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Note From the Editor-in Chief

Gyulim Jessica Kang

Sophia Reiner

Welcome to the fourth volume of Spectrum Magazine! This school year, our team has been working hard to curate an issue filled with informative and engaging STEM content, covering a diverse range of topics from the brainless intelligence of slime molds to the reasons why we have yet to meet any aliens. In this issue, we're excited to spotlight the works of the many new editors who have joined our team as well as the old. Read on to find out what we've been up to!

We'd like to say a huge thank you to our teacher sponsor, Ms. Wang, for her support, and our talented team of editors and designers for their unwavering dedication. To our readers, we value your feedback and ideas for future issues. Thank you for your continued support, and have fun reading!

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SCIENCE & MATHEMATICS

The Science of the Very, Very Small

by Nikita

Photo by Justin Case on Unsplash

Nanoscience is often described as the microscope of science.

It delves into the very building blocks of life, focusing on the understanding and manipulation of materials and phenomena at the nanoscale. Nanotechnology, an application of this science, combines elements of physics, chemistry, biology, engineering, and materials science to explore the unique properties and behaviors of materials at this incredibly small scale.

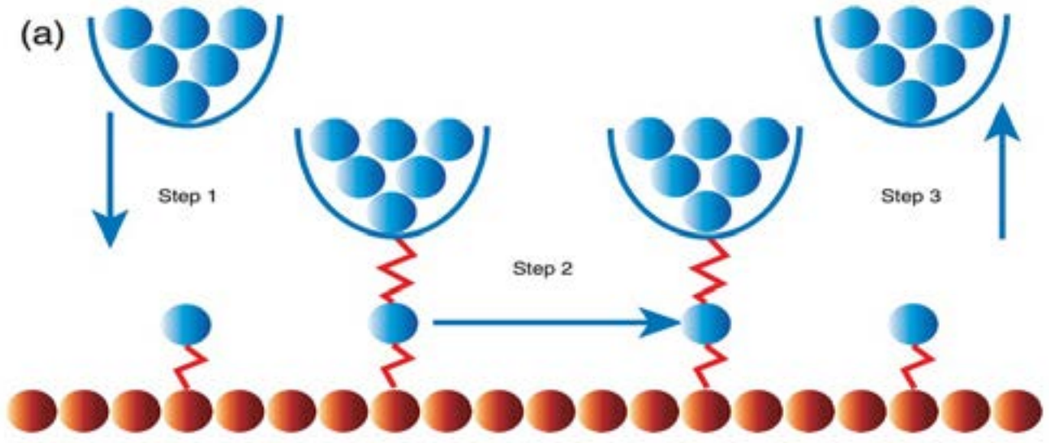
One particular example of this is the scanning tunneling microscope. Unlike a typical microscope, the scanning tunneling microscope (STM) can probe the atomic structures of surface materials, as well as manipulate single atoms. This concept first emerged during the early 1980s, when it was invented by IBM scientists Gerd Binnig and Heinrich Rohrer. In 1986, this groundbreaking discovery led them to earn the Nobel Prize in Physics, opening up the world to breakthroughs in materials science, molecular chemistry, quantum mechanics, and more (Oxford).

The way these machines can study atoms is through the quantum mechanical phenomenon known as tunnelling (Britannica). Disrupting the rules of classical physics, electrons can, essentially, jump energy barriers and "tunnel" to regions of a surface material where they shouldn't be able to appear. As the distance from the surface increases, the likelihood of detecting these rule-breaking tunneling electrons decreases exponentially. The STM takes advantage of this; by using its extremely fine tip, the microscope is positioned just a few angstroms (10-10 m) above the surface (Britannica). Then, an electric potential difference is applied between the tip and the surface sample, and electrons from the sample are tunneled to the tip. The small electric current produced by the tunneled electrons – the lesser the distance, the higher the tunneling current is – is amplified and sent to the computer. Based on the recordings of the tunneling current, we can discover information about the surface material, from studying the chemical reactivity of atoms to examining quantum mechanical phenomena.

Probing for information isn't all the STM can do. The manipulation of atoms has not only led to scientific discoveries but also made way for a new type of art – the creation of atomic structures.

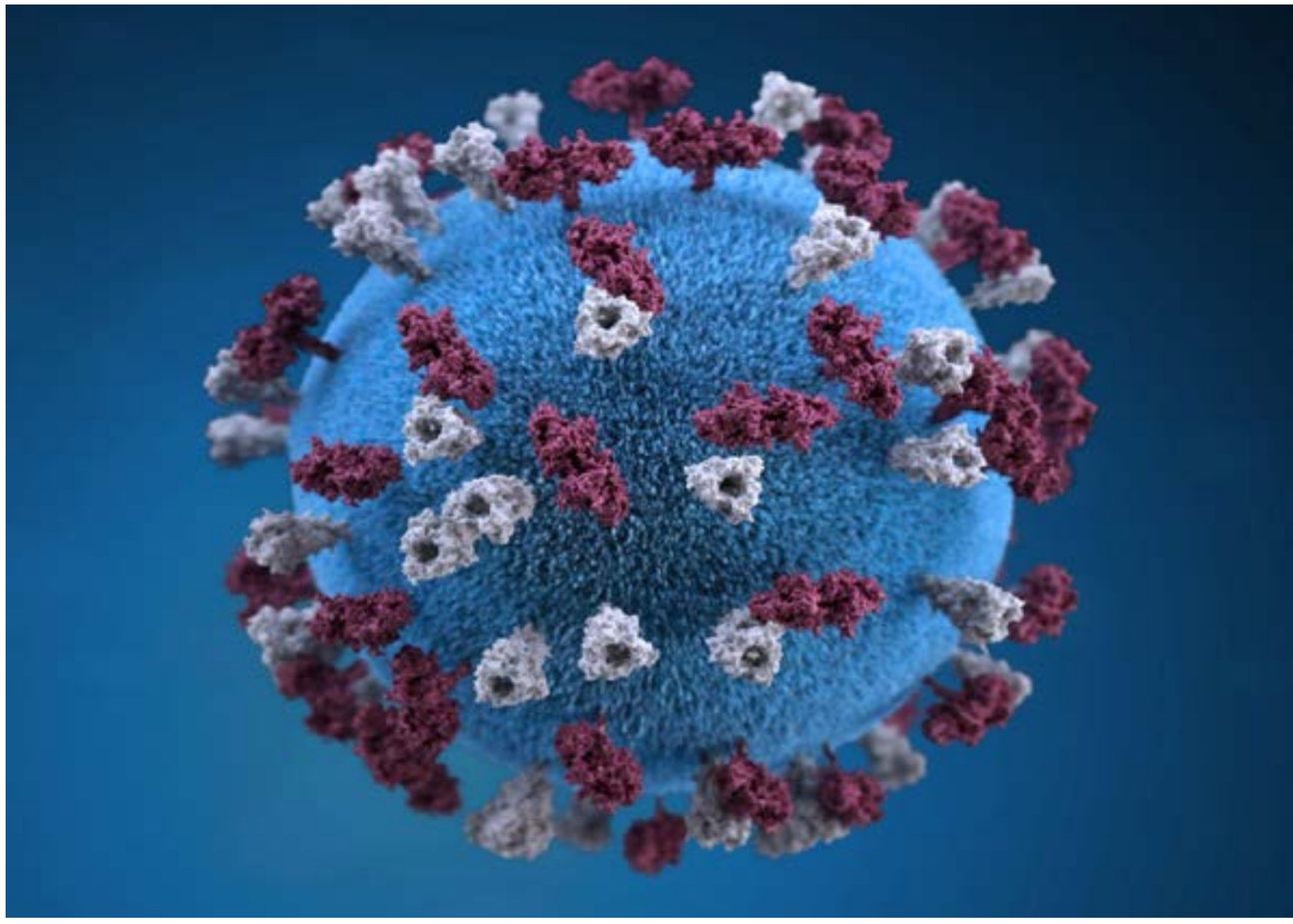
Perhaps the most popular method of STM atom manipulation is lateral manipulation. This technique involves the creation of a temporary atom-tip attractive force between the atoms on the probe tip and the adatom, or the atom lying on the surface. With the force in

place, the atom is then moved across the surface to a new position (Celotta et al). Finally, the STM tip is withdrawn to a point where the force between the adatom and the tip is negligible, leaving the atom bound to the final location on the surface, as shown in the diagram below (Eigler & Schweizer).



The first instance of lateral manipulation was used to position individual xenon atoms on a single-crystal nickel surface, building the "IBM" company logo (Eigler & Schweizer). Since then, IBM has expanded: holding the Guinness World Records record for the World's Smallest Stop-Motion Film is the movie "A Boy And His Atom," where IBM researchers moved carbon monoxide molecules frame-by-frame to create a 1-minute film – which can only be seen because the video is magnified 100 million times. This movie consisted of a boy dancing around with his atom and jumping on a trampoline of atoms while playing basketball and tennis. Filled with laughter, joy, tears, and awe, this movie was definitely ahead of its time (IBM).

At the time, IBM researchers were manipulating atoms to explore the limits of data storage (IBM). However, there are countless more applications to this aspect of nanotechnology. Different types of STM manipulation techniques are used to discover chemical reaction pathways, construct quantum structures, and use information about natural systems such as photosynthesis for solar energy utilization ().



Standing at the forefront of nanotechnology, scanning tunneling microscopy continues to inspire further innovations in the science of the very, very small.

Photo by Aldebaran S on Unsplash

Why Haven't We Met an Intergalactic Alien Species Yet?

by Kian Williams

There are an estimated 500 billion planets in the Milky Way, and thanks to the Kepler mission of 2009, we know that anywhere from 300 million up to 40 billion of those planets are similar to Earth and have the right ingredients to create and house life. Our galaxy is teeming with the possibility for intelligent life to be born and subsequently flourish and expand. Yet, other than us, there is no intelligent life, or life itself, to be found.

The Milky Way was formed a mind-stretching 13.6 billion years ago, but despite being host to all these planets that are ripe for life all this while, the Milky Way is yet to produce an ounce of serious, intelligent life. Why? Earth only joined the Milky Way's impressive collection of planets a mere 4.5 billion years ago. That means that other planets in the Milky Way, similar to our Earth, have had more than double the time to create life for said life to develop and reach the stars.

We humans were only brought into existence a cosmically insignificant 200,000 years ago. Yet in that short time, we have evolved and achieved so much. So why is it that we do not see this happening in any one of the array of planets in the Milky Way that have had so much time to do what we have done and more?

Why is it that in an environment filled to the brim with the potential for species to be created and expanded, we see nothing?

Is it not logical that if it took only 4.5 billion years for humans to come about and get into space, then somewhere else, something has done just that and more?

That is the question physicist Enrico Fermi asked in the 1950s, and he simply said, "Where is everybody?" The universe was vast and old, he reasoned, so why haven't other species emerged and evolved into an intergalactic civilization? The asking of this plain question has spawned years of physicists and philosophers trying to explain what has been dubbed the Fermi paradox. Two theories that have garnered quite a bit of attention are the Great Filter Theory and the Dark Forest theory.

The Great Filter Theory

The Great Filter Theory states that something is stopping life on any planet from passing a certain stage and evolving into the intergalactic species it could be. When we look at the numbers for the amount of potential life-hosting planets and the time they have had to create life, it makes no sense why an intergalactic species hasn't emerged yet. It took us humans a cosmically insignificant 200,000 years to make it into space, and our planet Earth had less than half the time most of these other planets had to create sentient life and allow it to evolve.

So, if it's so probable, why hasn't it happened yet? Perhaps there is something stopping life from exceeding a certain point in its evolutionary journey – a barrier that either keeps a species grounded to its planet or brings about its demise entirely. This is what the Great Filter theory suggests. On the way to becoming a multi-planet species or simply an intelligent and civilized species, there are certain hurdles to cross that are "great" and make the probable scenario of an intergalactic species existing an extremely unlikely one. What these "filters" or hurdles are isn't something that we can tell for certain. It may be something as simple as life becoming intelligent. There are an estimated 7 million animal species on Earth, yet only one, us, became intelligent enough to build cities and launch rockets.

Maybe the greatest challenge of all is for life to become intelligent and sustain itself. Some also say that maybe it is a natural occurrence, like an asteroid, volcanic eruption, or any other inevitable and naturally caused event that would ruin and devastate life on a given planet. Life on Earth was almost completely destroyed by an asteroid with around 75% of all life being annihilated – we just got lucky that mammals survived and were subsequently able to thrive. Maybe it isn't about the species' evolution or natural occurrences outside of their control; maybe the thing that ultimately dooms and filters out life on a planet is life itself.

Maybe it is inevitable that when a species reaches a level of technological prowess and advancement, greed, and corruption cause that civilization to end itself through war with weapons of mass destruction no one can hide from

Here on Earth, we all remember the Cuban missile crisis. We were so close to having an all-out nuclear war that may have left no survivors, yet in the final second, we were able to magically resolve the crisis and everyone went back home. There is a great deal of "maybes" regarding the nature of the filter, making this theory very vague; however, it is a viable one.

We humans have been through a lot of challenges to make it to where we are today. It wasn't easy, and there were a lot of places where everything could've gone wrong. With literally a click of a button, we wouldn't be here today. So it does make sense that life on other planets just gets gradually filtered out by the planet it's on or itself since where we have made it is no easy feat. That's the other interesting part of this, though; we have overcome a lot of challenges as humans, but have we passed through the great filter, or are we about to face it? War is everywhere at the moment, with Putin threatening nukes every hour; the planet is slowly dying with climate change eroding our way of life, racial and religious tensions are reaching a breaking point with BLM protests and the burning of the Quran in Sweden. Has humanity passed its ultimate test yet, or are we too going to be filtered out in the upcoming years? And if we are filtered out, will it be our own doing, and will it be avoidable?

The Dark Forest Theory

The Dark Forest Theory states that even if there are species in this galaxy and universe that can travel among the stars, they would choose not to make contact with us or even travel beyond their planet in the first place, out of fear. We humans are very eager to explore the universe and all its unknowns. We are constantly sending messages in the hopes of a response, constantly sending out probes

to the most dangerous and hostile parts of the galaxy, and putting up telescopes and satellites in the hopes of finding something, anything that we can talk to. We want to confront the unknown, traverse the unprecedented, and explain the unexplainable. However, we can't assume that if there are other species out there, they would approach the vast and difficult space with the same attitude. This is what the Dark Forest Theory suggests.

An intergalactic alien race hasn't emerged because it wouldn't be in their best interests to display themselves and make themselves known to the wider galaxy. While humans see the vacuum of space as welcoming and while we are open to discovering and communicating with new species, others out there might not be. They might not be as excited by space and what might be out there because they see other species as hostile and a threat. Therefore, this would keep them grounded in their planet or would make them conservative with how far they stretched and what messages they responded to out of fear. Fear that if they make themselves known, it will not reap benefits but rather consequences instead.

Is this fear that other species would treat them poorly not a valid one? When humans on Earth discovered those who were different from us due to race or religion, what did we do? We killed them. We declared the different the enemy. From the European wars of religion to the institution of slavery, we haven't exactly been the most naturally friendly and accepting people. So what's to assume that we would treat other species from whole different planets, who appear and behave entirely differently to us, with even a bit of care? That is the conclusion that the Dark Forest Theory suggests other alien races came to. They chose not to risk the potential dangers that broadcasting messages and launching rockets might bring but rather to stay safe from and oblivious to whatever is out there.

That brings about a question for us humans too, though.

Could putting the word out there as hastily as we are be dangerous?

Say there was another species out there that was way more advanced than us; would they not kill us and pillage our planet simply because they could?

Could making contact with an advanced intergalactic species be the last thing that humans do?

Minkowski's Cones: A Human Journey Through Space and Time

by Jessica Kang

Photo by NASA on Unsplash

Introduction

Delving into the vast expanse of the cosmos, physicists have grappled with the enduring challenge of understanding the intricate dance between space and time. At the heart of this cosmic inquiry stands Minkowski spacetime, a four-dimensional realm born by mathematician Hermann Minkowski. This construct played a pivotal role in untangling the mystery surrounding the speed of light in the realm of special relativity.

The Puzzle of Light's Constancy

Special relativity, Einstein's groundbreaking theory, reconciled the unchanging nature of the speed of light with the previously established principle of relativity. The 19th century brought forth a dilemma as conflicting theories unfolded between Newton's laws of motion and Maxwell's equations (Resnick, 1991). The central question emerged: How does the measured speed of light vary for an observer in motion?

Newton proposed a variable speed based on the observer's motion, while Maxwell insisted on a constant speed. The Michelson-Morley experiment of 1887 attempted to shed light on this contradiction by measuring the speed of light in the direction of Earth's motion (Shankland, 1964). The unexpected result, a constant speed, remained an enigma for over a decade.

An Insightful Resolution

Henri Poincare made strides in resolving this mystery, but it was Einstein who brought about a complete understanding. Einstein concluded that the speed of light remains constant in any reference frame, introducing the theory of relativity (Resnick, 1991).

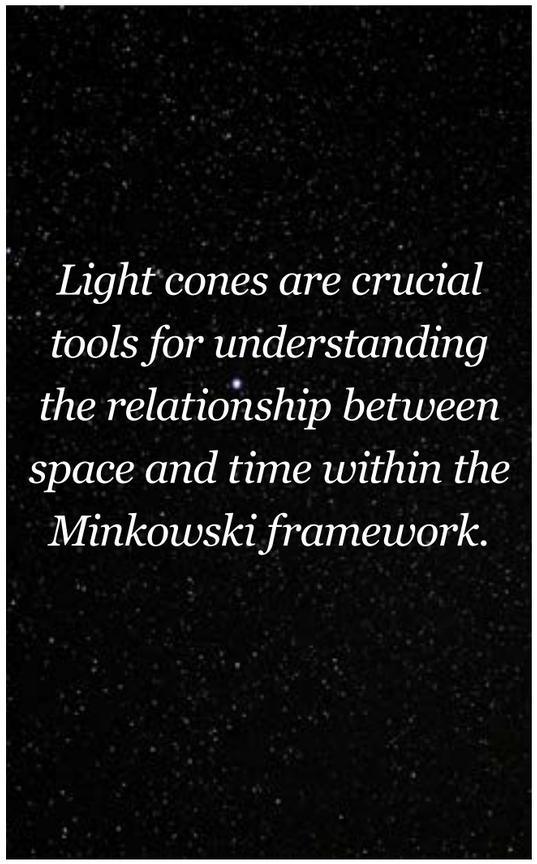
This revelation led Minkowski to a crucial insight – relativity is fundamentally about the geometric relationship between space and time.

Minkowski spacetime, a four-dimensional framework encompassing three spatial dimensions (x, y, z) and a single time dimension, serves as the canvas upon which cosmic events unfold

Photo by SpaceX on Unsplash

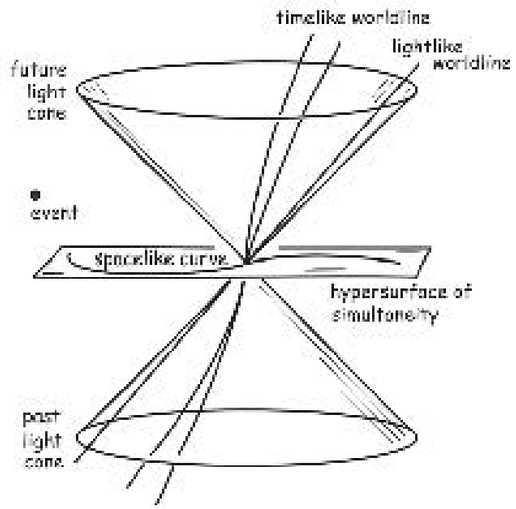
(Arthur, 2006). Within this spacetime, observers at different speeds may perceive space and time differently, yet constants endure – the unchanging laws of physics and the steadfast speed of light.

Imagine a powerful explosion where light radiates outwards to form an expanding spherical shell. This idea is captured in the concept of light cones, which map the potential paths light might take.



Light cones are crucial tools for understanding the relationship between space and time within the Minkowski framework.

Crucial Terminology



(Spacetime, 2015)

Spacetime: This is the fusion of an extra time dimension with space.
Event: Think of these as singular points in spacetime, representing specific locations in space at a given time.
Timelike Worldline: Envision the trajectory of a point moving at speeds less than that of light, confined within the light cone. This depicts the path of particles like electrons, protons, and neutrons, excluding photons.
Spacelike Hypersurfaces: These are snapshots of spacetime, capturing a moment in three-dimensional space within the four-dimensional spacetime.
Past and Future Light Cones: These represent all potential paths light could take at an event. The future light cone signifies upcoming possibilities, while the past light cone reflects historical trajectories.

Conclusion

Minkowski seamlessly blended concepts in mathematics and physics to reveal a spacetime where events unfold gracefully. We are here today because pioneers such as Minkowski and Einstein dared to reshape our understanding of the fundamental fabric of the universe.

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Photo by Pierluigi D'Amelio on Pixabay

"Star Noise": The Fascinating Discoveries of Radio Astronomy

by Fritzy Lingnau

In the early 1930s, young engineer Karl Jansky discovered radio astronomy in his efforts to find natural radio interference that might disrupt overseas telephone calls. The receiver he built spanned 100 feet and made a full rotation every 20 minutes, recording radio waves with a pen and chart. With this machine, he noticed not only radio interference from lightning storms but also what he called "star noise", a faint but mysterious noise emanating from outer space. For the first time in astronomical history, there was something new to be explored, completely invisible to the eye.

Radio astronomy was discovered from the creation of man-made radio transmissions, which harness a specific type of electromagnetic wave.

Though the discovery of cosmic radio waves was brand new, the astronomical community wasn't entirely invested. However, 7 years later, radio engineer Grote Reber began to meticulously investigate these sources of noise (APS). Presenting his own findings more widely in astronomy journals, radio astronomy progressed into a respected field, with the National Radio Astronomy Observatory founded in 1956 (Scoles). Currently, many scientists are involved in radio astronomy, cataloging celestial objects and investigating their properties. Radio astronomy is responsible for numerous crucial discoveries: pulsars, quasars, exoplanets, and cosmic microwave background radiation, a remnant of the Big Bang.

Radio waves are a part of the electromagnetic radiation spectrum, defined by their long wavelength size (the distance between two crests) and low energy. Greatest to least in wavelength size, radio waves are followed by microwave, infrared, visible light, ultraviolet, x-ray, and gamma rays. Sound communication utilizes radio waves because they are easy to make and travel well, interacting little with matter (Libretexts).

Many types of celestial objects emit electromagnetic radiation; however, they don't all emit the same amount or wavelength(s). Identifying these waves helps astronomers understand the motion and composition of far-off cosmic objects with the use of receiver telescopes. Using radio waves, astronomers observe cold hydrogen gas, (the most widespread element in the universe) allowing them to understand the structure of the universe based on the distribution of hydrogen (Hubble). Cosmic radio wave readings are made more accurate by increasing the size of receivers, which involves expensive materials, or by using interferometry arrays of telescopes that function together as a single telescope, reducing cost.

Individual Discoveries

As radio astronomy has developed and become more advanced, many have taken on the challenge begun by Karl Jansky and Grote Reber in investigating cosmic radio waves. Several extraordinary discoveries have been made by radio astronomers' efforts to observe the universe. In 1962, the bright radio source, "Star 3C 273," was observed by Australian astronomers Hazard, Mackey, and Shimmins. They discovered the source came from two, rather than one radio source, set extremely close together. Through later projects and collaboration, the celestial phenomenon of quasars, "quasi-stellar objects" was formalized. Supermassive black holes centering entire galaxies end up expelling excess gas and dust from two sides at extreme velocities, emitting all kinds of electromagnetic waves (Smith).

Another notable discovery of radio astronomy is cosmic microwave background radiation or CMB, the heat left over from the Big Bang. Noticed by Penzias and Wilson in 1965, CMB serves as evidence for the theory of the universe's origin. CMB has been detected in all parts of the sky, at all times of the day. The constant signal of CMB signifies that the universe was originally very dense and very hot, later expanding and becoming cooler over time (ESA).

Photo by Zhenyu Ye on Unsplash

In 1967, Jocelyn Bell Burnell, a graduate student studying quasars, discovered a strange "pulsing" signal that she originally believed might have been a message from an alien civilization.

However, pulsars were later realized to be an entirely new celestial object on their own. They were identified as post-supernova star cores, made of densely packed neutrons, rapidly spinning and emitting radio waves, appearing to "pulse" to a radio telescope. (NRAO).
In 1992, pulsars led to another important discovery. Exoplanets (planets outside our own solar system) were confirmed by two radio astronomers, Wolszczan and Frail. They observed a pulsar that emitted irregularly timed radiation. Upon further investigation, this was due to two planets orbiting it (Wenz). Many significant discoveries in the field of radio astronomy were purely accidental (pulsars, exoplanets, and even radio waves themselves), which gives some

Photo by Fonsi Fernández on Unsplash

Photo by Ben Wicks on Unsplash

insight into just how mysterious the study of the universe is. To this day, we have yet to uncover all that exists behind the radio emissions currently received by telescopes.

Looking to the Future

At present, a few notable arrays include the Atacama Large Millimeter/submillimeter Array in Chile, one of the most powerful radio telescopes; the NRAO's Karl G. Jansky Very Large Array in New Mexico; and China's Five-hundred-meter Aperture Spherical Telescope, nicknamed the "Eye of Heaven", the world's largest single-dish radio telescope. Each of these telescopes supports a host of advanced projects and experiments on cosmic radio emissions (Bradaschia).

One important ongoing project is the Square Kilometer Array, expected to become the largest radio astronomy observatory in the world (spread out across Australia and Africa). The huge area covered by the array will gather extremely specific readings, which will provide us with much finer details of the universe (Wild). A challenge that comes with ambitious projects like these is the money and international cooperation needed to build these large-scale telescopes, which are necessary to provide us with high-resolution pictures. Another major challenge to these projects is the increasing presence of satellite groups and other forms of manmade interference. The issue of Radio Frequency Interference, or RFI, is exemplified by increasing emissions from cell phones, aircraft, satellites, and other observatory equipment. RFI mitigation is being experimented with using AI deep learning methods which though not yet mainstream, show promising results in the detection of RFI (Tuccari).

Radio astronomy has strengthened many aspects of technology, computer science, and engineering, and uncovered a substantial amount of knowledge about how electromagnetism exists in the cosmos.

Hopes for radio astronomy as a field mostly revolve around the improvement of receivers and RFI mitigation techniques to understand more distant and more specific celestial objects.

Future observations of "star noise" may one day result in monumental changes to our civilization– the discovery of livable exoplanets, entirely new phenomena out there, or even alien life.

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Time Travel

by Divita Narula

Time travel is something thought to only exist in science fiction and ancient mythology, something only considered as a wish of many and probably not a reality.

There are, however, numerous theories developed by some of the greatest minds in humankind that prove time travel as a possibility, such as the theory of special and general relativity and the theory of wormholes.

Einstein's idea of special relativity in time travel is that time flows relative to how fast you're moving. By moving faster, time slows, and vice versa. His idea of general relativity in time works similarly, but instead of movement, gravity affects time in that the more forceful the gravity is, the slower time moves. According to Dave Goldberg, a cosmologist at Drexel University, "If the person who was near the black hole returned to this planet, they would have effectively traveled to the future." There are, however, problems with Einstein's theory, namely that his idea of relative spacetime is in fact, false. Although we may always be traveling through time, time travel generally refers to, "the possibility of changing the rate at which we travel into the future, or completely reversing it so that we travel into the past" ("Time Travel – Exactly What Is Time?"). Time travel is impossible in Newtonian (absolute time) and special relativity, but still remains a possibility in general relativity, as has been extensively researched by Albert Einstein and many others. It usually means that a person's mind and body remain the same, but their location in time changes.

Time travel to the future is relatively easy to understand, but there are significant issues in trying to travel back in time. One issue would be a phenomenon scientists know as "closed timelike curves". A closed timelike curve "describes the trajectory of a hypothetical observer that, while always traveling forward in time from their own perspective, at some point finds themselves at the same place and time where they started, creating a loop" (Higgins and Scoles).

This means that when a hypothetical observer goes back in time and then moves forward in time in their own perspective, they will find themselves back at the point at which they started, from which they'd go back in time again, which would keep the observer in an infinite loop. Another issue would be known as the Grandfather paradox, in which if you were to go back in time and kill your grandfather before he sired your father. This would be a problem because then how did you go back in time and kill him in the first place?

Another possibility for time travel is wormholes. Though they've never been found in space, wormholes have been described in the solutions to numerous physics equations, like the equations in Einstein's theory of space-time and general relativity. There is much debate in the belief of a wormhole's existence, however, because gravity influences everything in space, which would include wormholes if they exist. The problem, however, is that a wormhole would collapse on itself due to its gravity unless there is a negative energy counteracting the pull of gravity and stabilizing the wormhole. But scientists have found so far that negative energy only exists in quantities much too small to counteract the force of gravity on and from a wormhole. Wormholes still haven't been considered a part of mainstream science, but the same was true for black holes, so there's a possibility for proof of a wormhole's existence.

There are numerous other theories that make the possibility of time travel quite real, but as of now, debate still goes strong among numerous scientists, and it may be decades or even centuries before time travel is proven and a substantial concept.

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Photo by Camila Quintero Franco on Unsplash

What is Schizophrenia, and How Can We Tackle It?

by Phani Sikhakollu

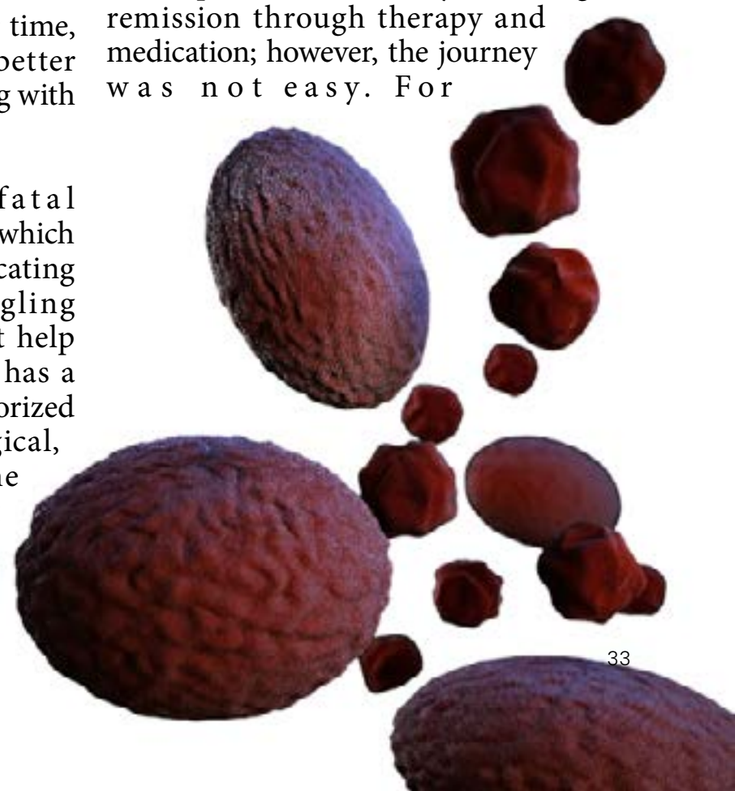
Imagine waking up in the middle of the night to find spiders crawling in your kitchen. You scream for help until your friend rushes by your side, but when you point towards the spiders, your friend looks at you puzzled, saying, "There's nothing there." Still, out of breath, your trembling hand reaches out for the spider, but you only feel the empty air. There was no spider; it was just a hallucination. This experience describes one of the several difficulties that people struggling with schizophrenia may face. Schizophrenia is a mental disorder where people perceive reality, social interactions, and thought processes differently ("Schizophrenia").

"24 million people have schizophrenia but less than 33% of them receive treatment" (Zauderer).

Although these statistics vary over time, by educating ourselves we can better support those in our lives struggling with schizophrenia.

Schizophrenia can have fatal consequences when left untreated which highlights the importance of educating ourselves because those struggling with schizophrenia can only get help from people who know them. It has a variety of causes that can be categorized into physical, genetic, psychological, or environmental factors. Some cases involve an excess amount of neurotransmitters--chemicals carrying messages between brain cells--in one's brain which is an effect of certain medications like dopamine. While heredity and emotional events like abuse can trigger it, they are not primary causes. Substance abuse can also increase the risk of developing schizophrenia (NHS). Additionally, people with schizophrenia have less gray matter volume (Yue). This causes them to have either too little or too much control over their movement, memory, and emotions (Schizophrenia and Your Brain). Due to the complexity and variability of the causes of schizophrenia, a definitive cure has not been determined, but treatment options like therapy are present. Nevertheless, the lasting effects of this disorder remain.

An example of the ramifications of schizophrenia becomes apparent considering Betty Ruoss' story. Betty, an author, struggled with schizophrenia and depression, ultimately achieving remission through therapy and medication; however, the journey was not easy. For



example, her initial lack of awareness about schizophrenia intensified the confusion, as she described it, "It wasn't just one voice talking [in my head], but many in a low tone" (Ruoss). Furthermore, her disorder presented itself through speech difficulties, an inability to experience pleasure, and behavioral changes such as sudden resistance to instructions (Wright). The effects of schizophrenia range from reduced motivation to hallucinations, with Ruoss experiencing one aspect. Understanding individual experiences is crucial as we navigate the complexities of supporting someone with schizophrenia.

Supporting someone struggling with schizophrenia may seem challenging, but our role is crucial. HelpGuide, a group providing evidence-based research on mental health issues, recommends promoting consistent treatment, such as low-side-effect medications, and offering emotional support, given the difficulty individuals with schizophrenia may have in trusting new people (Smith). Additionally, vigilance for signs like insomnia or declining personal hygiene can help prevent relapse. The significant influence of our role is shown by individuals who, like Tanara, achieved remission and continue to assist others with schizophrenia in understanding and pursuing their goals despite the challenges associated with their disorder (Tanara). The urgency of our involvement cannot be exaggerated, as the consequences of untreated schizophrenia will be severe.

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Strange Matters: Most Dangerous Substance in Existence

by Yvonne Li Yiwen

Think about a substance that it's so heavy that a spoon of it can fall straight into the ground, so strong that it can destroy anything immediately just by contact. This substance is called strange matter: a mysterious matter hidden deep in the center of neutron stars.

Neutron stars are the densest substance in space except black holes.

They are what remains after an explosion of a massive star in a supernova. In their cores, the most dangerous substance in space could be found——strange matter.

Everything in the universe is made of elementary particles called quarks, which are the tiny building blocks of every matter. There are six types of quarks: up, down, charm, strange, top and bottom.

(Cooper, 2022) On Earth, every proton and neutron are made by up and down quarks, which are the lightest and most stable quarks. (Kurzgesagt, 2019)

Other quarks are usually unstable and decay quickly, but in neutron stars, it's a completely different case. Some theories suggest, but it hasn't been proven experimentally that neutron stars consist of up, down, charm, strange, top, and bottom quarks. Quarks melt into one another in a neutron star due to its high pressure, and in the core of the star, some quarks, as some theories suggest, convert into 'strange' quarks. Strange quarks are stronger and heavier quarks with bizarre nucleic properties. Strange quarks can make 'strange substances' that are perfectly dense, perfectly stable, and perfectly indestructible. It's so stable that it could be 'infectious'. When it contacts non-strange matter, the powerful nuclear force can reconfigure the quarks in non-strange matter to match it with strange matter's perfectly stable low-energy state. Anything that contacts those strange substances is thus also turning into strange substances. Protons and neutrons dissolve into quarks and become strange matters, releasing large amounts of energy and continuing to 'infect' others. (Conocimiento, 2020)

Strange matter hypothetically only exists in the core of neutron stars, unless two neutron stars collide, causing the neutron stars to spew out droplets of strange matter called strangelets. Strangelets travel through space until they contact a star (or a planet), turning the star into strange matter. (Kurzgesagt, 2019)

Some theories suggest that strangelets are more than common. Some scientists even speculated that they could be the dark matter in space that holds the galaxies together.

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The (Not So Definitive) Collection of Cures to Hiccups

by Triston Wong

Hiccups (or hiccoughs) are the prime example of an uncommon yet extremely mundane event that a human can endure in their lifetime. Although hiccups have been around for as long as humans have existed, hiccups are forgettable (when's the last time you've hiccuped?) (Hiccups: Causes & treatment). I—a human who has hiccuped before—would argue that hiccups are not just forgettable, but vile. Beyond being mildly humorous from their spontaneous eruption of gas, hiccups ultimately give an unsatisfactory experience that leaves nothing to be desired.

These are the thoughts that loomed over me when conducting research on this topic. Despite the lack of a definitive understanding of the solutions behind hiccups, some general conclusions and patterns have been made. Antidotes have passed from generation to generation, ridding us of these dastard curses.

This information is a culmination of cures collected from a series of scientific journals and short stories. Some treatments will work more effectively than others. Some may not be effective at all. The topics addressed today specifically address chronic, transient hiccups.

So please, do not use this content as medical advice—refer to your qualified clinician or general practitioner.

A brief overview

Harvard Health Publishing describes hiccups simply: "as if you're taking a big breath of air much faster than normal (2020)". This can be split into two separate actions: the 'feeling' you get in your chest during the hiccup and the sound that is produced afterward. The action is an involuntary reflex between your diaphragm and the intercostal muscles in your ribs. During the hiccup, your diaphragm spasms and begins to contract and pull down, causing air to be forcefully inhaled into the body. This results in the closure of your vocal cords. When the space at the back of the throat fully shuts, it produces the distinctive hic sound everybody loves.

There is no definitive cause of why this occurs and how it erupts periodically. Still, there has been a common consensus gathered amongst experts—the hiccup reflex is part of the neuronal track between the phrenic and vagus nerves. Both nerves are located below the thorax and in the diaphragm. The phrenic nerve acts as a motor, sending signals from the brain to the diaphragm while the vagus nerve acts as its parasympathetic system, or its "rest and digest" reaction when the body needs to calm down (Nerves of the thorax: Acland's video atlas of human anatomy). The stimulation of the vagus nerves sends a signal to the medulla oblongata, or the area within the lower brain that assists in breathing, which completes the feedback loop through the phrenic system. This is the best proven theory on why you hiccup.

The causation of hiccups all connect to the flaring of the vagus nerve in the diaphragm. Any jumps or attacks that affect the throat can cause hiccups. The most common triggers include eating or drinking too much, chewing gum, and smoking. Beyond these, a sudden change in temperature and being prone to excitement or emotional stress are other factors that may cause hiccups (Mayo Foundation, 2023).

Definitive cures to hiccups

Interestingly, it isn't uncommon to begin hiccuping before you are out of the womb. Some researchers propose that it came from a digestive reflex that guards the uterus from inhaling the mother's amniotic fluid, while others believe it is a training mechanism for the respiratory system. There has even been evidence that hiccups date back to amphibian ancestors (Straus et al., 2003). These theories, along with a variety of cures, have been hypothesized hundreds of years ago. A common phrase used in 16th-century England was, "It is good to cast colde water in the face of him that hath the hicket. (2020)"

Unfortunately, there is no be-all, end-all solution to hiccoughs; many solutions spread from word-of-mouth that come with ranging amounts of success. What definitively stops hiccups are cures that create a stimulus that interrupts the hiccup reflex.

One common technique that one can efficiently perform is supra-supramaximal inspiration, which increases the carbon dioxide levels in your blood, thereby decreasing one's hiccups (2020). To perform this maneuver, simply take deep breaths and hold it in 10-second intervals. Then, without exhaling, breathe again and repeat the process. Another, more common method that people do is to hold their breath, which is said to reproduce this effect (Spectrum is not responsible for any harm or damages to bodily health. Discretion is advised).

Another tested solution that performs well is taking medications, specifically those that include thorazine, or chlorpromazine, which is used to treat psychotic disorders. Other drugs, such as baclofen and metoclopramide, have also been proven to be effective, though thorazine is the only FDA-approved drug.

(Not so) Definitive cures to hiccups

The solutions stated above are all definitive, proven cures to hiccups; however, there is also a plethora of techniques that have also worked amongst individuals with varying degrees of effectiveness. Drinking water in various ways has shown to be effective. Some people drink from the opposite side of a glass, which is believed to excite the nerves at the back of the throat. Others hang upside down while drinking or take sips in specific timed intervals.

There are also one-off techniques that, while suspicious, work for some people. Both the UK's NHS and Cleveland Clinic have stated that swallowing granulated sugars can help with hiccups, while another belief that pulling your knees close to your chest can slow down the hiccough reflex (NHS, 2023). Marijuana and acupuncture are also effective for selected individuals, with the latter even helping people with intractable hiccups (Zhang et al., 2021). Lastly, some people have found asking themselves arbitrary questions to be an effective hiccup solution. Although this sounds farfetched (because frankly enough, it is), one question that I have used to varying degrees of success is asking out loud:

"What is tofu made out of?"

Conclusion

Hiccups are one of the oldest phenomena known to mankind and have been around for as long as humans have existed. Although we have come to understand their occurrence, there is also a lack of definitive evidence on how to stop hiccups. I, myself, have asked a lot of people on their methods with hiccups and have learned the various rituals they conduct to cure themselves. This is an article built on scientific information yet should also be taken with a grain of salt (or a glass of water). Despite this, it is with my greatest sincerity that you may find a solution to the thousand-year-problem that plagues us today.

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Breaking Down the Tragedy Paradox Neuroscientifically: What Makes Sad Music Pleasurable?

by Taarini Gupta

The tragedy paradox, stemming from Aristotle's definition of tragedy, is often associated with the aesthetic value of suffering, more commonly understood as catharsis.

While individuals generally seek to minimize sadness daily, the tragedy paradox suggests pleasure is derived from sadness conveyed through aesthetic mediums—from tragic theater to popular music addressing topics like grief or heartbreak. Aristotle's concept of psychological rewards through catharsis in tragic theater, where the audience experiences and subsequently purges negative emotions, preceded modern psychological research on the allure of sad music (Schaper, 1968).

Previous studies distinguished between the emotion induced by sad music and the aesthetics of the music itself. Within the aesthetic context of listening, it was proposed that "negative valence" music, for instance, slow tempo, does not directly prompt sadness but rather influences the listener to perceive it as sadness (Garrido & Schubert, 2011). From this perspective, pleasure arises from physiological arousal, which can be attributed to induced by the musical structure. Research on physiological responses to music features, such as volume, tempo, or harmonic unexpectedness, supports this hypothesis (Arjmand et al., 2017). However, Garrido and Schubert's study lacks empirical measurement of the distinction between perceived emotion and aesthetics.

In contrast to the previous study, recent studies from the Indian Institute of Technology, Mandi, explored the neural correlates of the tragedy paradox in music. Beyond looking at aesthetics as

the cause of perceived emotion, these researchers conducted an experimental study to clarify whether there was a distinction between everyday sadness and that induced by external stimuli, such as sad music, regarding neurological changes. If so, this would undermine the idea that only the perception of sadness conveyed through the negative valence aesthetics of sad music leads to enjoyment of the music instead of the experience of sadness, in line with the tragedy paradox.

Beginning with a source-level autobiographical recall of sadness (SAR), participants in Gupta's study were instructed to recall episodic memories associated with a desired emotion. The results were then compared to the electroencephalogram (EEG) results of other participants exposed to sad music.

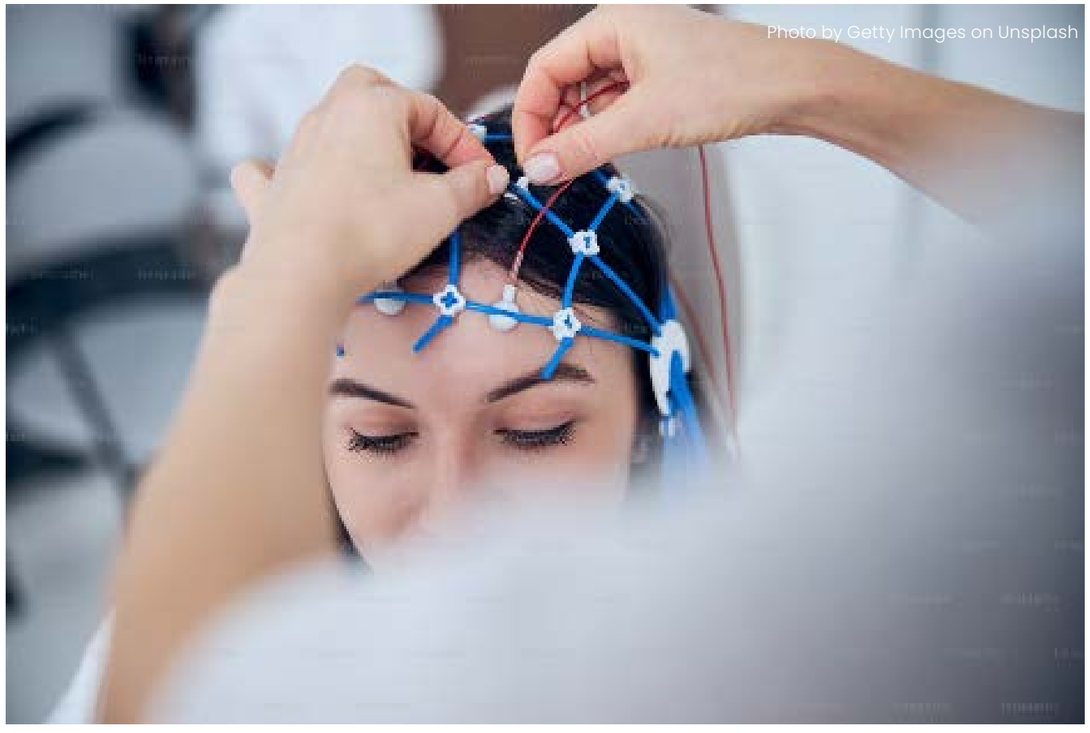

Photo by Getty Images on Unsplash

The results suggested distinct characteristics identified in the cingulate cortex complex and parahippocampus, which are regions associated with emotions and memory processing (Gupta et al., 2023). Specifically, increased gamma-band activity under SAR, a brain wave frequency associated with cognitive function, memory, and perceptual processing, was observed. The gamma-band activity reflects a mental state of intense focus and thought, which is the opposite of pleasure; this explains why everyday sadness is less enjoyable.

On the other hand, researchers found that increased alpha-band activity occurred with sad music exposure. Alpha-band activity, another brave wave frequency much slower than gamma-band waves, indicates a resultful and meditative restful state; this suggests that sad music acts as a coping mechanism in a non-threatening environment, inducing a cathartic response. Conversely, the increased gamma-band activity under SAR indicated enhanced problem-solving and concentration, explaining why everyday sadness is less pleasurable. Gupta's findings challenge Garrido and Schubert's hypothesis that the pleasure derived from sad music is solely linked to the aesthetics that induce physiological arousal. Still, it is plausible that both perspectives contribute to the complex nature of the pleasurable response to sad music.

Another proposal, which considers eight mechanisms by which music induces emotional responses, provides a comprehensive framework that encompasses both music's physiological and aesthetic aspects (Juslin, 2013). These various combinations and frameworks proposed by recent researchers suggest a prevailing uncertainty of what music features can be directly linked to the emotional response to sad music. Future research may build upon these insights to establish a neurological foundation for the pleasurable nature of sad music.

In conclusion, the pleasure derived from sad music, or any artistic works in line with the tragedy paradox, can be attributed to the physical arousal induced by the artistic structure and resulting in the neurological changes in brain wave activity facilitating cathartic processes. This paper has consolidated and compared various scientific bases explaining a universal self-regulating strategy—listening to soothing heartbreak songs during hard times.

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Smoking's Deadly Role: Revealing the Link to Cancer's Rise

by Bonjoon Koo

Introduction

There is a habit responsible for 20% of all cancer cases worldwide. This deadly habit affects people of all ages, genders, and backgrounds, and its consequences extend far beyond the individual smoker. This habit would be called smoking. Smoking is a serious issue that harms human health, and people need to be educated on the dangers it poses. In this article, we will explore the alarming connection between smoking and cancer, delve into the health issues it causes, and discuss strategies for smoking cessation.

Smoking Prevalence

While the information might be overwhelming, it's no surprise that smoking-related illnesses and fatalities are so prevalent all over the world. In 2020, 22.3% of the population smoked. Even so, the majority of adults smoke 6-10 cigarettes every day. With so many people smoking cigarettes worldwide,it's reasonable to see how millions of people die from smoking every year. Connections Between Smoking and Cancer

Given this prevalence, it is critical to educate general populations on the biological links between cancer and smoking to spread awareness about the dangers of smoking.

To begin, your body comprises cells, each of which has a nucleus. The nucleus is a component of the cell that houses chromosomes of DNA, and the genes in your DNA are constantly replicated by your body. Mutations that cause cancer can occur when your genes are duplicated or when they are repaired from genetic harm. While the majority of mutations are easily repaired, three types of gene alterations cause cancer. TSG, oncogene, and suicide switch mutations (Canadian Cancer Society, 2023) When these mutations occur, your cell is unable to repair the errors in its gene, it is unable to kill itself, and it begins to replicate at an alarming rate. This is how a cancer cell develops. So, how does all of this connect to smoking? Well, smoking causes genetic harm, resulting in the cells needing to repair themselves and duplicate. While most genetic damage occurs over time, smoking can contribute to additional genetic damage in the body. (Kurzgesagt – In a Nutshell, 2023)

Health Issues Arising From Smoking

Aside from cancer, smoking can cause a variety of other illnesses and ailments. People who smoke regularly are more likely to get heart disease, stroke, diabetes, and lung disease. Additional disorders such as tuberculosis, eye disease, immune system insufficiency, and various kinds of arthritis create numerous external health issues in the present and future. However, smoking is not just a personal health concern; it has a worldwide influence on civilians' lives. Smoking is a big issue because people suffer as a result of others' addictions. Nobody would dare suggest that smoking cessation awareness should not be increased when innocent people die each year as a result of secondhand smoke and tons of greenhouse gases and cancer-causing toxins being emitted into the environment.

Smoking Cessation

Despite the addictiveness of smoking, there are several options for someone to quit smoking. This,such as gradually cutting off or using treatment, can all be helpful. However, no matter what you do, you will achieve positive outcomes. Someone once stated,

"Quitting smoking is not a loss; it's a gain for a healthier, smoke-free life." Everyone should endeavor to quit smoking to make their lives and the lives of others less stressful and more liberal. Using nicotine replacement treatment, postponing tobacco use, exercising more frequently, and attempting to apply relaxation methods are some advice for those who want to quit smoking. These seemingly insignificant details might easily be the difference between life and death for you and others around you.

Conclusion

Overall, I hope you understand the dangers of smoking to one's health and the well-being of society. Quitting smoking is not a side quest; it is a critical activity that might help you live a much longer life. Thousands of scientists are currently working on cancer research and smoking cessation across the world. However, it is up to us to continue our efforts until the research is fully developed. Once the research is completed, people worldwide will be able to enjoy a cancer-free society. But until then, it's up to you to save the ones you love. The next time you see your family members smoking, educate them on the issues of smoking, and politely rip the cigarette out of their hands and carefully discard it.

Cigarette smoking is and will always be harmful, and it must be addressed.

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Smoking's Deadly Role: Revealing the Link to Cancer's Rise

Photo by D koi on Unsplash

Drug Treatments of the Thrombosis and Pulmonary Embolism

by Morgan Ahn

Thrombosis and Pulmonary Embolism

Thrombosis and Pulmonary Embolism (PE) are similar medical conditions that bring multiple health effects to humans. Thrombosis is the disease of the creation of blood clots in blood vessels around any part of the body - mainly in the legs and arms. Correspondingly, PE occurs when a blood clot migrates to the lungs, clogging blood flow and disfunctioning it. Given their potential to induce life-threatening consequences, advanced investigations have been conducted to apprehend and address the complexities associated with thrombosis and PE. According to the Centers for Disease Control and Prevention, 900,000 people in the United States are affected by thrombosis or PE, and 25% of them face sudden death due to the blockage of the blood circulation. (Data) The present project will examine the practicality of Dabigatran as a pharmacological intervention for preventing and treating thrombosis and PE.

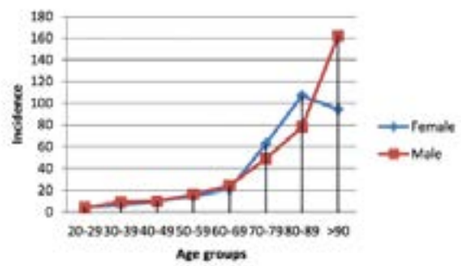

Figure 1 Incident rate of Thrombosis and PE by age group (Rapsis)

Embolism

Thrombosis and PE can be shown in various blood vessels throughout the body, with an eminent association observed in deep vein thrombosis (DVT) cases. DVT typically occurs in the blood vessels borderline (also known as the circumference). However, it can extend to diverse factors, including vascular injury, prolonged immobility, underlying malignancies, excessive body weight, smoking, hormonal contraceptives, pregnancy, and other contributing conditions. DVT is a severe disease due to its possibility of metastasis into another devastating disease. Countless risk factors also increase an individual's vulnerability to thrombosis, including familial history of blood clots, advanced age, surgical procedures, traumatic incidents, inherited clotting disorders, certain medications, and obesity.

Treatment of Thrombosis and Pulmonary Embolism

The treatment of thrombosis and PE typically involves anticoagulant medications designed to prevent the formation of blood clots These medications can be given orally or intravenously (injection). Mostly, oral medication is the most popular method for patients, but IV is only used when oral medication is unavailable due to physical conditions. In severe cases, surgery may be necessary to remove a clot or insert a filter into the vein to prevent further clots. However, this project will concentrate on the types of drugs that can cure these diseases and propose them.

Different types of drugs for treatment

There are multiple different types of drugs available for treating thrombosis and PE. Each different drugs have its own risks and limitation, but it depends on the target protein and gene they bind to. The most famous drugs are Warfarin and heparin, which a wide range of patients are available for access. Heparin is a fast-acting anticoagulant that can prevent the formation of newly created blood clots by inhibiting the formation of fibrin, a necessary protein responsible for blood clotting. As mentioned in the previous paragraph, Warfarin is one of the most popular treatments for blood clots. Warfarin inhibits the clotting factors activated by the vitamin K. This is how it ultimately results in the prevention of new clot formation and removement of the existing clots by dissolution. Compared to Heparin, Warfarin is mostly used as an oral medication unless there is a special adjustment needed for the patients. Warfarin is composed of enantiomers, which are “pairs of compounds with the same connectivity but opposite three-dimensional shapes” (Schaller) – S and R. As the chemical structure shown in Figure 2, a three-dimensional structure is noteworthy since Warfarin is one of the few drugs that vattach nearly completely to the complement protein: albumin. (Gellatly)

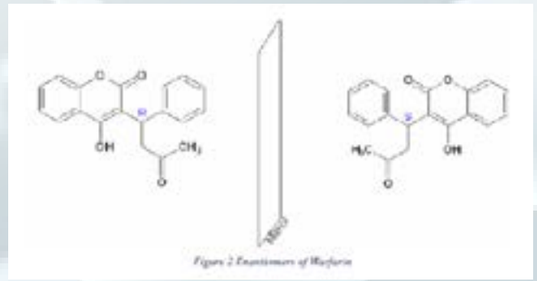

Figure 2 Enantiomers of Warfarin

The binding map of Warfarin is shown in Figure 4. As shown in the figure, the

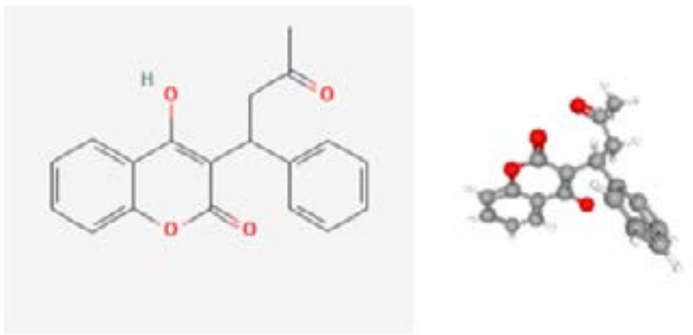

Figure 3 Structure of Warfarin

The 2D structure of Warfarin (left) explicitly indicates the R and S enantiomers. The 3D structure of Warfarin (right) gives an understanding of the binding process. (Warfarin.)

yellow molecule is Warfarin, making the pocket bond with the CYP2C9 gene. Looking at the binding area, it is easily shown that the OH functional group has an active binding with the part of the ribbon of the CYP2C9.

Adding to the Warfarin and heparin, direct oral anticoagulants (DOACs) such as dabigatran, rivaroxaban, apixaban, and edoxaban are also used to treat thrombosis and PE. DOACs are relatively newer anticoagulant medications that work by targeting specific clotting factors, such as thrombin or factor Xa, ultimately making it possible to prevent the clots.

It is important to note that the choice of medication for thrombosis and pulmonary embolism treatment depends on several factors, such as the severity of the condition, the patient's age and medical history, and the potential for drug interactions. Therefore, it is crucial to determine the most appropriate treatment process for each patient. Among these choices, dabigatran is going to be the main focused drug for creating analogs depending on the different target purposes.

Dabigatran is one of the DOACs, as explained in the previous section. It works by inhibiting the activity of the thrombin and reducing stroke, systemic embolism, and other clot-related problems. One of the advantages of using dabigatran is that it does not require frequent monitoring of blood tests and fewer interaction between different medications and foods. Following is the two-dimensional structure of dabigatran.

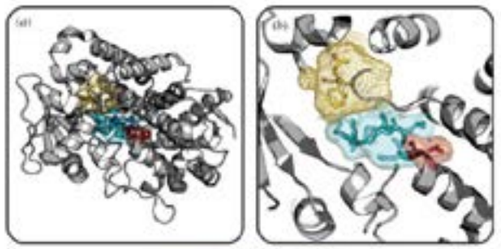

Figure 4 Binding map of Warfarin (Lahti)

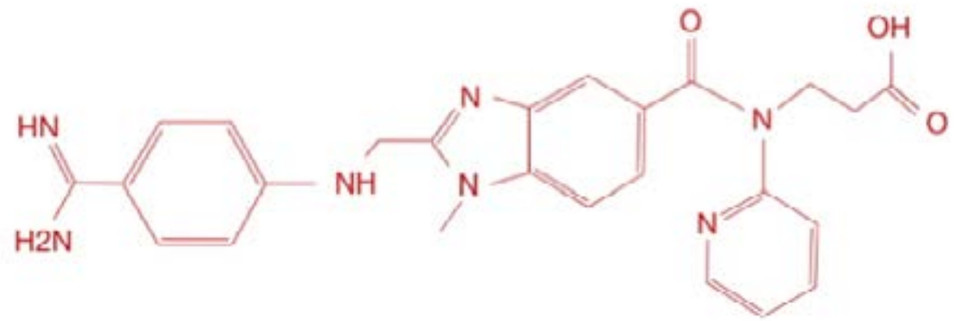

Figure 5 Dabigatran compound

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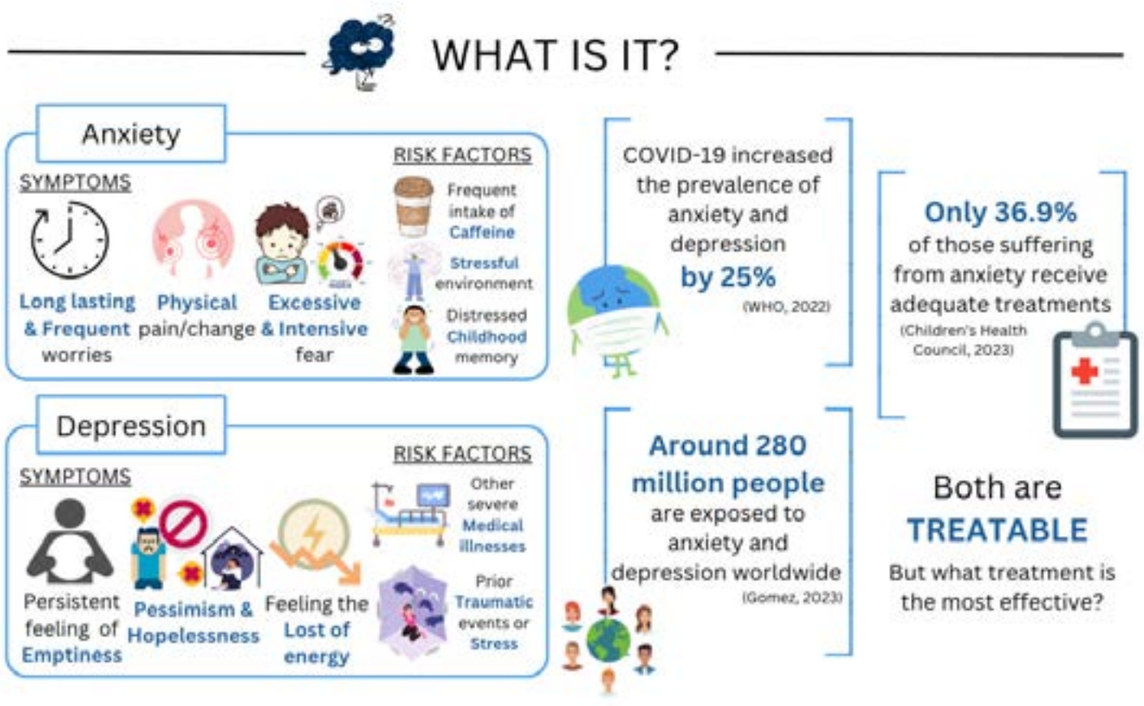
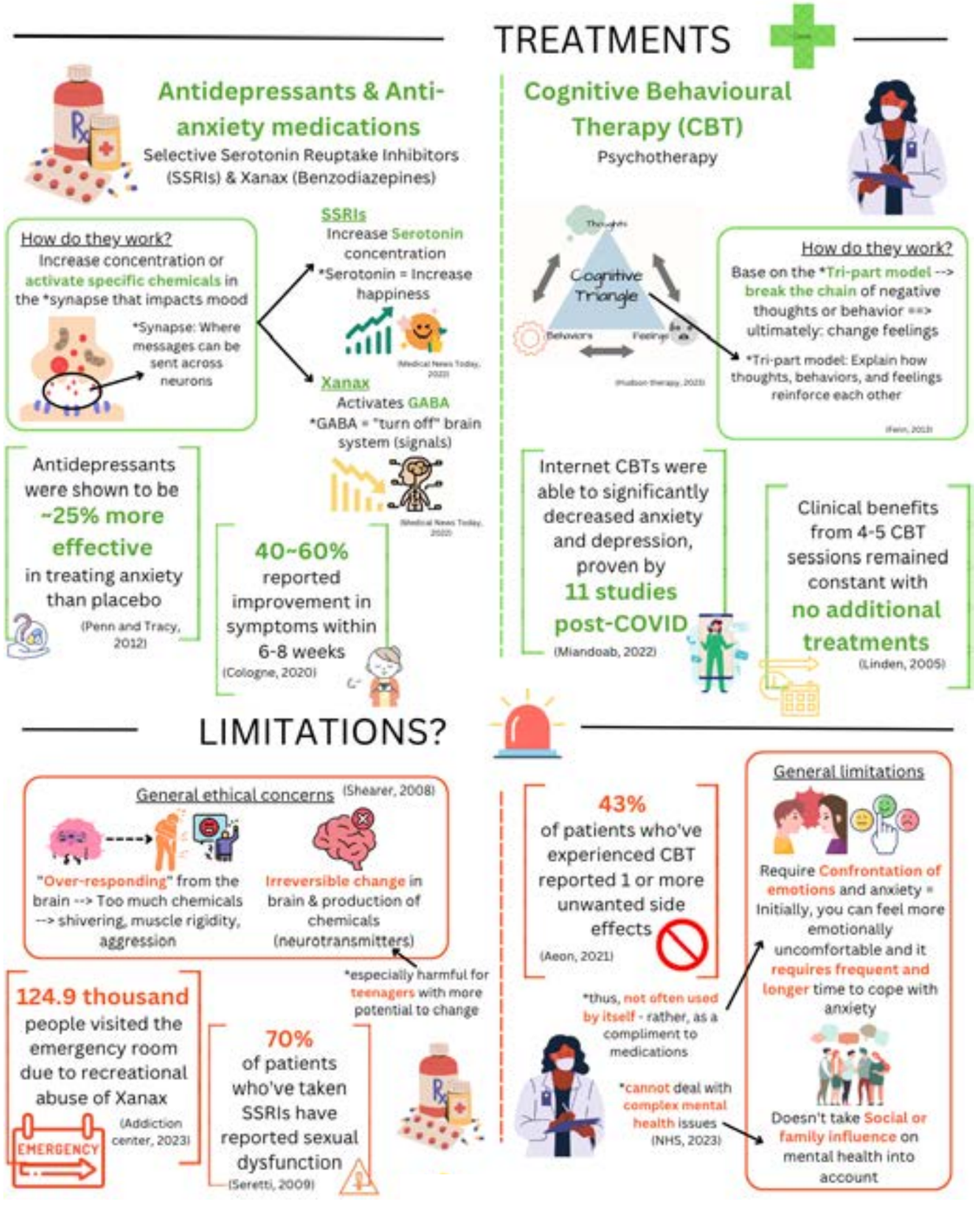
Treatments for Anxiety and Depression

What's the best treatment?

by Irene Choi





SO...?

No absolute best

==> Important to be **Aware** of the costs and benefits for each to make the best **Informed decision**

Looking for?

Short term, Immediate effect

Solution?

Medication (Effect - Xanax: 2-4 weeks, SSRIs: 4-6 weeks)

Long term, stable effect (preventing relapse)

CBT/Psychotherapy (Effect - months+)

Know anyone with anxiety disorders?

Help them choose the best treatment based on their symptoms!

Unsure? Find a psychiatrist for more information!!

Check if you have anxiety/depression!

- Feeling nervous, with increased heart rate for a long time?
- Trouble sleeping (Insomnia) or digestion (GI) problems?
- Uncontrollable breathing problems and sweating?

Need Help?

Mental Health America (US)

Chat OR Call 988

Singapore government Hotline

1800-202-6868 Call OR Other contacts

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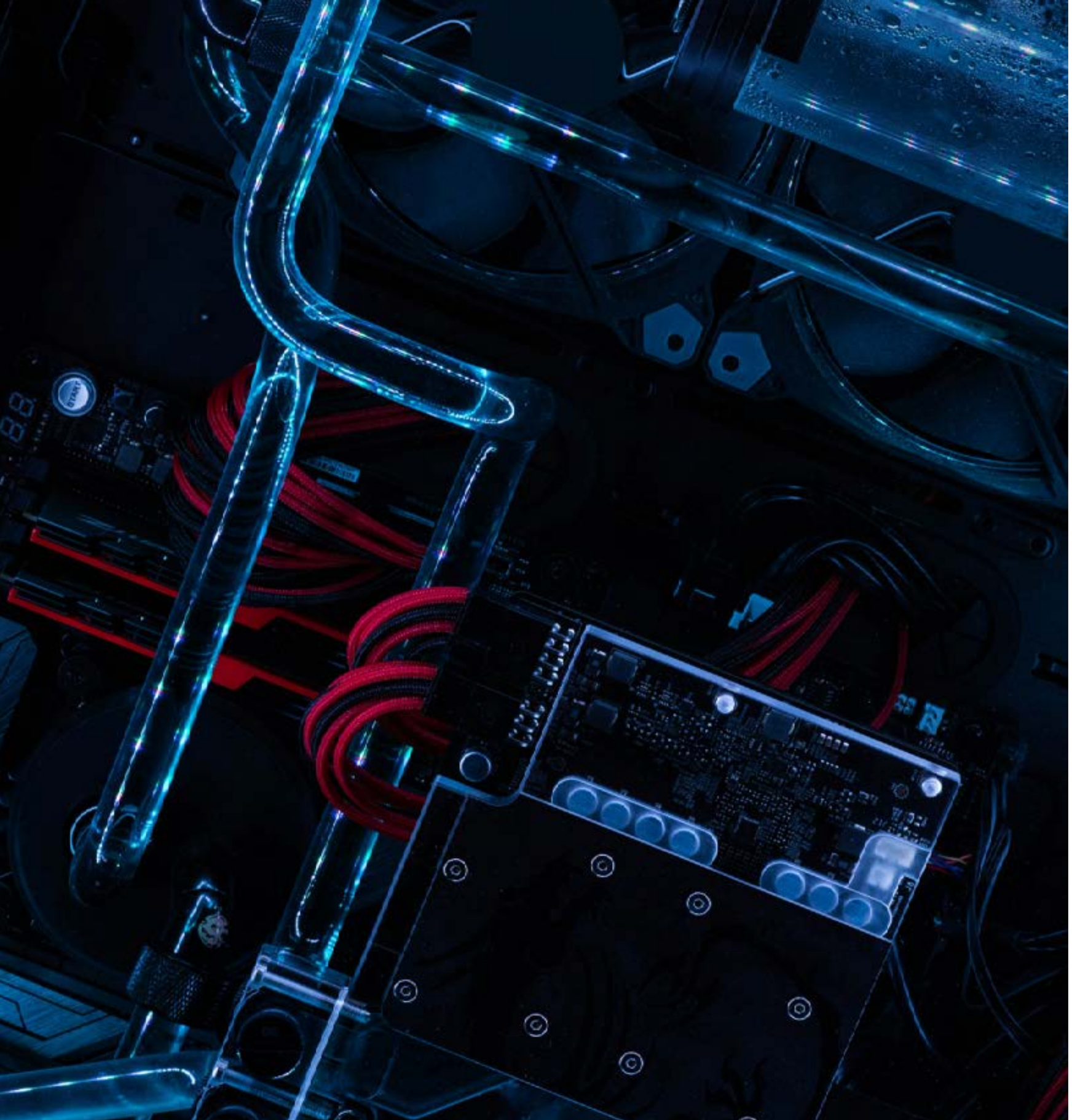

TECHNOLOGY & ENGINEERING

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Should AI be implemented in school settings?

by Vivian Jiang

Artificial Intelligence (AI) is to computer systems, the simulation of human intelligence by machines. From natural language processing to machine learning, AI is used in a lot of aspects, including education. In the context of education, AI aims to improve student outcomes, efficiently run administrative tasks, enhance accessibility, and provide valuable insights to teachers. These methods have been slowly implemented and have been shown to be very efficient. However, a problem arises with too much accessibility and efficiency of AI within students, making many students motivated to use it as a tool to cheat. Neverthless, AI is groundbreaking technology. According to Techopedia, an informational website about technology, AI algorithms are designed to analyze vast amounts of data, and learn from it while making predictions. This technology has rapidly evolved in recent years, enabling the development of virtual assistants like Siri and Alexa, autonomous vehicles, advanced healthcare diagnostics, and much more. AI's potential to improve efficiency is great, but it also raises concerns, particularly in areas such as the ethical use of AI (Rouse, 2023). As AI becomes increasingly prevalent in our daily lives, it is crucial to understand its capabilities, challenges, and controversies.

In the context of education, AI has become a useful tool in the classrooms. According to an article by Pearson, AI-powered educational tools can provide personalized learning experiences tailored to each student's needs. Adaptive learning platforms are capable of adjusting content and pace to match a student's skill level, enhancing their educational experience (Ewart & Light, 2023).

However, despite the promise of AI, its implementation in schools has faced controversial restrictions. For example, concerns about the use of AI, particularly in chatbots, have led to bans in schools. For example, the New York City Department of Education banned the use of chatbots in schools (Yang & Musk, 2023). This ban, along with other instances of AI-related challenges in educational environments, have raised valid discussions about responsible use of AI in schools, highlighting the need for comprehensive regulations to ensure that AI enhances the educational experience.

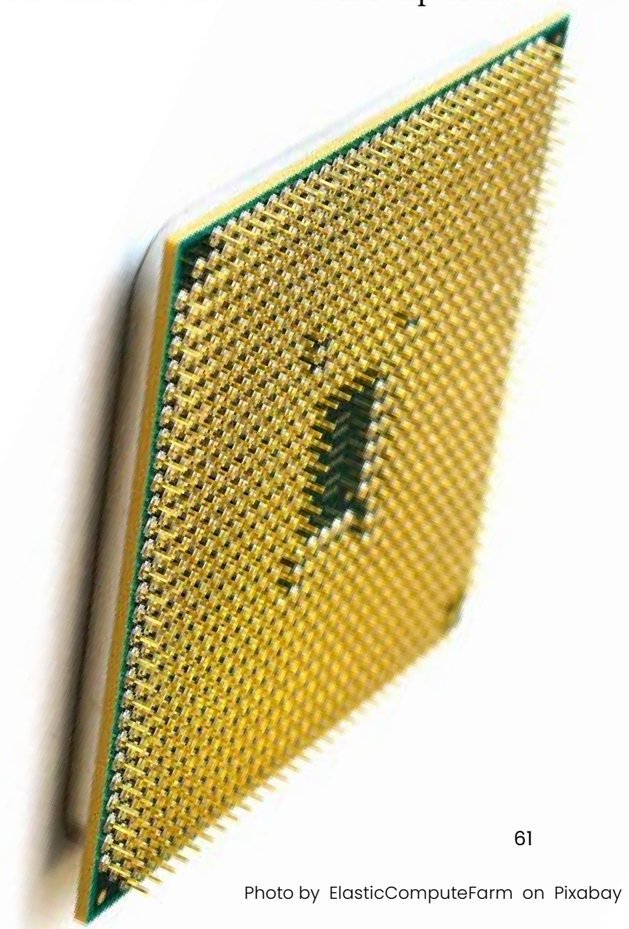


Photo by ElasticComputeFarm on Pixabay

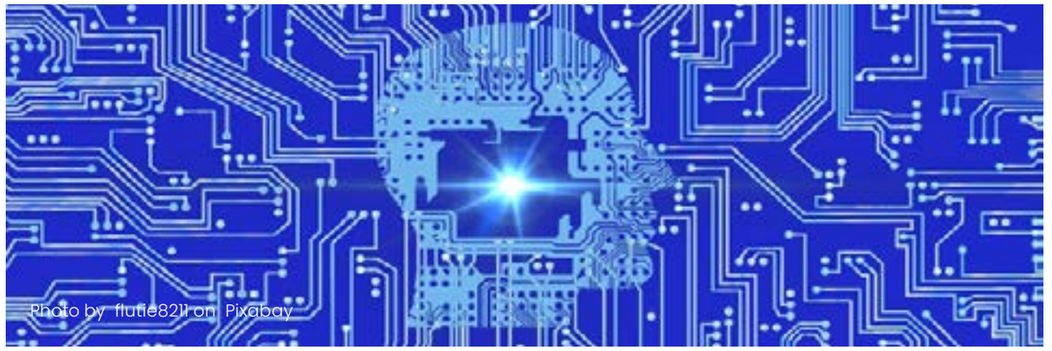
The Economic Times says that AI further increases the involvement of personal information, thus contributing to more and more cases of data breaches, posing a huge privacy risk. (“AI and Privacy”, 2023). This stresses the importance of transparency and accountability in the use of AI in schools. This perspective recognizes the potential of AI as a tool for personalized learning but calls for the need for regulations to ensure that AI benefits students while protecting their rights and data.

Additionally, while AI-powered tools can help students in research and coursework, they can also be misused for plagiarism and cheating. A recent survey of 1,000 students at colleges by Intelligent.com found that 30% of college students have used ChatGPT on written assignments (“As AI”, 2023). This statistic emphasizes the concern about the misuse of AI in educational contexts, where students currently resort to AI-generated content to gain an unfair advantage. As AI becomes more integrated into educational settings, it’s imperative to address these ethical concerns and establish clear guidelines. This helps ensure AI serves as a valuable educational tool while maintaining academic integrity.

Based on the current pros and cons, AI should be implemented in school settings as a tool, rather than banned entirely. By using AI responsibly, teachers can use its capabilities to provide tailored learning experiences for students. It can assist teachers by automating administrative tasks, allowing them to spend more time on personalized instruction. Additionally, AI can play a vital role in early intervention for students who need additional support, ensuring that no student is left behind (11 Ways, 2023).

By using AI responsibly, teachers can use its capabilities to provide tailored learning experiences for students. It can assist teachers by automating administrative tasks, allowing them to spend more time on personalized instruction.

In conclusion, this shows that AI has the potential to revolutionize



education by offering personalized learning experiences. While there are concerns regarding misuse and past implementation failures, it is essential to view AI as a tool to enhance education, rather than a cheating tool. With proper guidelines, AI can be a valuable resource in school settings, helping educators provide better learning experiences for students.

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11 Ways Artificial Intelligence is Transforming Digital Learning.

more than are efficient. As a result, a process called synaptic pruning is essential for healthy brain development and function. Microglia can engulf synapses, thereby contributing to synaptic pruning (Ji et al., 2013). Aside from participating in brain development, microglia also maintain brain health (Guy-Evans, 2021). When signaled, microglia move to areas of injury or disease to clear dead cells, pathogens, and harmful waste.

Other recent studies have shown that glial cells may be involved in chronic pain. When pain signals travel from the body, or the peripheral nervous system, to the brain, or the central nervous system, glia regulate the intensity and duration of the pain (Dobbs, 2021). When this process goes awry, glia may cause neuroinflammation and prompt nerve cells into sending never-ending pain signals. Microglial, astrocyte, and satellite cell activity have all been found to contribute to chronic pain, but researchers are not yet sure where and why glial functioning goes wrong. The involvement of glial cells would explain why current painkillers aren't effective: they only target neurons. Previously, researchers had struggled to find the biological basis of chronic pain, but now that they've identified glial cells as the issue, there's more direction for finding a solution. Despite this progress, treatment for chronic pain may still be a while away. Glia perform a range of functions and are so vital for other processes in the nervous system that trying to simply incapacitate them would cause more harm than good.

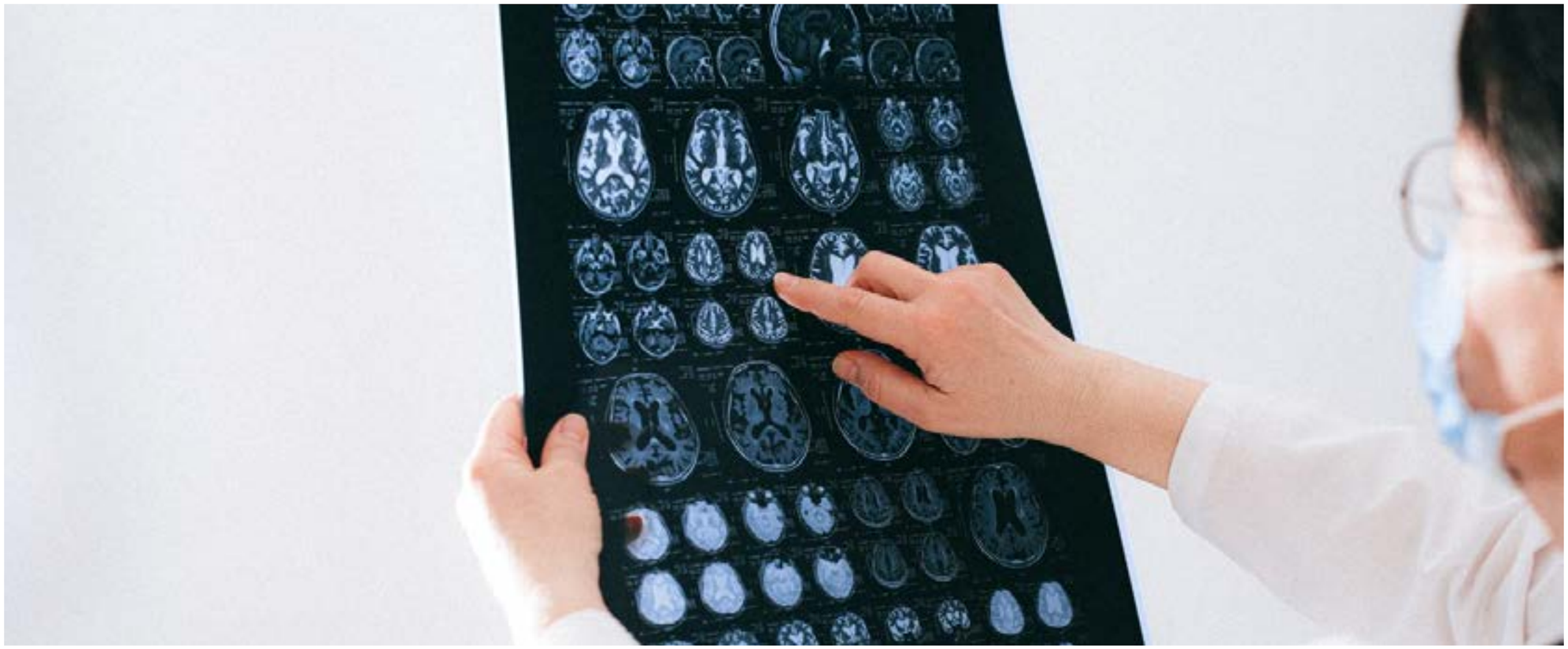

Photo by Anna Shvets on Pexels

As new discoveries are made, there has been increasing interest in the function of glial cells. Glia are not only vital in the development and maintenance of the brain, but have also been proven active in neuronal communication. Links between glia and certain neurodegenerative diseases plus the chronic pain issue open up new paths for potential treatments. This research, though, may progress slowly. As National Institutes of Health researcher Dr Doug Fields put it, "neuroscientists have studied neurons for over a century, but they are playing catch-up with glia" (Dobbs, 2021).

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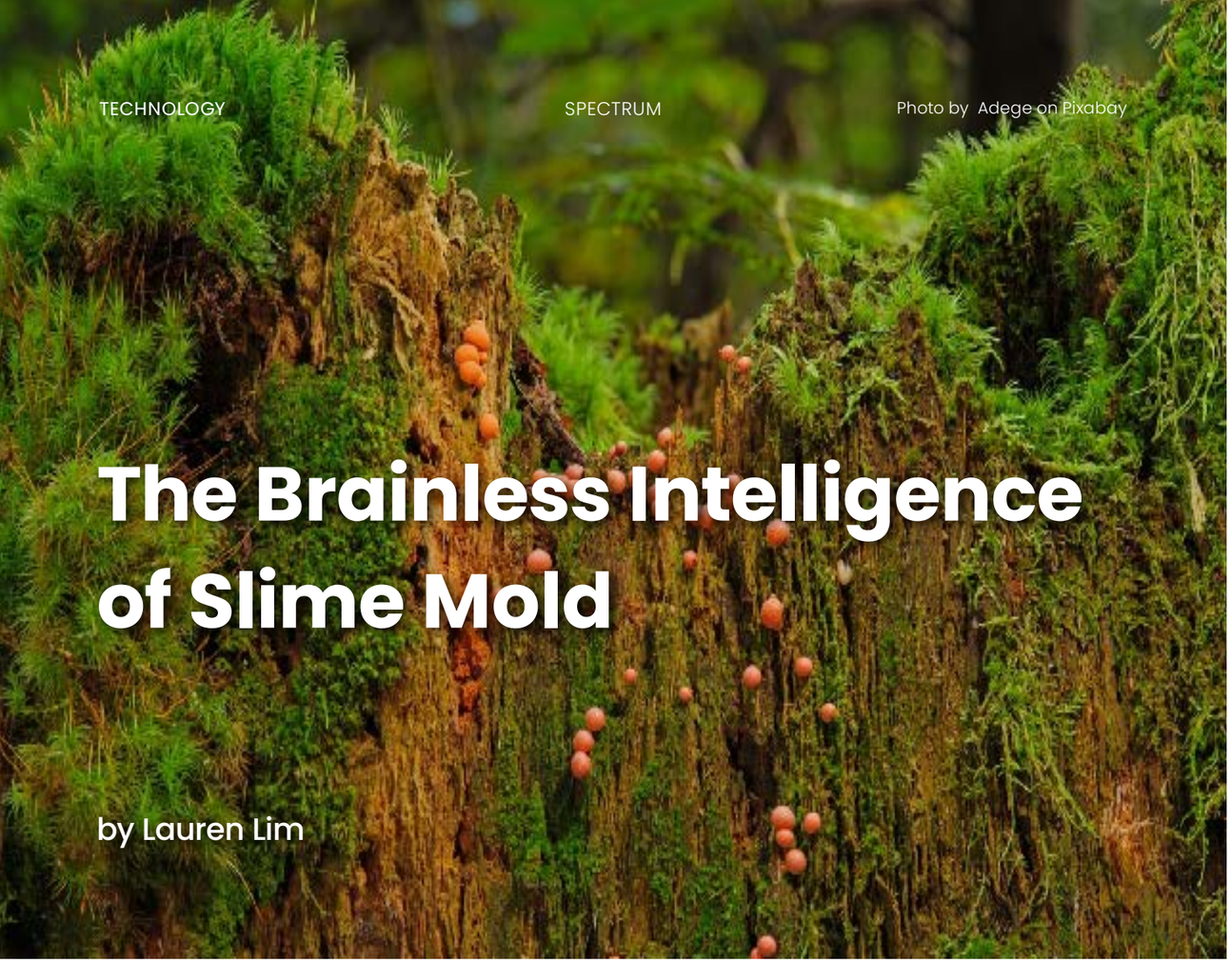

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The Brainless Intelligence of Slime Mold

by Lauren Lim

Slime molds are mysterious and easily misunderstood organisms. For one thing, it's not mold—it's not even in the same taxonomic kingdom as mold (Jabr, 2012). Slime molds are typically found in damp forest environments and are often easy to spot with their bright colors and odd formation. Some of the over 900 species of slime molds even have strange names—take wolf's milk or carnival candy, for example. Slime molds also don't have brains, so one might think they operate quite simply. In reality, slime molds are uniquely intelligent. We typically think of cells as microscopic, but slime molds are one of the exceptions to this, and really they defy most of our expectations of a cell. Slime molds are unicellular organisms that don't fall under the categories of animal, plant, or fungus, leaving them in the kingdom Protista. The term "slime mold" is also a sort of umbrella term, but the most well known types of slime molds are myxomycetes (The Editors of Encyclopaedia Britannica, 1998).

These slime molds have two main phases: plasmodial and fruiting.

In the plasmodial phase, slime molds are essentially large blobs of cytoplasm with thousands of nuclei. The reason this is still unicellular is because the entire thing is bound by only one cell membrane, and this giant cell is called a plasmodium. Plasmodiums grow and look for food as they 'ooze' around amorphously; they could spread thinly across a surface or collect into one distinct path. When reproducing, the plasmodiums form sporangia, which in turn produce spores. Like fungi, the spores release new cells. Called swarm cells, they have external flagella to help them move around and eventually form plasmodiums again.

The most recognized and studied species of slime mold is probably Physarum polycephalum, a type of myxomycete. Easily recognizable with its bright yellow web of veins, Physarum has been studied for its intelligence. Without any human sensory organs, slime molds can smell food (Greenberg, 2020). Similar to receptors that animals have in their noses, slime molds have receptors for odors along their membranes. When researchers placed slime mold in a maze with oat flakes at the beginning and end, the slime mold could branch out and find its way to the food.

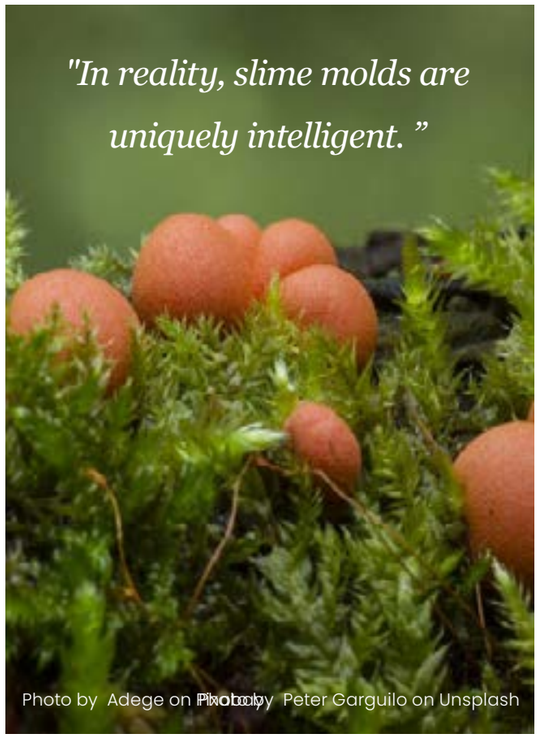
More significantly, the slime mold would eventually shrink back from dead ends until it only connects the two pieces of food, essentially finding the fastest path through the maze. Slime mold's navigational skills don't end here. Even without a brain, slime molds can "remember" where they've been in order to most efficiently move through or search their environments (Greenberg, 2020). By leaving a trail of slime, Physarum can track where it has been, creating a sort of "externalized spatial memory" (Reid et al., 2012). While this and other strange findings about

Photo by Adege on Pixabay

slime molds invite further exploration, the experiment with Physarum that spotlights slime mold's potential regards the Tokyo subway system.

When researchers at Hokkaido University placed oat flakes in the arrangement of Tokyo's subway stations and let a slime mold look for food, it spread out in search as expected. The impressive part is how, after finding its food sources, the slime mold retracted any extraneous webs and thickened the veins that led to pieces of food (Nast, 2010). The resulting network was uncannily similar to the actual Tokyo subway paths. Like humans, slime molds identify the most efficient paths, resulting in very similar results. Similar experiments have been repeated with European and Canadian transportation networks, and each time the slime molds were able to recreate the human-engineered pathways.

Researchers still don't know much about slime molds, but they've already discovered a variety of ways that slime molds are mysteriously smart. Physarum polycephalum introduces how unicellular organisms could have very complex and even intelligent behaviors. This invites research into not only slime molds but also other seemingly simple forms of life that might have something to teach us.



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Mixed Reality and the Future of Personal Technology

by Marcus Chin

Photo by Martin Sanchez on Unsplash

Mixed Reality. Another new buzzword used by tech companies, yet the technology seems promising. With the Apple Vision Pro releasing next year and the Meta Quest 3 launching recently, perhaps the future of "Ready Player One" isn't far from now.

For some context, Mixed Reality or MR is a term used to describe the use of virtual reality (VR) or augmented reality (AR) technology to merge the real world and the virtual world. Imagine seeing your friends standing in your room, even though they are thousands of miles away from you. Imagine watching movies in your home theater, even if you don't have a TV. Many of these childhood fantasies of hologram-like technology can become a reality with the promises made by companies pursuing the dream of mixed reality.

On the surface, mixed reality seems like the next global phenomenon. Headsets could replace phones, leaving us with infinite possibilities for entertainment, productivity, socializing, and more. But in reality, there are still many issues with immersive headsets, even with Apple's flagship mixed-reality headset launching in just a few months.

For one, tech companies have to come face-to-face with the current culture surrounding technology. Nowadays, everyone has phones - even young kids. These devices do everything for us, and we rarely need anything more. The only exception to this is desktop computers or laptops for productivity, intense gaming, and other similar activities. Breaking the norm is always hard, especially since asking people to strap computers to their faces brings several privacy and safety concerns.

Another major issue is the cost of producing high-quality mixed-reality headsets. To provide a truly immersive experience, a general consumer may need to spend around 4000 USD. Cheaper headsets like the Meta Quest 3 for 600 USD simply do not offer the same experience as headsets like the Apple Vision Pro, with distortion and low frame rates breaking immersion. The price needs to be lowered significantly to attract general consumers, which is an issue in itself due to various economic factors including inflation as well as the rising price of technology as a whole.

Finally, an indistinguishable virtual world cannot be realized yet without technology from the future. Although we have come extremely far since the early days of virtual reality, headsets do not have the technology to fully create the illusion of seeing the real world or the virtual world with our own eyes. Furthermore, the lack of realistic haptic controllers also restricts the possibilities of VR experiences, and omnidirectional treadmills have yet to go mainstream in mixed reality products. Without significant advancements in mixed reality technology, the experiences will not likely justify any price tag that a regular consumer would pay.

Even though there are several barriers to success for mixed reality, I still believe that soon, we will begin to see mixed reality headsets in many households across the world. The question remains of whether or not this is the right direction for technological advancements. Do we want to strap thousand-dollar devices to our heads all day? Perhaps we need to be cautious of the invasiveness of personal technology today. Only time will tell what will come of the new field of immersive technology.

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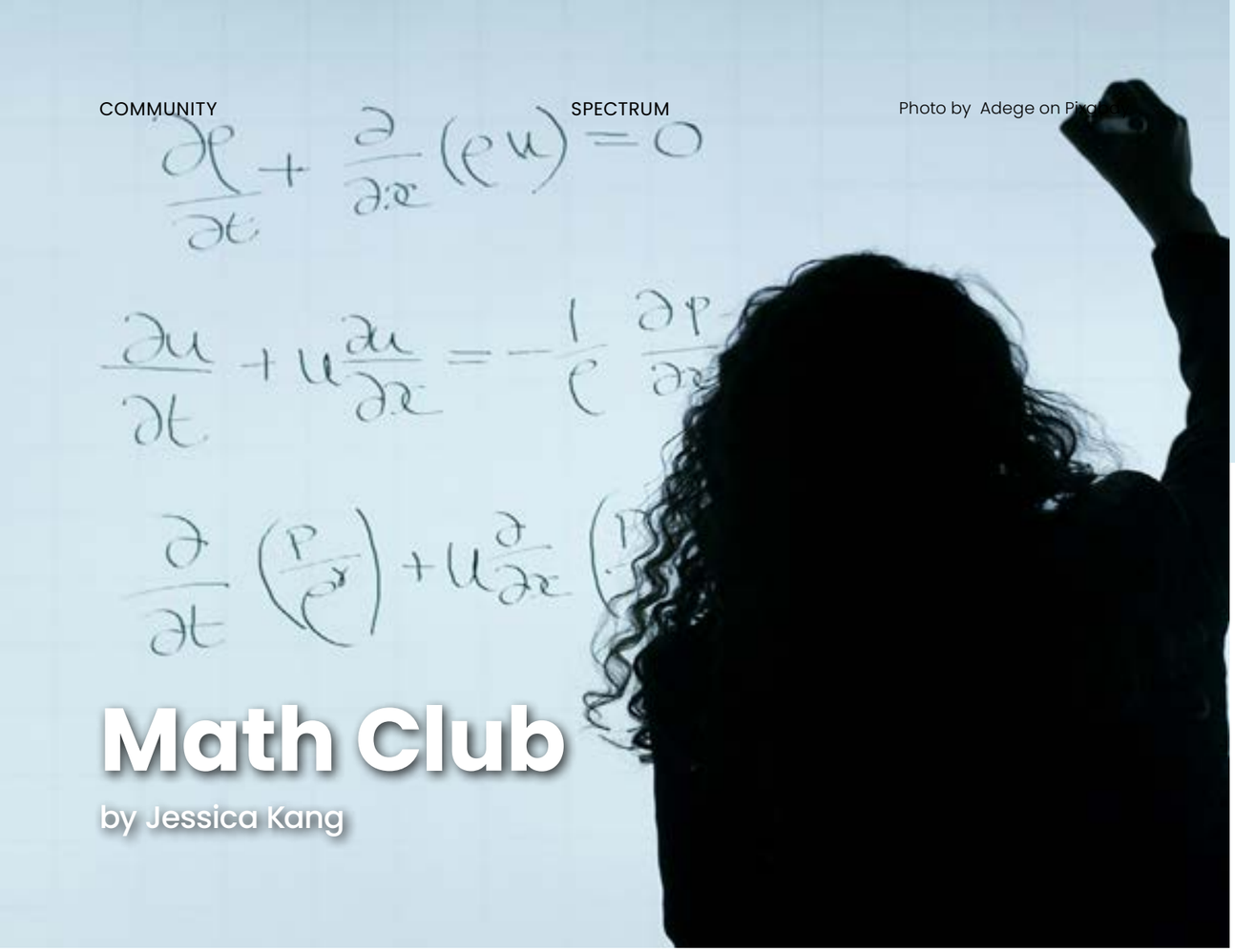
Community



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Math Club

by Jessica Kang

This year, the Math Club embarked on a venture to shake up our meeting dynamics, introducing mind-bending math puzzles and engaging mathematical debates! The puzzles have quickly become a favorite among our members, developing into a cornerstone of our meetings. Alongside dynamic presentations covering everything from logic statements to the intricacies of "sameness" in topology, we've continued to organize our themed competition series. During these events, students challenge themselves, racing against time to solve as many problems as they can accurately. Looking ahead, this semester will culminate in the Math Club's annual retreat, a cherished tradition where we come together to celebrate our mathematical community and create lasting memories!

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Science Club Presents... the First-ever Science Fair!

by Jessica Kang

Science Club came together with the shared goal of engaging more students and fostering a passion for science in SAS. This semester, the Science Club is holding the first-ever science fair.

In light of global environmental challenges, our focus this semester is on sustainability. We are calling aspiring scientists to participate by submitting their projects, research papers, or video demonstrations in one of three categories: Biology, Chemistry, or Physics.

After a careful evaluation of our high school faculties, winners in each category will not only earn recognition but also receive prizes in the form of $20 - $50 gift vouchers. (Don't worry – even if you don't secure the top prize, every participant will receive a Certificate of Participation!) For more details and submission guidelines, please visit our website.

We can't wait to see your brilliant ideas in action!

Photo by Mikhail on Unsplash

EHC, Introducing SAS Hacking Club

by Akshay Agarwal

Hacking. Words and numbers on a screen that get you what you want and into places you want to be. Have you ever wanted to uncover and understand the inner-workings of this intricate art in your favorite movies?

Well...welcome to EHC, SAS's ethical hacking club!

Every Monday lunch, we'll be learning about everything related to cybersecurity and hacking—ethically of course!

You'll be able to participate in weekly in-school challenges (known as CTFs), compete in international competitions with prize funds, and through webinars, even ask professional ethical hackers about their experiences.

And the best part is...you need no prior experience in anything STEM related—not even coding! So, if you want to get introduced to the amazing world of STEM, this club will be an extremely fun and insightful opportunity!

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