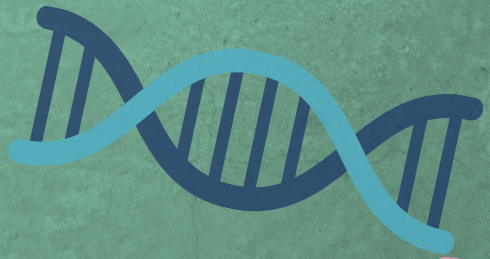
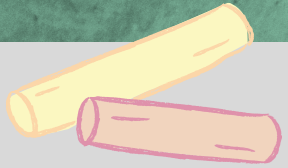
CATAPULTA!

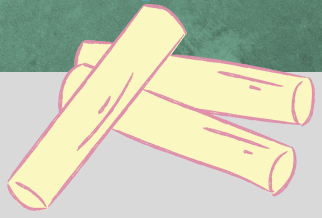
SPRING 2021

Agenda:

1. Biological data
2. Genes, genes, and genes!
3. Mental health
4. COVID-19
5. Origins of life
6. Snails (but poisonous)
7. Books!







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EDITORS' NOTE

DEAR READERS,

IN 2015, SMALLER VERSIONS OF JOHN AND NATALIA (IF THAT'S EVEN POSSIBLE TO IMAGINE) WALKED INTO A DIM DUNGEON OF COMPUTERS AND MONITORS THAT WAS ROOM 014. SIX YEARS' WORTH OF PRODUCTION WEEKS, ONE PANDEMIC AND 18 ISSUES LATER, WE HAVE TO SAY OUR FINAL GOODBYE WITH THIS ISSUE!

WHILE OUR JOURNEY WITH CATAPULTA MAY BE COMING TO AN END, SCIENTIFIC DISCOVERIES AND INNOVATIONS ARE DEFINITELY NOT. INSIDE THIS ISSUE, EXPLORE THE INTRICACIES BEHIND THE COVID-19 VARIANTS AND MARVEL AT THE DISCOVERIES THAT HAVE CHANGED THE WAY WE'VE THOUGHT ABOUT WHERE WE (AND ALL OF LIFE) ORIGINATED. IN KEEPING UP WITH YOUNG SCIENTISTS AND NEW IDEAS, CHECK OUT OUR INTERVIEW WITH VIVIAN YEE, A HIGH SCHOOL SENIOR AND 9TH PLACE WINNER AT THE NATION'S MOST PRESTIGIOUS SCIENCE COMPETITION. FINALLY, IF YOU NEED SOME IDEAS FOR A NEW BOOK TO READ, TAKE A MOMENT TO CHECK OUT THE BOOK RECOMMENDATIONS FROM OUR AMAZING SCIENCE DEPARTMENT, RANGING FROM THE INTRICACIES OF OUR DIGESTIVE SYSTEM TO THE DARK HISTORY BEHIND THE RADIUM GIRLS.

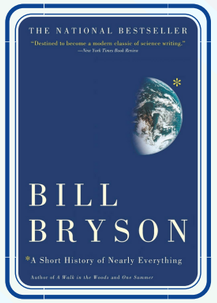
TEMPUS FUGIT, BUT SO DOES SCIENCE. AS OUR SIX-YEAR CHAPTER WITH CATAPULTA COMES TO A CLOSE, WE ARE EXCITED TO SEE THE WORK THAT THE NEXT GENERATION OF EDITORS AND WRITERS WILL CREATE.

BEST,
JOHN AND NATALIA
EDITORS-IN-CHIEF

SPRING ISSUE STAFF

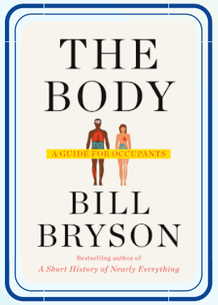
BOOK RECOMMENDATIONS

FROM BLS' AWESOME SCIENCE DEPARTMENT!



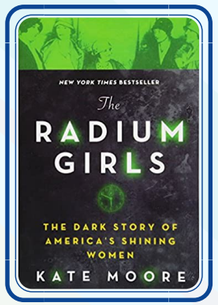
A SHORT HISTORY OF NEARLY EVERYTHING - BY BILL BRYSON

"He provides a humorous view of our scientific understanding about the world around us. As a non-scientist travel writer, he writes very well for the non-scientist." *-Mr. Osowiecki*



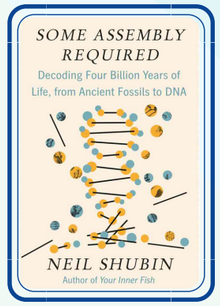
THE BODY - BY BILL BRYSON

"This book takes normal bodily functions and turns them into the most fascinatingly resilient and adaptive mechanisms one can imagine. You will never again take a beating heart or a healing wound for granted! This book is very approachable to high school students."
-Mr. Pietrangelo



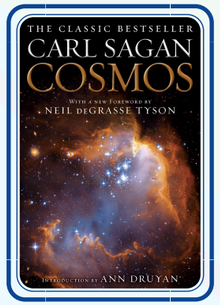
THE RADIUM GIRLS - BY CYRIELLE EVRARD

"This book details what happens when industry pushes forward without a strong understanding of science. It also tells the inspirational story of workers and lawyers who stand up to powerful interests." *-Ms. Garside*



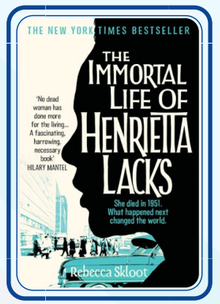
SOME ASSEMBLY REQUIRED: DECODING FOUR BILLION YEARS OF LIFE, FROM ANCIENT FOSSILS TO DNA - BY NEIL SHUBIN

"Dr. Shubin is a master storyteller, and this is his second book, as a follow-up from his first, "Your Inner Fish". Even someone who does not have a background in biology can find this book enjoyable, and science-lovers everywhere can relish Shubin's deep-dive into evolutionary biology. You won't be disappointed!" *-Ms. Castellanos*



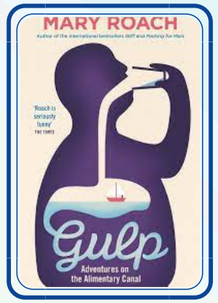
COSMOS - BY CARL SAGAN

The best selling non-fiction science book ever, for good reason, is still relevant all these years later, full of deep thoughts and big perspectives. *-Mr. Southwick*



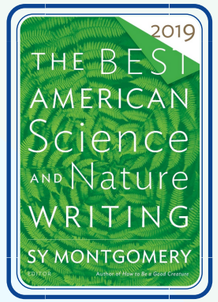
THE IMMORTAL LIFE OF HENRIETTA LACKS - BY REBECCA SKLOOT

"This is a well-written account of the injustice that took place when scientists stole cells from a woman of color for research. These cells, which were cancerous, were able to proliferate in the lab, solving a problem that researchers had been battling for years. Without consent or compensation, they took these cells and continue to use cells from this line today for research. Meanwhile, Henrietta Lacks' family currently lives in poverty, unable to even afford the healthcare that was so drastically advanced by their predecessor's cells. This book presents a historical account of the theft and examines the consequences for Lacks' family and families like hers." *-Ms. Garside*



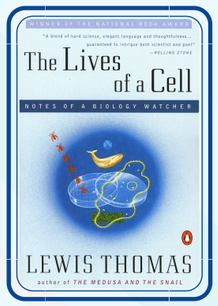
GULP! - BY MARY ROACH

"This exciting romp through our digestive system is packed full of good science and is described with wit and humor that keeps the reader busting their gut with laughter (pun intended)." *-Ms. Bateman*



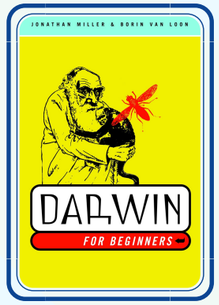
AMERICA'S BEST SCIENCE AND NATURE WRITING - BY VARIOUS AUTHORS

"An annual anthology, this series includes the most intriguing journal pieces from the previous year."
-Mr. Osowiecki



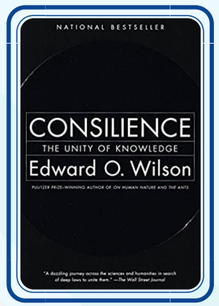
THE LIVES OF A CELL: NOTES OF A BIOLOGY WATCHER - BY LEWIS THOMAS

"This book is a compilation of short essays. In this very easy read, Thomas compares the Earth to the life of a cell and highlights the interconnectivity of the diverse components of Earth's biosphere with a focus on human behavior and nature. While seeming dated in its references to technology (written between 1971 and 1973), this book is prescient with respect to communication and medicinal technologies. Thomas reveals to the reader amazing aspects of biology and nature while using them as metaphors for human behavior and responsibility. I highly recommend this book to any curious mind - be entertained while you learn and are left with food for thought. " *-Mr. Tucker*



DARWIN FOR BEGINNERS - BY MILLER AND VAN LOON

"The story and influences behind Darwin and his reluctant inference of species "descent with modification through differential reproduction", or evolution through natural selection, is almost as controversial, inspiring and gripping as its implications. Like discovering your best friend lied to you! And since it's arguably the most important idea proposed by humans so far, it's critical each of us understands what it is and what it isn't. And why it's an inarguable fact. Put that story in comic book format with old-school artistry and wit somewhere between Monty Python and Mad Magazine and you really have something! Maybe you can relate to teenage Charlie...? (Also try "The Reluctant Mr. Darwin" by David Quammen for more details)." *-Mr. Spezzano*



CONSILIENCE - BY E.O. WILSON

"Like the Beatles and the Avengers, it can be difficult to get powerful and talented individuals to come together, and stay together, to produce "supergroup" outcomes. Why? When they do, it can be amazing! Wilson tackles this idea in "Consilience" by asking why the progression of human thought is so insular and fields like biology, anthropology, psychology, religion, philosophy and the arts can't come together and break open the often, slow "lateral movement" of knowledge. He suggests many of our stubborn questions could be addressed by reaching across the intellectual aisles to collaboratively create a new Age of Enlightenment! A nice way to tie together those courses you've already taken into a broader world view."
-Mr. Spezzano

CATAPULTA // SPRING 2021 ALEX CHOU - II | 09

MENTAL HEALTH STIGMAS AND THE PANDEMIC

Psychological disorders continue to be the leading cause of disability in developed countries, **surpassing even cancer and heart disease.**

In their academic studies, students are often taught to value deductive logic. For example, scientific research conclusions are formed strictly based on observable evidence. Ironically, this method of reasoning is why mental health is so heavily stigmatized. For disorders like depression, anxiety, and obsessive-compulsive disorder, the symptoms manifest themselves through behavioral and emotional abnormalities, rather than through visible injuries.

To those that may still be skeptical about the validity of mental health disorders, Danielle Moskow, a clinical extern at McLean Hospital and psychology doctorate student at Boston University, explains, “When our emotions become difficult to regulate and feel overpowering, it can be challenging to see the full picture. We view the world through a tinted shade of glasses, [and] it is important to understand that we all go through difficult times.”

Despite its label as a hoax, psychological disorders continue to be the leading cause of disability in developed countries, surpassing even cancer and heart disease. It is estimated that the lifetime prevalence of mental illness in the United States is around fifty percent. Even more shockingly, among Americans aged 10 to 34, suicide is the second leading cause of death. In 2018 and 2019, there were over 2.5 times as many suicides as there were homicides.

Unfortunately, the times of the pandemic have only increased feelings of grief, frustration, and loneliness.

"Growing awareness of recent social injustices, a controversial presidential election, mass unemployment, the subsequent financial instability, and the emergence of numerous variants of the coronavirus has put tremendous stress and pressure on Americans."

Unsurprisingly, Moskow has seen an increase in the number of patients seeking clinical psychological help. For affected individuals, the chaos of current times can worsen the debilitating effects of psychological disorders, which already compromise a sense of hope and normalcy.

Dr. Vanessa Prosper, the Boston Latin School Clinical Coordinator, explains that the pandemic has given rise to as well as exacerbated the symptoms of depression and anxiety among many students, making it more difficult for them to focus during classes or to find the motivation to do schoolwork. Given that online school drains students mentally and emotionally to a greater extent than normal school, it actually requires more energy and effort.

“Depression is like a very bad headache,” Dr. Prosper says, “but that ache is an emotional ache that makes it hard to want to do anything, just like a headache would.” Thus, one can imagine how students who struggle with mental health face tremendous difficulty as they attempt to balance academic work with after-school jobs and familial or extracurricular commitments.

Although some may have adapted relatively well to the “new normal,” the spread of the coronavirus has emotionally and socially affected us all in ways unimaginable before March 2020. “Something that is often minimized or not talked about in the media is that for all of us, whether or not you are experiencing mental health difficulties, the pandemic is a traumatic experience,” Dr. Prosper says. “That students are experiencing new or worsened symptoms of depression and anxiety is a normal reaction to this whole abnormality of the pandemic.” Thus, it is important to understand that while the times are strange, our reactions to them are not.

INTERVIEW WITH VIVIAN YEE:

A CALL TO ACTION FOR HEALTH EQUITY

These pages feature *Catapulta*'s interview with Vivian Yee, a student who won 9th place at the Regeneron Science Talent Search for her science project: A Novel Epidemiological Approach to Exploring the Implicants of Social Determinants of Health on COVID-19 Spread.

WHY DID YOU WANT TO STUDY THE SOCIAL DETERMINANTS OF HEALTH?

When the COVID-19 pandemic hit, I was disheartened to see the disproportionate impact the disease was having on under-resourced communities like locally in Detroit and others like New York City, the Rio Grande Valley, and more. As someone passionate and engaged in social justice activism, I sought to use my scientific research skills to not only better understand these struggles but also work towards remediating them. When I got the opportunity to design and execute a research project with Dr. Asad Moten of the United States Department of Defense, I was naturally drawn to the topic of social determinants of health, which are often neglected in public health interventions, to provide guidance to public health experts and policymakers to achieve health equity.

WHAT WAS A TYPICAL DAY LIKE IN DOING YOUR PROJECT?

I primarily performed this research over the summer through the Research Science Institute. During a typical day, I would begin working at 9am and set out an agenda of the tasks that I wanted to accomplish that day before beginning to work on the project. I normally started off my day reading scientific literature and news about emerging trends in COVID-19. Depending on which phase of the project I was in, I would be doing different tasks. Generally, I would work on the data compilation/organization, experiments, simulations, etc. until mid-afternoon. Occasionally, I would meet with my mentor Dr. Moten in the evening to discuss my progress or problem-solve any difficulties I encountered.

WHAT WERE SOME OF THE MOST SIGNIFICANT FINDINGS? DID YOUR RESULTS SURPRISE YOU?

In my project, I created a novel, comprehensive epidemiological modeling technique called the Social Vulnerability Index-stratified Susceptible-Infected-Recovered-Deceased model or SVI-stratified SIRD model. This approach allows for the user to account for fifteen distinct social factors when studying infectious diseases. This model also has applications beyond the COVID-19 pandemic and can be applied to other infectious diseases like influenza, HIV/AIDS, and future novel pathogens as well. I found that more vulnerable communities faced greater rates of COVID-19 incidence and fatality. In my modeling, I was surprised to see that the moderate vulnerability group experienced the greatest proportional COVID-19 toll. I also uncovered that governmental interventions effectively minimized health disparities between communities with differing levels of social vulnerability.

We know that your project focused on the spread of COVID on vulnerable populations. How can this data be applied to inform vaccine distribution?

With my mentor, I utilized my findings to write an action plan for improving health equity, identifying areas of focus for public health interventions and programs -- one of which discusses vaccine development and delivery. In regard to vaccine distribution, I wrote about how it is important to recognize greater COVID-19 transmission in socially vulnerable communities observed in my investigation to achieve herd immunity. In addition, I also recommended the creation of more community health education and outreach to improve health literacy which can help vulnerable communities access vaccinations. Our team forwarded the findings of my project and this action plan to the Congressional Coronavirus Task Force to aid in guiding COVID-19 relief and recovery efforts.

Where do you envision your project in helping inform decisions for future outbreaks and pandemics?

I hope that my project is not only able to improve our response to the current COVID-19 pandemic but also promote health equity in the long term. Many of the recommendations in the action plan I created have long-reaching impacts on health equity in non-pandemic times and for future pandemic preparedness. In addition, the SVI-stratified SIRD model I developed can be beneficial to understand the basis of health disparities for other diseases and future outbreaks. It will be a useful tool for addressing health disparities in these scenarios as well.

What were some challenges that you encountered for this project as well as in working in a virtual space?

Prior to this project, I only had experience in wet lab cell biology research, so it was absolutely daunting to research virtually. One of the greatest challenges was trying to learn new concepts and perfect new techniques. Through extensive literature review and plenty of trial and error, I was able to quickly pick up on new skills and execute my project. Another challenge was overcoming my own hesitance to venture into a new area of research, but I adapted by staying open-minded and pursuing a project I was passionate about.

What advice do you have for younger students who are interested in research?

I would definitely encourage younger students interested in research to never doubt their own abilities or view a project as too daunting. It is so important to recognize that the necessary elements to innovative research are just having an idea and the determination to see the project through. Undoubtedly, research will throw hurdles in your way, and it is through persevering and believing in yourself that you can tackle some of the world's greatest issues through science.

GENES

As we all know, genes play a massive role in the human body. From eye color to height, they determine the makeup of every part of us.

SO LET US DIVE INTO THE GENE POOL AND EXPLORE THE WONDERFUL WORLD OF GENES.

The term "gene" was first coined by Wilhelm Johannsen in 1909, and it comes from the Greek word genos, meaning birth. Genes are the basic unit of heredity. They contain DNA sequences that are used as templates to synthesize proteins, which control what traits an organism expresses. Occasionally, mistakes in the synthesization process, known as mutations, occur, and can lead to major changes in gene expression.

These changes affect fitness, an organism's ability to survive, playing a critical role in determining what genes are passed to the next generation, bringing about the famous phrase "survival of the fittest." Mutations have led to diverse gene pools and incredible traits, both intraspecies and interspecies. So, let us look at unique examples of genes within the human race and in other animal species...

First, humans.

Human beings have over three billion base pairs in our genome, and within that massive number we have unique properties from certain genes. For example, in chromosome 8, we have a gene called the gulonolactone oxidase pseudogene (GULOP). GULOP's primary function was to create vitamin C. But, around 63 million years ago, our ancestors lost their ability to synthesize vitamin C. This type of gene is called a pseudogene, or a non-functional gene. Luckily, though we can no longer use this gene, we are not all dead, indicating this gene is not integral to human life. However, it remains in our bodies among many other "dead" genes.

"Mutations have led to diverse gene pools and incredible traits, both intraspecies and interspecies. "

Second, elephants.

With more cells than smaller animals, larger animals may be thought to have higher rates of cancer development. However, this is not always the case: take elephants, for example. Although elephants have one hundred times more cells than us, they are less prone to cancer in old age. The numbers back this up: only 5 percent of elephants that contract cancer die of the disease while the mortality rate of humans with cancer is 11 to 25 percent. This is because of a unique gene in their body called TP53 that codes a protein that can destroy cancer cells. Although humans also have TP53, we only have one while elephants have multiple. While the gene TP53 is still studied, the effects cannot be under-stressed.

Third, octopuses.

Perhaps, the weirdest example of genes is found in the octopus. These sea-dwelling creatures can edit their genes. Yes, you heard that right, modify their own genes. Cephalopods — the family that octopuses belong to — took a different path to evolution. Unlike other animals that rely on random chance for mutations, cephalopods are able to use RNA editing. They do this by interfering with the DNA transcription and changing their genetic material through RNA editing. This effectively allows them to create multiple unique proteins from the same DNA. This ability is advantageous: Joshua Rosenthal, founder and director of the Institute for Integrative Nutrition, has found octopuses using RNA editing to survive in frigid waters. Although this is not a conventional system, it is useful for the octopuses' survival as they are one of the most intelligent and widespread animals in the world.

GENE EXPRESSION AFFECTS EVERY ANIMAL IN THE WORLD, AND THE INFLUENCE THAT MICROSCOPIC GENES HAVE ON THE CAPABILITIES OF HUMANS, ELEPHANTS, AND OCTOPUSES ARE UNIQUE AND AMAZING.

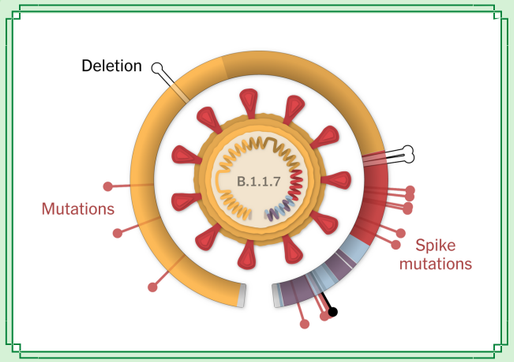
CATAPULTA // SPRING 2021 MIRA YU - III | 17

COVID-19 VARIANTS

AS YOU MIGHT RECALL FROM NINTH GRADE BIOLOGY, VIRUSES CONSTANTLY MUTATE, RESULTING IN NEW VARIANTS. UNLIKE PARASITES AND BACTERIA, VIRUSES CANNOT REPRODUCE ON THEIR OWN; RATHER THEY RELY ON INHABITING NEW HOST CELLS, AND COVID-19 IS NO EXCEPTION.

However, coronavirus particles produce genetic mistakes more slowly than other RNA viruses because they contain a certain enzyme, a protein that acts as a catalyst for chemical reactions, which corrects fatal copying errors. Based on samples, the generic SARS-CoV-2 virus only makes about two errors a month. Still, this has led to the occurrence of over 12,000 known mutations. Three specific mutations have become global threats.

The most transmissible variant of the virus is called B.1.1.7. First identified in the United Kingdom in late September of 2020, this virus has certain mutations — including a mutation named N501Y — that may help infected cells create new spike proteins more efficiently. In addition to being fifty percent more infectious, B.1.1.7 has also been found



A DIAGRAM OF B.1.1.7

o cause more severe illness. It has currently been detected in over 70 countries and 33 states. The B.1.1.7 variant was first identified in the United States at the end of December 2020. As of February 7, infections from this variant double every 10 days in the U.S.

Another variant, called B.1.351, originated in South Africa and has since spread to at least 48 countries. This variant was originally identified in early October of 2020, and it was first reported in the U.S. at the end of January 2021. Although B.1.351 shares some mutations with B.1.1.7, the variants evolved independently of each other.

This variant was originally identified in early October of 2020, and it was first reported in the U.S. at the end of January 2021. Although B.1.351 shares some mutations with B.1.1.7, the variants evolved independently of each other.

The third major global variant, P.1, emerged in Manaus, the largest city in Brazil's Amazon region. It was discovered in early January in travelers to Brazil who were tested during routine screening at an airport in Japan, and it was first detected in the U.S. towards the end of January 2021. The P.1 variant has additional mutations that make it more difficult to be detected by antibodies, blood proteins produced by the body to combat viruses and bacterial cells.

ANOTHER VARIANT, CALLED B.1.351, ORIGINATED IN SOUTH AFRICA AND HAS SINCE SPREAD TO AT LEAST 48 COUNTRIES

Are the existing vaccines effective against these variants? For the most part, yes. Vaccines seem to work well against B.1.1.7 (the U.K. variant). The effectiveness of some vaccines, however, seems to falter in the face of B.1.351. Specifically, the AstraZeneca vaccine had an estimated 10 percent efficacy in trials with the South African variant, and the Johnson & Johnson vaccine's efficacy rate dropped from 72 percent in the U.S. to 57 percent in South Africa. Similarly to B.1.351, P.1 may be able to overcome the immunity developed after infection to other variants. Still, the key N501Y mutation found in both B.1.1.7 and B.1.351 does not create resistance to immunity to the Pfizer vaccine.

FURTHER RESEARCH IS NEEDED TO REAFFIRM DATA THAT HAS ALREADY BEEN FOUND REGARDING THE EFFICACY OF VACCINES CURRENTLY AVAILABLE, BUT FUTURE VACCINES STILL IN DEVELOPMENT MAY PROVE USEFUL AGAINST THESE POTENT VARIATIONS.

POISONOUS SNAILS

Pheromones are secreted or excreted chemicals used by animals within a species to communicate or influence each others' behavior. What if an animal could be attracted in the same way by another species' venom?

In a study led by Joshua Torres, a medicinal chemist at the University of Copenhagen, small molecules in the venom of imperial cone snails, Conus imperialis, seem to initiate mating behaviors among worms, luring them out into the open and exposing them to predation.

When a cone snail sees its prey, it packs its venom into self-constructed harpoons and injects them into its prey. Some fish-hunting cone snails employ predation tactics that involve peptide hormones like insulin.

For example, one species produces weaponized insulin to induce hypoglycemia in fish prey to slow them down. The conopeptides of fish-hunting cone snails can selectively target receptors and vertebrate ion channels, allowing them to become excellent sources for derived pain drugs like Prialt.

Torres and his team noticed that two small molecules in the venom of cone snails, Conazolium A and genuanine, were strikingly similar to the pheromones used by marine polychaetes worms for mating. Unlike venom from other cone snail species, these molecules from C. imperialis did not seem to affect neuromuscular pathways. Torres hypothesized that Conazolium A and genuanine were mimics of pheromones in Platynereis dumerilii worms that the cone snails used to attract their prey.

The researchers tested their hypothesis by treating male and female P. dumerilii worms with Conazolium A and genuanine. Exposure to the pheromone mimics resulted in changes in swimming behavior and the release of sperm among the worms, both of which are common precursors to mating. After being exposed to the pheromone mimics, 7 out of 11 females started swimming around in tight circles and 13 out of 16 male worms released sperm. This suggests cone snails inject their venom into the water to attract their prey.

Studies on these cone snails, however, have only been conducted in labs, away from the worms' natural environment located in the sediments of the ocean. Thus, further research is needed in the species' natural environment to determine whether the venom serves as a mimicry hunting strategy.

A New Approach to the Origins of Life:

Wet-Dry Cycles on Land

Fossil evidence shows that life first came about on Earth at least 3.5 billion years ago, but how did disparate chemical compounds turn into intact organisms? Since the 1950s, many scientists theorized that life originated in hydrothermal vents, which are cracks on the seafloor through which heated water is discharged. Recent studies, however, have challenged this idea and instead argue that life began on land in small, shallow bodies of water that were alternately wet and dry.

Many scientists agree on three basic requirements for life. First, the organism must have information-storing molecules, such as DNA and RNA, that encode for physical traits. They can copy and pass these traits onto offspring, but this process is imperfect and therefore can give rise to new traits through mutation. Second, an organism must have ongoing chemical reactions to process nutrients into energy to fuel their survival and growth. Third, there must be something enclosing and holding together the various parts of an organism, for example, a membrane, keeping it separate from its environment.

The wet-dry land theory is a promising idea to explain the origins of life for three main reasons:

1. Exposure to sunlight
2. High concentration of chemicals
3. Alternating wet and dry conditions

In shallow bodies of water on land, sunlight can easily reach potential organisms, while only a miniscule amount of sunlight gets to the deep ocean. There have been multiple experiments showing that ultraviolet (UV) radiation from the sun can cause molecules to exhibit lifelike tendencies, such as dividing in order to replicate.

Chemical substances can also be highly concentrated in small bodies of water on land; this is much less likely in the ocean since its volume is so immense. And with high concentrations of chemical compounds, there is simply a much greater chance that the wide variety of molecules needed to create an organism could form.

Most importantly, the alternating wet and dry conditions could be crucial to life. Several studies have shown that exposing individual, simpler molecules to cycles of wet and dry conditions causes them to link together to form molecules that are more complex and close to actual biological molecules.

In fact, in 2009, researchers synthesized two types of nucleotides, which make up RNA and DNA, by applying UV radiation to phosphates and simple carbon-based molecules, which were highly concentrated and dissolved in water. Such results could not have been achieved deep in the ocean where UV radiation is extremely scarce, chemicals are not as concentrated, and wet-dry cycles are improbable. In short, experiments that simulate alternating wet and dry conditions on land have produced the building blocks of nucleic acids, proteins, and lipids.

One critique of the wet-dry cycle is that though dry conditions allow molecules to link, wet conditions break down the bonds connecting essential biological molecules such as proteins and nucleic acids. The wet-dry land theory, however, offers a solution.

Wet conditions seem to be essential for the formation of life because water drives molecules to become more complex. Molecules that have properties that protect them from being dissolved in water, such as being nonpolar (no net charge across the molecule) or combining with other molecules to shield, remain intact.

One study showed that when proteins combined with RNA, the molecules remained intact in water. In contrast, molecules that could not combine with other molecules in such a way or were soluble in water were destroyed.

As a result, with each cycle of wetting, the more complex molecules survived and accumulated, while the ones more vulnerable to water did not. A conglomerate of biological molecules simply existing is one thing, but a living organism must have complex, dynamic, and self-sustaining systems. The selective pressure of water could be a factor that pushed molecules to become more complex and closer to life. Therefore, dry conditions may be necessary to form biological molecules, but wet conditions are necessary to select for the most complex molecules that can eventually form an organism. In order for life to form — according to this theory — there cannot be too much water so that all the biological molecules break down before they can accumulate, but there has to be enough to put selective pressure on the molecules to change and become more complex.

A more traditional theory is that life began in hydrothermal vents on the ocean floor, where warm alkaline water seeping up from geologic formations drove simple metabolic cycles. Proponents of this theory argue that the chemistry associated with the formation of biological molecules in the wet-dry land theory is too miraculous and dissimilar from modern organisms. A counterargument to this, however, is that biological processes, like methods of synthesizing molecules, have evolved over time with selective pressures.

"Dry conditions may be necessary to form biological molecules, but wet conditions are necessary to select for the most complex molecules that can eventually form an organism."

In any case, to better understand where life originated on Earth, scientists still need to conduct further experiments about the chemical reactions that lead to the formation of biological molecules and the conditions they can occur in. Findings about how and where life on Earth may have originated can help predict whether life can exist on other planets, transforming our understanding of biology and the universe.

The Biodata Race

Last spring, as COVID-19 cases in America surged, the BGI Group (formerly known as the Beijing Genomics Institute), one of the world's largest biotech organizations, approached four U.S. states with an offer to build and run state-of-the-art testing labs for COVID-19. Despite the desperate need at the time, however, intelligence officials were unsure of the company's motives to provide these facilities.

BGI Group's established relationship with the Chinese Communist Party (CCP) worried skeptics, including former counterintelligence official William Evanina, a CIA and FBI veteran. He wrote a warning to states and individuals highlighting how "foreign powers can collect and exploit biometric information from COVID-19 tests." Evanina believes that these test sites are like Trojan horses that could infiltrate the biometric information of millions of Americans, which would benefit the CCP.

Edward You, an FBI Supervisory Special Agent and a former biochemist, echoes Evanina's worries, saying, "We need to step back and think 'Who has access to our data?'" The answer more often than not points to China.

You notes that the BGI Group, and by extension the CCP, has already acquired tons of our data through direct collection and the acquisition of other companies over the last decade, compiling massive databases of our biometric information.

But why exactly has the CCP made such a deliberate attempt to accrue this information?

Chinese President Xi Jinping has been quite open in his desire to dominate the West and reap the benefits of advances in DNA science and technology in the future. China wants to become a leader in the healthcare field, and further enhance their own technology and surpass thatthose of other nations.

In the future, with these databases, China could micro-target individuals, predict diseases they are susceptible to based on their genome, and recommend medications to them before the onset of disease. While this is beneficial to individuals, it would mean outsourcing a sizable chunk of our medicine and healthcare to China.

Evanina worries that this could lead to dependence on China, and as a result China would completely surpass American medicine. While this power would undoubtedly benefit the individual immensely, it can also be very dangerous. This threat is not from the Chinese people themselves, but the government.

China's motives are undisclosed, and it is unknown whether they will use the power of big biometric data for good. For example, the CCP has already utilized these databases to target Uyghur Muslims in China and place them in concentration camps.

Clearly, China recognizes the value of the DNA, and though they already have lots of domestic data, they have recently begun collecting DNA from around the world. The larger and more diverse the dataset, the more information and power gained. If supplemented with artificial intelligence, the possibilities are truly endless.

But what is it about our DNA and other biometric data that makes it so valuable?

DNA is like a double-helix blueprint coding for all of our traits from hair color to susceptibility to certain diseases; moreover, certain sequences of DNA code the same traits for all humans. If scientists can pinpoint what sequence corresponds to susceptibility to, for example, breast cancer, they not only can diagnose patients before cancer develops but could also provide clues that would lead to fruitful drug development. In fact, with just 10,000 DNA samples, scientists are able to locate certain biomarkers in the human genome. Imagine the improvement of the statistical chances to find markers (both in number and accuracy) if the dataset was increased to 10,000,000 samples. This is why China wants new data so badly.

At the same time, China has locked down access to its own biometric information. According to You, it is a "one-way street" when it comes to the exchange of this data. Additionally, they often acquire information through dishonest methods, such as hacking or stealing, according to Evanina. He states that current estimates point to 80 percent of Americans who have personally identifiable data stolen by China. In fact, last December, John Ratcliffe, the former Director of National Intelligence, named China as the number one threat to national security in America, citing their data and technology theft specifically.

Thus, big data, specifically biometric data, is a double-edged sword. While it can provide scientists with valuable information to develop treatments and diagnose disease, it can also be used to invade the privacy of individuals.

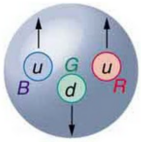
America has been doing its part in this field with genealogy companies like AncestryDNA and 23andMe, storing and selling the data of individuals who use their services, to develop new drugs. But this pales in comparison to China. 23andMe CEO Anne Wojcicki says that this research is vastly underfunded and lacks the organization that China has.

No matter who wins the biodata race, however, it stands to benefit us as individuals tremendously. There will be many lives saved regardless, but hopefully, countries can work together to prioritize the welfare of mankind, rather than for their own benefits.

PUZZLE: QUIZZICAL QUARKS

If we continuously zoom in, what is the smallest unit? Molecules are made of atoms, atoms are made of protons, neutrons, and electrons, and these are made of a sea of fundamental particles. While an enormous number of quarks make up each composite particle, valence quarks characterize them. Using the information below, can you figure out what valence quarks make up these interesting baryons? Bonus if you can figure out the baryon name/type!

NAME	SPIN	CHARGE (e)	MASS (MeV/c^2)
Up (u)	$\pm 1/2$	$+2/3$	~ 2.2
Down (d)	$\mp 1/2$	$-1/3$	~ 4.6
Charm (c)	$\pm 1/2$	$+2/3$	~ 1,280
Strange (s)	$\mp 1/2$	$-1/3$	~ 96
Top (t)	$\pm 1/2$	$+2/3$	~ 173,100
Bottom (b)	$\mp 1/2$	$-1/3$	~ 4,180
Anti-up (u)	$\pm 1/2$	$-1/3$	~ 2.2
Anti-down (d)	$\mp 1/2$	$+2/3$	~ 4.6
Anti-charm (c)	$\pm 1/2$	$-1/3$	~ 1,280
Anti-strange (s)	$\mp 1/2$	$+2/3$	~ 96
Anti-top (t)	$\pm 1/2$	$-1/3$	~ 173,100
Anti-bottom (b)	$\mp 1/2$	$+2/3$	~ 4,180

PROBLEM	VALENCE QUARKS?
EXAMPLE: Proton Number of Quarks: 3 Spin: 1/2 Charge: +1 Valence Mass: ~9.0 (MeV/c^2)	 Proton Spin $\frac{1}{2}+\frac{1}{2}-\frac{1}{2}=\frac{1}{2}$ Charge $+\frac{2}{3}+\frac{2}{3}-\frac{1}{3}=1$
Number of Quarks: 3 Spin: 1/2 Charge: 0 Valence Mass: ~11.5 (MeV/c^2)	
Number of Quarks: 3 Spin: 1 Charge: 0 Valence Mass: ~103 (MeV/c^2)	
Number of Quarks: 5 Spin: 3/2 Charge: 4/3 Valence Mass: ~175,700 (MeV/c^2)	