CATAPULTA

WINTER 2022

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EDITORS' NOTE

DEAR READER,

IT'S CRAZY TO THINK THAT THE RELEASE OF THIS EDITION COMES AROUND THE TWO YEAR ANNIVERSARY OF COVID-19 AS A GLOBAL CONCERN. WHILE OUR KNOWLEDGE OF THE UNIVERSE (AND THE VIRUS) CONTINUES TO EXPAND EXPONENTIALLY, EVERY FINDING WE MAKE JUST SEEMS TO BE MET WITH A BACKLOG OF COMPLICATIONS. WE EXPLORE THIS TREND THROUGH MULTIPLE ANGLES IN THIS SEASON'S ARTICLES.

HOWEVER, OUR HOPE IS THAT, RATHER THAN BEING DISMAYED BY THIS, YOU WILL INSTEAD REALIZE THE IMPORTANCE OF CURIOSITY -- HISTORICALLY, AT THE PRESENT, AND IN THE FUTURE. IN FACT, THE FATE OF THE HUMAN RACE RELIES ON THE PERSISTENCE OF YOUNG SCIENTISTS LIKE YOURSELF! WE SAW THIS MIX OF OPTIMISM AND ENDURANCE IN OUR FEATURED INTERVIEW WITH ABC BROADCAST JOURNALIST JAMES LONGMAN. HOPEFULLY, YOU ARE JUST AS INSPIRED AS WE WERE BY HIS THOUGHTFUL REMARKS ON CONTAGIONS, CLIMATE CHANGE, AND MENTAL HEALTH.

2022 HASN'T BEEN GREAT SO FAR, BUT WE ARE MANIFESTING GOOD NEWS COMING YOUR WAY SOON TO MAKE UP FOR IT!

- Alex & Sanjana
EDITORS-IN-CHIEF

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XENOBOTS

ON PAGE 05

PICTURE THIS!

A TINY ROBOT
- PAC-MAN SHAPED
- BIODEGRADABLE
- CAPABLE OF REPRODUCTION

SCIENTISTS FROM THE WYSS INSTITUTE FOR BIOLOGICALLY INSPIRED ENGINEERING AT HARVARD UNIVERSITY, UNIVERSITY OF VERMONT (UVM), AND TUFTS UNIVERSITY HAVE CREATED SELF-REPLICATING, "LIVING" ROBOTS-THE FIRST OF THEIR KIND. THESE INNOVATIONS, KNOWN AS XENOBOTS, WERE DESIGNED ON A SUPERCOMPUTER AT UVM AND THEN ASSEMBLED AND TESTED BY BIOLOGISTS AT TUFTS UNIVERSITY. THE MILLIMETER-WIDE ROBOTS ARE COMPOSED OF COMPLETELY BIODEGRADABLE FROG EMBRYO AND ...

IT MAY BE SURPRISING TO SOME THAT PLAYING OUTSIDE IN THE DIRT HAS IMPORTANT HEALTH BENEFITS, SUCH AS ACQUIRING VITAMIN D FROM SUNLIGHT AND DIVERSIFYING THE MICROBIOME, YET WE OFTEN OPT TO STAY INDOORS AND NEGLECT OUR DAILY WALKS FOR FRESH AIR. BUT WHAT IF I TOLD YOU THAT THE VERY SOIL WE STAND ON COULD PROVIDE A NATURAL AID IN TREATING MENTAL DISORDERS?

MYCOBACTERIUM VACCAE, A BACTERIUM OFTEN FOUND IN SOIL, WAS DISCOVERED IN 1971 WHEN THE ENVIRONMENT OF LAKE KYOGA IN UGANDA WAS INVESTIGATED FOR ABNORMALLY HIGH EFFICACY RATES OF VACCINES AMONG ITS RESIDENTS.

MYCOBACTERIUM VACCAE: A NATURAL DEPRESSANT?

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HOLLYWOOD SCI-FI RANT

Sci-Fi is a genre of fiction centered around technological innovation. At times, however, science fiction works (I am looking at you, Star Trek) egregiously misrepresent basic scientific concepts. Accurate depictions of science in science fiction are as important as those of history in historical fiction. For example, no historical fiction work of merit would include Napoleon putting gas in his car. Sci-Fi writers often are not held to the same standards as writers of other genres, which can cause serious misconceptions about scientific phenomena.

XENOBOTS

<MINISCULE CREATURE ORIGINS>

(continued from page 04) heart muscle cells. However, they should not be classified as frogs, nor were they assembled to function like one. UVM Environmental Program Lecturer Joshua E. Brown explains that, "[the] dead cells have been repurposed to serve another need," similar to how "a book is made of wood, [but] it is not a tree."

<DESIGNER PACMAN ABILITIES>

So, what makes these robots unique? Their most profound trait is their ability to reproduce, but xenobots are also capable of walking, pushing pellets, carrying payloads, and aggregating debris into piles. Additionally, they can pick up loose stem cells from the environment using their "mouth." Xenobots can also survive weeks without food or heal themselves after injury. Often the loss of a cell's form means a loss of function as well, but xenobots do not face this setback with their regenerative properties. According to University of Vermont Professor Josh Bongard, scientists would "slice the robot almost in half, and it [would stitch] itself back up and [keep] going."

To advance the design of these miniature-robots even further, additional motors and sensors have been incorporated into xenobots. This includes an RNA molecule that gives xenobots a molecular memory. In this case, "memory" entails glowing a specified color when viewed under a fluorescence microscope after being exposed to a particular light beforehand. Researchers have also found that replacing heart muscle cellular components with cilia—small, hair-like structures found on a cell's surface—allows the xenobot to maneuver itself in liquid environments. At the same time, though, the movement of xenobots with cilia is much less controllable than that of cardiac-driven ones.

<THE FUTURE>

Global health and environmental concerns continue to plague the future of the human race. It has been speculated that biotechnology like xenobots can be used to find and aggregate microplastics in the ocean, which can then be handled by recycling centers. Xenobots do not contribute to pollution while they work; the robots use energy from fat and protein stored in their tissue, so when the time comes for degradation, they simply turn into dead skin cells. Xenobots may have implications in the medical field as well, such as in targeted drug delivery. Xenobots made from the cells of a human patient could bypass immune response challenges that other micro-robotic delivery systems face. Such technology would then be able to remove plaque from arteries or, with additional bioengineering, could locate and treat other diseases as well.

"If we knew how to tell collections of cells to do what we wanted them to do, ultimately, that's regenerative medicine —that's the solution to traumatic injury, birth defects, cancer, and aging," says Dr. Michael Levin, a director at the Allen Discovery Center at Tufts University and co-leader of this new research. "All of these different problems are here because we don't know how to predict and control what groups of cells are going to build. Xenobots are a new platform for teaching us."

As with nearly all new technologies, some have expressed concern with this novel technology. Yet, Bongard argues that, "we have a moral imperative to understand the conditions under which we can control it, direct it, douse it, exaggerate it," and he explains that, "we need to create technological solutions that grow at the same rate as the challenges we face."

While advancements in science may seem frightening initially, it is nevertheless important to move forward. Perhaps it may be a good idea to work on conquering your own fears now, seeing as a tiny robot may be inside of your body cleaning your arteries in the near future.

NANOTECH AND YOU!

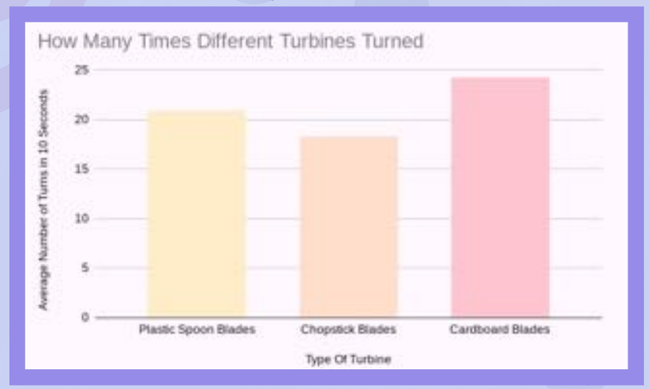
Nanotechnology, the study of near-microscopic materials, has been portrayed in numerous science fiction books and movies. Most recently, advancements in the field have been developed in and applied to different areas of science, including human anatomy. Researchers at New York University, for example, have created a nanoscale robot—composed of DNA fragments and capable of "walking" on legs about ten nanometers long—that can repair and even replace problematic biomolecules in human patients. In 2016, the Nobel Prize in Chemistry was awarded to a trio of scientists who produced similar microscopic machines composed of various ring-shaped molecules—catenanes and rotaxanes—linked together. Thus, materials impossible to see with the naked eye can still be controlled, and discoveries in nanotechnology may substantially impact the practice of medicine. For example, they may help battle prevalent diseases such as cancer or diabetes by introducing augmentable particles that target cancerous cells or produce necessary materials like insulin for survival.

While this breakthrough is promising, more research is necessary to minimize the risks of nanobot application. Foreign particles introduced into a person's bloodstream may attack healthy biological material and elicit unwanted health complications. Free radicals, which are molecules that have at least one unpaired valence electron, are highly reactive and actively seek electrons from other particles. When free radicals gain electrons through oxidation, the organism's cell consequently loses electrons through reduction, and this can fatally damage proteins and DNA. Nanoparticles have a risk of becoming free radicals, especially if their intermolecular bonds break, underscoring the need for caution with their anatomical applications.

However, the potential benefits of this technology far outweigh the consequences. Nanotechnology is currently being studied for its potential benefits in alleviating cancerous cells without harming normal functioning ones. Scientists are developing new particles that can rapidly detect molecular changes in a group of cells, which could detect the presence of cancer and drastically increase chances for survival. In the future, these particles may directly deliver treatment to the tumor itself, eliminating the need for costly and time-consuming processes like chemotherapy. Overall, nanotech is an innovative field with promising implications in medicine and other scientific disciplines, potentially improving our understanding of the microscopic world and the quality of human life.

TURBINES

Hydropower is a renewable energy source that can generate electricity from the movement of water. Given the abundance of water in our natural environment, hydroelectric power plants are an effective way to produce energy for people living in its nearby area. In fact, many today rely on hydroelectric plants; when a California plant, capable of generating up to 750 megawatts of energy, was shut down, neighboring residents were concerned about rolling blackouts.



Turbines are components essential to creating hydroelectricity. Moving water turns turbines, which are attached to electricity-producing generators. Rotating turbines spin coils of wire, which helps conduct electricity. Electricity produced in generators travels through a grid to supply power. Dams alter the normal movement of water; by directing water through turbines, dams, which have generators, can help create electricity.

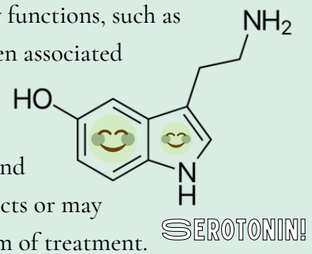
My experiment measured the efficiency of different water turbine models. I made three models of different blades: plastic spoons, chopsticks, and rectangular cardboard. I put them underneath the tap and observed the number of times each one turned in 10 seconds to determine which material worked best. My hypothesis that a turbine with larger blades would turn a greater number of times was supported. The cardboard blades were wider, which allowed them to turn more. Even though it might take more water to push these larger blades, all of the water was being used, as opposed to the chopstick blades, for which only some of the water was used. In fact, the collected data shows that cardboard blades were able to spin roughly 33% faster than the chopstick blades. In the future, to build on my research, I would like to further investigate how much power real life turbines generate and turbines' current impact in cities around the country.

MYCOBACTERIUM VACCAE: A NATURAL ANTIDEPRESSANT?

According to Dr. Christopher Lowry, a scientist observing links between bacteria and mental health, the vaccines may have worked better because of this microorganism, which seemed to substantially impact the immune system. Dr. Lowry became more interested in this bacterium during a clinical trial in which lung cancer patients were injected with *M. vaccae* in an attempt to improve their immune systems and lengthen their lifespans. Although the treatment failed to meet his original expectations, patients did report better quality of life. This inspired Dr. Lowry to conduct experiments on mice evaluating the connection between *M. vaccae* and the brain. He discovered that injecting a dead bacterium in the mice resulted in lower measured levels of stress when placed in strenuous environments. He also concluded that it had the potential to prevent "PTSD-like" symptoms in the mice.

The recent pandemic has magnified the effects of depression, anxiety, and stress among the global population. The cost of treating these conditions has also become a source of financial burden for many. Killing *M. vaccae* with heat however, tends to be inexpensive and shows positive results in animals, which begs the question: could this research propose new ways to treat mental health conditions or even create a vaccine against depression?

Serotonin—known as the "happy chemical"—is a hormone that controls many bodily functions, such as sleeping and eating, though it also helps stabilize mood. Low serotonin levels are often associated with depression. Popular antidepressants like Prozac and Zoloft—which are selective serotonin reuptake inhibitor antidepressants (SSRIs)—can slow down the absorption rate of serotonin, allowing the brain to retain higher levels of serotonin and thus improve one's mood. Yet, SSRI use may be accompanied by unpleasant side effects or may have very little beneficial effect for some, which can deter some from taking this form of treatment.



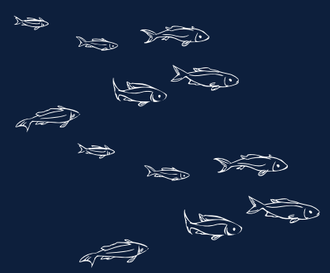
What does this have to do with *M. vaccae*? Research shows that injecting *M. vaccae* in mice produced serotonin, which appeared to yield an antidepressant-like effect. In addition, the bacterium has been used in treatments for other illnesses and has shown very few or mild side effects, demonstrating strong potential as a less harmful treatment for mood disorders.

The notion of a cheap, effective treatment (found in soil!) for depression with minor side effects may seem far-fetched. With the ever-increasing capabilities of technology and our improved understanding of ecological phenomena, however, it may be possible. For now, go outside and enjoy a natural mood booster!

ICEFISH COLONY DISCOVERED IN ANTARCTICA

Here in Boston, we are no strangers to cold temperatures. Despite this, very few of us would choose to spend much time in the frigid ocean waters at this time of year. Even aquatic animals that frequent New England shores like the humpback whale or the great white shark are known to migrate south to warmer climates during these winter months. There is, however, one little-known species that has evolved to thrive in the near-freezing waters of Antarctica: the icefish. Led by Dr. Autun Purser, marine biologists observing the Weddell Sea, just off the coast of Antarctica, have recently discovered the largest breeding colony of any currently known species of fish. In a survey of the ocean floor lasting four days, these scientists discovered over 16,000 active nests and estimated many more active nests—as many as sixty million—in the entire ninety-two square mile section of the Weddell sea floor. They also have set up a series of surveillance systems near the colony to learn more about the life cycle of this species of fish. Further study could reveal more about polar food webs, which could in turn help to conserve many species that live in similar habitats. This population of icefish, for example, supports a colony of Weddell seals.

Chaenocephalus aceratus, also known as the Antarctic blackfin icefish, is most well known for its unique physiology, which allows it to survive extremely frigid temperatures. It does not have blood cells, which typically use hemoglobin to carry oxygen throughout the bodies of vertebrate organisms, because these cells would quickly freeze in Antarctic temperatures. Instead, it has clear blood and has evolved to absorb oxygen directly from the water through its scales. Other special features include comparatively low bone density and high-fat content, which allow them to rise in the water column to feed. In humans, this lack of iron (usually found in the bloodstream) would constitute severe anemia, and similar levels of bone density loss would be known as osteoporosis. Scientists are hopeful that continued research of the adaptive techniques of the icefish could lead to breakthroughs regarding these serious medical conditions.



Interview with ABC National News Correspondent James Longman

On January 30th, 2022, Catapulta Editor-in-Chief Alex Chou (I) conducted a Zoom interview with ABC News Foreign Correspondent James Longman. An Emmy-nominated journalist and recent guest host on Good Morning America Weekend Edition, Longman has served as a reporter for numerous national television programs, including ABC World News Tonight, Nightline, and ABC News Live. With a decade of experience in journalism, Longman has covered a wide range of international topics in over 40 countries. The transcript has been lightly edited.

What inspired you to pursue a career in journalism?

I began as a journalist by accident: I was doing my master's degree in Arabic (and later International Relations) in Syria for a time. In 2011, the protest movement started, and I was in a good position to document what was happening. Even at that time, it wasn't because I wanted to be a journalist—it was because I was just interested in Syria and wanted to see for myself what was happening, and it was going to form part of my studies (my master's thesis about Syria). It was only a friend who said, "You realize, James, that there aren't many people able to go into Syria at the moment. They're not giving visas to journalists—you might want to touch base with a couple of newspapers and let them know that you're there." I did, and sure enough, some newspapers were interested. That's how it began.

What makes a good journalist?

I think what makes a good journalist are the same attributes that make you a good human being: being interested in other people's lives, wanting to know more about them, and seeing the world through different perspectives and not just your own.

In this job, your life intersects with another human who is going through possibly the most difficult thing they will ever experience. It's a test to see how you respond in that moment, and it's really important that you get it right. There is a transactional nature to journalism: I need something from you, and I need you to tell me your story because it is my job. You need to make that transaction easy for the other person without feeling as though you're just using them and going to move on.

"All of these require the same skills as life requires: to be good to other people, to feel that you value them for who they are and not just for what they can give you."

How do you persevere through news assignments that may be particularly disheartening?

What I'm most inspired by is that human beings are fundamentally good people. It's just true. Wherever you go in the world, you can go to a refugee camp in the middle of the freezing blizzards of northern Syria, or you can meet indigenous people mourning their relatives in Brazil who've died of COVID, or you can meet young people on the streets of Hong Kong protesting for a better future. All of these people have one thing in common: they want good things for their families.

One thing I've learned preparing news for public consumption is that the audience is also good. They want to hear good. They don't want to be told "the world is bad" and "the world is ending" and "we're all going to die." They want hope. The stories I've done that have received the most interest have always been stories that—not just "this is happening" and "this is serious" and "this is why you should care"—but have another element of "this is why there is some hope." We always joke in journalism that your story is only ever going to be popular online if it includes a panda, or that the public only really wants to click on pictures of puppies. Well, they want to do that because people like to be happy! I didn't get into this job to depress everybody.

"I did it because I wanted to—yes, tell people that there were serious things happening around the world—but also inspire them to do good in their own lives."

Spreading awareness of pressing issues involves directing others toward action, but journalists are expected to do so without inserting personal bias. How do you balance the two?

I always say it's important not to show the audience what you think, but you absolutely can show them how you feel. To strike that balance is hard, but I think it's okay (and actually really important) to show the audience that you really feel passionate about something without telling them what your opinion is or what you think their opinion should be. That's what I try and do. It's hard these days. Media, especially television news, is so stratified in the US, and people now unfortunately tend to gravitate towards the media that best serves their own bias. I think we do a great job at ABC of not doing that and of having people who give the audience a sense about how much they care about something.

In Oct. 2020, you wrote in an article that small countries like Liberia, "one of the poorest in the world, had set up a system" that worked more effectively than those in developed nations. Does this remain true?

Well, Liberia—to use that example—had the experience of Ebola, which meant that when a public official told you to wash your hands, you did it because you'd seen Ebola kill very quickly. While Omicron is by no means Ebola, it's still an infectious disease. People had, I suppose, the muscle memory there, as well as the infrastructure: there were basins outside of public buildings, there was signage, they had the basic kind of building blocks for public response to a contagious disease outbreak. In places like Africa, people also spend a lot more time outdoors. And, it's not that they might not have very high COVID numbers: they're just not transmitting it as much, they have a much younger population, and (I think probably the biggest part of it all) the numbers probably don't get reported as fastidiously as they do in other parts of the world. So, comparing one with the other is always really hard.

What I would say is that you have much less complex public debate about issues that may not need debate in a place like Liberia. Issues there are not as politicized as much: if you get told by a public official to wear masks, you just do it. Not everything is seen through the lens of politics. I think it's safe to say that is what has happened in the US. However, it's always so difficult to actually compare one country with another. There are all sorts of reasons why the US has seen a bigger death rate in different parts of the country than it has in others. In the UK, we don't have a particularly vaccine-reluctant population—we have a population that is quite keen to follow the rules. The politicized nature of every single public decision isn't necessarily as strong as it is in the United States, and yet Britain has one of the highest—if not the highest—death toll from COVID in Europe. Britain had everything in place, and we still had a high death toll. But, it's certainly true that the politicized nature of the debate about COVID in the US hasn't helped.

Aside from affecting our physical health, the pandemic can have serious tolls on mental health. What long-term psychological trauma might the current public health crisis pose?

I think we probably haven't really understood the impact this is going to have on children or school-folk. They say kids are resilient, but I don't know if we really understand the impact that this has had on people going to high school and university. I hope that there's help for them going forward because it's never happened before—only maybe in World War 2—when so many young people had their lives uprooted in the same sort of way. Certainly, it has impacted development in a massive way, but we're yet to really know what the real impact will be.

Dr. Fauci described our next steps as "not eliminating [COVID-19] but it gets down to a level that it's integrated into general respiratory infections." How would this timeline look in the United States and foreign nations?

When we're looking at it from abroad, the US is enormous! You are many countries in one. So, talking about the United States' response is always hard because it's so different across the states. It feels as though we're on the way out from this, but I think what COVID has told us is that it is always too soon to make any predictions. It's less about what the virus is doing and more about what politicians are willing to risk. In Britain, there is a government in place which believes that more restrictions at this point would outweigh the negative impact of the virus because the virus is weaker than it was. It seems to be the case in the United States. We might be at a point where it doesn't really matter what the virus is doing—it's what governments decide to do—but it's so hard to predict.

In your documentary "Virus Hunters," you explored current research toward stopping future pandemics. What were you surprised to learn?

I was surprised about the idea that pandemics don't just happen—they're not something that is completely divorced from what we do as human beings. They are actually closely linked to our relationship with the natural world, and I hadn't realized in how many ways human beings are making more pandemics more likely through this: seeing things like deforestation; seeing the mining activities in the rainforest; getting closer to animals that human beings don't usually get that close to; getting to grips with the physiology of bats, the idea that there are some 1800 species of bats, but they haven't collected anywhere close to the full number of diseases that they may carry. It was fascinating but scary. It was also interesting to witness how food is cultivated in the US and again how close we always are to infectious diseases spilling over from animals to humans—zoonotic diseases—especially because of the way animals are farmed in the US and the poor conditions a lot of animals are kept in. [Stopping the next pandemic will] require enormous international cooperation. Some of that cooperation is being damaged by more nationalists around the world who don't believe in international cooperation. If we destroy these really valuable international networks—sharing knowledge, sharing expertise—then the ability to fight the next pandemic will be cut off.

Are there similarities in the politicization of the pandemic with that of climate change?

It's probably clearer with the pandemic than it has been with climate change. It does feel to me that any issue in the public realm now is automatically jumped upon and politicized to a point where some of it is almost laughable when you hear some of the opinions being presented, that we live in a world now where there is no truth: there's your truth and there's your neighbor's truth, and you have to kind of negotiate a middle ground. It seems to be a very strange world to live in when that's the case, but there it is—that's our world.

"Humans have an incredible ability to adapt when they need to. There are all sorts of incredible things being done all around the world to help save the planet. You've got to have hope. If you don't, there's not much left."

HOLLYWOOD SCI-FI RANT

(cont. from page 4)

Space is not an ocean. Spacecraft are not boats.

The “space is an ocean” metaphor has led to misunderstanding about the properties of space. Objects in space are constantly moving relative to each other. Currently, Mars is approximately 200 million miles away from our planet, but in roughly 4 months, it will be just over 120 miles away. Every spacecraft travels a unique path, so shipping lanes, for example, are infeasible. The only time spacecraft could be even remotely close to one another would be during low-cost Holman maneuvers, which are only available at specific times depending on the start and destination. Even then, though, they would still be thousands of miles apart.

Another misconception is that space is cold. While technically true, this idea may be misleading. Space is empty, not cold, and all spacecraft are actually more at risk of overheating than freezing up. There are only three ways to release heat: conduction, convection, and radiation. Conduction and convection both require a surrounding substance to serve as a recipient of heat, which space does not have, so spacecraft must rely on massive radiator panels to discharge waste heat.

Finally, there is no possible stealth in space. Any spacecraft would be quite noticeable in the -455°F temperature of space, since maintained temperatures sustainable for human life would be hundreds of degrees warmer than the surrounding vacuum.

Just as space is not, in fact, an ocean, spacecraft are not comparable to boats. The most egregious misrepresentation of spacecraft in Sci-Fi may be those that include cruise liner-like floor plans. In reality, the “down” in a spacecraft would be opposite from the direction of travel, so spacecraft are more similar to skyscrapers than boats in this regard.

Spacecrafts' depiction as fighter jets often comes with numerous inaccuracies as well. There is virtually nothing in space, which means a lack of friction to resist movement. If a spacecraft wishes to stop, it would need to produce thrust in the opposite direction, possibly by flipping around. The first half of a trip in space would be spent pointing towards the destination, and the second half would be spent facing away from it. Thus, spacecraft would move less similarly to fighter jets and more similarly to overloaded eighteen-wheelers driving on ice.

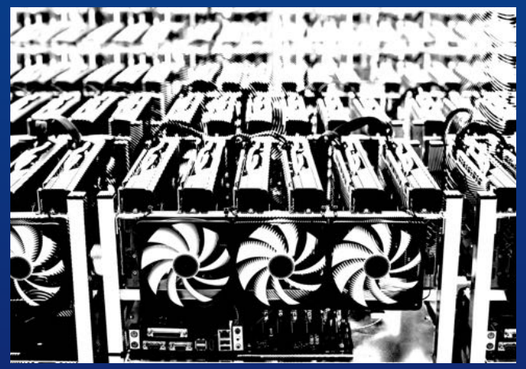
Finally, spacecraft would not look aesthetically pleasing. The mass of a spacecraft has huge implications -- every gram counts. Therefore, many spacecraft prototypes often include a tiny living space out front with a slightly larger cargo box, both of which are then connected by long aluminum beams to huge fuel tanks, engines, and heat radiators essential for a space odyssey.

While inaccuracies in Sci-Fi may continue in movie adaptations, they can still be corrected when spotted - if the populace can identify them. Correcting these misrepresentations can have a huge impact on promoting accurate information and knowledge within our communities.

Cryptocurrency's Environmental Impact and How To Fix It

Cryptocurrency is rising rapidly in popularity among investors and the general public, and concepts of the digital coin have pervaded modern media, spurring on its investors and generating seemingly unstoppable momentum. From the inception of Bitcoin in 2009 to now, it has appreciated nearly 15,000% in value (as of December 8th, 2021). Originally intended for everyday transactions, Bitcoin—and cryptocurrency in general—has snowballed into a volatile but profitable asset of investment.

Yet, behind the enthusiasm and press lies a sinister truth. A core tenet of cryptocurrency is its inherent decentralization; no singular authority maintains control over its issuing. Therefore, cryptocurrencies must ensure the security of their digital money. The current solution is mining: by verifying a complex group of transactions, competing miners are rewarded with new cryptocurrency. However, mining requires constant energy inputs, as miners must use specialized and energy-exhaustive computer systems to remain competitive. This "Proof of W-ork” system increases computing power as cryptocurrencies are issued, instigating greater energy consumption. The University of Cambridge found that Bitcoin alone consumes approximately 120 terawatt-hours each year, more than the consumption of Apple, Facebook, Microsoft, and Google combined.



Worse yet, the energy for emerging and sprawling crypto farms comes from non-renewable sources. Each year, it releases close to 23 million metric tons of carbon dioxide into the atmosphere, the carbon footprint equivalent of billions of homes. Furthermore, its need for coolant requires the use of massive quantities of water, which are returned to the environment at much higher temperatures afterward, damaging surrounding ecosystems and posing danger to aquatic animals.

So cryptocurrency is bad, right? Well, the reality is complicated. Another less commonly utilized system, proof-of-stake (PoS), has the potential to greatly reduce the amount of energy that verification and mining consumes. This process does not incentivize the excessive leeching of electricity, and its aggregate energy use is a whopping 99% more efficient than proof-of-work (PoW). The cryptocurrency Cardano already implements PoS with significant effect, observed by a recent surge in popularity increasing its market capitalization to 50 billion dollars. Still, this dwarfs in comparison to Bitcoin’s 1.03 trillion total market value.

Looking ahead, the future of cryptocurrencies is uncertain, and it is up to investors to decide its eventual direction.

CLIMATE CHANGE: GAS EMISSIONS

BACKGROUND

The effects of climate change continue to negatively impact humanity and global society. Climate change has been happening since 4.5 billion years ago, but humans have dramatically increased levels of greenhouse gases such as carbon dioxide trapped in the atmosphere. If we do not act now, the entire human race may face extinction. In fact, it is estimated that a billion animals have already died because of climate change, while over 10,000 animal species are still threatened by its effects. Climate change in the past decade has been more drastic than ever within the span of 1000 years, with areas like Northern Siberia hitting record temperatures as high as 100.4°F.

We can slow the effects of climate change by eating locally, limiting food waste, and consuming organic food. These efforts can reduce carbon dioxide emissions, with the first item in particular preventing unnecessary plastic and transportation gas from being released into the environment.

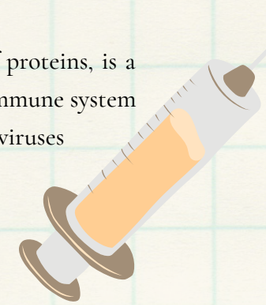
	CO_2 PRODUCED IN MILE 1	CO_2 PRODUCED IN MILE 2	CO_2 PRODUCED IN MILE 3
DIESEL	299 grams	598 grams	897 grams
M-G GAS	455 grams	910 grams	1365 grams
AVERAGE	377 grams	754 grams	1131 grams

In my experiment, I found that, the more miles a delivery truck travels on diesel or M-G gas, the more carbon dioxide that is produced. The data shows that M-G gas produces nearly double the amount that diesel produces when traveling the same distance. However, walking to nearby grocery stores produces zero grams of carbon—since humans do not produce carbon by walking—compared to an average 377 grams per mile for delivery trucks, which burn gasoline to produce carbon dioxide gas. Thus, my hypothesis that shopping locally can reduce carbon in the atmosphere was supported. In the future, I would like to further investigate why diesel produces less carbon than M-G gas and explore corporate initiatives around climate change, particularly in terms of delivery trucks and gas.

The Past, The Present, and The Future:

mRNA Developments

Not too long ago, scientists were frantically working to create an effective vaccine to protect the global population from COVID-19. This vaccine entered its trial phases and soon became available to essential personnel and eventually to the general population. The key to the rapid development of this vaccine can be credited to a technology that had been researched and developed for decades prior: messenger ribonucleic acid (mRNA).



mRNA, a form of genetic code that provides instructions regarding the translation of proteins, is a nucleic acid found in cells. All viruses have specific proteins on their surface that your immune system can recognize and react to. Vaccines featuring mRNA technology do not contain active viruses and instead provide instructions to construct the proteins on specific viruses based on synthesized mRNA sequences. By creating these proteins, the human immune system is able to effectively recognize the virus and create antibodies against it, in the case of an actual encounter.

DNA

Double-stranded

Made up of deoxyribose sugar

Present in the nucleus

mRNA

Single-stranded

Made up of ribose sugar

Diffuses into cytoplasm after synthesis

While many people may have only recently heard of mRNA technology, it has a six-decade history. Findings were first published in 1961, and clinical research on its applications began later that decade. In an unmodified state, mRNA can cause inflammation, but developments in 2005 yielded findings on a chemically modified version of mRNA that does not cause inflammation. Another turning point in this field came when it was found that wrapping mRNA in a lipid could help your immune system fight disease.

Modern interest in this technology has grown because it would considerably decrease production time compared to other vaccine creation methods. mRNA vaccines are also more effective than other types, and, aside from COVID-19, researchers are also developing them for diseases including influenza, human immunodeficiency virus infection (HIV), and sickle cell anemia. At the same time, scientists are exploring the applications of mRNA in cardiovascular regeneration therapy and cancer treatments.

"Vaccines featuring mRNA technology do not contain active viruses and instead provide instructions to construct the proteins on specific viruses based on synthesized mRNA sequences."

(continued on page 18)

The critical difference between mRNA applications for something like COVID-19 and cancer is the timing of their use. Typically, vaccines protect individuals before the virus enters their body, but a cancer vaccine would be used as an intervention therapy for an already-active disease. In this case, synthesized mRNA would help create T cells—which are part of the immune response and have been known to kill cancerous cells—rather than antibodies. These T cells would find and terminate cancerous cells based on their antigens, the molecules that can trigger an immune response. Ultimately, a successful vaccine would produce a robust CD8+T cell response. Experimental cancer treatments using mRNA date back to 2008, and scientific studies continue to this day.

From past to present, mRNA technology has undergone tremendous development, and innovations will surely continue, given its novel popularity with the widespread use of the first mRNA vaccine. In the future, it will provide multitudes of new pathways for disease treatment and prevention.

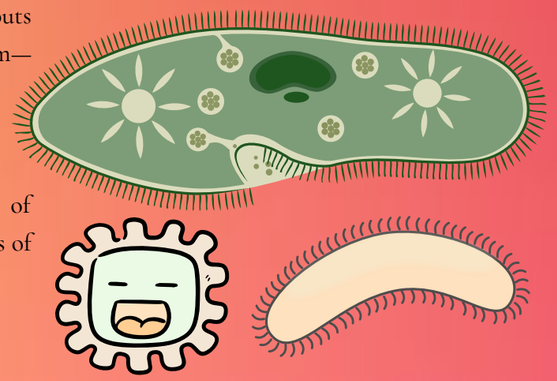
YOUR STRONGEST WEAPON IN THE BLOODIEST BATTLE:

THE IMMUNE SYSTEM

Boom! A grenade explodes a few yards away. The sound deafens your senses for a few seconds. The sky is in total darkness; fog permeates the air.

Many of us may have vague notions of the war experience for active duty soldiers. However, a similar struggle is happening right now inside of us. Constant threats of bacteria, viruses, protozoa, and fungi barrage our body, but the immune system—our intelligence, our troops, our artillery—keeps us healthy by fighting against these foreign pathogens.

A germ has infiltrated the body. Just as an army would send scouts to monitor the opposing force, the innate immune system—encompassing the cells that fight the pathogen as well as other components such as skin, mucous membranes, and stomach acid—is swift to act. This first layer of defense is essential to our health, as humans have roughly 1,000 species of bacteria on their skin! Without the skin, for example, thousands of enemy bacteria could pose a significant threat to our well-being.



ACT I: Innate Immune System Scouts Out (and Sometimes Captures) Bacteria

ACT I CAST:

Direct Fighters: Macrophages & White Blood Cells

Backup Reinforcements: Dendritic Cells

In addition to these tools, the innate immune system uses cells like macrophages, white blood cells, and dendritic cells to facilitate the immune response. Macrophages and white blood cells are direct fighters, killing any germ present in your body. Dendritic cells—the backup reinforcements—respond to pattern recognition receptors, which detect common molecules in pathogens. Once activated, these cells seek out and capture the antigen, the invader of your body. Apprehending key information, the duty of scouts, has the potential to turn the tide of battle from stalemate into victory. Once the dendritic cells have done this, they can travel to hundreds of lymph nodes, which are glands that contain helper T-cells. T-cells bring your adaptive immune system into the battle, an action critical for adapting responses to different pathogens.

ACT II: Travel to Lymph Nodes!

Once dendritic cells have reached a lymph node, the search for the one specific cell, out of billions of helper T-cells in the body, with the capacity to produce the correct antibodies commences. A dendritic cell activates the specific T-cell by identifying and matching its unique antigen, after which the T-cell starts duplicating rapidly. From here, some T-cells travel to the infected site and release cytokines (chemical messages that invigorate the macrophages to keep fighting the pathogen), while the others induce the activation and duplication of B-cells—antibody factories—through a process similar to T-cells involving specific antigens. Out of many B-cells producing specific antibodies, only a few produce the proper antibodies to attack pathogens, each at a rate of ten thousand per second. Antibodies are Y-shaped proteins that destroy and mark pathogens so your other cells can kill them. They also inhibit pathogenic movement, making them easy targets. One by one, enemy troops dwindle as the immune forces ambush them from all sides.

ACT III: T-Cells Activate Immune System Battle Mode

ACT IV: T-Cells Reach Infected Site & Release Cytokins

ACT V: T-Cells Activate B-Cells (Antibody Factories)

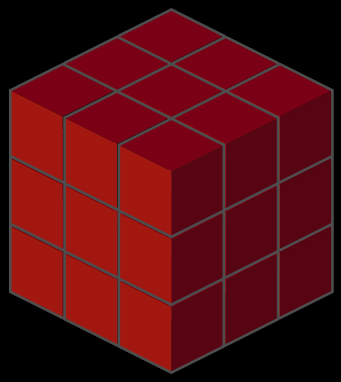
ACT VI: Antibodies and Cells Destory & Mark Pathogens

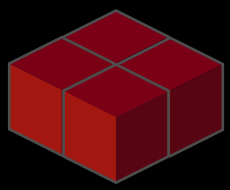
When the last pathogen is gone and the exhaustive battle is finally over, most cells will undergo apoptosis—cell suicide—in order to save resources. Even after you feel better, a few cells from the battle remain in preparation for the next attack. T-cells become memory cells that have the capacity to remember the exact attacker in the case of return, while B-cells become antibody-producing memory B-cells that help you gain natural immunity against this attacker. Ultimately, this infrastructure ensures that the same pathogen would be ensnared in a death trap if they dared to fight again. While remnants of the war disappear into memory, you accidentally cut your finger. A sneaky new invader creeps past your skin, entering your body and starting the bloodbath all over again.

ACT VII: Cells Undergo Apoptosis (Cell Suicide)

Submit an answer to this puzzle to catapultasciencebls@gmail.com for the chance to win a $25 gift card!

Your good friend Mr. Math has saved enough of his money to buy a house and move out of his city apartment. However, he has a bit of a problem that he can't quite solve.



6 x 

3 x 

He has several items that he has to pack into a **3 by 3 by 3 box**. These are his last items that have to be stored. He has **six 1 by 2 by 2 boxes** and **three 1 by 1 by 1 boxes** that need to be fit into this larger box.

Help him figure out how to place all these boxes into the larger box! Good luck!

π DAY

ON MONDAY, MARCH 14

after school
in the dining hall
tickets are $3
voting is $1