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Contents

ANXIETY AND EVOLUTION

By Dorrie Peters

As this semester reaches a peak, many students will begin to experience heightened anxiety revolving around coursework, college applications, and social events. According to the National Institutes of Health, roughly one-third of teenagers suffer from a serious anxiety disorder and many more develop various symptoms of anxiety from daily stressors. Given that humans are so closely related to other members of the animal kingdom, it would seem natural that other organisms on earth experience similar mental inflictions to humans. While they may never encounter the struggles of high school, wild animals face their own unique stressors such as escaping predators or scavenging for sustenance. But where does anxiety come from, and why does it afflict humans in such primitive ways? The answer lies in the evolution of the limbic system.

The Limbic System

To understand the mystery of anxiety in humans, it is essential to first locate where anxiety resides in the brain. While severe anxiety can affect nearly every corner of the body, its main home is in the limbic system, which is a combination of regions in the brain that monitors all emotional and behavioral responses. Though definitions of the limbic system vary, many neurology professionals agree that it consists of five core areas: the cingulate gyrus, the thalamus, the hypothalamus, the amygdala, and the hippocampus. Most animals have some kind of limbic system, although not all are as developed as that of the human brain.

For example, the limbic systems in dogs are very closely related to our own, alluding that dogs experience emotions in similar ways to humans. On the other hand, the limbic systems in amphibians such as frogs are arranged in a completely different manner. So, while modern technology does not allow scientists to examine the thoughts and feelings of another species, the drastic contrast in the layout of a frog's limbic system implies that they process fear and emotion differently than humans.

The Amygdala and Anxiety

Individuals with anxiety disorders experience heightened activity in the limbic system when the brain perceives a social threat. This causes the amygdala, the node in the brain that is in charge of processing fear and emotion, to become hypersensitive and disregard certain limits within the body. For example, many people develop shortness of breath or rapid heart rate during periods of anxiety. These symptoms arise because the amygdala overestimates the severity of a threat.

Evolution

The common symptoms of anxiety in humans — hyperventilation, increased heart rate, and sweat — may be a nuisance, but they stem from an important survival mechanism that was passed down through evolution. The same manifestations of anxiety that plague humans are remarkably useful to animals in the wild. When faced with the threat of a predator, these responses from the amygdala are designed to aid an animal in escape. Quick breathing, bursts of adrenaline, and a racing heartbeat are all useful tools that increase efficiency and speed. Due to natural selection — an evolutionary process also known as "survival of the fittest" - organisms with highly reactive amygdala responses lived to pass on this trait, eventually transferring it to humans.

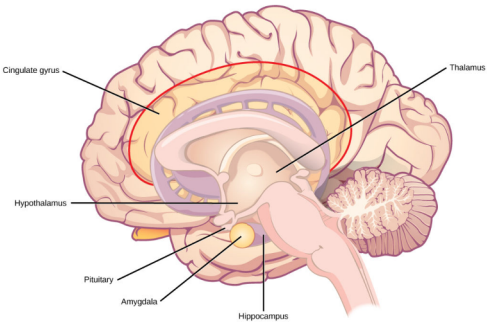


Diagram of the various parts of the human limbic system

Source: *Lumen Learning Biology for Majors II*

Conclusion

When one looks at the limbic system, it becomes evident that anxiety in humans is a lingering effect of evolution and survival of the fittest. Given that humans have progressed beyond daily threats of hunting and being hunted, the fear responses produced by the brain seem outdated and bothersome. While these biological responses may have been useful for the survival of our wild ancestors, they are usually a burden to us. Modern-day humans face their challenges in a different way, so while there may not be the need to run from predators or hunt for food, the stress of high school is a wilderness of its own.

Prey evading a predator using responses from the amygdala

Source: *Digital Safari, CGTN*

PRESCRIPTION FIRES

A Look into Protecting the World's Largest Trees

By Bhavyaa Chauhan

Wildfires have been a hot topic in the mainstream media in the past decade. Forests, specifically those in California, have been prone to intense wildfires, creating threats to biodiversity and the climate. The giant Californian native, is no stranger to fires. In its 2,200 years of life, it has been exposed to over 100 prescribed burns. Prescribed burns are controlled fires that are planned out by scientists to help trees build resistance and, for sequoias, better reproduction. Even though this year's fires making their way across the Sierra Nevada serve serious threats, The General Sherman and its grove is protected with prescribed fires since the 1960s. Luckily, The General Sherman, the largest tree in the world, has been protected with "a fireproof blanket".

THE KNP COMPLEX: A POSSIBLE THREAT TO SEQUOIAS

The KNP (Kings Canyon National Park) complex fire is one of four active fires currently burning in the southern Sierra Nevada which is a mountain range on the west coast that contains the majority of the world's Sequoias. These fires were caused by a lightning storm, and so far, they have burned over 28,421 acres of land.

The closest flames to the Giant Forest were only a mile away. However, the Giant Forest is well prepared to withstand any fires that come its way. The main problem that creates a threat to the forest is the damage that can happen to the foliage of the trees. Sequoias have thick bark that can buffer high intensity fires, however, the intensity of the KNP complex and the warming climate could mean hotter and taller fires that the trees are not prepared to withstand. Taller fires could mean that the Sequoias' foliage, hundreds of feet above the ground, could burn and cause severe damage to the tree's main hydraulic system, causing the tree to die. Fortunately, scientists have quickly recognized this imminent threat and raked away any debris close to the border of the grove. The debris could catch on fire and create an even more intense fire. The fire has so far only had minor contact with 4 of the Sequoias from the Giant grove.

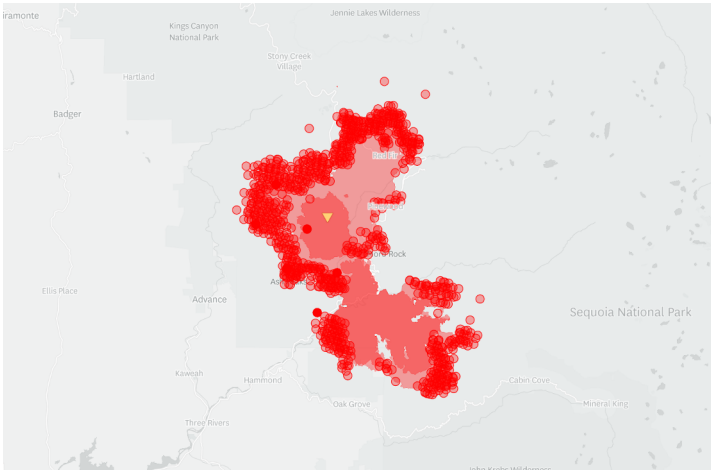


Figure 1. The red dots indicate hotspot perimeters of wildfires.

Source: *San Francisco Chronicle: California Fire Map & Tracker*

SHOULD WE BE WORRIED?

At first glance, it seems that the Sequoia groves are well protected and do not need much attention. But, the real threat lies for groves other than the Giant Forest which are not well prepared to handle fires and are in remote areas that are difficult to access. These trees are surrounded by smaller trees that have had no controlled fires or treatments over the years. Since the smaller trees block the sequoia groves, scientists have a difficult time reaching the sequoias to conduct controlled fires. If the smaller unprescribed trees catch on fire, there is a better chance that the flames could spread to the Sequoias faster.

HISTORY OF FIRE AND PRESCRIBED BURNING.

Fires behave differently now than they did a few hundred years ago. Due to the warming of the climate and human caused fires,

wildfires have become much more aggressive. Before the West was colonized, Native Americans used fire to manage and shape landscapes. In fact, "prescribed burning" originated from Indigenous tribes. The regular fires kept the forest healthy and allowed Sequoias to produce seeds faster. Prescribed burning was done by tribes like the Yurok, Karuk and Hoopa Tribes of Northern California in order to have richer harvests and support life cycles of the trees. When you have a prescribed fire, it helps make the trunks of trees more resistant to fire and assists in delivering more nutrients to the canopy of the trees. However, the white settlers from the East completely misunderstood the practice, and by the 1900s, there were laws put in place that ordered all and any fires to be terminated. Additionally, logging practices created more debris making the forest more prone to wildfires. Charcoal remnants in tree rings tell scientists about the progression of fire frequency. These suppression rules primed forests for intense wildfires that could've been prevented if they allowed prescribed burns. These laws eventually changed and allied wildlife scientists to conduct prescribed fires and help save many of our world's largest trees including the Sequoia.

DRYING OUT OF THE WEST

California has been one of the largest victims to historic drought and extremely dry climates. Climate change is only speeding up the process between droughts in California. Furthermore, wildfires and human activity combined are creating a disproportionate amount of greenhouse gases, which are the driving force behind climate change. If rapid intense wildfires continue through the West coast, it could mean the extinction of several plant and animal species—including the Sequoia. As of now, scientists have done everything possible to protect and care for General Sherman, but as wildfires are increasing, it can become harder to protect these giant trees.

Wildland firefighters creating a controlled fire line in a mixed conifer forest

NPS/Anthony Caprio

A tree set ablaze

Source: *Noah Berger/Los Angeles Times*

THE NEW UBER?

By Avyay Duggirala

Uber and other rideshare companies have become immensely popular in the last couple of years. But, regardless of whether you are getting in an Uber or even driving yourself, one problem still exists - traffic. However with the new technology created by JOBY(a partner of NASA), Air Taxis, which would take travel to new heights, might become a reality. NASA recently tested these all-electric Air Taxis in flight and they flew more than 150 miles successfully, meaning that they can move on to the next stage of testing and eventually be rated for customer use.

This air taxi, which is essentially a crossover of a car and helicopter, was created by a company

WHAT IS IT?

named JOBY, who recently partnered with NASA due to their groundbreaking work with electric flight projects. Their goal is to create a safe, efficient, and non-polluting form of air transportation that is accessible to everyone. They recently finished their prototype and have just started to test it out. So far, the taxi has been very successful and flew more than 70 miles.

As for how this plans to work, NASA's AAM (Advanced Air Mobility Project) has shared an outline. Their initial goal, once this "air taxi" passes all protocols, is to create a network of aircrafts to transfer cargo. This network will be used for NASA to monitor the safety and efficiency of these aircraft. Then, once deemed safe enough, these planes will also be integrated into an Uber-like network. JOBY and NASA's long-term plan is to create a rideshare system like Uber and Lyft to the final goal of actually moving people, diminishing the effect of traffic on users of this system.

FUTURE IMPACTS

An innovation of this magnitude will lead to massive changes to the way society views transportation. People will no longer have to worry about things like traffic, as they can take the bus, walk, drive or even fly. The Air Taxi can also become a major industry similar to that created by current ride-share companies, which would open up hundreds of potential job opportunities. This also means that we are closer than ever to potentially having flying cars or maybe even things like floating roads by using the same technology like that from the Air Taxis. Finally, we can use the zero-emission lithium batteries used by these Air-Taxis to power other forms of transportation and reduce our ecological footprint.

CONCLUSION

The future is closer than we think, and with amazing ideas and inventions like these, we learn more than we have ever known. The technology used is a result of hard work and dedication and will lead to hundreds of job opportunities and a cleaner and faster form of transportation. The Air Taxi is set to start its taxi service sometime around 2024, so look to the sky, as it may soon be filled with Air Taxis.

CHANGING SOCIETY

How Robots Can Encourage Inclusivity

By Anisha Kolambe

As the world continues to advance itself, technology becomes even more ingrained into the lifestyles of everyday people. Robots are no exception, especially considering their vast influence in working environments within a short time frame. Usually when robots are thought about in the context of the labor market, they are associated with causing unpredictability (V. Briciu and A. Briciu, 2020, p.1), creating conclusions about their potential in eliminating careers and excluding communities from having access to equitable resources. However, the impact of robots and artificial intelligence is largely dependent on the method of its implementation. Rather than employing robots as a replacement for human workers, another unique approach being explored is a robot's ability to assist its human counterpart. Teleoperation consists of remotely controlling a robot to perform tasks, enabling the possibility of 'avatar work' that allows for an individual to express themself by using the robot as a representation of their own personality and interests. Through the adoption of AI to create unique tracking systems for individuals to operate the robot, people with limited movement due to age, congenital conditions, or other factors can still make valuable contributions to society.

Integration

Ory Laboratories is a robotics startup company located in Japan that aims to reduce the negative emotions resulting from social isolation. Opening up a two week avatar cafe called "Cafe Dawn", the company evaluated the performance of its robots OriHime and OriHime-D in communicating with customers and creating a comfortable ambience. Working as waiters, the individuals operating these robots had conditions such as ALS, AVM, SMA, spinal/cervical cord injuries, and other disorders that largely constrained their overall movement (Takeuchi et al., 2020, p. 4). Due to their unique physical capabilities, individuals had a vast range of methods to input responses for the application controlling their respective avatars, including mouse (hands), mouse (jaw), and a gaze input device that was utilized for the analog keyboard of the communication software called OriHime eye. ALS operators also used the speech synthesis function to talk with customers.

In order to measure the influence of avatar work on the mental state of both waiters and customers, several questionnaires were administered to both groups throughout the duration of the experimental study. Figure 1 displays the data collected of the prior acquaintance 700 diners had with the disabled population, allowing for multiple responses (Takeuchi et al., 2020, p. 4). Only 6 percent of people had no experience at all, showing the widespread potential of telepresence in everyday life. A second survey was conducted to record how operators of OriHime-D were impacted by the change in lifestyle in terms of mood, fatigue, and mental fulfillness (Figure 2). The work completed usually also sparked an increase in mood and fullness values, while maintaining or decreasing the same value of fatigue. OriHime robots were successful in the integration of a population that would otherwise be excluded from the daily workings of society due to factors outside of their control. Furthermore, the customer response to the concept of the cafe was enthusiastic and supportive in nature. The work that teleoperators completed was thus both rewarding to self and useful in its overall benefits to society.

Effects

OriHime robots allow access to a previously untapped workforce, advancing equity by providing fairer access to resources and opportunities. Yuki Aki, the COO and cofounder of Ory Laboratories explains, "One man using it said he was able to earn money for the first time in his life, and decided to buy clothes for his mother, who cares for him because he cannot work" (Brandvoice, 2020). Avatar robots are also being deployed outside of the cafe setting, partly encouraged by implications in the physically distanced setting of COVID-19. Employees now have the option to attend office conferences as an avatar while students can use OriHime in physical classes if confined to a virtual setting. OriHime

robots have also been greeting visitors at hotels and other reception areas to decrease risks of exposure. Additionally, OriHime and other avatar robots show possible potential in influencing a redefined lifestyle even beyond COVID-19. Not only do the robots encourage collaboration, they also allow for greater flexibility and self-reliance. Robots can be utilized within nursing homes or with the elderly to provide independent care and promote a safer environment. Difficulties in commute or the rise of unexpected circumstances would no longer hinder ability to participate in the office working environment and the robots would make it possible to meet with clients and businesses from other locations without the need for travel. Overall, OriHime provides a versatile style of communication that accounts for multiple perspectives and abilities without discrimination, advancing humanity's ideals and progress in creating an open and equitable society.

Conclusion

In finding a solution to loneliness and solitude, OriHime concurrently tackles deep rooted issues within the modern world that may inherently contribute to forms of unconscious prejudice within societal structure. By creating new methods of communication across multiple communities and minorities, avatar robots account for an expanded range in which individuals can collaborate and contribute on a larger scale to advance opportunities and resources for everyone, regardless of background or physical characteristics. OriHime and other similar projects pave the way for a future in which humans and robots can unite in advancing the entirety of our world's condition.

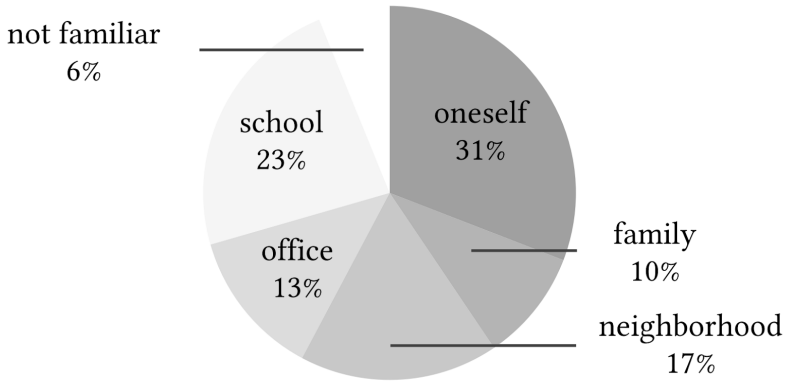


Figure 1

Statistics showing the familiarity customers had with people with disabilities within their community. Source: OryLab

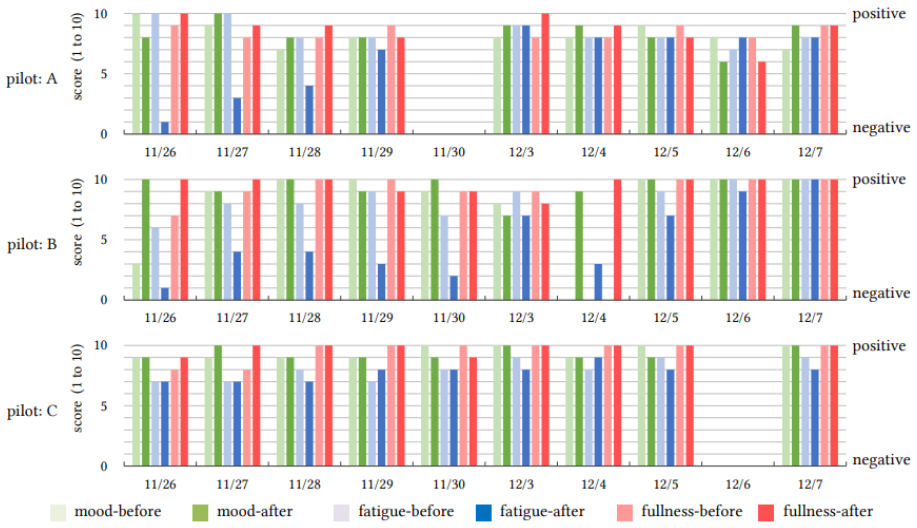


Figure 2

Responses from operators about their feelings before and after their working schedules.

Source: *OryLab*

THE RARE AND ELUSIVE SPIRIT BEAR

By Aleksandar Simeunovic

Deep in the forests of Canada, along the rainy coasts of British Columbia, two bear cubs play in the shallow waters of a river. One is as white as a Christmas morning, the other as black as a midnight sky. The striking difference in appearance may lead some to believe that the well-known polar bear has begun to migrate south, but this bear is no polar bear. In fact, the two cubs are related, sharing the same set of parents. Both are black bears, while the white specimen is called a Kermode Bear (Ursus Americanus Kermodei). But, what is the story behind this unique difference and how did it come to be?

The Rainforest's Very Own

Hugging the southern edges of Canada's west coast lies the Great Bear Rainforest. Contrasting with the more commonly known Rainforests of South America, Central Africa, and Southeast Asia, the rainforests of the Pacific Northwest are much cooler and even receive quite a bit of snow during the colder months of the year. The trees that make up the tall treeline are some of the biggest in the world, some even spanning several meters in width and hundreds in height. To add a beautiful backdrop to the striking combination of ocean and rainforest loom towering mountains. Combined, all three of these views paint the perfect picture for one of the rarest varieties of bear in the entire world. The Great Bear Rainforest is the only location across the entire globe that Kermode Bears, also known as spirit bears, call home. The dark green of the forest contrasts sharply with the bright white of the bear, giving it an eerie and looming presence to those that come across it. This mysterious appearance led to the coining of its most used title; the spirit bear.

A Ghostly Mutation

Many who see the bear make two false assumptions regarding its fur color...

They assume that it is a Polar Bear. (Ursus Maritimus)

They assume that it is albino.

Both of these assumptions are, in fact, incorrect. The kermode bear scientifically identifies as a black bear. Its northern cousin, the Polar bear, is much larger and can be up to five times heavier. Polar bears also differ significantly from black bears in that they are carnivorous, while black bears are omnivorous due to having a diet consisting of many berries alongside meat.

Contrary to popular belief, the kermode bear is not actually albino. Albinism is caused by a lack of pigment, and specimens lack color in all areas of their body, not just their fur color.

Pink eyes and mouths, both common traits in albino species, are not found in Kermode bears. The white hue in their fur is actually caused by a recessive gene that is also found in humans. While this may come as a surprise, it is actually the same gene that causes red hair in humans, making kermode bears the redheads of the bear family.

A Shrinking World

We live in a world that possesses uncountable amounts of natural beauty, humanity continues to disregard this and exploit the natural world. Many human-caused problems have caused the spirit bear population to dwindle, the largest of which are fishing, forestry, and climate change. Overfishing as well as increased ocean temperatures have drastically decreased salmon populations in the Pacific Ocean, and, being the Kermode Bears' main source of food, consequently has hurt the populations of this rare bear species. The rivers of the Great Bear Rainforest normally contain about 80,000 salmon on a given day, but those same rivers have now decreased to about four to five thousand of vital fish. However, all hope is not lost for the bears, and efforts are being taken to fix the problems we, as humans, have caused.

The Kitasoo/XaiXais Nation has called the Great Bear Rainforest home for as long as they can remember. Having worshipped and fought to protect the spirit bear for hundreds of years, they essentially kept the species in complete secrecy in order to protect them from fur trappers and trophy hunters. This method worked, and the spirit bear remained relatively unharmed by hunting during a time where many North American species were being hunted at rates rarely seen before. However, the Kitasoo Nation's work was not yet done. They went on to become one of 27 Nations that negotiated with the Canadian government to conserve the rainforest and protect the species within. Their goal was finally achieved in February of 2016 when 85 percent of the land became officially protected by the government.

A Bright Future Ahead

The official protection of the Great Bear Rainforest has been a step in the right direction-- not just for species of western Canada, but of the entire animal kingdom. Leaders in other areas of the world can look to the story of the Spirit Bears' evasion of death and put its lessons into practice within their own countries. By preserving the rare genetic beauty found in these bears, we can help them thrive on this planet for years to come.

A mother Black Bear stands atop a rocky outcrop with her two cubs. The genetic mutation that causes the white appearance of Kermode Bears is not always passed on to both cubs, and it is quite common for some of the cubs to appear the usual black color while the others appear ghost-white.

Source: *timescolonist.org*

A Kermode Bear lounges near a river. Constant overfishing as well as increased ocean temperatures pose threats to the Spirit Bear's home.

Source: *Spirit Bear Lodge*

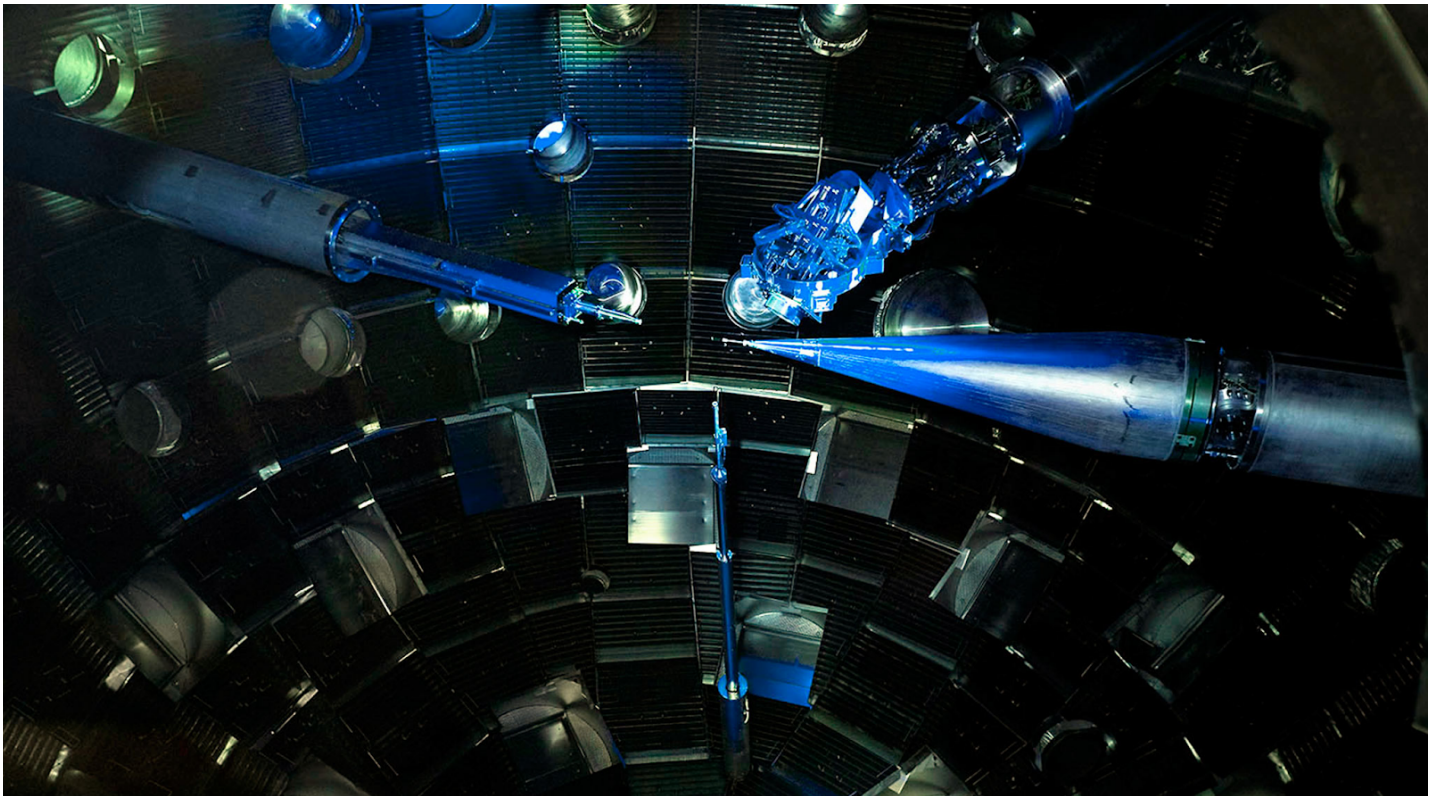


Figure 1: The NIF's lasers converge on a singular, minuscule point. Source: [Science.org]

HOW LASERS COULD SOLVE THE WORLD ENERGY CRISIS

By Colin Ward

On August 8th, an experiment by the National Ignition Facility made an astounding discovery in nuclear fusion when they came closer than ever before to "igniting" a nuclear fusion reaction, the very same reaction that powers our sun. Ignition is a term used when a fusion reaction yields more energy than is required to initiate it. This means that they are coming closer to providing a potentially monumental source of clean energy that might be able to solve the world's energy crisis.

The Conventional Method

Nuclear fusion is conventionally achieved through two main elements: temperatures six times hotter than the sun's core (despite being the very method of energy production for the sun), and an extreme amount of pressure. Fortunately, humans are able to recreate these conditions at the National Ignition Facility.

The National Ignition Facility (NIF) is: "the world's most precise and reproducible laser system. It precisely guides, amplifies, reflects, and focuses 192 powerful laser beams into a target about the size of a pencil eraser in a few billionths of a second, delivering more than 2 million joules of energy…" This facility, which is the size of three football fields, is a miracle of engineering in and of itself, as it is capable of heating its target to more than 180 million degrees Fahrenheit, an impressive feat.

By focusing the lasers of the NIF on a capsule less than five millimeters in diameter, the scientists were able to create a fusion reaction. This reaction, despite returning only 70% of the energy of the laser used to ignite it, actually created more energy than it absorbed, as some of the lasers' energy was lost during the ignition process, and not put into igniting the reaction.

The Unconventional Method

As previously mentioned, fusion is the very same process that the sun uses to power itself. But, given the required temperature (six times hotter than the sun's core), how is it possible for the sun to achieve this? The not so simple answer is "quantum tunneling."

The coulomb barrier is heavily involved in this process. This is the barrier that prevents protons lacking enough kinetic energy (in this case heat) from becoming attracted to one another. Given that these protons will nearly never cross this barrier on their own due to lack of energy in the sun , quantum tunneling is used to move them through the barrier, allowing them to become attracted to each other and begin a fusion reaction. Due to the uncertainty of the location of protons, on exceptionally rare occasions a proton will end up across the coulomb barrier without having the energy typically required to do so. This is called quantum tunneling, as it is as though the proton had tunneled directly through the coulomb barrier.

Given this abysmally low probability, this is not a feasible process of energy generation here on earth, but it occurs within the sun rather frequently due to the immense quantity of protons capable of quantum tunneling.

What Does This Mean for Renewable Energy?

Should it be properly achieved, fusion energy would be one of the best energy sources for the world, as it doesn't produce greenhouse gases or radioactive waste. This recent experiment produced eight times the amount of power as previous ones, potentially indicating more rapid progress towards fusion energy. Despite this, scientists believe large-scale fusion power to be a long way off, as laser plasma physicist Stuart Mangles stated, "There will be a huge amount of work needed to turn the technology into a viable source of energy."

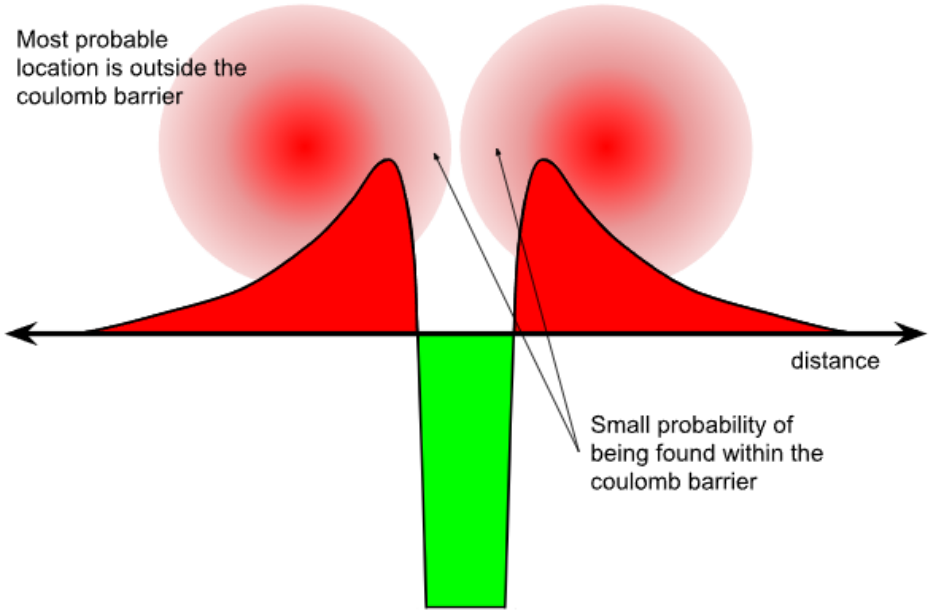


Figure 2: A representation of how the coulomb barrier works Source: [Mr. Toogood's Physics]

THE PHYSICS OF WATER WAKES

Written by: Gautham Anne

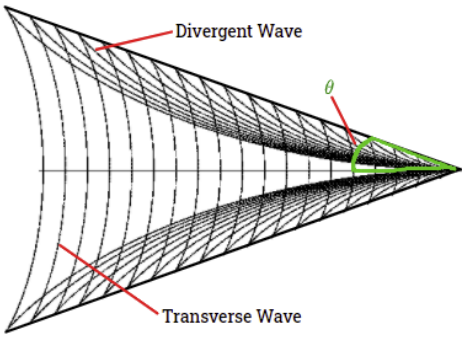
Figure 1

Source: Google

While watching boats travel by or a duck on a pond, one might wonder how the astonishing wake patterns emerge, such as the ones depicted in figure 1. One might also note that the wake patterns, regardless of whether it is being produced by a duck or even a cruise ship, all seem to have a similar shape. The famous physicist Lord Kelvin noticed an interesting fact about the wakes. Using rigorous mathematics, he determined in 1887 that the angle θ (Kelvin angle) that the wake fans out is always the same, regardless of the object and its speed, is approximately 19.47 degrees. In 1984, Frank S. Crawford, a professor of physics at the University of California at Berkeley, found θ using only elementary mathematics — specifically geometry and trigonometry. This article will attempt to present this solution as well as some controversies regarding the Kelvin angle.

Key Concepts and Vocabulary

In order to derive θ, first, one must learn the essential concepts and vocabulary in order to do so. There are two types of waves in a wake: transverse waves and divergent waves, as depicted in figure 2. However, the divergent waves are of more interest, since they are directly related to θ.



While light and sound waves propagate with the same velocity, and m/s respectively, the velocity of water waves depends on their wavelength. That is, the longer the wave, the faster it propagates. This is the fundamental reason why water wakes differ from other phenomena, such as a mach cone, which is the pressure wave produced by bodies moving faster than the speed of sound.

On what factors do the velocity of the waves depend upon? Certainly, the wavelength λ, the depth of the water H, surface tension σ, the gravitational force g, and the density of water ρ are all factors. However, it can be assumed that the water is sufficiently deep enough to not be a factor and since the surface tension only affects short waves, it is negligible.

The phase velocity is the velocity of the individual wave crests. Its equation is

$$v_\phi = \sqrt{(g\lambda/2pi)}$$

The group velocity is the velocity of the overall shape of the wake. From the expression of group velocity and the given expression of phase velocity, it can be determined that

$$v_g = v_{\phi/2}\,,$$

that is, the group velocity is ½ of the phase velocity. Using this relation, and the fact that water waves disperse, a geometric representation of the wake can be generated, such as the one in figure 3.

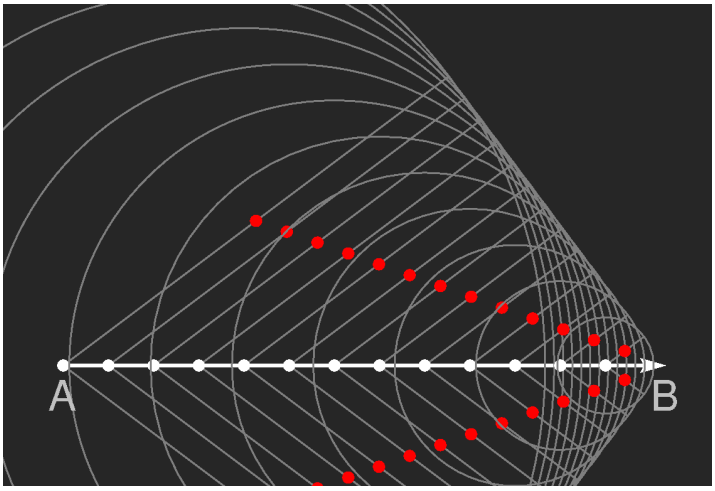


Figure 3

Geometric representation of a water wake, showing the individual propagating waves. The red dots represent the phase velocity and the shape of the wake. Boat located at point B.

Source: *University of Hannover in Germany*

Derivation of θ

If point B is the location of the object traveling across the body of water, then multiple constructions can be formed with point A representing the epicenter of all waves emitted from it, relative to point B. This is shown in figure 4, where each circle from point A represents a wave moving at phase velocities of 10, 20, 30 … 99.99 percent the speed of the object. Constructing tangent lines to each individual wave, joining them with point A, and representing where the waves are when the boat is at point B with the red dots as indicated in the figure, the sequence of red dots forms a circle with radius AB/4.

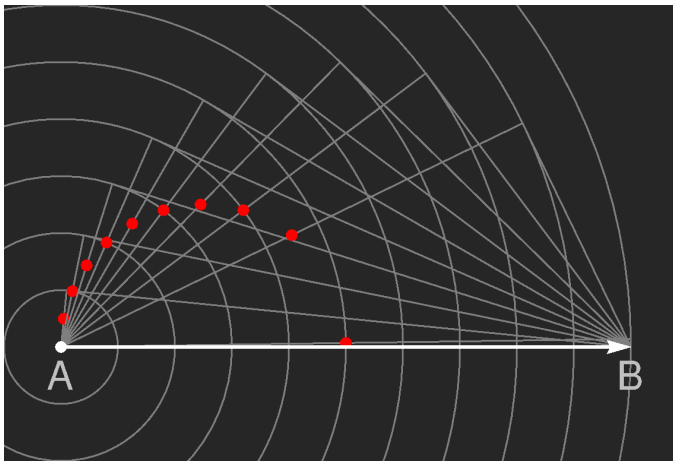


Figure 4

Source: University of Hannover in Germany

Constructing a tangent line to the red circle, as shown in figure 5, yields a right triangle with the side opposite to θ with length x, and the side along AB with length 3x. Using trigonometry, it can be shown that

$$\sin(\theta) = x/3x = 1/3 \implies$$
$$\theta = \arcsin(1/3) \approx 19.47°$$

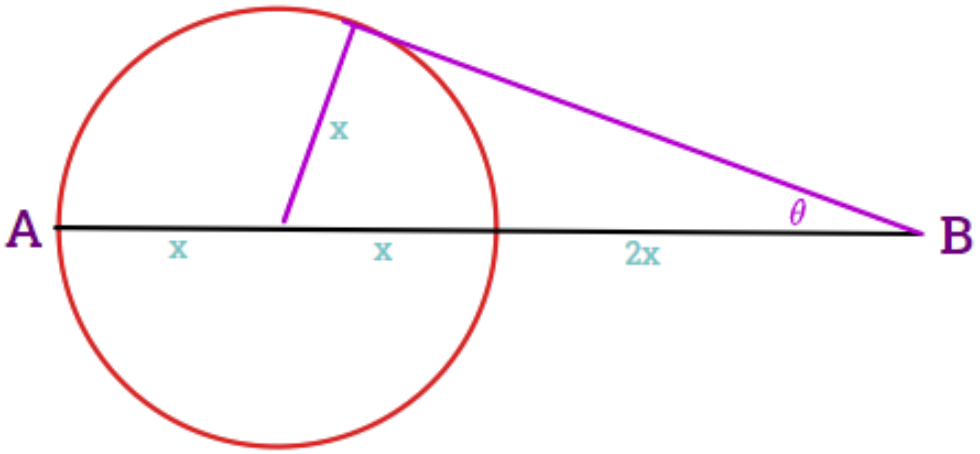


Figure 5

The Kelvin Wake Controversy

While looking at Google Earth images of ships, two French physicists Marc Rabaud and Frédéric Moisy, saw that some of the wake angles were not 19.47 degrees, that is, they did not conform to the prediction that Lord Kelvin made in 1887. Before their discovery, narrower wakes have been spotted, but scholars stated that they were due to unique circumstances such as shallow waters, turbulence, and more. Raubad and Moisy discovered that even without all of these circumstances, some ships still had smaller wake angles. They created new mathematical models to describe the narrower wakes through analyzing the images and making measurements of the hull lengths, wake angles, the velocities, and assuming that an object of length b cannot produce wavelengths greater than b. Their numerical simulations seem to suggest that at higher speeds, boats would produce smaller wake angles. Figure 6 shows the effect of higher speeds on the wake angle α. Fr represents the Froude number, which directly varies with respect to the velocity of the object.

Professor Simen Ellingsen of the Norwegian University of Science and Technology recently found the solution to the controversy. He proposed that the reason why boat wakes may be narrower than 19.7 degrees is due to a phenomenon called shear flow. Shear flow occurs when there are different currents in different layers of water, and Kelvin's theory on boat wakes would not be applicable. His idea worked in theory, and all the mathematics was proved correct. His research was published in the prestigious Journal of Fluid Mechanics, but there was no empirical evidence at the time of publication. 5 years later, the PhD candidate and a master's student that he was supervising were able to conduct experiments in a specially engineered tank, and the results backed up the theory. In fact, these results may have practical applications, such as reducing fuel consumption in ships. Much of the fuel is actually put into generating waves of the boat wake. If there were to exist a solution to minimize the wave production, it would revolutionize the fuel industry for ships.

Conclusion

While the mathematics of water waves is difficult in comparison to sound and light waves, due to the fact that they propagate with a velocity directly proportional to the wavelength, a beautiful phenomenon occurs as a result - the Kelvin wake. Professor Crawford showed that the Kelvin angle can be found through the use of elementary mathematics. Raubad and Moisy showed that at higher velocities, boats may create narrower wakes, but this was still highly debated. Professor Simen Ellingsen later showed that the reason some wakes may have smaller angles is due to shear flow. It is beautiful that the wakes of a duck and a boat may be the exact same shape, regardless of the size or velocity, and how physics and mathematics can help explain these amazing occurrences. The phenomenon exemplifies the elegance of the natural world, as well as having many practical applications, such as reducing fuel consumption and consequently, emissions.

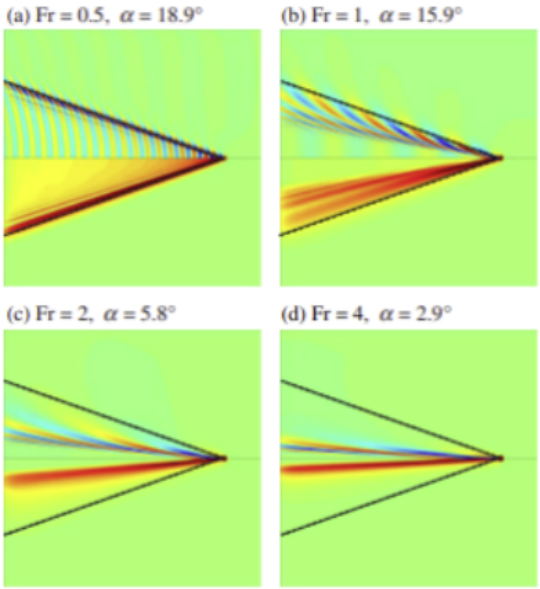


Figure 6

Source: *Physical Review Letters; Ship Wakes: Kelvin or Mach Angle?*

SCHWARZSCHILD COSMOLOGY AND BLACK HOLE-CEPTION!

By Laya Gopalakrishnan

1 x 10^-43 seconds. This is the duration of time that our universe was able to remain within a 1 x 10^-33 centimeter confine. Following this was a phenomenon that many of us are familiar with: The Big Bang. There are many theories regarding the origins of the Big Bang, one of the more astounding ones being that the singularity from which our universe expanded was that of a black hole. According to this theory, our universe is the product of the expansion of a black hole in a "parent universe". If proven true, this would mean that universes are layered within universes, and that it is possible to travel through black holes into entirely new universes. Whether one would survive this journey is dangerously unlikely, but the possibility still stands! This theory is called Schwarzschild Cosmology.

Deep and Dark and Dangerous

The black hole is quite a terrifying cosmological entity. They are invisible, distinguishable only by the warping of matter around their event horizons, and have the strongest gravitational pull in the known universe. Not even light can escape their grasp. It is still debated whether or not black holes can be everlasting, a war between the classical theory of relativity and quantum mechanics, but in either scenario, they are just as disconcerting.

The anatomy of a black hole can be broken down into seven main portions. Forming the outermost "barrier" of the black hole is the **accretion disc** - a superheated mass of gas, stardust, plasma, and other particles, orbiting the black hole. The term accretion, as used in astrophysics, is the converging of matter to form larger entities. Thus, we know that accretion discs are the driving forces behind a black hole's release of quasars - spiraling gas turrets originating from what is perceived as the entity's "center" - and X-rays. Along the inside rim of the accretion disc lies the **innermost stable orbit**. As the name may suggest, it is the closest that matter can orbit a black hole without being drawn past the **event horizon** - more popularly known as the "point of no return." The **photon sphere** and **relativistic disk** are similar in characteristics - both being forms of fast moving particles, light or radioactivity respectively, that are manipulated by the warped gravity of a black hole. The final part of a black hole is the **singularity**. All matter and energy that is drawn into a black hole is collapsed into this singular, infinitely dense point in space-time.

There are several types of black holes that exist in our known universe. Based on mass alone there are Primordial Black Holes, Stellar Mass Black Holes, Intermediate Mass Black Holes, and Supermassive Black holes. Black holes can also be classified based on their rotation and charge. According to German physicist Karl Schwartzschild, non-rotating black holes with neutral charges are created when the radius of an entity in space is smaller than a theoretical number assigned to it called the Schwarzschild Radius. This number can be calculated using the following formula, where r is the radius of a black hole's event horizon, G is the gravitational constant, M is the black hole's mass, and c is the speed of light:

$$r_s = \frac{2GM}{c^2}$$

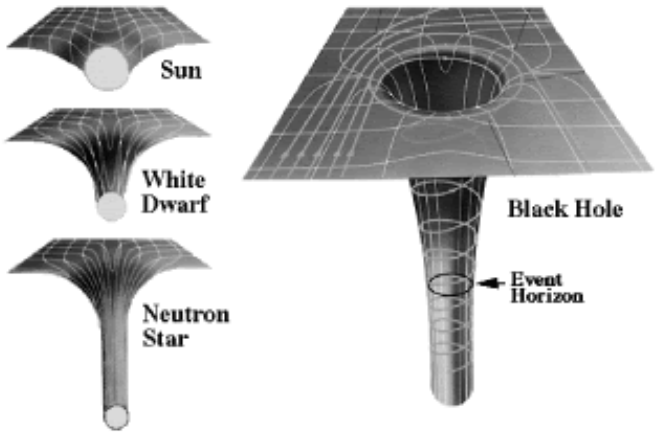


Figure 1: Black holes are often modeled as spherical entities surrounded by orbiting gas clouds. It is important to remember and visualize a black hole as a "sink hole" within space-time.

Source: *[NASA Goddard Space Flight Center]*

These black holes are known as Schwarzschild Black Holes. Kerr Black Holes, more commonly found in space, have neutral charge but measurable rotation. Finally, there are Charged Black Holes, which have an electric charge assigned to them and can either be non-rotating or rotating.

Similarities Lie in the Singularities

The Big Bang being the expansion of the universe from a 1 x 10-33 centimeter point is similar to the incredibly dense "core" of a black hole. But what if this infinitely dense singularity was not so infinite after all? What if instead of culminating in a definitive point in space time, these singularities began expanding within the seemingly "bottomless" black holes themselves.

During an interview with National Geographic Magazine, Dr. Nikodem Poplawski from the University of New Haven points out that not only are infinities rarely found in nature, they are improbable. It is far more likely that black holes empty into an incredibly dense point, upon which they create a "seed" to a new universe.

Most importantly, it has recently been proven that the behaviour of spacial properties from and beyond the event horizon of a black hole, are *identical* to those from the event horizon down to the black hole's singularity. And we know that a constant state of expansion preceded the Big Bang, a driving force allowing our universe to expand to what exists in our universe today. So it is entirely plausible that our universe stems from a supermassive black hole in a parent universe, and that supermassive black holes in our universe lead to new universes, and that we live in a multiversal reality, where universes lie within others. This itself opens a gateway of possibilities, a new approach to proving the all-too-sought-after multiverse theory.

Though our favorite SciFi novels may be incorrect to assume the ease of travel from universe to universe , the existence of this reality leads to new horizons of knowledge. Scientists may finally be able to research the origins of our universe by studying those being created in black holes within our galaxy. Additionally, scientists may be able to trace back through parent universes in space-time, creating a line of ancestry.

Conclusion

Black holes are one of many fascinating astronomical entities in our known universe, but some of the properties that make them so abstruse may not be irrational after all. It is possible, even likely, that the singularities of black holes are the sources of universal expansion. Infact, it is possible that *they* are the culprits behind our Big Bang, and others, and the cause behind the existence of universes within universes. Though this would likely be an inefficient method of inter-universal travel, these ideas of universe-originating-singularities and black hole cosmology lead scientists closer to finding the origins of our universe. Additionally, we near the story behind origins of our parent universe and the origins of the first universe to occupy space time.

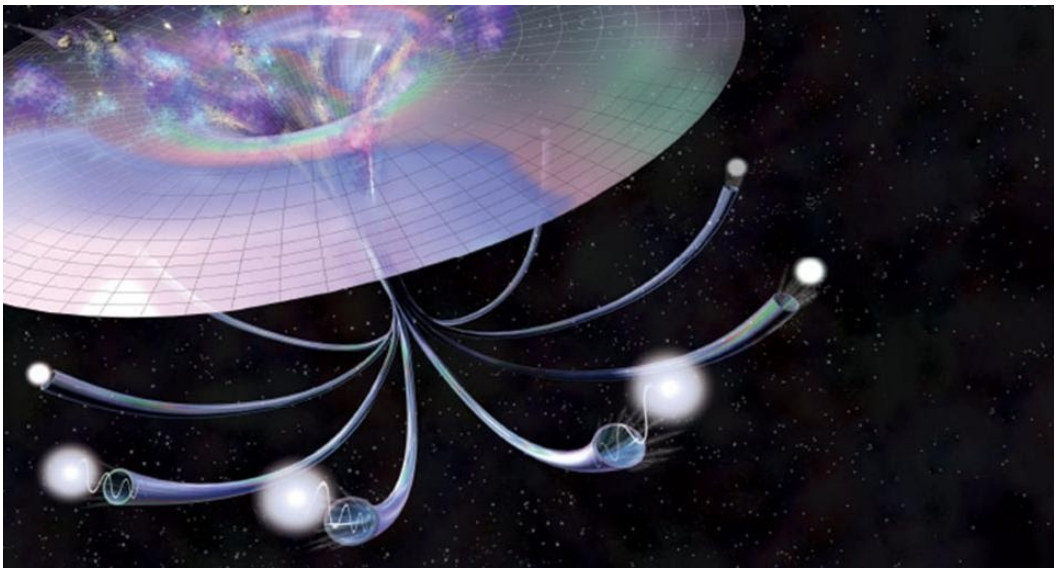


Figure 2

It is possible that black holes may expand within themselves, creating untravelable "portals" to new universes.

Source: *[Forbes]*

THE FUTURE OF SPACE TOURISM

By Edgar Carlos

Space tourism has greatly changed over the last two decades, from companies offering utterly unaffordable space rides to now offering a somewhat fair price to experience an exhilarating experience. However, while companies like SpaceX, Blue Origin, and Virgin Galactic were very successful in sending civilians to space this year, many companies before these three were not so lucky in sending civilians to space. These space companies had many overpromised projects that never came to fruition due to their lack of experience and funding. While some organizations failed, those who succeeded were able to kick off a new age of civilian space travel.

Brief History of Space Tourism

Space tourism organizations have come and gone over the last few decades. Many of them no longer exist and some have gotten to the point of sending humans to space. This year marked the first year in which SpaceX, Blue Origin, and Virgin Galactic were able to successfully send civilians to space, breaking a record that was once thought of as a fictional idea. Before companies like SpaceX and Blue Origin existed, numerous space tourism companies came up with ludicrous space tourism projects. The first major space tourism company, Bigelow Aerospace, proposed to build an enormous space hotel for moon missions and low-earth orbits. Even though Bigelow Aerospace had enough experience in the space tourism industry, they didn't have the proper funding to continue building space facilities, which is why the company laid off all of its employees in March 2020 after 20 years since its founding. Countless other space tourism companies with big promises of amazing civilian space flight advances just like Bigelow failed either due to their lack of experience or lack of funding.

The Future of Civilian Space Flight

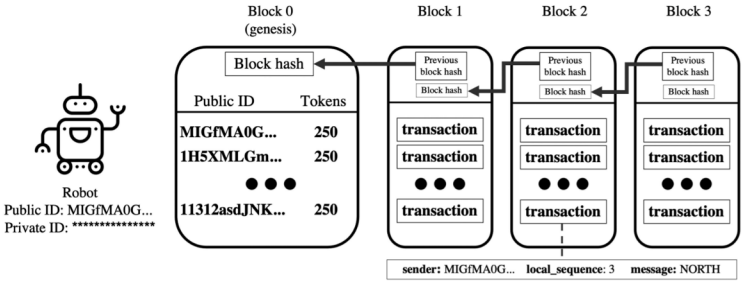
One company that was able to send civilians to space after numerous challenges was Virgin Galactic. It was first founded in 2004 and after only one year since its founding, the company was able to create a suborbital rocket called SpaceShipOne that won numerous awards for its rocket design and test flight. Sixteen long years later, Virgin Galactic sent a crew of five civilian members and CEO, Richard Branson, to space. The fact that it took Virgin Galactic sixteen years to launch their first civilian space flight shows the immense difficulty of successfully sending civilians to space without absurd costs. Virgin Galactic is now one of the leading space tourism companies. After their initial success of sending five civilians to space, the company will continue to conduct more and more civilian space flights, meaning that space tourism will eventually become cheaper and more widely accessible to everyone.

Conclusion

The future of space tourism is very bright. As companies such as Virgin Galactic continue sending civilians to space, going to space will become more accessible and cheaper for average civilians. Even though the history of space tourism had a rocky start, as many companies came with absurd ideas and projects, the companies that survived created a new age of civilian space flight. While it may not be easy launching a successful space company, in the end, those that do find success have created a whole new form of travel.

NOT JUST BITCOIN

Blockchain for Communication



Visualization of the robots' communication blockchain given three transactions each containing three fields: the sender robot, local sequence index, and the instruction message.

Source: *Ferrer et. al., 2021*

By Gloria Wang

With the boom of cryptocurrency in the last couple years, decentralization — distributing control away from a single source— has become an increasingly popular methodology. Blockchain, a technology widely known for its applications in Bitcoin and other cryptocurrencies, is the core of the decentralization process. As its name suggests, blockchain is fundamentally composed of "blocks"— data structures composed of a transaction history, a hash, and the previous hash. A hash is like a digital fingerprint; a completely unique representation of a transaction typically of alphanumeric composition. Because each block is linked to the one before by the previous hash, changing one hash means changing them all, which is nearly impossible.

Application in Robotics Communication

The decentralization aspect of blockchain technology comes from the distribution of the recorded transactions. Every user has an identical copy of the blockchain, so there are multiple sources that can collectively verify the accuracy of any given account. Due to this ability to authenticate each transaction, blockchain's application in security is appealing — especially for communication. In a paper published in *IEEE Transactions on Robotics* just last month, researchers at MIT and Polytechnic University of Madrid explain that blockchain technology could make communication between robots more secure by comparing each copy of directions and ignoring the one that doesn't match the rest.

In addition, the researchers' system is designed so that "lying costs money." Each leader robot receives a certain number of tokens, which will be confiscated for every misinformation spread. "When the malicious robots run out of tokens, they can no longer spread [false information]. So, you can limit or constrain the lies that the system can expose the robots to" (Ferrer 2021). With this system, the study found that while a follower robot was initially misled, it was able to complete its assigned task.

Applicable in self-driving car systems used to transport passengers or deliver goods, blockchain for secure communication in robotics could become more relevant in the immediate future than many expect.

Applications in Social Media

Similarly, in social media, privacy is a growing concern. Platforms such as Facebook, Twitter, and Tiktok collect data on millions of users. Data collection tactics have included reading users' clipboards and aggregating personal information, leading to concerns over privacy and data security. As the popular saying goes, "In big data, the consumer is the product."

UTU.ONE is one of the first platforms attempting to decentralize social media. Built on the EOSIO blockchain, it supports both efficient and environmentally friendly development. While the Bitcoin network uses the Proof-of-Work (PoW) consensus mechanism which has "a vast army of nodes on the network competing to solve a mathematical puzzle and 'mine' tokens," EOSIO implements the Delegated Proof-of-Stake (DPoS) mechanism that delegates work to 21 nodes — saving processing power and electricity.

Eliminating bots and fake accounts through Certified Biometric Liveness Detection and 3D face authentication, UTU is pushing for a safe and secure environment. With the open-source EOSIO blockchain, cyberbullying and fraud is traceable and contained.

Conclusion

While security and privacy concerns are still extremely prevalent in this tech-driven world, researchers and innovators are working to make technology safer and more secure. Through applications of blockchain technology in a variety of fields like robotics and social media, perhaps communication will become more trustworthy.

THE EVOLVING MEDICAL POWER OF PSYCHEDELICS

By Marko Ilic

Psychedelic drugs have recently risen to increased prominence in the medicinal world, and many stigmas that enveloped the various drugs - MDMA, Psilocybin, LSD, Ketamine - have weakened due to surges in mental health crises and a growing void in solutions to combat them. A 30% rise in suicide rates since 2000 coupled with exponentially rising drug overdoses, namely due to synthetic opiates such as Fentanyl, has forced medical professionals to seek mental health therapy differently, leading to the re-introduction of psychedelics in psychiatry. A positive re-evaluation for these drugs through the lense of lawmakers and the public can be ignited through encouraging clinical trials, further research, and social de-stigmatization - leading to eventual legal use throughout the medical world against various mental illnesses.

History

In the 1950s, numerous psychedelic drugs such as LSD and Mescaline, the latter being a derived substance of the San Pedro Cactus, began to be used in trials aimed at treating alcoholism and schizophrenia. Early studies indicated it to be largely effective, showing effective results in mitigating alcohol addiction. Researchers like Stanislov Grof, a renowned Czech Psychiatrist, popularized the study and use of LSD, preferring it to the common mental therapy methods of the 1950s such as electroshock and artificial fever therapies. Grof was quoted by NPR's Arun Rath: "This was a tremendous deepening and acceleration of the psychotherapeutic process, and compared with the therapy in general, which mostly focuses on suppression of symptoms, here we had something that could actually get to the core of the problems." Despite promising results throughout psychedelic therapy, the drugs became synonymous with the Hippie and Anti-War

movement, becoming commonplace in recreational drug circles. In 1970, Richard Nixon's Controlled Substance Act passed, which effectively outlawed LSD and other similar hallucinogens as Schedule 1 drugs, destroying the momentum and future study of these compounds as therapy mechanisms.

Re-Introduction and Therapeutic Promise

With the destructive effects of the opiate crisis and Covid-19 exacerbating burnout, depression, PTSD, and overall stress levels, many medical professionals are seeking new therapeutic outlets. Psychedelic drugs such as Psilocybin and MDMA increase levels of serotonin, a neurotransmitter which increases happiness and stabilizes mood. A large majority of people with depression have been correlated to have a serotonin deficiency within the brain. Different chemicals produced by these drugs, for example oxytocin, sends feelings of intense love, sedating users in a medical setting which allows them to open up about past experiences. MDMA, which produces large amounts of both chemicals, has specifically been used in therapy centers as a PTSD "miracle drug", with 107 patients used as subjects in clinical trials held by the Multidisciplinary Association for Psychedelic Studies. The subjects underwent MDMA therapy sessions with regulated dosages and in a safe environment. After a year, over 68% of patients did not meet the requirements for a PTSD diagnosis. Due to its tendency to make users feel open, unafraid, and euphoric, MDMA could especially be utilized against PTSD, which as a therapy field has had little success in remedying the chronic symptoms experienced by people, namely trauma-victims and military veterans.

Psilocybin, the psychoactive ingredient in Magic Mushrooms - a group of fungi which host hallucinogenic properties - has been largely used in research for depression. While the inner workings of a psychedelic mushroom experience can be hard to articulate, patients most clearly align it with "soul-searching," since the brief trips can take users down long paths of self-reflection and personal understanding. The sessions are followed up with reflections with psychiatrists which are focused on understanding the root of the patient's issues. The entire approach is predicated on understanding a patient's personal woes and finding the internal remedies to that problem, by using intense trips to understand a person's psyche and thought process. A study led by the Centre for Psychedelic Research at the Imperial College in London showed that a 6-week trial between Lexapro - a commonly prescribed antidepressant - and Psilocybin, showed little difference in their impact on treating depression. While both compounds are shown to have benefits, Psilocybin therapy is not repetitive nor does it have any damaging side effects in a safe setting. Lexapro needs to be taken every day and can have negative effects such as weight changes and severe withdrawal episodes. The advantages offered by psychedelics against prescribed medications, many which are expensive, repeating, and potentially harmful, is something to consider in therapy despite the social taboo In spite of the fact that research in psychedelic therapy is promising, it is largely preliminary and needs more legal advocation to see mainstream implications throughout the medical world.

Pathways to Widespread Psychedelic Therapy

Within the past 3 years, psychedelic drugs and consequentially, therapy methods, have been largely destigmatized and promoted by various lawmakers within the US. Denver became the first city in America to decriminalize Magic Mushrooms and their psychoactive compound, psilocybin. The act doesn't allow for users to be prosecuted for obtaining and using the mushrooms, and several cities in California followed suit. As recent as June 2021 a bill in California is preparing to face further legal clearance, but early votes show promise in its ability to be passed. The bill would decriminalize a large number of psychedelic compounds isolated for their potential therapeutic effects, and it includes Magic mushrooms, psilocin, dimethyltryptamine (DMT), ibogaine, mescaline, LSD, and MDMA. If passed, the bill could lead to further legal clearance around the country and could spark the momentum needed to catapult psychedelic therapy into the conventional medical world. As a whole, the psychedelic realm has been largely damaged through repeated recreational abuse, but shifting the conversation about these drugs from recreational to

medical use may be the necessary catalyst to extract their therapeutic properties.

Conclusion

While psychedelic research and drugs were cut off due to their recreational abuse in the 1960s and 70s, the headway in its therapeutic properties have made in the 2010s make it a prime candidate to assert itself in the medical world as a legitimate remedy to increasing mental conditions such as PTSD and depression. The social taboo and stigma that shrouds these compounds has held them back from reaching their medical potential, but increased legal and social support has shifted the widespread negative perception of these drugs to something which can at the very least be mentioned as an outlet of mental support. Further research and trials which determine the effectiveness of various drugs against mental illnesses can legitimize them as tools for people suffering, and with social and legal support can open up the medical field's arsenal and subsequent success in combating the exponential growth of mental illness.

A recreation of a DMT visual while hallucinating

Source: *Cuppa Tea - Youtube*

USAGE OF HYDROGELS IN WOUND HEALING

By Shiqi Cheng

Recently, hydrogels, a type of water-filled polymer, have been found to be a useful material for effective wound healing, which this article will explore.

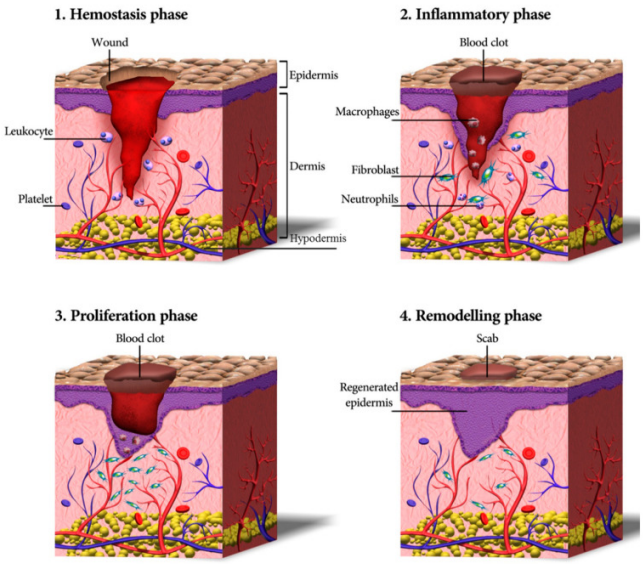
INJURIES TO HUMAN SKIN

The skin is the largest organ in the human body and acts as a useful physical barrier that keeps humans alive. It allows the body to retain water and maintain homeostasis while also deflecting toxic substances. The three layers normal skin possesses are the epidermis (external barrier), the dermis (main structural layer), and the hypodermis (fat storage). Wound healing to these skin layers consists of four overlapping phases: homeostasis, inflammation, proliferation, and maturation. In the first few minutes after an injury, blood platelets will begin to stick together and fibrin is activated to form a mesh to prevent further blood loss. During the inflammatory phase, immune cells gather at the wound site and absorb bacteria, pathogens, dead cells, and other debris. Afterwards, during proliferation, fibroblasts (a cell that creates collagen and other fibers) multiply to cover the wound site. Finally, epithelial cells migrate to the wound edges to cover any remaining defects. While skin has self-regenerating properties, injuries to the skin that are larger than a certain diameter aren't able to heal by itself, thus, requiring skin transplants.

COMMON SKIN INJURY TREATMENT METHODS

The most used method to treat skin wounds today are skin grafts, where a patch of skin is surgically removed from one area of the body and transplanted to the injured area. However, this is often not a viable method when there is extensive skin loss or immune rejection. Additionally, skin grafts can cause lots of pain and scarring with slow healing times. Other methods include skin flaps, tissue expansion techniques, and dermal substitutes. A skin flap is when healthy skin in a local area is used to cover a nearby wound and remains connected to a blood vessel. Tissue expansion involves growing extra skin by inserting a silicone balloon expander underneath the skin to encourage stretching. Dermal substitutes involve biologically engineered material (composed of collagen and glycosaminoglycans) which is able to act as

Figure 1



Diagrams depicting the four step (homeostasis, inflammation, proliferation, and maturation) process of wound healing.

Source: *US National Library of Medicine*

scaffolds and promote new tissue growth. Recently, hydrogels have drawn attention as a skin injury treatment method due to their unique ability to mimic the skin microenvironment.

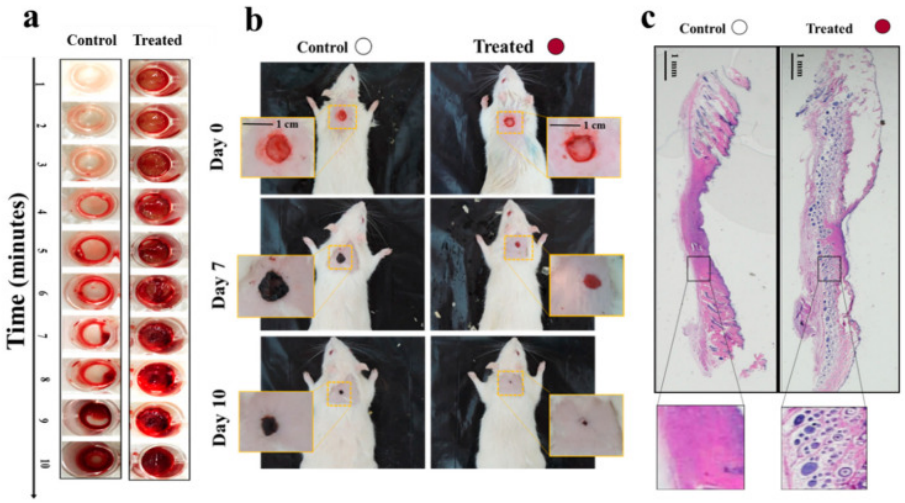
USING HYDROGELS

The word “hydrogels” refers to the class of materials used in soft tissue engineering of skin, muscle, blood vessels, and fat. Hydrogels are insoluble and made up of hydrophilic polymers. This allows them to effectively absorb wound exudates while also allowing oxygen diffusion which increases healing times. Hydrogels are also highly soluble which allows them to maintain high moisture levels and morph into any shape. With all of these traits, hydrogels provide an environment that promotes tissue regeneration and are very biocompatible. These advantages are seen in in-vitro experimentation where a nanocomposite hydrogel dressing based on polydopamine modified ZnO was used. This hydrogel spray, combined with antibacterial dressing, facilitated rapid wound closure as seen in Figure 2.

CONCLUSION

Overall, hydrogels are materials with a lot of potential in the field of wound healing. Their ability to imitate human skin and support wound healing are currently found to be very significant in in-vitro experimentation. This has a lot of applications in the medical field and can improve the quality of life for people that suffer from large open wounds.

Figure 2



ZnO based hydrogel spray on wounds in mice demonstrates faster and better healing.

Source: National Center for Biotechnology Information

NEW COVID-19 VARIANT SPREADING ACROSS SOUTH AMERICA AND THE UNITED STATES

By Samuel Go

A COVID-19 variant from Colombia called Mu has spread across the entire US, leading the World Health Organization to declare it a variant of interest. A team of Japanese researchers published an unreviewed preprint paper on September 7 detailing how the Mu variant was more resistant to vaccines than all other COVID-19 strains, including Delta. However, Delta remains much more competitive and dangerous than any other COVID-19 variant, including Mu.

How is this variant different from Delta?

Mu was first sequenced in Colombia in January 2021 and declared a variant of interest on August 30, 2021, by the World Health Organization. It is still a new variant, so there is not much known about the differences between it and widespread COVID-19 strains like Delta. A group of Japanese researchers did discover that Mu was more resistant to vaccines than any other strain of COVID-19, including Delta. However, the research paper has still not been peer-reviewed as of September 11, 2021, so the findings are not conclusive. There is still not much information about Mu as there have been so few studies on the variant.

How concerned should we be about Mu?

From the information available, Mu may be more genetically resistant to COVID-19 immunity from vaccines and infection than other strains. As a result, it may cause breakthrough infections for those who have already been infected by other COVID-19 strains. However, vaccines still protect against serious cases of COVID-19 from even the most genetically resistant strains like Beta and potentially Mu.

Over the summer, the percentage of total active Colombian COVID-19 cases caused by Mu fell by 6 percent while the percentage of Delta cases rose by 13 percent. The data indicates that Mu is nowhere near Delta in terms of infectiousness. Even though Mu is more resistant to treatment, it is nowhere near as concerning as Delta, which is much more transmissible than Mu and therefore able to outcompete it anywhere.

Conclusion

Currently, nobody knows whether Mu will become the new “super-variant.” Mu may be worse than Delta because it is more resistant to vaccination and treatment, but Delta has already outcompeted Mu everywhere, even in Colombia where Mu originated. The best course of action to stop COVID-19, according to many health experts, is to focus completely on containing the spread of Delta through public health efforts like vaccination campaigns, enforcing social distancing, and mask mandates.

Figure 1

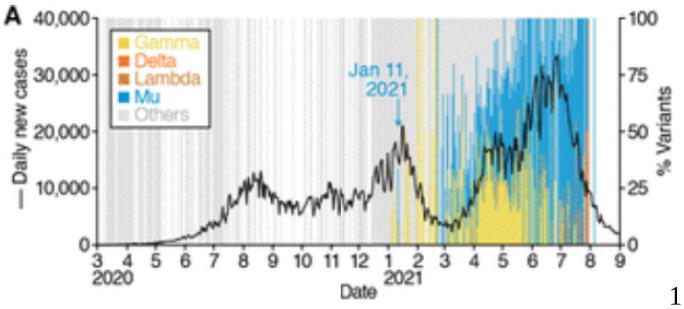


Figure 2

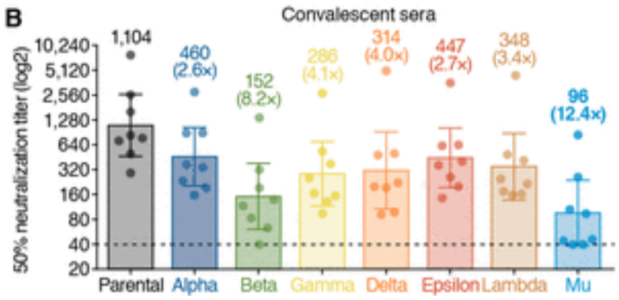
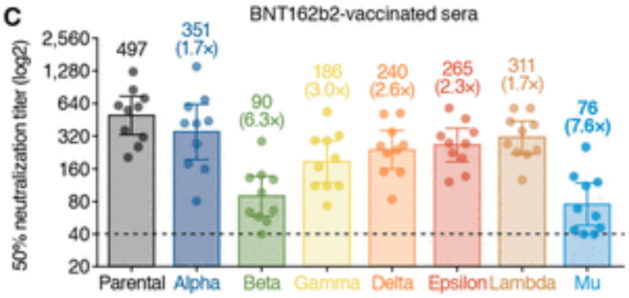


Figure 3



1. Daily new Colombian COVID-19 cases on the y-axis. Date on the x-axis. Percentage of cases caused by a particular strain as colored bars

2. Virus neutralization assay comparing the geometric mean titers of previously infected people. A lower number on top of the bars means that a virus can only be detected under a more concentrated blood serum sample and vice versa. A lower number on top also means that the virus can better evade antibodies targeting it compared to other viruses.

3. Same as (B) but with vaccinated people

Source: *BioRxiv*