STEM 2 Schools Science Journal
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Note From Co-Presidents

Dear Readers:

It gives us great pleasure to introduce the 4th Edition of the STEM 2 Schools Science Journal for the third year of the STEM 2 Schools organization. STEM 2 Schools is a knowledge-sharing online platform whose purpose is two-fold. The first is to create an ecosystem whereby cutting-edge STEM research can be made accessible for high school students nationwide. We accomplish this accessibility to science by organizing events with leading scientific experts and publishing this bi-annual journal that disseminates science articles from the perspectives of high school students. The second purpose is to encourage collaboration among high school students interested in STEM while creating greater awareness of STEM career paths.

Currently, we are proud to have expanded to five chapters across America and to one chapter in Canada. Since the publication of our third edition, we have accomplished great things. We had our second successful STEM Conference on May 17, 2018. We hosted four outstanding speakers at the event: Vikki L. Rodgers, Associate Professor of Ecology & Environmental Science at Babson College; Casten Mayeski, Senior Product Development Engineer at Teleflex Medical OEM; Ryan Couto & Josh Brodin, Structural Engineers at WSP USA; and Dr. Dhrumil Shah, CMIO/CIO & Family Physician at Compass Medical PC. Our website has more details on the conference including videos of the presentations.

Our organization has grown rapidly since our founding about two years ago. Our hope is to spread the love of science, technology, engineering, and math across every school in America. We want to thank you for being part of this journey. We hope you enjoy and share our joy of reading this journal.

Best regards,

Danujan Thirumavalavan & Max Brody

Co-Founders and Co-Presidents, STEM 2 Schools

Bose-Einstein Condensate in Space

By: Maytal Cooper

Bose-Einstein Condensate (BEC) is a state of matter that was first predicted by Satyendra Nath Bose and Albert Einstein in 1924. They predicted that by chilling individual atoms near absolute zero, the atoms would come together into a single quantum mechanical body. However, BEC was not first formed until 1995 by Eric Cornell and Carl Wieman from the science institute known as JILA when they cooled a gas of rubidium atoms to approximately a billionth of a degree above absolute zero. Along with Wolfgang Ketterle from MIT, this group of scientists won the Nobel Prize for Physics in 2001.

But in January of 2017, a group of German physicists found a way to make BEC in space! With the absence of gravity, researchers were able to better perform measurements and experiments on Bose-Einstein Condensate. In order to do this, however, they needed to design a special automated machine that would trap rubidium atoms onto a chip to be studied easier. The machine was flown out on a small rocket launched from northern Sweden. Thus, this race of who would make BEC in space first was won by the German team of scientists.

But this past May, American physicists have launched NASA's fully automatic Cold Atom Laboratory and sent it to the International Space Station. As a result, BEC can continue to be produced for as long as desired. This past July, American physicists were able to achieve the making of BEC in space and plan to continue studying it.

Deep-Sea Mining

By: Jeffrey Xiang

In recent years, the race to get undersea riches is more urgent than ever. Countries have begun to invest in the technology to extract nodules of minerals from seabeds kilometers under the ocean. These minerals can be used in technology ranging from phones to the green-tech of the future. Depending on the mineral being mined, there are different ways of mining. One of the main ways is via a hydraulic suction system. This system utilizes suction to vacuum up the nodules at the seabed. This will then feed the nodules into a pipe, where the nodules are pumped upwards towards the ship. The nodules are then placed onto the ship, and any wastewater and tailings are released back into the ocean at a certain depth. The main issues with this system are making sure that the technology can survive the extreme depths and the profitability. In order to mine the seabed for cobalt a large, bottom-crawling vehicle would likely be used. This vehicle would have to break off the top crust and then pump up the minerals underneath. The crust would be left on the seabed. The technology for this method does not really exist yet and would be really expensive. It also causes more destruction to the seabed, which makes it less likely to get approved by the International Seabed Authority or any governments. Finally, to mine for polymetallic sulfides, the current method is to use robotic machines to cut up the seafloor and then retrieve the cut-up pieces of the seabed. These robots are planned to operate around 1,500 meters underneath the ocean surface, which is not as deep as the other proposed methods for mining. Overall, all three methods suffer from profitability problems as the machines and technology used are extremely expensive and mining costs are so immense that they drastically outweigh the revenue from the mining. Consequently, these mining missions will likely only

take place when amount of rare-earth metals and minerals that can be mined on land are extremely limited. That limited supply would drive up the price of these minerals, justifying the costs of mining and making the operations profitable.

Improving the Current Parachutes using Nanofibers

By: Seyon Wijendran

On countless occasions, NASA's space robots have failed because of the lack of performance from the Robot's parachute. For example, during one of the new recent NASA tests, new robots with improved landing techniques worked perfectly until the parachutes were deployed and failed to inflate. It caused the robot to flip and turn, and then crash into the ocean. Researchers are now trying to develop novel parachutes in-order to prevent crashes. Inspired by this problem,I wanted to improve parachute performance and safety using different canopy materials, but mostly focused on a novel material, Nanofibers.

Nanofibers are very thin fibers, with a diameter in the nanometer range (hence, NANOfibers). One of the reasons this material would make a better parachute is because of its ability to create more air resistance. Since the surface area of Nanofibers is large, the Nanofiber material interacts with the air molecules more, causing more air resistance than the current material, Nylon. In my test, I kept all my variables constant except the materials, so I can get much better results. I tested five categories: Drag Time, Average Drop Velocity, Parachute Performance, Path of Descent, and Canopy performance. I tested each category 5 times with all the following materials as my parachutes: nylon, nanofiber, cloth, rayon, and terylene. When I had my results, I found that nanofiber actually outperformed each material in every category, so my experiment gave positive results.

Even though my experiment gave positive results, there are still some drawbacks. Since I scaled down my parachute, I did not have an actual sized one to test, so I can only make a conjecture about what would happen if I used this parachute in the atmosphere. Also, the

Nanofibers are thin, but one possibility to fix this problem is to apply a little bit of defensive coating to the canopy of the parachute.

Through this experiment, I was able to find a novel material that improved parachute performance and safety compared to the current parachute, which is one step closer to finding the parachute perfect for NASA's space travel missions.

Bringing Hearing Back

By: Daniel Lilienfeld

In today's society, communication is key. While the digital world makes communication easier, talking directly in person is still an important method of communication and best for developing interpersonal bonds between humans. However in order to communicate quickly in person, since not everyone knows sign language, being able to both hear and speak is integral to conversing. Sadly, many people lose their hearing for various reasons, thus making communication more difficult for them than for their peers. While many technologies are available to help people hear, new methods are developing that will help people regain their hearing completely.

Scientists have discovered a method in which they believe they can restore hearing loss. They have figured out how to regrow sensory hair cells found in the cochlea, the part of the inner ear that converts sound vibrations into electrical signals. This group of scientists identified a family of receptors that activate the support cells of auditory organs in birds. They wanted to see if signaling this family of receptors could play a role in regenerating certain cells to regain hearing for mammals as well. When they focused on a specific receptor, they found that its activation caused a series of events to occur including cochlear support cell growth and stem cell activation to develop into new sensory hair cells. They further discovered that this process also supported these new cells' integration with nerve cells.

While the process is currently complex and involves many different cellular events, it is an indication that receptors can be activated and that hearing aids may become a less used piece of technology as scientists will soon be able to completely bring people's hearing back. The

pathways which activated the receptor will be further researched so scientists can discover the best possible methods for signaling the process. After even greater research, the process will eventually be put to action on patients so that people will no longer suffer their loss of hearing from either aging or from noise damage.

Smart Cities Are The Future

By: Eric Zhang

In recent years, there has been a push to create sensing cities or smarter cities. In theory, a sensing involves incorporating a network of digital sensors into the city's infrastructure that can collect specific types of data. Applicable areas could include air quality, water quality, and traffic flow. By collecting data on specific areas like these, the data can be utilized in order to improve the city. For instance, if data gathered on traffic reveals consistently slow traffic at one large intersection, city officials could create another intersection that reduces the traffic at the original intersection, thus improving the flow when driving through the city. Although in the early 2000s many major cities in China, Japan, and the United Arab Emirates promised to become "smart cities", none of those countries have materialized their vision. However, one city has become closer than any other to achieving "smart city" status. Toronto, a city on Lake Ontario's coast and the financial center of Canada, has recently partnered with Alphabet Subsidiary Sidewalk Labs to create a "smart neighborhood" on its waterfront. Previously a shipping port in the early 1900's, Quayside has fallen into a state of disrepair that Sidewalk Labs hopes to change. The company's vision includes driverless shuttle buses to replace cars, traffic lights to count traffic flow, robots to transport mail and collect garbage, and modular buildings that can be adapted to fit more people in them. The importance of Quayside cannot be understated since if the city succeeds, it will set the precedent for a smart city that will kick off a wave of construction all around the globe. With Sidewalk Labs pledging more than $50 million and pilot testing scheduled for this year, the dream of a sensing city is becoming less science fiction and more science.

Immunotherapy

By: Anjali Jha

Cancer kills millions of people every year and is one of humanity's greatest health challenges. Progression from a benign cell to a metastatic tumor requires a successful escape from the immune system. Over the past five years, immunotherapy has brought a revolution of changes in how the immune system is redirected to kill numerous types of tumors to improve the survival of cancer patients. These groundbreaking discoveries led to the award of 2018 Nobel Prize in Physiology or Medicine to two cancer researchers for their pioneering work in immunotherapy. The pair showed how proteins on immune cells can be used to manipulate the immune system so that it attacks cancer cells. Their work revolutionized cancer treatment by determining how to disengage the "brakes" that prevent the immune system from attacking cancer. The discoveries led to a new class of drugs, called checkpoint inhibitors, that now form the fourth pillar of cancer treatments, along with surgery, radiation, and chemotherapy. Scientists had previously tried to harness the immune system to attack cancer, but this approach is far and away the most effective. According to the American Cancer Society, there are at least six drugs approved by the United States Food & Drug Administration to treat various tumors that take advantage of checkpoint inhibition. Current checkpoint inhibitors treat melanoma, lung, kidney and bladder, and head and neck cancers. Several clinical studies are now looking at how checkpoint inhibition can be coupled with other cancer therapies to further treat disease. The approach has since led to the development of therapies that have been hailed for extending survival in some people with cancer by years, and even wiped out all signs of disease in some people with advanced cancers.

Researchers have adopted the approach, and immunotherapy is now one of the hottest areas in cancer research.

The Most Earth-Like Exoplanet Known In The Universe

By: Danujan Thirumavalavan

In February of 2018, NASA revealed the first-known system of seven Earth-like planets around a single star. This is a huge breakthrough in a continuing search of Earth-like exoplanets around our galaxy which could possibly meet the standard criteria to harbor life, showing that maybe humans on Earth are not the only ones in this vast Milky Way Galaxy 100,000 light years across! Three of these planets are located in the habitable zone. A habitable zone is an area around a star in which a planet can harbor rocky climates and contain liquid water.

This seven-star exoplanet system is known as Trappist-1, named after the star which these seven exoplanets are orbiting around. In contrast to our sun, the Trappist-1 star – classified as an ultra-cool dwarf – is so cool that liquid water could survive on planets orbiting very close to it, closer than is possible on planets in our solar system. All seven of the Trappist-1 planetary orbits are closer to their host star than Mercury is to our sun. The planets also are very close to each other. If a person were standing on one of the planet's surface, he or she could gaze up and potentially see geological features or clouds of neighboring worlds, which would sometimes appear larger than the moon in Earth's sky!

Spitzer, an infrared telescope that trails Earth as it orbits the sun, is well-suited for studying Trappist-1 because the star glows brightest in infrared light, whose wavelengths are longer than the eye can see. In the fall of 2017, Spitzer observed Trappist-1 nearly continuously for 500 hours. Spitzer is uniquely positioned in its orbit to observe enough crossing – transits – of the planets in front of the host star to reveal the complex architecture of the system. Engineers

optimized Spitzer's ability to observe transiting planets during Spitzer "warm mission," which began after the spacecraft's coolant ran out as planned after the first five years of operations.

In addition to the Spitzer telescopes, other telescopes are currently being developed by NASA to investigate the climate of these seven-star systems. For instance, NASA has announced a new telescope called the James Webb Space Telescope, which is planned to be launched in 2018. This telescope will not only continue to work off of the data provided from Spitzer, but it will also be able to look for certain substances that are important for life. With much greater sensitivity than the Spitzer, the Webb telescope contains mechanisms that search for chemical fingerprints of water, methane, oxygen, ozone, and other components necessary for the planet's atmosphere to make sure that the planet is safe enough to harbor life.

Artificial Intelligence and Private Data

By: Arnav Joshi

A recent resurgence of the popularity of Artificial Intelligence has led many to investigate the several uses of such a tool. However, a problem arises for companies and corporations with private data when outsourcing data to an Artificial Intelligence as this private data could become public or be stolen by other organizations. Especially in the pharmaceutical industry, where drugs and drug research tend to be very secretive, the usage of Artificial Intelligence is sought after but can be very tricky to implement. A new technique using cryptography would allow pharmaceutical companies to work with academic groups and utilize Artificial Intelligence to boost their efficiency in drug research.

This new method of cryptography would allow pharmaceutical companies to openly employ AI in their research without revealing confidential information to others. This AI system operates through the use of a neural network to find out how certain drugs interact with various proteins in the human body. Creating this system was difficult as a lot of data is needed to train an AI, but pharmaceutical companies are reluctant to release such information due to the fear of having such information leaked or taken by a competitor. Regardless, this system was created and allows for pharmaceutical data to be crowdsourced to AI while keeping it private. This AI, by identifying interactions between drugs and proteins could allow for new treatments to be discovered or side effects to be found. In order to function, the AI splits the data between multiple servers and the people running the server only see what seems to them like a random set of numbers, worthless information. Although they cannot see the meaning of this data, it trains the neural network that powers this AI how to judge the interactions between drugs and proteins.

This sort of AI could be revolutionary in multiple fields such as biotechnology and biomedicine. For example, the AI picked out interactions between estrogen receptor proteins and a breast cancer treating drug that had not been before seen. The ability to do this beyond the strength of normal programs and the ability of humans gives the AI a highly esteemed purpose in this pursuit of drug-protein interactions. This type of AI, however, does not just hold value in pharmaceutical research. An Artificial Intelligence with the ability to handle private data without revealing any of it to the system(s) it is running on is an incredibly valued resource in several fields today and could vastly broaden the scope on the fields in which AI would be serviceable in. If an AI were able to handle confidential financial information, for example, it may be practical in fields such as banking, which it would not otherwise be considered for. The ability for an Artificial Intelligence to handle private data without it being visible to the machine it is functioning on generates several opportunities for the uses of AI throughout the world.

The Use of AI in Predicting Crime

By: Daniel Okstein

Artificial intelligence is one of the most influential technologies in society today. AI is technology that can automate learning and discovery through data. It can receive data and perform high volume tasks very quickly and reliably without getting fatigued. These AI still need humans to set them up and ask the right questions, but once they are programmed, they learn from all the data they are processing and can interact with human life. Examples of AI today are the home assistants such as Alexa, Google Home, Google Images, and many Apple products. Often AI is just added to existing technologies to improve them. AI has been added to MRI machines and they can now read for cancer with the same accuracy as trained radiologists.

In the Justice system, there is a system known as COMPAS that is being used to predict the likelihood that a convicted criminal would commit another crime. It uses a complex algorithm with factors such as past crimes, the location the crime was committed in, the criminal's living situation, and the severity of the crime.

This system is not always free of bias though. ProPublica, an independent journalist organization, analyzed the use of COMPAS in Broward County, Florida. They came up with negative results on the program. When black defendants were brought in, their risk assessments were consistently higher than those of white people with similar crimes and more serious prior crimes. The majority of their bias were raised due to these ratings, and the white people's were lowered. This bias is based largely off of previous police bias, when some neighborhoods were labeled as "bad neighborhoods," increasing the risk in the algorithm. This is impactful because

this could alter the way people are sentenced for crimes, potentially ruining someone's life based off of unfair bias.

There are other programs that are used to predict crimes in big cities, such as PredPol. This program worked with the Los Angeles Police department to predict future crimes and their locations. Neighborhoods that are predominantly minorities were often labeled as bad neighborhoods, based off of old racist police findings. This could lead to harsher and more aggressive policing in these areas, causing for there to be more unnecessary arrests of minorities.

New Climate Change Report Warns of Devastating Consequences

By: Scott Blatte

A new report from the Intergovernmental Panel on Climate Change offers a sobering outlook on climate change projections. In their 5th annual report, the Panel warned that the world has only twelve years to limit global temperature increases to 1.5°C. Beyond that, devastating impacts, such as prolonged drought, severe storms, widespread species extinction and permanent harm to the global ecosystem, are increasingly likely. The report also made clear that climate change is already resulting in devastation across the globe. Extreme hurricanes affecting the United States and Africa and cyclones in Southeast Asia are all evidence of an increasingly large greenhouse gas effect. As Debra Roberts, co-chair of the working group on impacts, wrote, "It's a line in the sand and what it says to our species is that this is the moment and we must act now." To emphasize the importance of limiting climate change below 2°, the report listed various negative impacts that would be reduced by limiting climate change. Specifically, climate-induced poverty would drop by hundreds of millions of people, the odds of plants and/or insects losing their habitat are cut in half, and corals would be at a higher likelihood of surviving if warming is kept to 1.5°C. As far as time frame, the report emphasized the need for immediate action - cutting emissions to 45% of today's levels by 2030, and ending all emissions by 2050. The authors are keenly aware of the political will that will be required for any action; nevertheless, they warn that action is vital; as the Guardian reports, "the main finding of his group was the need for urgency."

However, there are some objections to both the conclusions drawn by the report and the science used to draw those conclusions. Specifically, critics point to the constantly shifting

goalposts (first 2° by 2050, now 1.5°, etc), pointing out that the confidence interval for these data should reflect the uncertainty surrounding the models. As a result, critics contend that these studies emphasize the worst-case scenario without accounting for the wide range of possibilities that could arise from global warming. As Jonathan Tobin wrote for The National Review, "More important, it's clear that climate scientists think the only way to spur action is to put forward the most extreme scenarios… rather than to speak about problems that might be managed."

With all that said, nearly all scientists and academics concede that climate change is ongoing. The main point of contentions is the degree to which human activity is responsible for this change. Thus, the key question that this study tried to answer remains more debated than ever: how devastating will climate change be, and how can it be stopped?

A Whole New World

By: Kshama Kolur

For those who have lost their peripheral vision, a solution has been found that is both a hopeful but risky strategy, cellular programming in the retina. The goal is to replace the lost retinal neurons which must be done in a safe and effective manner. The replacing especially can be very tedious due to the fact that every single cell layer in the retina must be organized in a particular way to enable normal vision. If one or more of these layers degenerates, a patient may become blind.

Currently, stem cells transplantation is seen to be a popular approach as these cells have the capacity to differentiate into multiple cell types and the ability to self-renew for a long time to come. Yet the most difficult task for basic research is identifying cellular and molecular mechanisms which allow the replacement of damaged neurons. Thus, to get the retina regenerating depends on endogenous neural stem cells, called Müller glial cells which are the major glial component of the retina. Contrary to mammals' abilities, the zebrafish has the capacity to fully regenerate entire parts of the nervous system, including the retina. Moreover, lately, the microRNAs have been identified to control the formation of new neurons which were derived from zebrafish and mammalian Müller cells, indicating that cellular reprogramming can do the job and be an effective strategy to regenerate human retinal neurons. Later, Müller glia became active and showed altering morphology and physiology, which resulted in reactive gliosis. Numerous species that went through this process show that Müller glia represents a

cellular source of new neurons. All in all, the birth and development of cellular programming has evolved an thus created a hope, a belief that no problem goes unsolved.

Ability Grouping

By: Max Brody

Ability grouping is the practice of placing students of the same academic ability in the same classes by a means of grade skipping or early admission into kindergarten or college. This method of education gives students early access to courses more fit for their accelerated or decelerated learning styles. However, many critics of the idea believe it creates more of a divide in an environment that should be united.

"Although acceleration is widely supported by research as an effective strategy for meeting the needs of advanced learners, it's still rarely used, and most schools do not systematically look for students who need it," said study co-author Paula Olszewski-Kubilius, director of the Center for Talent Development at the Northwestern's School of Education and Social Policy. While the United States spends nearly $600 billion on public education, it generally goes toward bringing the less accelerated kids up rather than helping the already accelerated kids thrive. The proponents of ability grouping argue that the teachers are able to more effectively teach a class containing similarly advanced learners than trying to balance their teaching style to a mixed class. Those who refute the educational system believe there would be a loss of character development and unique qualities within each grade level as the demographics of the accelerated children may lack diversity.

Both the supporters and those who are against ability grouping as a method of teaching in school systems have great points. As of now, school systems in the United States do not use this

system, supporting diversity, personality, and unique qualities within each grade level. In the future, however, schools may gravitate toward ability grouping, using the research and evidence that are available. Picture a world where one's schooling was based on ability and not by age: how would that make certain individuals of different abilities feel? These are the important types of questions schools must ask themselves in the future if they ever think about implementing the ability grouping system.

Team Discovers New Method to Prevent Nuclear Disasters

By: Stefan Pedicone

Nuclear power plant meltdowns are one of the scariest and most dangerous modern-day catastrophes, leaving effects that may last many years afterward. There have been many accidents throughout the years of nuclear power, some of which have led to massive amounts of radiation being released and required the evacuation of hundreds of thousand residents. Recently a team of researchers from the University of Hawaii at Manoa released a study that may have found a solution to this looming threat, which involves the cooling systems used in nuclear power plants.

Nuclear power is generated from the splitting of the uranium atom, releasing a massive amount of heat that boils water to create steam, which is then pushed through a turbine generator to generate electricity. All of this heat cannot be contained and large amounts of it are released, which is why cooling systems are so important: this heat will cause the containment units to melt and can cause explosions. Currently, this heat is released through the boiling of water, which is the cause of the steam seen rising out of the towers of a nuclear power plant. Although boiling is usually associated with heat, it is often used in industrial applications to cool extremely hot components through latent heat, or the heat absorbed to change water into vapor, which takes a large amount of heat from a hot surface.

The cooling process through boiling works well, but there is a limit to the amount of heat that can be absorbed and increasing this tolerable heat limit is the solution. Overcoming the

tolerable heat limit or critical heat flux (CHF) means that the water will be able to absorb more heat energy before boiling off, thus helping to prevent a meltdown. In 2011, when an earthquake and tsunami struck eastern Japan, the Fukushima nuclear power plant experienced a meltdown because the cooling systems were disabled and all of the water was evaporated too quickly, leaving nothing to cool the surface. This event sparked the extensive research that has gone into increasing the CHF. Currently, the most effective way is to add nanostructures to the surface that is being cooled, allowing heat to be transferred in more sites.

The team from Hawaii has found another solution: coat the hot surface using nanoscale bimorphs, which are long pieces of metal that will bend if exposed to heat because of thermal expansion. The heat from the reactor causes the bimorphs to spontaneously deform, which creates favorable conditions for boiling and thus increases the CHF. This approach was found to be ten percent more effective than previous attempts to enhance CHF, and the team expects to conduct more studies involving the geometry and material of these bimorphs to create the optimal boiling conditions.

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