

the scientific marksman

■ Volume 08 2019-2020





the scientific marksman

The Scientific Marksman scientific journal at St. Mark's School of Texas showcases notable endeavors and discoveries in the sciences, technologies, engineering and mathematics (STEM) fields both in and outside the community.

■ Photo by Meyer Zinn



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■ OPENING



T

he polymath—scholar of math, engineering, anatomy, geology, astronomy, paleontology, architecture and more.

Throughout history some of the most influential thinkers did not restrict themselves to a singular field: Aristotle, Leonardo da Vinci, Nicolaus Copernicus, Benjamin Franklin.

A few hundred years later, the same can't be said about even our greatest minds. As all areas of knowledge are getting more complex, STEM is becoming a narrower, more defined set of fields.

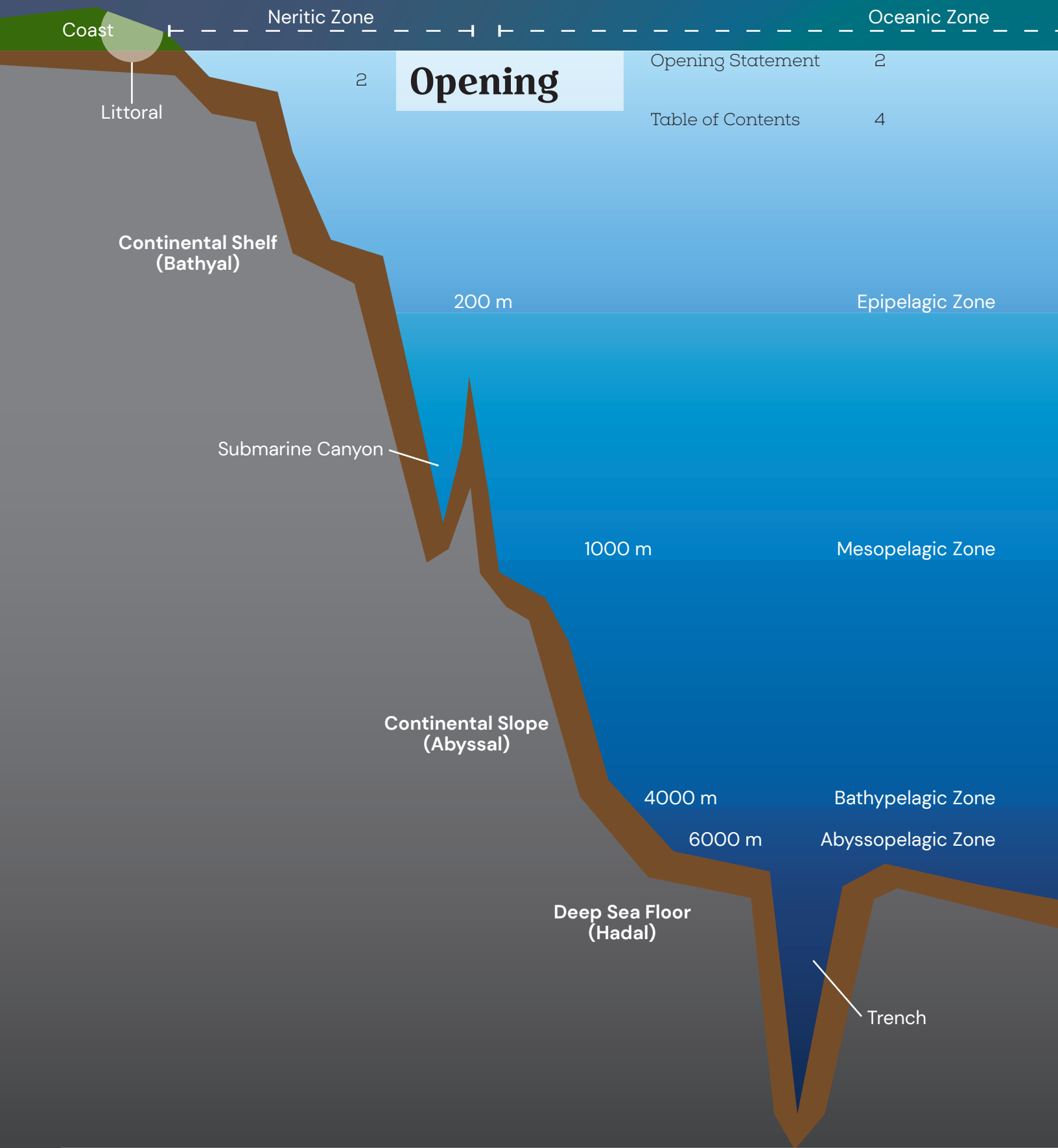
The 8th edition of the Scientific Marksman aims to give a look into the modern scientific world, no matter how interested you are in STEM. Just like the levels of the ocean—from the surface level, Euphotic, to the middle level, Dysphotic, to the deepest level, Aphotic—the articles in this issue get increasingly complex the deeper you read.

Climate change has become a defining issue for this generation. The world is in a deep, divided discussion - some people believe there is no threat to humanity while others believe global warming is the greatest threat to this planet. At the beginning of every section, we have created a special four-page story that dives into modern-day climate change, its impact and our work to fight it, to hopefully show you how and why you should be active in the discussion.

Although production was delayed by the impact of the Coronavirus, we hope you still enjoy the writing and design within the pages of this magazine. With that said, it is our great honor to present to you the 8th edition of the Scientific Marksman.



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The Euphotic section highlights recent inventions, discoveries, and events that have a big impact on our lives. From telemedicine to online banking, this section provides scientific analyses of seemingly day-to-day occurrences.

EU-PHO-TIC

of, relating to, or constituting the upper layers of a body of water into which sufficient light penetrates to permit growth of green plants

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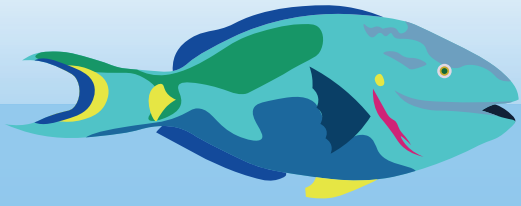
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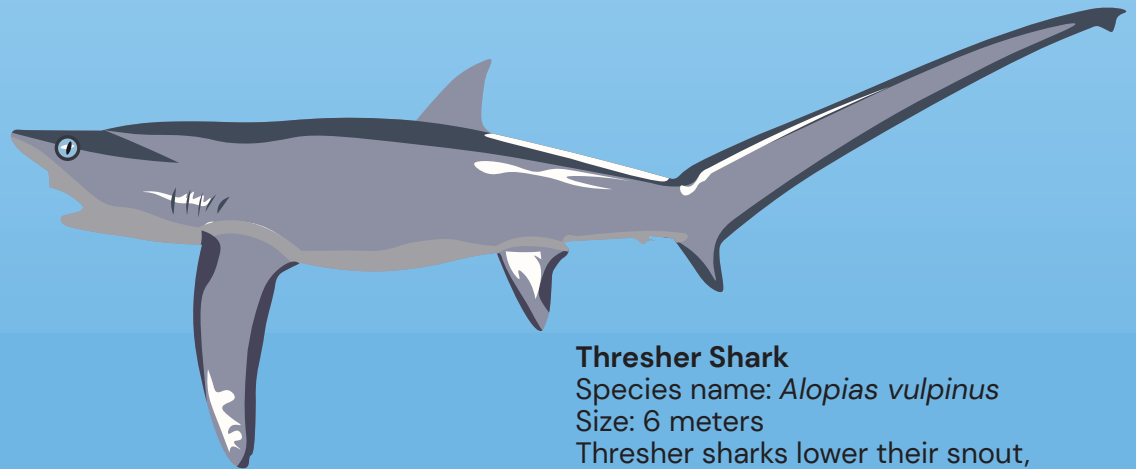


Parrotfish

Species name: *Sparisoma viride*

Size: 0.3 to 1 meter

Parrotfish envelope themselves in a transparent cocoon made of mucus secreted from their heads to protect themselves from predators, like the moray eel.



Thresher Shark

Species name: *Alopias vulpinus*

Size: 6 meters

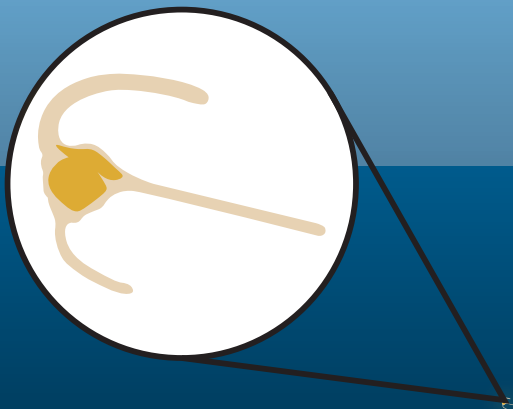
Thresher sharks lower their snout, swing their whole body forward, and flex the base of its tail to hunt fish. This slings the tail tip over its head like a trebuchet, with an average speed of 30 miles per hour.

Ceratium

Species name: *Ceratium furca*

Size: 20 to 200 micrometers

Because of rising surface temperatures of the ocean, Ceratium move to deeper layers of the water column as they are temperature sensitive. Due to this behavior, they are used as biological indicators of how dire the impact from global warming is.



Climate change. Some claim it is very much real, while others deny its existence.

Compiling coinciding evidence from various sources, we argue that it is real, and it is a severe problem that threatens the wellbeing of all humans living on Earth. Young, old, rich, poor—no one can escape the repercussions from climate change.

Not only are humans affected, but animals and plants experience the ramifications as well. Shrinking ice sheets are driving polar bears to extinction while warming oceans causes coral reefs to lose their vibrant colors.

The question now: what do we need to do in order to stop the rise of the Earth's temperature before it is too late? ►

Changing the role of climate change at our school

As the Earth's temperatures increases, students and schools must take action.

■ **Story** by Jeffrey Chen and Rishi Mohan ■ **Graphic** by Jeffrey Chen
■ **Photos** courtesy of National Park Service

Climate change is a major crisis that endangers how society can function. According to NASA, each year the Earth's surface temperature rises 1.62 degrees Fahrenheit. As a result of climate change, rising sea levels threaten coastal cities, natural disasters become more frequent and extreme, and shrinking ice caps endanger wildlife native to glacial areas. What can our school do to combat this?

The best source of climate change information on the planet is the United Nations' Intergovernmental Panel on Climate Change (IPCC). Compiling credible research that is widely-agreed upon by 97-98% of all climate researchers, the IPCC declared that human influence on the climate system is clear.

For shifts in temperature to count as climate change, the IPCC agreed that studies of weather trends must take place over long periods of time. In their 2014 Synthesis Report:

Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The period from 1983 to 2012 was likely the warmest 30-year period of the last 1400 years in the Northern Hemisphere, where such assessment is possible. The globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85°C over the period 1880 to 2012, when multiple independently produced datasets exist.

While the IPCC has confirmed that temperatures are increasing, global warming results in gradual changes over time. Because

this change is so slow, people often do not notice the weather being a bit warmer each year, Dan Northcut, Director of Environmental Studies, notes.

"Climate change happens slowly enough that people don't notice much, so they're not motivated," Northcut said. "Humans are much more motivated by sudden catastrophic things, not by, you know, a degree or two difference in temperature over a few years of time. Humans just don't notice those kinds of differences."

While extreme events have been observed since about 1950, their causation by climate change is still in a probable state. The IPCC affirmed that it was only very likely that human influence has contributed to higher occurrences of heat waves, heavy precipitation events, and heat-related human mortality in various locations.

"We've definitely had climate change events easily a dozen times, at least, during our history," Northcut said. "The biggest difference, though, and what we're seeing now is that there is a likely correlation between human activities and more and more extreme weather."

Many organisms, mainly plants and animals, are unable to handle the rapid shifts in weather. Ecosystems deteriorate under quick change because organisms must move or adapt or they die, and evolution is a slow process of adaptation that cannot accommodate the speed of global warming.

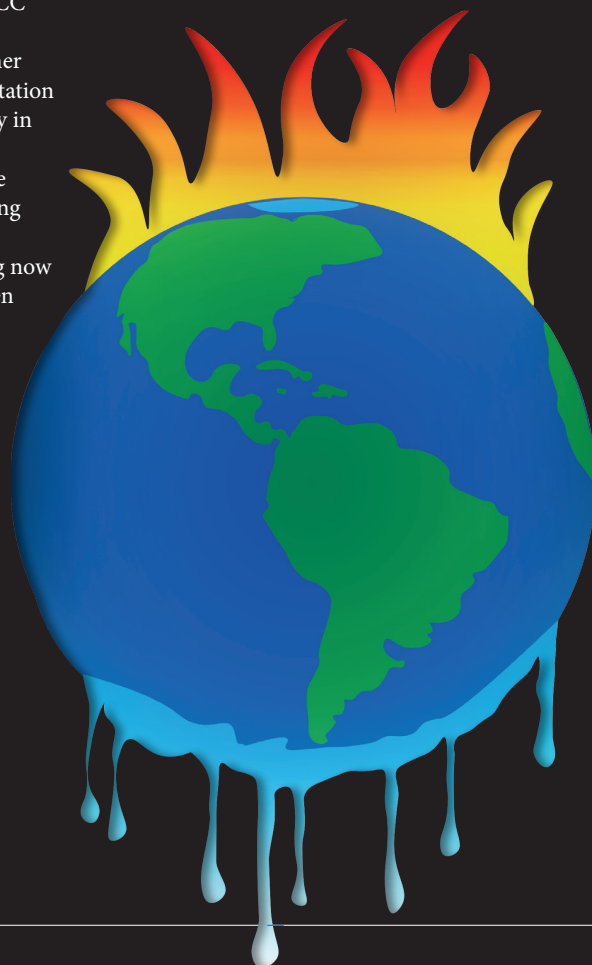
"Organisms can't deal with rapid global warming very well," Northcut said. "If you're a plant, you can't move, so you just die out. Most people don't realize that we've had climate change before, for sure, but the rate that we're doing it now is unprecedented. And that's the most dangerous: just how fast it's happening."

As a private school, our institution has dedicated a large portion of funds in the past few years to increase sustainability in buildings and practices. In 2010, a statement of environmental policy was laid out. The statement reads:

Respecting the needs of future generations, St. Mark's School of Texas will provide leadership in environmental sustainability and responsibility. The School assigns significant priority to integrating environmental awareness, understanding, and stewardship into its academic mission, campus improvements, and operations.

In accordance to this declaration, 10600 Preston Rd. has a few buildings that have been certified in Leadership in Energy and Environmental Design (LEED) requirements by the United States Green Building Council (USGBC), including Centennial Hall, Hoffman Center, the Winn Science Center and the renovated McDermott-Green Science Building.

The LEED system rewards points on a 100 point scale for buildings that achieve excellency in five distinct categories for eco-friendly and energy-saving design: water efficiency, energy and atmosphere, materials





1883



2013

- ^ Top- The ice levels on Lyell Glacier in Yosemite National Park have significantly decreased from 1883 to 2013.
- < Left- If we do nothing, our planet will be burning on one side and melting on the other.

and resources, indoor environmental quality and sustainability. To obtain the silver level, a building must have at least 50 points on the scale.

In addition to fulfilling energy concerns through architecture, our school has also switched to recycled copy paper, installed electric vehicle charging stations, held two e-waste recycling drives in the past two years and installed filtered water fountains in the Winn Science Center.

While these ambitions have certainly reduced the carbon footprint of our school, is there more we can do to help combat global warming?



DEFINE ME

While these two terms are used interchangeably throughout the climate change articles, their definitions are slightly different.

Global warming: the long-term heating of Earth's climate system observed since the pre-industrial period (between 1850 and 1900) due to human activities (NASA)

Climate change: long-term change in the average weather patterns that have come to define Earth's local, regional and global climates (NASA)

As the need for climate change education becomes more dire, St. Mark's must integrate effective and unobtrusive climate change units into science classes, particularly Earth Science.

A study done at Montview High School in Denver, Colorado, showed that a student-driven climate change unit not only educated students about climate change, but also motivated them to care about fighting it.

"My students understood the science behind climate, the evidence of why it's changing ('humans'), and reached consensus that something needs to be done" science teacher Lara Thomas said. "But this is where their learning stopped—in their eyes, climate change was systemic, inconvenient, someone else's problem."

Thomas implemented the Climate and Resiliency professional development project in her classroom. ►

► “I was very impressed with the level of audience engagement,” Thomas said. “Feedback from classmates reinforces the fact that the student teams need to ground their ideas in scientific reasoning backed up with evidence.”

With her strategy, Thomas’ students developed communication and research skills while learning that sustainability could reflect in reducing costs for the school as well.

“I learned that changing even small things makes a big impact,” a student said, “Change takes time and energy, and it’s important to be realistic.”

Our school already has stellar teachers and excellent curriculums that make it stand out among private and public institutions alike. While climate change is a significant element of the Earth Science classes, which all students must take, it may become necessary to include active participation in the fight against the disaster, as other schools have done.

What else can we, as students, teachers, and staff members of a high school, do?

One way people can help is by reducing their carbon footprint. A product’s carbon footprint is the amount of carbon dioxide produced

▼ Below- Our school has an electric vehicle charging station, which increases accessibility for students driving electric cars.

➤ Right- The glaciers of Kenai Fjords National Park in South Alaska are in jeopardy as temperatures rise about 1.62 degrees Fahrenheit each year.



to make it, usually produced by factory fuel costs.

“The best thing consumers can do is to watch how much they buy and what they buy,” Northcut said. “If shoppers watch what they buy then they can decide to buy products with a lower carbon footprint.”

Another way people can also reduce emissions is by eating more vegetables instead of meat. Raising livestock takes more resources to grow than plants.

“Anything that is meat-oriented has a bigger carbon footprint,” Northcut said. “Environmentally, meat takes a lot more energy and resources to grow.”

Livestock consume lots of food, land, and other resources as they grow and mature. About one third of agricultural land in the US is used to grow crops for cattle and other farmed animals according to a study by the United States Department of Agriculture (USDA).

“Instead of growing all those crops to feed the cattle, we could save a lot of resources by using that land to grow crops for humans to eat,” Northcut said. “That would be more sustainable in the long run.”

Bottled water also leaves a big carbon footprint. Drinking tap water is much more environmentally friendly.

“You can use a water filter, instead of buying bottled water that is from places far away,” Northcut said. “Bottled water leaves a huge carbon footprint, you know, for some thing you can get out of the tap.”

Instead of thinking that, as an individual, we are too small to help, everyone should work

together as a team to combat global warming.

“A lot of people throw up their hands and say I’m too small to change this, and that’s true for any single person by themselves,” Northcut said. “But if we all work at it together, then it can be done. We’ve faced major problems before as a country and as the world.”

Northcut believes that it is humanity’s responsibility to slow down climate change because we caused it. We have to create a healthy environment for the next generation of people to live in.

“We gotta keep trying,” Northcut said. “I mean, a lot of times it’s easy to get bogged down and feel helpless. But we all want to have a decent world for our offspring. We owe it to all the other life on earth to keep trying, because we made this happen. And it’s our responsibility to stop it.” ■

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Director of
Environmental
Studies Dan
Northcut

If we all work at it together, then it can be done. We’ve faced major problems before as a country and as the world.”

Electric vehicles: combatting global warming with tech

As the electric car industry expands, models predict emissions to drop significantly. Is there hope in the future?

■ **Story** by Jeffrey Chen ■ **Graph data** courtesy of Carbon Brief and the Electric Power Research Institute

Electric vehicles (EVs) are the future of transportation. More and more car manufacturers are investing into the new technology. They can run on renewable energy, which is better for the environment and reduces air pollution.

EVs do not produce harmful carbon emissions. In addition, electricity is cheaper compared to gasoline.

“Electricity right now is relatively inexpensive,” said Stephen Balog, Cecil H. and Ida Green Master Teaching Chair.

The battery packs in electric cars are very similar to the batteries in other electronic devices.

“It’s basically that lithium-style battery like in phones and iPods,” said Balog. “However, it’s much larger. It has to be larger because it must generate a lot more power. This is also why it takes a while for them to recharge. These newer batteries are like the new batteries we have in our phones, they can take lots and lots of recharges before you have any issue with what’s known as degradation.”

However, EVs have some drawbacks when compared to standard gas powered cars.

“From what I’ve been reading about them is that electric cars don’t have the same acceleration compared to a standard car,” Balog said. “So when a light turns green a gas car will take off faster than an electric car.”

Another drawback is that electric cars have limited range and take longer to recharge.

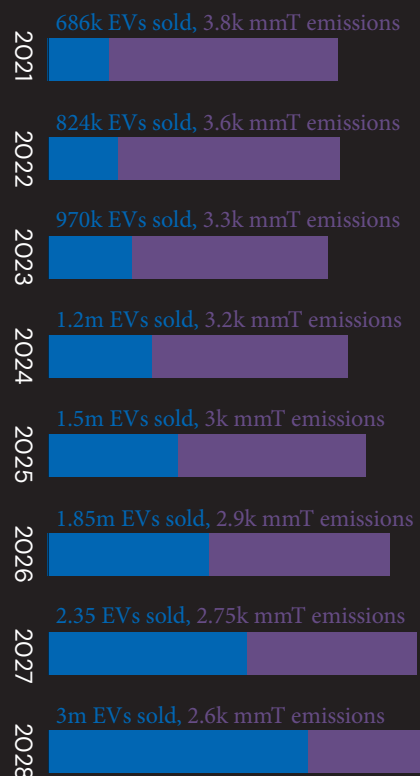
“Typically a car or truck or anything will go about 300 to 400 miles on a tank of gas,” Balog said. “To recharge your gas car you just stop for ten to fifteen more minutes to put more gas in the car and then you’re ready to go. In an electric car you may only go two or three hundred miles and then you have to stop for hours to recharge the batteries before you can go again.”

On the St. Mark’s campus there are two electric charging stations by Hicks Gym that students and faculty can use to replenish the batteries of their electric vehicles.

“Mrs. Barta, who used to be the department chair here, had an electric car for several years,” said Balog. “In fact, that’s why we have a charging station out there by Hicks, it was because she got it put in for her car.” ■

Carbon Impact

Models show that the popularity of EVs may be able to drop metric tons (mmT) of carbon emissions from transportation by 24% by 2030.



TaaS

Transportation as a service

Column by James Shiao

Transportation, or transport, as a service (TaaS) is a term used to describe the combination of electric vehicles and autonomous driving. Tony Seba, an entrepreneurship and clean energy professor in Stanford, believes it will dominate the future of mobility.

“Transport as a service is autonomous electric and on demand transportation owned by fleets, not individuals,” Seba said. “The day that it’s approved, the cost per mile of TaaS will be ten times cheaper than the cost of owning a car.”

Many companies such as Uber, Waymo, and Tesla are already creating technology to facilitate TaaS. Since 2017, Waymo has deployed over 600 vehicles in Phoenix, Arizona, to test the service.

“One year ago, Waymo became the first and only company in the world to launch a public self-driving ride-hailing service,” Dan Chu, Chief Product Officer at Waymo, said. “We’ve accomplished a lot this past year, but we’re never finished learning.”

Seba predicts that by 2030, 95% of miles traveled will be using TaaS rather than using owned vehicles. According to his models, there will be a 90% decrease in greenhouse gases from transportation in the U.S., and an 80% decrease in energy consumption.

Not only that, but worldwide, more than a million people die in car crashes each year. Because 95% of accidents are caused by human error, these figures could plummet by at least 80% with TaaS.

“At the end of the day, TaaS might be the biggest medical innovation in decades, even though it has nothing to do with pills or new equipment,” financial researcher Whitney Tilson said.

Why are entrepreneurs and financial researchers praising TaaS so highly, when it seems unknown to most people in the scientific world?

Despite most knowing about self-driving cars, the impact of combining autonomy and electricity powered vehicles has potential to be society-changing.

The question now isn’t if TaaS will be released, but rather: when it inevitably is released, how will we as a society react, and how will it change our lifestyle? ■

When facial detection goes racial

Facial detection seems to be an integral part of phone security and privacy protection, but is it really safe?

■ **Story** by Aditya Goel, Andrew Kogan ■ **Photos** by Apple, Matilda Wormwood, DGT Portraits, Ekaterina Bolovtsova

What if someone else could unlock your phone just by looking at it? They would be able to access all of your data and records. They would be able to go through your search history and see your entire photo album. They would be able to make financial transactions from your phone.

In general, the data stored on our phones is pretty secure. However, with the relatively new technology of facial recognition being incorporated in more and more phones, there is a chance that people with similar faces could unlock each other's devices.

Senior Rohit Vemuri recently experienced how computers can mistake the faces of closely related siblings. Over the summer, he used his face to unlock his brother's iPhone XR. Rohit's brother is Niteesh Vemuri, a St. Mark's alumnus who graduated in 2018, who is currently a sophomore at the University of Pennsylvania.

Rohit encountered no difficulty when he tried to open his brother's phone. In fact, he was able to do it on his first try.

"I just looked at it and it opened up," Vemuri said. "It worked very smoothly and unlocked itself as if I were Niteesh. The first time this happened was in August of last summer, right after the Morocco photography trip."

Apple still has not fixed the problem. When Niteesh stopped by his family's home the weekend before Halloween, Rohit was easily able to unlock his brother's phone.

"It worked last week too when my brother came back to visit from college," Vemuri said. "This time his phone was fully updated with the latest software update, iOS 13. I was still able to unlock it."

However, Niteesh is unable to open Rohit's phone.

"I think it is very strange that I am able to unlock his phone, but he is not able to unlock my phone," Vemuri said. "Our phones are both the same model, they are iPhone XRs. My whole family thinks that this is very amusing."

The two brothers do not share that much of a resemblance to each other. There are many characteristics on the sibling's faces that set their faces apart.

"We are both Indians and that's about it,"



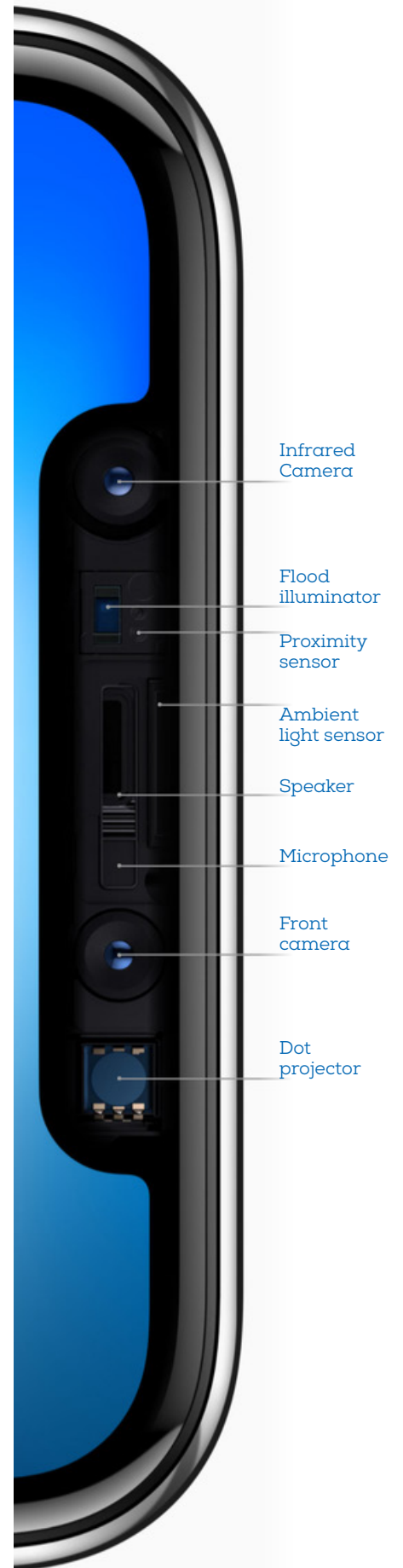
Computer Science Instructor Kurt Tholking

Any facial recognition software has the ability to make mistakes or the potential to be 'racist'."

Vemuri said. "We don't look that much alike. My brother's nose is much bigger than mine and he has bigger eyes than me. I also have a mole under my chin. He has glasses and I don't. His hair is more sparse than mine. My hair is thicker, almost like a forest."

According to Apple, the facial recognition technology on their phones works by scanning the shape of a person's face with infrared light. The camera tracks thirty thousand dots on a person's face and connects them to distinguish between faces.

"If Apple tracked more points on a person's face, I believe their face ID technology would be more accurate and make fewer mistakes," Vemuri said. "But in order to do that, they



would need to develop their technology more.”

Apple claims that the probability of a random person unlocking your phone is one in a million, but the company declares that the likelihood is higher for siblings and twins.

“The artificial intelligence on the phones is really not that great,” Vemuri said. “They advertise it like it is a one in a million chance that someone else could open your phone, but it can happen. I know that siblings are more likely to unlock each other’s phones, but my face is not that similar to Niteesh’s.”

Rohit admits that face ID has made using his phone much more convenient, but he does not think that it is worth the sacrifice for less security.

“Efficiency shouldn’t come at the price of privacy. I don’t care that much about phone privacy, but it just makes me uncomfortable that I am able to unlock my brother’s phone.”

Computer science teacher Kurt Tholking thinks that people should learn how face ID works and the benefits and drawbacks of the technology. This would allow consumers to make an educated choice when deciding on purchases or settings.

“I think people are willing to sacrifice many things for the sake of speed, especially if they are uninformed or do not know a lot about how the system works or the dangers of using it,” Tholking said.

Rohit thinks that iPhones should use touch ID instead of face ID. The iPhone 5S to the iPhone 8 used touch ID. However, starting with the iPhone X onwards, Apple switched over to installing face ID technology on their phones. Touch ID is just as convenient as face ID, but it is more secure. No two people in the world have the same fingerprint.

“Face ID is more efficient, however, I like touch ID more,” Vemuri said. “A computer can’t screw up a thumbprint. Believe it or not everyone’s thumbprint is different, even if you are twins. Thumbprint technology has been around for a while, so it is a far more proven method of unlocking phones. It is safer and just as efficient.”

Rohit observes that the quality of Apple products has been declining over the years. They have many problems, such as how he can unlock his brother’s phone. These errors upset Rohit, who is a fan of the Apple brand.

“I am an Apple dude, all of my tech products are made by Apple,” Vemur said. “I have an iPhone, iPad, and Macbook. But I have noticed that Apple is starting to have a lot of problems with their products. There are a lot of issues and they are making me unhappy. I think they should improve their products for better customer satisfaction.”

Rohit believes that Apple’s products are not as innovative as they were in the past. They do not have too many new exciting features and



the products have gotten a lot more expensive than it used to be.

“Apple’s product quality is declining,” Vemuri said. “I just don’t think they are innovating and making new products. They are charging too much for their products, and not releasing enough new stuff. I do not think many of the new products are worth the price. I would not recommend people to buy their products at the moment.”

Tholking says that hardware and software on iPhones limit the capabilities and precision of face ID.

“Any facial recognition software has the ability to make mistakes or the potential to be ‘racist,’” Tholking said. “A facial recognition system is only as good as the hardware such as cameras, and software, such as algorithms and AI backbone, it employs.”

Tholking thinks that if Apple uses a bigger database of faces and improves their algorithm, the facial recognition technology on the company’s phones could be improved.

“The algorithms need to be developed so there is no bias, and the AI needs to use a larger database of faces,” Tholking said. ■

< Left- Diagram of the top of an iPhone, where the front facing camera and numerous lights help the facial recognition software work.

^ Above- Despite the effort put into facial recognition, it’s still frustrating to many people when it refuses to cooperate.



SHOW ME

The National Institute of Standards and Technology conducted a study:

1. False matching For one-to-one matching, most systems had a higher rate of false positive matches for Asian and African-American faces over Caucasian faces, sometimes by a factor of 10 or even 100. In other words, they were more likely to find a match when there wasn’t one. (MIT)

2. Consistency One-to-many matching systems had the worst false positive rates for African-American women, which puts this population at the highest risk for being falsely accused of a crime. (MIT)

Dangers of playing violent video games?

Violent video games can have an effect on the human brain, but whether that effect is harmful or not is debatable.

■ **Story** by Paul Sullivan and Metehan Punar ■ **Photo** from Wikimedia
■ **Survey** by Jeremy Yu and James Shiao

GTA V. Call of Duty. Battlefield. These videogames share one thing in common: Violence. But what draws us to videogames such as these?

Is it the provocative and controversial behavior of the characters in the games that sucks us in?

Is it the fact that the player is experiencing something that they've never done before?

Is it the adrenaline rush from plowing through hordes of zombies?

One thing is certain: violent video games are popular. Call of Duty Black Ops 4 has sold over 14 million copies since it came out in 2018, and sales for all Call of Duty games made ever have topped 15 billion.

However, for all the popularity and interest behind these violent games, there is one question that has struck a generational controversy.

Do violent video games cause violent behavior in real life?

Although not many people talk about whether R or PG-13 rated movies with violence affect people, it's different with video games. The active role gamers have in partaking in violence is indeed different from passively watching John Wick take out a hundred henchmen. Whether it's playing a combat veteran in Iraq shooting insurgents, or wielding a magical staff to freeze demons, it begs the question of whether actively causing violence in a game can translate to aggression in everyday life.

In addition to that, many young kids today are playing violent video games that are designed to be played by people eighteen and older. Many kids overlook the ratings given by the Entertainment Software Rating Board (ESRB) in favor of games that are more

popular. Considerable research is being made to determine the effect of the blood and gore from violent video games on younger adolescents.

Psychologists are still struggling to figure out a cohesive answer, and that may be due to the fact that this is a relatively new topic. Psychologists are still studying the complexities of the human brain.

"Violent video games are significantly associated with: increased aggressive behavior, thoughts, and affect; increased physiological arousal; and decreased prosocial [helping]



Director of Counseling
Barbara Van Drie

We know that if you engage in aggressive behavior, it makes you even more aggressive."

behavior," according to the American Psychological Association (APA) in 2013.

While this was said in 2013, in March 2020, their position was actually updated to deny any causality.

"Violence is a complex social problem that likely stems from many factors that warrant attention from researchers, policymakers and the public," APA President Sandra L. Shullman said.

The APA believes that there is a small association between violent video game use and aggressive outcomes, such as yelling and pushing, but these research findings are difficult to extend to more violent outcomes.

"Attributing violence to video gaming is not scientifically sound and draws attention away from other factors, such as a history of violence, which we know from the research is a major predictor of future violence," Shullman said.

The APA continues to study the effects of video games and other media on children while encouraging respective industries to design interactive media with violence in moderation.

A closer look onto the community

at 10600 Preston Road provides opinions from students who play video games on why many of today's teens enjoy playing violent video games and whether or not they believe that these video games initiate aggressive, or even violent, behavior.

Junior Rahul Banerjee believes many students turn to violent video games to relieve stress accrued throughout the week. Stress is an increasingly significant presence, not only among Upper Schoolers, but also among many high schoolers across the world.

"I think violent games could impact people if those games are played way too much, but honestly if they are played in moderation then it's fine," Banerjee said. "I play games like FIFA, SURVIV.IO and Mario Kart on the phone. But people who play violent video games probably play for stress relief.

Junior Anish Karthik, on the other hand, doesn't play video games solely for stress relief, but also as a hobby.

"I play first person shooters (FPS), multiplayer online battle arenas (MOBA), online card games, and real time strategy games(RTS), like Overwatch, CSGO, League of Legends, Hearthstone, and Starcraft 2," Karthik said.

Karthik believes, however, that out of all the video games he plays, first person shooters definitely have the most violence.

"The reason I play those is because it adds a sense of urgency and an element of excitement to the game," Karthik said. "Violent games place greater stress on a gamer's ability to stay alive and skillfully deal damage and things like that. I play violent games like FPS for fun because it gives a sense of excitement and rapid action which may not be available by other means of the day.

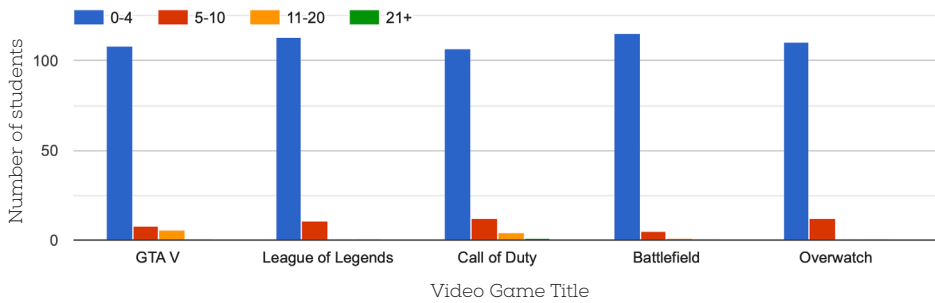
The other games Karthik plays, such as MOBAs and RTSs, have a type of violence that provides a different experience from a FPS.

"Other games with violence, but on a smaller scale like in Starcraft, provide a calmer experience although they have fighting," Karthik said. "Because it's a strategy game, the focus is not on violence but rather the moves and steps to play to secure victory."

Although Karthik believes violent video games can be stimulating, they don't make him aggressive.

"Violent games definitely impact me, but not in the negative conventional way of looking at it," Karthik says. "I don't get urges

Do you play any of these games? If so, for how many hours per week on average?



for violence because of the game. Through the games I get a fun activity I can participate with a bunch of friends to stimulate my mind. In my experience, I don't believe people would bring violence from a game into the real world. Maybe there is some physiological factor that affects gamer brains but I don't know."

Overall, Karthik doesn't believe that violent video games spread violent behavior.

"For the most part I think that the feelings of frustration that somebody experiences in a game is similar to any frustration that might occur in other aspects of their lives, like sports or something," Karthik says. "But I don't think violent video games promote violent behavior."

Director of Counseling Barbara

Van Drie believes that first person shooters aren't dangerous by themselves, but they can desensitize people to violence.

"I think they can desensitize you to shooting and improve your shooting skills," Ms. VanDrie says. "Does that mean that if you play first person shooter video games that then you will turn around and be violent? No. But does it mean that if you want to perpetrate violence, and you play first person shooter games, will you be more desensitized to doing it? Yes."

- < Left- Data showing the responses from the St. Mark's community on what video games they play and how many hours they spend per week playing that game.
- ✓ Bottom- A group of gamers playing in a tournament for Battlefield 1.

However, Van Drie says that one of the hardest things for psychologists to do is predict who will and who will not perpetrate violence.

"We know that if you engage in aggressive behavior, it makes you even more aggressive," Van Drie says. "If you take someone who's in a highly conflicted home, where people are being aggressive, or in a home where people are committing criminal acts, is it a good idea to play first person shooter games? Probably not. If you're in a loving home where people aren't committing aggressive or criminal acts, and the kid is healthy, is it harmful? Probably not. So it depends. You can't make a global all-encompassing statement." ■



From risky venture to necessity, Teladoc's universal impact

Medical tools are improving healthcare, and the newest medical tool is changing doctor–patient interaction for the better.

■ **Story** by Sahitya Senapathy ■ **Photo** by Bongkarn Tthanyakij

Feeling a little sick? You might drive over to the nearest hospital and wait a couple of hours until your doctor's ready to see you. By the time you get a prescription, your ailment may have worsened, possibly significantly.

But what if you could open your laptop and immediately interface with a personal pediatrician? If this sounds like something out of a science fiction novel, you'd be surprised to hear about Teladoc.

Teladoc is a telemedicine enterprise enabling users to receive on-demand medical care through videoconferencing, whether by phone or laptop. All you need is an internet connection and a device, and you're good to go.

The process is so simple that the company outlines only three steps needed to use the service: set up your account, connect with specialists, and get reviewed.

In fact, our school even provides Teladoc as a benefit to its employees.

Teladoc's services are relatively inexpensive, especially compared to competitors like hospital and specialized care. Everyday care costs around fifty dollars and interacting with medical experts is free. Whether you wake up with a fever at 2 AM or receive a serious diagnosis, Teladoc experts—like doctors, therapists, and medical specialists—can provide advice.

Everyday care, children's wellness, mental health, and medical expertise... the service can be helpful for all of these.

"No matter what you're facing, we're available from wherever you are by phone, video, or app," the company's website says.

Teladoc seeks to make healthcare accessible, and especially with waiting times



Co-founder of Teladoc
Michael Gorton

I was interested in finding things that I thought would transform industries or create a new industry."



DEFINE ME

You may have heard the terms telemedicine and telehealth being thrown around. What exactly is the difference?

Telemedicine: Telemedicine is the practice of medicine using technology to deliver care at a distance. A physician in one location uses a telecommunications infrastructure to deliver care to a patient at a distant site. (AAFP)

Telehealth: Telehealth refers broadly to electronic and telecommunications technologies and services used to provide care and services at-a-distance. (AAFP)

Telemedicine refers specifically to remote clinical services, while telehealth can refer to remote non-clinical services.

that can stretch up to weeks for individuals across the country, the service may serve useful.

Teladoc is the oldest and largest

company of its kind in the United States. The telemedicine enterprise was launched in 2002 by Dr. Byron Brooks, an engineer and physician for NASA and the Naval Labs, and Michael Gorton, an early and growth stage entrepreneur. And in less than five years, business was booming, and Teladoc was serving almost a million users.

The Scientific Marksman sat down in an exclusive interview with former CEO Michael Gorton, who detailed his earliest experiences with the telemedicine company. A serial entrepreneur, Teladoc was Gorton's eighth company.

Speaking about the inspiration behind Teladoc, Gorton said, "I was interested in finding things that I thought would transform industries or create a new industry."

Teladoc was born from a hiking trip Gorton made with Dr. Brooks on Mount Kilimanjaro, and the idea evolved from the healthcare sector's need for "simplicity—a telephone call, a medical record, a doctor, and a patient."

"Treating minor issues is more about listening to the patient and that is ultimately what created this industry—it's doctors who know how to look at a medical record, ask the right questions, and listen," he said.

But the journey to founding Teladoc was not entirely smooth—in fact, Teladoc faced immense opposition from established firms and organizations initially.

"The Board of Medical Examiners said 'Mr. Gorton, if you build this company, you will go to prison,'" Gorton said. "That was their reaction."

Gorton says that this resistance to telemedicine innovation in the early 2000's is what stifled the industry in earlier years. Gorton, however, does acknowledge concerns that Teladoc is not a panacea for patients.

"Medical examiners didn't want a new era of where doctors didn't touch their patients," he said. "There's things that you need to go into the doctor's [office] for—things that you can't solve telephonically."

However, Teladoc ultimately overcame these challenges by helping experts understand how the service would improve telemedicine and medicine. Gorton attested that organizations that came in as potential adversaries left as his friends.

Nina Dekka, a Senior Research Analyst at the research company ROBO Global, said in an interview that telemedicine is an effective solution to recent problems.



“Lack of access to healthcare and rapidly growing healthcare costs are two critical issues impacting the US economy, and they remain consistent topics of debate among policy makers,” she said. “Telemedicine, a service that connects a patient to a doctor remotely, has seen rapid growth in the last few years because it addresses both of these issues.”

Moreover, Deka asserted that Teladoc is trailblazing the industry, consistently forwarding innovations that better the healthcare status quo “both domestically and internationally.”

Examples of technologies developed by Teladoc including advanced analytics systems and a sophisticated and scalable platform for users.

And Teladoc has begun expanding the scope of its services: “it offers specialties such as behavioral health and dermatology. It also offers second opinion services for those who want to speak to another provider about a serious condition before undergoing surgery.”

Deka believes there is no doubt that the company can expand over the next five years.

Teladoc holds tremendous implications for the world of medicine. As the company continues to grow, and more competitors join the field of telemedicine, patients may see faster and more effective treatment. The prospect of staying at home and receiving on-demand advice is appealing, and with Teladoc leading the field, telemedicine is a sector to pay attention to. ■

Telemedicine in the COVID-19 Pandemic

■ Interview by James Shiao

We talked to nephrologist Jun Chen, a doctor who specializes in kidneys, working on the frontline of the pandemic to get her views on telemedicine.

James Shiao: What is the role of telemedicine in your field?

Dr. Jun Chen: When patients call in, they have some symptoms or abnormal labs, so we analyze the symptoms and the lab data. Then, we will make the diagnosis. Depending on the condition, we may prescribe them antibiotics, or if I see they see their kidney function get worse, I can order more lab works, order some imaging or refer them to a different specialty for consultation. Basically, the whole process is the same as you seeing the patient in person, except for you can't examine them. Down the road, when the COVID-19 pandemic improves, we will resume some of our original regular practice, but I don't think telemedicine will be stopped.

JS: How will telemedicine change how people receive health care?

JC: Telemedicine offers easy access for

^ Above- Doctors are able to provide prescriptions with patients remotely, which can help prevent disease spread.

patients, so patients can stay at home and remotely talk to providers. This is cost-effective, especially for patients that have difficulty moving around. Also, patients can be more relaxed at home—it decreases their stress level. And because they have easier access, patients get earlier diagnosis and treatments. That will decrease their hospital and ER visits, and will subsequently result in a decrease in mortality. This is especially important in rural areas as well, where patients have limited access to healthcare.

What are the limitations of telemedicine?

JC: Obviously, we cannot examine patients. But as technology improves, you may not need to directly contact a patient to examine them. There's a stethoscope that you can put to the phone screen and it actually listens to patient's heart! And the other limitation is the reimbursement from the insurance. This is a discussion in the future for insurance companies, and how they cover for telemedicine. Despite the downsides, this pandemic actually provides a good opportunity to show that telemedicine is integral to future medicine administration. ■

Examining the facts of coronavirus

With the outbreak of Coronavirus at the start of 2020 interrupting lives globally, taking a closer look at past research may be helpful.

■ **Story** by James Shiao

■ **Photo** by Alissa Eckert and Dan Higgins

As of this article's writing, the novel coronavirus, known officially as SARS-CoV-2, has infected and taken the lives of an unprecedented number of people worldwide. Since there are new news articles appearing seemingly every day, it seems unnecessary to include yet another story here.

However, we at the Scientific Marksman believe that accessibility to scientific facts is essential, especially in a time period when it is easy to misunderstand announcements and headlines. It is also vital to collect knowledge confirmed by credible sources to answer pressing questions plaguing our minds.

This article serves not as coverage of the effects of COVID-19, but instead a reference of past discoveries related to the virus, presented in a form that may be readily understandable to anyone who has taken a basic biology class.

**To clarify: the COVID-19 disease is caused by the SARS-CoV-2 virus. We will use the two terms interchangeably because getting the virus causes one to get the disease, but they are not technically the same thing.*

General Information

The term Coronavirus was first coined in the November 1968 issue of *Nature* by a group of virologists (Almeida). The specific name, coronavirus, was used because the strain appeared to be surrounded by a ring, similar to the sun's corona, when viewed under an electron microscope. This ring was later confirmed to be various spikes, generally club-shaped, that help the virus attach to host cells and fuse with that cell's membrane (de Groot).

While knowledge of certain coronaviruses was apparent since the 1960s, most experiments conducted where volunteers were infected with known strains of coronaviruses resulted in the volunteers experiencing the same symptoms as common colds (Kendall, Hamre).

Most strains of coronavirus appear to affect animals. Birds and bats, which are warm blooded flying vertebrates, are ideal hosts for the coronavirus (Woo). The human-infecting species of coronavirus were most likely transmitted through other animals, such as camels and pigs, as the coronavirus evolved. It is thought that the recent SARS-CoV (the cause of a 2003 epidemic) evolved from bats to infect mammals called civets, which later was able to infect humans (Song).

The scientific name for the coronavirus family is Orthocoronavirinae or Coronavirinae, which can be further split into four genera. In a study in the American Society of Microbiology's *Journal of Virology*:

Coronaviruses are positive-sense RNA viruses and are currently classified into four genera: Alphacoronavirus, Betacoronavirus, Gammacoronavirus, and Deltacoronavirus. Alphacoronaviruses and betacoronaviruses are found exclusively in mammals, whereas gammacoronaviruses and deltacoronaviruses primarily infect birds. (Joel)

Out of alpha- and betacoronaviruses, four usually produce symptoms similar to the common cold while three, specifically betacoronaviruses, produce severe respiratory symptoms similar to bronchitis. These three are:

1. SARS-CoV, which caused an outbreak in China in 2003
2. MERS-CoV, which caused an outbreak in the Middle East in 2012
3. and SARS-CoV-2, which caused the global outbreak starting in 2019

2003 SARS Virus

In 2002-2003, severe acute respiratory syndrome, abbreviated as SARS at the time, emerged with over 8000 infected cases and a mortality rate of almost 10% (Li).

The virus could cause upper respiratory, gastrointestinal, and central nervous system diseases, including pneumonia. Patients usually first experienced a high fever with temperatures greater than 100.4°F (38.0°C). Other symptoms would develop, including headache, an overall feeling of discomfort, and body aches. About 10-20 percent of patients have diarrhea. After two to seven days, SARS patients may develop a dry cough (CDC).

The proteins that the virus uses to replicate were found to be similar to those of HIV, influenza, and Ebola, meaning that the contagiousness of the virus is extremely high (Li). The virus was spread from human to human through close contact.

According to the CDC's case summary in 2003, close contact means "having cared for or lived with someone with SARS or having direct contact with respiratory secretions or body fluids of a patient with SARS".

Early in this pandemic, a combination of ribavirin, a respiratory drug primarily used to treat Hepatitis C, and corticosteroids, a drug that mimics the hormone cortisol, was used in Hong Kong and Canada, but was not effective (Tai). A treatment known as pulse methylprednisolone was reported to be effective for critical patients who needed ventilators and increased oxygen intake, but the results were not confirmed because of insufficient trials.

Various cases of cross-species events sporadically occurred in 2003 and 2004. Each case was determined to be caused by civet coronavirus. Despite several difference in the civet variety of coronavirus in the gene structure, mutations made it possible to be passed to humans, although rare.

2012 MERS Virus

Middle East respiratory syndrome (MERS), also known as camel flu, was first discovered in the Arabian Peninsula in 2012, and outbreaks occurred in South Korea in 2015 and Saudi Arabia in 2018.

As of January 2020, over 2500 cases of MERS and 866 deaths have been reported globally. This means the death rate is much higher than SARS-CoV, at around 34.3%.

The symptoms of MERS are largely similar to those of SARS; most commonly, patients exhibit fever, respiratory infection or pneumonia. According to lab results, MERS cases also have a reportedly low white blood cell count.

Many of the MERS cases discovered were infected by camels, and no human to human transmissions have been undoubtedly documented. A study in 2013 suggests that dromedary camels are a major reservoir host

and the animal source for MERS (Hemida).

While it is still unclear on how the virus transmits from camels to humans, one study found that a man who applied topical medicine to the noses of multiple sick camels. The same strains of MERS were discovered on the man and the camels, which may be evidence that camel noses carry a variant of MERS.

Through the 2010s, even though there was little information on the virus, the World Health Organization (WHO) advised people to avoid contact with camels, only eat fully cooked camel meat, and only drink pasteurized camel milk.

As of 2020, there is no specific vaccine to prevent the virus or an effective treatment for it. Extracorporeal membrane oxygenation (ECMO), where blood is drawn from the body and circulated after being oxygenated, seems to be the only way to improve outcomes of MERS cases. All other methods remain inconclusive.

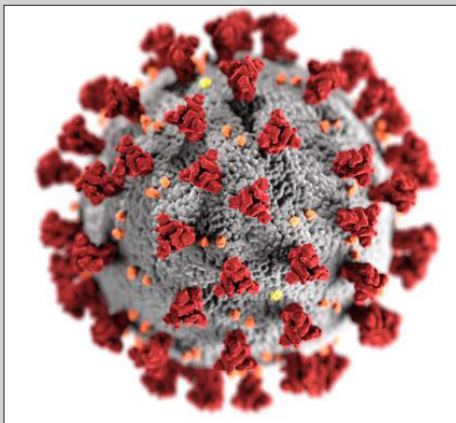
COVID-19 Pandemic

SARS-CoV-2, which is the official name of the virus, originated from Wuhan, China in December 2019. It is a similar severe respiratory disease to SARS-CoV, but the source of the virus remains unclear.

One facet that differentiates COVID-19 from SARS is the receptor binding domain (RBD) of the spike protein—that is to say, the method by which the virus attaches itself to human host cells, usually in the lungs, is different (Yuen). The COVID-19 virus appears to be able to infect more efficiently due to its RBD, which may allow asymptomatic carriers to transmit the virus easier.

A study that looked at postmortem patients that died from COVID-19 showed that alveolar damage was the leading cause of death in patients with or without invasive ventilation (Schaller).

Another study found that the lung infections caused by COVID-19 were more deadly than influenza, with microscopic clumps of blood cells forming in capillaries, blocking



DEFINE ME

Coronaviruses are typical viruses. Here are some general definitions and information related to viruses.

Virus: as opposed to a bacteria, which is a living organism that must survive and reproduce, viruses' sole function is to infect host cells with its genetic material. Viral infections spread easier than bacterial ones

Strain: a genetic variant or subtype of a virus, differentiated by a few mutations

Genome: genetic set of chromosomes in a virus, including DNA and RNA

Capsid: the protein shell of a virus, consisting of several subunits made of protein called protomers

off oxygen transportation (Ackermann).

The symptoms of this virus start out similar to SARS and MERS, but are more deadly. No effective treatments have been discovered, but many trials with drugs like hydroxychloroquine, which is typically used to treat malaria, have shown signs of hope.

However, one study found an antibody that can neutralize SARS-CoV-2. While further testing is required, the antibody may be able to alter the course of infection in a host (Wang).

Conclusion

With over 1 million cases worldwide, COVID-19 has become an unprecedented pandemic that has the potential to change normal life forever.

Due to the complex nature of viruses, treatments and the scientific side of the story, there is not much normal people can do to help development of an effective treatment.

According to the WHO, the best thing we can do is maintain social distancing of six feet in public spaces, wash our hands frequently, avoid touching our faces and public objects, and wear a mask in places of high risk.

There is still hope that a treatment will be created soon, but until then it is important to stay informed and keep yourself and those around you protected. ■

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< Left- This illustration of the COVID-19 virus is not completely accurate, but rather a tangible representation to help the public visualize the complex virus. It reveals membrane proteins (orange) which are structural, envelope proteins (yellow) which regulate replication, and spike proteins (red) which latch onto and allow entry into host cells.

Exploring the new MakerSpace

The MakerSpace gives the community new opportunities for their projects.

■ **Story** by Varun Trivedi, Morgan Chow ■ **Photos** by Michael Gao
■ **Extended Reporting** by Rishabh Siddamshetty

The Winn Science Center, which finished construction in December 2018, is the newest addition to the campus' educational buildings. With 50,000 new square feet filled with an 80-seat theater-style planetarium, a 230-seat lecture hall and rooms full of modernized labs and technology, the building is full of new and marvelous equipment.

Included is the MakerSpace and Shop, a space where students can experiment with computer programming, machining and even artistic pursuits. First-time teacher and MakerSpace director Stewart Mayer is in charge of the entire area.

"The MakerSpace is here to support any other teachers or students that have exciting projects they want to do or that they either didn't have the resources to use before or space to do them in," Mayer said. "Students should also know that if they want to make something and are willing to put in the time to learn how

to use a machine, I'm more than willing to help anybody."

Not only can Upper Schoolers use the space, but Middle Schoolers and Lower Schoolers also have chances to spend time there.

"There'll be similar opportunities for Middle School," Mayer said. "However, Lower School is probably more up to teachers who want to bring their kids in after-school clubs like the Make Club."

The Make Club, a club where

students learn about mechanical engineering, is one of the groups involved in the MakerSpace. Reagan Graeme, a sixth-grader and enthusiastic member of the club, enjoys the time he spends there and believes the most enjoyable part is getting the satisfaction of a functioning piece.

"I think the most fun part is actually seeing

it work," Graeme said. "Once you spend all this time connecting things and putting things in their place, it's satisfying when you finally see it work."

For the past few months, the club worked on a Halloween-themed design where an eyeball scared trick-or-treaters reaching into a candy bowl.

"We had been working on a project to make a Halloween trip thing where we used aluminum foil to sense when someone put their hands near the candy bowl," Graeme said. "We would then connect the foil to a motor that controlled an eyeball. We then added code so that the motor would be triggered when there was something near. When someone approached it, the eyeball would start moving."

Another member, fifth-grader Jack Shepro, is keeping an eye out for the future of his career at the club.

"It would be nice to come back to the club in seventh grade and be a helper," Shepro said. "I've also seen what [the Robotics Team] has done, and I'd be very interested in that later on."

To cut and make useful pieces of wood, the Make Club utilizes the laser cutter, one of the many machines in the MakerSpace. Tools like Computer Numerical Control (CNC) metalworking mills and blades, 3D printers, and much more line the entire workshop.

"We have a CNC metalworking mill and a CNC metalworking blade for making parts out of aluminum or steel," Mayer said. "We also have a gantry CNC machine for producing large wooden objects and the laser cutter for cutting designs and engraving wood in plastic. We have 3D printers as well for making 3D-created parts and printing them out of ABS [a type of engineering plastic], PLA [a polymer made from renewable sources] or other composite materials."

Before Mayer came to the school,

he owned a small business called camBLOCK, a company dedicated to the manufacturing and designing of portable motion control systems for cinematography, for ten years. Compared to genuine engineering workshops that he has worked in before, the MakerSpace is very standard.

"It's pretty similar to my Shop from my previous company," Mayer said. "Maybe a little bit bigger but most of the same capabilities. It's pretty cool that a high school can have the capabilities of a real engineering shop."

When Mayer was just a child, he had a passion for making and producing things, and he's surprised how much the encouragement of engineering has increased.

"I've just always been an inventor since I was a kid, taking things apart, putting them





- ⤴ Top- A milling machine that can cut through different types of materials including metals and plastics.
- ⤵ Left- A slant bed machine that helps design and manufacturing parts.
- ⤶ Bottom- A saw used for cutting wood and other mediums.



Makerspace
Director
Stewart
Mayer

The Maker-Space is here to support teachers or students that have exciting projects. "

back together," Mayer said. "I was a STEM kid before the term 'STEM' existed. And looking back, I think about how much better school would have been if I could go to school today instead of when I did since STEM is so much more supported and part of the curriculum these days."

The future of the space is uncertain, but Mayer will definitely be there to help students and teachers understand the wonderful prospects of the MakerSpace.

"Potential classes are being discussed right now," Mayer said, "but I'll surely be having other clubs and classes teaching kids how to use the equipment."

Although the community at St.

Mark's is amicable and friendly, many newcomers, students and teachers alike, may feel overwhelmed and intimidated as a result of the large campus and advanced colleagues. However, even though Mayer has only been here for a short time, he already feels welcomed and comfortable.

"I like it here," Mayer said. "It seems to be fairly relaxed, and overall, it's been a great, welcoming experience, and I'm very happy to be here."

The new MakerSpace, which arrived with the construction of the Winn Science Center, has already shaped the minds of many typically STEM-focused Marksmen, opening them up to a new world of possibilities with exceptional technologies, equipment, and teachers. With the immense potential that such an area possesses, the St. Mark's community can only dream of the future that awaits, filled with inspired minds, perseverant hearts, and passionate souls. ■



Taking a deep dive into the world of online banking

Online banking can help make our lives easier, but what are the security risks?

■ **Story** by Thomas Philip and Keshav Krishna ■ **Photo** by James Shiao
■ **Graphic** by Keshav Krishna

Online banking is one of the biggest trends in financial technology. The concept of online banking was first created in the late 1980s after the invention of the internet. Before online banking, people would have to go to a physical bank to make their transactions.

Between traditional banks and online banking, there was a brief phase in the early 1980s when distance banking services using electronic media were used.

Financial consultant Anand

Krishnaswamy has worked extensively in the financial technology field.

Since its invention, online banking has advanced and developed a lot.

“There have been so many new innovations in technology over the past 20, 30 years,” Krishnaswamy said. “And it has happened in different sectors. Online banking is, of course, a combination of finance, which has stayed relatively the same, but the technology part has drastically changed.”

Krishnaswamy says one of the reasons why online banking has grown is because it is more convenient than going to a bank.

“You can use online banking anywhere,” Krishnaswamy said. “As long as you have any type of electronic device and internet connection, which almost everyone does.”

Krishnaswamy says online banking is especially advantageous to small business owners.

“It’s great for them,” Krishnaswamy said. “It’s really easy to manage your money, and that will help small business owners immensely. You can keep an eye on your finances round the clock. Tax records are really easy to compile for them, too.”



Financial consultant
Anand Krishnaswamy

There are hackers and others who will try to exploit online banks.”

People who use online banking can even deposit checks without going to a physical bank.

“Just scan the check on your phone,” Krishnaswamy said, “and it gets deposited.”

Online banks also have financial benefits as well.

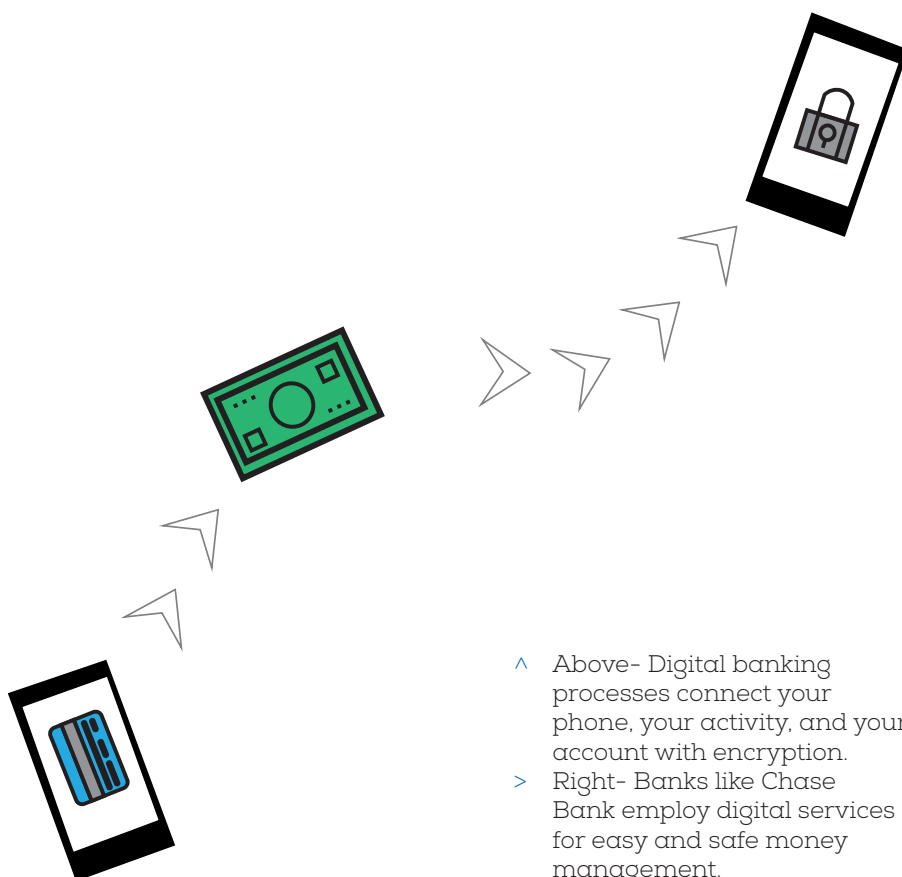
“Most brick-and-mortar banks have a minimum balance needed in a checking account,” Krishnaswamy said. “And if you have less than that amount, they will charge extra fees for that low balance. In an online bank, there is no minimum balance, and thus they do not charge the extra fees for being below that.”

Online banks also offer higher interest rates.

“For a physical bank, it is more expensive for them to operate than it is for an online bank,” Krishnaswamy said. “You have to pay the people who work there, you have to clean it, and you have to lease a property. There aren’t those costs for an online bank, which allows them to give higher interest rates.”

A purely online bank cannot offer ATMs and users cannot draw physical money, but Krishnaswamy says this has been addressed.

“If a person needs to use the ATM to get cash from an online bank without any physical locations, the bank will often offer withdrawals without fees,” Krishnaswamy said. “And if the ATM charges them, many times the online bank will even give them the money back.”



- ▲ Above- Digital banking processes connect your phone, your activity, and your account with encryption.
- Right- Banks like Chase Bank employ digital services for easy and safe money management.

However, Krishnaswamy says it is most convenient for a person to use a bank with both physical and online capabilities.

"It is what almost all large banks do," Krishnaswamy said. "A person can get the best of both worlds, and the bank is able to appeal to a younger person who may be more tech-savvy than an older person, who may prefer to go to the physical bank."

A major issue for online banks is security.

"Just like a robber will try to rob a physical bank, there are hackers and others who will try to exploit online banks," Krishnaswamy said. "And just like a physical bank might have

guards and security cameras, an online bank has security."

Social-security numbers, credit card numbers, passwords and banking information are some of the things that hackers try to steal while an online transaction occurs.

Krishnaswamy says it is a priority for banks to keep their clients safe from any sort of attack.

"A security breach has a lot of detrimental consequences for a bank," Krishnaswamy said. "It will get publicized and that erodes credibility, and credibility is at the utmost importance for any bank."

Banks try to prevent breaches by using a firewall and encryption.

"The firewall is the initial defense that cyber attackers must overcome," Krishnaswamy said. "Also, every piece of information is en-

crypted. It is quite complicated, but it basically ensures that it is harder for an attacker to access someone's information."

Krishnaswamy says there is still a lot of potential for online banks to grow.

"There has been a tremendous shift toward online banking fairly recently, but there are still people who do not use it," Krishnaswamy said. "As the world becomes more and more reliant on technology, I expect that those people, especially the younger generation, will cause online banking to grow even more than it is now. In fact, in the future, I believe that there is going to be a time when physical banks will be a thing of the past. ■

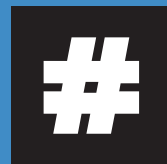


The Vescovo project—engineering with a scientific goal

How can the Robotics Team's prototypes translate into scientific discovery?

■ **Story** by James Shiao

■ **3D Models and Photos** by Andres Arroyo, Meyer Zinn, Nicholas Tsao, Faraz Asim, Stewart Mayer, Alex Emery, Justin Kim, Victor Vescovo



SHOW ME

Following the engineering process isn't very difficult, but it's absolutely vital to a project such as this one.

1. **Define** the problem
2. **Research** background information
3. **Imagine** and brainstorm
4. **Design** a solution
5. **Create** a prototype
6. **Test** rigorously
7. **Improve** the prototype and repeat the process

W

What happens when you sink a vessel with air trapped inside of it more than 10,000 meters below sea level?

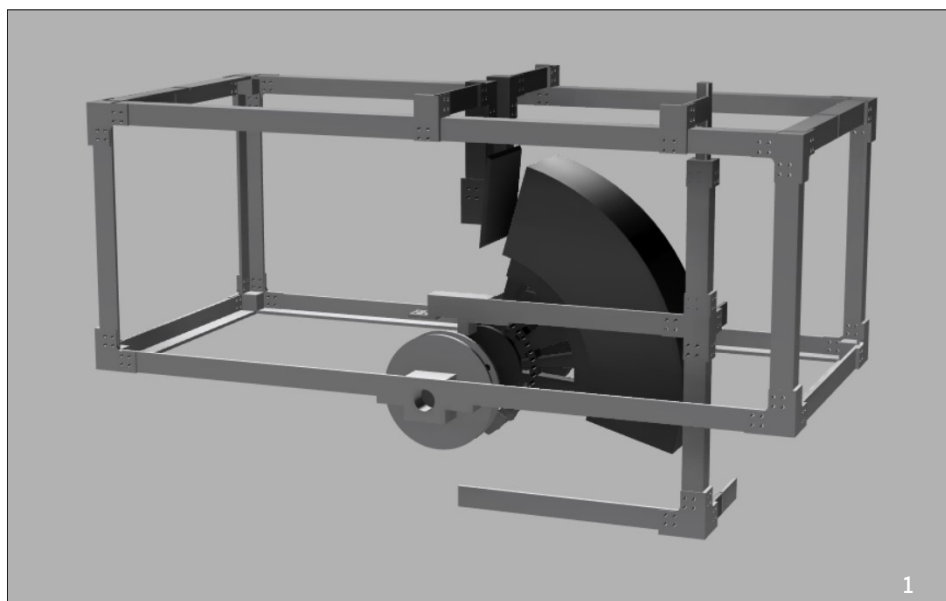
You get a pipebomb.

And so, the Vescovo project, nicknamed Project Pipebomb by the team members, began with the hope that the various prototypes by the end of the year would not implode under crushing depths.

"The opportunity to work with Mr. Vescovo was thrilling, unique and challenging because it allowed us to use our skills on a real-world application," senior Jackson Singhal said.

The challenge was to help Victor Vescovo, alumnus and world record holder for most vertical distance traveled without leaving the Earth, build a mechanical device to collect sediment samples from the bottom of the Red Sea without exploding. Electronic parts, such as motors, were unusable, because at that depth, they would be dysfunctional.

This lack of electric power meant that all power must be derived from gravitational potential energy. Using the force of hitting the bottom, a trigger could be set up to collect sediment after making contact. The team members came up with different methods to capture the material.



1

Team Macaroni

The toroidal tube prototype was nicknamed the Macaroni because of the tube's shape looking similar to a macaroni. The toroidal tube rotates upon impact of the sea floor using a latch mechanism.

When the device hits the floor, the vertical bar that extends below the rest of the frame gets pushed up, which releases a spring that holds the tube in place. The tube is then free to rotate, and since the device is so close to the sea floor, it will pick up sediment as it rotates. The tube is able to displace water using a one way valve that allows water to pass through, but not sediment.

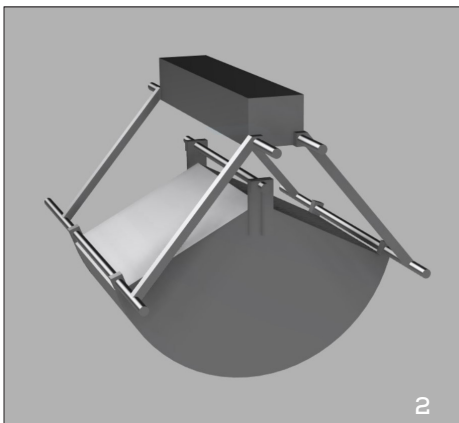
After rotating fully, the tube is capped shut

by a stationary cap and the device is ready to be lifted out of the water and sent to a lab.

The design has gone through multiple iterations. At first, the macaroni was a circular tube, but it was changed to a rectangular tube for easier manufacturing. The frame also changed. As the team looked through materials to use to build the final prototype, it was clear that common aluminum bars would need to be used to build the frame. In this version, the frame is built using right angle bars, but the final version would instead use T-slotted bars.

When tested, this design successfully picked up sediment and brought it to the surface, but as the submarine was being lifted out of the water, a big wave hit it and cause the macaroni to release its contents. This can be easily fixed with a lock, so it does not leak.

- △ 1- The Macaroni design has its own frame for the lid and trigger to connect to. 2- The pooper-scooper may have a suggestive name, but it suggests great sediment collection. 3- The screw design features the school logo proudly. 4- The landers have been tested by Vescovo and his team.



Senior
Jackson
Singhal

The opportunity to work with Mr. Vescovo was thrilling.”



Team Pooper-Scooper

The claw prototype, nicknamed the poop-er-scooper because of its resemblance to a common tool to pick up items from the ground, is able to pick up sediment and keep it contained.

When deploying the mechanism, the two sides of the claw are drawn apart using a spring. The spring’s potential energy will allow the claw to close despite the friction of water.

The device includes a vertical trigger that is placed between the two claw halves. It hits the ground first and releases the spring. As the claws close, the trigger is pulled up, allowing the claws to close completely.

Once sediment is within the claw, one would have to open the device manually to retrieve it. This is important because it means there is no chance for samples to leak out of the mechanism. While there may be obstacles, such as rocks and fish in the way of the lander, the poop-er-scooper most likely will not break.

One downside to the claw prototype is its potential to trigger on a false alarm. If the trigger hits an object that is not the bottom of the ocean with enough force, the claws will close without capturing any useful samples.

With the lander travelling down for hours, the velocity, even against with the water’s buoyancy, would be very high the more distance travelled. This risk is unlikely, and with multiple devices installed on the lander, even if one fails, there are more that can collect samples.

The truth is that there is some risk to all of the devices that could result in failure due to the high speeds and pressures going down to the bottom. However, the triggers are usually designed in a way that small objects would not be able to actuate the mechanism. For example, if the trigger has enough area on the bottom of it, it would only activate when hitting something large enough to press up the entire area—such as the ground.

Team Plunger

The plunger prototype was modeled closely to a prototype that Vescovo tried using in one of his deep-sea dives. The mechanism involves using a vacuum-like tube to quickly suck up sediment.

The modified prototype included a different trigger mechanism. While the original model was simply a tube with a syringe-like base pulling back to create a vacuum, the new design uses a series of springs to ensure that the plunger is on the sea floor before actuating.

In addition, a cover for the bottom of the tube was added. The previous model had no cover, and sediment would fall out if it hit any obstacles as it was being pulled out of the ocean.

Magnets lose their magnetic properties in low temperatures, which posed a problem for using normal iron magnets at such depths. The cover, however, is sealed close with neodymium magnets, which are predicted to still retain functionality despite the temperature.

Team Screw

The screw tube prototype was created using the simple idea that rotating a tube rather than using a suction force would easily collect sediment without needing complex mechanisms.

The screw is wound around a rotary spring, which stores enough potential energy for at least one full rotation. With stronger springs, even more rotations can be fulfilled and the mechanism would capture more sediment.

The risk of leakage is rather important, because there is not a simple way to cover the bottom hole after the prototype collects its payload. If the lander does not rise out of the water faster than the sediment inside the tube leaks out, the trial will be a failure.

A simple way to counteract this failure is to simply employ a longer spring, which can hold more revolutions. This would mean the screw can spin around more, collecting even more sediment. ■

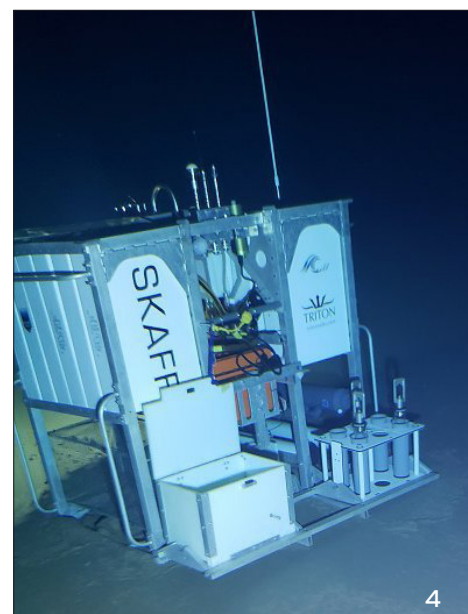
The Lander


The lander is the transportation that the devices are planned to travel on to get to the depths of Challenger Deep.

It goes down with the weight of gravity and the help of ballast weights. The weights are held on it with a cable, which gets cut to release them and resurface the lander.

The silt at the bottom is extremely compressible, so some mechanisms might even be inside the silt, the ideal case for poop-er-scooper and macaroni.

The lander is connected to the submarine, allowing Vescovo to control how the lander is lowered when nearing the bottom. It is ultimately connected to the ship so that it can be pulled up efficiently.





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DYS-PHO-TIC

1. having enough light to see, but not enough to carry out photosynthesis.
2. term used to describe the Twilight zone

The Dysphotic section is the realm between the surface-level science and the deepest, most complex discoveries. Covering topics similar to the ones found previously, the articles in this section dive deeper into the subject matter.





Cookiecutter Shark

Species name: *Isistius brasiliensis*

Size: 40 to 60 centimeters

These tiny sharks aren't named "cookiecutter" for their size, but rather for their feeding habit of biting off small circular chunks from their prey, as if using cookiecutters on a tray of dough. While their bites aren't deadly, they are certainly painful and certain to leave an eerie scar behind.

Lovely Hatchetfish

Species name: *Argyropelecus aculeatus*

Size: 70 millimeters

Lovely hatchetfish have a silvery coloration and bioluminescence, which allows them to hide from predators and prey in the low light of the twilight zone.



Yellow Sponge

Species name: *Aplysina fistularis*

Size: 0.3 to 1 meter

Sponge cells do not have specialized purposes—each of a sponge's individual cells can transform to complete the job of any other cell in the body. In fact, in laboratory settings, a sponge that is destroyed in a blender can reform itself as cells take on the form and job needed for recovery.



espite how ambitious educators and students can be, one school can only do so much to analyze and fight global warming.

But a city can do much more.

Looking through the damage the tornado caused the city of Dallas in October 2019, we wondered if there was anything the city could do to prevent tornado damage and if tornadoes could be contributing to the overarching problem.

The truth is that meteorologists predicted the storm would cause a tornado but couldn't estimate the damage. Many people in the city were in a state of shock at the storm's aftermath.

Despite our research, we found that there is still much mystery surrounding the cyclones known as tornadoes. Is it possible to find a connection between the weather phenomenon and climate change?



Forecasting the tornado and extreme climate in Dallas

How does a tornado happen and what technologies are in use to anticipate one's occurrence?

■ **Story** by Tamal Pilla, Antonio Quiñones ■ **Photos** by Miscellaneous

Debris scattered across the road, houses crumbled into piles of their former glory and cars flipped over with smoke originating from a broken part. A tornado is violent, powerful, and destructive; that much has become evident to the members of the Dallas community.

As part of the colloquial tornado alley, Texan citizens were generally used to tornadoes, but nothing of the magnitude that the October tornado brought. They saw the sheer force of the whirlwind and its ability to level houses and leave nothing but rubble in its wake.

While the effects of a tornado are clear, what causes such a deadly natural phenomenon?

Tornadoes are elements that can form in ordinary storms, but require certain conditions. According to National Geographic, like a thunderstorm, a tornado forms when warm, humid air collides with cold, dry air.

The hot air rises, and if the third crucial ingredient, wind, is present, the air will begin to spin and form what is called a supercell. The supercell is the name given to the spinning air high above the ground, which causes a tornado down toward the surface. This, however, only causes a tornado 30 percent of the time.

Although some initial conditions are known, the reason that a tornado sometimes forms and other times does not is still a mystery. After a tornado is formed, it usually lasts less than ten minutes, but the reason for it dying is also unknown. Scientists have different hypotheses about a tornado's death, one being that a tornado stops when the air gets too cold, 'choking' the airflow into the storm.

As scientists began to understand more about tornadoes, they needed a system of classification to rate the power of tornadoes. The Fujita scale was an effective solution to this problem, pioneered by severe storm researcher Tetsuya Theodore Fujita. From a paper published by the National Oceanic and Atmospheric Administration:

Fujita showed that a damage assessment could be performed in a systematic, analytic manner, with the goal of determining air-flow characteristics of tornadoes and their immediate surroundings. The damage scale assigned levels of destruction to "well-built" homes in a range of F0-F5 levels.



NBC Meteorologist Rick Mitchell

We kind of have to walk a fine line in that we can't go out every time and say that it's going to be wind and hail and tornadoes."

In other words, the Fujita scale measured how much damage the tornado caused and worked backward to find how fast the winds must have been moving. Because the scale would often underestimate the damage caused to residential houses, people began to doubt its accuracy. According to Roger Edwards, a researcher at the Storm Prediction Center, due to a lack of rural DIs, or damage indicators, the



DEFINE ME

Tornadoes aren't the only type of cyclone that can cause catastrophe. Here are how some other ones are caused:

Hurricane: Winds funnel into a low-pressure disturbance, evaporating warm surface ocean waters and releasing energy as rising air, which condenses into storm clouds. (Sciencing)

Mid-latitude cyclones: The dynamic interaction of warm tropical and cold polar air causes the warm air to be cyclonically lifted vertically into the atmosphere where it combines with colder upper atmosphere air. (U Illinois Atmos.)

Polar lows: Frigid air from the Arctic icecap or cold landmasses flows out over the warmer sea. Drawing heat and moisture from the water, this creates a type of thunderstorm. If the overlying atmosphere is also cold, the result is an extremely unstable air mass. (BarentsWatch)

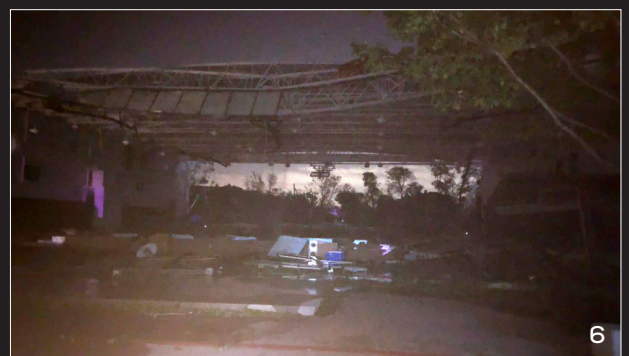
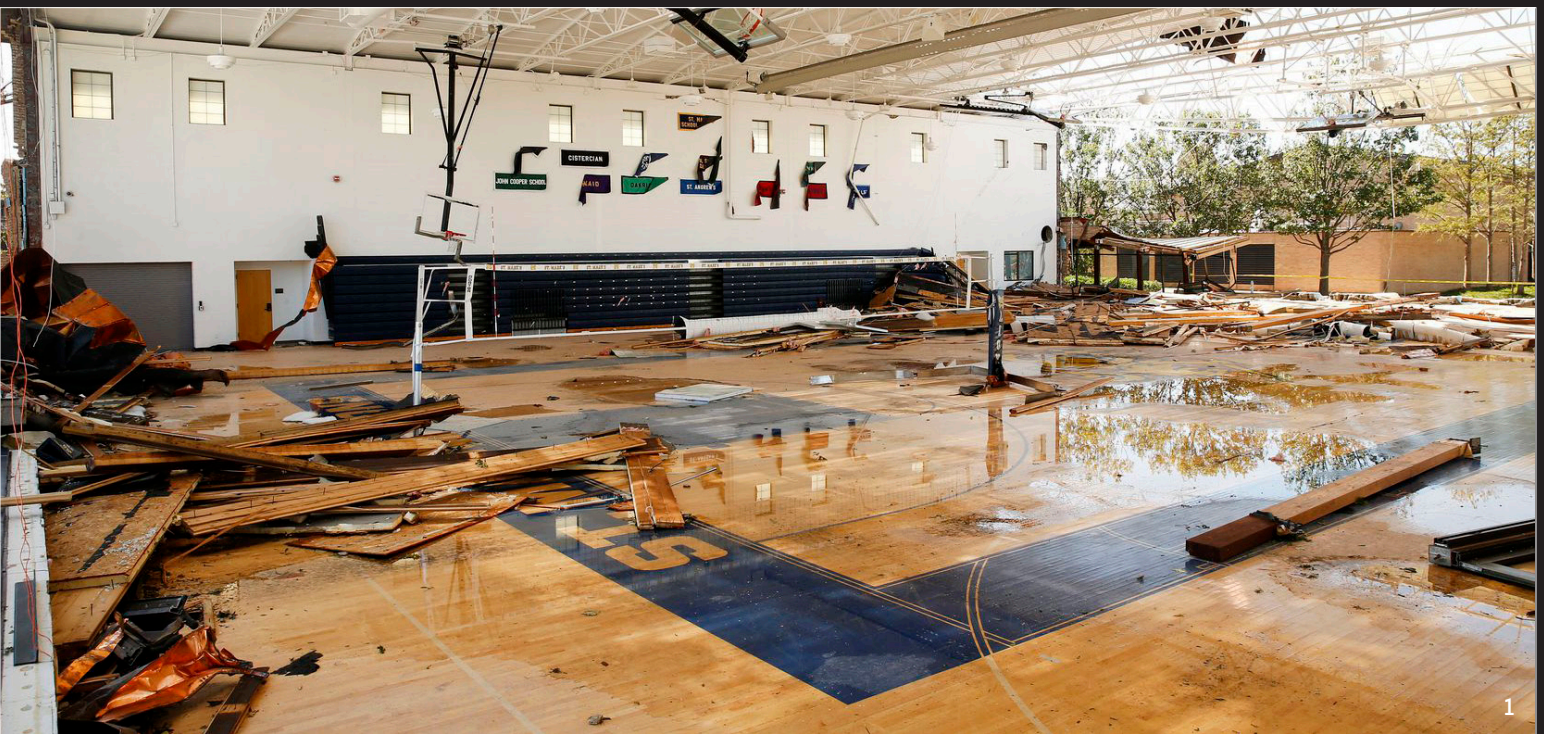
scale could not accurately rate the wind speeds of the tornadoes.

"The process of rating the damage itself is largely a judgment call -- quite inconsistent and arbitrary," Edwards said. "Even meteorologists and engineers highly experienced in damage survey techniques may come up with different F-scale ratings for the same damage."

The scale was eventually replaced in 2013 by the Enhanced Fujita (EF) scale. The EF scale was created to fix some of the flaws that the original scale had.

"A steering committee, composed of meteorologists and engineers, was convened in the early 2000s to discuss these concerns and incorporate an engineering-based understanding on the wind speeds leading to common failure levels of various potential DIs," Roger Edwards, a researcher at the Storm Prediction Center, said.

The transition to the Enhanced Fujita scale meant that more precise damage indicators were spread out in order to ensure more accurate results. This system continues to be used in the United States today. ►



1 Hicks gym was severely damaged by the tornado. 2 Renovations and repairs took upwards of three months to complete 3 The tornado's path cut through some of the busiest parts of the city. 4 Local businesses were devastated, including the Preston Hollow Shopping Center. 5 Imagery from the air shows the path the tornado took through parts of Dallas. 6 Estimates of \$2 million of damage was caused in the city of Dallas.

► Understanding the scale that rates tornadoes is important to understand the power of the tornadoes that hit Dallas.

“The EF scale is comprised of EF0 through EF5. 0’s and 1’s are considered to be weak tornadoes,” Mitchell said. “That’s what you have for most tornadoes in the United States, most of them fit into that category. The 2’s and 3’s are considered to be strong tornadoes. They don’t happen quite as much, but they do happen. Finally, you have the 4’s and the 5’s, and those are considered to be violent tornadoes...I know the 5’s occur less than 2% of the time, but they’re responsible for 70% of all fatalities.”

Dallas was hit by not one, but three tornadoes that each had varying degrees of severity. According to CBS DFW, an “An EF-3 tornado hit Dallas, an EF-1 tornado hit Rowlett, and an EF-0 tornado struck Wills Point. To grasp what that means, the largest tornado, an EF-3, had estimated winds of up to 165mph and caused severe damage.

As important as assessing the damage done by a tornado is, getting accurate prediction results are just as important. After the Dallas tornado, there were many misconceptions about how much the weather experts knew before the event. The words that the weather service use are so important in accurately representing the certainty of the information they collect.

“We kind of have to walk a fine line in



▲ Above- Despite the awesome wind speeds and surrounding devastation, the Path To Manhood statue remained unscathed.



▲ School-owned vehicles, including school buses, were blown away and destroyed the night of the disaster.

that we can’t go out every time and say that it’s going to be wind and hail and tornadoes,” NBC Meteorologist Rick Mitchell says. “We have to try to use that word tornado respectfully... This is what we will say: ‘the threat for wind and hail is the highest, we can’t rule out a tornado or two.’ I don’t remember that we downplayed it in October, but we just didn’t play it up.”

If the weather service issues a tornado warning every time there is severe weather, there will be widespread public fear. But if they say there may be a tornado and there isn’t, over time people will start to ignore the warnings.

This leads to a dilemma the weather service has to face every time they detect the possibility of a tornado. In order to determine whether it is worth reporting to the public, meteorologists have to determine how likely a tornado is and whether it is safer to not cause panic in the public by not issuing a tornado warning.

In order to assess the likelihood of a tornado given certain weather events, the meteorologists have a few tools at their disposal. There are two main stages of the process: detection and prediction.

“For detection we are using an S-Band Radar, and it’s a wonderful piece of equipment

and we have our own radar. A lot of TV stations don’t necessarily have their own radar. They are ingesting the radar information from the national weather service which comes in roughly every two to three minutes where ours comes in every thirty seconds and so that is a tool that is tremendous in detection.”

Mitchell says prediction, on the other hand, is a bit more abstract in terms of the actual process.

“With prediction, you’re relying on your knowledge, your experience, and your computer models to help you to get an idea. When you model the atmosphere, you’re basically saying ‘ok, I want to know what’s gonna happen not now, but six hours from now’... [the computer models] are going to be very high resolution. In theory, you’re going to be able to see thunderstorms that could produce tornadoes, but you don’t know when they’re going to be accurate, because at times, they are going to be inaccurate. So you’re left to wonder ‘this model is showing this. Do I believe it? Or is it going to lead me astray?’ And that’s where being a meteorologist is critical.” ■

Sources used: Edwards, R. (2010). *The enhanced Fujita scale: Past, present and future.*

Is climate change correlated to tornadoes?

What evidence is there to show that climate change is contributing to the rise in tornado occurrences?

■ Story by Tamal Pilla, Antonio Quiñones

As so many families attempt to rebuild and move past the devastation caused by the tornado, people look to the future and wonder if another similar event is likely. Researchers around the world are trying to communicate the dangers and problems caused by global warming. The news seems to say that as the world gets hotter, severe weather events will become more common. It certainly seems that way with so many hurricanes and tornadoes in the news, but is there really a connection?

The first step in understanding whether climate change could increase the likelihood of a tornado would be to understand what causes a tornado.

As previously mentioned, however, this is a very difficult concept to fully understand, and scientists do not fully comprehend why a tornado was created in conditions that in other times a tornado was not created. This lack of understanding of the severe weather event impedes scientists' ability to find a link between climate change and tornado frequency.

Lack of data is a problem throughout more than just the creation of tornadoes, however.

According to the Center for Climate and Energy Solutions (CCES), "Measuring the presence of tornadoes relies on eyewitness accounts and aftermath damage assessments rather than quantifiable data."

Researchers find it difficult to analyze long-term data when that data is potentially unreliable. The problem goes even deeper, since it is difficult to identify long-term trends in tornado records, which only date back to the 1950s in the U.S.

Fortunately, the population in many areas affected by tornadoes has grown, contributing to increased eyewitness reports and greater property in harm's way (CCES), so the number

of reported tornadoes has increased as Americans moved into areas that are likely to be hit by tornadoes. Before, when tornadoes strike in empty fields or scarcely populated areas, little to no people would report them. This may change with time.

Even though the basic effects of climate change are fairly well known, the repercussions they would have on the frequency of tornadoes are still difficult to understand.

A warmer world would have two outcomes that have potentially opposite effects. On one hand the climate will likely be unpredictable, experiencing wild shifts more often than before. On the other hand, the warmer weather may lessen chances for wind shear, or sudden shifts in wind current (CCES). It is unclear which factor may outweigh the other, and it is still possible there are other effects that have yet to be considered.

Atmospheric carbon levels can be mapped back thousands of years, but the tornado data only goes back around seventy years. By the time the data for tornadoes spans enough time to properly analyze, the effects may already be

clearly visible.

The answer, however, is not a resounding "we do not know."

According to the fourth climate science special report from CCES, "Tornado activity in the United States has become more variable, particularly over the 2000s, with a decrease in the number of days per year with tornadoes and an increase in the number of tornadoes on these days."

In other words, there may be fewer days with reported tornadoes per year, but on days that have tornadoes there are more tornadoes per day.

Although these results again seem to point in two different directions, it does follow what the news often say about climate change: global warming makes the weather more unpredictable.

Severe weather, when it occurs, is more devastating since there are on average more incidents in a given outbreak.

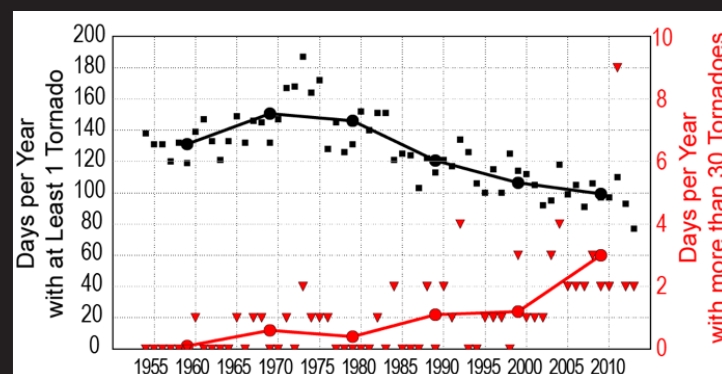
"The extent of the season over which such tornado activity occurs is increasing as well: although tornadoes in the United States are observed in all months of the year, an earlier calendar-day start to the season of high activity is emerging," a team of climate change scientists led by D. J. Wuebbles said.

None of the data suggest that the world will be inundated with more tornadoes, but there are consequences of global warming on these severe weather events.

For our community, this issue is even more important since Texas has the largest average number of tornadoes in the United States per year at 140.

As new methods for analyzing tornadoes and their effects emerge, the correlation will be better understood. Regardless of the effect global warming has on the frequency of tornadoes, it is clear that a changing climate affects severe weather events in some way, but how exactly is still yet to be understood. ■

Sources used: Fourth National Climate Assessment (NCA4), Volume I; Center for Climate and Energy Solutions: Tornadoes and Climate Change



< Meteorologists are finding that the number of single tornado incidents has been decreasing since the 1980s, but the number of collections of more than 30 tornadoes in a day has been steadily increasing since 1955.



The adventure of two Nicholases

Two students take an in-depth academic tutorial on modern physics and organic chemistry.

■ **Story** by Jeremy Yu and Austin Zang

■ **Photos** by Tyler Nussbaumer

Seniors Nicholas Tsao and Nicholas Cerny are pursuing their interests in science through an advanced tutorial with Cecil H. and Ida Green Master Teaching Chair Stephen Balog and chemistry instructor Kenneth Owens. Their content goes far beyond any high school's curriculum, as it covers the in-depth of many topics from modern physics and organic chemistry.

"Generally we do a lot of relativity and quantum stuff that's not in the standard curriculum, and we also derive equations and famous constants, which is pretty cool," said Tsao. "Organic chemistry is briefly covered I believe in regular and AP Chemistry, where you learn the nomenclature and some basic structures like functional groups, but that's it. Real organic chemistry is way deeper than that."

Interestingly, the seemingly unrelated subjects are actually closely bound.

"I think that there is more of a bridge

than a lot of people realize just because you've got this situation when you're talking about particles and orbitals and the Schrodinger wave equation," Cerny said.

While quantum mechanics are classified as physics, Cerny sees this concept show up in chemistry, and even medicine, when one talks about orbitals and the history of the atom.

"And so, in the medical field, I think that can definitely be drawn upon when you're talking about radiation and radiology," he said. "Especially with coming up with safe ways to track the metabolic pathways as they go through the human body."

The tutorial has helped Cerny, who has always had an affinity for organic metallic chemistry, discover a liking for physics.

"Right now [in October] we're learning the Schrodinger wave equation, which essentially ties into the idea of wave-particle duality," Cerny said. "So for every electron or for any particle, it also acts as a wave, and therefore

you can model that through a mathematical equation."

Cerny thinks one of the most

interesting aspects of this concept is that waves have to be described in terms of probabilities.

"Because you don't actually know where the particle is in the system by Heisenberg's uncertainty principle, which states that you can't know the velocity and the position of a particle at one instance, the whole idea of quantum mechanics relies on probabilities," he said. "But then, to go and actually figure out where that is and to try to model it with mathematical equations is especially fascinating."

Even though the material covered by the Modern Physics curriculum may seem daunting, Tsao assures that it's actually deceptively approachable.

"We do relativity and stuff like that. We touched a little on kinetic theory, and after that we did a lot on quantum theory, which is a more modern topic than traditional physics," said Tsao. "Sure, it's more modern than Newtonian physics, but it's still just physics."

Tsao and Cerny are especially

looking forward to the organic chemistry portion of the tutorial, which begins in January. "Organic chemistry problems are like puzzles, which is really interesting because you get a toolbox, with different kinds of tools, and you try to piece together the puzzle and what happens," said Tsao. "It's comparable to doing a Sudoku or something similar."

Tsao believes that studying these deeper levels of science will lead to revolutionary developments in the future.

"Organic chemistry has been fundamental to the development of drugs, pharmaceutical companies and green chemistry for a significant amount of time—they're really fundamental fields to new technologies," Tsao said.

Tsao has also done independent research on the topic outside of school, and he believes there is a lot yet to be discovered.

"There's a lot of stuff we don't know about quantum science," he said. "For example, there's still a lot of unsolved problems that relate to how quantum mechanics interact with other theories. Quantum gravity is a big problem; you also have other questions regarding modern physics in, for example, black holes. For organic chemistry, people are working at it every day and trying to find new drugs and more effective ways of synthesizing them."

The tutorial itself is structured slightly differently from the average class.

"The primary day to day of the modern physics tutorial consists of just lecture classes three times a week, in which most of the time, we read up on a chapter beforehand and then we get there and we talk about it and derive equations," said Cerny. "I believe for the organic chemistry component, Mr. Owens has the intention of also including a lab section within it so that we get more experienced at the macroscopic scale instead of just the microscopic."

However, the information that they learn is not tested by their instructors. Tsao believes that this has its benefits.

"It's just the three of us, so it's easier to tell if we understand or not and it's basically up to us to keep up with the material. It'll certainly be used later on in competitions or in future studies, but I don't think that testing is that important per se," said Tsao. "I think that's a good aspect of the



Senior
Nicholas
Tsao

It's just the three of us, so it's easier to tell if we understand or not and it's basically up to us to keep up with the material."

- < Left- Nicholas Tsao on the right and Nicholas Cerny on the left are hard at work learning the information taught during class.
- ✓ Bottom- Nicholas Tsao raises his hand to ask and question.

tutorial just because you can focus on learning without having to focus on keeping up with grades and that kind of thing."

Cerny, who has previously taken on the challenge of college-level summer science courses at the University of California at Berkeley, believes that his current tutorial is more mathematically advanced.

"[I'm] also trying to understand [the course] on a much more difficult scale and so there's a lot of math, differential equations, and integrals that are very difficult to solve," said Cerny. "I think that the AP doesn't stress the importance of all of these mathematical concepts and deriving the equations. The APs are more focused around making sure you understand the concepts and how they relate to each other, whereas this is a very narrow approach to specific subjects, so there's a lot more in-depth information."

Regardless of the courses' difficulties, Tsao hopes to see the course become available to more students at our school—assuming their science skills are up to the challenge.

"I think if there is enough interest, it could certainly benefit students to have exposure to these more advanced fields that are not traditionally high school level," said Tsao. "They're very fascinating fields to talk about, and I think organic chemistry, for example, is a very fun field of study that a lot of high school students don't get exposed to, which is a little bit disappointing."





Is a **microdrone** spying on you?

Does the decreasing size of drones diminish our privacy?

■ **Story** by Arjun Agarwal, Varun Trivedi ■ **Photos** by Ben Hao ■ **Graph** courtesy of Pew Research Center

Drones are, without a doubt, remarkably useful in everyday lives. They can deliver packages, provide entertainment for homes and theaters, make scientific discoveries in places too dangerous for human exploration, and even stop wildfires before they spread.

However, all of these advantages come with a price. With the announcement of Amazon's delivery drone service, along with similar services of other companies such as Shell, BBC, and EasyJet, regulations have already been put into place regarding small unmanned aircraft.

flying, restricting their ability to fly by limiting areas and times of use.

Furthermore, the FAA states that drones must weigh less than 55 pounds and more than .55 pounds and be registered with them. Reasons for the upper bound include hazards stemming from malfunctioning drones or falling objects, which have the potential to cause serious damage and possibly result in fatal incidents. On the other hand, drones are getting even smaller, and FAA regulations may not be able to keep up.

DeepFly3D is an American company that recently released its findings on deep-learning based cameras used to design robots in the

shape and size of flies. Their models have been vetted by countless scientists and scientific journals. While the concept is good and the math is sound, perhaps the world isn't ready for drones that small.

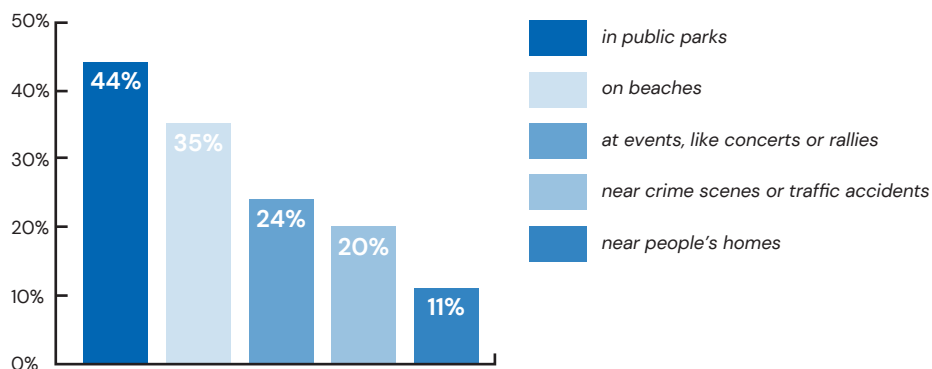
With his experience in developing an engineering curriculum and sponsoring the Robotics Club, science instructor Douglas Rummel had much to say on this issue.

"There is a real issue: privacy crime," Rummel said. "It's like anything else. With any piece of technology, people find a way [either] to abuse it or to use it for the good of mankind, and I'm assuming that [small drones] are going to become more and more ubiquitous."

According to the Federal Aviation

Administration (FAA), "you must have a visual observer always keep your aircraft within unaided sight." This clause prevents the use of binoculars or cameras to keep track of drones to remove the possibility of drones flying outside of the aided sight and/or signaling range. The FAA also prohibits the flying of a "small unmanned aircraft system over anyone who is not directly participating in the operation." As a result, professional and recreational drone flyers alike have to take extra precautions when

Percentage of Americans backing private citizen drone usage in...



- < Left- High quality drones are being made smaller in size.
- > Right- The Federal Aviation Administration (FAA) enforces how heavy a drone is allowed to be.
- ✓ Bottom- The size of an average drone with a hand to scale.

Rummel said that drones could be used for a variety of illicit actions like delivering illegal substances, surveillance and recon, and most importantly, data gathering.

What if microdrones were stationed everywhere you go, gathering information about the places you visit, the things you buy, and the people you talk to? That information in the wrong hands leads to targeted advertising, identity theft, and even organized crime. However, Rummel said that this may already be happening today. Mobile phones, although essential to a full life in the 21st century, are also a huge threat to personal information.

"We are walking around with devices in our pockets that collect everything about us, and we've all got profiles out there that would scare you," he said. "I don't know if there's that much more privacy to lose because, frankly, there is not much privacy anymore."

DeepFly3D uses deep learning, a type of machine learning based on artificial neural networks, for its three-dimensional imaging camera technology. A.I. will have a major impact on the drone sector.

"The most important is the ability to path," Rummel said. "I mean, just the inverse kinematics of flight control, we keep these things upright and balanced. The reason why you haven't seen quadcopters before a decade ago is because we didn't have enough computing power that was small enough."

Rummel is excited because, by the end of the 2019-2020 year, St. Mark's could potentially have small laser altimeters, instruments used

to learn about the topography, or the shape of the surface of a planet. Drones use these on a much smaller scale to model their surroundings in order to fully be aware of the space they are in. The size is akin to that of a pack of saltines. Not much more mass is packed that small that can do rangefinding in three dimensions.

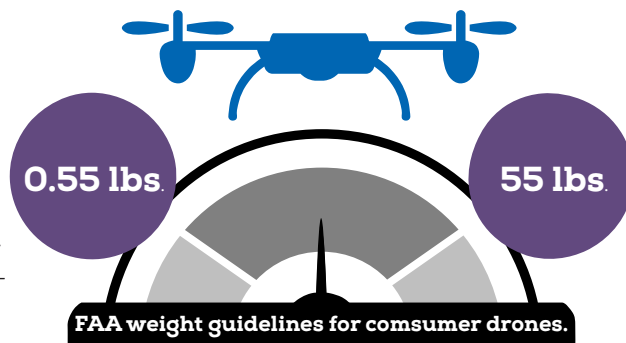
"So while you're in flight," Rummel said, "you cannot just use a camera, you can then map out your height, your left, right, up, and down. You know what the obstacles are, and if you're small and agile you can respond. The idea is you wave your hand and these things just kind of scatter and move like bees in a swarm."

This ability makes drones perfect for emergency disaster relief. With advanced mapping abilities, drones can get vaccines into deep Congo where organizations could not before. Things such as obtaining blood tests of Ebola patients have increased capacity with drones.

Although unmanned drones have been around for quite some time, none have been small enough to be functional, effective, and efficient.



Animal Dynamics, a British startup from Oxford University, produces biologically inspired vehicles and drones—including the dragonfly-inspired "Skeeter," a drone the size



of a pen intended for military reconnaissance. This drone is one of the smallest equipped with a camera in the world, and it is only accessible to the military.

The future implications of miniature drones are uncertain. As a result of their small size, they are undetectable. Although this characteristic is beneficial for information reconnaissance, it also highlights the ethical issue that drones present. Undetectable drones pose increased privacy concerns, especially as advancing technology starts implementing them into everyday lives.

There's also the question of whether insect drones are as feasible as Animal Dynamics claims. Many previous startups have failed, citing an approximated period of ten to fifteen years before the technology matures to support energy-efficient, cost-effective models.

"The design is very challenging and subtle," said Adrian Thomas, CEO of animal Dynamics in an interview with OZY. "But we have cracked the issues and Skeeter flies outside nicely. We are currently working to increase flight time, and increase its robustness and operating lifetime."

Microdrones have been invented and working models have been created, but they are extremely inefficient and are nowhere near the level they would have to be at in order to be accessible to the public.

"The biggest issue is power," Rummel said. "Miniaturization of batteries is not realistically extending to products and support structures. So you can make tiny things but you have to essentially power them. It's really hard to keep them flying."



Rummel knows drones will be a big advantage to the future of humanity and feels the pros do heavily outweigh the cons.

"All sorts of really cool things that we couldn't otherwise do, we can do now," said Rummel. "I think there's a lot of good that can come out of drones, and that's the thing that we're excited about right now." ■



Music's role in scientific ventures

Exploring the significance of music in our lives and what learning it can do.

■ **Story** by Rishi Mohan, Maxwell Chuang ■ **Photo** by Moose Photos
■ **Graphic** by Morgan Chow

Music has a transformative effect on the brain; not only do the notes evoke emotions such as sadness and joy, but they also directly influence our brains — often in more interesting ways than one might think. Some are of the opinion that music belongs in the concert hall, the auditorium, maybe even the public park, but music has expanded its frontiers to hospitals, public libraries, and other seemingly odd locations.

In world-famous hospitals such as the MD Anderson Cancer Center in Houston, Texas, “integrative medicine,” a form of therapy involving music as a therapeutic tool is an official, board-certified, and very important treatment. In MD Anderson, specifically, a group called The Celebration Singers, a support group and

choir for cancer survivors and medical professionals, has drawn national attention for its inspirational musical performances to patients and caregivers. These groups show that music has applications in medical fields (such as in the growing area of music therapy). But what other applications does music have, and why are we only discovering these uses of music now?

In a course taught at the University of Central Florida titled “Music and the Brain,” neuroscientist Kiminobu Sugaya and violinist Ayako Yonetani have developed links between music and neurogenesis, the creation of neurons.

Another neuroscientist, Daniel Levitin, a professor at McGill University, in his book *This Is Your Brain on Music*, explains that listening to music definitely involves large structures such as the cochlea, brainstem, auditory cortices, and cerebellum, but the two UCF professors have shown that so much more is affected.

Experiments conducted with patients with Alzheimer's and Parkinson's diseases at UCF have revealed that at least some part of every lobe in the brain contributes to the act of listening to music.

Not only does this discovery have implications about forming stronger neural connections and memories while listening to music, but music may actually be able to assist in repairing brain damage and preventing neurodegenerative diseases.

Even though research concerning music's ability to cause healing is just starting, the fact that leading hospitals and other organizations are turning to music as a useful tool indicates that there is much promise in this area of research.

One valid reaction to this research is a wonder as to why music's new applications are just now being discovered, researched, and implemented.

Music has been prevalent in human society ever since cavemen started beating against rocks with sticks and carving out bone flutes from deceased animal carcasses. Since the arrival of Western medicine, however, other “voo-



SHOW ME

According to the Andrew Weil Center for Integrative Medicine at the University of Arizona, integrative medicine is “healing-oriented medicine that takes account of the whole person, including all aspects of lifestyle.” Here are the eight primary principles for this form of therapy, as defined by the center:

- 1. Partnership** The patient and the practitioner are partners in the healing process, so they must agree to all steps of the process.
- 2. Holistic approach** All factors that influence health, wellness and disease are taken into consideration, including body, mind, spirit and community.
- 3. Alternatives** Appropriate use of both conventional and alternative methods can facilitate the body's innate healing response.



4. Invasiveness Effective interventions that are natural and less invasive should be used whenever possible.

5. Open-mindedness Integrative medicine neither rejects conventional medicine nor accepts alternative therapies uncritically. Any medical procedure chosen must be backed by evidence to be trusted.

6. Objectivity Good medicine is based in good science. It is inquiry-driven and open to new paradigms.

7. Prevention Alongside the concept of treatment, the broader concepts of health promotion and the prevention of illness are paramount. Leading a healthy lifestyle leads to faster recovery.

6. Self-reflection Practitioners of integrative medicine should exemplify its principles and commit themselves to self-exploration and self-development.

As the field of music therapy is further explored, more evidence shows that it can help in the integrative medical process.

> Right- Listening to music can affect one's emotions, as if their mind changes its colors.



doo” or osteopathic medicine varieties were shunned by the public (mostly due to effective advertising by pharmaceutical companies) as they were not considered effective or trusted enough. Since scientists have now realized that such potent chemicals come with serious side effects, many organizations are now turning to alternative methods of care, such as music.

Music, however, does not just have a profound impact on its listeners. The players producing the music experience equally interesting effects.

While learning to play an instrument might not increase IQ or intelligence (as some may claim), it definitely does aid in memory and motor skills, morphing a musician’s brain to become more adept at these abilities. These findings are also in agreement with the phenomenon of neuroplasticity, the brain’s ability to physically change.

Dr. Sarah Choi, orchestra director and professionalist cellist, has lived with music her entire life. Choi has studied music and has

played cello and piano for over twenty-five years. Along with cello and piano, Choi has mastered the alto saxophone and is a proficient vocalist.

However, this skill has not come naturally. From a young age, Choi has studied through the Suzuki method, an internationally renowned music curriculum that teaches through imitation.

“I was doing pretty well at school,” said Choi. “The teacher suggested to my parents that they should look into the Suzuki program because it was in the neighborhood and it was established and it was well known at the time.”

Taking her teacher’s advice, Choi dove into the musical world, eventually mastering



Orchestra
Director
Sarah Choi

Music has the power to do all those things. It can calm you. It can soothe you. It can rev you up.”

the piano, cello and alto saxophone. After these instruments, Choi said she was able to join the choir because “once you have the musical skill and knowledge, it’s transferable between instruments.”

Music has brought insight and pleasure into many people’s lives. Choi’s favorite part of being a musician is collaborating with other artists.

“The best part is when you get to play with other people,” she said. “When you get to play with other people and you get to express yourself with other people, that’s the best feeling.”

Through expressing emotions, musicians are able to express their happiness or pain. Music becomes an outlet for emotions. However, there is a cost.

In order to perform, music requires “mental focus and physical coordination.” Not only does performing music involve every lobe in the brain, but it also requires muscle memory and dedication. Regardless, the power of music, whether listening or performing, can change the emotions of anyone.

“Music has the power to do all those things,” Dr. Choi said. “It can calm you. It can soothe you. It can rev you up. It can get you to focus. It can get you to sleep.”

While listening to music can evoke

emotions and assist in repairing brain damage, there are additional benefits of playing on instruments. Because of the dopamine released in your brain, music brings happiness and friendships. Through collaborating on different pieces with friends, musicians form bonds that are different from a regular friendship.

Even though listening to music is great for the brain, according to a study by McMasters University, an institute renowned for its innovation, “early musical training benefits children even before they can walk or talk.” Babies who were exposed to musical training at an early age were more prone to learning and overall better communicators. Spread into two different classes, one with listening and interacting with music, one with just listening to music, the class that interacted with music had better results when identifying scales. The classes that just listened to music had a tougher time with the same task.

Through scientific studies and professional testimonies, the positive impact of playing and listening to music has on the brain is boundless. From repairing the brain, changing one’s emotion, to muscle memory, music is able to do things no other activity can do. Whether it is during the drive to school or while doing homework, listening to music has been proven to bring benefits. ■

From scraps to a winning robot

After two months of building, testing, and revising, the Robotics Team created an android capable of helping communities recover after a natural disaster.

■ **Story** by James Shiao ■ **Graphic** by Morgan Chow
■ **Photos** by Stewart Mayer

Eyes focused on the robot, robotics captain Faraz Asim strategically maneuvers the Robotics Team's scissor-lift robot through the maze of obstacles on the field.

"I practiced driving the robot a lot during our late nights," Asim said. "And even though it was difficult because of the controller's sensitivity, my technique became refined."

His spotter, captain Meyer Zinn, directs Asim while anxiously hoping that the robot's autonomous mode works.

"The autonomous mode got us the most points each round," Zinn said. "That isn't to say that our robot didn't work, it's just that with the short amount of time we had it was best to get points from the autonomous runs."

These moments flashed through the captains' minds while they held up the BEST Award and third place trophies. The team endured many challenges to get to this point: the brainstorming process, the practice field, the tiring late nights. They relit the torch passed down from the year before and soon hope it will be passed again.

The robotics team participates in the Boosting Engineering, Science, and Technology (BEST) Robotics competition annually, each year with a different theme. The theme of this year's competition was "Off the Grid," which entailed research and application of robots to provide relief and restore power after a natural disaster, such as our very own tornado.

"The theme was about engineering robots that could actually help in a real

disaster," Asim said.

While there were many components to the game field of the competition itself where the robots compete, each team only had three minutes to complete the challenges. To answer what they wanted to focus on, Asim decided to prioritize the sections with the most points: the autonomous portion and restoring power lines.

"The field simulates a neighborhood



Robotics
Captain
Faraz Asim

I practiced driving the robot a lot during our late nights."

that was devastated by a natural disaster," Zinn said. "If our robot was a real machine that construction workers would operate, it would rebuild parts of the neighborhood such as power lines and transformers as well as clear debris. Because the field is a simulation, our robot executes the same functions on a smaller scale. So the power lines are hanging ropes, and transformers are PVC pipes with velcro on them."

To deliver the power line on the highest level, the team designed a scissor lift with a mechanical arm that could extend to seven feet tall but still fit in the two foot cube that the robot was required to fit in at the start.

Serious problems, however, came up from this mechanism when the team

built their first wooden prototype. The lift was unstable when rising because the beams on the scissor lift were wooden and flexible, unlike real scissor lifts that are made of metal. The turning screw rod that lifted the scissor lift also was not strong enough to stabilize the robot's swaying. In order to make the claw more stable and raise to the desired height more rapidly, the student-engineers added trusses and two more levels for a total of five layers of crossbars.

They then designed a mechanism to extend an arm with the claw attached by rotating it using a servo, which is a type of motor that is relatively weaker and can only turn to a certain angle. With the arm folded down, the robot fit within the space limit for the start of the match. This design was used as an alternative for a hook placed on the side of the lift because it was harder to control.

"The arm was a bit difficult to use, so we switched to the side hook instead," Asim said. "The lift does become less stable because the rope pulls the whole robot rather than just the arm, but it's easier to control."

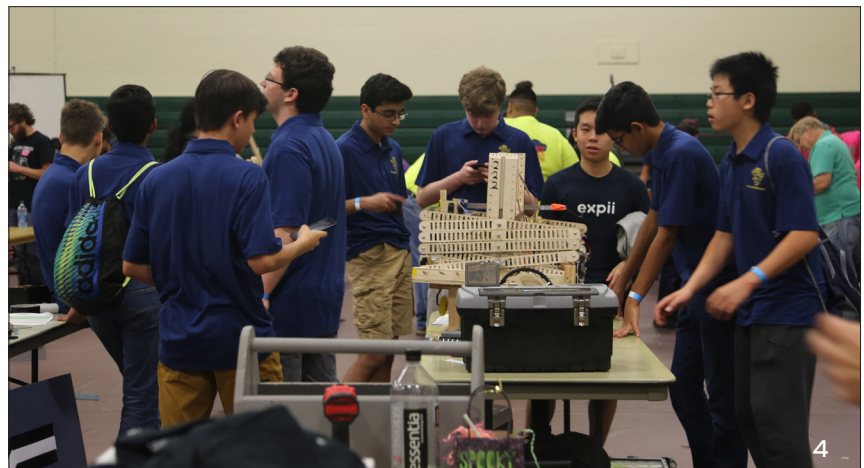
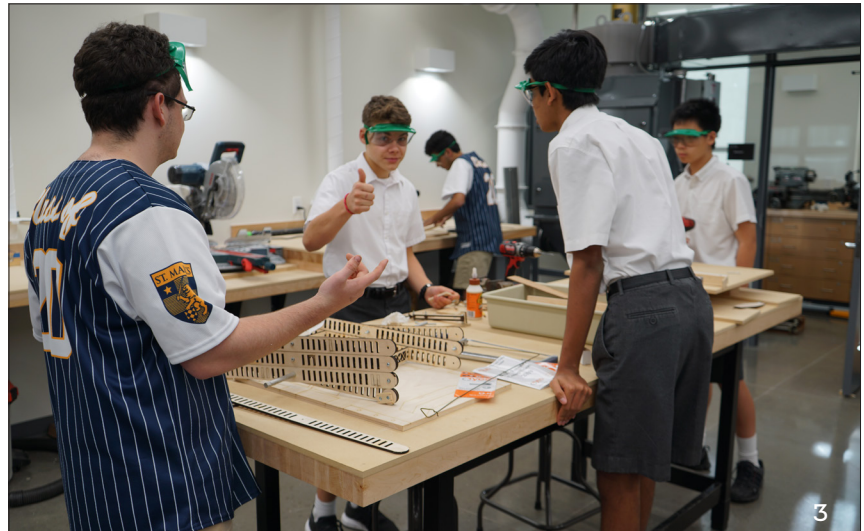
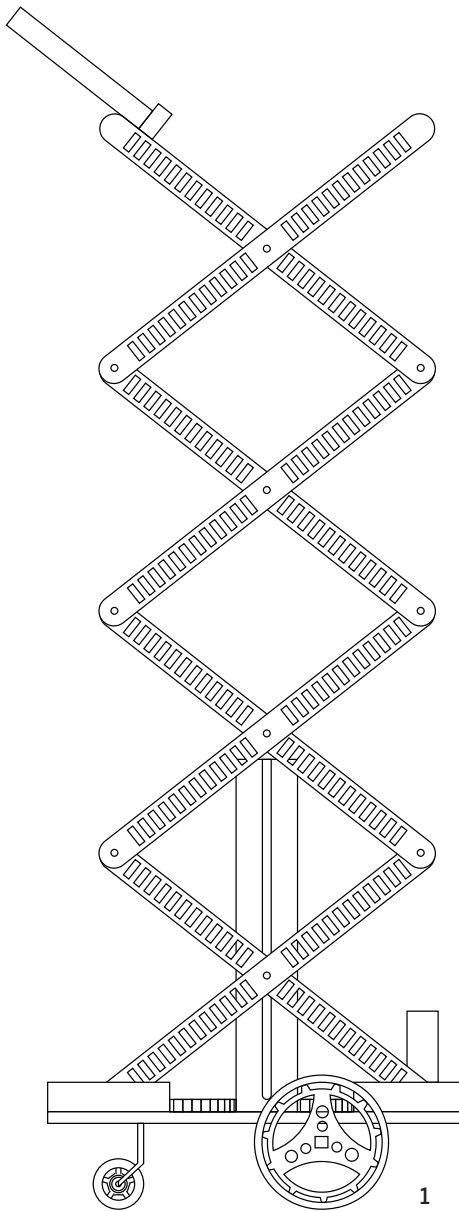
To test and debug the autonomous mode software, junior Jordan Gaines employed a number of different techniques. They used Apollo, a tool that is built onto the robot that allows him to read its sensor input as well as several other pieces of data.

"This was useful as it allowed us to see what the input was and then compare it with our desired output for the input," Gaines said. "Effectively, it allowed us to eliminate controlled defects/miscommunications reasons for incorrect program behavior."

After placing in Regionals and qualifying for the State competition, the robot was redesigned to be easier to control and more stable. The scissor lift design was replaced with a telescoping arm, which used a bungee to control the arm's movement.

"The telescoping arm is easier because it can rotate freely while also having a faster control scheme," sophomore James Singhal said. "We can effectively pull the ropes with the arm without putting strain on the robot's base."

At the state competition in December, the team was able to win 49th place out of more than 500 teams. ■



SHOW ME

The 2019 BEST Robotics competition was an engineering competition that featured teams from all around Texas:

300 middle and high school students that participated

21 Marksmen worked on a robot as part of the school robotics team

6 weeks to set up the playing field in the Winn Science Center and create a working robot to compete for regionals

8 weeks to refine the robot for state

> **1-** The regionals design of the robot relied on a scissor-lift to raise a hook high enough to reach the ropes. **2-** Students from all over Texas gathered in the Winn Science Building to watch the demo on Opening Day. **3-** The team stayed many late nights to finish the robot in time. **4-** The competition was stressful for the team, but they worked together and stayed calm.

Our exodus to Mars

Analyzing the feasibility of human migration to Mars

- **Story** by Michael Gao, Will Spencer ■ **Photos** courtesy of NASA
- **Extended Reporting** by Renil Gupta, Ashvin Nair
- **Data** courtesy of NASA

In the future, instead of just probes and rovers, human explorers may someday tramp the red deserts of Mars.

In greenhouses, plants could thrive almost like those on Earth.

In Martian bases, a new civilization could be born. People of every kind could live in harmony, and, some day, Mars could be made to be more like Earth. Water could be introduced onto the Martian surface. The atmosphere could become breathable. A climate-controlled suit could become obsolete.

And, best of all, this isn't some science fiction fan's pipe dream. The rebirth of Mars is achievable, and it could be coming in the future.

increasing human knowledge of space. Taking this into account, NASA plans to land humans on Mars in the future. In order to prepare for



Mitch Schulte, Mars 2020 program scientist

The next logical objective is to expand our reach and eventually take humans to Mars."

this, scientists at NASA plan to explore the Moon first.

"Once we have established that we can successfully explore the Moon and, perhaps, that we can use the resources we find there, the next logical objective is to expand our reach and

eventually take humans out to Mars," Dr. Mitch Schulte, Mars program scientist at NASA, said.

This process, however, won't be a small commitment, and it will take plenty of time to complete.

"Because of the direction to go back to the Moon before sending humans to Mars, it will likely be quite some time before a human landing on Mars will happen," Schlute said, "I hesitate to put a number on it; we will have to see how things progress with the return to the Moon."

The density and composition of Mars's atmosphere could also prove to be a problem for spacecraft landing.

"Primarily, one has to consider the thin atmosphere on Mars and the fact that there is no 'life support' on Mars," Schlute said. "There is enough air on Mars that it is a factor in landing, generating heat from friction with atmospheric entry and providing a little bit of help in slowing down spacecraft, but not enough to really help a lot with the landing."

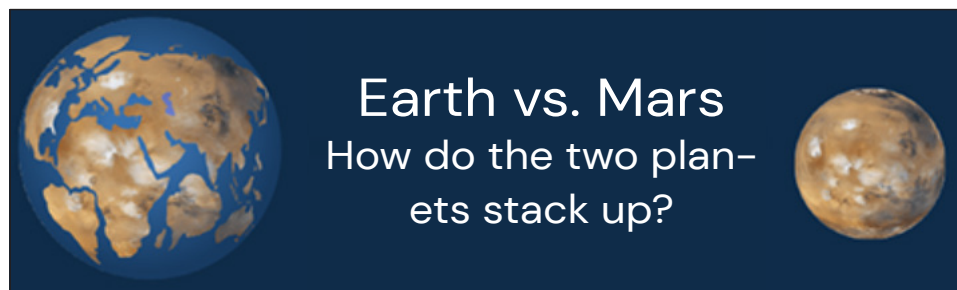
Humans would also have to bring their supplies with them, further complicating human exploration.

"This [bringing supplies] increases the mass that has to be flown to Mars, which also makes landing more difficult because it takes more energy to soft-land," Schlute said.

Another pressing concern that scientists have to take into consideration is the time that it takes to get to Mars. For reference, it takes roughly 8 months for a spacecraft to efficiently reach Mars, while Apollo 11 took three days to get to the Moon.

"The astronauts have to be ok with being in a closed environment for the duration of the trip to Mars," Schlute said. "During the transit, there is a higher radiation environment in space versus being inside Earth's magnetic field."

The more that technology increases, the more and more the idea of settling on Mars comes closer to reality. Colonizing other planets could solve overpopulation on Earth while



Earth vs. Mars How do the two planets stack up?

7926

1.00

160

1.00

23:56

1.00

N/O₂

78/21/1 other

57/14

Fahrenheit/Celsius

365

1.00

93,000,000

1.00

Size

Diameter in Miles

Weight

Effect of Gravity in Pounds

Day

Length in Earth Hours:Minutes

Atmosphere

Composition of Elements (%)

Temperature

Averages

year

Length in Earth Days

Distance

Average Distance from Sun in Miles

4220

0.53

100

0.63

24:37

1.03

CO₂/Ar/N

95/2/2/1 other

-81/-63

Fahrenheit/Celsius

687

1.88

142,000,000

1.53

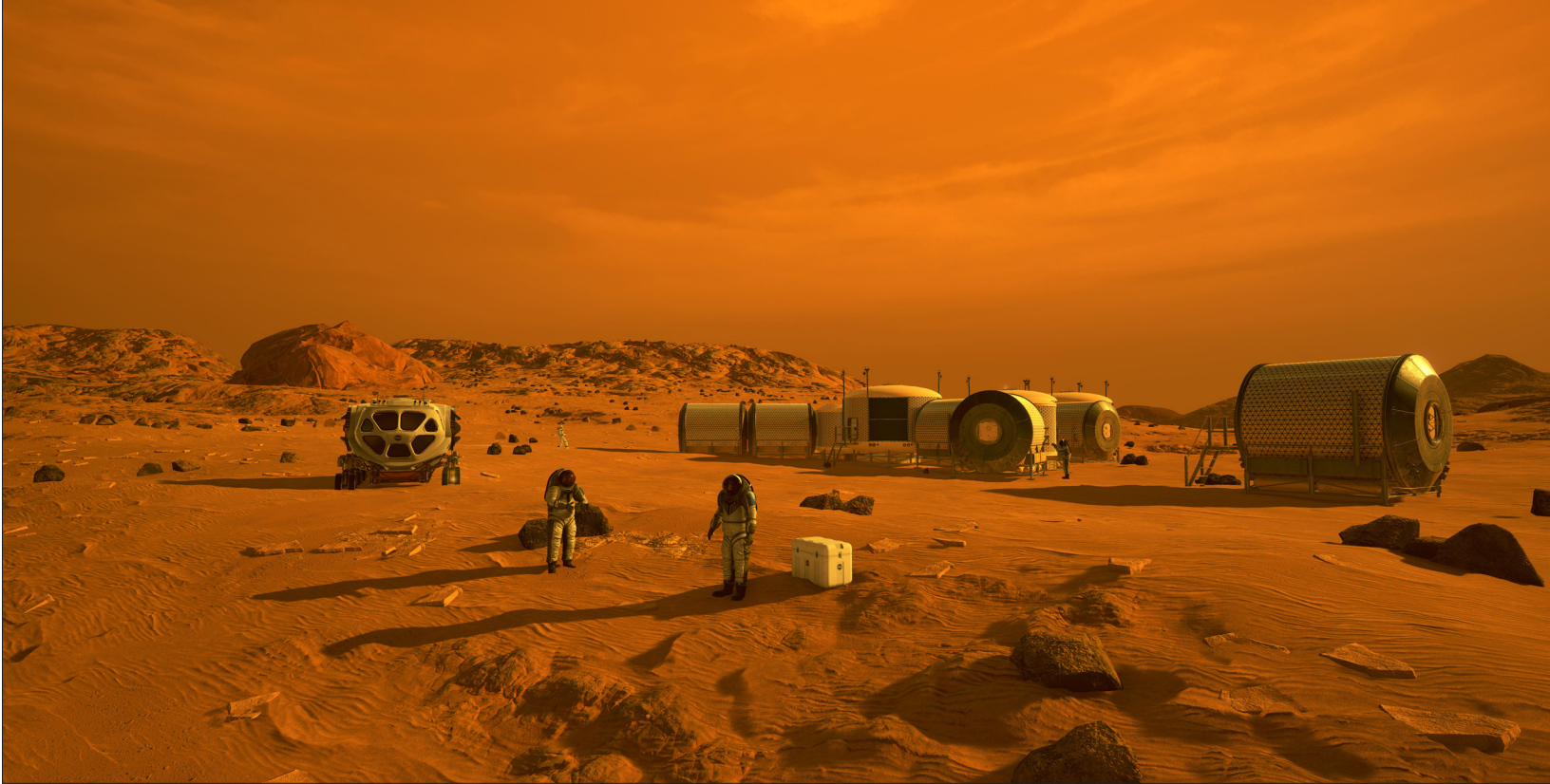
With all these challenges, some

people are considering robots for the mission, but they carry their own host of problems.

"For robotic missions, we worry about a lot of the same things, except of course having to keep humans alive," Schlute said. "We have to deal with the atmosphere and make sure our landing systems are capable of soft-landing the mass we have sent."

This doesn't mean that robotic missions are not an option for getting us to the point of Mars habitation. NASA has been conducting these robotic missions since the 1990's. In fact, these missions could be paving the way to landing the first humans on Mars.

"Our robotic missions to Mars have been very successful recently," Schlute said. "These missions have also provided a lot of great information and data relative to landing on Mars,



which human missions can take advantage of.”

Among other potential problems, NASA and other space programs require plenty of stable funding.

“We have a long way to go, but as you note, we are making progress,” Schlute said. “Much of this depends on our funding level and whether that continues in the future.”

Furthermore, the location of a potential colony also matters. Choosing the polar caps would give the colony a supply of water but expose them to low temperatures while situating it in the desert would require expensive water reclaimers.

“My opinion is that wherever we find the most resources that are relatively easiest to obtain (water primarily, but also shelter) would be the best place to start,” Schlute said, “but we are still investigating where that would be.”

While the risks are high so are the rewards. There would be far more doors opened in terms of space exploration because of its lower gravity and geological resources.

“If a colony could be established on Mars with enough materials to make it self-sufficient,” Schlute said. “It obviously is easier to launch from Mars because of the lower gravity.”

As for us regular humans that might not get the chance to venture up into space, we could wonder what companies are doing to make space travel more affordable for the common folk.

“One of the big things companies are doing is making it a bit less expensive to get to space,” he said. “I do think that a lot of these companies have not paid enough attention to the challenges of human space flight in particular though.”

Hopefully, the developments that are being

made to land on Mars would help in developing cheaper technologies.

“While companies’ activities may eventually increase our chances of getting humans to Mars, and perhaps staying there, we still have a long way to go.” ■

- ^ Above- Concept of first astronauts and human habitats on Mars
- Below- Atlas V-541 launch vehicle
- ✓ that took the Curiosity Rover to Mars on November 26, 2011



DEFINE ME

Spacecrafts are classified into seven classes. Which are the most impactful ones for the goal of making Mars habitable?

Lander spacecraft: designed to reach the surface of a planet and survive long enough to send data back to Earth. The Mars Pathfinder, which landed on Mars in 1997 collected atmosphere, interior and soil data. (NASA)

Penetrator spacecraft: designed for crash-landing on the surface of a body, surviving the impact, measuring, and sending the properties of the surface. The Deep Space 2 launched in 1999 was supposed to contact Mars, but was not heard from after launch. (NASA)

Rover spacecraft: designed for various purposes from taking images to collecting samples for return to Earth, they are electrically-powered, semi-autonomous and steerable from Earth. The Sojourner rover helped the Mars Pathfinder collect samples. (NASA)



Build the future in your home

Computers can cost a fortune. But not if you make them yourself.

■ **Story** by Alex Geng, Thomas Phillips ■ **Photos** by Evan Lai

Personal computer (PC) technology continues to improve each year, with new graphics cards, motherboards, and CPUs coming out each year. Sophomore James Singhal knew he wanted to build a PC when he realized the possibilities when it comes to gaming. But despite these new innovations, building your own custom PC is still more accessible than ever.

Many St. Mark's students have decided to build their own PCs for gaming, content creation, or even just school work. The advantages of building your own PC seem enticing: from cheaper costs to higher frame rates during games. With all the advantages, is building a PC worth it for everyone? Singhal says building a PC was a great way to get more into gaming.

"My friends were playing video games on consoles, but I really wanted to try playing video games on a computer," Singhal said. "But you had to build your own computer to play games

on it. Micro Center is a store in Dallas that has a 'Build Your Own PC Section', and the store tenants there will help you choose the right components and help you build your own computer. So the summer after fifth grade, I started building my own computer."

Building your own PC for gaming

has become increasingly popular in the past few years, but getting started isn't always easy. Sophomore William Fitzpatrick says he had to save up money for parts before he could start building.

"I started building my own PC probably back in seventh grade," Fitzpatrick said. "A few of my friends were building PCs so I decided to try it out. I thought, 'that seems like a fun idea.' And at the time, I liked playing video games and all that, and I wanted to play PC games.

So I decided I'd try building a PC. But it's not cheap, and I was only in seventh grade, so I had to accumulate all the money, which took three months probably. Then, actually making the list of all the parts was one week and then building it was another four or five hours."

Junior Rikhil Manduva says building your own PC isn't just useful for gaming.

"Building your own PC is useful for 8K videos, editing videos, simulations, and anything else that requires higher graphics power," Manduva said. "The two biggest things about custom PCs are more aesthetics and more performance. It comes down to the individual's education on the subject. But by buying the right parts, a buyer can maximize the bang for their buck. When Walmart released overpowered PCs, they were using cheaper versions of the components they were claiming to use. Pre-built PCs generally have lower performance and unnecessary bloatware. Building your own PC can save you money and give you a better end result."

> Left and Below- Justin Kim's PC is currently under construction.

Before he got started building, Singhal says he had to research online to find the right components because there's a wide range of price points.

"There can be some really cheap components that will fail after a year or two, but there are really expensive components in the thousands of dollars that will have great performance and won't fail quickly," Singhal said. "And it took me a while to find the right price point where I could afford it, but it wouldn't fail very quickly, and the computer I have is lasting so far for five years, so I think it's working pretty well."

With so many sites claiming to

offer the best components, it can be hard to know where to look, but online resources are a good place to start to research which parts to buy.

"I mainly went on YouTube. That was probably the best option because there are videos online that actually show you how to do it and instead of just you reading stuff and figuring it out for yourself," Fitzpatrick said. "I would decide which parts to buy by looking at benchmarks for certain components, seeing how they performed in different games that I was going to play, and comparing the different price points."

New innovations in PC components every year give PC builders the modularity to upgrade and build extreme computers with top-quality parts. Senior Justin Kim is passionate about computer hardware, and rather than upgrade his computer with new parts, he generally builds a new computer to house the latest innovations.

"I prefer to build new computers than to upgrade my existing one, as new parts come out each year with each one bringing a whole new set of features," Kim said. "Let's say you want to upgrade your CPU. Intel CPU's essentially force its users to upgrade multiple components simultaneously, which can cause upgrades to be rather pricey. AMD, on the other hand, takes a more consumer-friendly approach and often only requires the old CPU to be swapped with a new model. However, recently, they have introduced newer features in motherboards, leaving those with older computers unable to take advantage of such features upon upgrading to a new CPU."

Companies are starting to take

into account the different uses for PC's which are not limited to only gaming and content creation. The variety of uses for a PC have garnered interest from people to build their own

PC's, rather than have to buy multiple machines and consoles to accommodate both gaming and work.

"I think that as people want to spend more and more money, they can spend \$2,000 on a PC that they can use for not only gaming but also working and content creation. You can't use a console for office work or other work. And so I think many more gamers want to use one machine," Singhal said. "And I think a lot of the



Junior Rikhil
Manduva

**Building
your own PC
can save you
money and
give you a
better end
result."**

PC building comes from people wanting to save money because you can save the two hundred dollars of labor that you might spend on a pre-built computer by building your own. So I think the DIY community has really influenced more people to start building their own computers."

With so many new components available and information being more accessible than ever, PC building is a great way for students to explore technology and try something new.

"Getting into the PC building world is rather simple," Kim said. "There are tons and tons YouTube channels like LinusTechTips and forums like Tom's Hardware or Reddit on the internet that go through virtually every single aspect of building a computer, from how to choose parts and put them together to how to overclock said parts to get that last bit of performance out of a graphics card, for example. I'd say that building a computer is as simple as building a Lego set once you've done the proper research." ■



2019 Nobel laureates in the fields of science

■ **Story** by James Shiao ■ **Graphics** by James Shiao
■ **Extended Reporting** Paul Sullivan and Rishab Siddamshetty

Introduction

What exactly earns a scientist a Nobel Prize? The Peace Prize is given to outstanding activists and people who defend others' rights or fight for the wellbeing of those in need, but what constitutes a significant achievement in the sciences?

The will of Alfred Nobel, the wealthy inventor who posthumously founded the Nobel Prize, does not seem to provide a sufficient answer for a scientist's importance.

"My remaining realizable assets are to be disbursed," his will says. "One part to the person who made the most important discovery or invention in the field of physics; one part to the person who made the most important chemical discovery or improvement; one part to the person who made the most important discovery within the domain of physiology or medicine."

If the original founder's instructions are this general, then how are the prizes awarded? Looking at the laureates of this year's Nobel Prizes in Physics, Medicine, Chemistry and Economic Sciences, the answer can be summarized in one word.

Impact.

From the theoretical discovery of exoplanets to methods of increasing access to education for the impoverished, these Nobel Prize winners have shown how their achievements have shaped the world.

Nobel Prize in Physics

The Nobel Prize in Physics was awarded "for contributions to our understanding of the evolution of the universe and Earth's place in the cosmos," as read on the Nobel Prize's website. The award was divided into two halves, one given to James Peebles and the other given to Michel Mayor and Didier Queloz.



Peebles, a Canadian-

American astrophysicist and astronomer, currently teaches at Princeton University. Peebles won his Nobel Prize for discovering that the cosmic microwave background's radiation could identify dark energy and dark

matter.

"James Peeble had revealed how, by looking back in time at the cosmic microwave background radiation, a radiation which has been travelling toward us for almost 14 billion years, in that radiation you can read off the contents of our universe," Ulf Danielsson, Member of the Nobel Physics Committee, said.

In addition to this theory, Peebles has made many noteworthy contributions in the areas of primordial nucleosynthesis, dark matter and the formation of galaxies and other structures in space.



The other half of the

Nobel Prize in Physics was given to two scientists, Swiss astrophysicist Michel Mayor and Swiss astronomer Didier Queloz for their discovery of an exoplanet that orbited a solar-type star.

Mayor currently teaches astrophysics at the University of Geneva's Department of Astronomy. He has made considerable contributions in astronomy but focuses on finding other habitable planets like Earth.



Queloz, who won the

award concurrently with Mayor, serves as a professor at the University of Cambridge. He and Mayor's discovery championed a field of star detection using various astronomical techniques.

"If you look at a star and carefully measure its color, you can see that the star is wobbling along the line of sight," Danielsson said. "Then you can calculate the effect of a planet which is doing that. That was the technique created and used in this particular case."

Nobel Prize in Chemistry

While the lithium-ion battery has been around since the 1970s, the Nobel Prize in Chemistry is awarded to three figures who contributed to its beginning stages of development: John Goodenough, M. Stanley Whittingham and Akira Yoshino.

Currently, lithium-ion batteries power almost all portable electronics that people use on a daily basis.

"The benefit of this battery is that it actually enables the revolution of the mobile world," Olof Ramström, member of the Nobel Chemistry Committee, said.



Whittingham is a pro-

fessor of chemistry and Director of the Institute for Materials Research at Binghamton University. Whittingham first started work on the battery during the 1970s energy crisis by researching ways to achieve fossil-fuel-free technologies.

He found that the compound titanium disulphide made an effective cathode, a negatively charged terminal through which electricity can enter a device that could house lithium ions. The anode, or a positively charged terminal, was partially made of metallic lithium.



Goodenough, professor

of mechanical engineering and materials science at the University of Texas at Austin, believed that the cathode could be improved by using a metal oxide over a metal sulfide and found that cobalt

oxide could be a better anode to house lithium ions. This was a breakthrough that led to more powerful batteries.



Yoshino is a professor

at Meijo University in Nagoya. Using Goodenough's cathode, Yoshino created the first commercially-viable lithium-ion battery in 1985. He replaced the metallic lithium inside the anode with a

material made of carbon. The product of this was a light, durable battery that could be used many times before losing its effectiveness.

These batteries resulted in a wireless revolution, empowering many of the devices we use now in our daily lives.

"Lithium-ion batteries are now dominant and are really enabling the renewable energy situation," Whittingham said in his Nobel lecture. "What energy storage is going to enable is renewable energy that is cleaner, more sustainable, and allows us to mitigate global warming."

Nobel Prize in Medicine and Physiology

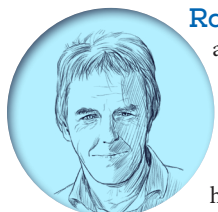
The 2019 Nobel Prize in Medicine was given to William G. Kaelin Jr., Peter J. Ratcliffe and Gregg L. Semenza for their discoveries of how cells sense and adapt to oxygen availability.

"The prize is for sort of a thermostat for the oxygen levels or a damper that you'd have on your furnace to let in more or less oxygen at any given time so that the flame burns just right," Randall Johnson, Member of the Nobel Medicine and Physiology Assembly, said.



Kaelin, currently a pro-

fessor at Harvard University, utilizes a lab there to study tumor suppressor proteins and continues to make contributions in the field of oncology. He spoke about his work on sensing oxygen usage in von Hippel Lindau disease, a tumor-suppressor gene which is mutated in a cancer syndrome, in his Nobel lecture.



Ratcliffe is a physician

and scientist. He was trained as a nephrologist, a doctor who specializes in kidney treatment and medicine. His primary focus is renal oxygenation, and he and his team uncovered a process that animal cells use to measure oxygen

that was disrupted in numerous tumours. This process is known as "hypoxia" and its discovery is the reason that Ratcliffe was awarded the prize.



Semenza is a professor

at Johns Hopkins College. Semenza has made contributions in radiation oncology-- the treatment of tumors using targeted radiation, a typical alternative to chemotherapy-- as well as the studies of biological

chemistry, medicine and tumors.

"This discovery affects people's lives because it is already helping people develop new medicines," Johnson said. "Finding different ways to influence this fundamental process has already shown itself to be potentially very useful in medical applications."

While animals use oxygen to make food and energy for their body, scientists did not understand how cells alter their conditions to work with oxygen until this discovery. These scientists discovered how molecules help regulate gene activity in the presence of oxygen and how oxygen levels affect cellular metabolism and physiological functions in the body.

"For example, if you want to increase the levels of your red blood cells, you want a signal to tell your body to make more blood cells," Johnson said. "A drug that can raise the levels of this can trigger new blood cell production."

Their work has furthered many branches of medicine and has paved the path to find treatments for cancer, VHL, and for anemia--a condition in which the blood has a reduced ability to carry oxygen.

Timeline of the Nobel Prizes in the Sciences

1901- First winners of the Nobel Prize

1903- First woman to win is Marie Curie

1915- First year with no prize in Medicine

1916- First year with no prize in Physics or Chemistry

1939- 3 German scientists are unable to receive the prize due to WWII

1962- Linus Pauling wins a prize for Chemistry, then one for Peace

1969- First year the Economic Science prize is awarded

2009- Total of 5 women win Nobel prizes

Nobel Prize in Economic Science

The Nobel Prize in the Economic Sciences was given to three people for their scientific experimental approaches to solve a major global issue: poverty.

Abhijit Banerjee, Esther Duflo, and Michael Kremer were honored with the 2019 Nobel Prize in Economics for their work enhancing the world's ability to combat poverty. Essentially, what they have done is divide the issue of poverty into smaller, easier to handle questions that are best answered by specific experiments on those in poverty. As a direct result of their studies, more than five million Indian children have access to remedial tutoring and education in schools.

"This prize is about a new approach in development economics," Jakob Svensson, member of the Prize Committee for Economic Sciences, said. "It's an approach that helps us better identify ways or policies that we can use to reduce global poverty."

When asked to explain the technique, Svensson used a metaphor: to find the causes of poverty in a particular place, the technique has an economist first ask broad questions and narrow down the questions as he/she answers them with more and more detail, so that he/she can use empirical reasoning to deduce the causes and effects leading up to poverty.



Kremer is an American

development economist and the Gates Professor of Developing Societies at Harvard University. In the 1990s, Kremer found just how effective this technique really is, conducting experiments with the intent to test different methods for improving school results in Kenya.



Banerjee is an economist

and is currently the Ford Foundation International Professor of Economics at the Massachusetts Institute of Technology. Borrowing from medical research, Banerjee implemented field experiments to great effect in the fields of economics

research.

"Field experiments, sometimes known as RCTs (randomized control trials), look at interventions to the comparison of random treatment of control groups-- people who are randomly chosen to get an intervention and people who are randomly chosen not to get an intervention, to compare them to know what impact the intervention had," Banerjee said.



Duflo is a Professor of

Poverty Alleviation and Development Economics at the Massachusetts Institute of Technology. Like Kremer, she performed studies of issues related to poverty. The two economists' methods are now widely used within the field of development

economics.

The work of these laureates has improved the ability of the world to fight poverty. Their findings haven't only helped relieve poverty today, but they also offer a great possibility to further improve the lives of those in need. ■

Humpback Anglerfish

Species name: *Melanocetus johnsonii*

Size: varied

Female anglerfish are large (15 cm), ambush predators while males are very small (3 cm) and are not predatory. Males spend all of their energy searching for mates, biting onto them, and fertilizing their eggs. Unlike other anglerfish, this union is temporary.



Our final section, the Aphotic section, explores the deepest parts of science that many of us do not know about or understand. It is our goal to shed light on these varied yet interconnected topics that can give us a new perspective on the world or potentially shape our future.

A-PHO-TIC

depths of oceans or lakes beyond which less than 1 percent of sunlight penetrates, extending to the bottom of the body of water

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around the clock

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Our first invaders are 60
not extraterrestrial

Gene editing: current 62
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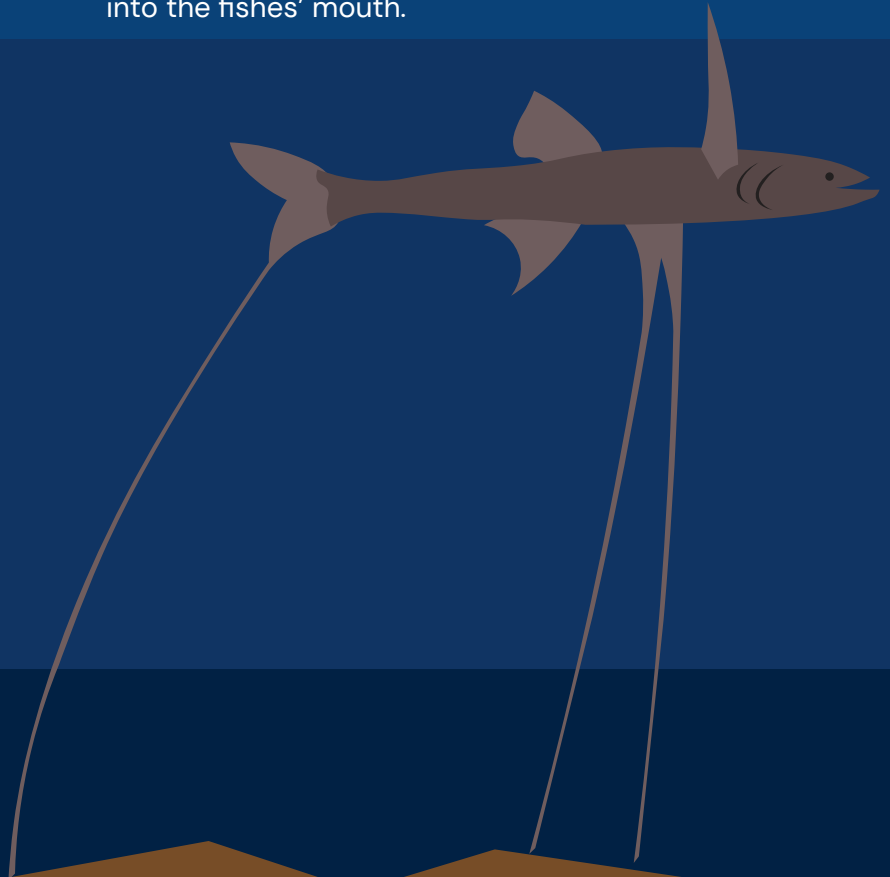
Quantum computing: 64
the tool of the future

Tripod Fish

Species name: Bathypterois grallator

Size: 35 centimeters

Tripodfish have long, bony rays that stick out below its tail fin and both pelvic fins, which they use to find food. The front fins can knock food into the fishes' mouth.



Hydrothermal Vent

Temperature: 60 to 464°C

Black smoker vents emit particles with high levels of sulfur, while white smokers emit lighter-hued minerals, such as barium, calcium and silicon. Both types coexist in the aphotic zone, and they form ecosystems of bacteria and microorganisms.



August 14th, 1912. Rodney and Otamatea Times, Waitemata and Kaipara Gazette: “Coal Consumption Affecting Climate.” The section reads, “The furnaces of the world are now burning about 2,000,000,000 tons of coal a year... This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.”

More than a century later, climate change is a widely discussed topic with an extensive political footprint. Leaders from around the world meet in UN Climate Change Summits, the most recent held in Madrid in December 2019, to discuss limiting carbon emissions to avoid permanent damage to the earth. As climate scientists and political activists debate on the urgent timeframes of permanent damage, another question lies in the background: What is being done? ►

Algae: A new secret weapon to combating climate change?

As awareness of the protection of trees increases, a new method of producing fresh air is on the rise.

■ **Story** by Alex Geng and Varun Trivedi ■ **Graphic** by Varun Trivedi

Trees are becoming less and less sustainable as time passes. With the constant problem of deforestation, ecosystems, mostly in cities, have already adapted to the lack of trees, so planting trees as quickly as possible would not be a viable option. While foresting areas could potentially increase the air quality and serve as a solution to climate change, there are problems. A World Research Paper brings up the fact that planting trees could displace land that would be used for

agricultural means, which could drive food prices up. They predicted that up to nine gigatons of carbon a year could be removed, but food prices would in turn be raised 80% by 2050. Even with current technology, it is hard to monitor and control the growth of so many trees at once, and funding is also an issue.

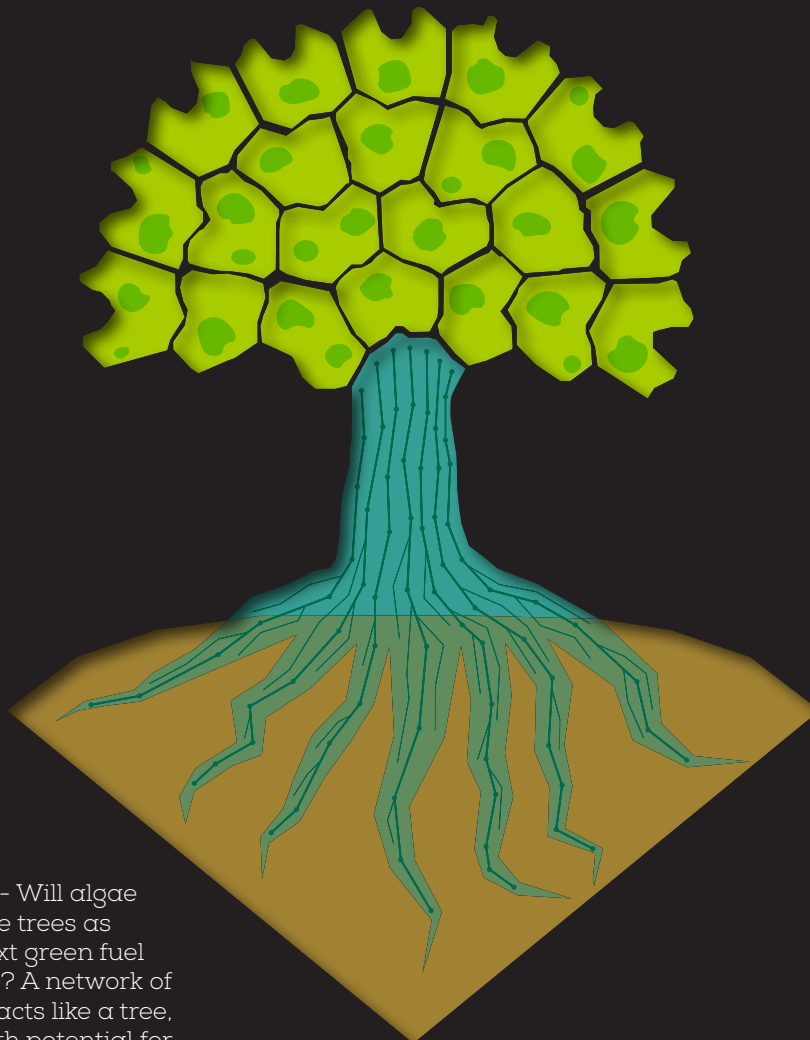
Algae has the potential to fight climate change because a variety of uses, while being very easy and sustainable to grow and harvest. Algae can be grown in bioreactors,

which are cultivation vessels that enable chemical reactions within the algae. With an AI-powered bioreactor, algae can be 400 times more efficient than trees at removing carbon from the air. Using algae is also much easier to control because of its relative size, and it grows at a much faster rate than trees do.

Algae does not only serve as a carbon sequestrator, however. Algae can also serve as a very rich source of food as algae oil, which can be turned into supplements. It is less water and land intensive than other similar foods, and could be a viable food staple in the coming years. Algae can also be made into a 3D printer polymer, substituted for the typical plastic filaments. Using the algae as raw material dramatically cuts down the amount of pollution and emissions that would be produced if made with plastic. Major companies like Merrill, Adidas, and H&M have already used algae foam for shoes. Another viable commercial use of algae is biofuel. Using algae is much more sustainable than using other carbon-based fuels like petroleum. However, the process is still very early in the works and requires a lot of effort and cost to be able to produce today.

One company which already started research and development of harnessing algae to convert carbon dioxide into oxygen sustainably as well as provide fuel for daily use is Hypergiant. Their EOS bioreactor is focused around obtaining the biomass from algae to create fuels, food sources, oils, and more. The harvesting system is completely AI based to ensure that the optimal amount of algae is used to convert carbon dioxide into oxygen, and Hypergiant claims the reactor can take in 60-90 percent of CO₂ to convert into oxygen.

Obviously, fully switching to algae will be a long, slow process with many challenges. Making big changes will no doubt be very difficult, as consumers and companies alike will need incentive to switch. However, with the growing climate change crisis, it may be necessary in the future to switch from the idea of planting more trees to harvesting more algae and utilizing the world's oceans and lakes. ■



> Above- Will algae replace trees as the next green fuel source? A network of algae acts like a tree, but with potential for a stronger impact than planting trees.

Even as of the 21st century, climate change has already impacted our economy in major ways. The media attention on the climate increases day by day, and new programs are developed to help manage climate change. Faculty member David Fisher says climate change will inevitably have an effect on the economy.

“Over the course of time, is there going to be an economic effect that results from climate change? Yes.”

What this effect may look like for the posterity of America, nobody knows with certainty. However, Fisher believes that the results will be noticeable in our daily lives.

“In everybody’s lifetime, we’re going to experience more days in which the temperature will go over 120 degrees, more days in which we’re hit by tornadoes, because of the climate. The weather is that much more unstable.”

Fisher goes on to cite examples of conspicuous results of climate change: “Food prices are likely to go up. People’s travels are likely to be hampered by the fact that you’re going to be taking into account the uncertainty of weather patterns, and so forth.”

As of now, if left unattended and unchecked, Fisher believes climate change will have a big toll on our economy in the future.

“If we do nothing, if there really is no adaptation, will climate change result in negative effects for the economy? The answer is yes. If we just take agriculture, for instance, there is likely to be a net loss of production as a result of climate change. Yes, certain parts of the world might be able to produce more, but there will be significantly more parts of the world that produce less as a result of desertification and increased crop diseases.”

However, Fisher believes we can mitigate and eventually prevent some of the effects of climate change. He suggests an interesting idea: a carbon tax.

“A place to start is where most economists want to go, which is with a tax on carbon. It is the most efficient way of dealing with what we know to be the negative effects of carbon. The reason economists prefer it is you are essentially putting a price on carbon. You are letting people know that when we do things like drive a car, we are not only getting a benefit out of

The future of climate change: an economic analysis

Climate change has the potential to impact multiple facets of the economy.

■ **Story** by Alex Geng and Varun Trivedi

■ **Photos** by James Shiao

driving a car but also creating a negative, pollution”. This global warming will lead to harmful effects for the planet.

This method of taxing carbon generates awareness for the public and gives people a decision to make—whether or not to trade time and energy for the cost of using carbon-related items. Of course, many different propositions as to how to implement these regulations for the public to cut down on emissions to better save the climate exist. One thing remains constant: we have to take it slow.

“We have an economy. We have industries. We have lines of work and employment that are all geared to the carbon economy. Shifting away from the carbon economy is not going to happen overnight. Nor would I propose that it does happen overnight because that would be a tremendous blow to our economy.”

Today, companies that are

switching to alternative energy sources and promoting the transition away from harmful emissions are thriving. One such example of a successful company is Tesla.

Tesla’s growth as a company exceeded almost the world’s expectations, as it grew so fast in such a short amount of time, all while going against the established norm. Its success in creating electric vehicles is unprecedented in our time.

Of course, alternate energy companies still have room to grow. Even in Texas, alternate energy companies continue to grow and expand.

“In Texas, wind farms are big. Companies are making profits from marketing solar panels. Let’s do more of that. But we have to encourage those companies. We have to create an environment in which those sorts of businesses can be profitable. This is where I do see some sort of a role for government.”

Today, we hear many advertisements on doing our own part individually to help protect the climate. However, Fisher presents a different viewpoint.



▲ Above— A solar panel cell on average generates alternate energy upwards of 265 kilowatts per hour per square foot. Left— Wind energy is used in coastal places like Hawaii for sustainability.

“If you choose not to fly on a plane, you’re doing your bit for the environment. On one level, on a moral level, on an awareness level, sure that’s doing some good, but in the grand scheme of things, that’s doing very little. If we really care about the environment, that has to happen at the level of government”.

Fisher believes government intervention is absolutely necessary for regulating climate change and keeping our economy on track.

“The government always intervenes in the market. We usually want the government to intervene if there’s such a thing as market failure. The very existence of pollution is evidence of market failure. It means that nobody really knows the price of that pollution”.

To resolve these issues, one way Fisher proposes awareness for climate change for everyone is location-based taxing.

“You can have different tax rates depending on where you live, you can have a tax on miles that you cover as opposed to the fuel itself, right, which would be a different way of looking at it. You can have differential taxes depending on the type of vehicle that you have.” ■



Utilizing electrocatalytic CO_2 reduction to produce clean fuel

The increasing ability to transform a pollutant into an energy source can change how we use electricity.

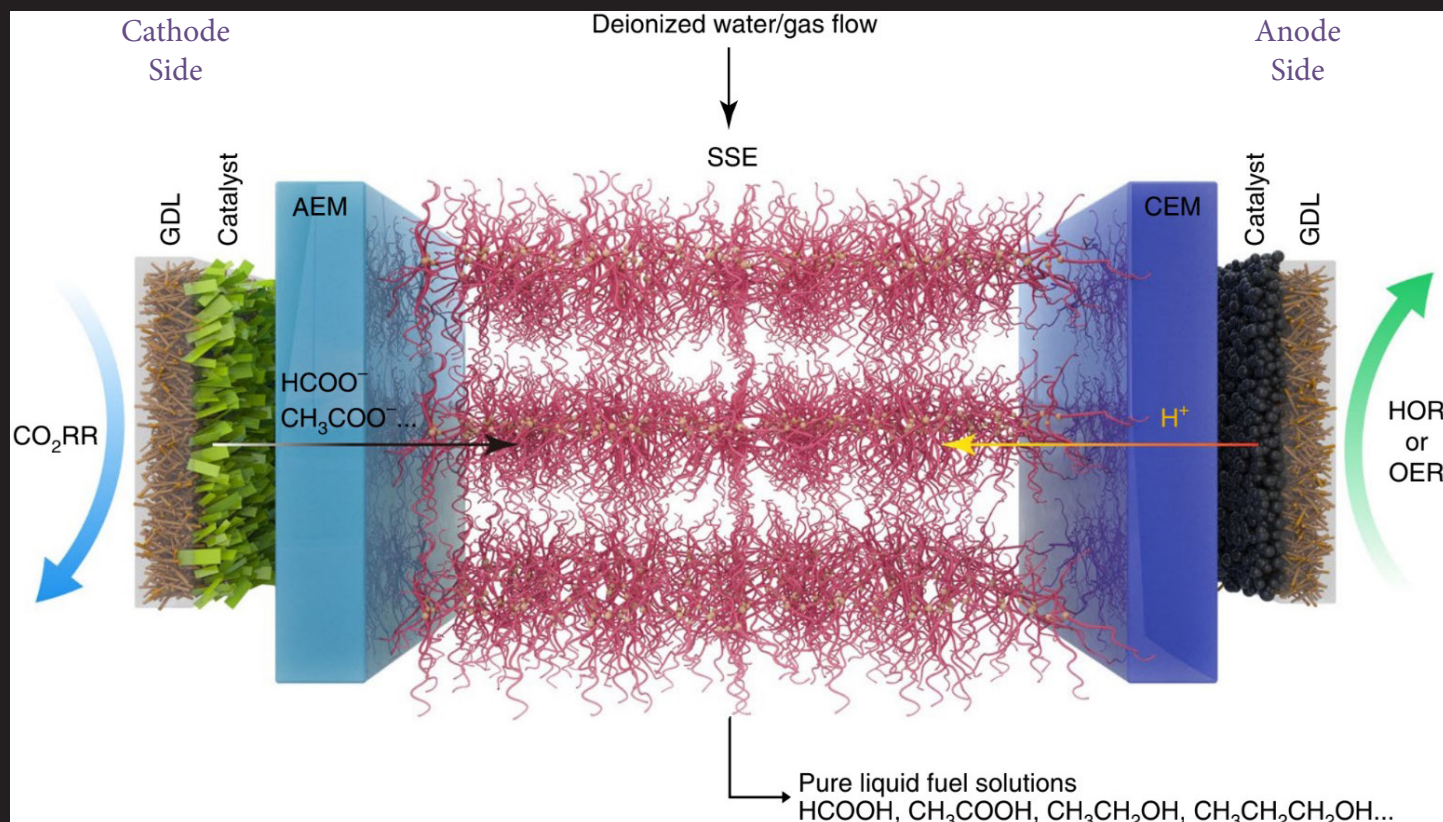
■ **Interview** by Varun Trivedi and Alex Geng
■ **Chart** by Jeremy Yu ■ **Graphic** courtesy of Dr. Chuan Xia

One of the most frequently talked-about topics regarding climate change pertains to carbon emissions and the effects of carbon dioxide released into the environment. Research shows that CO_2 trapped in the atmosphere has led to increased global warming, differences in climate patterns, rising sea levels, and more. Lately, scientists have been attempting to capture the CO_2 and convert it into some sort of fuel source. Until recently, no ways of capturing and reusing carbon dioxide to reduce the impact of carbon emissions on the climate were sustainable commercially.

Just last year, a technological breakthrough made by professor Haotian Wang, Postdoctoral Fellow Chuan Xia, and their team from Rice University changed all that. Wang's research at Rice deals with how to recycle greenhouse gases into usable substances. The original idea: change unusable carbon dioxide released into our atmosphere into a storable and usable form, formic acid. The innovation: construct a new bismuth catalyst as well as a new electrolyte which increases the efficiency of the reaction, enough to be able to be commercially used.

We spoke with Xia and his team to see the ideas and processes behind his findings. Their work has the potential to impact carbon dioxide emissions in the future.

A Schematic Overview of the Cell and Process



Note: Catalyst-coated gas diffusion layer (GDL) electrodes acted as the cathode and anode of the cell, separated by anion and cation exchange membranes (AEM and CEM). The solid-state electrolyte (SSE) is either an anion or a cation conductor, made up of ion-conducting polymers with different functional groups.

The GDL and HCOOH -selective catalyst reduce the CO_2 at the cathode side, generating HCOO^- . This negatively charged molecule is pushed by the electrical field through the AEM and towards the middle SSE channel. On the anode side, protons generated by water oxidation move across the CEM to compensate for the negative charge. The HCOOH (formic acid) product is formed via ionic recombination between the middle channel and one of the two membranes (depending on the SSE).

Varun Trivedi: Can you give a brief overview of the process? How is it different from other electrosynthesis processes?

Chuan Xia: We used the porous solid electrolyte (instead of a conventional aqueous electrolyte like 1M KOH) to separate the cathode and anode of the reactor. The humidified CO₂ was fed to the cathode and reduced into HCOO⁻ anions. Meanwhile, the H₂O was oxidized into O₂ and protons at the anode. Then, the HCOO⁻ anions and protons moved into the solid electrolyte layer driven by the applied electrical field and recombined into HCOOH molecules, which were flushed out by clean water. By tuning the water flow rate, pure HCOOH solution with a different concentration was collected.

The use of a porous solid electrolyte instead of a conventional aqueous electrolyte avoids subsequent separation processes, making our strategy more energy efficient. Additionally, our new Bi-catalyst makes the CO₂-to-HCOOH conversion process more efficient and stable than before.

VT: What are the implications of this process in the larger context of climate change?

CX: Our strategy can help to recycle the emitted CO₂ in the atmosphere, creating a carbon-neutral future. We can collect the CO₂ from the air and convert it into HCOOH fuel. HCOOH fuel is a promising energy carrier that can be used to power cars, industry plants, etc. The generated CO₂ from HCOOH decomposition can be further reduced back to HCOOH using renewable energy.

VT: How does the cost of creating and maintaining these reactors compare with the positive effects generated by them?

CX: The cost for mass HCOOH production using our reactor is far lower than that using current commercial technology (see the techno-economical analysis in our paper),* helping to reduce CO₂ emissions.

VT: How did you come up with ideas for the bismuth catalyst as well as the newly designed catalyst?

CX: Intrinsically, the Bi-catalyst is favorable for CO₂-to-HCOOH conversion. However, its activity is quite low. By nanoengineering, we developed a new process for kilogram synthesis of the Bi nanosheet catalyst.

VT: How does this process compare to simply planting more trees to use up CO₂ and produce oxygen (in the context of climate change)?

CX: This process is much more efficient than



Rice University Postdoctoral Fellow
Chuan Xia

This process is much more efficient than simply planting more trees."



SHOW ME

The results of Xia and his teams' calculations are as shown in this analysis.

Techno-Economical Analysis

CO₂ reduction to Formic Acid at approximately 200 mA/cm² with HCOOH Faradaic Efficiency of 80%.

Total required current: 6,065,858.4 A

Total electrolyzer area: 3032.9 m²

Power needed: 16.7 MW

Total gas flow: 8589.8 m³/hr

Production costs of central grid CO₂ Electrolysis

Ref. electrolyzer cost	\$991.7/m ²
CO ₂ electrolyzer cost	\$2,789,290
Balance of plant cost	\$1,501,926
Distillation cost	\$5,963,289
Pressure Swing Adsorption cost	\$7,980,731

Total Cost of Production over 3032.9 m² is then \$19,217,059

Operation costs of central grid CO₂ Electrolysis

Electricity cost	\$12010/day
Maintenance cost	\$199/day
Distillation operating cost	\$13,015/day
PSA operating cost	\$1546/day
Water and CO ₂ cost	\$3859/day

Total Operation cost over 1 day: \$30,630

Current HCOOH market price: \$0.735/kg

Yearly Profit: \$15,004,495

Payback time for capital costs = 1.28 years

simply planting more trees. Using electrochemistry, we can not only reduce the excessive CO₂ in the air but also produce value-added liquid fuels. Then, we can create a carbon-neutral energy cycle, e.g. CO₂→HCOOH→CO₂.

VT: How is this process improving? What are some components in it that can be improved in the future to increase efficiency?

CX: Improving the CO₂-to-HCOOH selectivity and stability under extremely high production rate (e.g. 1A/cm² current density) can further push forward this technology. Catalyst, solid electrolyte and membrane design can further increase efficiency.

VT: How long did the research portion take? What were some challenges you had to face when designing and carrying out the production of the reactor?

CX: It took us almost one year to finish the research work. The most challenging part of this work was to design the stable and efficient porous solid electrolyte.

VT: Where did the inspiration for this come?

CX: We were inspired by the chemistry of the solid-state battery.

VT: Do you think that this type of process will become commercial? How would it be integrated into the world/society? How long would the process take, and what barriers would prevent it from becoming a mainstream source of energy production?

CX: We believe that this type of process would definitely become commercial owing to its sustainability. The Tesla electric car is a good example. Using renewable energy to replace fossil fuels is the current trend, and we believe that more and more cases like Tesla will emerge within the next ten years.

Looking to the future, science and technology will only get more and more advanced. To truly help preserve and regulate the climate, however, it is imperative that we use our technology and resources to conquer this challenge. Whether that means an embrace of governmental control, a surge in support for algae and trees, or other innovations like converting carbon dioxide into fuel, the human race must come together to protect this planet we call home. To do so, we must raise awareness, making sure everyone has knowledge of our climate crisis. Only together, with the use of our current and future technology, we can conquer this crisis and make sure the generations to come have a healthy planet to live on. ■

Visiting scientists

We interviewed a visiting scholar and three STEM conference participants to find out more about their work.

■ **Interviews** by Austin Zang, Will Spencer, Michael Gao, James Shiao
■ **Photos** by Ben Hao

Naia Butler-Craig is a member of the Georgia Institute of Technology's High-Power Electric Propulsion Lab and is a NASA Pathways intern in the Science and Space Technology Systems branch at Glenn Research Center.

Austin Zang: How did you become interested in aerospace engineering?

Ms. Naia Butler-Craig: My first time getting exposed to aerospace engineering was in the eighth grade when I took a class called Earth-Space Science. It piqued a huge interest for me around space. I ended up doing research in the eighth grade on what careers included science, engineering, and space. I did a summer camp at Embry-Riddle Aeronautic University in Daytona. My first airplane flight was at that summer camp, which I didn't even know was going to happen. I went home and I was like, "Mom, Dad, I flew an airplane," and they were like, "you mean a simulator?" And then I showed them the video, and they very closely soiled their trousers. I absolutely loved the summer camp and did another one at the other location. I still loved it, and I have just never looked back.

AZ: One of the things that stood out on your background was the sub-kilowatt propulsion. Can you explain that a little more in depth?

NBC: I'll start with electric propulsion, just a super basic explanation. It's ionizing a gas to create thrust. The ions produced from that gas basically accelerate out of the back to produce thrust. You can accelerate them through different mechanisms: there's electrostatic acceleration, there's electromagnetic acceleration, and there's electrothermal acceleration. My focus is electrostatic. The sub-kilowatt electric propulsion, SKEP for short, is a thruster that uses less than a kilowatt of power. The novelty about it is that it's miniaturized, so it can be used for smaller vehicles, like CubeSats, nanosatellites, and something called ESPA-class satellites.

AZ: Can you elaborate a little on what CubeSats do?

NBC: CubeSats are basically nanosatellites. They condense the operations of a traditional satellite, which is about one ton and very ginormous, into a size as small as a loaf of bread. Right now, the furthest a CubeSat has gone is Mars. That was the Marco CubeSat. I believe they'll continue to push the boundaries as people continue to develop them. They're so versatile. I love them.

AZ: What do you think are the best ways to get the young people and the people that you want to reach the most interested in STEM?

NBC: I believe the best way is to just show them: hands-on projects, like workshops. You're not just showing them, and you're not just inspiring them, you're empowering them, too. But, on the other hand, I really don't think we have a deficit of people interested in STEM. I believe we have a lack of ability to retain talent. That can be for different reasons: definitely culture. It can be very homogeneous. I believe as we continue to up our diversity initiatives, we'll be able to retain diverse talent.

Dr. Murat Çobanoğlu is the co-founder of Accelerated Informatics, a company that develops computational drug-discovery



methods in order to accelerate drug development. Çobanoğlu is a distinguished fellow at the Lyda Hill Department of Bioinformatics at the U.T. Southwestern Medical Center.

Will Spencer: What caused you to choose computational biology as an area of study?

Dr. Murat Çobanoğlu: When I was in high school, I realized that computer science held a very strong potential for being important. The advance of computing in the 21st millennium would change everything. I thought I should study something that had that kind of transformative potential. Towards the end of my studies, I started looking at what I wanted to do with my computer science degree. I knew that I wanted to go into research. It was more like, "I want to do a Ph.D., but which field do I want to do a Ph.D. in?" I wasn't really thinking of an industry career at that point. I did an internship in pure, essentially machine learning AI, and I realized that I didn't enjoy that kind of work. That led me to search for these application areas and I got into bioinformatics. Once I realized that any sort of work in this field could potentially lead to drug therapies, I switched to it.

WS: How was starting up your company, Accelerated Informatics, different than your previous work?

MC: That was actually very different than being a Ph.D. student or just doing research. Basically, me and my classmate, Aaron Wise, started out together. One thing we realized is that, up until that point, there was a task that needed to be done: there's homework, or there's a project, or there's a research question, or something, and we just worked on that. But once we started the entrepreneurship route, we realized that there's actually a lot more social networking, and an aspect of getting investments. Most of those things don't necessarily involve any kind of objective metrics. We wanted to do an artificial intelligence-guided drug discovery platform that was robotically operated, and that required a lot of investment. Until we had investments, people wanted to see lab results, but we couldn't get lab results without having a lab, which required an investment. We did some computational work, but they wanted to see lab results. When you're going into entrepreneurship, I think one of the things to be aware of is that you need to carefully think about the specific options and choices that you have access to and their sufficiency.

> Left- Naia Butler-Craig talks about space exploration, Right- Dr. Murat Çobanoğlu explains his work to students in the Science Lecture Hall. Top right- Dr. Jodi Cooley answers questions during her talk about dark matter.

WS: How would you best describe your job?

MC: Basically, my job is to develop computational methods to find cancer treatments. What we do is we try to develop new computation programs to analyze large-scale public data and extract useful, actionable knowledge from that. Once we do that, we then seek to test those drugs. These can be direct human tumors that are extracted for the patient's medical benefit. We have some promising early results in that manner.

WS: What are you most proud of in your work so far?

MC: We have two drug candidates that are showing promising results, so those would be what I'm most proud of. There's one prediction that I made back in Ph.D., that actually got some promising results that I'm very proud of. That was essentially a computation prediction that I made that led to a clinically impactful repurposing, and we'll see how that goes.

Dr. Jodi Cooley is an Associate Professor in the Department of Physics at SMU. In 2018, Cooley was elected as a fellow of the American Association for the Advancement of Science for her contributions to the search for dark matter scattering with nuclei.

Michael Gao: What exactly is dark matter?

Dr. Jodi Cooley: It turns out, if we do an inventory count of the matter content of the universe, only 15% of the matter is ordinary matter, and 85% of it is some kind of matter that we haven't been able to detect yet. We call it dark matter.

MG: How do we know dark matter exists?

JC: The reason that we know it exists is through astronomical observations of structures like gal-



UTSW
Distinguished
Fellow Murat
Çobanoğlu

My job is to develop computational methods to find cancer treatments."

axies. Back in the early 1970s, a scientist named Vera Rubin had done a study of the rotation of spiral galaxies. You would expect that stars near the center [of a spiral galaxy] to be moving faster than the stars at the edge of the galaxy. That's because of gravity, which affects the rotation and velocity of those stars. And so, when she made those measurements, it turned out they were moving at the same rate. What that tells you is that there must be some extra matter that is adding extra gravity and causing the system to rotate at this speed.

MG: What got you interested in dark matter?

JC: I did my graduate Ph.D. work in neutrino physics, and I actually worked on a neutrino telescope. That was buried in the ice at the South Pole. After I got my Ph.D., I was thinking about what types of projects I could work on where I could adapt my skills and the things I learned in graduate school. I wanted to continue working in neutrino physics, but also in dark matter as well because these two fields have similar problems. To me, the excitement of being able to discover something that we didn't know about seemed very exciting.

MG: What is an average workday like for you?

JC: I have two aspects of my duties. One is teaching students in either the undergraduate or graduate level in a classroom. The second aspect is the research. I have a group of students and postdocs doing research at my university that I have to supervise. I have three graduate students, one postdoc and three undergraduates right now working with me.

Dr. David Shoemaker worked on interferometric detection of gravitational waves in the early 80s. He then led the Advanced LIGO Project, which made the first detection of gravitational waves in September 2015. He was elected for a 2-year term as Spokesperson of the LIGO Scientific Collaboration in 2017.

James Shiao: As spokesperson for LIGO, were you more focused on the business, scientific or engineering side of the project?



Dr. David Shoemaker: So the collaboration was 1300 people or so. About a third of them dealt with making the instrument better, either by working directly on it or working on ideas. About two thirds of the people work on understanding the signals, writing papers about that, and so on. One of the challenges for me as a spokesperson was to understand the issues involved in doing astrophysics. Fairly shortly after I took on the role, the most important discovery that we've made to date was observing a binary neutron star coalescence. And that didn't require any work on the instrumental side. But the challenges on the astrophysics side were immense. So I have to say that most of my time, in fact, was not spent with the instrument but rather with the science.

JS: Is there a major discovery that LIGO has made?

DS: One of the things that Einstein predicted in his theory of general relativity was that gravitational waves and light would travel at the same speed. This event [binary star coalescence] took place about 40 mega parsecs away, which is about 130 million light years, and assuming the gravitational waves and light are emitted at the same time, if they traveled at any different speed, they would have arrived at very different times. They arrived within 1.7 seconds, which means that the speed of light and the speed of gravitational waves is the same to at least 1.7 seconds, over 40 million light years. So it's an extremely good test of that particular part of Einstein's theory.

JS: What's the farthest object you've detected?

DS: The farthest we've been able to see neutron stars is about 200 megaparsecs. Black holes, make much stronger signals. And so the furthest system is something like two gigaparsecs away, which is 2000 mega parsecs away. Still, it's only a fraction of the universe. It's still maybe a hundredth of the universe that we're able to see so far. ■

Maintaining the rhythm around the clock

Our bodies are all governed by an inner clock. When we stray from this clock, the consequences are easily detected.

■ **Story** by Darren Xi, Svanik Jaikumar, Tomek Marczewski

■ **Photo** by Darren Xi ■ **Graphics** by Darren Xi and Svanik Jaikumar

Junior Jack Genender needs sleep to function in school. Taking notes. Focusing in class. Doing well on tests.

But more than just school, sleep helps him maintain his circadian rhythms, bodily cycles that rely on the time-dependent mechanisms found in his body.

“Circadian rhythms are biological phenomena that change rhythmically over the course of the 24 hour day,” University of Texas Southwestern (UTSW) professor Dr. Carla Green. “They include things like activity (sleep/wake) rhythms, eating rhythms, hormone rhythms, gene expression rhythms, metabolic rhythms.”

These rhythms are governed by endogenous, autonomous, and time-keeping “clocks,” which are located in every cell of the body. The master pacemaker, which influences all of these clocks, is located in the hypothalamus of the brain.

On weekdays, Genender gets

anywhere from three to seven hours of sleep. Because of homework loads and stress from school, it is difficult for him to find eight hours of sleep in a single night.

He finds his lack of hours spent asleep affects him significantly during the school day.

“During tests, I make a numerous amount of silly errors, and in class, it is hard to take notes and think,” Genender said. “When I am truly sleep-deprived, my attention span is cut in half, and I have half as much incentive to do anything.”

On weekends, he can catch up on his sleep, getting up to ten hours per night. For Genender, these hours do magical work, removing the

sluggishness and making him happier in general.

But when Genender gets sleep-deprived, his circadian clock, which maintains the circadian cycles, gets offset and leads to hunger and sleepiness, along with other symptoms of general unhappiness, all of which Genender experiences when he loses sleep on weekdays.

“The circadian clocks, which are located throughout the body, control the expression of thousands of genes,” UTSW professor Dr. Carla Green said, “and these rhythmic genes control things like neuron activity, which can drive sleep/wake cycles and rhythmic production of hormones, which can drive hunger and many other physiological responses.”

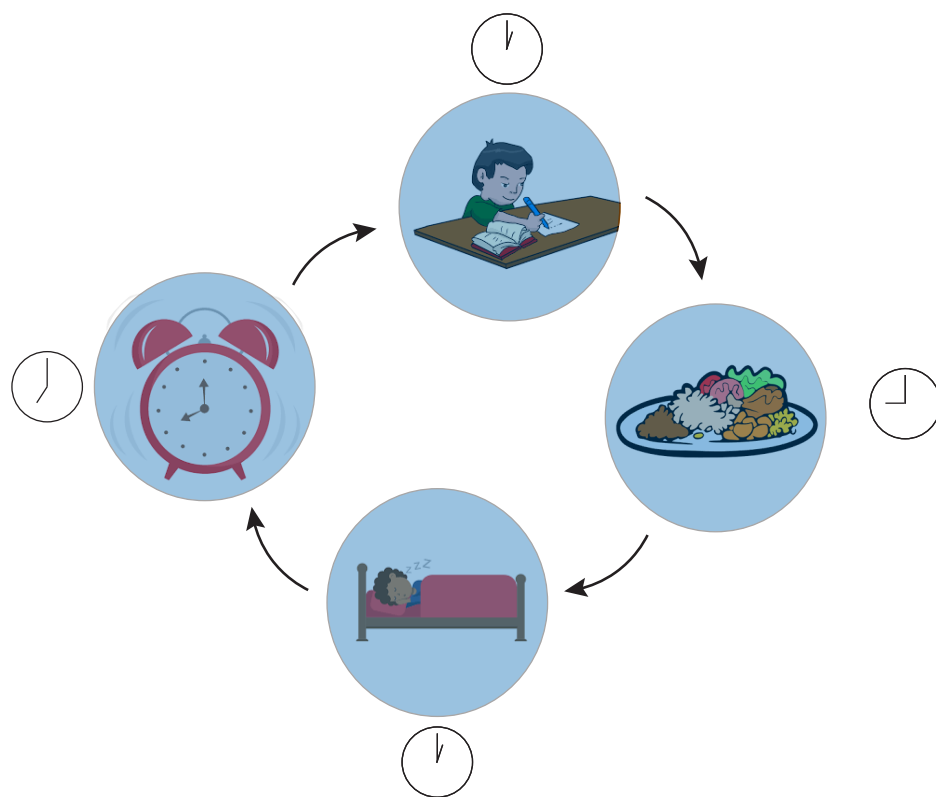
Sleep deprivation isn't the only way the endogenous circadian clock can be disrupted.

“Good examples of disrupted

rhythms are what happens during jet lag or shift work when the endogenous clocks think it is one time but the human's activity, food intake and light exposure is at a different time,” Dr. Green said.

Genender only faces loss of attention and energy when he disrupts his cycle, but larger changes can bring about more significant effects.

“Jet lag and shift work [working during night shifts] are common circadian rhythm disruptions,” UTSW professor Dr. Shin Yamazaki said. “Also, seasonal affective disorder



has been seen in persons living in the northern part of the country during the winter. This is believed to be caused by short day lengths and decreased light intensity experienced during winter.”

And if the disruptions go on for far longer than just two or three days, the effects can become permanent.

“People who shift work to all different schedules for years, or long-distance flight attendants who travel back and forth between hugely different time zones, they can be more prone to certain types of cancer and cognitive deficits,” Dr. Green said.

After disrupting the circadian clock and the cycles, it takes time to readjust. But not



UTSW
professor
Dr. Shin
Yamazaki

Several human disorders are partially caused by the disruption of the circadian clock."

- < Left- Wake, work, eat, sleep... the typical routine for an upper schooler has its own rhythm.
- > Right- Working late into the night can disrupt your circadian rhythm.
- √ Bottom- Everyone has a metaphorical circadian clock in their head.

impeding on the cycles to begin with and keeping the clock constant can be done very easily.

"Having consistent sleep cycles helps keep the body's circadian rhythm robust, which prevents social jet-lag [the body's confusion about when to sleep because of a lack of sunlight]," Dr. Yamazaki said. "Working or going to school early during weekdays, then sleeping in and staying up late on the weekends can cause a circadian disruption. Minimizing this inconsistency helps avoid these effects."

Social jet-lag is a very common effect of disruption, and it includes symptoms similar to jet-lag, like shifted sleep schedules and difficulty concentrating.

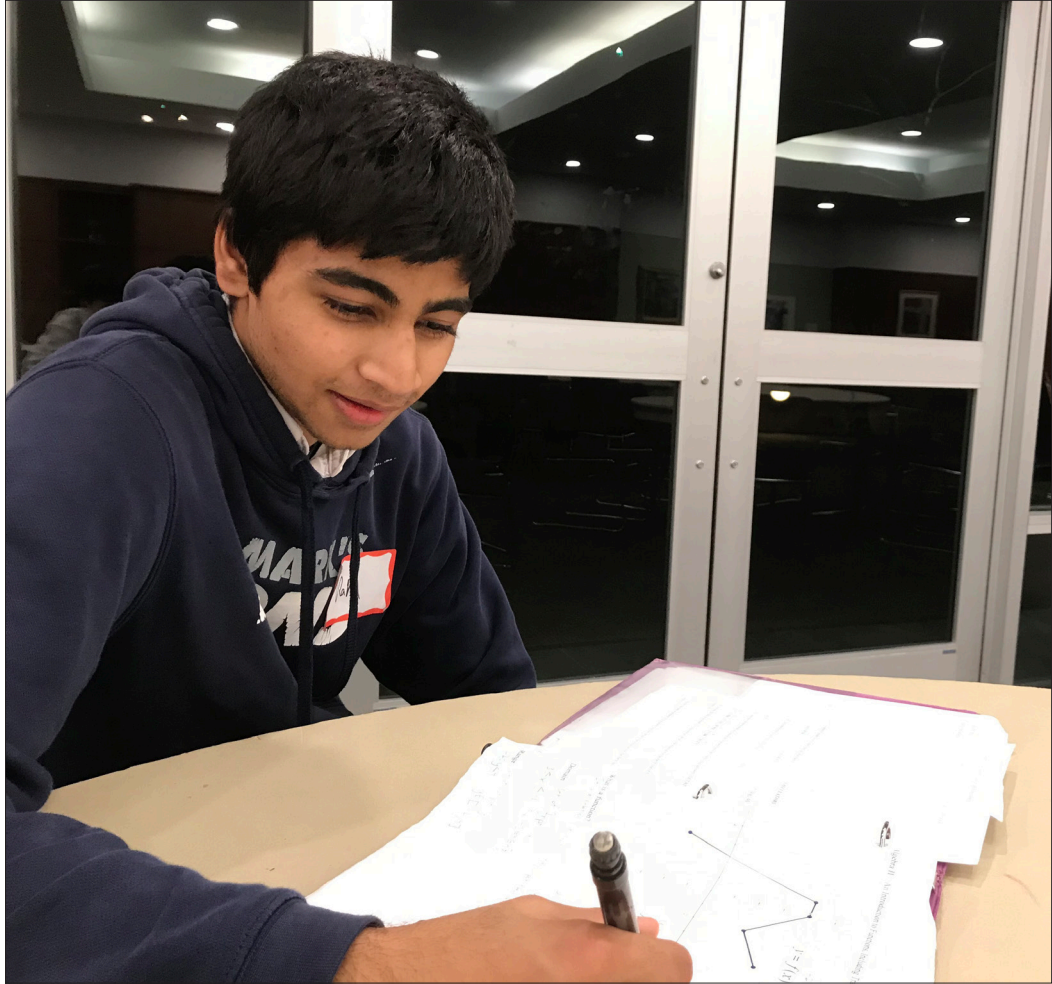
Light is one of the largest

components of maintaining the clock. It influences the endogenous cycle to align with the environmental cycle, and spending time outside and under the sun during the day will keep the rhythms constant. But because light is such an important factor in maintaining consistency in the clock, it can also disrupt the clock.

"This includes light at the inappropriate time, night for humans - which resets the clock so that the rhythms happen at the wrong time," Dr. Green said.

For high schoolers like Genender, the easiest way to maintain their rhythms is also often a luxury.

"Getting enough sleep and getting it at the appropriate time of day is very important for keeping the circadian rhythms synchronized to the environment and for good health," Dr. Green said. ■



Looking at traditional Chinese medicine

Looking at an alternative form of medicine that is thousands of years old and its uses in treatment today.

■ **Story** by Ishan Gupta, Sampath Rapuri ■ **Photo** by Ben Hao

No pills. No injections. Yes, it's a clinic. A medical one. But when patients go to see Dr. Ying Cao, senior David Li's mother, they're not expecting just another checkup.

Cao practices the more-than-3500 year old science of Traditional Chinese Medicine (TCM). But in America, it's relatively new.

Some people defend the practice. Others see no science behind it at all.

Either way, Cao knows one thing for sure: it's growing, and it's here to stay.

TCM is a mix of multiple different

methods of treatment. Cao focuses on acupuncture - the insertion of thin needles into key points of the body - and herbal treatment. But TCM also includes cupping therapy, massage (tui na), dietary therapy and more.

As we've become more globalized, western medicine - what most Americans are used to in their daily lives - has influenced modern TCM practices. But many people still don't believe in TCM's validity.

The philosophy behind the practice is based on the idea of balance in the body. Much like the Chinese idea of Yin and Yang, TCM claims medical ailments are a product of imbalances in the body. Scientific research hasn't found evidence of the importance of this balance, but the practice can be effective nonetheless.

Cao leads the Cao Ying Acupuncture & Chinese Medicine Clinic in Plano. After majoring in TCM at Tianjin University Of Traditional Chinese Medicine, she immigrated to the United States in 1998.

"When I first came to the United States, I didn't know how to speak English," Cao said. "I learned how to read and speak English in a community college."

Immediately after learning her second language, she was offered a job at Dallas College Of

Oriental Medicine and Acupuncture, a graduate school located on Walnut Hill and I-35. She was new to the country, but she has teaching experience from China, and that was an opportunity the school did not want to pass up.

At first, Cao expected some people to be unreceptive to her acupuncture teachings. But surprisingly, she was welcomed with open arms.

"Nowadays, more and more people accept [TCM]," Cao said, "especially people considering the medications' side effects, who are looking for a safer treatment to help their body heal."

The increase in acceptance of TCM stems from all the way back in 1971, when then-President Richard Nixon visited China, accompanied by New York Times journalist James Reston. During the trip, Reston developed appendicitis, and after his appendix was removed, his postoperative pain was treated by acupuncture.

Reston was so impressed with the procedure that he published an article about his experience soon after, and it's often cited as the first exposure of TCM to the United States.

"That [treatment] was an intentional Chinese governmental decision because they knew that herbal treatment is cultural, and it's difficult to make it popular around the world," Cao said. "So they thought acupuncture could be the first step to TCM being accepted by the United Nations and around the world."

On the other side of the spectrum

is UT Southwestern Assistant Professor Dr. Renee Enriquez, who specializes in spine procedures and pain management. To her, the philosophy is the most important part of TCM.

"To understand [TCM] you have to understand what Daoism is, the type of philosophy that goes behind the Yin and Yang, the actual qi and flow," Enriquez said. "There always has to be a balance. When there's an imbalance, the qi doesn't flow and there's not an equal balance of the Yin and Yang within somebody's physical

being."

The philosophy of TCM focuses on the root cause of the illness instead of the specific symptoms, so there are no opioids used in TCM. When facing the ever-present opiate crisis, TCM can be an alternative method to pain management and a possible solution.

"With the crisis we're going through in this country, we have to be careful about over-prescribing opiates," Enriquez said, "so we also are looking for other options for the patients [like TCM]."

Western medicine is more powerful but sometimes too powerful with significant side effects, unlike TCM, which focuses on the inner balance in the body with a slow course of action. Like many of her colleagues practicing pain management, Enriquez offers TCM as an alternate treatment option.

"We don't do just injections," Enriquez said, "we look at other approaches, which includes... other forms of traditional Chinese medicine to treat our patients."



You at least have to give credit to a practice that has been around for thousands of years."

UTSW
Assistant
Professor
Dr. Renee
Enriquez

In fact, it's not only the physicians who take the initiative to provide TCM. UT Southwestern radiation oncology specialist Dr. Nina Sanford conducted a study regarding the use of complementary medicine, one of the more common forms being TCM.

"Actually, a lot higher proportion of patients are engaging in these therapies," Sanford said, "about a third of patients used complementary alternative medicines [like TCM]."

Although TCM has become prevalent among a big part of the patient population, the practice wasn't always widely available in the United States, and not every doctor has used TCM as a treatment. Initially, Enriquez was introduced to TCM through her interest in Daoism. After graduating from Rutgers Medical School and completing a residency in physical medicine and rehabilitation at Northwell Health School of Medicine, Enriquez studied TCM in China.

"I was very interested in eastern philosophy in regards to Daoism and energy and flow," Enriquez said. "There was a course offered through the Chinese International



School of acupuncture and Eastern medicine in China, Beijing... [I studied] there for about four to six weeks, and took courses in Chinese medicine, which included acupuncture, moxibustion and cupping.”

But Enriquez’s experience with TCM isn’t limited to studying. She’s lived with esophageal reflux disease her whole life, and it got much worse during her time in China.

“I discussed this with my doctor... and they had performed two sessions of acupuncture and moxibustion,” Enriquez said. “And after two sessions, I had almost nine months of relief of my reflux.”

Despite Enriquez’s successful treatment with TCM and other examples, many skeptics remain.

“You at least have to give credit to a practice that has been around for thousands of years,” Enriquez said. “And there is some evidence, although the evidence and studies always have limitations.”

Despite what Enriquez thinks, not

every one of Cao’s patients trusts the science behind TCM. She remembers one patient* who was referred to her from a colleague - his face was clearly swollen, and he was about to have his ninth nasal operation due to sinusitis. The normal procedures just weren’t working for him.

“But he said he didn’t believe in acupuncture,” Cao said. “He didn’t believe in the herbal treatment. The reason he came? He was approached by his colleague who told him he should try it.”

The patient felt a ‘flame’ deep in his nasal cavity, almost all the way up to his brain. Headaches, heavy eyes - as an engineer, it affected his focus and his job to a point he couldn’t tolerate. He was frustrated.

“So yes, he didn’t believe, but he was willing to try,” Cao said. “I did a one-time acupuncture treatment, and then I gave him a one-week worth of herbal.”

After already having met twice in one week, Cao’s patient met with his original nasal doctor. His doctor was shocked.

“Just one day of two-time acupuncture and a week of herbal treatment, and it made his ‘flame’ disappear by about 80 percent,” Cao said. “The doctor asked what happened, and he said that he’d visited me.”

From that point, the patient was willing to see Cao for the next five weeks, even though his

insurance only covered acupuncture and not the herbal treatment.

“After all the entire six weeks of treatment,” Cao said, “[the patient] said the nasal doctor measured, and the flame was gone by 91 percent. It’s funny that it’s 91 - I’m not sure how it’s that specific, but it was gone by 91 percent.”

The patient’s nasal doctor even asked Cao to share her methods because the improvement was so unexpected. In fact, more and more doctors of western medicine are seeing the effects of TCM, and insurance companies recognize it, too.

“There must be something to it if some insurance companies are willing to pay for it,” Enriquez said. “A lot of insurance companies don’t like paying for stuff.”

As countries start experimenting with TCM and see its benefits, Cao sees the age-old practice spreading across the globe as other medicines continue to advance in the near future.

“From my graduate school, we have a professor working with African and European countries to help them build up the acupuncture and TCM system,” Cao said. “The UN is starting to push acupuncture and herbal, and its promotion will give TCM popularity for the next couple decades. Soon, I think it will spread to the whole world.”

*The patient in this story cannot be identified due to HIPPA laws. ■



- < Left- Cao has many different types of herbal and traditional medicine.
- > Above- TCM specialists use experience and empirical deductions to determine how much of a treatment a patient uses.

A peek inside the brain

How exactly do research scientists examine and treat memory disorders?

■ Story by Jeremy Yu

■ Graphics by Jeremy Yu

Just how much is there to be understood about memories and the brain? The Senior Research Scientist in the Cognitive Neuroscience Laboratory of Memory at the University of Texas at Dallas Dr. Michael Motes explains what it is like to be a professional in the neuroscience field.

"In my current research, I am examining semantic processing- particularly, the structure and impact of semantic memories and cognitive processes involved in retrieving semantic memories," Motes said. "I am fortunate to be able to work on both theoretical problems and applications across various training and treatment settings."

Motes has been working with psychology and the brain since he was in college. Since then, he has built a passion for research that stemmed both the intellectual and hands-on aspects of the job.

"As an undergraduate, I became fascinated with experimental psychology," said Motes. "The mix of creativity and technical elements in designing experiments really appealed to me."

As a research scientist, Motes applies essential problem-solving and analysis skills every day on the job.

"A lot of my time is spent thinking about designing studies and thinking about how to analyze data and how to interpret findings," Motes said. "This includes reading articles, analyzing data and writing papers and grants."

According to Motes, discoveries regarding cognitive function and memory take place all the time. These discoveries, however, are built off of previous discoveries - which can then lead to more discoveries in the field.

"Psychology and neuroscience research



UTD
Cognitive
Neuroscience
Laboratory
of Memory
Research
Coordinator
Elizabeth
Morris

We're trying to get the pre-frontal cortex to become more active so that it can dampen the stress response."

Below- Although the structure of the brain seems like a vague mass of neurons, doctors can study the brain through magnetic resonance imaging, or MRI, to find any abnormalities in the structure.



consists of building on existing scientific knowledge... so knowledge grows in iterations over time rather than through "big breakthroughs," said Motes. "I think of the phrase 'standing on the shoulders of giants' when I think about and talk about my own contributions."

That all being said, what exactly are the best methods for reinforcing memory? Interestingly, as Motes currently works with semantic memory, he sees the benefit in employing mnemonic devices.

"A number of different methods for improving memory have been identified," Motes said. "There are mnemonic techniques like forming associations with numbers or pegs, rhymes, etc. Techniques of this sort are useful for remembering lists or details about things. Although there are times where the goal is to memorize 'lists,' we often want to form deeper, richer memories, and we often actually maintain different levels of richness to our memories."

Take learning a language, for example: the process begins with memorizing grammar and specific phrases, but once you obtain a better grasp of the language through more exposure, you can creatively weave together sentences to better express ideas-mnemonic devices assist in this process.

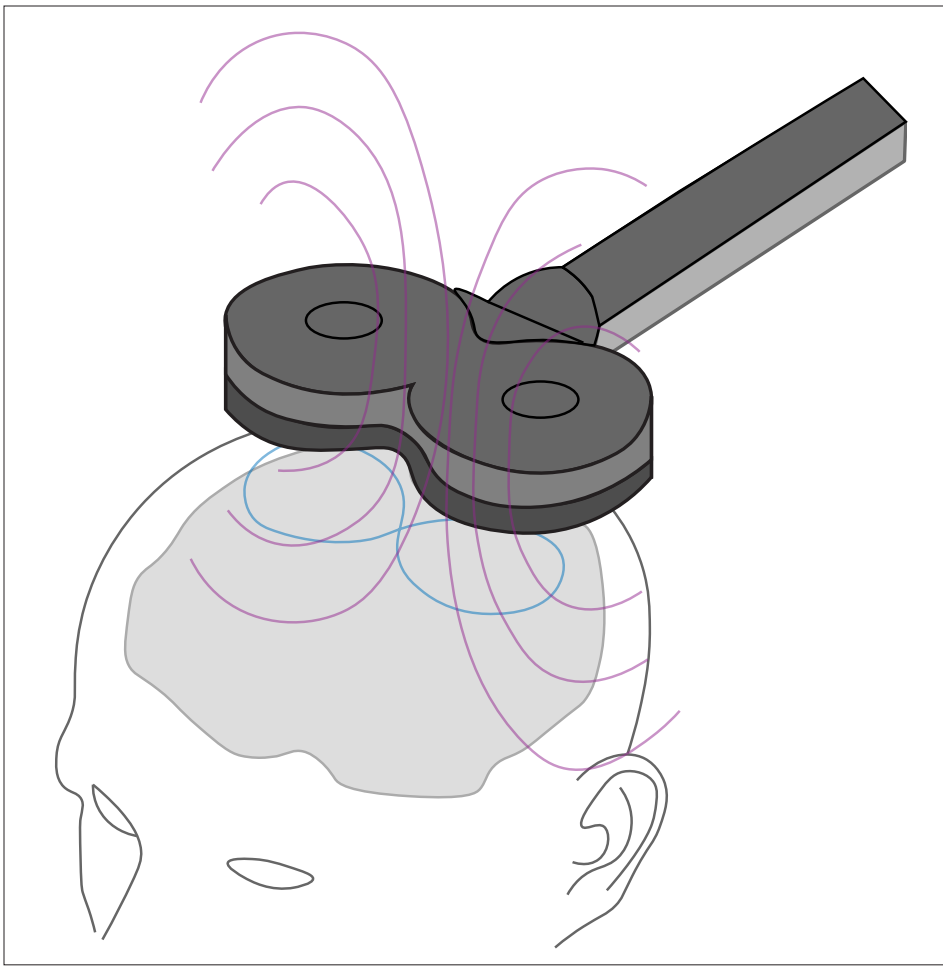
In other words, using the classical acronyms such as "ROY G BIV" for the colors of the rainbow and "FANBOYS" for subordinating conjunctions have been shown by research to be some of the most effective ways of memorizing things.

On the other hand, our brains can sometimes be the source of trauma, which is the case with memory disorders such as Post Traumatic Stress Disorder (PTSD) or any other traumatic brain injuries. UTD's Research Coordinator in the Cognitive Neuroscience Laboratory Dr. Elizabeth Morris works with PTSD patients and conducts research on the best way to treat their illnesses.

"We consider PTSD as a disorder of memory, meaning that they [war veterans] have not fully processed what happened to them during combat, and they are not able to return back to their baseline level of functioning," Morris said. "So, because the memory of the traumatic event is still so intrusive and pronounced in their lives today, that is part of what causes their PTSD."

The patients undergo very specific treatments designed not only to help researchers better understand the illness but also to decrease the severity of the illness.

"If they [the patients] are new, and we're



< Left - Transcranial Magnetic Stimulation. The purple lines show the magnetic fields that are used to treat the brain.

“One of the things that we noticed was that there were changes in the brain structures pre- and post-treatment,” Morris said. “So, pretreatment we noticed that the amygdala, which is the fight or flight response [and] threat detection, was over responding. And then the quieting down part of the brain, the prefrontal cortex, was under responding. We saw that in the MRI. Then, post treatment, we noticed the reverse: the stress response had normalized, and the prefrontal cortex that was supposed to quiet down the stress had become stronger.”

The effectiveness of the treatment stems from the new technology used to stimulate the patients’ brains.

“It’s called Transcranial Magnetic Stimulation (TMS). So basically, it is a magnet in the shape of a figure eight, and the magnets pulse back and forth,” Morris said. “That creates a small electric current, and the electric current penetrates to the skull and activates the neurons and the connectivity in the prefrontal cortex. We’re trying to get the prefrontal cortex to become more active so that it can dampen the stress response.”

Morris and her lab have discovered a breakthrough that involves pairing psychotherapy with the TMS technology to more effectively treat PTSD, and they are currently working on replicating these results.

“One of the big breakthroughs that is currently developing is for the treatment of PTSD in the past,” Morris said. “The primary effective treatments have been psychotherapy, but that’s really only effective for maybe 60 to 70 percent of people. So, we have found that pairing psychotherapy with brain stimulation is more effective than psychotherapy alone. So, we are doing this new study which we just started which is a national replication of one [we] did from 2011 to 2015. We’re going nationwide now, so we are working in conjunction with the VA hospital in Tampa, Florida. We’re trying to replicate our findings because in research you can’t just do one study and call it a day; you have to make your findings replicated. That’s what we’re doing now, and we hope to further the science on these breakthroughs.” ■

trying to determine if the person is eligible for participation, then they have to do four things,” Morris said. “They have to come in and meet with a psychologist and get a full mental health assessment that not only focuses on their PTSD symptoms, but also asks them about their mental health history, medications, [and] military participation, then we have a lot of discussion around their combat. They also have to get an EEG [electroencephalogram], which is basically measuring their brain activity in response to several different tasks or exercises that they have to do mental exercises in the lab. They also have to get an MRI, which is magnetic resonance imaging, to look at the brain structures. Then, we do a brain stimulation setup where we would have them sit in the brain stimulation chair and determine what levels and settings we would need for the machine.”

The data they collect then determines the patients’ eligibility, and if they are eligible, then they go through 12 sessions of active treatment of brain stimulation coupled with psychotherapy. Their progress is then tracked over a span of 12 months.

The process for diagnosing and treating PTSD has already been honed to detect certain signs, one of which is an alteration in the brain’s threat detection that can be seen in the MRI.



SHOW ME

“It’s not that big a deal.” While not as immediately life-threatening,

psychological disorders, such as depression and post-traumatic stress disorder (PTSD), are more prevalent than most physical diseases.

354 million adult survivors of war who suffer from PTSD

3.5% of US adults will be diagnosed with PTSD in their lifetime

30% of veterans have had PTSD in their lifetime

13.1% of young adults aged 18-25 are diagnosed with depression

Data Courtesy of American Psychiatric Association, US National Library of Medicine, US News & World Report

Our first invaders are not extraterrestrial

There's fungus, bacteria and chemicals living in our body's microbiome. Do they pose a threat to our immune system?

■ **Story** by Maxwell Chuang, Sampath Rapuri

■ **Photos** by Sampath Rapuri

One-hundred and eleven trillion cells. That massive quantity is what comprises the microbiome.

Outnumbering the body's cells by a factor of 3:1, the microbiome is present throughout our entire body. If you think that's disgusting, think again.

Without the microbiome, we would probably be dead. However, only one thing is for sure. All 111.6 trillion of these cells are here to stay. Whether the microbiome is for our benefit or our detriment is debatable.

From the immune system to the nervous system, the microbiome, shapes the organ system around it.

Along with the immune system and the nervous system, mental health is also affected by the microbiome. Nothing in our bodies is spared from the microbiome's reach.

The microbiome is revealing medical mysteries that have stumped scientists for decades. With the microbiome, scientists can finally unlock hidden secrets and create novel medicines to treat all sorts of disorders in the body from cancer to autism.

to antibiotics. Now, her research focuses on the microbiome's interactions with the immune system and the other organ systems.

"The human microbiome refers to all the microbes that colonize the human body: bacteria, fungi, and protists," Palmer said. "Microbes normally colonize our bodies at multiple sites, like the skin, mouth, and intestinal tract."

The microbiome is made of various organisms, including bacteria. Single-celled bacteria are organisms that live in nearly every possible environment on earth, hot or cold. They envelop our entire body, producing our body odor and forming the plaque on our teeth. Of utmost importance to scientists today are the bacteria and other microorganisms in the intestinal tract. The bacteria in the intestinal tract have a tremendous influence on a seemingly unrelated organ system, the nervous system.

The nervous system, the network

of nerve cells and pathways which conduct nerve impulses around the body, is crucial from

everything from thinking to moving.

Dr. Dwight German, a researcher at UT Southwestern, is actively investigating the effects of the microbiome on the nervous system.

He earned his bachelor's degree in Psychology, the study of behavior, at Southern Methodist University. German went to graduate school at the University of Oklahoma to study Experimental Psychology and Neuroscience.

After studying at the University of Oklahoma, he now focuses on the effects of the microbiome on neurodegenerative disorders, diseases that primarily destroy the neurons in the brain, and developmental disorders, a category of mental health disorders that delays the accomplishments of early developmental tasks like talking and walking.

Studies have shown that what we

eat and drink affects our microbiome, but, interestingly, replacing our foods and drinks with what we're not used to can drastically affect us.

"People talk about going to Mexico, drinking the water there, and getting diarrhea," German said, "the bacteria in the water in Mexico don't agree with our microbiomes and a number of our current bacteria are killed."

The bacterial warfare results in the growth of the new foreign bacteria displacing the previous native bacteria. Rather than the water quality affecting us, it is the microbiome fighting the new bacteria that causes diarrhea.

However, "once we've been there for several days and we're used to the drinking water; we come back to the US and once again start drinking US water," German said, "it's got the different bacteria and the same thing as before happens and we get diarrhea."

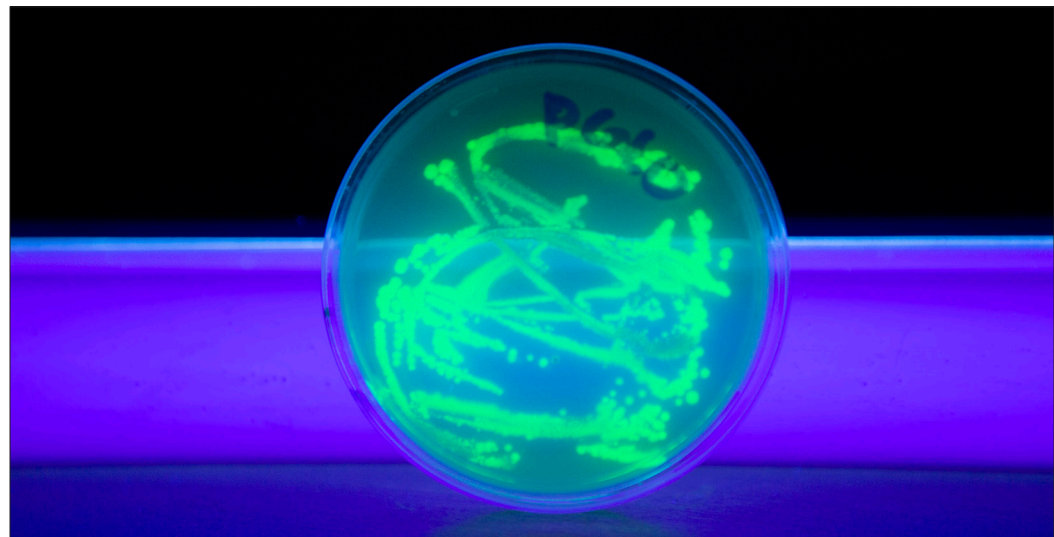
A less known factor that can change the microbiome is actually the friendships and bonds that we create.

"Banishment from tribes was considered

Dr. Kelli Palmer, an assistant

professor of molecular and cell biology at The University of Texas at Dallas, is fascinated by the microbiome.

As a sophomore majoring in microbiology at the University of Oklahoma, Dr. Palmer washed dishes for a research lab, gaining exposure to the vast field of biology. There, she garnered interest in how bacteria developed resistance to antibiotics and how the microbiome also developed resistance. Realizing the possibility of the microbiome affecting antibiotic resistance, she jumped on the opportunity to study how the microbiome affects resistance





the ultimate punishment in the past,” German said, “the feeling that nobody likes you has a big effect on the microbiome by altering the balance of chemicals in the microbiome, and ultimately altering the composition of the microbiome.”

Strange and abstract concepts like social relations can affect the tiny microorganisms inside of us, affecting our health.

More importantly, changes to the microbiome can be drastic and affect mental health, leading to an increased susceptibility of Parkinson’s and Alzheimer’s disease and even autism spectrum disorders.

“Pregnant mice subjected to footshock stress [mild shocks to its feet] give birth to offspring with behavioral and anatomical features of autism,” German said. “Feces from the footshock stressed mom given to other non-footshocked mice will result in those other mice giving birth to offspring with autism.”

Just from changes in the microbiome, a behavioral disorder like autism can occur. The intestinal microbiome greatly influences the nervous system and plays an important role in our neurological health. Changes in the microbiome can even lead to Parkinson’s and Alzheimer’s disease.

“DDT, a pesticide, can impact the balance of microorganisms in the intestinal microbiome,” German said, “we have found that increased DDT changes the microbiome in such a way that the amyloid precursor proteins are

turned on, leading to a heightened Alzheimer’s pathology [features of the disease].”



Psychiatry
and Neuro-
science
Professor
Dwight
German

People talk about going to Mexico, drinking the water there, and getting diarrhea. The bacteria in the water in Mexico don't agree with our microbiomes."

turned on, leading to a heightened Alzheimer’s pathology [features of the disease].”

Pesticides, commonplace around

the entire world, may not be as harmless as advertised. A devastating disease as Alzheimer’s can simply be brought about because of the increased prevalence of pesticides in the diet.

Overall, the microbiome has drastic effects

on all parts of the body. From mental health to the immune system, nothing escapes the reach of the microbiome. Although there may be many alternative causes to the success and downfall of the microbiome, diet is the main factor.

“Microbes in the intestinal tract can degrade or otherwise alter drugs that we take, thereby preventing them from working effectively,” Palmer said.

Thinking the drugs are intruders, the microbiome attacks some medicines we take, rendering them useless. However, being too protective has its perks.

By preventing prescription drugs from working, the microbiome also prevents pathogens from colonizing, thereby protecting us from infections.

The microbiome, however, acts like a double-edged sword: while defending against harm, it also prevents some prescription drugs from working.

It’s important to think of our diets and lifestyles in order to take care of our health. Limiting pesticides and other harmful substances can have a profound impact on the microbiome, leading to a huge impact on the health of a person.

Essentially, we should think about what we eat before we put it in our bodies, and keep our microbiomes healthy, which will result in better mental and physical health. ■

Gene editing: current uses and future direction

Looking to the future, while covering the medical and ethical side of gene editing

■ **Story** by Ashvin Nair and Andrew Kogan
■ **Graphic** by Andrew Kogan

The concept of gene editing was introduced in the early 1970s with the idea of transgenesis: the transfer of a gene from one organism to another.

It has come a long way to the point where it's been used on human beings.

In the past decade, the topic of utilizing genetic engineering to edit the human genome has generated varying views on the extent that it should be used for.

Despite recent international experiments stirring controversies among the scientific community, gene editing is becoming more practical according to Jonathan Ploski, Associate Professor at The University of Texas at Dallas's School of Behavioral and Brain Sciences.

Ploski graduated with a bachelor's degree from the University of Buffalo, and he received his PhD from Mount Sinai School of Medicine.

On October 21st of 2019, the National Institutes of Health awarded Dr. Ploski \$1.5 million for development of methods and research on pharmacologically enhancing the modification of strong modification-resistant memories.

Gene editing, apart from being used on human beings, has also been used for fields other than disease research, including gastronomy and agricultural science.

Among the many methods of gene editing that have been in development since its origin, CRISPR, the most recently developed technique, has remained at the forefront of these gene editing systems.

"Gene editing is a very broad field," said Ploski. "It has enormous implications for basic research, agriculture, and clinical treatments. I think most scientists working with CRISPR



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The procedure to operate CRISPR is difficult to understand fully, but

it can essentially be boiled down into six basic steps, which can be reproduced in a typical biology lab:

1. Decide which gene to modify (cut, activate or inhibit). The user interface of CRISPR has been simplified so that you create a file out of the gene code.

2. Decide which endonuclease protein to use, or in other words, the "scissors" used to cut the genes. The most common one is an enzyme called Cas9.

3. Design the gRNA to target the gene of interest. The gRNA (guide RNA), in layman's terms, tells the scissors where to cut.

4. Assemble the gRNA expression vector in your browser. Using plasmids, or clumps of nucleotide chains not connected to the main DNA of the cell, customize the gRNA to have an easier time navigating the cell.

5. Assemble the plasmid at a bench. Using various enzymes and chemicals, the program makes the specific protein to modify the cell's DNA.

6. Engineer the Cells! Finally, injecting the proteins into a culture of cells, the cells will have their genetic material edited before they reproduce.

Process courtesy of Medium.com

based gene editing technology recognize its power and potential."

With the creation of CRISPR, gene editing has skyrocketed in popularity. First discovered in bacteria, CRISPR is an extremely easy way to study gene function in cells as well as in model organisms.

It utilizes the cas9 enzyme to make cuts in DNA strands that either repair or deactivate certain sections of the genome. There are many factors that are present when considering what pushes gene editing forward, as well as what hampers its overall development.

"Money and infrastructure are necessary for all research including research focused on the gene editing field," said Ploski. "The United States has been a world leader in scientific research due to the economic investment it has historically put forth for this endeavor and the fact that the US has been able to attract great talented scientists from all over the world."

Through experiments, it becomes evident that standards about ethicality are held and agreed upon by both the Chinese and American governments, the two leading countries in genome editing.

In the end, however, for all countries, it becomes up to the specific governments to decide on whether each individual experiment is ethical as well as permissible.

"How [gene editing] might be used or misused will largely depend on the regulatory bodies of these countries and others to ensure that safeguards are put in place to ensure its proper use and to use it ethically," Ploski explained. "We have already seen rogue scientists create a genetically modified baby using CRISPR technology."

Scientists and organizations

across the world have spoken out against this recklessness, including the Chinese government.

Mainstream media has a tendency to portray gene editing as a dangerous, menacing super-weapon.

Despite its ethical gray areas, gene editing is unanimously agreed upon, by the scientific community and according to Ploski, as something that ought to be pursued for pragmatic applications.

A new question arises: is gene editing a useful instrument or dangerous weapon?

"Advances in gene editing will lead to an increase in research productivity in the laboratory and this will lead to better treatments for human ailments faster," said Ploski. "There is nothing unethical about gene editing. The vast majority of scientists are using it as a tool in the laboratory to better understand the role of genes in their area of

study.”

This is usually occurring in cells grown in dishes or model organisms – NOT humans.

However, some gene therapy approaches designed to cure people with genetic disease may use CRISPR gene editing technology.

“The one area that makes people uncomfortable or wary is the potential to genetically edit human germline cells – cells giving rise to human sperm or oocytes or human zygotes, so the whole organism will be genetically altered and therefore progeny would carry this genetic change for all subsequent generations,” said Ploski.

At the pace that it is moving currently, the field of gene editing has brought great advancements to the biological community and other fields of science.

Later down the line, its application will begin to see implementation in many other parts of life, like advancing the efficiency of agriculture.

Whether fast or slow, the

progression of gene editing development is truly inevitable, whether it be the result of an avid individual or a series of regulated experiments.

“We will produce more information about how genes shape biological systems at a much faster rate,” said Ploski. “We will begin to cure genetic diseases. We will develop treatments for a wide variety of disorders faster.”

For the improvements that have been made since it first began and the pace that it appears to be moving at, gene editing should be appreciated as a leading, salient scientific project.

Its regulations, however, might need to be reconsidered and agreed upon globally so that no new controversies might arise in the future that cloud its positive outlook in the eyes of the general public. “

All new information gained from research is positive,” said Ploski. “The pace of CRISPR gene editing has been very fast. It was just in 2012 that CRISPR components could be put into non-bacterial cells and could edit the genome of human cells grown in dishes. Since then, there have been many adaptations of this technology. The future looks bright.” ■

▽ Below- CRISPR works like molecular scissors that splice DNA, but the actual molecules are much more complex than two blades.





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The statistics associated with quantum computing and the calculations it is

able to do show the impact this innovation has on the scientific fields.

Between 1000 and 100,000

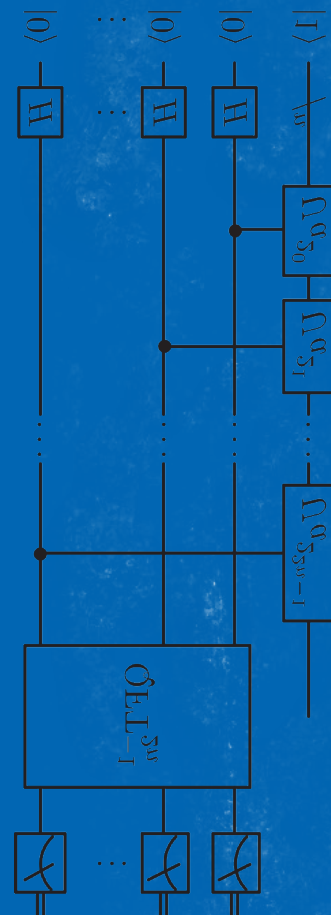
times more qubits needed to correct quantum noise compared to class computation noise. This is because of the uncertainty that comes with locating a quantum particle, so systems of thousands of qubits are needed to take into account each other's margin of error.

-273°C is the temperature that the quantum computer must be maintained at to function. Absolute zero is exactly -273.15°C , but the computer is kept at a little bit above that to facilitate movement.

1,099,551,473,989 is the record for the biggest and most complex number a quantum computer could factor. It's prime number factors are 1,048,589 and 1,048,601.

Shor's Algorithm Created in 1994 as a theory, Shor's algorithm is used by modern quantum computer to find the prime factors of big numbers using the following process (pictured at right)

Data courtesy of Atos



✓ Left- Artist's rendering of the Google quantum computer, which proved that quantum supremacy was true.

Quantum computing: the tool of the future

These efficient machines will make sense of complex ideas faster than ever before

■ Story by Tamal Pilla ■ Graphics by Morgan Chow, Jeremy Yu

As our technology progresses, computers are only getting more and more capable every year. Quantum computers take these capabilities to the next level.

These computers use the laws of quantum mechanics, in the form of “qubits” instead of regular bits, to process information, allowing them to make calculations and predictions beyond the scope of an everyday desktop’s ability.

The Copenhagen interpretation is a fundamental interpretation of quantum mechanics that describes physical objects as not having definite properties until being measured.

Schroedinger’s Cat, a classic thought experiment conducted by one of the pioneers of quantum mechanics, Erwin Schrödinger, represents the non-binary, qubit-esque behavior of an everyday object like a cat. The cat, residing in a box subjected to radioactive poison, has an equal chance of living and dying. Until the box is opened, the cat exists in a state of quantum superposition of being both simultaneously alive and dead.

The question is, then, what does this have to do with computers?

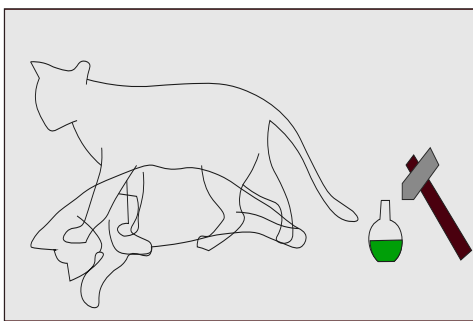
Senior Jackson Singhal broke it down to the essentials, explaining the basic idea of why quantum computers are so powerful.

“The idea of a quantum computer is that... classical computers work on binary—there’s on then there’s off, one and zero, only two possible options—but a quantum computer, as opposed to the bit, which is the binary, has qubits, which are the certain superimposed state where it can be one or zero, or both one and zero, and it’ll tell you essentially what the probability is of each,” Singhal said. “So it can store a lot more data than just a simple, classical computer.”



Senior
Jackson
Singhal

A quantum computer would be able to try the most likely combinations as opposed to trying every single one.”



△ Above- Schroedinger’s Cat helps to explain the Copenhagen interpretation and Quantum Superposition.

Stephen Balog, Cecil H. and Ida Green Master Teaching Chair in Science, detailed the changes that have enabled computers to become more advanced.

“The general idea is that unlike most systems that we have now, which basically work on a binary system of on-off, yes-no, most quantum computers’ concepts work on multiple stages, so you [have] more than just an on-off, or binary, response—you can have multiple variations. It’s easy to do branching, in terms of your programming, but you kinda really have to know what you’re doing to get it to branch

right,” Balog said.

To better explain, Singhal came up with an analogy.

“Imagine you’re trying to throw a ball into a little cup,” Singhal said. “You know where the cup is, but a computer doesn’t necessarily know where the cup is. It has to throw the ball in every possible place and it has to go get the ball every single time. But a quantum computer is able to use its qubits to assess the probability and compute a faster path to the answer.”

Singhal said that the new form of processing using the qubit that quantum computers employ also allows for a level of efficiency exceeding that of a classical computer.

“As opposed to bits, meaning one or zero, quantum computers use qubits, which are one or zero or both,” Singhal said. “Qubits allow the computer to hold more information. For 128 bits, a normal computer would have to try every combination, but a quantum computer would be able to try the most likely combinations as opposed to trying every single one. Quantum computers are more efficient.”

Jackson Singhal shared that quantum computing innovations bring exciting new possibilities to what computers can do.

“Because it’s about the probability that it’s either one or zero, it can do things that a normal computer can’t do, or things much, much, much faster in a much different way than a normal computer could do, it doesn’t necessarily do them in the same way,” Singhal said. “For the vast majority of things, a classical computer is fine. But for things that are very specific and involve very, very, very large numbers like cryptography, the quantum computer is much more capable because it’s not just trying to go one at a time, it is using the probability states to guess that answer much more quickly.” ■

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