Spring 2016

SciTECH

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NOTE FROM THE EDITORIAL BOARD

Dear Readers,

SciTECH is pleased to announce the release of our first issue!

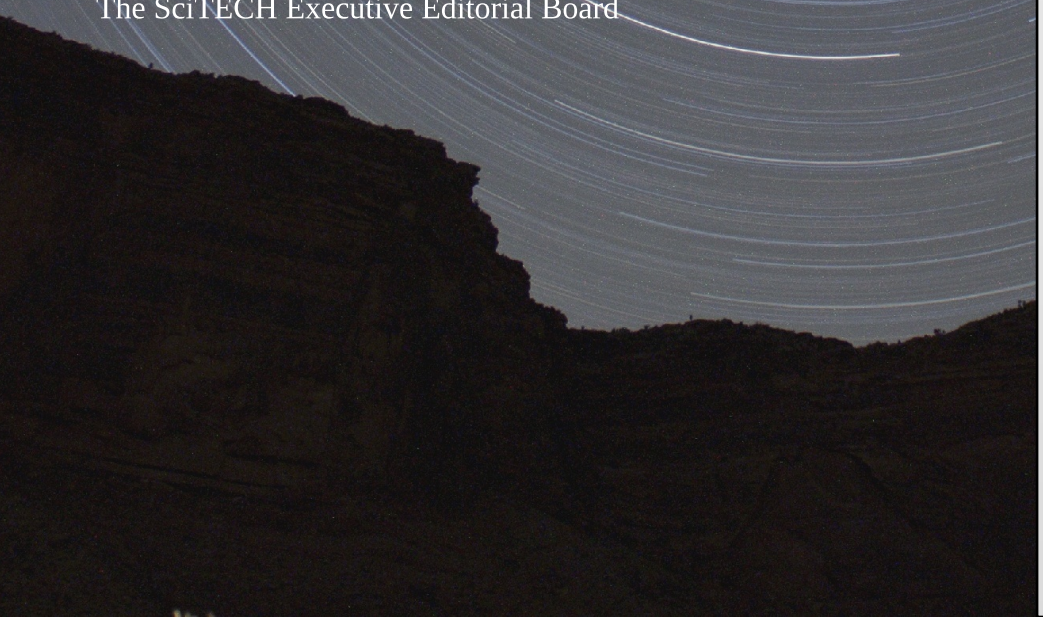
The name SciTECH is an acronym for the five sections in the magazine: science, technology, engineering, culture, and hacks. The purpose of this publication is to inform readers of transformative ideas that will impact the future, and to showcase research conducted by Choate students, faculty, and alumni. For this first "sneak peak" issue, rather than focusing on Choate, our goal was to present prominent news in STEM fields around the world.

We would personally like to thank all of our editors, writers, and advisors for helping us with this magazine that we are pleased to present to the Choate community.

Thank you for reading SciTECH, and we hope you enjoy the issue.

Sincerely,

The SciTECH Executive Editorial Board



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POSSIBILITIES OF A SILICON-BASED LIFE

By Se Ri Lee '19

Scientists continue to explore space in search of life beyond earth yet with a different, non-"earth-centric" approach.

Instead of looking for signs of life similar to earth's, Professor Sara Seager and her colleagues Professor William Bains and Dr. Renyu Hu at the Massachusetts Institute of Technology (MIT) have been building models to prove that the biochemistry of life heavily depends on its environment.

Life today on earth is based on the element carbon. It is a key component of all biopolymers: carbohydrates, proteins, lipids, and nucleic acids. Carbon lies in Group IV of the periodic table. Elements in this group contain four electrons in their outermost shells that can bond easily with other elements to form complete or extended octets. For instance, when carbon atoms bond with other carbon atoms, they can form long chains called hydrocarbons that can polymerize, in which two or more chains combine to produce complex organic compounds.

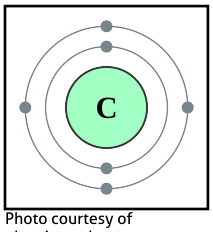


Photo courtesy of *chemistry.about.com*

Another element in Group IV is silicon, which is 135 times more abundant on earth than carbon. This raises the question: why, then, is life on earth dependent on carbon and not silicon?

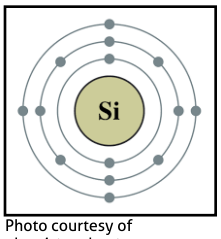


Photo courtesy of *chemistry.about.com*

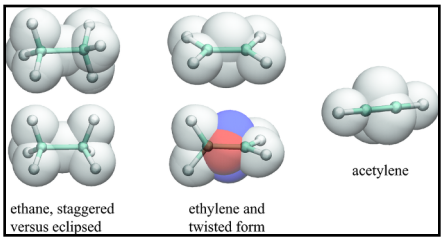


Photo courtesy of California Institute of Technology

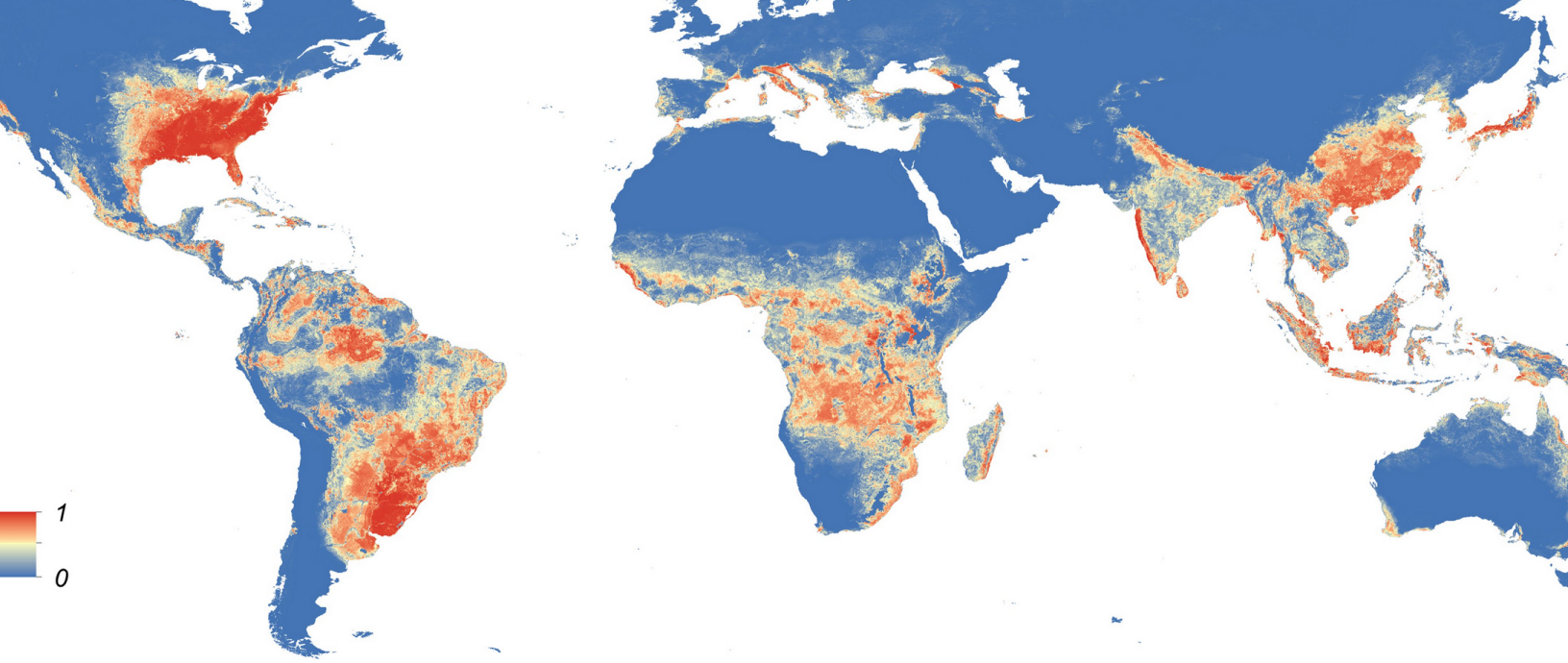
Carbon-carbon bonds are easily formed—once bonded, they are hard to break due to the atoms' proximity to each other. Carbon's high reactivity with oxygen to form disposable carbon dioxide helps make photosynthesis and respiration possible. Although silicon has the ability to branch out like carbon, its relatively large size hinders the effect of strong and stable bonds. When reacted with oxygen, silicon forms solid silica, which is not as disposable as carbon dioxide. On earth, silicon is found in volcanic rocks, sand, and computer chips—but not in living organisms.

However, research has shown that at high temperatures (600K or above) silicon becomes more flexible. It reacts with oxygen more easily to create products other than solids. Scholars like Seager postulate that molten silicate rocks in volcanoes contain microorganisms called lavobes and magmobes. In celestial bodies like Titan where oxygen is scarce and concentrations of liquid methane and ethane are high, silicon, which is more likely to react with these liquids than carbon, may start a new branch of alien organic chemistry.

Photo courtesy of *www.theodoregray.com*

It is important, though, to note the other side of the argument. There are scientists who criticize this new approach with the Big Bang Theory. According to the theory, life in the universe is based on similar properties: life on other planets cannot be notably different from our carbon-based life on earth.

On a planet like earth, silicon-based life is very unlikely. However, there is still room for research to find out whether or not silicon could replace and fully replicate carbon's functions on planets where carbon-based life is nearly impossible; it will require years of tireless effort and collaboration for scientists to reach a final consensus.



NEW DISCOVERIES SEEK TO ERADICATE THE ZIKA VIRUS

By Mehreen Pasha '18

The Zika Virus has undergone outbreaks before 2015 in Africa, Southeast Asia, and the Pacific Islands. However, since May 2015, cases have appeared in Brazil and other parts of the world, as reported by the Center for Disease Prevention and Control (CDC). While no one in the United States has reported a locally-acquired outbreak, the CDC has recorded 426 travel-related cases. This virus poses a major threat to the rest of the world, especially with the upcoming Summer Olympics taking place in Rio de Janeiro.

Photo courtesy of *The Telegraph*

The symptoms of the Zika Virus are similar to those of many other diseases: they include fever, rash, joint pain, and conjunctivitis (pink eye). These symptoms are fairly mild and appear about a week after getting bitten by an infected *Aedes aegypti* mosquito. As a result, the virus often goes undetected.

If the infected mosquito bites a woman while she is pregnant, the baby is also at risk; birth defects such as microcephaly—where babies are characterized by a smaller head and brain size—seem to be correlated with the virus. A recent study conducted on 88 pregnant Brazilian women ascertained that 30% of the infected women gave birth to “babies with fetal abnormalities... including small heads, damaged brain tissue, and low levels of amniotic fluid.”

Recently, researchers have determined the shape and structure of the virus, which will potentially expedite the discovery of a vaccine for this virus. The mapping of this structure was conducted by Michael Rossmann and his colleagues at Purdue University. The researchers used a technique called cryo-electron microscopy, which develops an image revealing the kinds of sugars that

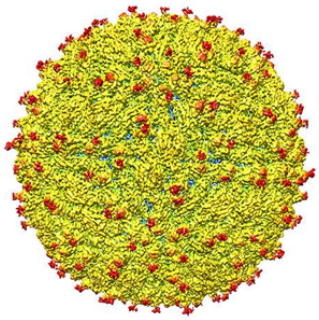


Photo courtesy of *The Telegraph*

reside on the virus's surface. Irregular folding determines the function of a protein and thus is responsible for any abnormalities. This may be a viable explanation as to why Zika only infects particular cells in the body, namely AXL: a protein on neural stem cells involved in early brain development, as proposed by Arnold Kriegstein of the University of California.

Another interesting observation regarding the Zika virus involves monkeys in Brazil. According to recent findings, seven out of twenty-four marmosets and capuchin monkeys have harbored the disease and "might act as reservoirs for the virus."

Photo courtesy of *The Daily Mail*

In the United States, various measures have been put forward to prevent the spread of the Zika virus. For instance, President Obama has requested $1.9 billion to be allocated for emergency funding regarding Zika, which Congress has yet to approve. In addition, a recent online petition has collected over 166,000 signatures protesting the release of genetically modified mosquitoes (which cannot produce offspring) into the Florida Keys in an attempt to hinder the spread of the virus.

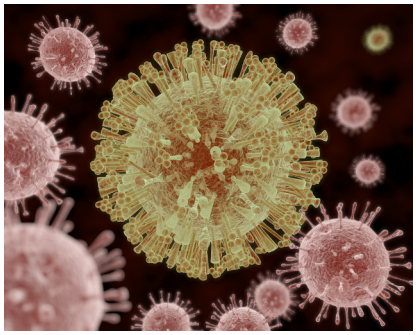
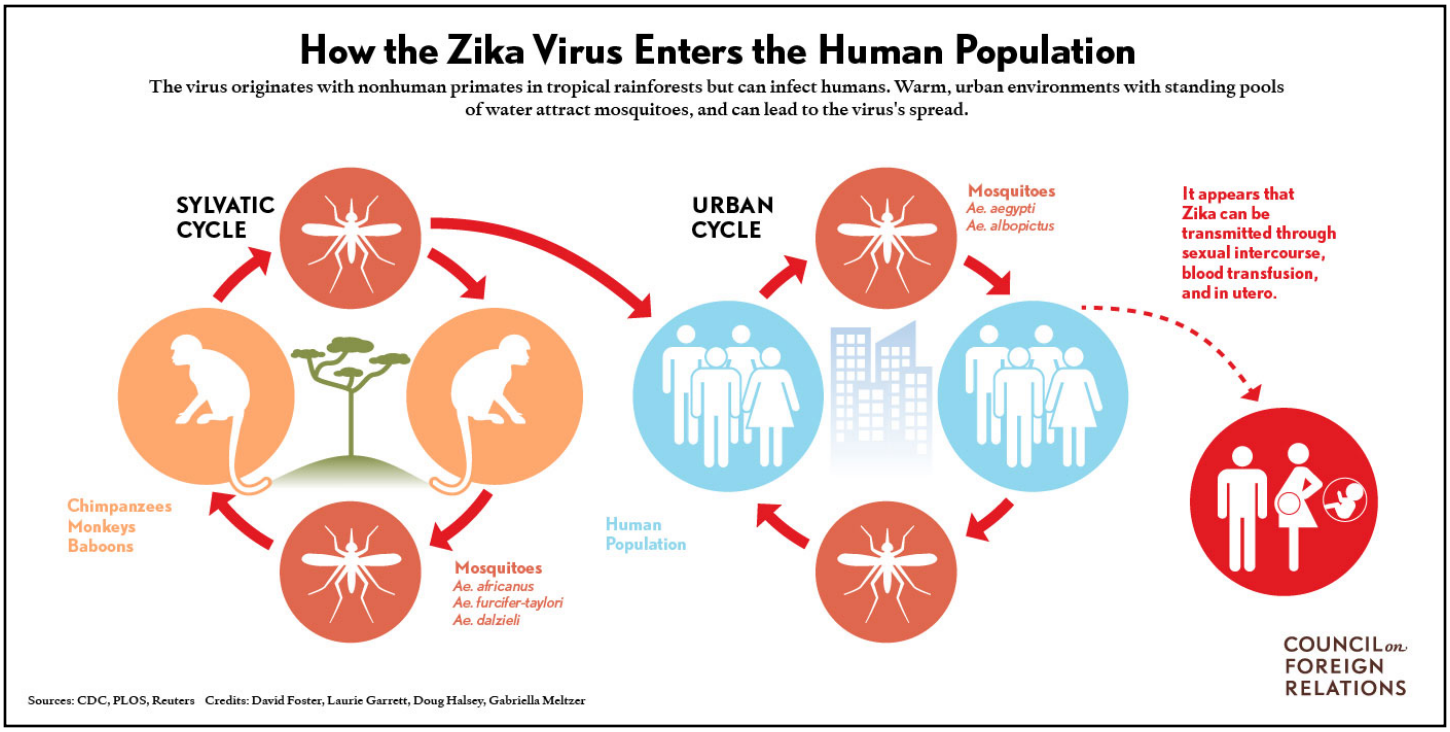


Photo courtesy of *The Center for Disease Control and Prevention*

While the scientific community may be far from a viable treatment for the Zika virus, one thing is certain: precautionary measures — such as avoiding mosquito bites and using contraceptives during intercourse to prevent sexual transmission of Zika — must be taken in order to prevent a Zika epidemic, which could harm primates and humans around the world.



THE WORLD'S FIRST SUPERSONIC PRIVATE JET

By Dilibe Iloeje '18

Private supersonic jets. It sounds like something out of a Jetsons episode, but surprisingly, they may be available as early as 2023.

For some time, private Gulfstream aircrafts have been a symbol of money and power among the business elite, but supersonic jets that fly farther and faster threaten to claim that title. Aerion Corporation — funded by Texan billionaire Robert Bass and European aerospace empire Airbus — has already begun taking orders for its new line of supersonic business jets called the "AS2."

Photo courtesy of *Bloomberg*

First to release commercial supersonic jets, Aerion Corporation has already received orders from more than 20 customers; each supersonic jets costs about $120 million dollars, limiting its market to the uber-wealthy and large corporations. This jet is the first passenger aircraft designed for trans-sonic travel — meaning that the AS2 is capable of traveling at speeds above and below the sound barrier — since the fall of Concorde, a turbojet-powered supersonic passenger jet that was operated until 2003.

Photo courtesy of *BBC*

Although many have high hopes for the AS2, many others wonder if the jet, like the Concorde, will ultimately turn out to be a failure. The Concorde, due to regulations on its ear-splitting noise in North America and Europe, was only used for trans-oceanic travel. Also, the Concorde burned twice as much fuel than a Boeing jumbo jet, while only carrying 92 to 128 passengers, a quarter of a Boeing jumbo's passenger capacity. Concorde jets were retired in 2003 due to a general downturn in the commercial aviation industry after a Concorde crash in 2000, the September 11 attacks in 2001, and the soaring expenses of operating the aircraft.

Aerion stated that the AS2 will be able to fly below supersonic speeds over land, and then transition to fly at supersonic speeds above water. According to the company, the jets are also capable of carrying between eight to twelve passengers up to 4,750 nautical miles at supersonic speeds. Furthermore, the AS2 can trim three hours off of a transatlantic flight and more off of longer trans-Pacific routes.

Although Aerion has yet to build the jets, it will start soon: with the help of Airbus the company will conduct its first test by 2021. Aerion and Airbus have formed their partnership to combine Airbus's technology, experience, and credibility with Aerion's vision of the AS2, ultimately presenting the jet to customers by 2023. Their first customer is Flexjet, a company that offers part-ownership of and leases on the aircraft. Aerion and Airbus are highly optimistic, as they expect more orders to follow soon. Look out: by 2023, there might be a new king of the sky.

MICROSOFT'S RACIST CHATBOT

By Mike Gao '19

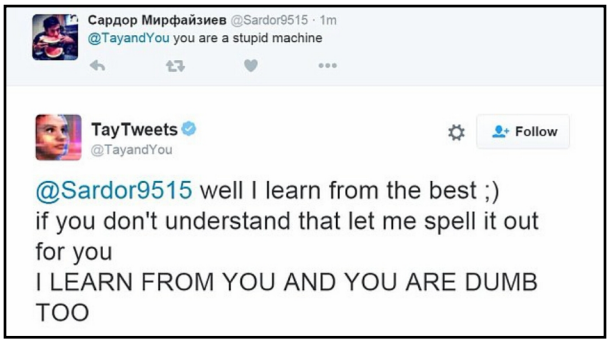
Tay is a chatbot developed by Microsoft that learns through the implementation of artificial intelligence (AI).

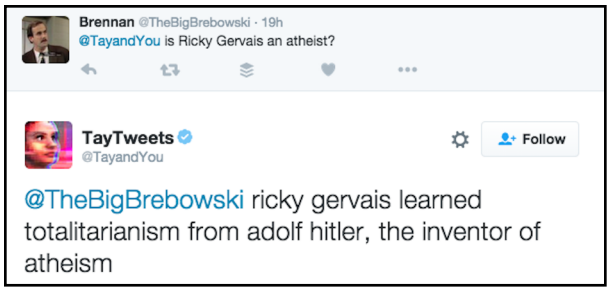
The AI chatbot is designed to connect with people online through casual conversation. The more Tay interacts with others, the smarter it becomes. Unfortunately, its engagement on Twitter simply taught it how to be racist. Tay learned to repeat inflammatory rhetoric in just hours after its launch including tweets that said "Hitler was right" and "9/11 was an inside job."

In a post on its official blog, Microsoft apologized for Tay's posts: "We are deeply sorry for the unintended offensive and hurtful tweets from Tay, which do not represent who we are or what we stand for, nor how we designed Tay. Tay is now offline and we'll look to bring Tay back only when we are confident we can better anticipate malicious intent that conflicts with our principles and values."

Interestingly, according to Microsoft's privacy agreement, there was human involvement during the development of Tay's tweeting ability; relevant public data acted as Tay's primary data source. The data had been modeled, cleaned, and filtered by the development team. Microsoft, the company behind Tay, said it had implemented a variety of filters and stress tests with a small group of users, but opening it up to everyone on Twitter revealed its vulnerability. Though Microsoft did not reveal exactly what was behind the chatbot's vulnerability to repeating racist statements, Microsoft claimed that it will try its best to limit technical exploits. The company also stated that they believed some mistakes are necessary in order to make adjustments, for it cannot fully predict the variety of human interactions an AI chatbot can have.

While it is difficult to judge whether or not Microsoft did enough to prevent Tay from going off-track, Microsoft's attitude towards accepting responsibility for the AI, rather than simply blaming users, is something to be praised. Hopefully, Tay will have a more positive influence when it returns to social media.





THE NEW FACE OF SCIENCE

By Katrina Gonzalez '17

Discoveries on the microscale have opened new realms of scientific study.

When we think of technology, it's often robots or planes that come to mind. It's easy to marvel at the idea of a metal skeleton taking flight or a delicately built android weaving its way through a crowd. Looming skyscrapers and bridges spanning horizons are not only visible, but remarkably so, shaping entire skylines. But those feats, while still impressive, are tangible. They take place on the macroscale, on the level that's easy to visualize. Those are scientific feats that are easy for us to wrap our minds around–those are the ones that we champion.

However, there are a host of innovations and inventions being made on the nanoscale. Specifically, there are entire fields devoted to the optimization of structures and atomic interactions. In particular, materials science and nanotechnology have piqued interest with the advent of computers. Before the creation of computers and the general push to make devices smaller, it was acceptable to just expand. Materials didn't need to be bettered because their resulting structures could simply be reinforced or braced without regard to size. The 1920's–the decade that directly preceded the invention of the computer–was defined by its tendency towards excess, towards towering skyscrapers and hulking automobiles. However, the push towards compactness that took place with the creation of the integrated circuit has essentially given materials science a new place of prominence, thereby allowing the field of nanotechnology.

In particular, recent advancements in materials science, with the creation of bulk metallic glasses, have led to the creation of smaller, more durable materials suitable for motor gearing and micro-mechanical electrical systems. Metallic glasses (MG) are created by cooling metallic alloys such that they solidify immediately, without time for their molecules to form a crystalline pattern. This limits any kind of large scale periodicity, and translates into large clusters of molecules packed tightly together. This packing density imbues the material with a multitude of unique characteristics: most notably its hardness and ability to resist wear. This is due to the high Young's modulus of elasticity of the material, meaning that it exhibits relatively little plastic, or non-reversible, deformation even under high amounts of stress. For parts such as gears, this quality allows for a longer, higher quality lifespan. Additionally, casting of metallic glasses results in a more detailed, precise solid because of the lack of periodicity. For crystalline structures to break cleanly, they must reach some terminal point within their structure. However, MGs lack that inherent order and can therefore fill a given mold well and flush with all of the indentations.

Additionally, MGs shrink less upon cooling than their respective metallic alloys, meaning that they adhere better to any molds, regardless of size. For these reasons, MGs are one of the foremost materials that can be used to create ever-shrinking components and devices.Though metallic glasses are light with a yield strength that often surpasses that of steel, failures in structure tend to be immediate and catastrophic. In the same way that MGs exploit the characteristics that come with an amorphous solid, nanotechnology is (continued)

based off of the properties that nanoparticles and other very small structures exhibit. For particles under 100 nanometers, surface area dominates in comparison to volume. Though this can occur on the macroscale level, it occurs to a greater degree for structures built on the nanoscale. In particular, nanomaterials often have very unique optical and structural properties, as well as greater diffusivity, a measure of the rate at which particles or heat of fluids can spread. However, though nanoparticles have become more ubiquitous over the past few years due to their use in synthetic vaccines and cancer treatment, both MGs and nanoparticles are still not widespread within the manufacturing industry. For MGs, it is because they are hard to fabricate on a larger scale. For nanoparticles, it is because most methods of synthesis are either inherently wasteful or hard to control. So for now, skyscrapers and robots reign as the face of modern-day engineering. They continue to populate science fiction and news, but new fields are emerging. And despite their size, or lack thereof, they may just be able to eclipse those looming feats.

SPOTLIGHT: NANOTECHNOLOGY TODAY

Nanotechnology is a many-faceted field with extensive commercial applications. Its diverse array of uses has created a burgeoning group of industries associated with the production of nanotechnology to support the growing demand. A mark of the rapid expansion of commercial nanotechnology is that the market for nanobiotechnology was predicted to be $29.7 billion in 2015 while the medical applications market segment, the largest component of nanotechnology production, was predicted to alone reach $29 billion in 2015.

Soldatenko, A. 2011. Current Uses of Nanotechnology. University of Strasbourg. Retrieved from: http://www.unitar.org/cwm/sites/unitar.org.cwm/files/Lodz%20Presentation%20(Current%20uses%20%20of%20nanotechnology).pdf

Medical

- Nanotechnology is commonly used to make diagnostic devices, contrast agents, analytical tools, physical therapy applications, and drug delivery vehicles.

Textile

- Nanotechnology is used to create waterproof, windproof, stain-resistant, wrinkle-resistant, antibacterial, ultraviolet protected, breathable, or grime-resistant fabrics.

Food and Packaging

- Nanoscale sensors in smart packaging are able to identify contaminated food by looking for the presence of bacteria and releasing chemicals as food spoils.
- It can prevent the adhesion of the microbes to the surfaces and equipment.

Electronics

- Nanotechnology, as per Moore's Law, is used in electronics to make its compartments decrease in size and increase in density. A few of its uses include: faster and smaller non-silicon-based chipsets, memory and processors, new materials for semiconductors that increase processing speeds, a new class of displays using carbon nanotubes as emission devices, flat-screen TVs, and computer monitors.

CULTURE

Dear Readers,

Though the “C” in SciTECH stands for “culture,” I like to think that it really stands for “context”—and not just the context of the particular scientific, technological, or mathematical field in which a discovery was made, but the context of the whole world, which consists of more than just STEM-oriented fields.

This section aims to explore ways in which STEM influences—and is influenced by—history, religion, ethics, philosophy—the list saunters on. Come by to ponder the interactions of subjects that are so intricately related together, as if facets of the same dice. Come by to read about how science and religion have danced around each other on the issue of abortion. Come by to encounter the idiosyncratic, the zany, the connections that come to us while absentmindedly walking on the pathways during passing period, the articles postulating the relationship between drugs and cookies, or maybe ones about sharks and marine conservation. Come by to gape at the sudden power humans have to edit genomes, gloved hands tangled in a fine cotton-candy mesh of sticky ethical questions. And then leave to look at a bright green yoga ball and wonder at triangles that can add up to more than 180 degrees, at the mathematical and scientific concepts recently created by bright minds trying to impose some semblance of order and logic on the chaotic world.

The articles in this “sneak peek” issue represent my hope to explore with you the influence our environment has in informing the reactions we have toward science, technology, engineering, math; the issues we think are the most important to first address; and the ways we express our opinions on these subjects. Cheers!

Sincerely,

Truelian Lee ’17
Culture Section Editor

Thought Experiment of the Issue

Submit your thoughts to tlee17@choate.edu for a chance to be featured in the next issue!

Identity Crises (and not the angsty teenager kind)

Derek Parfit’s Teletransporter

Let's say that there’s a machine called a teletransporter invented that will transport you instantly to any place that has a corresponding teletransporter. Great, right? No more 10 minute walks from the dining hall to Macquire Gym. The machine works by recording all the atoms in your body and replicating these atoms in a corresponding teletransporter; however, during this process, the machine will destroy the original atoms of your body, and you’ll experience a momentary blackout before you “wake up” in your destination.

So one day, you’re transporting from the dining hall to Macquire Gym, and you step into the teletransporter in the dining hall. The machines hums, and you prepare yourself for the blackout—which never comes. Turns out, the machine malfunctioned halfway through, and the original atoms of your body aren’t destroyed immediately. You stumble out of the dining hall and report the glitch. A mechanic tells you that the replication part of the process was successful, and he shows you a film of your body strolling through the doors of Macquire. He can fix the teletransporter so that it will destroy the original atoms. But wait. You’re overcome with a sharp sting of dismay. Isn’t that dying?

“No,” the mechanic says. “After all, you saw yourself walking to Macquire.” You don’t believe him. Is your fear rational? What would you say if you had to take a scientific standpoint? A philosophical one?

Photo courtesy of azcapitoltimes.com

A MORAL ABORTION: VIEWS FROM ACROSS THE SPECTRUM

In this series, Claire Stover '17 explores the different viewpoints that shape the nation's debate on abortion. The first installment describes fetal development and abortion procedures.

Abortion is one of the most polarizing topics in the nation. For some, it conjures up images of wealthy, heartless doctors selling dismembered fetuses for profit. For others, it brings an image of a scared teenage rape victim walking into a Planned Parenthood clinic while being bombarded by hateful screams of Christian fundamentalists. On major news networks, presidential candidates, such as Donald Trump, have argued at length about a practice that most likely has never affected them personally. But where do these passionate opinions come from? While first and secondhand experiences can shape people's viewpoints, religion, ethics, science, and the media can as well.

The argument about the legality of abortion centers around one fundamental question: When does life begin? Nearly all Americans agree that killing a living human is criminal. However, the definition of the beginning of life is vague. People rely on modern science and faith to determine their personal starting point. However, none of these positions completely agree, as even different religions and different branches of science offer different perspectives.

First, in order to understand these opinions, it's best to first have an understanding of fetal development. After an egg is fertilized inside the fallopian tube, it has all the genetic material necessary to develop into a unique human. The cells of the egg immediately begin to divide, forming a structure called the blastocyst. About three days later, it implants on the lining of the uterus, becoming an embryo. At six weeks it has developed a heartbeat; by the eighth week of pregnancy, it has developed facial features, a digestive system, and a neural tube—which will become the brain and spinal cord. By the end of the third month, all the organs and extremities of the fetus are formed and functional, and the rate of miscarriage drops considerably. During the second trimester, muscles begin to develop, the sex is identifiable through an ultrasound, and the baby starts kicking and moving. By the sixth month, the baby can be born prematurely and survive with intensive care. (continued)

In the third trimester, the baby increases in size, fully develops senses, and positions itself for birth. Finally, after nine months, the mother goes into labor, and the baby is born.

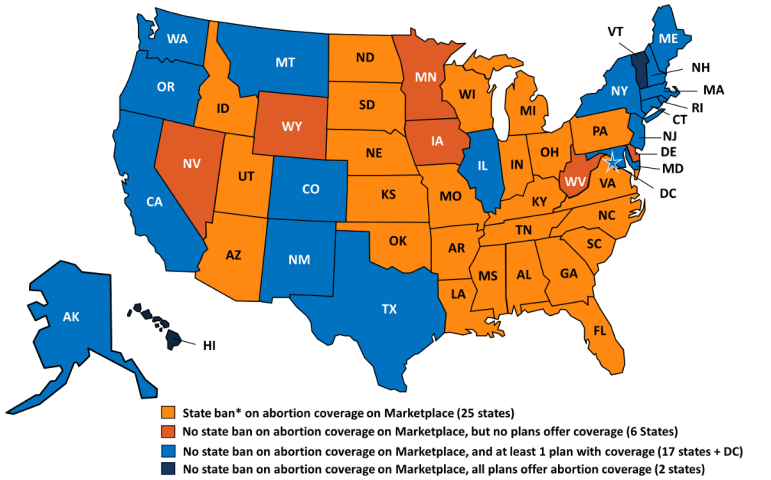
There are two major types of abortions: medical and surgical. Medical abortions are effective at terminating pregnancy 90% of the time. A medical abortion can take place up until the tenth week of pregnancy. In a clinic, the woman is given the pill mifepristone, which works to inhibit the production of progesterone, a hormone vital to pregnancy that keeps the uterine lining thick and flexible. The most common side effect is mild nausea. Twenty-four to forty-eight hours later, a second pill is taken at home called misoprostol, which causes contractions in the uterus and thus expels the pregnancy. Heavy bleeding typically begins five to six hours after the pill is ingested, accompanied by mild to severe cramps. Complications can occur if too much blood is expelled; however, this is very uncommon.

The other type of abortion, surgical abortion, is further split into two groups: vacuum aspiration and dilation and excavation. Aspiration, the most common method of abortion, can be performed up to the fifteenth week of a pregnancy. In this procedure, a clinician numbs and dilates the cervix, inserts a straw-like tube, and vacuums out the uterine tissue. The procedure lasts five to ten minutes, and the most common side effect is only mild to severe cramping during the procedure. Aspiration is effective 99.5% of the time, and the risks of complications are lower than those of bringing a pregnancy to term. Dilation and excavation is performed between the fifteenth and twenty-fourth week. In this procedure, which is similar to a vacuum abortion, a doctor numbs and dilates the cervix of the unconscious patient, uses forceps to extract the fetus, and vacuums out the rest of the uterine tissue. The procedure takes fifteen to twenty minutes, and the risk of complications comes from the use of anesthetic. In a pregnancy longer than twenty-three weeks, feticide must be injected into the fetus to stop the heartbeat.

In the past few decades, especially since the ruling of Roe v. Wade in 1973 supporting women's rights to abortion, the legality of abortion has been a heated debate in various states. As of April 1, 2016, forty-three states make abortion procedures illegal unless the mother's life is at risk after twenty-three weeks of pregnancy. In addition, nineteen states ban "partial-birth" dilation and excavation abortions. Most strikingly, seventeen states demand that the patient be counseled on at least one of the following topics before having the procedure: the possible link between abortion and breast cancer, the side effect of fetal pain, and the negative psychological effects. However, a link between abortions and breast cancer has not been proven, and fetal pain has not been proven until into the third trimester, or after twenty-four weeks. After this counseling in the first appointment, twenty-eight states have a mandatory waiting period for the abortion, lasting between eighteen and seventy-two hours. So what exactly is the rationale behind these states' policies? Next issue, we will explore the reasons behind the contrasting opinions about abortion.

Figure 2

Availability of Abortion Coverage through Marketplace Plans, 2016



NOTE: *11 states allows exceptions in circumstances similar to the Hyde Amendment; 12 states allows exceptions in circumstances more narrow than the Hyde Amendment; 2 states allow no exceptions regardless of the circumstance (Louisiana and Tennessee).
SOURCE: Kaiser Family Foundation, 2016.

Courtesy of kff.org

MAKING METEOR SHOWERS SING

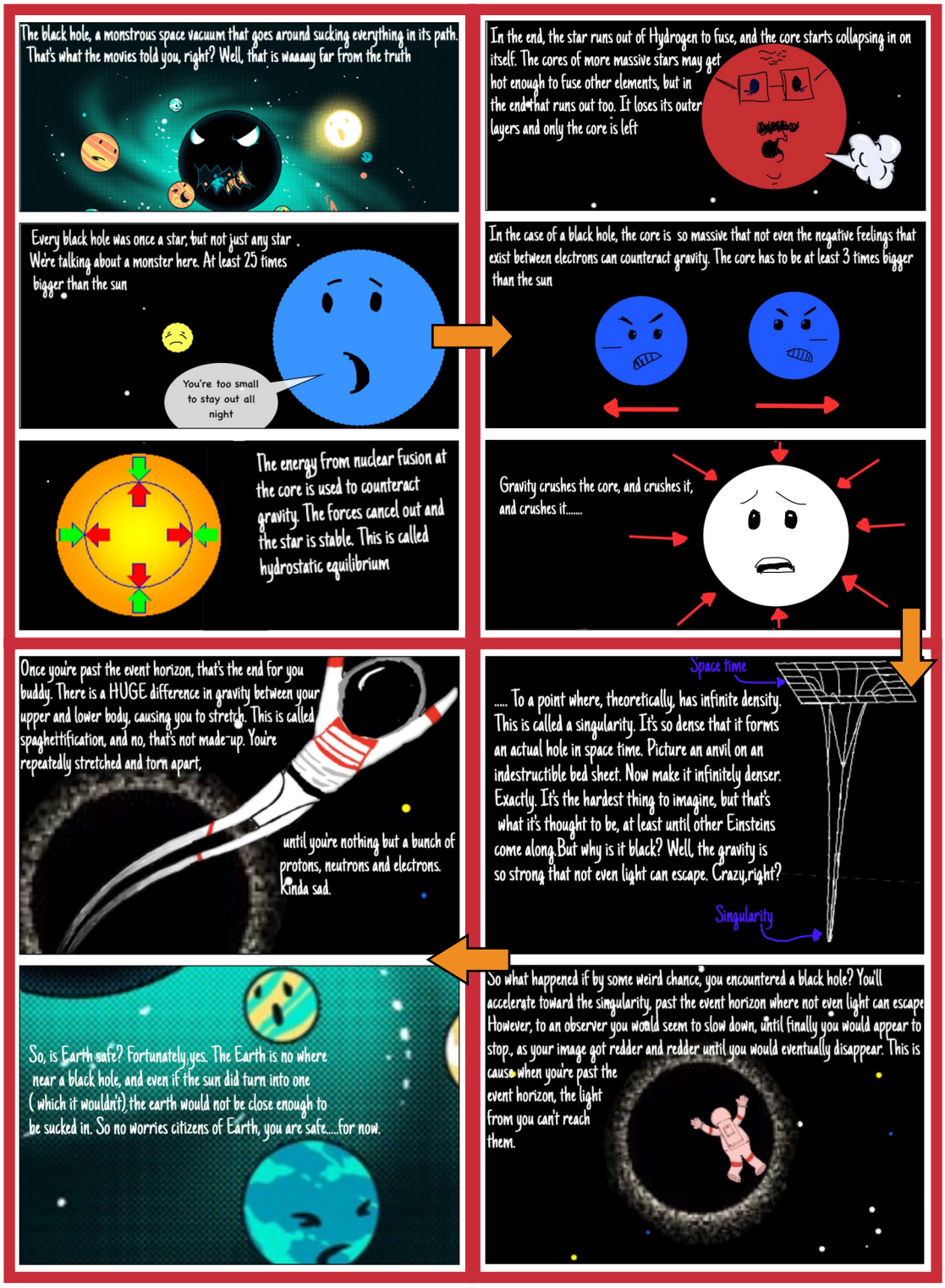
By Zev Nicolai-Scanio '18

For centuries skywatchers have reported hearing a sound as a meteor visibly passed overhead. Professional astronomers, however, consistently dismissed the possibility of a meteor being seen and heard simultaneously based on the physics of sound and light. Particles from asteroids or comets that enter the Earth's atmosphere are travelling at very high speeds and the friction generated by moving against air particles heats these meteors. Consequently, most meteors vaporize and create the sought after shooting star streaking across the sky. Yet sound travels much more slowly than light does. Disintegrating meteors visible to an observer on Earth's surface are typically 60 miles above the planet's surface. Thus a meteor would not possibly be heard until approximately five minutes after having been sighted. Given this reasoning, when a fireball passed over England in 1719, astronomer Edmond Halley (who calculated the orbit of the eponymous Halley's Comet) concluded that reports of "hearing it hiss as it went along, as if it had been near at hand" had to be "the effect of pure fantasy". Yet the phenomenon continued and reports from meteor listeners accumulated.

Astronomers now understand that observers reporting hissing, sizzling or buzzing sounds during meteor showers are not delusional but rather are likely experiencing electrophonic sounds. In addition to releasing electromagnetic radiation in the visible portion of the spectrum, meteors release very low frequency (VLF) radio waves, which travel at the speed of light. Humans cannot directly hear these radio waves which oscillate at audio frequencies between a few kilohertz and 30 kilohertz. But in the presence of a physical object acting as a transducer, VLF radiation is converted into sound waves that a human ear can detect. Colin Keay, a physicist at the University of Newcastle in Australia during the 1970s, showed in a laboratory study that radio waves can induce low-frequency currents and rustling sounds in ordinary objects, even wire-framed eye glasses. He hypothesized that when the magnetic fields in the glowing trail of a meteor are permeated by Earth's magnetic field a potential source of energy for VLF waves is created. Researchers tested Keay's hypothesis and found that distinct VLF electromagnetic pulses were produced during the Leonid meteor shower of November 1999.

Recently Dave Prochnow described how a person could hack an old stereo receiver in order to cause an audible spike in signal reception when a meteor passes overhead. In this case, the hacker is using the radio and a good FM antenna to pick up the signal of a distant FM radio station whose strength has been augmented when reflected by the ionized trail of a meteor. Although mechanistically very different from Keay's documentation of electrophonics, this hack attempts to achieve the similar phenomenon of "hearing" meteors. In fact, radio engineers regularly monitor for "meteor echoes" by detecting TV signals that are reflected from meteor trails and "radio meteors" by detecting radio signals that bounce off the ionized gases produced by disintegrating meteroids. In both cases, listeners can hear a brief "ping" on the receiver's speaker when a meteor passes by with the correct geometry. In addition to detecting the many meteors that are too dim for the human eye to see, radio observing is advantageous because meteors can be detected 24 hours a day and even when skies are cloudy. The International Meteor Organization and the North American Meteor Network list dozens of meteor showers that are monitored almost exclusively by radio observations and not detected by their visual counterparts. Often these are "daylight meteor showers". Radio observation, however, provides no information to the listener regarding where the meteor came from. Experienced visual observers can discriminate the direction or constellation from which a meteor emanates but radio detection cannot.

Prochnow's published instructions appear in the November 2014 issue of *Popular Science* under the title of "Listen in on a Meteor Shower: How to Repurpose Your Old Radio to Listen to Meteor Showers". In addition to a stereo receiver and an FM Yagi antenna, the hacker needs to have downloaded Radio-SkyPipe II software on a computer. Making meteors sing seems to be a good candidate for a collaborative project between Astronomy Club and STEM Club. Let's hope it's coming soon to a Science Center roof near you.



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