such as climate change. This is where the difficulty lies. Media coverage of scientific issues is not always adequate in this respect, leading to the misrepresentation of research findings and confusion as to what, exactly, is going on.

Oberlin Professor Matthew Elrod, an atmospheric chemist, points out that a fundamental flaw in the reporting strategies employed by mainstream media is that "particularly for subjects in science that have implications on policy and therefore politics […] they assume that there are always two sides that are more or less equally valid, or at least need to be explored." But in the scientific community, it often doesn't make sense to give dissenting opinions equal weight. Dr. Elrod makes it clear that, "a scientist would never say that an opposition viewpoint on the Second Law of Thermodynamics deserves to be discussed…while science has legitimate controversies, it's not because scientists think that multiple correct answers exist, it's just that we haven't yet found the one explanation that explains all of the observations."

Elrod explains that scientists operate on the principle that eventually a consensus explanation will be reached, but "by definition, modern research topics are not in that category." While presenting two sides of a controversial topic as equally valid is a reasonable approach to covering politics, it is misleading to use this model for science journalism. Elrod points out that this tendency surfaces in the editorial pages of traditional newspapers, which often publish the same number of letters in support of action on climate change as those that counsel inaction by arguing that there is no scientific proof for climate change. The problem here is that these opinions are not equally valid in the way that differing views about politics are equally valid. He cites a study in which an academic journalist analyzed scientific papers on climate change and determined that 98 percent of the experts believed humans are responsible for climate change, "but if you read the average editorial page of a newspaper, you'd think it was 50 percent." As this example suggests, there is frequently a disconnect between how the scientific community is actually divided on an issue and how the media portrays that division since it gives equal weight to perspectives that are rejected by the vast majority of the scientific community.

Dr. Elrod remarks that in his field of study, atmospheric chemistry, it is easy to convey the relevance of his research to non-scientists because it directly relates to environmental issues. The hard part, he says, "is that scientists tend to work on very, very small sections of very, very large problems." Often nonscientists are aware of the general symptoms of climate change, but don't realize that individual researchers' work actually focuses on much more specific issues, such as how the chemical content of the atmosphere is changing. Furthermore, describing how data is collected to someone unfamiliar with the complex, technical methods used in highly specialized fields is nearly impossible.

Fortunately, Oberlin professors are committed to teaching students how to overcome these difficulties. Dr. Jan Cooper of the Rhetoric and Composition Department works with students to develop the science writing skills they need to successfully present complex scientific topics to a general audience as well as to experts in their fields. When she first began developing her Writing in the Sciences course, Dr. Cooper interviewed colleagues in the natural sciences departments and found that, "they considered writing to be a very big part of what they do, even though it's not a big part of every class […] they felt a certain amount of responsibility to communicate about responsible science to the public and they thought that students who graduated from a liberal arts college ought to be able to translate the things they were learning about science for a non-scientist audience as well as for other scientists." Providing students with the opportunity to practice effective strategies for communication with a more general audience is one major focus of her class, along with preparing them to write more technical articles intended for an audience of scientists. She says that "it's actually harder in some ways to accurately portray complex scientific problems for readers who have little to no background in it. It's almost a trickier art to do that than it is to write to fellow scientists in the same field." She believes that what she "can do for science students is increase their knowledge of how to use language" to communicate effectively in writing.

Dr. Cooper warns that there is a delicate balance between overloading the reader with cumbersome, unfamiliar scientific jargon and oversimplifying the topic: when it "oversimplifies things and talks down to the reader, or uses a lot of clichés […] or makes extravagant claims for very new research," science writing is ineffective. In order to craft a piece of scientific journalism that successfully conveys research findings to a wider audience, she emphasizes that "you have to learn how to represent numbers and statistics accurately and sensibly." It's also necessary to understand the difference between a cliché and a "fresh, informative metaphor" that helps explain an unfamiliar concept or idea. Furthermore, writers must be careful "to give definitions for difficult terminology in a graceful way" so as not to overwhelm the reader with technical jargon. Cooper points out that although writing is often thought of as a solitary endeavor, that is a misconception, especially in the realm of published work. In writing about science for a general audience, it is particularly helpful to receive feedback before publication from a reader who is not in the same field as the writer; successful science writing "involves getting trusted readers to give you advice about where you're leaving a different kind of reader behind."

Dr. Cooper and Dr. Elrod both stress the importance of identifying a target audience and understanding the background, interests, and expectations of that audience. In the second half of her science writing class, Cooper helps students learn to transition "between communities of readers and…discover what the needs of different readers in different situations are" and then "apply their knowledge and skill in science to writing things that will meet the expectations of those different kinds of readers." Elrod points out that the term "general audience," taken to mean non-scientists, encompasses an overwhelmingly large array of different groups of people. Attempting to present information in a way that is accessible to all of them is extremely difficult because their different experiences and expectations impact how they "consume the information you're trying to pass on." Narrowing the audience can be an effective tool in more successfully communicating information to a larger group of non-scientists.

Both Oberlin professors also note the importance of learning to recognize reliability in media sources. The Internet makes knowledge acquisition easy—in fractions of a second, search engines deliver a seemingly infinite array of information on any topic imaginable—but many of these sources are not credible. However, biased media is nothing new, and as Dr. Cooper explains, obtaining unbiased information "just requires, as knowledge has always required, developing skills of testing reliability, developing a discerning eye for what you trust." Dr. Elrod adds that, "it's so easy to get information now that somebody who really cares about finding the best source" can do so.

But improving the level of understanding possessed by non-scientists would require substantial reform of the vehicles by which scientific research is conveyed to the public. People who care about finding accurate and unbiased sources will find them, even if it takes some searching. However, if this kind of information were more readily accessible, it might reach a wider audience—one that includes people who may be interested in environmental issues or medical advances, for instance, but who are not necessarily inclined to sift through the overwhelming variety of media sources to locate the best ones.

One suggestion Dr. Elrod put forth for improving the dissemination of research findings to the public is to create a nonprofit organization that is not funded by the government or influenced by partisan politics. If the media is truly going to play a "watchdog role" in alerting the public to environmental issues and informing them on current research, the transmission of information has to be separated from politics. As Elrod suggests, perhaps this might be more readily accomplished if responsibility for enforcing freedom of the press is shifted from private entities to public nonprofits created solely for the purpose of transmitting scientific knowledge. This kind of organization would be "dedicated to different kinds of information, from science news with an environmental bent to science news with a medical bent, [focusing on] things that people care about" and offering them an unbiased source of information.

Dr. Cooper points out that organizations of the type Elrod described already exist, just not focused exclusively on science writing. For example, the Reveal site of the Center for Investigative Reporting "works on issues that involve interpreting science, especially on environmental topics." Another site founded on similar principles is Pro Publica, which includes reporting on environmental and health topics. Cooper explains that "both of these organizations also contextualize the science they report on by discussing the political or economic implications of their topics. That is how they make the topics interesting to general readers." This seems ideal for a community of non-scientist readers: an unbiased source that also places scientific topics in context so as to make them relevant to everyday life. If the mainstream media could begin to move towards this model, perhaps the gap between the scientists and the public would not loom so large.

The Super-Kamiokande Neutrino Observatory, Tokyo

2015 Nobel Laureates

By Nora Newcomb

Every December, the eyes of the world turn to Oslo, Norway for the awarding of the Nobel Prize. Founded by Alfred Nobel, this prestigious award, consisting of a medal, diploma and a financial certificate, is awarded to people that have made significant contributions over their lifetimes to the fields of Physics, Chemistry, Physiology or Medicine, Literature, Economic Sciences, and/or Peace. The Nobel Committee was established in the will of Alfred Nobel, a scientist perhaps most well known for his discovery of dynamite. This action was famously spurred on by an event in Nobel's life wherein a newspaper prematurely printed his obituary, titling it "The Merchant of Death is Dead." Upon reading this, he became so overcome with concern about how history would remember his contributions to the world, that he created the Nobel Prize. Each year the recipients, known as Nobel Laureates, are selected from a list of nominated individuals, all of whom have been recommended by important people, such as heads of state and previous Nobel Prize recipients. Throughout the year, the vast number of nominations are whittled down to a short-list, and from there the final recipient(s) are chosen for each award.

Since the advent of the award, three Oberlin alumni have been recipents. They are Robert Milikan, OC 1891, Physics, 1923; Roger Wolcott Sperry, OC '35, Medicine, 1981; and Stanley Cohen, OC '45, Physiology or Medicine, 1986.

> "When the brain is whole, the unified consvciousness of the left and right hemispheres adds up to more than the individual properties of the separate hemispheres."
>
> - Nobel Laureate Roger Wolcott Sperry, OC '35

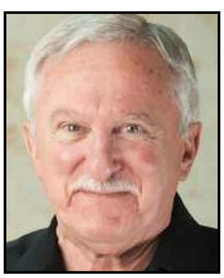
Physics:
Arthur B. McDonald, Takaaaki Kajita


Drs. Arthur B. McDonald and Takaaki Kajita, from Queen's University in Ontario and University of Tokyo respectively, were jointly awarded the Nobel Prize in Physics for demonstrating that neutrinos have mass. Neutrinos, a type of subatomic particle, were thought to be massless. Drs. McDonald and Kajita proved otherwise by showing that neutrinos could oscillate, change their identities, and therefore must have mass. The mass of a neutrino is given as 0.320+/-0.081 eV/c2 for the sum of the three types, electron, muon and tau neutrinos. eV (electronvolts) is a unit of energy roughly equal to 1.6x10-19 Joules, with eV/c2 being used as a non-SI unit of mass with a value of 1.782662x10-36 kg. That means that the mass of the sum of the neutrinos, in kilograms, is 5.7013152x10-37 +/-1.44314622x10-37 kg. For comparison, the mass of a hydrogen atom is 1.67353276x10-27 kg.



Physiology or Medicine:
William C. Campbell, Satoshi Ōmura, Tu Youyou

Drs. Paul L. Modrich, Thomas Lindahl, and Aziz Sancar were awarded the Nobel Prize in Chemistry for their work in understanding how cells repair DNA. This is incredibly important because damaged DNA can lead to dysfunctional proteins, which can lead to a wide range of health problems. Each of these researchers had a different, yet related, focus. Dr. Modrich, of Duke University School of Medicine and the Howard Hughes Medical Institute, studied how mistakes made in DNA replication were corrected by cells. Dr. Lindahl, of the Francis Crick and Claire Hall Laboratory, determined how cells repaired damaged DNA. Dr. Sancar, of the University of North Carolina, Chapel Hill, studied how cells repaired DNA that was damaged by ultraviolet light.



Chemistry:
Paul L. Modrich, Tomas Lindahl, Aziz Sancar

Drs. William C. Campbell, Sotoshi Ōmura, and Tu Youyou were awarded the Nobel Prize in Physiology or Medicine for their work in developing anti-parasitic drugs. Drs. Campbell and Ōmura collaborated to develop the drug Avermectin, which is used to combat the parasitic worms that cause river blindness and filariasis by producing an environment that is toxic to the parasite but not the host. This is done by increasing the affects of glutamate, a neurotransmitter, at a specific type of ion channel, leading to a heightened level of chlorine beyond which the worm can sustain. Dr. Tu, the chief professor at the China Academy of Traditional Chinese Medicine, discovered Artemisinin, an anti-malarial drug. Artemisinin is a derivative of sweet wormwood, or qīnghāo, which has been used to treat malarial symptoms since the sixteenth century and has been known in China for its medicinal properties for at least the past two-thousand years. She is the first person from China to be awarded a Nobel Prize in the sciences.

*Laureates are pictured left to right

Are We Entering a Post-Antibiotic Era?

Tracking the Rise of the Superbug

By Tara Santora
Illustration by Ashley Graumen

Imagine that, in picking up this magazine, you cut your finger and your injury becomes infected. In today's world, your paper cut is of little consequence. However, getting a similar scratch any time before the mid-1950's could easily have threatened your life. Before antibiotics, luck was often as helpful as a doctor. The treatment for tuberculosis was fresh air, and surgery of any kind welcomed life-threatening infection.

In 1928, Sir Alexander Fleming, a Scottish biologist, returned to his laboratory after a family vacation to find that one of his glass plates, which had previously been covered in the bacteria staphylococcus, now had mold growing on it. This mold, penicillium notatum, had killed the surrounding bacteria in a circular ring.

In a world where pneumonia and childbirth killed too frequently for comfort, this discovery was groundbreaking. Fleming soon found that the bacteria-fighting mold could be given to small animals with no negative effects. Ten years later, Fleming's research was continued by two Oxford University researchers, Howard Florey and Ernst Chain. These scientists managed to isolate penicillin, the bacteria-killing substance, from its parent mold.

In 1941, a doctor named Charles Fletcher performed the first human trial with penicillin on Albert Alexander, a patient who was infected after being scratched by a rose thorn while gardening. Alexander was near death, and penicillin seemed to be his only hope. The drug caused a remarkable recovery in Alexander. However, penicillin was extremely difficult to produce and only a limited quantity was available for this trial; after several days of recycling the antibiotic from his urine, Alexander died because there was not enough of the drug available to eradicate his infection.

Soon, at Florey's bidding, an American drug company began mass producing penicillin. This manufacturing began at a crucial time during World War II; by D-Day, there was enough penicillin to treat all infected Allied soldiers wounded in the famous battle. In 1945, Fleming, Florey, and Chain jointly received the Nobel Prize for Medicine for initiating the Antibiotic Era.

> At the time, these few instances of resistance seemed inconsequential; if a strain of bacteria became resistant to one antibiotic, there was a new one to take its place. However, no new classes of antibiotics have been introduced in over thirty years.

The years between 1950-1970 reigned as the golden age of antibiotic discovery and development. However, as early as four years after penicillin was publicly released, antibiotic-resistant infections began to be reported. At the time, these few instances of resistance seemed inconsequential; if a strain of bacteria became resistant to one antibiotic, there was a new one to take its place. However, no new classes of antibiotics have been introduced in over thirty years. Drug companies have slowed their pursuit of new antibiotics as their remaining efforts have become less fruitful; for example, it now takes about ten years and $300 million to bring a new antibiotic to the market.

Antibiotic resistance is a natural process of evolution. When antibiotics are administered, they kill most of the bacteria within a setting, but some bacteria are more resistant to the antibiotic than others. Some of the resistant strain survives, reproduces, and shares its resistant DNA with other bacteria. Due to this selective pressure, the majority of the bacteria colony can become resistant to the antibiotic.

Natural selection can cause this selective pressure, such as when one type of bacterium produces antibiotics to fight a competing type. However, when humans interfere, the magnitude of the resistance is greatly intensified. The Center for Disease Control (CDC) currently reports that in the United States, two million people become infected with antibiotic-resistant superbugs and 23,000 die from these infections each year.

Bacteria can become antibiotic-resistant superbugs in two different ways. The first way is by acquiring random mutations that lead to antibiotic resistance. The second way is by sharing their antibiotic-resistant DNA with non-resistant bacteria, transferring resistant properties in a process called horizontal gene transfer. Horizontal gene transfer can occur through three different methods. In a first method, a virus can transfer DNA from one bacterium directly connected to another, which is called bacterial transduction. In a different method, one bacterium exports a strand of a plasmid (a small piece of DNA separate from the main chromosome) to another bacterium through a process known as conjugation. In a third method, one bacterium can export DNA as a plasmid into the surrounding environment, and this plasmid can later be imported by a different bacterium, which is known as bacterial transformation.

The rapid increase in the number of antibiotic-resistant superbugs is due largely to the human abuse and overuse of antibiotics. In 2013, the CDC announced that up to half of all human antibiotic use in the United States may be unnecessary. When pressured by patients, doctors sometimes prescribe antibiotics for colds and other viral ailments, even though they provide no beneficial effect. In some countries and online, antibiotics can sometimes be purchased without a doctor's prescription. Even when antibiotics are correctly prescribed, patients sometimes do not take their full prescription, leaving the most resistant bacteria alive and able to spread their superbug DNA. As antibiotic resistance becomes more prevalent, the remaining effective drugs will become more scarce and expensive. The chance of bacteria becoming resistant to multiple antibiotics will increase and the amount of resistance-caused deaths will follow.

Antibiotic resistance is not a speculative event that may or may not happen in the distant future. The danger surrounds us right now; it is undeniable, and it is spreading. There is only one antibiotic left used to treat gonorrhea, and it has failed in several cases in several different countries. In 2013, there were 480,000 cases of multidrug-resistant tuberculosis, and HIV antibiotic resistance is also climbing.

Earlier this year, researchers in China found that the infamous E. coli bacteria is now showing resistance to colistin, a last resort antibiotic. Colistin is the drug prescribed when no other drug can possibly work, but now this antibiotic safety net is failing too. The project's research team, led by Dr. Jim Spencer, found that 15% of tested raw meat carries this resistant strain, and they suspect that this resistance is not isolated to China. One of the most worrisome findings of this study is that the antibiotic-resistant gene, MRC-1, is located on the bacteria's plasmids. These plasmids are shared through both conjugation and transformation, so the resistant genes can be shared by a population much more easily than if the gene was on chromosomal DNA. The recipient bacteria do not even have to be E. coli.

While human activity is responsible for much of this growing trend of resistance, humans are not the only ones consuming these drugs. 80% of the antibiotics used in the United States are given to livestock, mostly for prolonged doses throughout long periods of time. The main reason that farmers give animals antibiotics is not to cure illness. Instead, antibiotics serve as growth hormones, placed daily in the food and water that the livestock are given to eat.

There is considerable controversy over whether the use of antibiotics in raising farm animals is dangerous to humans. Some researchers claim that the antibiotic-resistant bacteria in the livestock are passed on to humans when meat is not handled and cooked properly. Additionally, these animals' feces can contain bacterial superbugs which can spread to food crops that people consume. However, others claim that there is no sufficient evidence to prove that livestock antibiotic use is hazardous or that a significant amount of the superbugs created in this way are ever introduced to humans.

Regardless of the controversy, the European Union has banned the use of antibiotics as growth promoters on farms. Earlier this year, the Obama administration released a National Action Plan For Combating Antibiotic-Resistant Bacteria. Now it is illegal in the United States for antibiotics to be given to animals strictly for growth promotion. However, the law still allows for the antibiotics to be given for health reasons, but it is difficult to distinguish why a farm is using antibiotics, creating a large loophole for the livestock industry.

> We may soon be entering a Post-Antibiotic Era. In this age, any small infection could spiral out of control and leave someone in a hospital.

We may soon be entering a Post-Antibiotic Era. In this age, any small infection could spiral out of control and leave someone in a hospital. Concerns are particularly heightened for the elderly who are already sick and in hospitals. Last year, Dr. Arjun Srinivasan, assistant director of the CDC, stated, "We're in the post-antibiotic era. There are patients for whom we have no therapy, and we are literally in a position of having a patient in a bed who has an infection, something that five years ago even we could have treated, but now we can't."

Individuals can take measures to curb antibiotic resistance, such as practicing good hygiene (therefore reducing the need for antibiotics) and taking the drugs only as prescribed. However, antibiotic resistance is a global issue because superbugs and their DNA can spread between different parts of the world. Countries, especially less developed ones, need to increase regulation of antibiotic use and improve sanitation to prevent the impending doom of an antibiotic apocalypse.


KATSARIDAPHOBIA
THE FEAR OF COCKROACHES
RAID
vacuum
fwoop!
PEOPLE WITH THIS PHOBIA ARE SCARED OF LESS THAN ONE PERCENT OF THE 4,000 SPECIES OF ROACHES IN THE WORLD. BUT WHAT ABOUT COCKROACHES CAUSES THIS COMMON PHOBIA?
WELL, COCKROACHES ARE ODDLY FASCINATING
THEY CAN HOLD THEIR BREATH FOR OVER 40 MINUTES.
MOST ARE BETWEEN A HALF TO TWO INCHES LONG BUT SOME CAN GROW UP TO SIX INCHES LONG! YEESH!
THEY CAN LIVE WITHOUT A HEAD!
THEY BREATH THROUGH THEIR SKIN!
THEY CAN GO FOR WEEKS WITHOUT EATING.
THEY EAT JUST ABOUT EVERYTHING, INCLUDING SOME LOVELY EXCREMENTS
THEY CAN RUN UP TO THREE MILES AN HOUR. FOR THEIR SIZE, THAT'S PRETTY FAST!


HAVING ORIGINATED MORE THAN 280 MILLION YEARS AGO, THEY HAVE EVOLVED INTO ONE OF THE MOST ADAPTABLE SPECIES ON THE PLANET.
GETTING RID OF THEM TAKES GUTS...
HOWEVER,
DESOLATION
THEY CAN WITHSTAND 10 TIMES MORE RADIATION THAN HUMANS!
DOOM
... AND HIGH EXPLOSIVES.
THESE GUYS DON'T GO DOWN EASILY!

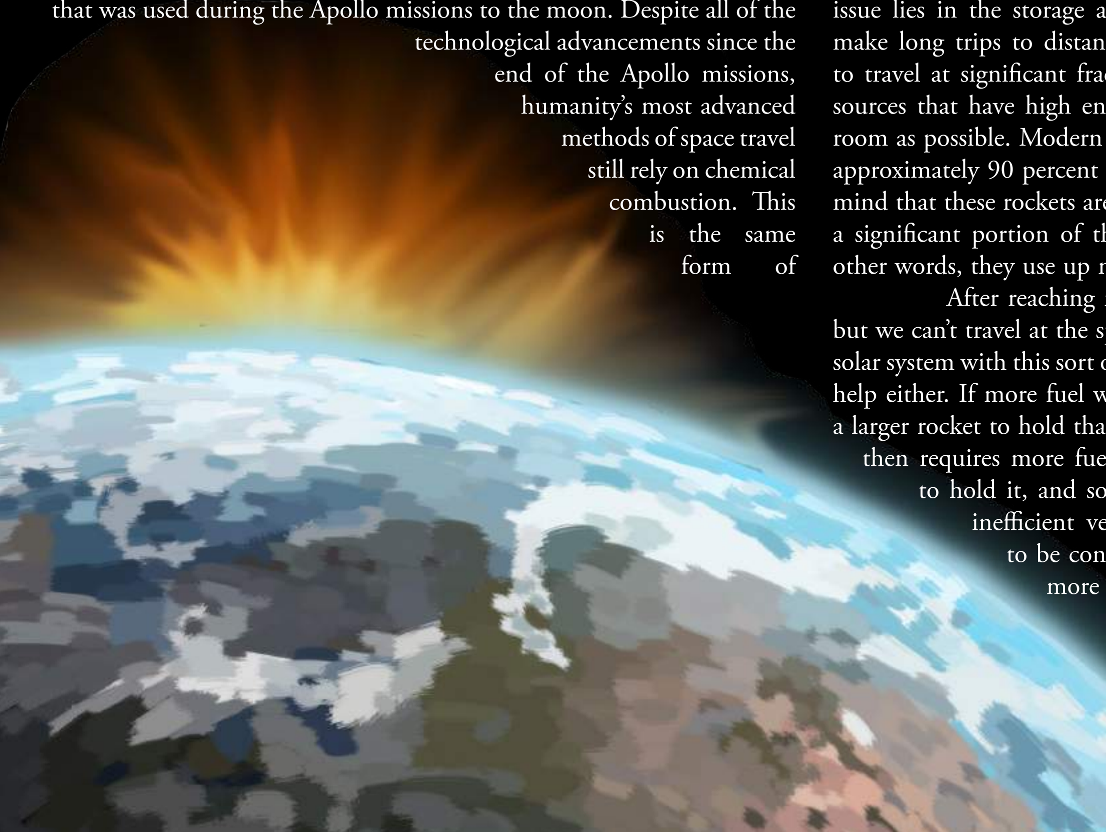
Come Sail Away With Me To The Stars

How Solar Sails Might Someday Bypass Our Need For Fuel

By Jacob Turner
Illustrations by Rachel Dan

For almost 60 years, the prospect of space travel has captured the imagination of entire nations, and has spurred one of the most significant periods of technological advancement in human history. The prospect of humans reaching and perhaps living on another world is a quickly approaching reality. In the more than 40 years since the Apollo missions ended, we have explored all of the solar system's planets, many of its large moons and dwarf planets, and one of our spacecrafts has even entered interstellar space. It's only a matter of time before we hear word of the mission that will finally carry us to the stars—except for the fact that our spacecraft technology has not improved since the Apollo missions.

The most powerful rocket ever built, the Saturn V, is the rocket that was used during the Apollo missions to the moon. Despite all of the technological advancements since the end of the Apollo missions, humanity's most advanced methods of space travel still rely on chemical combustion. This is the same form of propulsion that was in use when NASA's most advanced machines had less computing power than the phones most of us carry in our pockets. Mechanistically, there's nothing wrong with these rockets. They're incredibly powerful, can carry heavy loads, and have a high reliability. The main problem comes from how these rockets are powered.

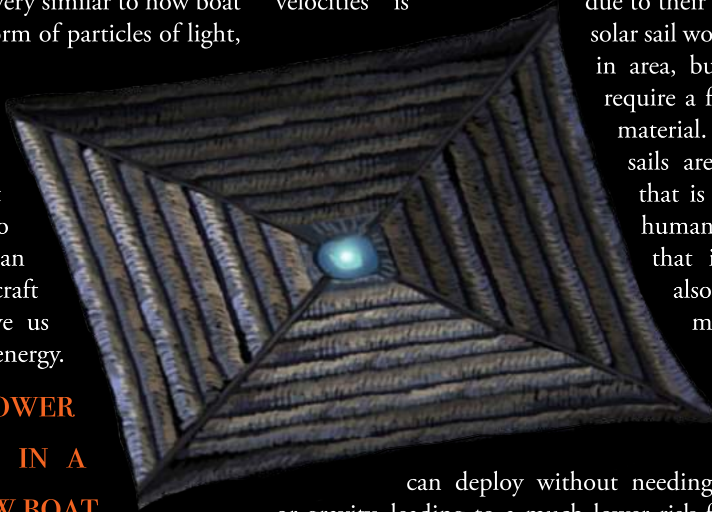


> MODERN ROCKETS REQUIRE THEIR FUEL SOURCES TO COMPRISE APPROXIMATELY 90 PERCENT OF THEIR TOTAL MASS.

Chemical fuel isn't inherently a bad fuel source. The majority of modern vehicles run using some form of internal combustion. The issue lies in the storage and usage of this fuel source. If we want to make long trips to distant worlds, we require spacecraft that are able to travel at significant fractions of the speed of light and run on fuel sources that have high energy output efficiencies and take up as little room as possible. Modern rockets require their fuel sources to comprise approximately 90 percent of their total mass. It is important to keep in mind that these rockets are taller than most skyscrapers and they detach a significant portion of their body after reaching low Earth orbit. In other words, they use up most of their fuel just escaping Earth's gravity.

After reaching near-space, rocket fuel is reasonably efficient, but we can't travel at the speeds necessary to explore worlds beyond our solar system with this sort of technology. Simply adding more fuel doesn't help either. If more fuel were provided for the rocket, it would require a larger rocket to hold that extra fuel, which means a heavier body that then requires more fuel, which then requires an even larger rocket to hold it, and so we end up in a cycle that becomes energy-inefficient very quickly. If the human race doesn't want to be confined to just exploring our own solar system, more advanced methods of space travel are needed.

Enter the solar sail. When considering all possible options for future space travel, the solar sail is currently the most practical, and is in the midst of undergoing test flights in space. The most appealing aspect of solar sails is that they solve the issue of needing a larger body to hold more fuel by removing the need to carry their own fuel in the first place. As the name suggests, solar sails rely on the power of the Sun as propulsion in a method very similar to how boat sails use wind. The Sun gives off energy in the form of particles of light, called photons. While photons are massless, they do contain energy. As demonstrated in Einstein's Theory of Special Relativity, mass and energy are two sides of the same coin. This fundamental property of matter means that light has an intrinsic momentum, allowing photons to exert pressure on objects such as solar sails, which can absorb some of the light's energy, giving the spacecraft a tiny push. Such methods of propulsion give us access to what is essentially a limitless source of energy.

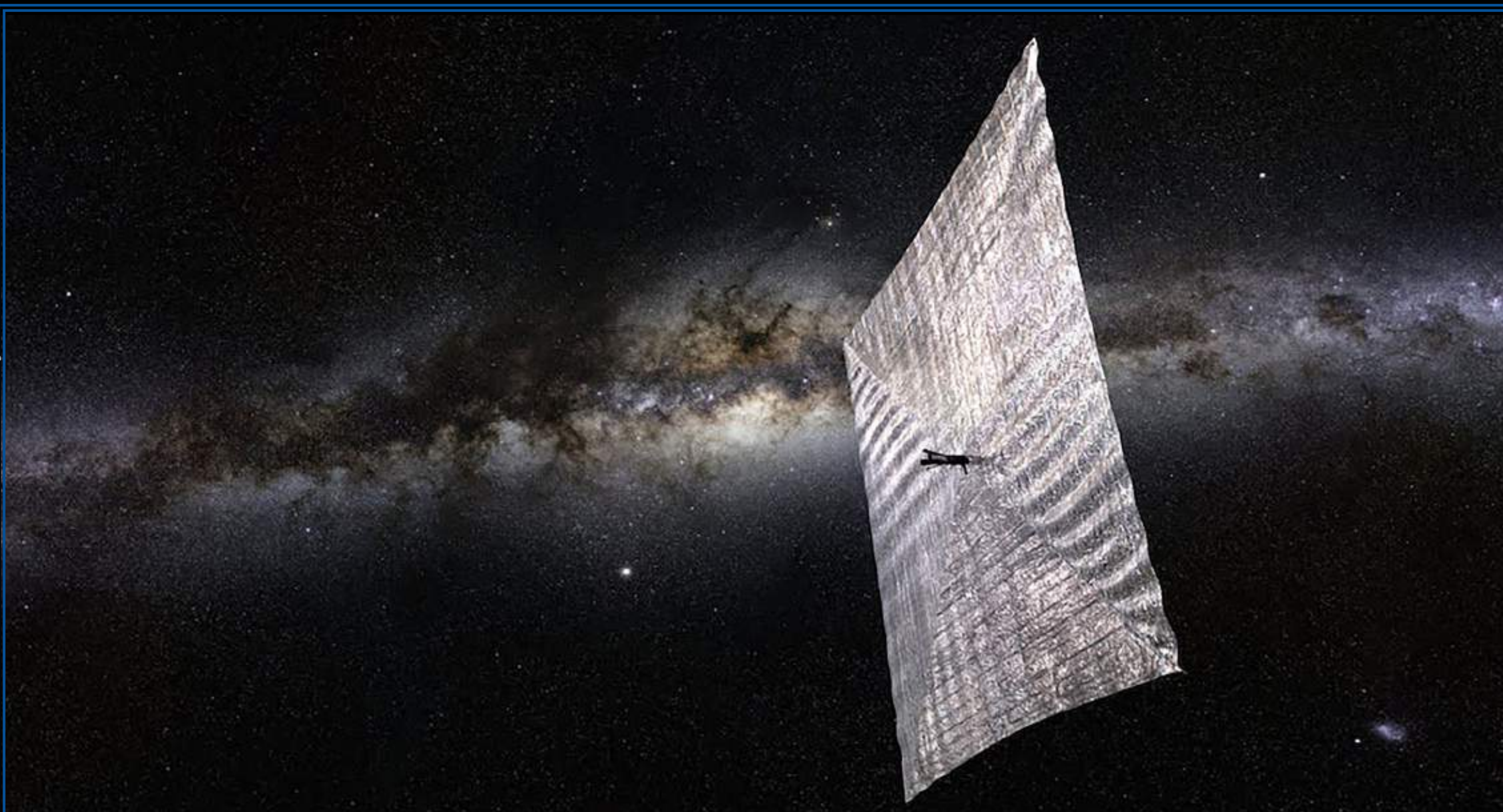


> SOLAR SAILS RELY ONITHE POWER OF THE SUN AS PROPULSION IN A METHOD VERY SIMILAR TO HOW BOAT SAILS USE WIND.

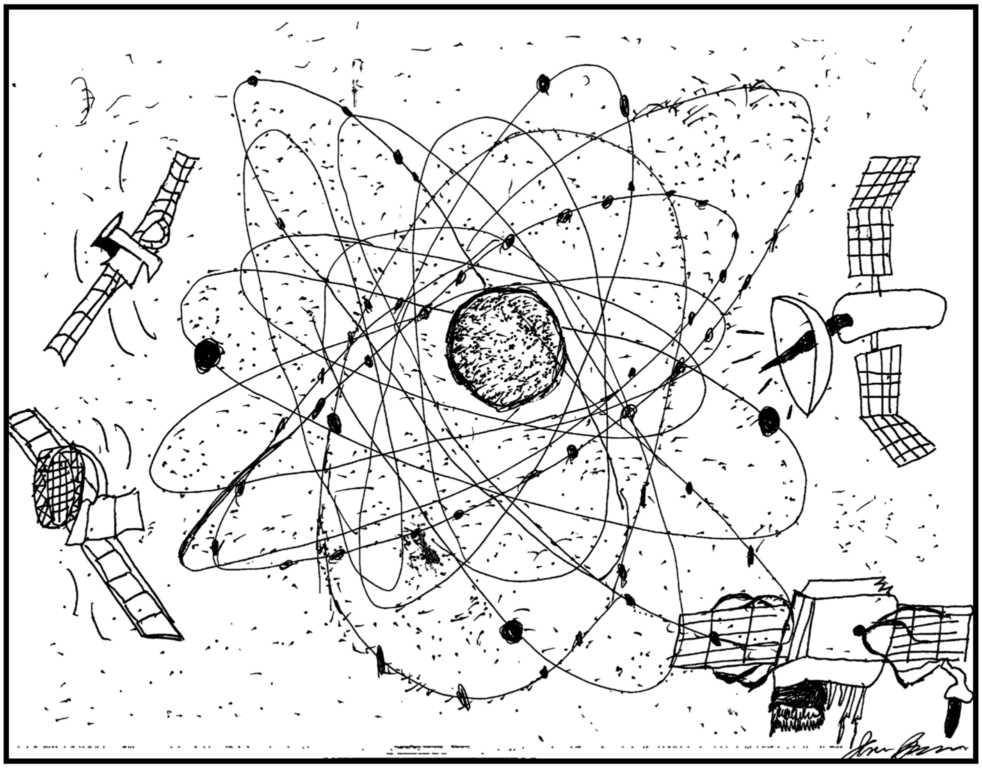
Another useful quality of solar sails is that limitless energy sources such as the Sun provide a continuous force, and unlike chemical rockets are not limited to sequences of energy bursts from a predetermined fuel supply. Since a medium such as space has nothing that would provide resistance like wind does on Earth, solar sails can build up ever increasing accelerations, theoretically reaching a significant fraction of the speed of light. If a solar sail started its voyage by initially completing a gravitational slingshot around the Sun, it could theoretically achieve a velocity approaching 1/2000th the speed of light (roughly 300,000 miles per hour).

One of the main reasons that solar sails can reach such high velocities is due to their incredibly low mass. Ideally, a solar sail would be a few square kilometers in area, but at the very least it would require a few hundred square meters of material. Despite these large sizes, the sails are made of a reflective metal that is only 1/100th the width of a human hair, resulting in a structure that is not only lightweight but also very flexible. This flexibility means that a solar sail can be launched completely folded up with a volume of only a few cubic meters. Once safely in space, the sail can deploy without needing to account for air pressure or gravity, leading to a much lower risk for mechanical complications.

We have only just begun to harness the potential of this technology. Over the summer a crowd-sourced campaign called The Planetary Foundation, headed by Bill Nye, successfully built and launched a 32 square-meter solar sail. While they were unable to achieve the launch height needed to test the propulsion of the sails, they were successful in deploying the sail without any mechanical problems. They hope to do a full demonstration sometime in 2016. After that, if all goes well, humankind may be literally sailing to the stars.



PICTURED ABOVE: Bill Nye's solar sail *LightSail*™ was launched into space May 20th, 2015 and successfully completed its test flight in June, paving the way for a second mission in 2016. *LightSail,*™ whose four triangular Mylar sails expand to 32 square meters once unfolded, was deployed in a three-unit CubeSat (a type of miniature satellite) about the size of a loaf of bread. (Photo Credit: The Planetary Society)



Elevator to Heaven

Are Elevators the Future of Space Travel?

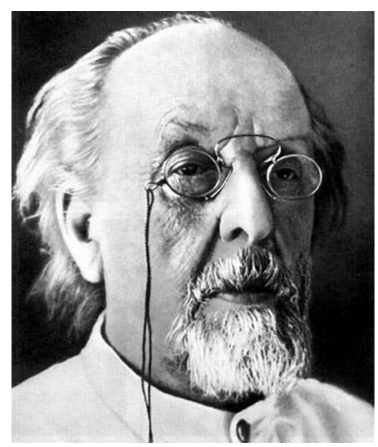
By Oliver Meldrum

Illustration by Jordan Joseph

Have you ever dreamed of going up in a real skyscraper? Not one that is 168 floors tall and barely reaches some clouds, but one that extends 22,240 miles through earth's atmosphere into outer space? Although this may seem completely absurd, with an interesting physical phenomenon and some advanced materials technology, it may soon be possible.

Ever since Sputnik 1, we've been spending billions of dollars on sending equipment and people into space. Up until now, everything in orbit has been put there by rockets. This is an incredibly expensive and potentially dangerous process as it uses a huge amount of fuel and the materials are generally completely unable to be reused. As a result, people have been searching for alternative ways to send things into space. One such possibility historically comes from Konstantin Tsiolkovsky, a Russian scientist.

Up until now, everything in orbit has been put there by rockets. This is an incredibly expensive and potentially dangerous process as it uses a huge amount of fuel and the materials are generally completely unable to be reused.



Russian Rocket scientist Konstantin Eduardovich Tsiolkovsky, 1857-1935

In 1895, Tsiolkovsky proposed an Eiffel Tower type structure that would reach the height of geostationary orbit. At this height, a satellite would complete one full circle in the time it takes Earth to rotate. Therefore, it would remain in the same place in the sky if it was directly over the equator. As a result, as you climbed the tower, you would feel like gravity was decreasing until, at the top, you would be in free fall just as if you were orbiting the earth yourself. In fact, you would actually now be in geostationary orbit. This is because as you climb the tower and get farther away from earth, the force of gravity would decrease. In addition, your velocity would increase and you would feel like you were being pulled away from the earth more and more. This is a result of the centripetal acceleration, and is the same as the feeling you get when you go fast around a corner in a car.

If this tower could be constructed, it would offer many advantages over rockets. Firstly, you could "pull" yourself up the structure, which is more efficient than using rockets. Secondly, it would allow a slower descent through the atmosphere, which would be much safer than the current rocket method. In addition, almost everything in the process would be reusable. Perhaps one of the most exciting advantages is that if the elevator were extended a mere 9,000 more miles, something released at the end would have enough velocity to escape the earth's gravitational pull and could easily be sent off to other planets or beyond.

Many scientists since 1895 have thought about the possibility of an elevator to the stars, and there have been various improvements to the idea. For example, it is now widely accepted that it would only be feasible if instead of using a tower, a tether was used in conjunction with a counterweight orbiting farther out in space than geostationary orbit. This would provide an outward force greater than the gravitational pull, which would keep the tether taut.

Despite improvements in the idea over the years, there are still some very major difficulties. Perhaps the most pressing is the search for a material that is both strong and light enough to support the huge tension. The most promising material right now is carbon nanotubes. However, scientists claim they are only about two-thirds of the strength they would need to be in the space elevator. So, although there may be hope, we are far from realizing Tsiolkovsky's vision.

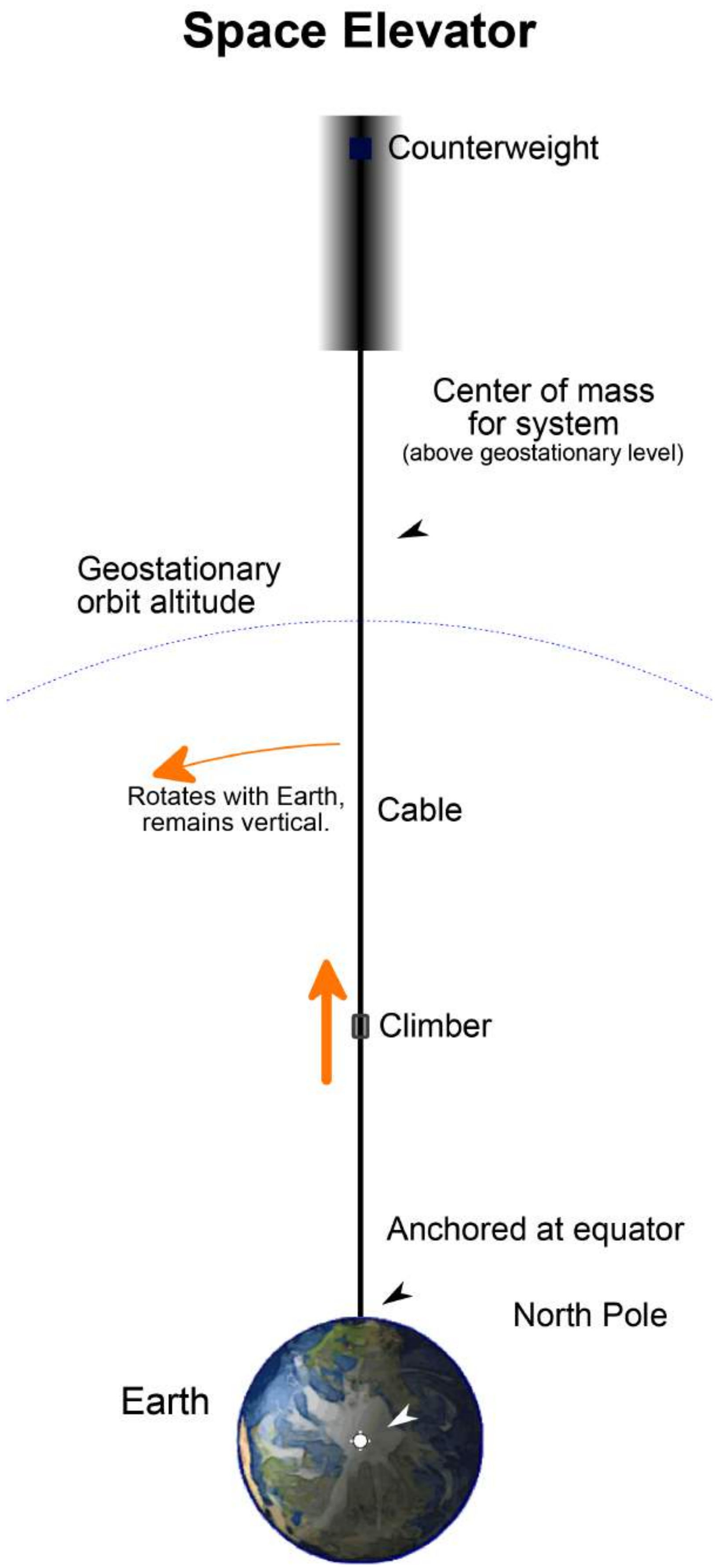
Another major concern is how easily the structure could be destroyed. There is currently a huge amount of satellites and "space junk," or debris from previous space missions, in orbit around the planet. It would be very hard to prevent this from hitting the elevator. We could program everything in orbit to maneuver out of the way, but this would involve updating or taking down everything already up in space, which would be a tremendous amount of work. Another potential hazard could be terrorist or military attacks. It would be incredibly difficult to protect the structure from human attacks and it would most likely be an ideal target. There are also many other logistical and physical problems, such as the trip up to geostationary orbit taking months.

There is currently a huge amount of satellites and "space junk," or debris from previous space missions, in orbit around the planet. It would be very hard to prevent this from hitting the elevator.

Despite all of these issues, many believe that the structure is still very possible in the relatively near future. There have been many design competitions and a lot of research with the purpose of developing the technology necessary for this space elevator. However, there are also many skeptics that say that there is absolutely no possibility of this happening anywhere in the near future, if at all.

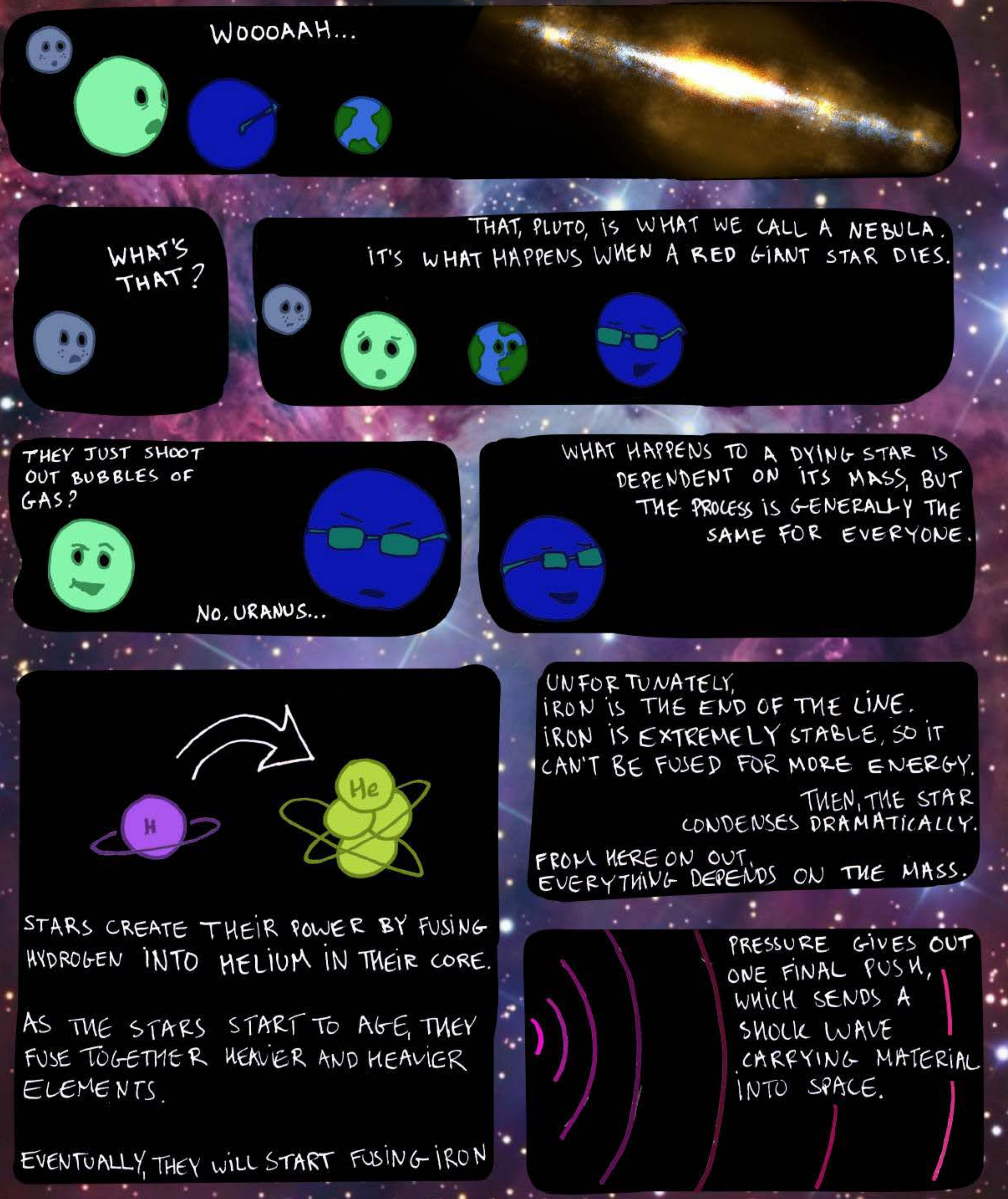
Even if it is ultimately impossible or not practical on the earth, it is very feasible to construct such an elevator on objects in space with lower gravitational pulls. For example, we have all of the necessary technology for constructing a space elevator on the moon. Construction would be much easier on the moon because a space elevator would rely on being suspended between the moon and the earth, feeling the gravitational effects of both objects, so the tether wouldn't have to be as long.

Regardless of whether this is going to happen on the earth, it is a very interesting conceptual idea. Imagine telling your grandchildren, while riding up the elevator, about how back in the old days we used to use big rockets instead. It would be like learning that we used to use candles instead of light bulbs!



Size Matters

WRITTEN BY EYDON THOMASHOW ILLUSTRATED BY BEATRIX PAROLA




FOR SMALLER STARS, LIKE THE ONE WE JUST OBSERVED, THIS MATERIAL TURNS INTO A PLANETARY NEBULA.
THE STAR ITSELF WILL CONDENSE TO ABOUT THE SIZE OF YOU, EARTH.
THESE ARE CALLED WHITE DWARFS, WHICH IN MOST CASES IS THE LAST STEP.
LARGER STARS WILL GO THROUGH SUPER NOVA EXPLOSIONS, WHICH CAN BE LIGHT YEARS ACROSS. OUT OF THESE, SMALLER STARS WILL CONDENSE DOWN TO 10KM IN DIAMETER.
THESE ARE CALLED NEUTRON STARS
THE BIGGEST STARS WILL TURN INTO BLACK HOLES. ALL THE MATTER IN A BLACK HOLE CONDENSES INTO AN INFINITELY DENSE POINT WHERE GRAVITY IS SO STRONG...
EVEN LIGHT CAN'T ESCAPE
WOW.
SO... WHAT WILL HAPPEN TO OUR SUN?
OUR SUN IS CONSIDERED A LIGHTWEIGHT STAR.
WHEN THE TIME COMES, IT WILL EXPAND INTO A RED GIANT
AND COLLAPSE INTO A WHITE DWARF
WHAT WILL HAPPEN TO US?!
LETS JUST BE GRATEFUL WE DON'T HAVE TO WORRY ABOUT IT FOR ANOTHER 5 BILLION YEARS!
DON'T WORRY EARTH, THE HUMAN RACE WILL BE LONG GONE BY THEN.
AS FOR US THOUGH...

Would You Flip the Switch?

What the "Trolley Problem" says (or doesn't) about human nature

By Nathaniel Bohm-Levine
Illustration by Mikaila Hoffman

Can your response to a single scenario predict your day-to-day decisions? Can it predict how you decide when saving a life is—to put it bluntly—worth it? To put this question to the test, we will examine a classic philosophical thought experiment known as the "trolley problem." Introduced by philosopher Philippa Foot in 1967, the dilemma goes something like this: imagine you are walking by a train track, when out of nowhere you notice a runaway trolley with failed brakes. Several yards from the trolley's path are five people who are helplessly tied to the tracks. In front of you is a switch that would divert the path of the trolley, but doing so would cause the trolley to hit and kill someone who happens to be crossing the sidetrack. What do you do?

In strict utilitarian terms, the clear choice would be to save the life of five at the expense of one. Utilitarianism, a subset of the philosophical framework known as consequentialism, is a school of ethics that can essentially be summarized as "the ends justify the means." In the flip-switching scenario, people typically side with the utilitarians—repeated studies have found that an average of ninety percent of respondents will choose to divert the trolley's path if it means saving five.

You can intensify the situation by introducing a complication to the problem (this variation is sometimes called the "Fat Man," regrettably): you are now standing on a footbridge above the track, observing the trolley as it nears the five victims. There is a large man standing along the bridge's railing; his weight would unquestionably stop the trolley in its tracks. Of course, if the man were pushed over, he would be immediately killed. Do you push him?

Again, if utilitarian considerations were all people cared about, the decision would be easy: act and kill one, do nothing and five die. Yet in this case, polls show that a clear majority will choose not to act, even though like last time, saving the five justifies killing the one. Perhaps people are now acting under a different philosophical framework, one where the individual has greater value. This framework is known as deontology, which simply put is the belief that there are intrinsic "right" and "wrong" actions. Under deontology, no degree of lifesaving is worth an act as perverse as murder.

Faced with the switch, most decide to kill, but when confronted with pushing the man off the bridge, most choose inaction. Why do people follow a utilitarian framework in one scenario, but a deontological one in another? How—suddenly—do the ends no longer justify the means?

> Under deontology, no degree of lifesaving is worth an act as perverse as murder.

Unsurprisingly, philosophers, psychologists, and most recently cognitive neuroscientists have swarmed over this phenomenon. Spanning the last several decades, the field of "trolleyology" has taken off, and a variety of explanations or solutions to the trolley problem have been offered (if it's any indication of its omnipresence, current trainees at West Point take courses on trolleyology in preparation for a career in military ethics). Researchers have posed a variety of variations and manipulated conditions, all to ask: When and why do we choose to flip the switch?

Researchers have posed a variety of variations and manipulated conditions, all to ask: When and why do we choose to flip the switch?

* * *

A number of interesting findings regarding the trolley problem have appeared over the years: people choose not to flip the switch when the one killed on the other track is a loved one or romantic partner. Men might be more likely to push the large man over, and might even possess a greater tendency to flip the switch. Watch a comedy clip before being polled and you're more likely to push the man off the bridge; watch a tedious historical documentary and those odds go down. After surveying 103 bar-goers in Grenoble, France, researchers found a high blood alcohol content was correlated with an increased propensity for flip-switching. Does a career in philosophy make a difference? Surprisingly, no: professional philosophers respond to the dilemma in the same manner regardless of their level of education—or even their previous knowledge of the trolley problem.

Now, to complicate the situation even further: What if your own weight were enough to stop the trolley? Would you throw yourself over the bridge? Researchers at the University of Michigan found that people are more likely to choose sacrificing themselves over the innocent bystander.

* * *

What do all of these results tell us about human nature? Not much, perhaps ("I don't do trolleys," as one famous philosopher has exclaimed). Situations like the trolley problem rarely occur in day-to-day life, and few have the luxury to sit and muse on some theoretical moral quandary.

In an effort to connect these findings to a slightly more "real-world" scenario, researchers at Michigan State University placed participants in virtual reality headsets and had them pull (or not pull) a real switch as they observed a box car hurtle towards five realistically animated people, who even screamed as the box car neared. Even with the added motivator of five virtual deaths, the results were nothing new: most would flip the switch; most would abstain from the push. Still, no one could conclude from this contrived situation that it irrevocably represented the response from a typical human who is put into the situation.

However, for answers as to why most people respond to the trolley problem the way they do, maybe academics were looking in the wrong places. Maybe the key to understanding comes from a key feature of human nature that most philosophers had neglected: emotion.

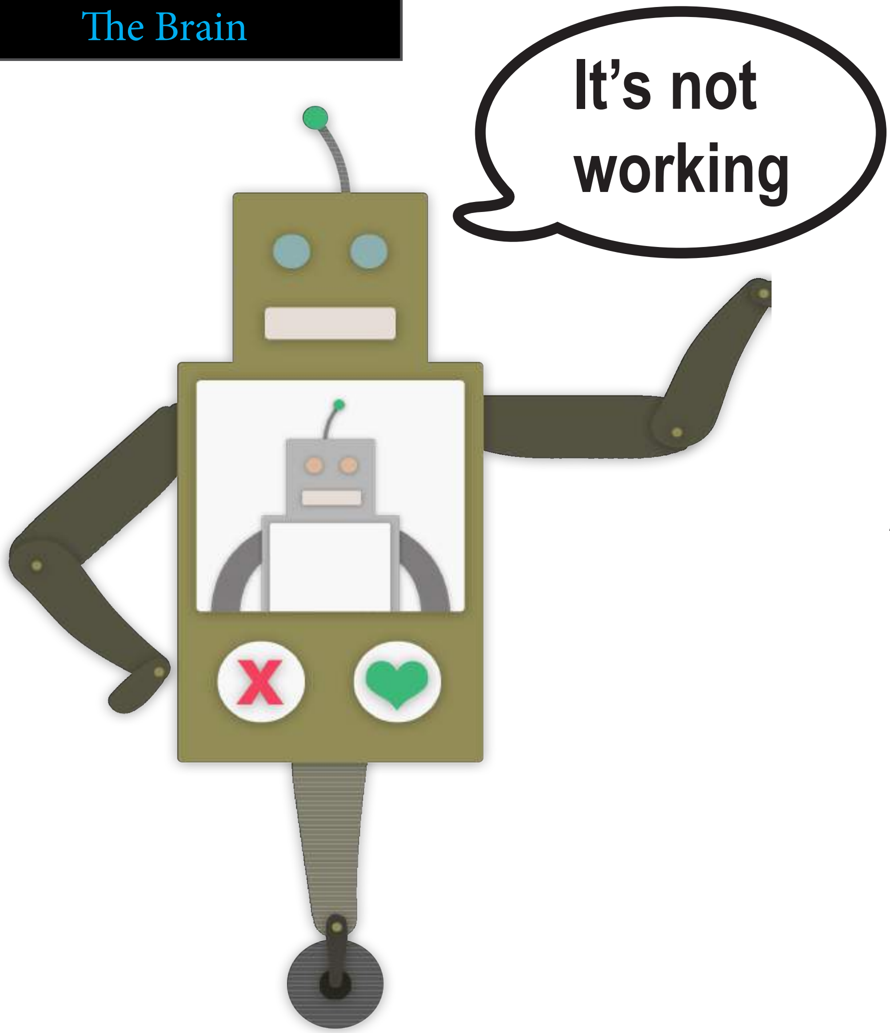
Following this lead, a team of researchers at Princeton, led by Joshua Greene, used functional magnetic resonance imaging to discern brain activity while people read and considered two ethical dilemmas: the traditional version of the trolley problem and the "footbridge" variation. There are obvious differences between the two scenarios: one allows the person a certain degree of removal from the situation, while pushing someone over a bridge is violent and unavoidably visceral—what cognitive scientists might call "emotionally salient."

In the body-pushing scenario, areas of the brain that had previously been found to be involved during times of sadness or fear—medial prefrontal cortex, posterior cingulate, and amygdala—became active as participants mulled over their decision. These areas of activity did not appear in the other trolley scenario, which actually showed relatively more activity in two classically "cognitive" brain regions, the dorsolateral prefrontal cortex and inferior parietal lobe. Greene and his colleagues concluded that our brains recruit emotional processing when faced with "up close and personal" scenarios. This emotional system must then override our more rational brain decision-making regions when presented with situations that are intensely personal.

This interplay between two decision-making systems in our brain—a rational set of cognitive processes versus a set of emotional ones—reveals itself in the reaction time of the participants. When faced with the decision to push the man off the bridge, those who responded "yes" took longer to respond than those who said "no"—while the "yes" participants eventually decided on the utilitarian outcome, they had to overcome an initial tendency towards the deontological decision triggered by the emotional system. In contrast, for those who were faced with flipping a switch in the original version of the trolley problem, people responded "yes" just as fast as "no."

It might seem abstract, but the trolley problem has its real-life counterparts: the decision to drop the atomic bombs at the end of World War II was rationalized by arguing that a quick end to the war would save lives in the long run. And the decision to torture suspects connected to terrorist plots is influenced by a belief that the harm of one does not outweigh the potential safety of hundreds or maybe thousands of individuals. Deciding whether to save the many at the expense of few is not just an isolated, armchair-philosophy dilemma: understanding moral decision-making gives us key insights into the deepest of human tendencies across time.

"Faced with the switch, most decide to kill, but when confronted with pushing the man off the bridge, most choose inaction. Why do people follow a utilitarian framework in one scenario, but a deontological one in another?"



#SwipeRight

The Compatability Formula

By Gailyn Gabriel
Illustration by Beatrix Parola

The advent of the internet has spawned a digital age where we now live in a world more interconnected than ever. eHarmony research reveals that today about 30 percent of U.S. couples have met online and that by 2040, that number is estimated to be 70 percent. Culturally, online dating is gaining more and more acceptance. The modern ability to match couples from a wide pool of users based upon criteria as specific as your love for Disney movies (as the site Mouse Mingle does) signifies a global dating revolution. According to an infographic compiled by the Berkeley School of Information Science, online dating is more prevalent than ever before. Dating sites like Match.com, OkCupid, and dating apps like Tinder cater to users through algorithms ensuring compatibility.

With the average user spending an average of 12 hours a week on online dating avenues and the membership on leading dating sites averaging over 64 million people, these websites and apps garner massive amounts of data, propelling dating to the world of big data. Big data analytics is an effort to translate the ambiguous mounds of data produced by systems of users into something meaningful. While much of this data is questionable, generally because data collected through user decisions do not factor important intangible aspects of love that cannot be currently quantified, the big data collected from these sites reveals some interesting trends.

The heart of dating websites is in their algorithms, or step-by-step computational methods for their results. While most dating sites keep their compatibility algorithms a secret, OkCupid has one that has been patented. OkCupid's algorithm operates based on answers from questions it asks its users as well as the level of importance of each question to the user. It takes into account physical preferences of the user as well as the answers to questions dealing with personality and psychological preferences. For compatibility, the algorithm then uses a match percentage and pairs couples based on their scores.

According to an infographic compiled by the Berkeley School of Information Science, online dating is more prevalent than ever before. Dating sites like Match.com, OkCupid, and dating apps like Tinder cater to users through algorithms ensuring compatibility.

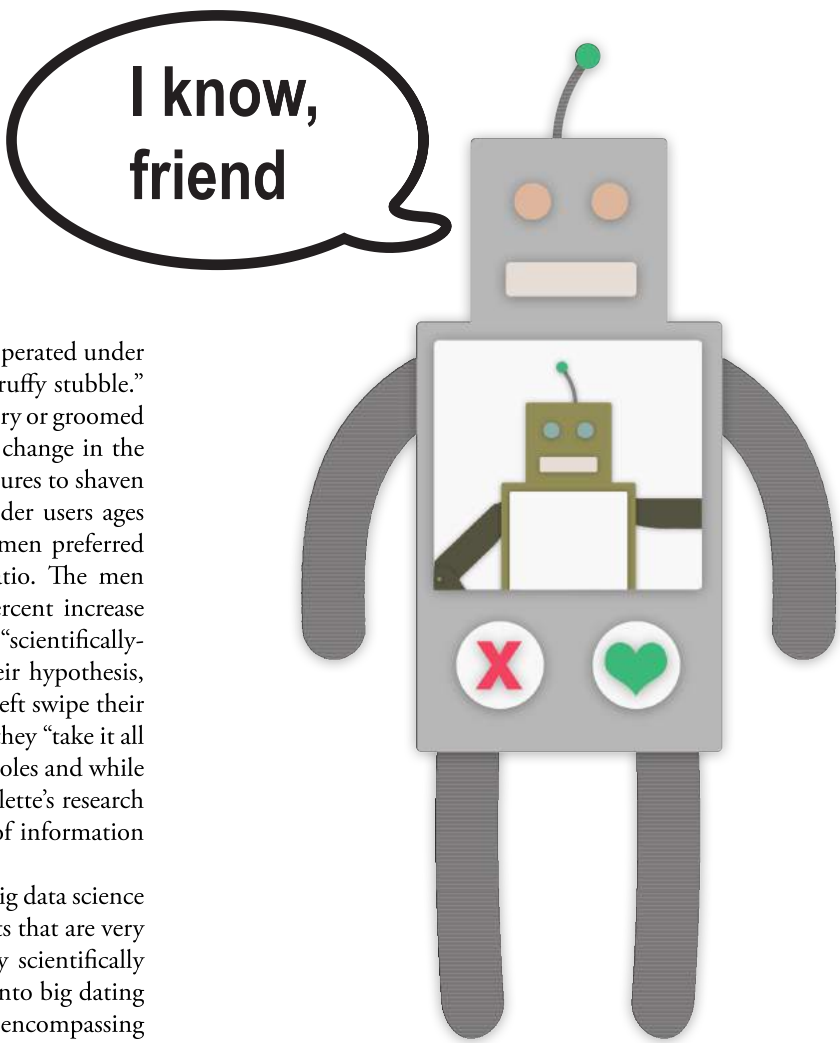
Match.com makes more use of how its users interact with the site. "Synapse", the code name for Match.com's algorithm, operates in a similar manner to sites like Amazon, Pandora, and Netflix in its search for potential matches. Ultimately, it operates in a similar fashion to the way the human brain learns. The program actually learns about user behavior based on choices and the results of those choices and does so through a variety of means. One unique aspect of the algorithm takes note of your behavior and choices outside of your set preferences. "Synapse" analytics show that 57 percent of women who claimed a desire for wanting children as a non-negotiable trait expressed interest in users who clearly did not want children. For men, 62 percent of those that claimed a solid income as a top priority in a partner expressed interest in women who did not have a solid income. "Synapse" takes these changes into account and learns from them. Additionally, "Synapse" uses triangulation, the process of taking into account the choices of users similar to you as well as users similar to those you like or view as a potential mate.

> The results of big data science in terms of dating do not account for unquantifiable aspects that are very important to dating and therefore cannot make any truly scientifically valid love formula.

Unlike most dating sites, Tinder is unique in that it does not have an algorithm for compatibility, but connects users based on mutual Facebook friends and location. The data Tinder collects comes from who the user "swipes right" for and when. From this data, researchers are able to pick up on a variety of trends and information about Tinder users. Through data analytics, researchers have examined how straight male users' swipes correspond with time to create a bell curve illustrating how males use the app; on the other hand, female users have established no trend. Gillette took advantage of Tinder's emphasis on appearance by paying Tinder analytics to conduct several experiments regarding male facial hair and the probability of a right swipe. They operated under the hypothesis that "ladies prefer well groomed faces to scruffy stubble." First, they examined 100,000 college-aged males to see if hairy or groomed men were more preferred and second, they examined the change in the amount of matches when men go from bearded profile pictures to shaven ones. Tinder found that based on 99,809 U.S.-based Tinder users ages 18-24 from October 10, 2014 to October 31, 2014, women preferred well-groomed men to unkempt men in a two-to-one ratio. The men involved in the second experiment saw an average 19 percent increase in right-swipes on their shaven profiles. Based upon these "scientifically-sound" data points, Gillette feels that they can accept their hypothesis, leading to the conclusion that college-aged males should "left swipe their beards" because "girls like your stubble. As a friend," but if they "take it all off...maybe she will, too." Surprisingly, the study is full of holes and while chances of Gillette appearing in Nature are quite slim, Gillette's research speaks to the potential of big data analytics in the realm of information technology and how it coincides with society.

As seen through Gillette's research, the results of big data science in terms of dating do not account for unquantifiable aspects that are very important to dating and therefore cannot make any truly scientifically valid love formula. Big data does not necessarily translate into big dating and while we don't entirely know how to construct a fully encompassing formula for love, the value of big data and the trends that can be divined from it are unequivocally promising. For example, Tinder's adoption of its new data analytic partners found, after analyzing data, the tendency of some users to blindly swipe right are limited; this greatly enhances the validity of a right-swipe and the integrity of Tinder's data.

Over time, the tendency of big data will not only amass data of quantity, but quality as well. Perhaps in due time, as the advances of big data continue and the trend of personalization progresses, we will see a formula for compatibility become a reality. While the context of this article examines the promises of big data in the realm of online dating, its potential spreads endlessly, especially in fields of health care and economics.



The Effect

A Review of Lucy Prebble's Play on Psychopharmacology and Romance

By Emilia Varrone
Illustration by Lydia Newman-Heggie

The Effect is not your typical love story. This is a play about neuroscience, the nature of science and how we perceive our environment. Prebble sets the play at a clinical trial for anti-depressant side effects in healthy individuals. Two of the volunteers, Connie and Tristan, meet at the start of the trial when Tristan inquires whether he should hold Connie's urine sample. A decidedly quirky couple, their chemistry (pun not intended) jumps right off the page. However, their attraction is complicated by the fact that they may be on antidepressants. After all, love is a blend of dopamine, serotonin, and oxytocin, right? Couldn't a drug induce the same effects and make you think you're in love? If love is simply a chemical cocktail in the brain, what is love? Does it matter if it is artificially induced? These are the questions that Lucy Prebble makes us ask in the twists and turns of her play.

The clinical trial is dramatized. If two subjects in a clinical trial were actually romantically fraternizing, they should be dismissed from the trial in order to preserve the integrity of the data. That being said, Prebble does point to something commonplace in science. If we accidentally add an extra milliliter of hydrochloric acid, we write it down. If it doesn't skew the data the wrong way, we keep the sample in the experiment. Does that skew the results that we find? Probably. How many experiments are successful because the intern dropped the centrifuge tubes on the floor? Do mistakes increase our rate of false positives? Perhaps Prebble is right, and we as scientists should be more willing to get rid of data that is tainted by a mistake, even if it supports our desired results.

Similarly, Prebble questions the effectiveness of modern day antidepressants. Prebble declares: the "history of medicine is a history of placebo," which is probably true. Though willow bark contains salicylic acid and actually reduces inflammation, there are many natural remedies that probably did nothing metabolically, and yet people felt better. Though accurate, Prebble's view is cynical. Today, we know more than ever about our medicines, and increasingly we are developing drugs based on molecular targets, rather than trial and error. Antidepressants do work better than placebo in meta-analyses, even if current drugs don't directly target the molecular basis of depression.

Of course, the crux of the play lies in the question: what is love? When we fall in love, certain hormones levels are increased. Is the stammering, the blushing, the energy associated with falling in love just our bodies' reaction to compatible pheromones? Prebble suggests that love is more than just chemicals ebbing and flowing. Prebble seems to suggest that any external manipulation of the brain isn't 'real', and true love between Connie and Tristan was there all along. The problem is, we are defined by our perceptions, so when Tristan says: "I can tell the difference between who I am and a side effect," he isn't necessarily telling the truth. All we know as humans is what our brain is telling us.

Our brains evolved to make sense of our environment to best respond to it—best respond, not correctly respond. By extension, we define ourselves based on the environment. If consciousness is a reaction to our environment, then the concept of the individual is a side effect of the body navigating an environment. A favorite example of mine is that there are blind spots in the middle of our visual field due to the exit of neurons from the retina to the optic nerve. Even when you close one eye, our brain "photoshops" in what it thinks is probably there. Generally, this system is seamless, we can't tell the difference between what light is actually reflected from the pigments and what our brains have guessed. Perhaps, if we induced the production of the same hormones that are released when we fall in love, then our brains would default, and think that we have fallen in love. If we define our emotions as our bodies responding to external stimuli, the manipulation of dopamine by drug is no less real than falling in love. Love can be interpreted as bodily sensations that the brain tries to make sense of. If that is the basis of love, then perhaps pharmacological manipulation of love is 'real love'.

Neurotribes

An Interivew with the Author, Steve Silberman

By Gabriel Hitchcock

I was seated at a table in Slow Train, waiting for the treasurer to arrive to discuss magazine finances, when my phone rang. The unfamiliar number and California area code piqued my interest as I slid it out of my pocket. I answered and was met with "Hi. Gabe? This is Steve Silberman." Shocked does not adequately describe my state of mind upon hearing that voice. I had been trying to nail an interview with Silberman for over a month to no avail. I had been introduced to his work by director of Disability Services, Jane Boomer, when myself and a friend of mine, one Martin Mancini, met with her to discuss an event we were planning. Silberman had recently risen to fame with his book *Neurotribes: The Legacy of Autism and the Future of Neurodiversity.* After reading the book, it was clear why Silberman's work had been nominated by a myriad of awards, as well as called one of the best books of 2015 by *The York Times*, *The Financial Times*, *The Boston Globe*, *The Economist, ad infinitum*. This also explains my stupefaction at receiving his call. This was a busy man and I was, after all, a lowly college student. However, Silberman and I did have some connection: he graduated from Oberlin College in 1979.

Silberman studied psychology at Oberlin, took a course at the Buddhism-based Naropa University in Colorado, and ended with a masters in English literature from Berkeley, California. Silberman went on to writer for the San Francisco *Chronicle* and, always a proud deadhead, co-authored a book on the Grateful Dead. But as time passed, Silberman found himself drawn to science writing.

Silberman became a senior writer for *Wired* magazine, a popular science magazine, in 1999. He says that "by doing science coverage for *Wired* I was able to blend two of my life long interests: science and writing." In part, it was the impact that one of his articles made upon the readership that led to his writing Neurotribes.

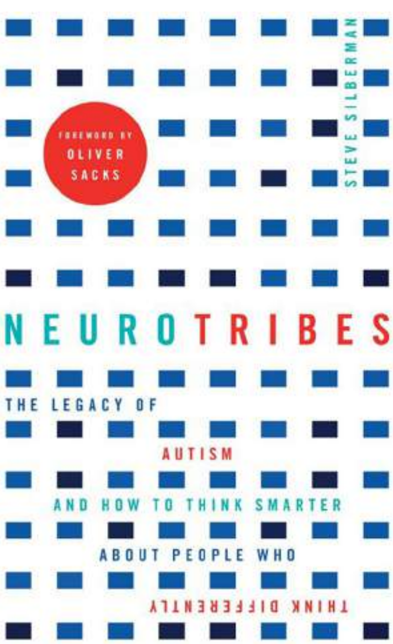
In 2001, *The Geek Syndrome* was published. "I started getting emails immediately, before it even came out, actually . . . I got emails from the families of autistic people, from autistic people themselves, and from people that thought maybe a relative of theirs showed autistic characteristics." Silberman goes on to say that "while I'm getting all this mail, the whole world was having a conversation about autism, but it's almost entirely about whether vaccines caused autism . . . society thought that it was having a serious conversation, but really it seemed like they were grappling with an entirely different set of issues than autistic people were dealing with."

This other conversation was precipitated by a 1998 study by a british researcher, Dr. Andrew Wakefield. In his study, Wakefield drew a causal link between vaccination and autism. Unfortunately for Wakefield's career, he had either invented or misinterpreted data for each of his 12 participants and the paper was later withdrawn. However, the damage had already been done. The repetition of this factoid by politicians and public commentators has kept the myth alive to this day.

While the emails continued to pour in, and this larger debate surged onward, Silberman became critical of the reporting of other writers on the topic of autism. "In every news story about the undeniably startling rise in diagnoses since the 1990s, it was always called something like 'a baffling enigma' or a 'mystery,' and I thought really? We're science journalists, shouldn't we be able to figure this out? I decided to begin to do the research, and that was the spirit under which I began the book." His work began with the dark beginnings of autism research, cultivating what sparse materials there were to construct his narrative. He then traversed the modern scientific literature, conducted numerous interviews, and read the work of those that came before. His research was expansive and thorough, and, at 542 pages, his book reflects that breadth.

Over the course of his book, Silberman details the journeys of some of history's most important autistic people, as well as chronicles the difficult and lonely stories of less known autistic people and their families. He introduces us to Leo Kanner, a child psychiatrist who ran a surreptitious campaign to suppress knowledge of the autism spectrum for fifty years; to Hans Asperger, whose story, despite his name recognition, had never been told; and to the growing number of neurodiversity activists seeking respect, institutional support, scientific research, accommodations in the workplace and education, and the right to self-determination for those with cognitive differences.

Silberman's book is a milestone in the story of autism. It takes the complexities of scientific literature and gracefully brings them down to a layman level, clarifies a topic riddled with inaccuracy and conjecture, and tackles the greatest myths surrounding autism. Finally, and most importantly, Silberman provides us with the knowledge to move forward and create a society that is more inclusive and supportive of those with cognitive differences.



PLAUGE!

Tracking Cholera

By Willa Kerkhoff
Illustration by Rachel Vales

PLAGUE! We think of "ring around the rosy" and men in vulture masks driving carts piled with corpses. Maybe we think about some Firefly style dystopian future when a biologically improbable health crisis has left humanity a race of wise cracking space cowboys and outer belt cannibals. Or maybe we think of that weird *Contagion* movie starring Gwyneth Paltrow. Unfortunately, for history teachers and pop culture nerds alike, pandemic is an issue much more real than a powerpoint presentation or fifty minute TV episode. Sonia Shah, OC '90, came to Oberlin on October 27 to deliver a convocation speech telling us why these diseases have tormented the human race for the entirety of our collective memory. And, unfortunately for us, predicting the next pandemic is not a question of if it will happen, but a question of how it will happen and which pathogen will be responsible.

The "how" component of that question has become something of a professional passion for Sonia Shah. She is currently promoting her new book called *The Fever: How Malaria has Ruled Humankind for 500,000 Years.* While back here in Oberlin at Finney Chapel, Ms. Shah delivered an engaging and thoroughly researched talk that proved that each word of critical praise and each award she has earned was quite deserved. After graduating from Oberlin College with a degree in philosophy, Ms. Shah began writing exposes on some of world's biggest issues. She has tackled enormous topics such as human drug trials in underdeveloped countries and the history and growth of oil as the fuel for our entire world. Her written works have routinely been described using the phrase "a tour de force". The TED talks she has given have been viewed millions of times, and her appearances on the radio have brought important awareness to the public. Her focus is global and her views are cross disciplinary, combining elements of social, political, economic, and scientific analysis to give a complete picture of the issues that shape our future. Despite all these lofty achievements, when Ms. Shah took the stage on October 27th, she opened with the personable aside that she felt more nervous on the stage in Finney than she ever felt on the TED stage.

So how do you give a complete and well-reasoned talk on pandemic, on one of the most complex and hot topics of our time? Well, if you're Sonia Shah, you pick one pathogen and then you start at the beginning. And for cholera, the germ of interest for this particular speech, that beginning was a peaceful, ecologically balanced existence in the brackish waters of the Sundarban in the Bay of Bengal. But once the Imperialist White People, in this case the British, begin constructing rice farms in those waters, cholera began adapting to a new environment: the human body. In the human body, cholera has a much more devastating effect than in its natural environment. People infected with cholera can completely dessicate in just a couple of hours as the bacteria reverses the functioning of their gut and causes the expulsion of all forms of moisture and nutrients. Cholera began to spread across the Asian continent, eventually reaching Europe. To achieve true pandemic status, cholera would have to cross the ocean to the New World, and that wasn't easy in a time when the trip took over two weeks. But cross the ocean cholera did, and new shipping technologies made that trip even easier.

By the time of Tammany Hall and the Robber Barons, cholera had already caused five fully global pandemics, characterized by the crossing of oceans and the infection of multiple populations. Cholera had infiltrated every cubic centimeter of Manhattan's murky ground water through the expulsion of infected waste, causing a new pandemic based from the city. One particularly nasty story comes from the Manhattan slum Five Points, which was built in the middle of the island on top of a former pond, the only source of fresh water on the island. The pond had been filled with trash and then the slum had been built on top, leading to a source of fresh water easily contaminated by the cesspools and wells from the surface. At this time, a little-known company was tasked with providing water to the island. However, instead of drilling their main well upstream, where cholera waste had not reached, they chose to drill their well directly in the middle of Five Points, saving the money that allowed them to become what they are today. The company specifically responsible for deliberately funneling cholera-rich water directly into the throats of one third of Manhattan's poorest now goes by a different name: J.P. Morgan Chase. Corporate scum right from the start.

What, then, are our current concerns? Well, to start with, our global economy now allows more contact across oceans than at any time in human history. Thousands of flights crisscross our world, and we pack more densely into our cities even as we stretch our chainsaws further into the untouched regions of this world. It is not surprising, therefore, that the last sixty years has seen the appearance or return of over three hundred deadly pathogens with the capacity for pandemic-scale devastation. The most headline-worthy in the recent years have been Ebola and Avian flu, both of which have sparked media frenzies and local violence in affected areas. It takes a lot to get from a new pathogen to a pandemic, though. It has to be able to infect humans, for one. It needs to find a place to amplify, a reservoir for growing in number. And even after all this, "we don't take these things lying down", to quote Ms. Shah. We put political safeguards and medical solutions in place. We mobilize and target the source of our fear, misguided or not. The only time when pandemic can fully take hold is when all of these fail. Maybe we can take that as a source of comfort, but history tells us we should not feel complacent. So does Sonia Shah. In her work, there is an opportunity to learn about the world around us and change the habits of our history into the hope for our future.

> "In the nineteenth century, cholera struck the most modern, prosperous cities in the world, killing rich and poor alike, from Paris and London to New York City and New Orleans. In 1836, it felled King Charles X in Italy; in 1849, President James Polk in New Orleans; in 1893, the composer Pyotr Ilyich Tchaikovsky in St. Petersburg."

-Sonia Shah, *Pandemic: Tracking Contagions, from Cholera to Ebola and Beyond*

H[1]onors Research

Featured research by Oberlin College students

At Home Away from Home?: Plant-Soil Feedbacks and Nutrient Limitation in Bur Oaks

Jake Nash
Honors advisor:

Trees culture the microbial community in the soil surrounding their roots in ways that affect the fitness of future generations. These effects, called plant-soil feedbacks, influence the likelihood that trees will be able to recruit under their own canopy and ultimately affect patterns of forest composition. My research will involve determining whether bur oaks foster facilitative or detrimental soil microbial communities by comparing the growth of seedlings in soils taken from under bur oaks with soil taken from under other co-occurring trees. I will also be describing the microbial communities in these soils using molecular genetic techniques. The combination of the growth experiment with the microbial community characterization will allow me to correlate differences in bur oak growth with the presence and abundance of specific microbial species in different types of soils. I am also going to evaluate how nutrient limitation affects the relative benefit that fungal symbionts – termed mycorrhizae – provide to bur oaks. Because mycorrhizae aid in nutrient uptake, I am expecting that the alleviation of nutrient limitation will result in this symbiosis being less beneficial to the plant.

Habitat Selection and Activity Patterns among Wading Birds

Nate Wehr
Honors advisor: Mary Garvin

As global warming causes worldwide water levels to rise, the habitat available to wading birds will be dramatically altered. Increased water levels create less accessibility to primary prey species found in shallow waters. In this study, we seek to better understand foraging habitat selection patterns among wading birds to create a more accurate model of their behavior. Our study is being conducted at Old Woman Creek National Estuarine Research Reserve, a joint branch of both the National Oceanic and Atmospheric Administration and the Ohio Department of Natural Resources' Division of Wildlife, in Huron, Ohio. Data is collected via cameras and active transects conducted in the estuary. We hypothesize wading birds will not use areas of tall, dense emergent vegetation as much as less dense emergent vegetation and open water. We also reexamine Bancroft et al.'s (2002) hypothesis that wading birds will not use water depths greater than 40cm. Our results will inform management strategies for both natural and newly created wetlands thereby promoting the overall health of these ecosystems.

Changes in composition and structure in an Ohio hardwood forest: 1974-2015

Laura Shriver
Honors advisor: Roger Laushman

Permanent plots are a useful ecological tool for examining change over time, succession, and the effects of disturbance on vegetation. A grid of permanent plots was established in 1974 in the Chance Creek Natural History Reservation as part of a tree species survey. The plots were sampled again in 1986, 1998, and 2015 (this study). We re-sampled the plots to explore the effects of the widespread death of ash trees due to the invasive emerald ash borer. As in previous studies, we measured for all stems > 2.54 cm in 33 0.04 ha plots. We also recorded count data for seedlings and saplings in smaller plots. We will compare 2015 composition and structure with that of the three previous surveys using standard diversity measures (Percent Similarity; Shannon's H', and Pielou's J'). We will use canonical correspondence analysis to correlate species composition with ecological variables, such as slope, aspect, light, and soil characteristics (organic matter; N, P).

Title: Developmental Change in Achievement Goals During Middle Childhood and Early Adolescence

Carly Oddleifson
Honors advisor: Travis Wilson

The aim of this study is to investigate the changing nature and expression of achievement goals during middle childhood and early adolescence. Data were collected via self-report and teacher-report across 4 grade levels in 5 schools of an urban city. My ancillary research question is as follows: do children in middle childhood and early adolescence have discernable achievement goals? In response to this question, I examined the factor structure of the Patterns of Adaptive Learning survey (Midgley et al., 2000) in the entire sample and at each grade level. The interpretation of scores on the survey reliably indicated the presence of achievement goals, i.e mastery, performance-approach, and performance-avoidance. I will run an analysis of variance to determine whether there are grade level differences in the expression of these achievement goals. My final set of questions concerns the debate between the mastery and multiple goals perspectives. I will compare (a) students high in mastery goals and low in performance-approach goals (i.e., mastery students) and (b) students high in mastery goals and high in performance-approach goals (i.e., multiple-goal students). First, what proportion of students at each grade level can be classified as mastery students and as multiple-goal students? Second, how do mastery students and multiple-goal students differ in terms of their academic competence, namely in their academic reputation among peers, academic self-efficacy, and teacher-reported academic performance? Finally do these patterns differ by grade level? All statistical analyses will be run in SPSS. To conclude, by understanding the patterns and development of children's academic strivings, concerned adults can help to facilitate age-appropriate learning environments that contribute to children's optimal development.

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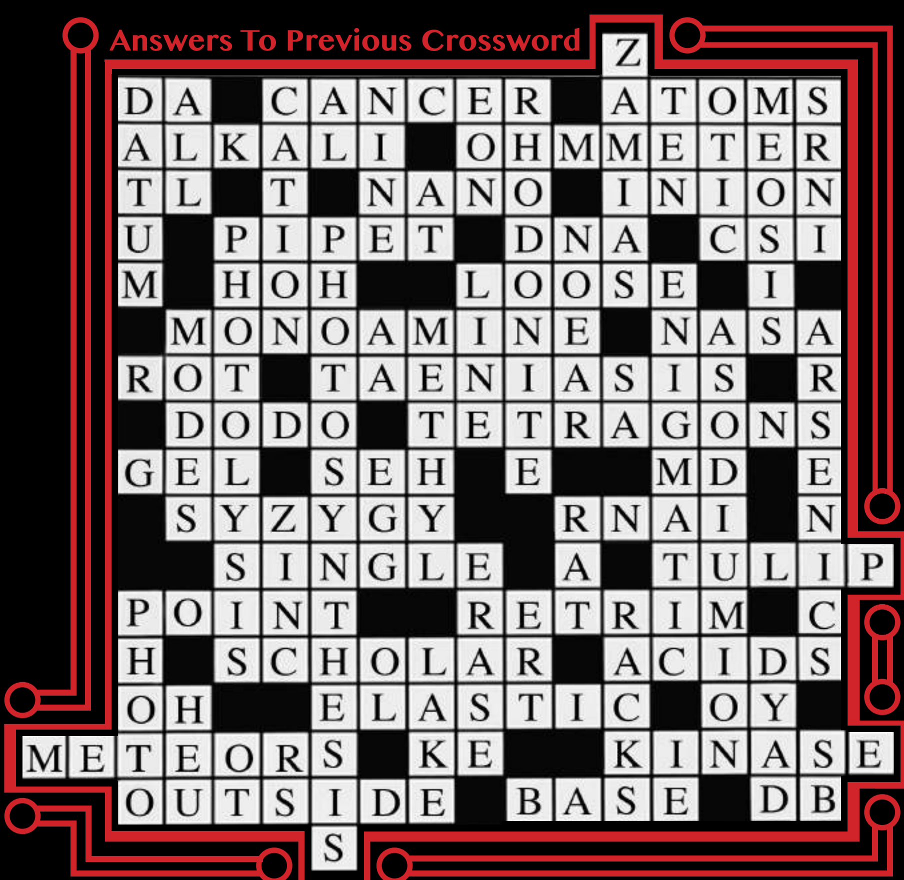
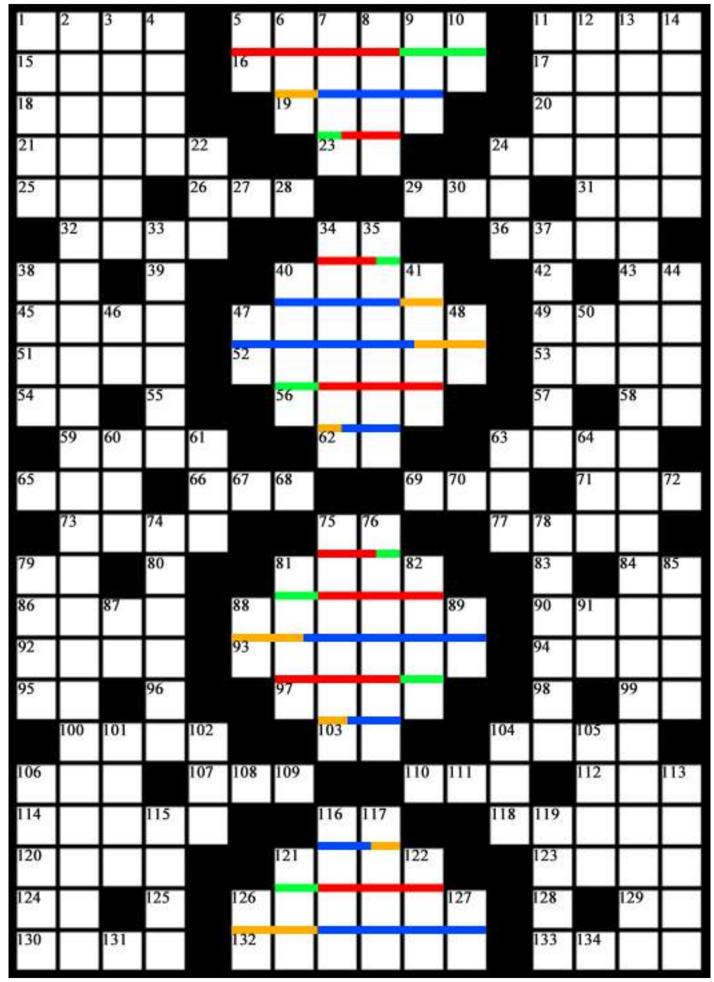


Crossword Corner

By Rachel Dan



ACROSS

1 Actin assembly-producing protein, abbrev
5 Polar region
11 Carotid artery location, reversed
15 Himalayan goat
16 Carbolic acid
17 South Indian cooking utensil
18 Brain tissue: _____ matter
19 Group of interrelated families
20 Cow's aortic cells, abbrev
21 Viral hemorrhagic fever
23 Lipoprotein, abbrev
24 Darwin's bird
25 Boolean operator
26 Schrödinger pet
29 Constricting snake
31 Ion ending indicating a low oxidation state
32 A covered portico, as a promenade
34 Sound made during an exam
36 Culture component
38 Boisbaudran's element, abbrev
39 Element from the Greekmeaning 'purple,' abbrev
40 Our sun in one
42 From center to perimeter
43 More than is prescribed, abbrev
45 Persian astronomer Khayyam
47 Skillful, cunning
49 Circles: (42 ACROSS)^2
50 Melbourne medical research facility
52 Alternative gene forms
53 Betwixt midbrain and medulla
54 Released into synapse, abbrev
55 Radioactive element
56 Events worsened by treatment, abbrev
57 Most abundant element
58 Elements comprising fatty acid chains
59 Parasite's home
62 Symbol of 61 DOWN
63 Small island or peninsula
65 Klinefelter Syndrome
66 Elemental ending
69 Innermost of meninges
71 Tailless primate
73 Waterfall, archaic (Scottish)
75 Gonad hormone, abbrev
77 Often paired with HCl
79 Ethane minus H_5
80 Negatively charged particle, abbrev
81 To block, as a vein
83 mol/L
84 Most abundant metal in Earth's crust
86 Basil, dill, or parsley
88 Bond type
90 Prefix meaning 'many'
92 Point of interest
93 Summer triangle: Aquila
94 Flying saucers
95 Initials: Olduvai Gorge paleoanthropologist
96 Molarity ÷ Moles
97 Architectural degree from Paris
98 Symbol: Angular momentum
99 32, Periodically
100 South American sloth
103 Second Noble Gas, abbrev
104 Toothed wheel
106 $C_3H_7NO_2$ abbrev
107 Experimental part of science class
110 Agency started by President Nixon
112 Sodium Hydride
114 State of matter
116 Most prominent cortical sulcus, abbrev
117 Micro_____
120 Compounds: same formula, different arrangement of atoms
121 Sea dweller
123 Dried, hulled, and split legumes
124 Astronomer Annie Cannon's home state
125 Gravitational constant
126 Venomous snake
128 With H_3, amine
129 Binary prefix for 'exbi'
130 Plant apoplexy
132 Amino acid from the Latin for 'silk'
133 Prescription

DOWN

1 Mid-range marker made of 7 recombinant proteins
2 Hydrophilic white polymers derived from cellulose
3 Einstein: _____ of Relativity
4 Functional group from an aromatic ring
5 Some high-school courses
6 Organorhodium Chemistry focuses on compounds with these elements
7 Building block of life
8 Gene locus related to Endochondral Ossification
9 Charged particle
10 With 57 ACROSS, stomach acid
11 Extinct Afro-Asiatic language of Nigeria
12 Skulls
13 One who measures the brain's electrical activity
14 Ecology: relational position of a species in an ecosystem
22 DNA sequence for stop codon
24 Government agency responsible for developing civil aeronautics
27 Blood type
28 Adenine associate, abbrev
29 2nd row element that ignores the octet rule
30 Transported by hemoglobin
33 The dog star
34 Central cores of vascular plants
35 Precambrian eon
37 Chart or diagram
38 Quark
40 Acid + Base = Water + ?
41 Abnormal rattling sound heard examining unhealthy lungs with a stethoscope
44 IUPAC: Goes between a number and letter
46 Brave New World author, initials
47 Dopamine, abbrev
48 SciFi author Ursula K __ Guin
50 Father of the atomic bomb, initials
60 Prefix meaning 'presence of oxygen'
61 Stannum, archaically
63 Fleming who created a non-chemical Bond
64 Elemental symbols spelling the official language of Laos
65 Female sex chromosome
67 Yellowcake
68 Force ÷ Acceleration
69 15, Periodically
70 Halogen #4
72 Energy symbol
74 Outer space gas cloud
75 Celiac disease
76 All acid and ___
78 Sealed glass capsule containing liquid for injecting
79 Produces 2 salt molecules when combined with 2 of 77 ACROSS
81 Virus: Common ___
82 Neuron's nanny cell
85 To undergo lysis
87 He coined the term *Dinosauria*, initials
88 Unit of mass on molecular scale, abbrev
89 68, Periodically
91 Elements between Nitrogen and Neon
101 Opioid antagonist, first 4 letters
102 Occupational overuse syndrome, alternatively
104 State of matter
105 Indonesian buffalo
106 Facet, alternatively
108 ? = πr^2
109 Less common blood type
110 Electric field, abbrev
111 First initial of male physicist Curie
113 With 88 ACROSS, this crossword
115 61 DOWN minus 19 protons
116 Alkali #2 + Halogen #3
117 Limits Serotonin reabsorption
119 DNA copy synthesized from mRNA
121 Edison to Tesla
122 Chinese dynasty with metallurgy innovations
126 [Xe] $6s^1$
127 Element derived from the Greek for 'moon'
131 Graphite or diamond
134 Avogadro's number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