CATAPULTA

BOSTON LATIN SCHOOL SCIENCE MAGAZINE

FALL 2024

FEATURING: OUR MEMORIES INSIDE, SEAPORT VS THE SEA, ARE OUR FALL LEAVES FADING?

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EDITORS' NOTE

WELCOME TO THE FALL 2024 ISSUE OF CATAPULTA!

ANOTHER SCHOOL YEAR, ANOTHER FALL SEASON OF DIFFICULT ASSIGNMENTS, FOREBODING DEADLINES, AND DREADED TERM TESTS. ON TOP OF EVERYTHING, IT'S AN ELECTION YEAR! WE RECOGNIZE THAT WE ARE PRODUCING AND PUBLISHING THIS LATEST ISSUE DURING A TIME OF TREPIDATION FOR BOTH THE NATION AND THE BLS COMMUNITY. NEVERTHELESS, WE HOPE THIS MAGAZINE IS A REFRESHING BREATHER FROM YOUR DAY-TO-DAY BUSINESS. TAKE SOME TIME TO ADMIRE THE AUTUMN LEAVES (PAGE 12) AND REMINISCE ABOUT HAPPIER TIMES BY LEARNING ABOUT THE SCIENCE BEHIND OUR MEMORIES (PAGE 11).

OUR BOARD HAS BEEN HARD AT WORK THIS FALL TO BRING THIS MAGAZINE TO YOU. FROM A NEW LUPUS TREATMENT TO DISCOVERING THE "IMPOSSIBLE" BLUE LED, CATAPULTA STRIVES TO COVER THE CUTTING-EDGE OF SCIENTIFIC INNOVATION WHILE RECOGNIZING HISTORIC ACHIEVEMENTS. LIKEWISE, WE WISH YOU A SCHOOL YEAR FILLED WITH SUCCESS. HAPPY READING!

SINCERELY,

Emily and William

FALL ISSUE STAFF

THIS ISSUE OF CATAPULTA HAS BEEN MADE POSSIBLE BY THE BOSTON LATIN SCHOOL ASSOCIATION AND OUR FACULTY SPONSORS:

MR. GALEGO
MRS. BATEMAN

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"Biotwang"

Sounds of Mariana Trench Discovery

Scientists believe only five percent of Earth's ocean has been explored, with the remainder left for humans to discover. Consequently, many mysteries of the aquatic world are still unexplained. One enigma in particular has left scientists baffled for over a decade until September 2024, when the necessary clues finally reached the surface.

Starting a decade earlier in 2014, strange, low-pitched noises emerged from the deepest part of the ocean: the Mariana Trench. Known by researchers as "biotwang" noises, these sounds were originally picked up through an oceanic survey conducted in the Mariana Trench using passive acoustic monitoring (PAM). PAM tracks the sounds of a variety of marine life. So, while noises heard in deep waters are normal, these biotwang sounds had a crucial difference: scientists were not able to match these noises with any audio records on file.

Pinpointing the source of these seemingly unrecognizable sounds was the top priority. Some scientists hypothesized that the noises were whale calls; however, there was limited concrete evidence to support this theory. The issue was the lack of convincing connection between existing audio recordings of whales—or, for that matter, any other species of marine life—and these biotwang sounds. Matching these new noises could take hundreds of thousands of hours of scanning against the existing recordings of marine animal life.

However, in September, substantial evidence was published in the journal Frontiers in Marine Science that painted the mystery in a new light. The source of the biotwang noises that had stumped researchers for years has been revealed: Bryde's whales.

This breakthrough occurred when a group of scientists from the National Oceanic and Atmospheric Administration and the Marine Mammal Institute spotted a species of whale known as Bryde's whales (*Balaenoptera brydei*), members of the baleen whale group. In a visual survey conducted off the coast of the Mariana Islands, multiple Bryde's whales were seen as the biotwang sounds were detected. Even though these sightings provided the first substantial evidence that baleen whales were behind this discovery, researchers sought more definitive proof. The connection solidified when the audio recordings of the biotwang noises emerging from the area matched with existing recordings of whale calls from Bryde's whales using Google's advanced artificial intelligence. The technology permitted simultaneous comparisons of many recordings with the biotwang sounds, with weightings of highly similar sounds reinforcing the neural network and validating the connection. This research, now immortalized in publication, finally ended the search, putting to rest the mystery behind the source of the biotwang noise.

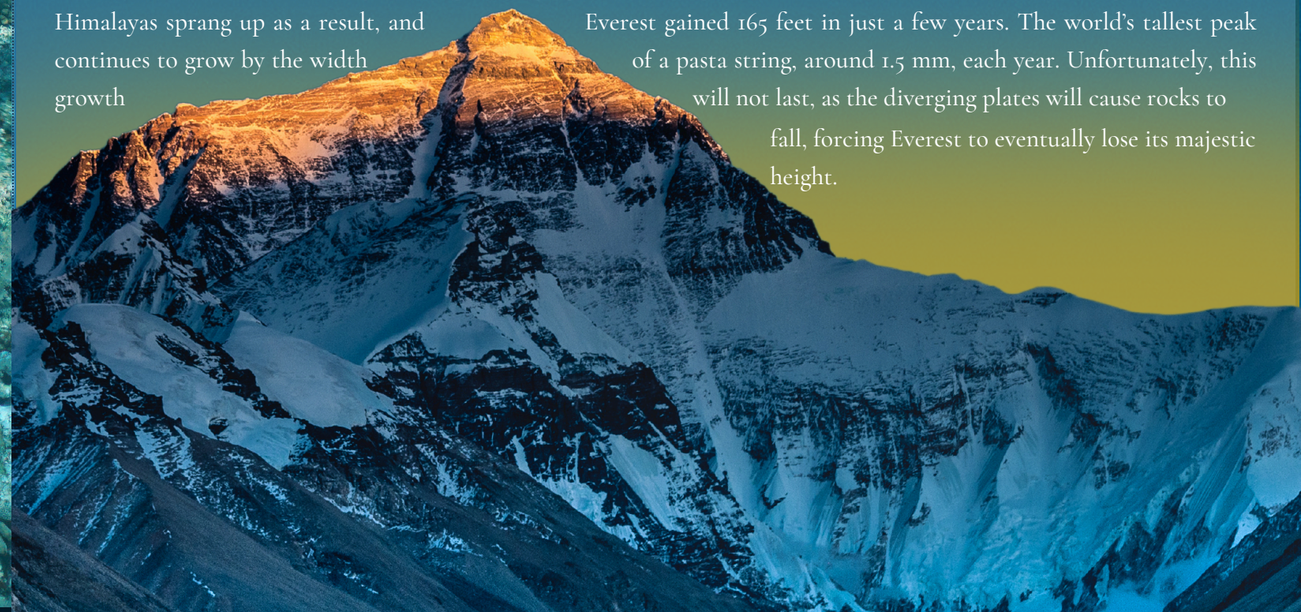
Everest

Taller than it Used to Be

Mount Everest: the tallest mountain on land. Towering at 29,032 feet (about 5.5 mi) above sea level, its peaks bury secrets which cannot be uncovered. Whether you call this colossal art of nature Chomolungma in Tibetan or Sagarmatha in Nepali, it surpasses every other Himalayan peak. In addition, scientists have discovered something else: it's the fastest growing mountain in the world. So what gave this mountain superiority over its neighbors, rising at millimeters per year, when every other mountain is on the verge of shrinking?

The answer, as suggested in an experiment near the goliath's base, could lie in two rivers merging together some 89,000 years ago. The Arun River, along with the Kosi river system, eroded tons of the Earth's crust on which we live today. Now that this weight has been displaced, it allows the crust to float a few hundred feet higher above the mantle. The Earth's crust is very flexible, and, when a huge mountain pushes it downward, the crust pushes back up. It's, in the words of BBC scientist Adam Smith, "almost as if the Earth is breathing." The phenomena is like if Everest was "standing on a bouncy castle," rising with the buoyancy of the air mattress.

What causes this force imbalance? A violent, fast-flowing, rock-eating river. On a map, the Arun River carves a peculiar winding path, setting it apart, much like Everest. It starts off in the northern Himalayas, winding through a ridge near Everest, suggesting that this river may not have been connected in the past. Via computer simulations, scientists have discovered that the Kosi river system began merging and "stealing" the water from the Arun about 90,000 years ago. The Himalayas sprang up as a result, and Everest gained 165 feet in just a few years. The world's tallest peak continues to grow by the width of a pasta string, around 1.5 mm, each year. Unfortunately, this growth will not last, as the diverging plates will cause rocks to fall, forcing Everest to eventually lose its majestic height.

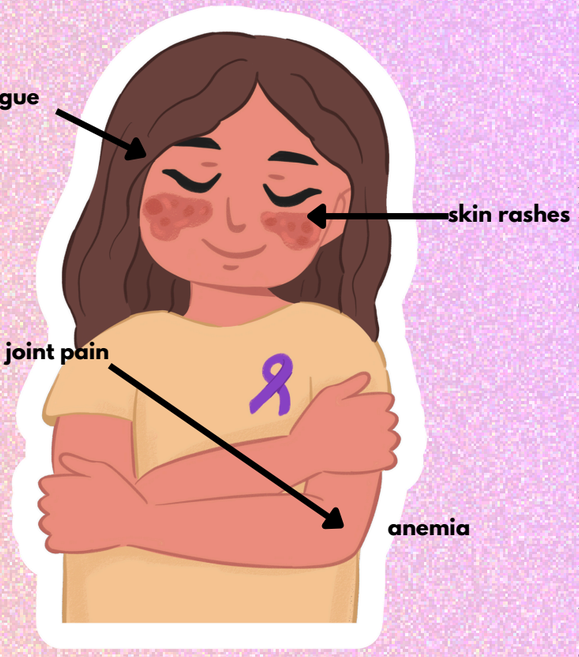


A NEW ERA:
Lupus Treatments Without Total Immune Suppression

Worldwide, over five million people live with the daily effects of lupus, an autoimmune disease whose cause is still largely uncertain. Lupus is characterized by extreme fatigue, joint pain, skin rashes, anemia, and, in extreme cases, kidney and heart failure—symptoms which not only make everyday tasks significantly more challenging but also have the potential to become life-threatening.

autoimmune diseases
(noun)

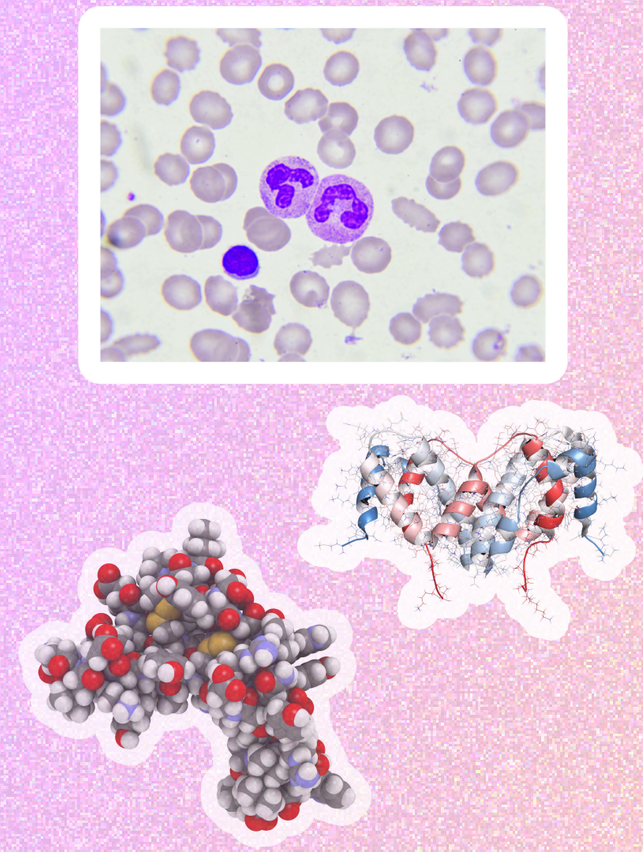
A disease in which the body's immune system attacks healthy cells.



Based on research conducted over the past seven decades, lupus is believed to be caused by a combination of genetics, hormones, and environmental factors. Though no single group of genes is associated with the disease, over fifty genes have been identified to be more common in people with lupus. As over ninety percent of people with lupus are women, scientists have historically looked towards estrogen and various other hormones as possible causes. Though no direct link between any hormone and lupus has been found, research continues as hormones are the body's messengers and are crucial to maintaining proper bodily functions. Environmental triggers for lupus include ultraviolet light from the sun, infection, emotional stress, tetracycline-based drugs, and silica dust.

Researchers at Northwestern University and Brigham and Women's Hospital have recently proposed an alternate explanation for lupus. After analyzing blood samples from 19 patients with lupus and comparing the samples to blood from healthy patients, they found that people with lupus have too many cytotoxic T cells —white blood cells that help your immune system figt germs and associated with damage—and too few regulatory T cells, which are are associated with repair.

Furthermore, patients with lupus had excess amounts of Type I Interferon: a cell signaling protein that plays an essential role in immunoregulation, tumor cell recognition, and T-cell responses. This increase blocks aryl hydrocarbon receptors, over-stimulating the body's response to bacteria and environmental pollutants. Suppressing these receptors ultimately limits the development and responses of mature B cells—which protect the body from infection by producing antibodies—, weakening the immune response and increasing the probability of inflammation. Instead of mature B cells, any immature B cells present produce antinuclear antibodies, which attack healthy cells rather than foreign pathogens. This further increases the likelihood of symptoms.



Pictured Above: cytotoxic t-cells (a type of white blood cell)
Left: Type 1 Inferon **Right**: aryl hydrocarbon receptors)
Two molecules that were found in excess in patients with lupus.

Existing treatments for lupus aim to suppress the immune system, including cells associated with producing harmful antibodies and T cells. While immunosuppression can decrease lupus symptoms, it also places the patient at higher risk for infection. However, potential new treatments present novel hope. These treatments would aim to activate aryl hydrocarbon receptors and limit the accumulation of T cells and immature B cells which promote the disease. These types of treatments would mitigate lupus-related symptoms while maintaining the overall strength of the immune system. Still, the major challenge lies in ensuring that aryl hydrocarbon receptors are not activated throughout the whole body; this would affect metabolism and enzyme transcription.

While extensive research still needs to be done to understand lupus and properly treat it, current advancements are, at minimum, opening new paths for future research.

CONQUERING THE MOON: A MISSION TO MARS

After almost 50 years, NASA is once again planning to launch astronauts to the moon. This ten-day mission is part of a multi-step process to sustain a lunar presence known as the Artemis program. This program consists of up to 13 steps and four missions to further humanity's advance to the stars. The first mission, Artemis I, was an uncrewed test flight of NASA's Deep Space Exploration Systems completed in December of 2022. The Space Launch System, a super-heavy-lift rocket, took the Orion spacecraft thousands of miles beyond the Moon over the course of about a three-week mission. At the Kennedy Space Center, the Exploration Ground Systems processed and launched the rockets, and also recovered the spacecraft when it splashed down in the Pacific Ocean.

The next mission, Artemis II, will build on the success of Artemis I, sending four astronauts around the moon. This lunar flyby will be NASA's first mission with crew aboard the Space Launch System and the Orion spacecraft, confirming all the systems operate as intended with crew aboard in the environment of deep space.

Now, what does this mean for the future? The Artemis Program aims to not only create a moon base but also collect and bring samples back to Earth in order to further advance knowledge for future developments. In fact, Artemis III will send the first humans to ever explore the moon's south pole! It will also land the first woman, Christina Koch, and person of color, Victor Glover, onto the lunar surface. The planned launch in September 2026 will mark the United States's return to the moon 54 years after the last moon landing during Apollo 17.

Eventually, with the success of the Artemis program, NASA will establish a lunar space station! When they complete Artemis IV, astronauts will be able to make direct contact with the moon on NASA's new lunar orbital space station, the Lunar Gateway, performing experiments that will establish a moon base and prepare for a human mission to Mars.

The Impossible Blue LED

In the United States, a whopping forty percent of people list blue as their favorite color.

For centuries, the color blue has been widely sought after, and for good reason, too. Very few plants or animals produce a true blue pigment, and for a long time, the color blue could only be obtained by mixing naturally occurring pigments in a swirling array of colors, much like the way artists mix their acrylic paints to temper the right tint. The lack of a "true blue" in nature rendered the color a fascinating phenomenon.

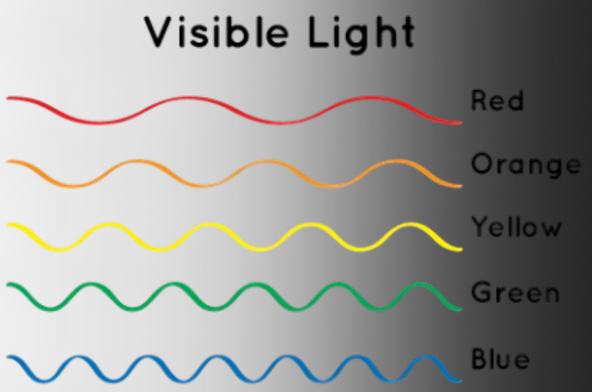
In the modern day, humans owe the convenience of efficient, low-energy-consumption lighting to the invention of light-emitting diodes (LEDs) that power everything from traffic lights to smartphones and laptop screens. Compared to traditional incandescent lighting, which only produces up to 5% light (with the remaining energy being lost to heat), LEDs can produce up to 40% of their energy as light.

LEDs are semiconductor devices that emit light when a current flows through them. In 1962, American engineer Nick Holonyak invented the first visible LED. Etched in tiny print, "the magic one, GaAsP (Gallium Arsenide Phosphide)," was a nod to the semiconducting material that glowed a faint red. As if summoning the sorcery of magic, Holonyak had conceived the world's first red LED.
Eventually, the "GaAsP" red glow could be seen in indicators, calculators, and watches. Merely a decade later, Monsanto, an agrochemical company, devised the first green LED. As LEDs were thrust into the limelight, researchers and engineers continued to build on the technology, eventually developing brighter and more colorful LEDs through experimentation with chemical substrates.

Disclaimer: for aesthetic purposes, the Catapulta layout board has chosen this bulb image. Please be advised that what is depicted on Page 9 is an incandescent bulb. The LED bulb resides in Page 10.

Still, one color was missing: **blue**.
In fact, the creation of the blue LED was deemed "impossible".

With blue, every electronic company would be able to create white lights (a combination of red, blue, and green), along with the entire spectrum of colors. But why did it take nearly four decades after the first LED for a blue one to be developed?



Despite millions of dollars invested into research, tech giants like Sony, Toshiba, and Panasonic were unable to create and find the perfect materials and structures to develop a blue LED. This is because a photon of blue light has a shorter wavelength, meaning it requires relatively more energy to exist. In addition, near-perfect crystal lattice structures are crucial, meaning scientists will also need a larger band gap: the minimum energy needed in order for an electron to be promoted to a state for conduction. Any obstruction in the flow of electrons results in the energy being dissipated as heat.

Shuji Nakamura was the first scientist to crack this challenge. Rather than gaining his renown as a scientist from a company giant, Nakamura had been a scientist at Nichia, a company whose experimentations had led itself close to bankruptcy.

By developing a substrate with a near-perfect lattice structure through a metal organic chemical vapor deposition (MOCVD), Nakamura focused on gallium nitride. The compound had long been considered a "dead end" for blue light LED research since it can contain billions of lattice point mismatches. However, with just a dream and the goal of developing a commercially viable blue light, Nakamura was able to successfully modify the MOCVD apparatus to create a bright, long-lasting violet LED. To make it blue, Nakamura sandwiched indium alloy, which contains blue, between its layers.

Nakamura had achieved the impossible: the world's first **blue** LED.

OUR MEMORIES INSIDE

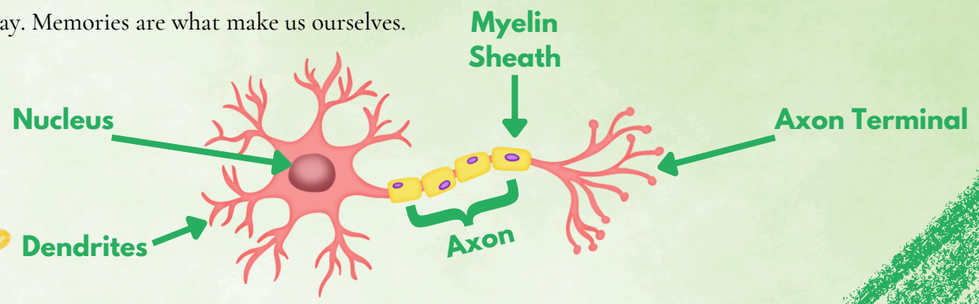
Disney's *Inside Out 2* is about a teenage girl named Riley and her journey through adolescence. The movie makes us ponder our own emotions tapping on the console in our brains, deciding for us how to react to the outside world. Riley stores her experiences in the form of "core" memories, which are represented by colorful, spherical gems.

BUT IN REAL LIFE, HOW DO WE STORE OURS?

When we experience something, we form connections between neurons in our brain. These new circuits arise in synapses, tiny gaps connecting neurons which send and receive electrical impulses. Whenever the electric charge of any cell changes, it releases neurotransmitters—chemicals that allow neurons to communicate—through these synapses. Neural circuits are crucial to our brain's ability to work. They receive sensory inputs, make computations, and generate appropriate behaviors. The synapses get stronger or weaker depending on how frequently they are used. When anyone practices a skill regularly, they get better at it, because the human brain reshapes itself and forms additional connections with each new memory.

Our memories are stored in many different parts of the brain, but the hippocampus plays the key role in transferring memories from short-term to long-term. When you continuously carry out an action, the hippocampus strengthens the circuits, and the memories are transferred to the neocortex, where they become long-term memories. The neocortex, the wrinkly outside of our brain, is responsible for most of our conscious experience, including our awareness of the world around us and ability to perceive emotions.

We are almost entirely shaped by the experiences we live through. Our brain's structure and components allow us to store these experiences, creating memories that guide the decisions we make day-to-day. Memories are what make us ourselves.



Are Our Fall Leaves Fading?

The Northeastern United States is renowned for its stunning fall foliage. Flocks of people come each year in the cooler months to witness beautiful warm colored forests. As temperatures grow colder and days get shorter, trees develop less chlorophyll in preparation for the winter, and the reds, oranges, and yellows associated with fall become apparent.

As of recently, however, warmer temperatures due to *climate change* are disrupting this process.

Warmer autumns and longer growing seasons are delaying the onset of fall color. In some areas of the Northeast, leaf colors appear less vivid. Frost timing, which is critical for the bright red color on leaves, is also changing. Usually, colder nights in the fall cause sugars produced in leaves to be trapped. This is what leads to the brilliant warm colors. Without cold fall nights and early frosts, though, less sugar in the leaves is trapped, which causes the production of the red pigments to be less effective. Moreover, rainfall patterns make lands more drought-prone, stressing the trees out and resulting in duller colors and the earlier dropping of leaves.

Ultimately, the differences observed in fall leaves are connected to the effects that climate change has on weather patterns. While colorful foliage is still visible, it becomes more inconsistent each year, leaving uncertainty in the future of this beautiful natural event. With that in mind, it is important to note that climate change is actively impacting the features we cherish in this region of the world, establishing a new appreciation for the time when they are still here.

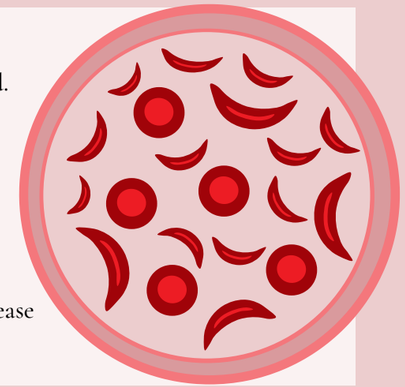
The Dire Promise of Modern Treatment Against

SICKLE CELL DISEASE

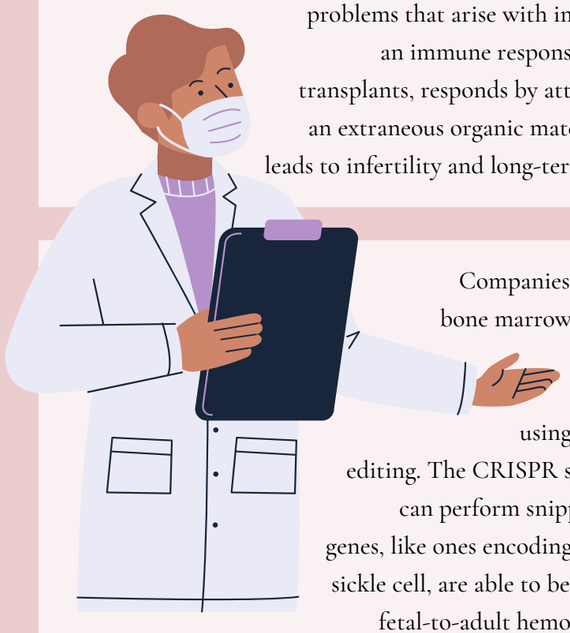
Sickle cell disease, traced back over 7,000 years ago, was one of the first genetic diseases to be understood, making its first appearance in medical literature in the early 1900s by Chicago physician James Herrick. It is a hereditary illness, meaning it can be passed down from parent to child. A single mutation in the red blood cell hemoglobin gene may show no symptoms. Two copies passed down, however, may have excruciating effects, including the production of abnormally shaped blood cells, which are curved into their characteristic “sickle” shape. Oxygen delivery becomes heavily constrained as these sickle-shaped cells are prone to clumping and are less flexible, leading to oxygen deprivation in tissue cells and, more concerningly, paving the way for more severe complications like sepsis, stroke, organ damage, and heart attack. Periodic episodes of extreme pain, known as sickle cell crises, are also frequent.

This disease is extremely widespread; some estimates place the approximate number at around twenty million worldwide, with underfunded regions like Sub-Saharan Africa taking the brunt of the impact. In these low-income countries where treatment is minimal, children with this disease can die within just five years. Recent advancements in science, though, have brought attention back to combating this long-ignored disease, with numerous screenings and treatment opportunities expanding to various places of the world, increasing patient accessibility.

Despite being caused by only a single mutation, the complexity underlying the cause of sickle cell disease should not be underestimated. This is due to a variety of factors that determine how it affects different patients. Treatment is still immensely difficult and tedious over a century after the discovery of the disease. Different methods of attack have been proposed, but the main attraction of the problem is the bone marrow—the system responsible for creating red blood cells. If researchers can stop the production of faulty red blood cells, this disease may as well be cured.

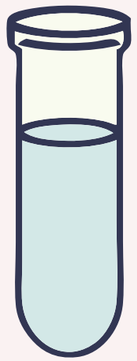


One solution is through bone marrow transplants, but this method proves difficult due to the various problems that arise with immunogenicity, a foreign substance's ability to induce an immune response from the body. The body, often unable to recognize transplants, responds by attacking it — it turns out our body does not appreciate an extraneous organic material being surgically inserted within itself. This often leads to infertility and long-term reliance on drugs that suppress the immune system.



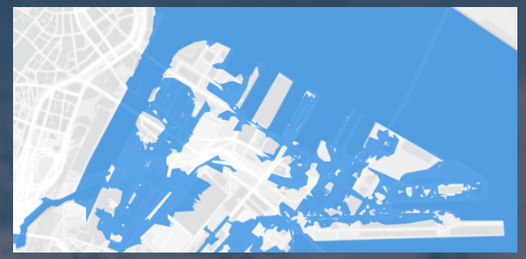
Companies have tried various methods to improve the success of bone marrow transplants through gene editing, directly modifying the genes of stem cells to force production of healthy hemoglobin. Numerous therapies are also being done using a relatively modern technology called CRISPR-Cas9 editing. The CRISPR system is an extremely precise "molecular scissor" that can perform snippets at specific parts of the genome. This way, certain genes, like ones encoding for fetal hemoglobin (HbF), which are unaffected by sickle cell, are able to be completely deactivated, resulting in a more balanced fetal-to-adult hemoglobin ratio in lifelong sickle cell patients, mitigating many sickle cell disease symptoms. Future research in gene therapy to combat sickle cell disease includes the use of messenger RNA (mRNA), which can directly make edits in the hemoglobin gene to produce more healthy proteins.

There are, of course, many challenges in getting these new technologies out to the public. First, *in vivo* (test tube) experiments vital to cell testing are not one-to-one replicas of the complex system of the human body. There is still an extremely large gap between in vivo testing and large-scale clinical trials where populations of volunteers serve as hosts for the technologies. Second, current gene therapies are extremely costly and challenging to scale due to the lengthy process of individually editing each batch of cells. These complications make it extremely difficult for infected individuals, particularly those with poorer economic statuses, to receive treatments—especially in Sub-Saharan Africa, where three-quarters of all reported sickle cell cases occur. Despite these limitations, it is entirely possible for a breakthrough to happen in the near future that may cure this deadly disease once and for all.



The Seaport Vs. The Sea

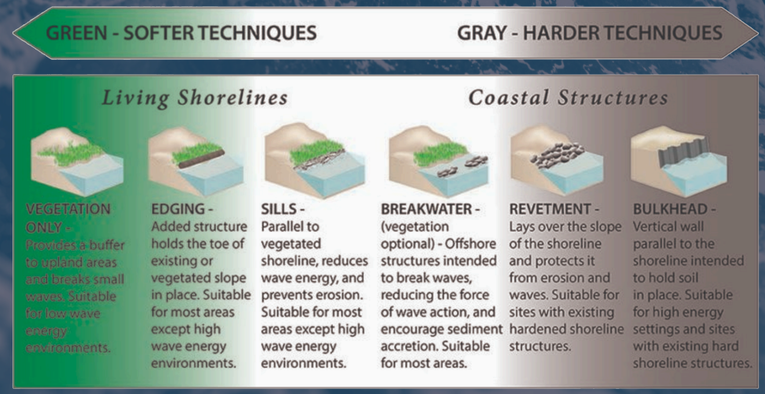
In the past twenty years, the Seaport District has gone from parking lots to expensive high rises. It is now one of the most expensive neighborhoods in Boston. Rising sea levels, however, could soon wash away all of this development. A once-in-a-century storm could temporarily flood half of Seaport as soon as 2030, and a high tide could permanently flood it in 2070. The city clearly needs to take action to ensure the Seaport doesn't become the sea.



Projected map of Seaport in 2070 during high tide

Scientists predict that tides in Boston will surge as much as 15 feet by 2100.

Every flood protection measure exists on a scale of green to gray. On the green side, you have a natural vegetated slope. On the gray side, you have a seawall. Green techniques are longer lasting and are more sustainable, but take up much more space.



One common green technique is to build parks near the coastline that are designed to be flooded. These floodable parks provide recreational space in normal conditions, a buffer zone during storm surges, and a permeable surface to mitigate runoff. However, many cities end up using gray techniques to save space for valuable shoreline development. Currently, Seaport uses gray planned flood protection measures.

Many existing buildings in Seaport have minimal flood protection measures such as keeping only important rooms above ground level or buying temporary flood barriers in case of heavy storms. However, initiatives are attempting to solve this. Current development will be much more resilient, raising all floors above the estimated three feet sea level rise in 2070. The City of Boston also plans to protect the entire Seaport district by raising the harborwalk around the Fort Point Channel and building additional seawalls, but the project is still under review. For now, it is up to each real estate developer to future-proof their buildings against the threat of rising sea levels.

PUZZLE

EACH QUESTION MAY BE ANSWERED IN ONE OR TWO SCIENTIFIC TERMS. TAKE THE FIRST LETTER OF YOUR ANSWERS TO CREATE THE FINAL PHRASE!

1) The “solar system” model of the atom

2) A negatively charged Iodine is called ___.

3) What contains thousands of planetary systems?

4) What is the decay in which a neutron becomes a proton and an electron?

5) What is the imaginary line where a celestial body rotates?

6) Identify the part of an atom that has no charge.

7) The greater the mass, the greater the ___.

FINAL ANSWER: _ _ _ _ _ _ _ _ _

EMAIL CATAPULTASCIENCEBLS@GMAIL.COM TO CHECK YOUR ANSWER!