



# STEM 2 Schools Science Journal

Edition #1

January 2017

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# **Note From Founder and President**

Dear Readers:

It gives me great pleasure to introduce the inaugural issue of the Stem2Schools Science Journal. I founded Stem2Schools.org, a STEM (Science, Technology, Engineering and Math) knowledge-sharing platform for two reasons. First, to build an ecosystem whereby cutting edge STEM research can be made accessible for high school students nationwide. We try to make science accessible through events we organize with leading scientific experts and through this bi-annual journal disseminating science news and articles from the perspective of high school students. Second, to encourage collaboration among high school students interested in STEM and create greater awareness of STEM fields and career paths.

We have been expanding beyond Sharon High School and have members from other schools as part of our network. Our hope is to spread the love of science across every school in America.

I hope you enjoy and share the joy of what you read in this journal.

Best regards,  
Russell Rapaport  
President and Founder, STEM 2 Schools

Max Brody, Sharon High School Class of 2019

### The HiRO

In all the American wars there have been 651,008 Battle Deaths; and about 1.2 million deaths during service in war time. About 42 million people have served in the military during wartime. About 1/50th of the people serving during a time of war have died. The number of deaths from battle can be decreased using new innovations in medical military robotics. Italo Subbarao, DO, senior associate dean at William Carey University College of Osteopathic Medicine, and Guy Paul Cooper Jr., a med student at the college are striving in this field.

As we know, getting a sufficient amount of paramedics to a very hard to reach area is very difficult. New drone technology is coming into fruition that will enable the easy quick transport of medical necessities to various locations. This drone system is known as the HiRO system. “The HiRO (Health Integrated Rescue Operations) drone system delivers a case that includes medical supplies as well as a cellular-connected Google Glass smart glasses. A person near the stricken patient is expected to put on the glasses, which send the video in front of them to a remote physician. The physician can then see what’s going on and lead the deputized civilian through the necessary treatment steps that utilize the supplies in the case.” This technology is instrumental in the well-being of injured civilians and soldiers in the heat of battle. This is also useful for treating mass casualties, for there is another type of package that the drone is able to transport that is more specified for mass injury.

New medical technological innovations are necessary for providing medical treatment, cost- efficiently, and effectively. There are many new innovations coming out

like the HiRO drone system that will be implemented, for the benefit of many, into critical situations. The only thing stopping them is the ability to fund the programs. As long as the economic part to these essential programs and technologies is covered, there is a guaranteed upside to them. There will be less severe injuries and deaths caused by wartime injuries.

Russell Rapaport, Sharon High School Class of 2018

### Alzheimer's Research

Alzheimer's disease is the progressive mental deterioration that can occur in middle or old age, due to generalized degeneration of the brain. It is the 6th leading cause of death in the United States, and has been named the coming pandemic of the West by the World Health Organization. Every 66 seconds, someone in the United States develops the disease. So, Alzheimer's research has been rapidly expanding, and the amount of trials conducted is increasing. However, only one percent of those trials have been deemed successful. One of the major reasons why trials have been unsuccessful is because it cannot be predicted, as it is not genetic in most cases. The research in Alzheimer's is desperate for a breakthrough, and in Antioquia, Colombia, a lot of questions about Alzheimer's may finally be able to be answered.

Within a 100 mile radius, Antioquia is the only place in the world where people are certain to receive early onset Alzheimer's. Through a genetic mutation in chromosome 14, a person is certain to develop Alzheimer's. Early onset Alzheimer's, which strikes people in their forties, is deadly ten years later. In Antioquia, 200 people, all who are a part of the same family, each have a 50/50 chance to develop the mutation. If they get the mutation, they are 100% certain to get Alzheimer's, and die because of it. This stunning development allows researchers to test prevention methods on patients who will develop Alzheimer's: a simple test determines if they have the mutation.

After testing the patients for the mutation, half are given an immunotherapy drug, which aims to remove the amyloid plaque from the brain. The other half of people are given a placebo, which does not contain the drug. Because Alzheimer's has been linked

to growth in amyloid plaque, researchers seek to remove the plaque, and evaluate the results. If this trial is successful, Alzheimer's disease would receive a tremendous boost in its prevention research.

Because there has not been much success in treatment of Alzheimer's, prevention may be the only solution to stopping the quickly growing disease. Although Alzheimer's has seen nearly zero success in its trials in the last 20 years, it may have a glimmer of hope, originating in Antioquia, Colombia.

Maytal Cooper, Sharon High School Class of 2020

### Silver Nanowires Demonstrate Unexpected Self-Healing Mechanism

With its high electrical strength and optical transparency, indium tin oxide is one of the most widely used materials for touchscreens, plasma displays, and flexible electronics, but it has a price that is rapidly rising. Can the electronics industry find an alternative?

One potential alternative that is more profitable than indium tin oxide is a sort of film made with silver nanowires. These wires are so extremely thin, that they are one-dimensional, embedded in flexible polymers. Similar to indium tin oxide, this material is transparent and conductive. But, it's development has halted due to the scientists lack of basic understanding of its mechanical properties.

But now, Horacio Espinosa, the James N. and Nancy J. Farley Professor in Manufacturing and Entrepreneurship at Northwestern University's McCormick School of Engineering, has led research that has expanded the understanding of silver nanowires and how they behave in electronics.

Espinosa and his team investigated the materials cyclic loading, which is an important part of fatigue analysis because it shows how the material reacts to varied loads of stress. "Cyclic loading is an important material behavior that must be investigated for realizing the potential applications of using silver nanowires in electronics," Espinosa said. "Knowledge of such behavior allows designers to understand how these conductive films fail and how to improve their durability."

By varying the tension on silver nanowires thinner than 120 nanometers and monitoring their deformation with electron microscopy, the research team characterized



the recurrent mechanical behavior. They found that permanent deformation was partially recoverable in the studied nanowires, meaning that some of the material's defects caused by the varied amounts of stress actually healed itself and disappeared. These results indicate that silver nanowires could potentially withstand large amounts of pressure for long periods of time, which is a key attribute needed for flexible electronics.

### Croton Nuts

Means of energy and fuel has been a major obstacle in Africa for a number of years, but a new discovery has led to a new source of energy that literally grows on trees. Kieron Marks of CNN reported that croton nuts, which grow from the megalocarpus tree, have been found with certain proteins and oil that can be used for fuel. This is a monumental discovery, since many government officials of Africa have been searching for cost-effective means of fuel and have been unable to find any until now. These trees are extremely popular and prevalent in central and eastern Africa. The company Eco Fuels Kenya has been researching croton nuts and the practicability of using them as a main energy source. EFK Managing Director Myles Katz not only talked about how it would help with energy, but also the economy. Once the crotons become popular, the farming industry will generate major revenue. This could help stimulate economic growth and encourage farming, which in some cases could be helpful for the environment. Over 1,000 tons of croton nuts were produced this year, which is an increase of 500 tons from the previous year. EFK is making sure no part of the croton nut goes to waste. Studies have proven that the shells of these nuts can be used as fertilizer, while other parts of the nut are healthy and edible.

EFK is also prioritizing that all their products are local. According to Katz, “Everything we source, process and sell should be within 100 kilometers of the factory.” The fact that they are maintaining their local approach allows for costs to stay low, and helps with the local economy. Crotons are going to replace diesel, and have advantages

over diesel in almost every category. Since they grow from the fruit of the tree rather than the tree itself, then no deforestation has to take place in order to produce the fuel.

This new development of the croton nut is revolutionary, and could have major implications for the future. Using the croton nuts also will alleviate the struggling conditions of the environment in Africa. The environment struggles from harsh air pollution as well as water pollution. This is an effect of the all the attempt to retrieve energy from the Earth. Also, crotons were wasted before, so food will not be taken from animals or humans. There are so many different ways that these discoveries will help the people in Africa, and this trend could spread all over the world.

Max Brody, Sharon High School Class of 2019

## Acoustic Manipulation

Acoustic manipulation is when a standing wave is used to manipulate the motion of particles in a certain way. Acoustic manipulation has been used to levitate objects. This is a very important discovery because we have found that we are able to manipulate matter solely using sound waves.

Researchers Marco Andrade and Julio Adamowski at the University of São Paulo in Brazil, along with Anne Bernassau at Heriot-Watt University in Edinburgh, UK have discovered recently that they are not only able to levitate small objects with acoustics, but that they are also able to levitate objects that are larger than the wave used to levitate it. These researchers also discovered that if they use multiple sources of acoustics, they are able to lift a bigger load, reaching a load of about 3.6 times the wavelength. In another study done, the researcher, Daniele Foresti, found that you are actually able to control the object's movements when it is levitated acoustically. He was able to rotate a toothpick, merge droplets of water, and separate droplets of water.

These findings are instrumental in the field of chemistry. Now, chemists are able to chemically combine substances that before were not able to. This is because some chemical reactions and biological processes are compromised by surfaces, and certain substances disintegrate on contact with a surface. The potential in this field is endless. There are many things in the works using this technology, including, although it might sound ignorant, hoverboards, and many other forms of frictionless transportation.

### Allergic Reactions: What to know

One out of every five people in the United States have a food allergy: the United States spends about twenty five billion dollars on children with food allergies. The following how to catch an allergic reaction early, the different types of allergic reactions, and various triggers an allergic reaction.

Most allergic reactions, if they aren't anaphylactic, do not happen right away. They take up to 72 hours to get to its maximum stage. As stated by Christian Nordqvist in his article, *Allergies: Causes, Diagnosis and Treatment* some early signs of an allergic reaction can be swelling lips, itchy mouth, stomach cramps, shortness of breath, and hives. If a person has an anaphylactic allergic reaction, then the reaction can begin within five minutes. An individual can tell if the person is having an anaphylactic reaction due to the quick reaction timing, as well as side effects including vomiting, pelvic pain, loss of bladder control, low blood pressure, confusion, headache, anxiety, and lightheadedness.

There are two types of allergic reactions; anaphylaxis and a regular reaction. Anaphylaxis is the most severe reaction. This type is life threatening. Individuals can experience harsh vomiting, trouble breathing and an abnormal heart rate. If the individual isn't injected with an epi-pen or brought to the hospital immediately, then they are at a high risk of death. However, with a regular reaction, the body will be infested with hives and will have swollen lips and throat.

The trigger for an allergic reaction to food is the body's immune system thinks that the allergen in the food that is consumed is harmful for the body. It sends out immunoglobulins throughout the body. The immunoglobulins cause chemicals in the

body to be produced. The histamine chemical is the chemical that brings about the reaction. It causes all the symptoms of an allergic reaction whether it's anaphylactic or not.

Food allergies affect children and adults all around the world. They provide daily challenges, sickness, and sadly, sometimes even death. There are many things to know about how to catch an allergic reaction early, the different types of allergic reactions, and what the trigger is of an allergic reaction.

Max Price, Sharon High School Class of 2018

### The Statistics Behind Election

On November 8th, 2016, Donald J. Trump was elected to be the 45th president of the United States, despite losing the popular vote. This baffled many Americans. They wondered how someone who did not garner the most votes had won the election. The answer begins and ends with the Electoral College, a system outlined in the Federalist Papers (1788) that sought to protect the rights of each state, small or large, to have a say in any national election.

The system grants a certain number of electoral votes to each state, roughly based on population; the votes go to the winner of the popular vote in each state. For example, the Democratic candidate, Secretary Hillary Clinton, won the state of California and thus won its 55 electoral votes. This begs the question: how is the number of electoral votes for each state determined?

Originally, an electoral vote was granted for each state representative in Congress. However, this resulted in an “inflation” of the electoral vote as the number of states grew along with the total voting population. The total number of electoral votes, which is currently capped at 538, requires a candidate to receive 270 votes to win the election. The number for each state is found first through the original method of counting state representatives and senators (for example, California has two senators and 52 representatives). Then, based on fluctuation in the populations of each state as measured by the decennial national census, the votes are “redistributed” in order to more accurately represent the number of voters in each state.

This system has its pros and cons. One advantage is that it provides representation for smaller states. Without the Electoral College system, the voices of small states like Wyoming and Delaware would be drowned out by the command of exponentially more populated states, such as California and Texas.

Detractors argue that the system unfairly benefits the voters of certain states, stating the fact that every individual does not have the same voting power, violating a key value of democracy. For example, Richie Bernardo of WalletHub.com cites data from FiveThirtyEight to demonstrate that an average voter from Arizona has had up to 560% more say in past elections than a given Californian voter. This is how, despite losing the popular vote by upwards of 2 million votes, Donald Trump won the presidency by garnering the required 270 electoral votes.



Maytal Cooper, Sharon High School Class of 2020

## Using Oxygen as a Tracer for Galactic Evolution

Oxygen, we use it to breathe, it is the 8th element on the periodic table, and it is pretty much everywhere! But, at the University of California (UC), Riverside astronomers have found a way to use oxygen to go back in time. More specifically, it will be used as a tracer for galactic evolution by using the changing strengths of oxygen emission lines from the present day to as far back as 12.5 billion years ago.

Galaxies produce new stars from cold gas, and obviously, some galaxies produce more than others. What roughly defines the evolutionary characteristics of a galaxy is the rate of star formation, stellar mass, and gas content.

The amount of ionizing energy inputted into oxygen by newly formed stars was much higher in the early universe. The strength of doubly ionized oxygen atoms increases going back in time, while singly ionized oxygen atoms increases up to 11 billion years ago and then decreases for the remaining 1-2 billion years. This study concludes that the rate at which stars form in the galaxies has not always been the same. For the first 2-3 billion years after the big bang, the rate at which stars formed increased, but has decreased from the last 10-11 billion years.

In other words, the galaxies in the universe are becoming less active in creating new stars. And because cold gas is the fuel of star formation, it is very important to understand how the physical conditions of the gas are changing throughout the universe's history.

“One way to study the gas in star forming regions of galaxies is to observe the spectral emission lines,” said Ali Ahmad Khostovan, lead author of the paper and a

graduate student in the Department of Physics and Astronomy at UC Riverside. Spectral emission lines form when light from extremely large and bright, short-lived stars interact with the surrounding elements which create regions where atoms are broken up or ionized.

Emission lines are only visible while the biggest stars shine, so the timescale traced by these lines are dependent on the lifespan of these stars (about 10-50 million years). Therefore, emission lines can be used to trace the immediate activity and condition of the star-forming regions of the galaxies.

In the study, the researchers used a sample of galaxies selected by emission lines from the High-z Emission Line Survey (HiZELS) to trace the evolution of strength for emission lines associated with singly ionized and doubly ionized oxygen. The importance of these two lines is that they provide information regarding the actively ionized state of oxygen since the main difference between the two lines is the amount of energy needed to go from singly to doubly ionized oxygen.

This is accomplished because of the unique design of HiZELS. The survey uses four narrowband filters. These filters are narrow enough that the light from an emission line would dominate the detector of the telescope. As emission lines are narrow and redshifted, they act as proof of four different time slices (one for each filter) of the universe's history.

The result of this discovery are possible future surveys using next-generation telescopes, such as the upcoming James Webb Space Telescope which will allow researchers to study inside star-forming galaxies all the way back to the era of the first galaxies.

Russell Rapaport, Sharon High School Class of 2018

### Solar Panels: Re-inventing the Way We Use Energy

Scottish scientist James Clerk Maxwell wrote in 1874 to a colleague, "I saw conductivity of Selenium as affected by light. It is most sudden. Effect of a copper heater insensible. That of the sun great." The most polarizing issue that the world faces today is the availability of energy. At the current rate, there will be no more oil left in the world in 38 years. Similarly, within the next 80 years, uranium and gas will no longer be available. Without energy, people would simply not be able survive: therefore, a new way of utilizing energy was essential. In 1839, Alexandre Edmond Becquerel discovered the photovoltaic effect, explaining how electricity can be generated from sunlight. He concluded that shining light on an electrode submerged in a conductive solution would create an electric current. Then, over 100 years later, Russell Ohl, with the help of the transistor, invented the solar cell in 1941. Since then, Solar Panels have developed and progressed into one of the most effective ways of prolonging the world's available energy.

A Solar Panel, comprised of many smaller units called photovoltaic cells, works by allowing photons to free electrons from atoms, generating a flow of electricity. Many photovoltaic cells, which convert sunlight into electricity, make up a solar panel. To work, photovoltaic cells need to establish an electric field, which is similar to a magnetic field, in that an electric field occurs when opposite charges are separated. To get this field, manufacturers "dope" silicon with other materials, giving each slice of the sandwich a positive or negative electrical charge. Phosphorous is seeded into the top layer of silicon, giving a negative charge to that layer. Then, the bottom layer gets a dose

of boron, which results in a positive charge. Consequently, as electric field is created between the two charges. So, when a photon of sunlight knocks an electron free, the electric field will push that electron out of the silicon junction. Finally, these electrons are turned into usable power. Metal conductive plates on the sides of the cell collect the electrons and transfer them to wires, so that the electrons can flow like any other source of electricity.

Today, solar energy provides five-tenths of 1 percent of the total energy consumed in the United States. Although this statistic may not seem like a large amount, when the amount of energy that people use is considered, five-tenths of 1 percent is actually a very significant figure. Even though solar panels have made tremendous advances in the last century, the future is bright for further advancements. Future solar panels might rely on perovskite, a promising material that has the potential to make panels cheaper, simpler, and more efficient. Scientists just need to tweak perovskite to maintain its light-absorbing capabilities for longer periods, and researchers at Los Alamos National Laboratory are coming closer and closer to reaching that goal. If solar panels can be made cheaper and operate more efficiently, they will become an even more prominent part of the energy business.

### 3D Printing

One night in 1983, Chuck Hull had a major breakthrough. Using a class of materials called photopolymers and ultraviolet light, he created the very concept that is changing the world today, 3D-printing. However, 3D-printing has only become quite a popular resource and point of discussion recently. The 3D-printing industry grew by 35.2% in 2014. The uses of this technology are limitless, especially now that it is becoming cheaper. Machines, using the basic techniques Chuck Hull invented, can create whatever you imagine. One of the most prevalent uses so far of this developing technology is in the medical field. However, most medical solutions are still in the testing process. So far, the results have been outstandingly possible. 3D-printing cuts medical procedure costs while improving the human condition. Objects as simple as casts and as complicated as airway splints that grow with the body are actively being produced. Chuck Hull was the pioneer in exploring the endless possibilities that objects printed from a digital model could achieve.

The production of prosthetic limbs has helped improve the lives of the millions of people around the world living without their limbs. Before 3D-printing technology emerged, prosthetics cost between \$5,000 and \$50,000, unaffordable for many people in need. Since the limbs have to be made to fit a specific person, 3D printing allows the limbs to be custom-tailored quite easily. Not only does it decrease the margin of error in sizing, it also brings the price down to as low as \$50, much more affordable. It also decreases the amount of time it takes to produce and calibrate the limbs with the

prospective owner from months to a single day. With new technology becoming widely available, sensors can be placed inside the limbs to allow more natural joint movement.

The production of bone is very common in physical and cosmetic problems. Ear and nose cartilage can be produced for people who have suffered tragic accidents, were born without it, or would like to change the way they look. People in need seeking skeletal augmentation, suffering from trauma or congenital defects, can now receive implants that are made to fit perfectly into their anatomy. Biomedical engineers working with a surgeon ensure the perfect shape and size needed for each individual patient. New materials now allow for the implant to unify with the actual bone of the possessor.

Engineers and cosmetic companies are in the process of creating a large enough quantity of 3D-printed skin to treat burn victims. L'Oreal alone has invested one billion dollars alone into research for methods of creating artificial skin. They are trying to produce usable human tissue from donated skin cells. The pieces of skin being manufactured today cost roughly \$70 for quite a very small piece. Additive manufacturing is only in the experimental process for many of its medical uses, but multiple accredited professionals have voiced their opinions about how safe and durable the products in the trials have been in animals. After much more testing to prove inserting 3D-printed objects into the human body causes very little to no harm to humans and the benefits outweigh any possible risks or complications. 3D-printers are becoming cheaper and more readily available to create knick-knacks along with medical tools and products. The world of medicine is constantly changing and evolving, and this is the next step.

## CRISPR: The Game-Changing Technique For Genetic Engineering

CRISPR is a short acronym for Clustered Regularly Interspaced Short Palindromic Repeats. CRISPR is a relatively new but revolutionary discovery in the field of medicine. It is going to change the way we target genetic diseases, fight off cancer, and possibly create new humans. CRISPR was first identified in the bacteria of E. Coli. CRISPR is an immune system used by bacteria and many other microorganisms that genetic engineers are trying to incorporate in our bodies to prevent and eliminate genetic diseases. Francois Mojica, from the University of Alicante in Spain, was the first person to discover CRISPR and its function. From the 1990's to the 2000's, he reported the common repeat sequences in the DNA of E.Coli, and noticed that these repeated sequences shared a common set of features. In 2005, he noticed that these sequences matched with parts of the genome of bacteriophages; thus, he was able to hypothesize that CRISPR was an adaptive immune system found in bacteria. Since then, scientists have still been working on how to successfully adapt CRISPR for genome-editing in eukaryotic cells in order to completely erase mutations in our genome that translated to proteins that don't function correctly and cause genetic disease.

CRISPR works by removing or replacing an existing gene, switching a gene on or off by altering the gene expression, or inserting a new gene altogether. CRISPR not only finds its target gene, but it also delivers an enzyme that cuts the DNA. It does this with extreme accuracy due to the fact that it is composed of ribonucleic acid (RNA). This is called the Guide RNA, which is matched with the DNA gene sequence, and the DNA-

cutting enzyme, also called the nuclease, cuts the DNA at specific positions to remove the target gene.

CRISPR is unique from many other gene-editing techniques such as zinc-finger nucleases and TALENS. One huge difference is that CRISPR can target multiple genes in a cell at once, Considering that most diseases involve more than a single gene, CRISPR is a much more effective than other gene-editing techniques. However, CRISPR does have limitations. CRISPR is not completely reliable in that it can make unintended cuts outside the target gene, which can either remove essential genes or reduce gene expression. Also, scientists are trying to figure out how to create replacement genes after deleting the target gene.



### Photic Sneeze Reflex

Have you ever looked (not directly) at the Sun and suddenly felt the urge to sneeze? If the answer is yes, then you have experienced the photic sneeze reflex. For me personally, whenever I am suffering from bad allergies, looking anywhere near sunlight makes my eyes water and my nose run, so I can definitely relate to this topic. Ironically, the acronym ACHOO (autosomal dominant compelling helio-ophthalmic outburst) was used to describe the syndrome. Science has not found a root cause for this phenomena, but there are a few theories regarding evolution, our nervous system, and simply the way our brains are wired, but nevertheless, there are many varying speculations on how the ACHOO syndrome originated. One such is that the contraction of our retinas somehow is linked to the impulse of our brains to sneeze, so when the retina is suddenly contracted, we feel the urge to blurt out a sneeze. Since the knowledge of this phenomena will not greatly benefit the human race in any way.

Approximately fifteen to thirty percent of the human population experience this photic sneeze reflex, and it is twice as probable for a boy to have ACHOO syndrome than for a girl to have it. The trait is found to be a dominant one as well. Ethnic backgrounds also play a role. Only two percent African Americans have ACHOO syndrome. Scientists have deemed that this reflex is dangerous for pilots, drivers, or any operator of vehicle. This is due to the fact that if one has a tendency to sneeze when bright lights are seen, then the control will be impaired for a large portion of the transportation. Sunglasses are now used to fix this issue. Scientists also confirmed that not “just any light, but sudden flashes” were needed to trigger the sneezes and nose running.

Andrew Hay, Sharon High School Class of 2018

## Learning Languages Through Synesthesia

People with synesthesia experience the world in a unique way. For example, they "taste" words or "hear" colors. New research suggests that people who learn a second language but aren't exposed to that second language very early in life are more likely to have this sensory-switching ability than those who are natively bilingual.

Marcus Watson, a highly trained professional in experimental psychology and study co-author, stated, "Groups of people with different linguistic backgrounds have different rates of synesthesia. Quite different rates, as a matter of fact. It ranges from 0 percent to about 5 percent depending on what their language background is."

These findings support a theory that synesthesia may develop to improve learning in more difficult, longer tasks such as mastering reading, music theory and time telling.

People with synesthesia have mixed experiences with their senses. For instance, they may see certain colors pop out when hearing certain sounds, or see letters that correspond with certain colors. Previous experiments have shown that anywhere between 1 and 5 percent of people show symptoms of synesthesia. If synesthesia run in your family, you are more likely to have it, as well. In contrast, most people whose family has the gene do not exhibit the trait, so why does it still happen?

Some believe synesthesia develops as a learning aid. For example, when younger children begin learning at a novice level, matching letters to specific colors could help them differentiate between letters that look alike, such as an "B" and a "D." Similarly, seeing color in music could help greatly in differentiating tones.

Scientists have found that children master the categorization of colors between ages 4 and 7, right around the time they begin learning to read and write. Letter-color synesthesia, meanwhile, develops between ages 6 and 11. Scientists also have shown that synesthesia helps children understand certain kinds of grammar.

Marcus Watson thought that if synesthesia is an aid for learning, then people with different language backgrounds should develop synesthesia at different rates. Him and his colleagues belief was that children who grew up hearing and speaking two languages from a very young age would have higher rates of synesthesia than those who either did not learn a second language or learned one later in life. Overall, the link between learning a second language later in life and synesthesia is certainly remarkable, but one question still remains and no exact answer may ever be found for it: Why is that the case?

## Black Holes: One of the Strangest Phenomenons in Our Universe

Black holes are a region in space, specifically in space-time, where the gravitational pull is so intense that the escape velocity required by an object to escape the black hole is faster than the speed of light; thus, no forms of electromagnetic radiation can escape, making the events that happen inside a black hole a very controversial topic among many astrophysicists today. Black holes were first discovered by Albert Einstein, who proved their existence through his famous general theory of relativity, which was published in 1916. Ironically, Albert Einstein himself did not himself believe in the existence of black; however, his theory showed that they do in fact exist. Today, scientists have observed that black holes are one of the most important features of our universe, as they play a vital role in the formation of galaxies.

Although black holes can't be seen directly, they can be detected through the gravitational pull of other objects. Black holes don't have to be just formed from the aftermath of a star's fate if the star's core has a mass of more than 2.8 times the mass of our sun. In fact, anything can become a black, as long as you can compress the object smaller than its Schwarzschild radius. The equation is  $R = \frac{2GM}{c^2}$ , where  $G$  is the universal gravitation constant ( $6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2\cdot\text{kg}^{-2}$ ),  $M$  is the mass of the object, and  $c$  is the speed of light ( $3.00 \times 10^8 \text{ m/s}$ ), derived by Karl Schwarzschild, German physicist during 1915 and was best known for finding the exact solution to Einstein's field equations for general relativity. To put this in perspective, Mount Everest can be turned into a black hole if it is compressed to the size of a nanometer. The Earth and Sun can be turned into a black hole if it is compressed to the size of a peanut and the size of Central

Park. Obviously, those three scenarios are not possible. But in stars with a core of a mass of 2.8 times the mass of the sun, once iron is fused in the core, the star will collapse on itself due to the gravity overcoming the force pushing outwards, generated from the fusion of elements within the core. In addition, as Albert Einstein said, a black hole warps the fabric of spacetime so much that not only is it that light can't escape from a black hole, but that any event that happens inside a black hole can't be known, since those events don't occur in time. If you were to fall in a black hole, you would see all of time pass behind you as you disappear from the known universe!

Black holes are one of the strangest phenomenon in our universe today. As comedian Steven Wright once remarked: "Black holes are where God divided by zero." Due to the black holes' unique properties, black holes have become a very controversial topic in astronomy today. Although we still don't know everything on how black holes work, we do know one thing for sure: Black holes are a vital part of the formation of galaxies. They have been found in the center of almost every galaxy in the known universe, and play a fundamental role in the formation and evolution of the universe that we inhabit today. Although they may seem like a scary phenomenon, we would not be here today without them.

Max Price, Sharon High School Class of 2018

### Advances in Concussion Imaging Technology

Despite swells in popularity and ratings for NFL football in recent years, many fans and players are concerned about new developments in regards to the long term effects of head injuries, specifically concussions, attained while playing football. New data has come out over the past couple of years that has prompted the retirements of many players, and has made parents think before letting their children participate in contact sports.

In 2015, Boston University released their findings; after scanning and studying the brains of 91 former NFL players who had suffered concussions, they discovered that 87 of them (a 95% likelihood) showed evidence of CTE, or Chronic Traumatic Encephalopathy, a largely unexplored neurodegenerative disease that can impair cognition and often precedes dementia. The researchers at BU came across similarly worrying findings in many veterans who had suffered head injuries while serving in the military. Through utilization of magnetic resonance imaging (MRI), they found “brain scars” in the examinations of more than 50% of the 834 surveyed.

These results only served to leave people with more questions. Are all head injuries likely to lead to brain damage? Is there specific trauma that can make such a disease more likely? Are concussions more serious than previously thought? What *is* a concussion, exactly? Luckily, those driven to find answers to these questions appear to be on the cusp of revolutionary medical technology, geared towards finding and treating these head injuries, and most importantly, figuring out how to prevent future damage to the brain.

The first step to treating any injury is to diagnose it. Claiming that CT and MRI scans are prone to issues with imaging and cause unnecessary exposure to radiation, Ronald Hayes of Banyan Biomarkers is in the process of developing a blood test that can be facilitated on the athletic field, the battlefield, or in the doctor's office. He is currently in a clinical trial with over 2,000 participants in order to garner FDA approval. Hayes is leading the charge towards less invasive techniques for the diagnosis of concussions.

In addition, there have been significant developments towards more advanced imaging technology that could catch the details that CT and MRI scans miss, along with reducing radiation exposure and inconvenience. This technology, according to neuroradiologist Gerard Riedy, will be put to use in the military and could eventually make its way to hospitals and doctor's offices. The clues that are better picked up by these new methods can help to better diagnose traumatic brain injury, and also detect the best treatment.

The future of medicine for this tricky set of traumatic injuries to the brain that we call "concussions" is clearer now than ever. The diagnoses of tomorrow will be made using these new technologies that apply better detection along with higher convenience, with the goal of helping those with head injuries recover and get back to doing what they love. The big questions about concussion curability, as well as the lasting effects of brain trauma, have yet to be fully contested, but it is undeniable that these exciting new discoveries are paving the way towards the answers.

## The Great Barrier Reef

After nearly 25 million years, the Great Barrier Reef is facing its slow extinction. Hundreds of different species of coral have succumbed to coral bleaching, which is caused by nutrient, light, and temperature deficiencies. Coral is crucial to the survival of ecosystems, with some reefs supporting the lives of nearly 4,000 different species of fish. With roughly 93% of the reef in grave danger, scientists are working on new methods to preserve the reef. How can the coral be preserved? Can it be regrown at a rate faster than it is already dying? Under what optimal conditions can coral survive, thrive, and reproduce? And under what conditions will it die off?

Our experiment is centered around determining the optimal conditions for coral growth, and its threshold for the maximum intensity of conditions the coral can survive under. As oceanic environments are constantly changing, it is important for us to discover the range of varying conditions in which a species of coral can survive. It is crucial for us to know the maximum intensity of a condition a coral species could survive under in case an ecosystem were ever to naturally exceed this threshold. If an environment were to change in a way that would lead to the coral's death, it would be helpful to know the limit at which the environment needs to reach before it becomes a legitimate concern. Knowing this information would also help in restoring coral populations, since after the optimal conditions for coral growth are discovered they can be applied to laboratory propagations. The end goal of our experiment is to regrow dying species of coral at a fast and efficient rate in a laboratory.



To begin the experiment, we will create simulated aquatic environments to grow our coral in. Certain factors that change on a daily basis in a natural ocean environment, like temperature or pH, will be kept constant in all tanks. The factors we will focus on will be the strength of current flow, light intensity, and light color. These conditions can change slowly and dramatically in the environment. They create massive problems for coral species that require delicate conditions to survive under, so knowing how to avoid these problems would be vital for their survivability.

We will be using one large tank, divided into three sections with plexiglass inserts. This is for the purpose of ensuring that the coral samples are under the same water conditions and ion levels, but allowing us to test factors like light without it affecting the corals next to them. All coral samples will be derived from a mother plant, residing in a tank with relatively standard conditions. This “mother coral” will be monitored daily, and the conditions of its tank will be recorded constantly. This is to ensure that the varying growth patterns are not simply because of different genotypic traits between two different plants. The tank in which the mother coral resides will simulate an oceanic environment, containing other aquatic organisms. This is to mimic how our experiment can be used in the real world. If a strain of coral from the environment is in critical danger of dying out, it will be harvested from the ocean and placed under our tested conditions to regrow it at a quick and efficient rate. Thusly, it would make sense for the mother coral to live in an ecosystem with other organisms, just like it would in the ocean, and for the propagations to be placed in a strictly controlled separate tank, like a in a laboratory.

The coral samples in the experimental tank will be monitored daily for growth. Growth will be measured several different ways, like the diameter of the base, or the width from the furthest left branch to the furthest right branch. The tank status that the propagations reside in will also be measured for hidden factors that could put it at risk of dying, like calcium or kH. One trial's worth of propagations may not reveal to us the exact threshold for our experimental condition, and may not reveal to us the optimal level for growth. Because of this, multiple trials over multiple weeks may need to be performed.

After several trials of data, we will evaluate and extrapolate our results. We will determine the optimal level for growth with our experimental conditions, followed by the threshold of growth. Our data will be graphed, and we will observe the trend in growth for the data we have recorded. We can use this graph to make extrapolations as to the exact level of growth we are looking for. The data we discover can be posted for public use on a variety of websites, including STEMtoSchools.org, an organization whose goals are to bring science to the classroom and to involve students in the scientific community by connecting students all across the world through research articles. Our data can also be published to other locations studying coral growth, who might find our testing useful for their own experiments. Further experimentation can be performed based on the feedback received by our publicly posted results.

Photosynthesis of *Volvox Aureus* and *Chlamydomonas*

Many tests can be done to secure quantitative data about the quality of a water ecosystem, but a need for a better understanding of how different stimulants affect local organisms persists. (Robba, Lavinia, Russell, Barker, Brodie, 2006) Indicator species are commonly used to obtain this information by monitoring population and different chemical reactions they produce if applicable. (Omar, Wan Maznah, 2010) Algae are often used for an indicator species because of their short life cycle and fast reproduction rates. It is probable than in most scenarios algae should be abundant because they are a primary producer, and are the base of many aquatic food chains. (Omar, Wan Maznah, 2010) . Their population (given that there are no consumers) should solely rely on the chemical makeup of present chemicals in their environment. Furthermore, concentrations of algae in different areas of one body of water could be used to determine possible zones that were contaminated, allowing action to be taken.

The most common stimulants of microalgae population are nitrogen compounds. Nitrogen is an imperative facet of algae nutrition along with phosphorous, and the majority of algae blooms are caused by an increased concentration of nitrogen. This poses a problem to Long Island specifically because of its unique quality of being surrounded by bodies of water. Nitrogen comes from a variety of sources; farm fertilizer, lawn fertilizer and septic systems being most prominent. This has had a noticeable influence on the population in the local area to extent of local residents taking action. Regulation of nitrogen sources is a common method of controlling nitrogen pollution,

however better understanding of algae growth rather than just nitrogen concentration is needed to determine a plausible technique of controlling algal blooms.

Compounds other than nitrogen also have an effect on the concentration of algae in aquatic ecosystems. Iron plays a key role in nitrogen assimilation and photosynthesis electron transport. (Chi, Chen, Shi, and Zheng, 2009) Therefore an increase in algae concentration may not be caused by increased nitrogen concentration, but rather increased nitrogen absorption due to higher levels of iron. An increased pH in the aquatic environment has similar effects on algae concentration, as well as an increased level of phosphorus.

There is a direct correlation between photosynthesis rates and algal growth. (Sakshaug, Egil, Johnsen, Andresen, Vernet, 1990) Photosynthesis rates can be determined by monitoring pH of water (hydrogen carbonate indicators are used to measure pH). Carbon dioxide is given off as a product of photosynthesis, and therefore lowers the pH of the water that the algae is suspended in. This change in pH can have implications on the growth of algae over time and might have to be controlled for.

Through careful culturing and introduction of stimulants, responses of algae can be recorded, providing accurate data of when these simulants will affect an aquatic environment. This data can be applied to multiple aspects when measuring quality of water in a non-laboratory setting, and provides insight into local problems with algae blooms.

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