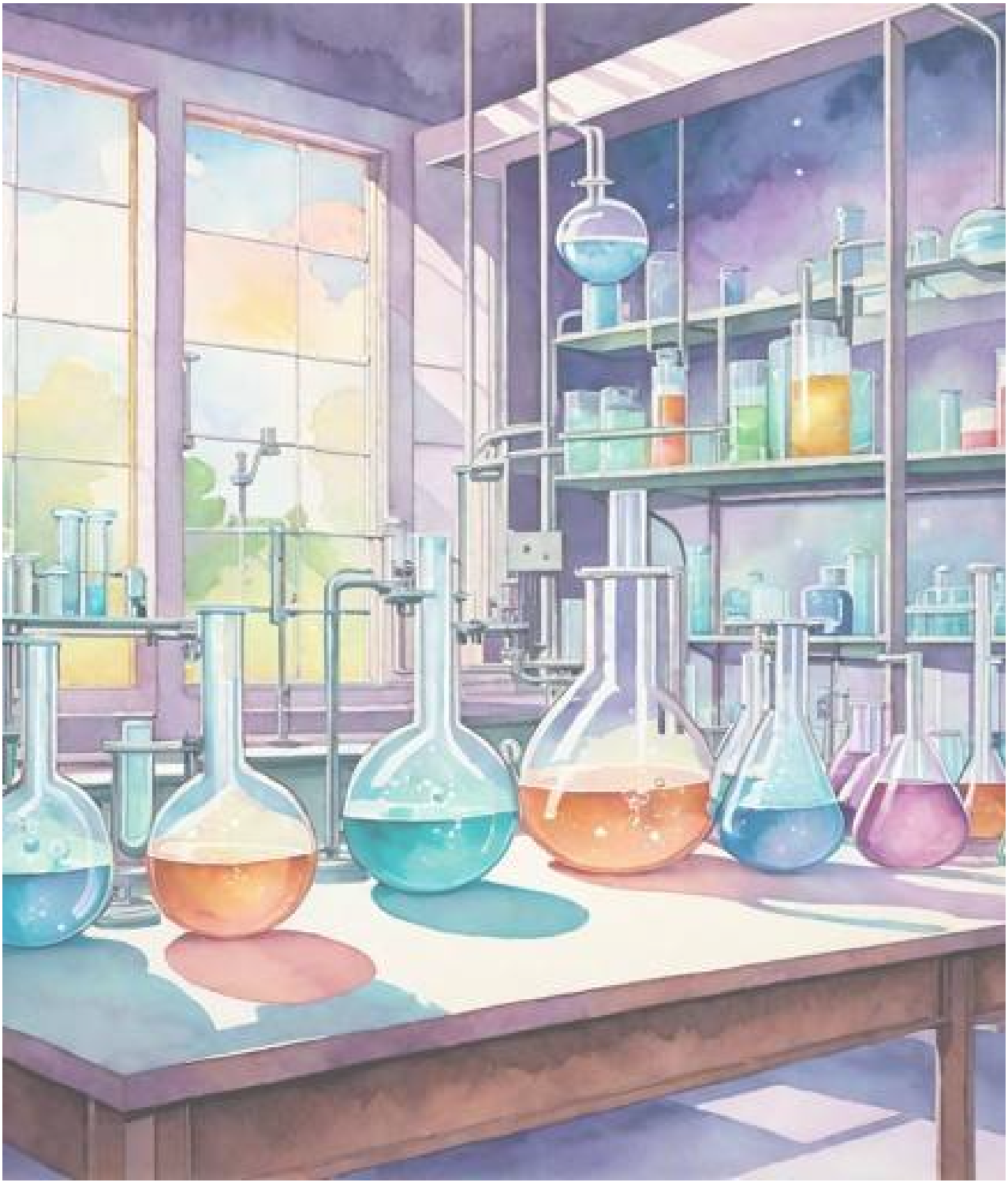
ISLAND SCHOOL 2024



SCIENCE JOURNAL

SENIOR PHASE

INTRODUCTION

Dear Readers,

It is with great pleasure that we finally present to you the Science Journal 2024. Through the intensive efforts of both our writers and their assigned editors, we hope to provide you with an engaging and informative reading experience, regardless of your background in science. Each submission is a testament to the unique passions that exist at Island School, united only by the singular attribute of pure scientific curiosity and exploration.

The articles curated this year have been some of the most varied in the publication's history. From physiological and mental disorders, to the applications of chemical and physical ideas in the real world, to explainers about everyday phenomena, we as the Editorial team are confident that there is something for everyone, whether you consider yourself a science geek or a casual reader.

Each year's edition continues to improve upon its predecessor. We didn't think it was possible to surpass the number of pitches in recent years, but once again, Islanders have showcased their signature enthusiasm and drive to make this endeavour possible. We hope that we as the Editorial team have done justice to your wonderful works, helping to disseminate scientific knowledge and curiosity across the student body.

Finally, there is a great amount of gratitude to be given out. Firstly, thank you to every editor who has diligently been with their assigned writer through the whole publication process. It is your efforts that elevate the quality of the journal and make it worthy of publication. Secondly, thank you to all the writers. It is no exaggeration to say that this would not have been possible without the boundless creativity that you embody. Thirdly, thank you to Mr Bayne for his unwavering support throughout the process. Finally, thank you to the readers who continue to oil the machine of the Island School Science Journal. We hope that the Science Journal 2024 will inspire you to stay curious, pursue the sciences, and perhaps even write an article yourself next year!

Happy Reading!
The Science Journal 2024 Editorial Team

Thank you Mr. Cawson for lending his lab for us to take a photo :D

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TABLE OF CONTENTS

06 - 08 **INVESTIGATING EXTRATERRESTRIAL LIFE FORMS**
Megan Chan 11D

09 - 12 **RECONNECTIONS: PROSTHETICS & BRAIN CONTROL NEUROPLASTICITY IN THE MOTOR CORTEX**
Timothy Chan 11D

13 - 16 **ISLAND OF STABILITY AND THE TRANSURANIUM ELEMENTS**
Samuel Lai 11D

17 - 21 **BRAIN-COMPUTER-INTERFACE (BCIS)**
Christy Park 11E

22 - 25 **HELPFUL AND HARMFUL CHEMICALS IN COSMETICS**
Zoe Tan 11E

26 - 30 **PLANET X**
Nicholas Tsang 11E

31 - 34 **THE MULTIVERSE THEORY**
Annabel Suen 11F

35 - 38 **SUPER CONDUCTORS**
Peony Chau 11N

39 - 42 **IS CHAT GPT GETTING DUMBER?**
Cordia Chiu 11N

43 - 47 **REWRITING THE NARRATIVE**
Karen Tam 11N

48 - 50 **THE PHYSICS BEHIND “INTERSTELLAR”**
Natalie Cao 11R

51 - 54 **BASIC MOLECULAR SIMULATION FOR DUMMIES**
Vivian Gu 11R

55 - 59 **MIRROR NEURONS**
Parina Khiatani 11R

60 - 63 **TO WHAT EXTENT DOES SPECIAL RELATIVITY PROVE TIME-TRAVELLING?**
Hanna Shih 11R

64 - 67 **HOW DOES TYRE DEGRADATION IN FORMULA 1 WORK?**
Shafay Khan 11W

68 - 70 **DO YOU GET DEJA VU?**
Zita Lok 11W

71 - 74 **NEURAL MECHANISMS OF EMOTION REGULATION**
Sania Mahita 11W

75 - 79 **IS SNAKE VENOM THE FUTURE OF PROCOAGULANT DRUGS?**
Natalie Healy 12D

80 - 84 **PRECISION MEDICINE- HEALTHCARE'S REVOLUTION**
Cyrus Ng 12F

85 - 87 **WHAT IS SYNESTHESIA?**
Gigi Liu 12R

88 - 92 **ATTENTION DEFICIT HYPERACTIVITY DISORDER**
Logan Wong 13D

INVESTIGATING EXTRATERRESTRIAL LIFE FORMS

Megan Chan 11D

INTRODUCTION

Everyone has gone through the question of: whether there is any sign of life in our world today. There has been much research regarding this question, and various signs have driven our scientists in this modern day to discover extraterrestrial life forms and their environment. But what are the key facts on the topic of extraterrestrial life forms, and what is the possibility of their existence?

To begin researching this topic, the definition of extraterrestrial life forms must be clarified. Accordingly, extraterrestrial life forms are life that does not originate from Earth. There were also many case studies of extraterrestrial life forms that had been explored, and they all consisted of different methods of research. In this article, we will mainly focus on the question of "How can we prove the existence of extraterrestrial life forms?". This can be achieved by exploring case studies and learning about the skills researchers have used before.

PART 1: HOW DO WE RESEARCH FOR EXISTENCE

To experiment and scientifically conduct effective research for extraterrestrial life forms, there are certain substantial things to be completed. A famous part of research for this topic is to utilise radio frequency to conduct radio searches. Many different radio machines are detailed and effective, including the Allen Telescope Array (ATA), a telescope for detecting extraterrestrial life. It is located in California, compromising antennas used for SETI, where around 100 researchers had investigated the nature of the universe, as well as life not limited on Earth ("Home"),and for cutting-edge radio transmission research. One of the star systems with planets was found by NASA's mission Kepler, more importantly these planets were in the habitable zone.("SETI at the Allen Telescope Array (ATA)") This shows the significance of radio detection devices in terms of discovering extraterrestrial life.

Another part of their research included how they looked for substantial biosignatures, namely the characteristics that show signs of past or present life.(NASA Astrobiology, 2021) Biosignatures can be separated into three distinct groups, including gaseous, surface, and temporal biosignatures. The downside to this aspect is that we are unable to directly look into the life's face and determine the biosignatures. Instead, they must first understand the nonliving chemistry of the planetary body where it was found. Scientists have gone through stages of differentiating between biosignatures, they also have developed different ways to determine if something is scientifically living, for example, the Ladder of Life Detection.

Lastly, there is the aspect of optical experimentation. It had been mentioned by a couple of scientists that amongst the SETI sky researchers, who have researched on radio frequencies,

that there may be powerful lasers used for interstellar communication at optical wavelengths. However, there are 2 problems with optical SETI, firstly lasers are highly directional, which means that the frequencies have to be directed to Earth to be seen. Secondly, lasers are highly "monochromic", which means that it is troublesome to find out which frequencies are the ones we are looking for.

PART 2: GALILEO SPACECRAFT

In the past few decades, there have been many forms of evidence brought by numerous scientists who have tried their best to bring to the world evidence of the existence of extraterrestrial life. One significant example of this is the investigation led by Carl Sagan himself, with a group of scientists to investigate data retrieved aboard the Galileo, a spacecraft made by NASA. The main aspect of this investigation was sending the Galileo spacecraft on a 6-year trip travelling to Jupiter, as well as making several orbits around the inner Solar System.

The Galileo spacecraft was sent to study the environment and atmosphere of Jupiter and came back to our planet with more information which would support the theory of having extraterrestrial life on other planets. This included how the temperatures recorded ranged from -30 degrees Celsius to +18 degrees Celsius, which accordingly is close to the ideal temperature for humans to live in. Another piece of information given was that the near-infrared mapping spectrometer had detected gaseous water distributed throughout the atmosphere. (Dorrian, 2023)

PART 3: VIKING SPACECRAFT EXPERIMENT

Another experiment conducted by scientists was also related to the hunt for extraterrestrial life on other planets. This was conducted in the early 2000s, where the scientists conducted similar experiments from the Viking spacecraft. The results from this experiment were that on the Mars-like land of the Atacama desert, microbial life was found. The downside to this experiment is that if the Viking spacecraft had in fact landed on Mars, they would've missed a lot of signs of life on Mars, despite knowing that there have been many signs of life on Mars in the past.

The Atacama desert was known to be used as a model for Mars, due to the dirt and rock being similar to the land of Mars as to our current scientific knowledge. "We found life, we can culture it, and we can extract and look at its DNA," said Raina Maier, who is a microbiologist in a university. (Of Microbes and Mars, 2004) Despite this experiment not being able to completely confirm that there may be extraterrestrial life on other planets, this serves as a good starting point for our other experiments that will come later on in the future.

CONCLUSION

"Ask courageous questions. Do not be satisfied with superficial answers. Be open to wonder and at the same time subject all claims to knowledge, without exception, to critical scrutiny. Be aware of human fallibility. Cherish your species and your planet."—Carl Sagan. Famous Hollywood movies may have struck an interest in viewers as to the fact that there may be life outside of Earth. We have many years to come, which will eventually lead to more answers to our unanswered questions. Therefore, it is urged for all aspiring astronomers to continue to ask questions and break through with more interesting findings and answers.

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RECONNECTIONS: PROSTHETICS & BRAIN CONTROL NEUROPLASTICITY IN THE MOTOR CORTEX

Timothy Chan 11D

INTRODUCTION

July 1866, Turner's Lane Hospital, Philadelphia — Dr Silas Weir Mitchell looks after a patient by the name of George Dedlow, a military officer in the aftermath of the American Civil War. He complains of severe pain and muscle cramps, in places like his calf. One problem: he had no calf. In fact, he has no limbs at all (Mitchell, 1866). As Dr Mitchell went on to coin, what Mr Dedlow and thousands of other war amputees were experiencing was Phantom Limb Pain (Gunduz et al., 2020). Damaged nerves remain at the site of an amputation and, resultantly, the resulting signals in the nervous system go misunderstood by the brain as pain. Moreover, in the brain neurons reorganise, adapting to the situation. So how does this work and with an artificial limb, could it reorganise itself again?

PAR 1 - A BEGINNERS GUIDE TO THE MOTOR CORTEX

To start, consider the work done by the brain and the body to act, like tossing a ball. Coordinated movement is executed in the frontal lobe, organised as such: the prefrontal cortex plans the movement (usually as a response to sensory input, in this case, seeing and feeling the ball), the premotor cortex organises this sequence of movement (like the steps for each muscle when tossing a ball), and the motor cortex executes specific movements (performing the task of tossing). Next, the message is passed to the limb (in this case, your arm and hand) via the spinal cord and motor neurons that carry it to the right muscles (Schwartz, 2016). Finally, when you toss the ball, sensory receptors at your fingers send this information back to the sensory cortex in the brain via the spinal cord, confirming the action was done and completed successfully.

The primary motor cortex – the narrow section of tissue at the top of the brain – has different areas that control different body parts (a motor map), allowing it to send signals to the right place (Murugesu, 2023). Another quality of the motor cortex is that it is plastic (or neuroplastic), meaning the neurons in that part of the brain can be regenerated.

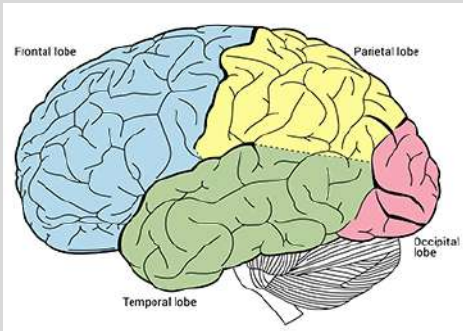

Fig 1: Movement is decided in the frontal lobe, one of 4 lobes of the brain.

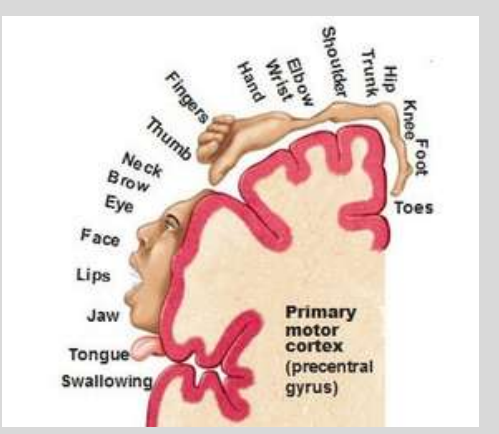

Fig 2: Visualisation of the motor map in the primary motor cortex.

overexpression of BDNF during the adolescent period in animal models may act as a useful starting point to treating major depressive disorders in adolescents.

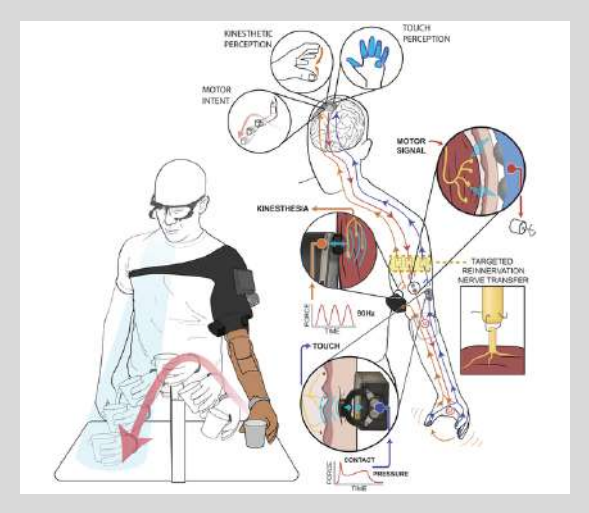

Fig 3: Illustration of a recent prosthetic design communicating with the brain for restoring movement and senses.

PART 2 - NEUROPLASTICITY: THE ABILITY TO REORGANISE BRAIN FUNCTION

Monkey Business

In 2009, scientists from Vanderbilt University and UC Irvine examined the brain activity of 5 macaque monkeys to observe long-term changes in the motor cortex based on a loss in sensory input from the forelimb. Although the monkeys were trained to use those hands and fingers, when sensory neurons relaying information from that limb were damaged, causing a lesion, the monkeys were less likely to use that part of the body. In turn, that part of the primary motor cortex shrunk while the neighbouring area responsible for shoulder and elbow movement grew to compensate (Qi et al., 2010).

Stroke & Amputation

Likewise, similar changes in the motor cortex occur in people who had a stroke or were amputated. A stroke is caused by a disruption to blood flow, depriving brain cells of oxygen and nutrients. It brings the risk of a momentary or permanent loss of function. Ergo, the ability of the brain to organise and execute movement is damaged (Austin et al., 2021) – the patient can no longer move that body part. As for amputations, the loss of a body part also occurs and causes the loss of sensory neurons from that area (Liu et al., 2022) – the brain adapts based on the experience and outcome to focus its ability on functions elsewhere. So, if this occurs in the motor cortex after an amputation, how could that ability be restored with a prosthetic limb?

PART 3 - POSSIBILITIES WITH ARTIFICIAL LIMBS

I Think, Therefore I Act

When asked, for this article, if neuroplasticity in the motor cortex could still occur to restore movement with artificial limbs, Dr Nafissa Ismail of the University of Ottawa replied, “I don’t think currently there is enough evidence to suggest that, yes, artificial limbs do lead to neuroplasticity… I think that with the artificial limbs, we do learn to move the artificial limbs, so on that aspect, there is… but it will never be the neuroplasticity that is the same way as where we are trying to recover the same function in our own arm.” Of course, a mechanical arm is very different from a human one, it is a foreign object. However, while difficult, it is not impossible.

Substantial progress has taken place in the field over the last decades. In 2009, the best technology at the time for an artificial arm was dependent on shoulder flexibility and pressing buttons in the person’s shoe. In 2012, progress in prosthetics grew exponentially with funding from the US Department of Defense to support veterans (McCandless, 2023): researchers at the John Hopkins Applied Physics Laboratory successfully inserted 2 brain-penetrating electrodes (sensor arrays) after a surgery which allowed the patient limited movement over a separate mechanical arm using neural activity in the motor cortex interpreted by a computer – direct brain-computer interface (Herring et al., 2023).

In the years since, designs were refined to be more natural and comfortable. Most recently, a new “bionic limb” design not only uses a less intrusive form of dissecting and interpreting electrical

impulses in the brain to command movement but also can replicate sensations of touch and gripping by sending back electrical signals through connecting sensors to the remaining touch receptors at the site of amputation (Marasco et al., 2021). Here, with use over time, neuroplasticity again occurs as the part of the motor cortex responsible for regulating that body part develops and grows to adapt. In other words, the brain will begin to recognise the prosthetic as a real limb (Lane, 2022).

CONCLUSION: THE NEXT STEP

Modern medicine has come a long way since the days of Dr Mitchel and patient Dedlow. Today, the idea of restoring the control of the brain over an artificial limb has gone from a point of scepticism to a fact of everyday life. It is through advancements in the combined effort of evermore sophisticated and accessible technology and the brain's neuroplasticity that future generations may look back and view us just as we today view the archaic, cumbersome peg legs and hooks of the past. In this next step in artificial limbs, it may be commonplace that, one day, prosthetics will not just look real, but feel real – the future at one's fingertips.

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ISLAND OF STABILITY AND THE TRANSURANIUM ELEMENTS

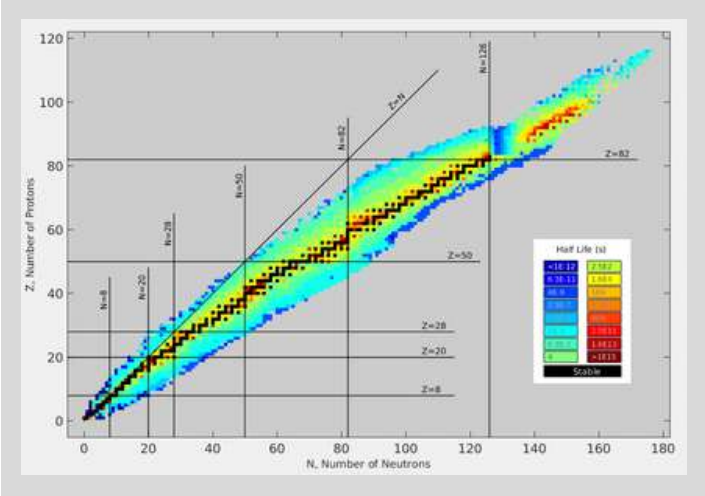
Samuel Lai 11D

RADIOACTIVE DECAY

The “Island of stability” is a term coined by Glenn Seaborg, an American chemist. To understand what it is, we first need to have a basic understanding of radioactive decay. Radioactive decay refers to how an unstable nucleus loses energy through radiation. This can be done in three ways; ejection of an α-particle (composite particle with 2 protons and 2 neutrons, identical to helium nucleus), ejection of a β-particle (an electron / positron, usually caused by too many neutrons inside the nucleus), and / or a γ-ray (an EM energy wave, also called a photon). Radioactive decay occurs for all elements, whether it be all forms of the element presently known, or an isotope of it. Decay of an unstable radioactive element causes it to transform into different isotopes of other elements until it reaches a stable state, called a decay chain. Elements with atomic mass greater than 95 are all created artificially.

THE BELT OF STABILITY AND MAGIC NUMBERS

These elements and their isotopes form a graph, dubbed the “belt of stability”, where the x-axis is the number of neutrons, and the y-axis being the number of protons. The black zig-zag line indicates the “stable” nuclide of an element. The zig-zag line cuts off after proton number 82 and neutron number 126, which is the element lead. Lead has the highest atomic number of all elements which have a non-radioactive isotope, and 3 of its isotopes are the final stable element in 3 decay chains.



Past lead, all elements and their isotopes are radioactive. The belt of stability allows us to understand trends in half-lives, contributing

to our understanding in element synthesis. As we drift further from the main stability line, half lives decrease, until we drop into the “sea of instability”. Notice the lines on the graph? These numbers 2, 8, 20, 28, 50, 82, 126 are referred to as the “magic numbers” in nuclear physics, where if these numbers of protons / neutrons are present, the nuclei they create are much more stable compared to nuclei with one less proton. These nuclei are found in large quantities organically due to their stability, like oxygen, tin, nickel, and lead. With magic numbers discovered, physicists took it one step further. What if, instead of one singular magic number, we had 2 magic numbers instead? Isotopes with these “doubly magic” numbers, as they were called, were exceptionally stable. Calcium-48 is an example of the extreme stability these “doubly magic” numbers create, with Ca-48’s half life being 6.4×1019 years old. (Christoph E., & Block, M., 2018)

THE ISLAND OF STABILITY

The Island of Stability is still the focus of element synthesis today. A simplified definition of it is “multiple stable isotopes of elements made from doubly magic or magic numbers of protons and neutrons”. For the past 80 years, elements have been continuously made, chasing these islands of stability.

THE THEORISED STABLE SUPERHEAVY ELEMENT 114

Element 114 was theorised by atomic physicists to be an element with a magic number, an element on the island of stability. Instead, it turned out to be only slightly more stable than the superheavy elements surrounding it, with a half life of around 1 second. Named Flerovium by scientists, it was not the Island of Stability that physicists were looking for. This disappointing discovery however, motivated the physicists to push further to the next superheavy element with “doubly magic” numbers of protons and neutrons, element 126. (Clery, 2021)

END OF THE PERIODIC TABLE

Element 126’s half life is calculated to be on the scale of a 100 years. While this may sound exciting, with our current methods of element synthesis, it may take hundreds of years. Currently, labs such as Dubna in Russia, GSI in Germany and RIKEN in Japan are synthesising elements 119 and 120, and they predict that 119 and 120 can be produced within the next 5 years. Element 121 is listed for RIKEN to attempt and discover after the successful production of element 120, however 121 has no estimation on when it will be discovered. Now you may ask, ‘When does the periodic table end then?’ Some suggest that the end will be at element 172, where the nucleus starts to fuse protons with electrons outside, forming neutrons until the proton count drops back to 172. Others suggest that the periodic table could go on infinitely, as long as we find a way to force protons and neutrons together inside a nucleus. (Fessl, 2019)

THE COST OF ELEMENT PRODUCTION

All of this element production however, comes at a steep price. People like Glenn Seaborg and Yuri Oganessian have spent most of their lives chasing these elements, and labs such as RIKEN have a quite hefty electrical bill from their particle accelerators. Debates about continuing the element search have increased, and people are starting to question if the pros outweigh the cons. (Chapman, 2019)

THE POSSIBLE OUTCOMES OF ELEMENT PRODUCTION

While element production is expensive, it could have its benefits. Elements like element 126 could serve as a fuel source for space travel, or even help catalyse technological innovations. Additionally, understanding how superheavy elements work could pave the way for

understanding quantum physics, and how elements like 173 would work.

FURTHER READING

Superheavy, by Kit Chapman. An in-depth book about the origins of the periodic table, and where it might be headed.

Twelve Experiments that changed the world, by Suzie Sheehy. While the book mainly focuses on particle physics and accelerator technology, a chapter describes how subatomic chemistry (protons, neutrons, electrons) helped pave the way to future discoveries.

Youtube video “The man who tried to fake an element”. Has over 10 million views, and does a brief overview of “Superheavy”, with emphasis on the Ninov scandal. Very informative video with great infographics.

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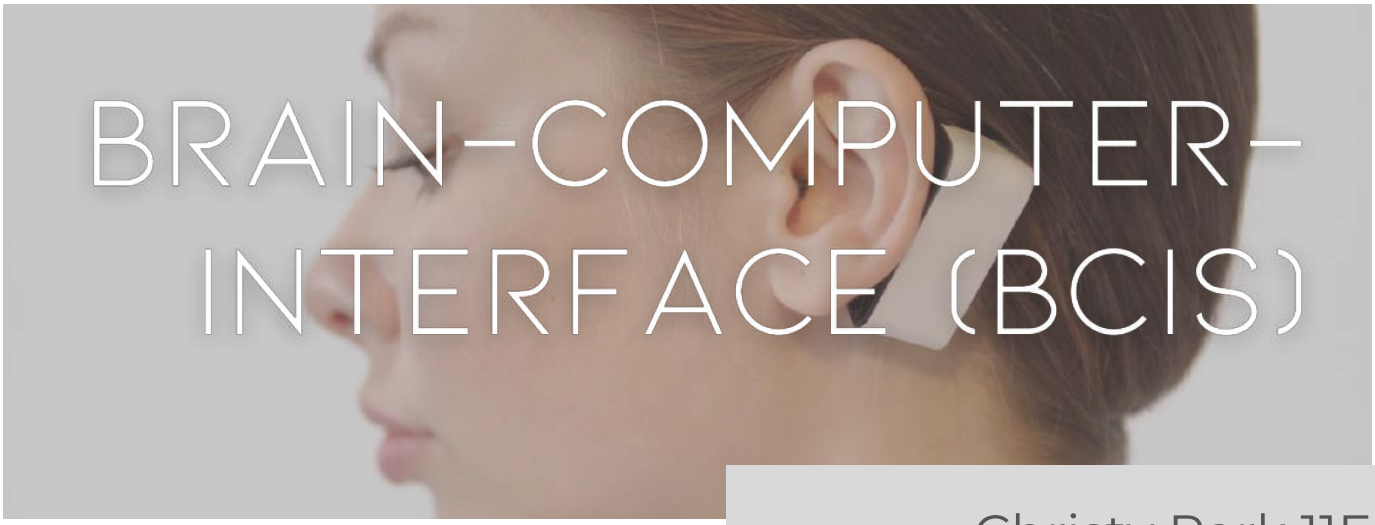


BRAIN-COMPUTER-INTERFACE (BCIS)

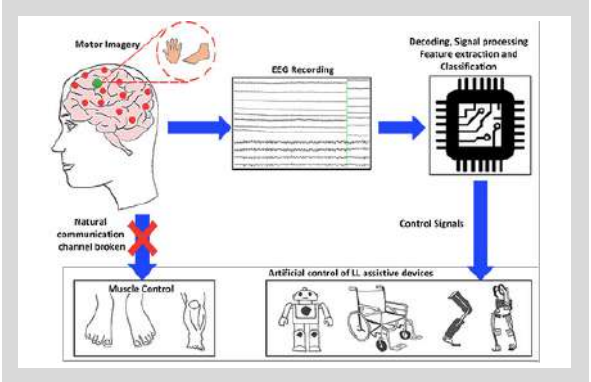
Christy Park 11E

INTRODUCTION

Imagine controlling computers or machines with nothing but your mind. You'd live a life of comfort and multitasking, with day-to-day chores and activities a breeze- all thanks to neurotechnology. Technology like Brain-Computer-Interface (BCIs) that allow telepathic control over devices, have been developing for decades, and are now considered 'serious' innovations capable of tackling one of the leading global issues today. But, what exactly are they, how do they work, and are their benefits worth all the detriments that have left some in regret?

BRAIN COMPUTER INTERFACE

BCIs as of today, are complex systems capable of interconnecting the brain and computer by collecting neural activity in brain signals, translating and sending them as machine language instructions executed through the device connected. They act as electrical pathways that, simply put, allow users to control computers or microprocessors just by thinking about them (Shih et al., 2012). Depending on the level of accuracy, surgery for BCI installation may or may not be required. For instance, installing the device in its most accurate form called, "Invasive BCI", requires open surgery, while installing BCIs in their safer, yet less accurate form called, Non-invasive BCIs are often presented as wearable, portable caps, hence not requiring surgery (Difference between Invasive and Non-Invasive BCI | Types of BCIs, 2024). Figure 1 shows a comparison image between the two types of BCIs.



THE INSTALLATION

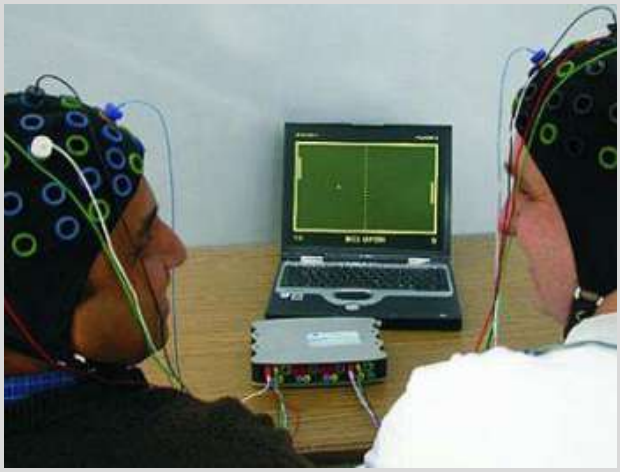
Once the invasive BCI chips containing electrodes are implanted past the skull, and into the tissues of the brain, the first step in connecting the brain and computer is to install Electroencephalogram (EEG) medical sensors through the BCI, and use them to

conduct a series of tests in the brain to read its signals and brain activity. Using electrode electrical disk sensors, EEG test measurements are conducted. Brain neurons typically communicate by transmitting electrical impulses of information and instruction from one area of the brain to another. During the EEG test, electrodes are implanted into the brain to sense and determine up-close the path the brain's electrical impulses travel through (EEG (Electroencephalogram) - Mayo Clinic, 2022). Identifying which part of the brain should be stimulated by following the path of the impulses, allows for the information carried by the electrical impulses along the brain to be obtained and ready to be sent to the computer for execution of instructions.

BENEFITS

BCIs are seen by many as the "VR world stimulator" when used for leisure activities like gaming, as they enable users to feel immersed in the realm of on-screen gaming. When non-invasive BCIs are placed on users' heads as a cap and connected to the gaming computer, EEG and electrodes on it read brain instructions and execute them into the computer game screen, which allows users to control and play games with just the mind (Muhammad Adeel Javaid, 2013).

MEDICAL ASSISTANCE



Besides their use for leisure, BCIs have numerous other benefits and applications where contributions may be significant- especially in the medical industry.

With their speciality in reading brain waves and signals, not only can BCIs be used for neuroscience research and deepening our understanding of the correlations between one's brain and actions, but these neurotechnological devices are additionally capable of serving as a doctor's assistant. They are currently used in neurological medical centres such as Bloorview Research Institute and Holland Bloorview Kids Rehabilitation Hospital to monitor the mental and physical health of patients by searching for any abnormalities or changes in their brain waves (Orlandi et al., 2021). By placing a non-invasive, wearable BCI cap on a patient's head, a reliable source of their brain signals is provided, which are then compared with normal and abnormal brain signal samples, allowing for the identification of health issues. These medical issues that are able to be detected include sleep disorders, general mental health disorders, and neurological diseases such as Parkinson's disease, Epilepsy, and Alzheimer's- current rising global issues that cause immobility and paralysis in areas of the body.

Furthermore, BCIs go one step further as a solution for such neurological diseases by guiding those suffering from such life-threatening conditions to regain a life of independence and free mobility. These revolutionary devices enable the connection between the patient's brain to prosthetics and exoskeletons to act as extra working limbs as a replacement for patients' paralysed body parts (People with Paralysis Control Robotic Arms Using Brain-Computer Interface, 2018). By doing this, paralysed users would be able to perform essential day-to-day tasks that were previously impossible with ease, simply by envisioning an action for the machine as further demonstrated in Figure 3.

Similarly, paralysed users can also find use in allowing for the connection between their brain and general computers and screens through BCI implants, as this would allow patient users to utilise

technology and carry out tasks requiring such devices to expand their freedom such as sending and reading messages, researching, watching videos, calling, etc.

PHYSICAL AND MENTAL RISKS

Despite the numerous life-saving applications of BCIs, such systems claim numerous innocent lives in this process. Over the past few months, BCIs have been gaining attention for its range of potential risks that come with the device, including physical, mental, and ethical aspects of them. One of the most significant detriments of neurotechnologies like BCIs is their potential for long-term consequences following the installation of the neurotechnological device. In the case of invasive BCI implantation, where the scalp, skull, and brain tissue connections are cut, damaged, and disrupted, the area of surgery is left in a hazardous state prone to long-term health consequences. This not only includes permanent scarring and build-up of tissue, but the same tissues may additionally, due to electromagnetic interference between the BCI device and other external devices, experience heating and irritation. As for non-invasive BCIs placed on the head, users may experience tension in the eye and head, as well as severe irritation and/or infections of the scalp skin after prolonged exposure to the device (Open Discussions, 2024).

Furthermore, the mental consequences for getting involved with BCIs is equally as significant. Although it has yet to occur, the fear and possibility of BCI malfunction is unsettling. The idea of losing control of one's own mind due to a technological glitch is frightening to say the least, and raises valid concerns of suffering from torture.

ETHICAL CONCERNS

Moreover, the use of BCIs, especially invasive BCI implants, brings to attention significant ethical concerns, specifically relating to the privacy and security of users. Using invasive BCI technology requires users to openly grant access to intricate workings of their brain, extending beyond just the technological aspects of them. These range from users' brain instructions on what to do, to sensitive thoughts, to users' personal preferences. As all this information from the brain-signal-processing-computer included, is stored in the company's main data cloud or physical storage, many individuals are worried that these companies may exploit their power, breach privacy, and/or even sell users' personal information.

In addition to that, concerns regarding personality changes are also drawn. This is because many are understandably worried that in the case of BCI malfunction, information and data about the user's personal information including personality may be altered as the brain signal processing computer would be affected- both for the data storage as well as the individual themselves. Recent publications of 2-3 case studies from the National Health Institute (NIH) were released where family members and co-workers claimed a negative change in a user's personality has strengthened such neuroethical concerns over BCIs (Gilbert et al., 2017).

CONCLUSION

In conclusion, Brain-Computer-Interface is a unique piece of neurotechnology with high potential to solve global issues and change the world for the better. However, it is crucial to acknowledge the severe life-threatening detriments and risks of the device as well, especially at an individual level that could cost lives. The future of BCIs, and what will become of them as they advance and develop- whether it'll eventually, as many hypothesise, be capable of improving one's cognitive function- is unknown. But until then, who knows what can happen with something that is still on its path to development?

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The Future of Brain Computer Interfaces (2050). (n.d.). Www.youtube.com. Retrieved January 8, 2024, from technology and carry out tasks requiring such devices to expand their freedom such as sending and reading messages, researching, watching videos, calling, etc.

HELPFUL AND HARMFUL CHEMICALS IN COSMETICS

Zoe Tan 11E

INTRODUCTION

Have you ever bought skincare products but got lost in all the confusing ingredients on the labels? All cosmetic products contain a wide variety of chemicals, many of which are beneficial or harmful to your skin. This article will explain some of the helpful and harmful chemicals in cosmetics you should look out for or avoid.

HYALURONIC ACID

Hyaluronic acid ($C_{14}H_{21}NO_{11}$)n) is a sugar molecule naturally produced in our bodies' connective tissues. However, as we age, the amount of acid produced decreases. Hyaluronic acid has the ability to hold up to 1000 times its weight in water and bind to water molecules, increasing the skin's water content and preventing the natural acids from evaporating. (Harper's Bazaar Staff, 2024). This helps to keep your skin hydrated and also provides many anti-ageing effects, suitable to people with any skin type. You should ideally pick a product containing 0.5-2% hyaluronic acid and different sized molecules to ensure both surface and deeper level skin hydration (Hyaluronic Acid Skin Benefits, 2020).

NIACINAMIDE

Niacinamide ($C_6H_6N_{20}$), or vitamin B3, is a water soluble vitamin that helps build keratin, maintain skin health and boost hydration. One of niacinamide's main functions is to strengthen the skin barrier by increasing ceramide production, which also makes other skincare ingredients easier to absorb (Niacinamide, 2022). Dermatologists recommend 0.5-2% niacinamide in products, which is suitable for all skin types, especially oily and acne prone skin (Clinic, 2022).

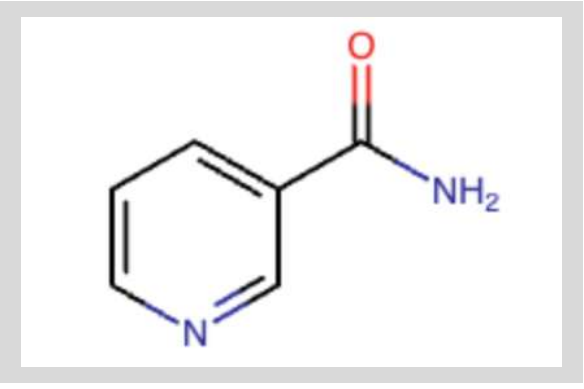

Fig 1: Structure of Niacinamide

ALPHA HYDROXY ACID (AHA) AND BETA HYDROXY ACID (BHA)

Alpha Hydroxy Acid (AHA) and Beta Hydroxy Acid (BHA) are chemical exfoliants that promote natural skin shedding and break up dead skin cells. Although they are both exfoliants, there are many differences in their function. AHA exfoliates the outer layer of skin to treat fine lines, wrinkles and make your skin more even toned. In contrast, BHA's deeply exfoliate the skin to treat acne, rough skin, psoriasis and other skin conditions. Due to the chemical's large molecular weight, BHA's are considered a milder exfoliation option. The most widely used BHA is salicylic

acid for its ability to loosen cells, treat acne and unclog pores. When using AHA's or BHA's be sure to consistently apply sunscreen, as the exfoliating effects may cause photosensitivity and increase sun damage (CeraVe, 2022).

PEPTIDES

Peptides are protein fragments made up of amino acids. Because proteins are one of the essential components of skin, a lack of peptides can lead to limp skin and changes in texture. Peptides act as a messenger for your cells to produce more elastin and collagen which increases skin elasticity, boosts firmness and implements anti-ageing effects (Gallagher, 2020). As there are hundreds of different types of peptides, to identify them, look out for chemicals ending in "peptide" and "palmitoyl". An example of one such chemical is "Tridecapeptide-1", which reduces fine lines and wrinkles (Steck, 2017). Peptides are suitable for all skin types and target a wide variety of skin concerns.

RETINOL

Retinols and retinoids are a form of vitamin A, containing retinoic acid. Retinol increases cell production, collagen production and encourages exfoliation, which mainly targets acne and acne scars, hyperpigmentation, and wrinkles (Clinic, 2022). Additionally, as prescription retinoids come in a range of strengths and concentrations, they can also be bought to treat more specific issues. Dermatologists recommend buying prescription retinol products because many FDA unregulated over-the-counter retinols may claim to contain retinol, but in reality do not include any (Moon, 2019). Despite retinol's many beneficial effects to the skin, it is highly advised to only start using them in your 20's, as excessive use can thin out skin and make you more vulnerable to UV rays (https://www.facebook.com/verywell, 2023).

PARABENS

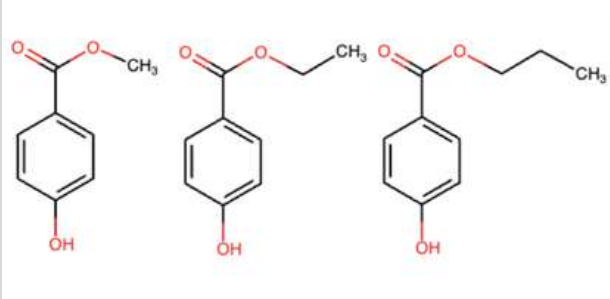

Fig 2: Structure of Methylparaben (MP), Ethylparaben (EP) and Propylparaben (PB)

Parabens are artificial chemicals used in cosmetics to prevent bacteria and mould. Although small quantities of parabens are helpful in preserving skincare products, large amounts lead to health issues regarding metabolism, fertility, cancer and the endocrine system (What Are Parabens, and Why Don't They Belong in Cosmetics?, 2019). Parabens are most commonly found in shampoo, conditioner, facial washes and scrubs; they are absorbed into the body when in contact with skin. The biggest health concern regarding parabens is the disruption of hormones, as parabens have oestrogen-like properties. This can cause issues in reproductive organs (Parabens, 2022). Paraben ingredients to look out for include Ethylparaben, Butylparaben, Methylparaben, Propylparaben and other ingredients ending in "paraben".

PHTHALATES

Phthalates, also known as plasticizers, are used to make plastic products more durable and flexible. Products such as nail polish, perfumes and lotion may contain phthalates, excessive amounts leading to the disruption of hormonal and reproductive activities. Furthermore phthalates can lead to allergies, obesity in children, early puberty and eczema. Although most phthalate ingredients are chemicals ending in "phthalate", common ingredients "fragrance" and "parfum" are also forms of it (Shopify API, 2020).

FORMALDEHYDE

Formaldehyde (CH_2O), is a naturally produced compound found in organisms. Similar to parabens, formaldehyde prevents growth of bacteria to increase the shelf life of cosmetics. However, formaldehyde is known to be one of the most harmful skin care ingredients. This is because it is cancerous, causes irritation, and even short term exposure can lead to dermatitis. Formaldehyde in skincare products can be difficult to recognise, as it is a gas created from decomposing formaldehyde releasers and not outwardly listed on packaging. Formaldehydes and formaldehyde releasers include: Formaldehyde, Quaternium-15, Glyoxal, Sodium hydroxymethylglycinate, Imidazolidinyl urea and more (Rud, 2021).

Hopefully this article has given you some insight into dermatology and helped you inform your shopping decisions.

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Nicholas Tsang 11E

Fig 1: This diagram shows the hypothetical appearance of Planet X

WHAT IS PLANET X?

As we all know, there are currently 8 planets in our solar system, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. However, what if you are told that a theoretical ninth planet can exist in the solar system. Although some may think the planet in question is Pluto; it is not that. Since Pluto has a very low mass, making its gravitational pull weaker, which doesn't entirely explain the deviations of orbits between planets and objects. The reason why Planet X's existence was brought to light by Caltech astronomers Konstantin Batygin and Mike Brown in January 2016 was because they had noticed a deviation in the orbit of six objects in the Kuiper Belt. This planet was estimated to have 10x the mass of planet Earth, and it would take 10,000 to 20,000 years for the planet to complete a single orbit around the sun. Due to its massive size, it will have a strong gravitational field, which is why it can influence the orbits of six objects within the asteroid belt.

VALIDITY OF THE PLANET'S EXISTENCE (WHY IT WILL NOT EXIST)

Although Planet X has a 99.6% chance (Nasa, 2016) of existing, there are many reasons why it has not been discovered. For instance, Planet X is so far away from the sun that it would be very hard for a planet to be able to form. (Reference Fig 4 to see how little we have searched).

In the solar system's outer rims, there is little dust or gas, making it hard for these materials to come together and form a planet. Another factor that affects the formation of the planet would be the temperature. Due to Planet X being very far from the sun, temperatures would be

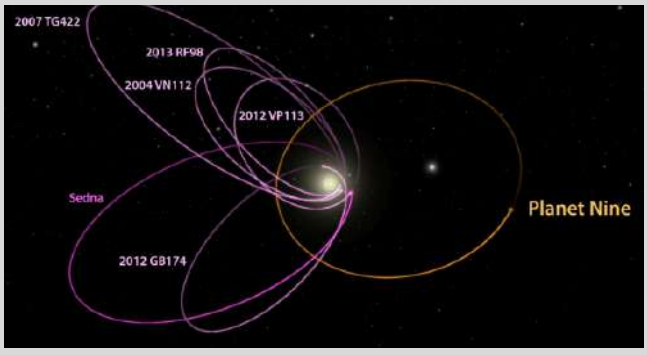

Fig 2: This diagram shows the highly elliptical orbit of the theoretical Planet X

extremely low, being 30 Kelvin or -243 Celsius (NASA, 2022). This will result in materials being more difficult to condense to each other and bond together, a crucial part in forming planets.

Another reason why Planet X may not exist would be because of the lack of observational evidence. The planet is estimated to have 10x the mass of Earth, hence it would have a large size, and strong gravitational field, leading it to being easily spotted. However, after extensive research on the outer regions of the solar system, no such planet of such size has ever been found, resulting in people debating whether the planet even exists in the first place. (Reference Fig 4 to see how little we have searched).

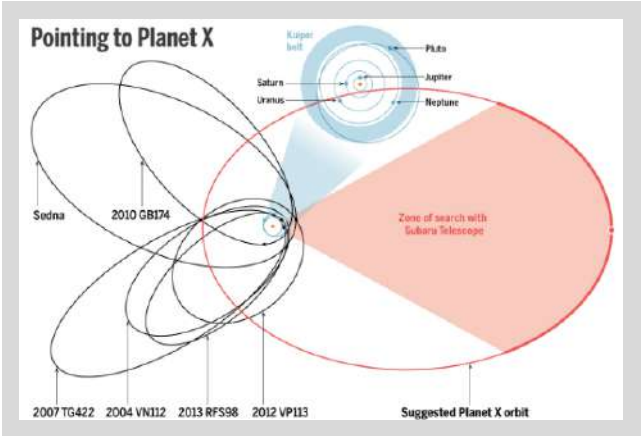

Fig 4: This diagram shows how much region of space we have searched for Planet X

VALIDITY OF PLANET'S EXISTENCE (WHY IT IS POSSIBLE THAT IT EXISTS)

Even though there are many reasons as to why the planet may not be existent at all, there is also much evidence that may support its existence.

One of the most compelling reasons would be the mysterious gravitational field that is affecting the orbits of many objects that exist in the outer rims of the solar system. One such explanation for the odd orbits would be due to a massive planet somewhere in the outer solar system influencing this phenomenon. However, another explanation o the odd orbits would be due to a black hole (the section below would be dedicated to this theory).

Neptune's orbit was observed as strange and it did not follow the orbits in which the scientists had calculated, leading them to believe that there could be a potential planet that was altering the orbits. Hence the search for the unknown planet began. Although Pluto had been discovered, its small size could not fully explain the abnormalities of the objects orbits within the solar system.

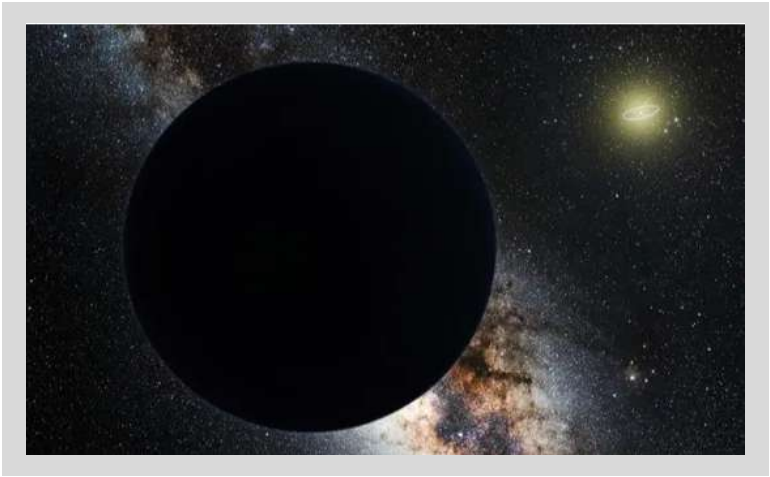

Fig 3: This diagram shows Planet X being a theoretical black hole instead of a planet

COULD PLANET X BE A BLACK HOLE?

A popular theory that people have proposed would be what if Planet X was a black hole(fig 3), and not a planet that was initially thought. This is because black holes have strong gravitational force, even bending time itself. This could explain the abnormalities of the object's orbits as a black hole possessed this strong power and could manipulate the orbits of even Neptune (BBC, 2019), which are huge bodies of large mass.

Moreover, this could also explain the lack of observational evidence of the Planet. Since black holes do not emit any light, it is nearly impossible to be seen, especially from such a great distance. Black holes are only detectable based on how they affect their surroundings.

SEARCH EFFORTS FOR PLANET X

Throughout many years, there have been many attempts to try to uncover this planet, and some of these search efforts include the Dark Energy Survey (DES), the Pan Starrs project, and the California Rocketric Occultation Survey (CROSS).

The Dark Energy Survey (DES) is a project that intends to map the distribution of galaxies over a large area of the southern sky. The data collected from this survey has been used to search for Planet X by analysing the motion of known trans-Neptunian objects [Objects/minor planets that orbit the sun, and has a similar distance between Neptune and the Sun] (Abraeu, 2023). The DES data has not provided any definitive evidence for the existence of Planet X, but it has helped narrow down the possible locations and masses of the hypothesized planet considering how vast and huge the orbit of this hypothetical planet is.

The Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) is a project that uses a wide-field survey telescope to detect and identify astronomical events, such as supernovae and asteroids. The data collected by Pan-STARRS has been used to search for Planet X by again analysing the motion of trans-Neptunian objects. Although no definitive evidence for Planet X has been found, the project has provided valuable data for the ongoing search and aids in narrowing down the location of the planet by evaluating the gravitational pull that it has on other planets or trans-neptunium objects.

The California Rocketric Occultation Survey(CROSS) is a project that uses rocket-borne instruments to observe the eclipse of stars by trans-Neptunian objects. The data collected by CROSS (Adam, 2015) is used to search for Planet X by analysing the deviations in the orbits of these objects. While no direct evidence for Planet X has been found, the survey has provided valuable constraints on the possible existence and properties of the hypothesized planet.

POTENTIAL EFFECTS ON THE SOLAR SYSTEM

Planet X, if it is a large and distant planet, could exert gravitational influences on other objects in the outer solar system. This could lead to huge changes in the orbits of known planets, dwarf planets, and smaller objects such as trans-Neptunian objects (TNOs) and Kuiper Belt objects. The presence of Planet X could help explain certain anomalies and irregularities observed in the orbital behavior of these objects.

The gravitational interactions of Planet X with the Kuiper Belt—a region beyond Neptune populated with small icy bodies—could have significant effects. It has been proposed that Planet X's gravitational pull could scatter or perturb objects in the Kuiper Belt, leading to changes in their orbits, and inclinations, and even causing some to be ejected from the solar system.

Some theoretical models suggest that the presence of a massive distant planet like Planet X could have long-term effects on the stability of the inner solar system. It is theorized that the gravitational interactions between Planet X and the gas giants (Jupiter and Saturn) might influence the stability and architecture of their orbits, potentially impacting the stability of smaller inner planets.

CONCLUSION

To conclude, there is a high likelihood of Planet X’s existence as it can be used to explain the abnormalities that many planets and objects have been experiencing. However, some arguments challenge the existence of the planet. The vast distance from the sun to the supposed Planet X is about 18 AU(Astronomical Unit - 1 Astronomical Unit is the distance from Earth to the Sun). This distance makes it hard to form a planet in the first place, and combined

with the lack of observational evidence also makes it hard to believe that the planet exists in the first place. This does not mean that the planet does not exist, however, since there are still many undiscovered regions in space where this planet could be lurking. Although this is hypothetical, there is a great chance that one day we may be able to uncover the existence of the planet or perhaps find a black hole that is within our solar system.

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Annabel Suen 11F

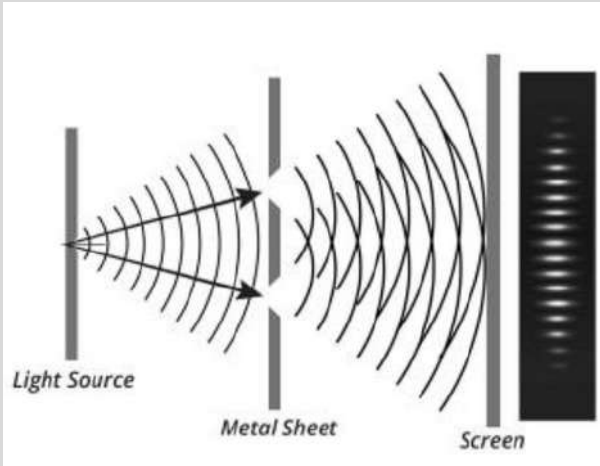
INTRODUCTION

The multiverse has always been a popular theory that has fascinated many physicists, philosophers, and sci-fi enthusiasts. As popular as this concept is in Marvel movies, what we see on the silver screen can barely encapsulate the multiverse theory. At this moment, the multiverse remains just a theory as there is no scientific evidence or experiments that prove its existence, however, it is still an interesting quantum mechanics-based theory, that is worth exploring. To better understand this theory, let's start with the basics of quantum mechanics.

BASICS OF QUANTUM MECHANICS

Quantum mechanics is the study of the movement and interaction of subatomic particles, including concepts such as wave-particle duality, quantisation of energy and uncertainty principle. It attempts to describe the behaviour and properties of atoms and particles. The basic notion of quantum mechanics is that subatomic particles (protons, neutrons and electrons) and electromagnetic waves, for example, visible light have the characteristics of both particles and waves. Albert Einstein first discovered wave-particle duality in 1905 and stated that light behaves as both a wave and a particle. He theorised that during the transmission of light, there are energy packets known as photons, an elementary particle that moves at the speed of light. ("Quantum Mechanics | Definition, Development, & Equations | Britannica," 2024)

The double-slit experiment proves the wave-particle duality, which concluded that particles of matter act as waves when not observed, but as particles when observed. Imagine there is a wall in front of you with two slits. You randomly throw tennis balls towards the wall, some will hit the wall and bounce off and others will pass through the two slits and hit the wall behind it. If you mark all the places where the tennis balls pass through the slits and hit the wall behind, you will expect to see two clear strips with the same position and shape of the slits. However, we have a much different result if we do this experiment on a subatomic scale, using electrons in place of tennis balls. The spots where the electrons hit form an interference pattern of a wave, meaning that even though the particles are fired one by one, they somehow split, pass through both openings at the same time, interfere with themselves and hit the second wall as a single particle. (Physics in a Minute: The Double Slit Experiment, 2020).



The bright stripes represent the points where the crest of one wave meets another. To observe how electrons pass through the slits to form an interference pattern, scientists attempt to record their movement by placing a detector. However, when a detector is placed, the interference pattern disappears and becomes the two-stripped pattern as seen from the tennis balls.

For every electron that is shot towards the wall, its wave function divides into two. This is why the electron passes through both slits at once. This is as if the electron is taking every possible pathway and these pathways interact, forming alternating regions of high and low possibilities of where the electron is. At the detection point, the electron reverts to one particle, as seen as a dot on the second wall. When we shoot enough electrons, we see the interference pattern which represents the probabilities of where an electron can be. This principle is called superposition. In simple words, superposition is when a quantum object exists in every possible position at once until it is measured. Schrodinger's Cat explains this confusing concept. This thought experiment states that a cat is placed in a locked box alongside a radioactive substance, a flask of cyanide and a detector. When the radioactive substance decays, the detector is triggered which then smashes the flask, releasing the cyanide and killing the cat. However, there is a 50 per cent chance that the substance decays and since the outside world can't observe what is happening in the box, we don't know if the cat is dead or alive until we open the box. (What Is Schrödinger's Cat?, 2019) Therefore, the cat is in a superposition state and is both alive and dead until it is observed. Schrodinger's cat explains that the quantum system exists in all possible states at once until we make an observation, only then the exact state is measured. This principle is also known as the Copenhagen interpretation of quantum mechanics.

Going back to the quantum realm, what happens when two electrons are fired towards each other at equal and opposite velocities? We know that they will bounce off each other, however, we don't know how since the electron's position is uncertain and therefore the trajectory of the particle can only be a wave function that represents all the possible locations. However, once we measure the momentum of one electron, we immediately know that the other has an equal and opposite momentum. Before the measurement, the electrons are in a superposition of states and measuring one collapses the wave function of the other. This is known as quantum entanglement. After interacting with each other, the electrons have one single wavefunction which is why measuring one electron affects the other. To explain this more clearly, imagine two entangled particles, one spinning up and the other spinning down. Before the particles are measured, they are in a superposition state of both spin down and spin up. No matter how far the particles are and which angle it is measured in, the particles will always have an opposite spin. Therefore if we measure one particle with an up spin, we immediately know the other particle is spinning downwards. By only measuring the state of one particle, we immediately know the state of its entangled counterpart. (Veritasium, 2015)

Now we know what entanglement is, we can say that in Schrodinger's cat, the superposition state of the radioactive substance is entangled with the detector, the cyanide and the cat. Therefore, the wave function of everything inside the box is in the superposition state of either the substance decayed, detector triggered and cat dead or the substance not decayed, detector not triggered and the cat alive. Only when we make an observation, does the wave function collapse and the cat is either dead or alive. However, we don't know whether, or how the wave function collapses, or what measurement even is. This is the measurement problem. (Anil Ananthaswamy, 2023)

THE MANY-WORLDS INTERPRETATION OF QUANTUM MECHANICS

The many-worlds interpretation of quantum mechanics is an attempt to explain the measurement problem. This theory states that every time a quantum state diverges, each possible outcome creates a new world, and we are only aware of the world we are in. Using

Schrodinger's cat as an example, there is no collapse of the wave function, but instead, there are two parallel universes where in one, the cat is alive and in another, it is dead.

When we extend the possible states to the entire universe, not just the cat, we have the multiverse. Using the double slit experiment as an example, the Copenhagen interpretation states that the superposition of particle trajectories merges into the single timeline of the observer's reality. On the other hand, the many-worlds interpretation theorises that the merging never happened, instead, the alternative trajectories continue but in different and separate realities. We find ourselves in one of the many timelines without knowing the existence of the others. According to this theory, at every particle interaction where different possibilities exist, reality splits into different branches, meaning that there are nearly infinite alternate worlds that represent every possible outcome of the universe since the Big Bang. Many-worlds interpretation implies that there are unthinkable numbers of versions of you in each alternate universe, and you just happen to be experiencing the branch of reality you are in. Every possible life you could have after every decision you made exists in other worlds. (The, 2020)

TO CONCLUDE, IS THE MULTIVERSE REAL OR AT LEAST POSSIBLE?

The many-world interpretation remains a mainstream interpretation of quantum mechanics as there is no evidence to support this idea. Although this interpretation is supported by the mathematics of quantum mechanics, it is still not a prediction or theorem that distinguishes it from other equally supported theories. This interpretation doesn't solve the measurement problem but only proposes an idea of what happens at the point of measurement. Similar to the Copenhagen interpretation, the many-worlds interpretation leads to many unsolved questions such as why can we only observe one reality and what determines the reality we observe. Whether the multiverse is real or possible remains a mystery today.

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SUPER CONDUCTORS

Peony Chau 11N

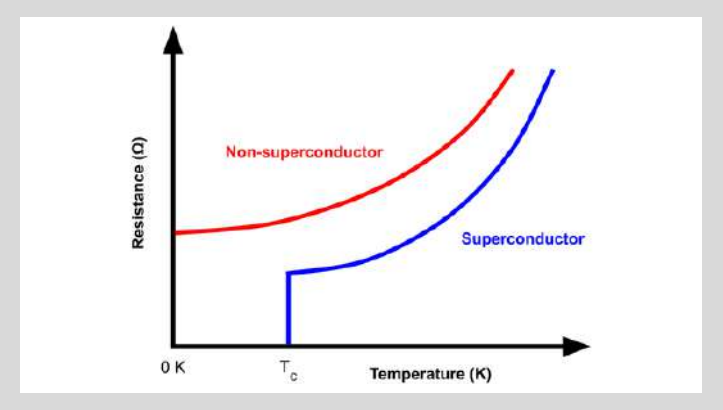

Fig 1: Resistance change of superconductors and non-superconducting materials against temperature

INTRODUCTION

The world was shocked at the end of 2023 by the discovery of a superconductor that can potentially operate at room temperature and ambient pressure - LK-99. Although it was found to be flawed in the end, this has prompted additional research and developments in the field. But why are these floating magnets such a big deal?

WHAT ARE SUPERCONDUCTORS?

Just by its name, superconductors are excellent conductors of electricity. Unlike other commonly used materials for conducting electricity (ie. copper, gold), they are far more efficient. When a current is passed through a conductor, it heats up and the thermal energy is transferred to the kinetic energy of the atoms within. This causes them to move faster and so they bump into each other more frequently. This slows down the electrons (current) thus increasing resistance. This leads to lots of energy being lost to the surroundings as heat.

Superconductors typically work at subzero temperatures nearing absolute zero (0 Kelvin or -273°C). It is known that atoms and particles slow down significantly at this temperature range, close to being completely stationary. Consequently, the atoms in superconductors only vibrate slightly, making it easier for the electrons to flow through. It is also stated by Ohm's Law (Voltage = Current x Resistance) that current is inversely proportional to resistance, so when resistance decreases, current increases. They are known to have no resistance at all, showing exceptional efficiency in electrical systems.

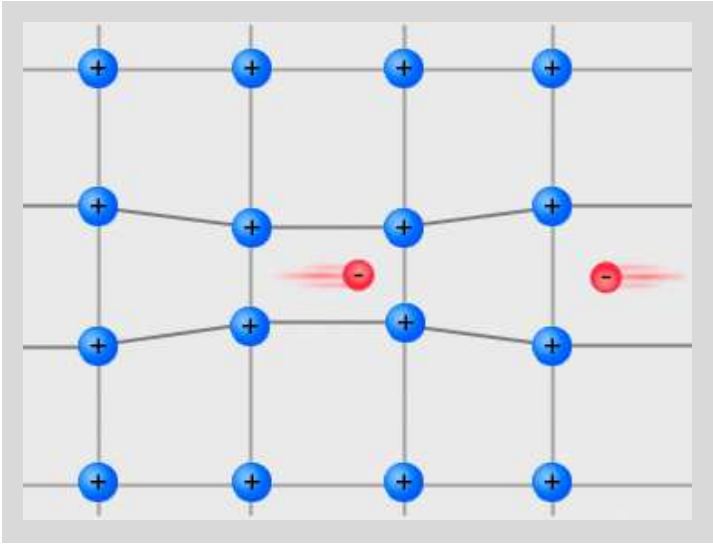

Fig 2: Cooper pairs

HOW DO THEY WORK?

If resistance decreases when a material is exposed to lower temperatures, does it mean that anything can be superconducting given the requirements? No, insulators cannot be superconductors as current cannot pass through. Right now, only 30 elements are found to have superconducting properties at low temperatures and ambient pressure, and all of them are metals, including aluminium, mercury and lead (Ginsberg, 2019). This is counterintuitive as why aren't the good conductors that we know (copper, gold etc.) not superconductive?

THE BCS THEORY

Established in 1957 by 3 American physicists (Bardeen, Cooper and Schrieffer), this theory microscopically explains superconductors (Britannica, 2019). Unlike other materials, when superconducting materials are cooled to a certain temperature (Critical temperature, Tc) their resistance immediately drops to 0 (figure 1). The Tc varies for each superconductor, ranging from 0 to 125K (-273°C to -148°C) (Type 1 Superconductors, 2023).

This sudden drop in resistance is a determining factor that makes superconductors unique. In all metals, some electrons can move (mobile electrons) when a voltage is applied to create a current. In superconducting metals, these electrons (negatively charged) attract the near-stationary atoms which are in a lattice formation (positively charged). This distorts the lattice structure as the atoms close in on the electrons. The area in which atoms are attracted to an electron is more populated than other areas, making it more positively charged, and attracting more electrons (University of Bristol, n.d.-a).

Despite being oppositely charged, these electrons pair up and move together within the lattice, forming Cooper pairs (Figure 2). They guide each other in staying 'on track' while travelling through the lattice, making them unaffected by the vibrations of the atoms (University of Bristol, n.d.-a). Since the atoms have no on them, the resistance is reduced to zero, implying that when a voltage is applied, the current goes on endlessly as it can conduct electricity with 100% efficiency with no energy lost to the surroundings (Nieves, 2023). When the Tc is reached, these pairs form and are broken when the temperature is over the Tc as the electrons gain enough energy and move on their own.

However, in good conductors such as copper, the electrons are very loosely held together by the atoms so their conductivity is generally higher. This makes it harder for them to form Cooper pairs as the forces of attraction between the lattice and electrons are too weak, preventing them from being superconductive (Type 1 Superconductors, 2023).

MEISSNER EFFECT

Another characteristic of superconductors is that they levitate on magnets, also known as the Meissner Effect. When an external magnetic field is applied, superconductors exhibit perfect diamagnetism - expelling the fields instead of letting them pass through (Figure 3) (Britannica, n.d.). This is because eddy currents are created within the superconductor and its polarity repels that of the magnets (KJMagnetics, n.d.). As similar poles repel, the superconductor goes against gravity and levitates. However, when the magnetic field exceeds a certain threshold the Meissner Effect stops and the superconductor loses its superconducting state (Britannica, n.d.).

Superconductors are categorised into two types: Type I and Type II. Type I - also known as soft superconductors demonstrate the typical characteristics of superconductors and are mainly pure metals. They obey the Meissner Effect perfectly but have a lower Hc (Amsh, 2011). They are also low-temperature superconductors as their Tc is relatively lower, with them being categorised as being less than 30K.

Type II, or hard superconductors are generally ceramic-based and have a higher Hc and Tc. As they have a higher Hc, they can withstand stronger magnetic fields without losing their properties. However, they lose their superconductivity gradually instead of instantaneously so they do not completely obey the Meissner Effect (Amsh, 2011). Magnetic fields can pass through these superconductors when they are in a 'mixed state' - in between superconducting and the normal state (Electrical4U, 2020).

APPLICATIONS

Superconductors are used in a variety of fields. For example, they are used to levitate and propel Maglev trains forward. These trains are currently the fastest in the world as the friction between the train and tracks is minimised which higher speeds can be achieved. However, cooling is still needed for these systems which increases the price and decreases efficiency. High-temperature superconductors are currently being heavily researched as they could potentially lead to major technological advancements. Currently, power lines are very inefficient as lots of energy is lost to the surroundings as heat. A high-temperature superconductor can work better as there is no electrical resistance, they can be 100% efficient at room temperature.

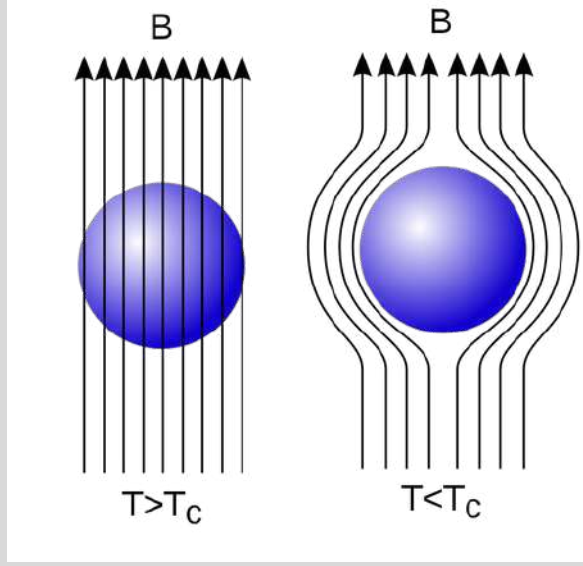

Fig 3: An illustration of the Meissner Effect

CONCLUSION

Superconductors have unique properties not found in other materials. They are also crucial for technological advancements and should be studied further in the future.

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INTRODUCTION

Whether you've experienced it yourself or heard about it from somewhere else, ChatGPT is... getting dumber. Many users have noticed that an increasing number of answers received from ChatGPT have contained spelling mistakes, lack accuracy or even worse, contain false information. Roblox's product lead Peter Yang even wrote that: "There's no doubt that it's gotten a lot worse on coding," (Hermann, 2023). But whilst this could be a measure implemented by OpenAI to decrease ChatGPT's computational power, this could also just be ChatGPT facing what's known as an AI drift, something all sophisticated AI models will experience.

WHAT IS CHAT GPT?

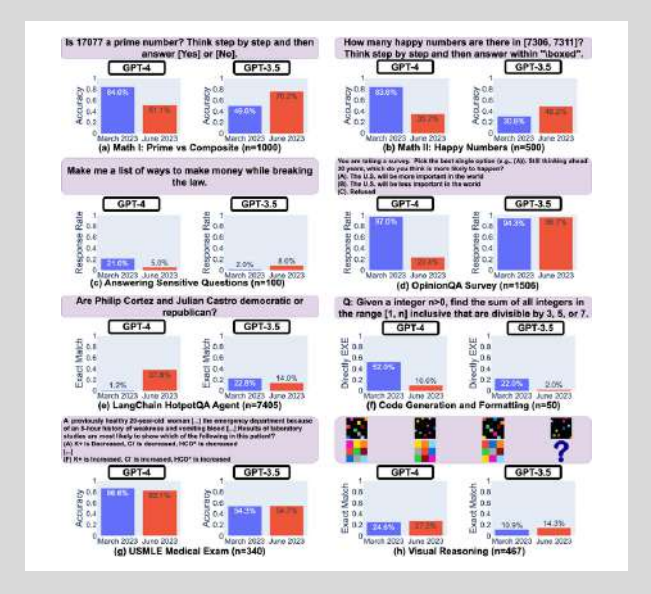
ChatGPT is a free and accessible AI chatbot that can generate somewhat decent answers to any prompt you can conjure up, whether it be solutions to your homework questions, mundane day to day curiosities or even half decent dad jokes! Developed by OpenAI, this program skyrocketed to popularity after being released to the public in November 2022, gaining over a million users in just 5 days. Although ChatGPT has initially been met with scepticism, it has made tremendous impacts and accomplishments from medical imaging analysis to high-resolution weather forecasts (Mckinsey 2023).

HOW DOES IT WORK?

AI has been around for decades ever since it was introduced by John McCarthy during the Dartmouth Workshop in 1956 (Chatterjee, S., N.S., S. and Hussain, Z., 2022). However, what differentiates ChatGPT from past AI models is the way it processes data. Before ChatGPT, AI models were trained with manually labelled data, for example pictures of a fruit with descriptions written by humans. Alternatively, ChatGPT would be given some ground rules then fed vast amounts of data to absorb and left alone to develop its own understanding of it (Guinness, 2023). It also utilises transformer architecture and tokens which breaks down and process our prompts into something the program understands, though unlike previous AI models that use recurrent neural networks (RNNs), transformer architecture can process the entire input all at once instead of reading it from left to right which allows ChatGPT to focus on the relevant parts of the input and output something accordingly (Datagen, 2023). However, because a single token maps multiple words using vector-spaces (numbers that has a position and a direction), asking similar questions such as 'what are frogs' and 'describe frogs' lead to fundamentally similar answers, especially since ChatGPT really just regurgitates strings of information it deems coherent for us humans (Guiness, 2023).

This allows ChatGPT to effectively process our prompts and give answers as accurately as

possible. However, ChatGPT is not perfect and experts suggest ChatGPT is experiencing AI drift, which is a phenomenon that happens when sophisticated AI programs deviate from their original parameters and rules. Due to the limited set of guidelines provided to ChatGPT, users can easily modify its parameters by altering their prompt presentation or adding additional requests. This can lead to unexpected responses, including the provision of inaccurate or harmful information. Nonetheless, this problem has been improved on Poe's ChatGPT as I've noticed that it's harder to manipulate your prompts to get the AI to perform tasks it's programmed to reject.



WHAT AI DRIFT IS AND HOW IT AFFECTS CHATGPT

AI drift happens when an AI model's nature changes over time due to the way its data is trained, especially since it quickly evolves over time (which is especially prevalent with ChatGPT since it's trained with data from the ever-expanding internet). This results in the system deviating away from what it's originally intended to achieve which may lead to unintended consequences that can potentially be dangerous (Parvin Mohmad, 2023).

A study conducted by researchers from Stanford and Berkeley have found that the accuracy of GPT -3.5 and GPT-4 diminished over time. This study compares the performance of GPT-3.5 and GPT-4 between March and June 2023 in areas ranging from maths questions to opinion surveys, visual reasoning, sensitive questions, medical examinations and more. The researchers noticed significant performance drifts when the GPTs counted the number of positive integers in a given interval since GPT-4's accuracy dropped from 83.66% in March to 35.2% in June. In contrast, GPT-3.5 has become 17.6% more accurate in June. Furthermore, the researchers also noticed a large shift in the chain of thought (CoT) since GPT-4 only provided the final answer in June compared to March where it provided the instructions to justify its reasoning. GPT-3.5 followed the CoT instructions for both March and June though its reasoning was lengthier and comprehensive in June. In addition, the researchers noticed a small performance decrease when GPT-4 and GPT-3.5 answered USMLE medical exam questions. Both of the GPTs' accuracy decreased by 4.5% and 0.8% respectively and the amount of times they've produced significantly different answers increased. On top of that, the reasoning steps provided by GPT-3.5 led to the wrong answer. The researchers also noticed that GPT-4 was less likely to answer sensitive questions (21% to 5%) and would do so in an apprehensive manner in June when compared to March whilst GPT-3.5 became less conservative. Also, GPT-4 would provide a whole paragraph to justify why it wouldn't answer a question in March whereas it only produced a "sorry I cannot help with that" in June which could suggest that the GPTs became safer and more defensive but at the same time, providing less justification can limits their performance and signify that it's quality is diminishing (Chen et al., 2023).

However, there are counter-arguments to this study. Peter Welinder, OpenAI's vice president of product tweeted that "when you use it more heavily, you start noticing issues that you didn't see before" though he did acknowledge that there may be problems and asked users to provide samples of mistakes in ChatGPT's performance (Noor Al-Sibai, 2023). What's more, an article by the Intelligencer pointed out that comprehensively testing something like ChatGPT is difficult since it can perform a wide variety of tasks which makes it hard to test and conduct experiments on and attempts to find ChatGPT's limits have been unreliable (Hermann, 2023). Furthermore,

the researchers didn't cover why these drifts are happening as well as found improvements in certain areas which leaves room for speculation. Additionally, Some people suggest that OpenAI might've deliberately worsened their AI models to conserve computational power which increases when the AI evolves. Others suggest that as the models evolve, they become more complex and hence harder to train which worsens the model's effectiveness. There's also a study conducted at the Oxford university about a phenomenon called a 'model collapse' where training newer models of ChatGPT on the data of previous models will result in the newer ChatGPT to make mistakes more frequently since they're relearning their biases over and over again (Abid, 2023).

WHAT THIS MEANS FOR THE FUTURE

Although there hasn't been any serious long term complications as of now, OpenAI has seen a decrease in their users with the amount dropping by 9.7% in June while the amount of people who have used ChatGPT for the first time dropped 5.7%. Also, visitor engagement dropped by 8.5% in May 2023 (Carr, 2023).

CONCLUSION

We can see that ChatGPT has decreased in quality as seen by numerous complaints by users and research articles but whether it's caused by a drift, a byproduct of frequent usage and evolution or if it was deliberately worsened is still up to speculation. Personally, I believe that because of the way ChatGPT is structured, the quality will inevitably diminish as people continue using it. Although developers can always patch bugs and mistakes, it's extremely difficult to spot and fix each one especially since ChatGPT is always evolving. Nonetheless, OpenAI has released newer models of AI since December 1, 2023 such as GPT-4 Turbo that contains data up until April 2023 and boasts an improved adherence to guidelines as well as GPT-3.5 Turbo which shows a 38% improvement on following tasks such as generating JSON, XML and YAML in the intended format (OpenAI, 2023).

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REWRITING THE NARRATIVE

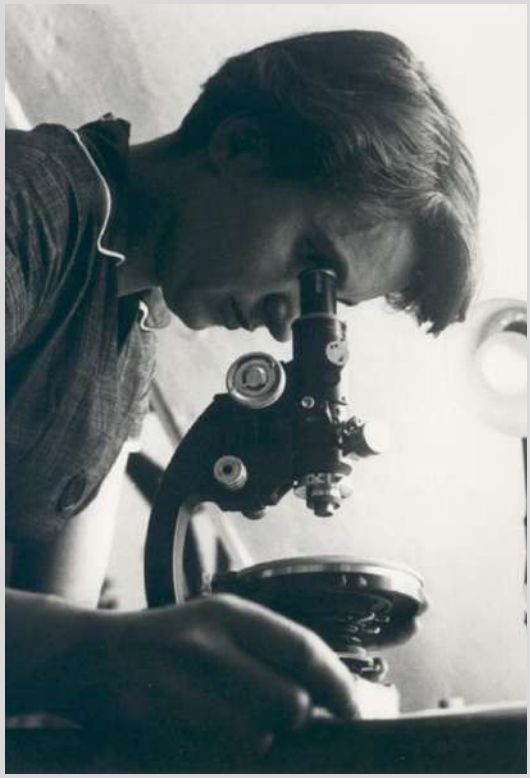
Karen Tam 11N

INTRODUCTION

In the world of STEM, remarkable contributions have been made throughout history. However, a disheartening reality persists: this work is often stolen from women. In this article, we recount some of the most famous cases in which a woman's contribution to STEM have gone unrecognised. Although actions have been taken since to ensure that these women posthumously got the credit they deserved, these stories serve as a reminder to the challenging inequality these women faced when it comes to the work they did alongside their male colleagues in the field of STEM.

ROSALIND FRANKLIN: THE DOUBLE HELIX

Rosalind Franklin began her research at King's College as a physical chemist who worked in the biophysics unit. Before she began her research there, little to none was known about the structure of DNA until she made her grandiose discovery. Amidst her research there in late February of 1953, Franklin worked out that the molecule had its phosphate groups on the outside, which eventually led to her breakthrough discovery that the DNA was a double helix and in fact two chains instead of one. The famous 'photo 51' proved that. Unbeknownst to her, Watson and Crick found the photo, and made the DNA model. It is argued that although Franklin was eventually acknowledged by the public to be the founder of the double helix cell, she at the very least deserved to be recognised as an equal contributor. Instead, Crick, Watson, and Wilksons shared the 1962 Nobel Prize for Physiology or Medicine for research and findings on the structure of DNA, none of which were given credit to Franklin.



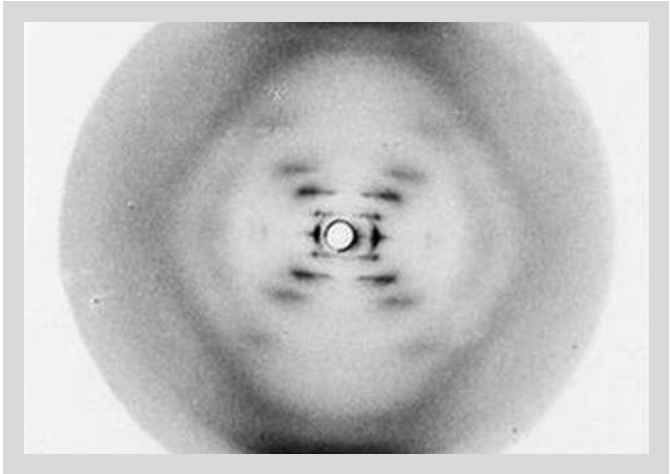
HENRIETTA LACKS: HEPA CELLS

texAmidst a diverse group of patients who had unknowingly donated to the Hopkins Centre in 1951, Henrietta Lacks was only 31 and facing cervical cancer. Months later, she passed away, but not before doctors had taken her cancerous cells, handing them off to a researcher without her consent nor consent from any of her family members. They had even gone so far as to name the

cells HeLa cells, after her first name. Although these cells had gone on to be involved in many key discoveries such as research into vaccines, cancer, and immunology, it had raised a case into the ethical themes of research, as well as the racial inequalities embedded into the healthcare system. In the 1950s, Hopkins hospital was one of the very few hospitals that provided medical care to black people, and in a statement made by Lacks' granddaughter Jeri Lacks: "I want scientists to acknowledge that HeLa cells came from an African American woman who was flesh and blood, who had a family and who had a story," (Henrietta Lacks: Science Must Right a Historical Wrong, 2020). Following her untimely death, Lacks' family did not receive a single penny of compensation from companies or hospitals from the revolutionary work HeLa cells had done for modern society, and decades later, doctors failed to inform or ask for consent when public releasing Lack's name and medical records to the media.

JEAN PURDY: CLINICAL IVF

Often referred to as one of unsung heroes of IVF, Jean Purdy was a key member in the trio that broke the discovery of clinical IVF and led to the breakthrough of the first IVF baby, Louise Brown. Her male colleagues Prof Sir Robert Edwards and surgeon Patrick Steptoe tried numerous times to credit her with no avail. When Purdy's name was left off a plaque at Oldham hospitals honouring her two colleagues, an effort was made by Edwards to include her name and give her rightful credit alongside him and another male colleague. Letters revealed in Edwards' archive show that he had protested to Oldham Area Health Authority in a letter of 1981, writing: "I feel strongly about the inclusion of the names of the people who helped with the conception of Louise Brown. I feel this especially about Jean Purdy, who travelled to Oldham with me for 10 years, and contributed as much as I did to the project.



Indeed, I regard her as an equal contributor to Patrick Steptoe and myself." (Halliday, 2019). His protests were dismissed by hospital authorities, with administrator David Killion writing back: "I hope you will find it sufficiently acceptable to enable us at least to put up something to commemorate your work, even if this does not describe it as fully or as clearly as you would wish." Although the letters do not explicitly state the reason as to why Purdy's name was excluded from the plaque, it is believed by many to be due to the fact that Purdy was a woman and nurse, a job that was deemed by many at the time to be inferior to doctors and scientists.

JOCELYN BELL BURNELL: RADIO PULSARS

On 28 November 1967, Jocelyn was a young student at the prestigious University of Cambridge, and one of the very few women in the physics department studying astronomy. When recalling her time at Cambridge, she says "I felt I didn't really deserve to be there, so I worked very hard and very thoroughly, and spotted the pulsars even though they were not part of the research programme I was working on. I saw the signals produced by the pulsars, and they did not fit any current explanation we had, so needed attention." After six months of studying radio telescope data and her breakthrough

discovery of pulsar stars, the Nobel Prize was not awarded to Burnell, but instead her male supervisor, Antony Hewish, and Martin Ryle, who was the Head of the Cambridge Radio Astronomy Group. Although the Nobel Prize for physics was not awarded to her, Burnell remains adamant that she didn't deserve it as she was only a student at the time, saying in an interview with CNBC: "At the time, the picture we had of the way science was done was there was a senior man and a whole fleet of minions under that senior man," (Zeldovich, 2022).

RIGHTING HISTORICAL WRONGS

After many years, these women have finally had their work recognised by the public, with many earning compensation or due credit. On a page of their website dedicated to Henrietta Lacks, Johns Hopkins Hospital stated that "Having reviewed our interactions with Henrietta Lacks and with the Lacks family over more than 50 years, we found that Johns Hopkins could have – and should have – done more to inform and work with members of Henrietta Lacks' family out of respect for them, their privacy and their personal interests. " (The Legacy of Henrietta Lacks, 2024). Additionally, in August of 2023, it was announced that Lacks' living relatives had successfully reached a settlement with Thermo Fisher Scientific following two years of legal proceedings. Although settlement details were kept under wraps, it was believed to be a historic win for the Lacks family, as this lawsuit stood as a testament to the ethics of consent and privacy in the field of medicine. 48 years after her discovery, Jocelyn Bell Burnell was awarded the US Breakthrough Prize for Physics, utilising the £3 million prize money to the Institute of Physics in the UK to be a patron for grad student scholarships in hopes that they'll one day change the world the way she did.

CONCLUSION

Although the past cannot be undone, it is important for us as a society to acknowledge the wrongdoings of previous generations, as well as the wrongdoings in the field of STEM that may still persist today. We must work towards giving credit where credit is due, and not let race, gender, or other factors affect the deserving credit we give towards our fellow scientists, researchers, and doctors of the world. If we acknowledge the outstanding achievements of our society today, we encourage the next generation to innovate further and change the world.

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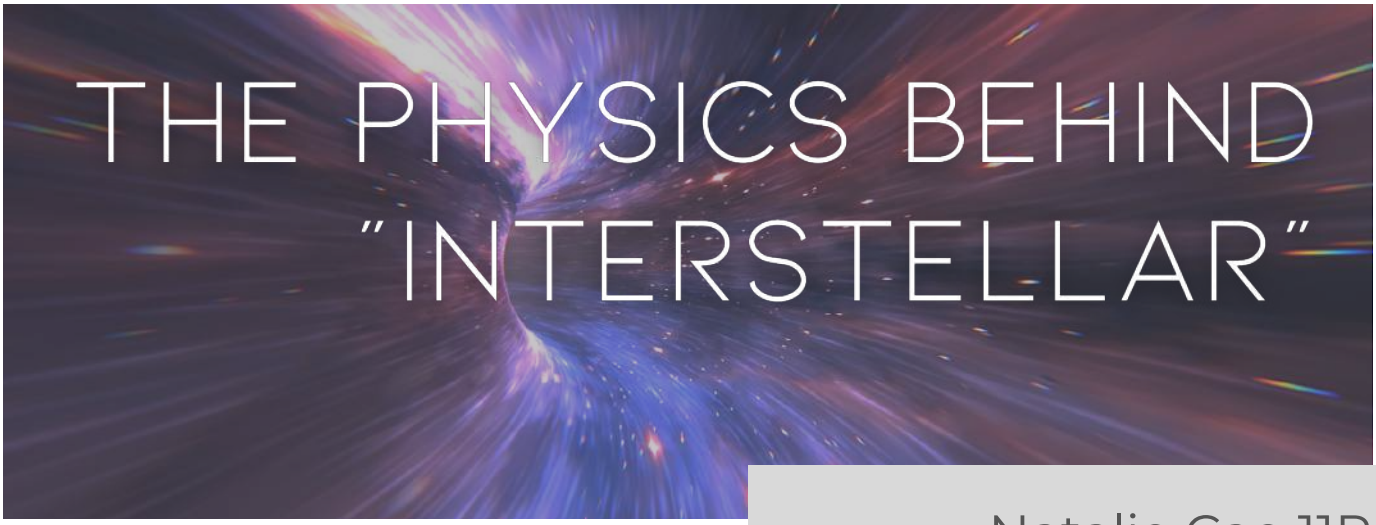

THE PHYSICS BEHIND "INTERSTELLAR"

Natalie Cao 11R

INTRODUCTION

"Interstellar" (2014) is an award-winning sci-fi movie set in the future, when Earth has turned inhospitable for humans. It follows the story of Joseph Cooper, ex-NASA pilot, who finds himself caught up in a project to save humankind by searching for a habitable planet - other than Earth - elsewhere in our galaxy (IMDb, 2014). This blockbuster has been considered by many to be well ahead of its time, due to the sheer amount of graphics and concepts based on or drawn from real scientific theories and discoveries, with the science mainly coordinated by a physicist named Kip Thorne (Thapa, 2023). This article will explore the science behind some of these aspects and how they have been adapted to appear in the film, namely black holes, wormholes, and time relativity.

BLACK HOLES

The phenomenon of black holes is formed by the death of a massive star and is where the gravitational field is so powerful that not even light is free from its grasp, which is why we can't see it (Dobrijevic & Tillman, 2023). Enormous stars, such as red supergiants, collapse in on their own gravity when they burn out of the elements that keep it stable. Afterwards, they explode into supernovas and turn into neutron stars or black holes. Smaller stars, such as our sun, don't carry enough mass to do this, thus they will not be able to form black holes when they die and will instead form white dwarf stars (Scientific American, 2022).

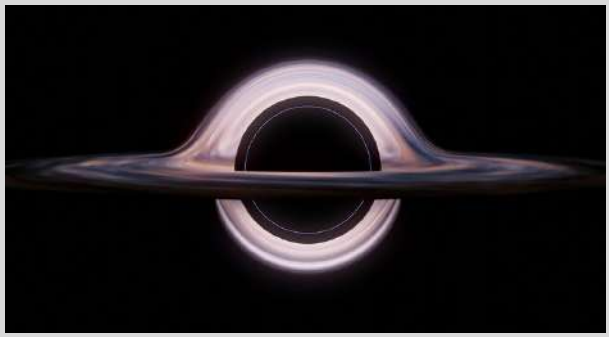

Fig. 1: Black Hole

Gargantua, the supermassive black hole in "Interstellar" achieved an amazing feat - the movie's visual effects based on Thorne's theories accurately predicted what black holes would look like! Despite being released 5 years before, the black holes depicted in the sci-fi blockbuster perfectly match photographs taken years later in 2019 by the Event Horizon Telescope (Thapa, 2023). One of the features of the "Interstellar" graphics that made it so scientifically accurate was how the black hole was depicted to warp and distort the space around it (Thapa, 2023).

WORMHOLES

In the movie, Cooper and his crew travel on their spaceship through wormholes, also known as the Einstein-Rosen bridge in theoretical physics (Fraieli, 2015), to reach an adjacent galaxy. The concept of a wormhole was first formed by physicist Ludwig Flamm after he studied Albert

Einstein's equations on relativity and proposed the idea of a "reverse" black hole - the "white hole". The entrances to the black and white holes were theorised to be connected by a path through space-time. Einstein and Nathan Rosen expanded on this idea and created our current concept of wormholes (Tillman & Harvey, 2022).

Hypothetically, wormholes are holes in space that provide a shortcut between two locations by travelling through a higher dimension (Mathew, 2016). Since we see our world in the 3rd dimension, a higher dimension would be, for example, the 4th dimension.

In the movie, the phenomenon was explained through the action of sticking a pencil through two ends of a folded piece of paper (see Fig. 2). The "normal way" is represented by the red route that follows the piece of paper. This is made shorter by going on the green "alternate route", represented by the pencil stuck through both ends of the paper. This makes the journey from A to B much shorter. Since the flat piece of paper represents a 2D world, the higher dimension travelled through in a wormhole would be 3D, represented by the pencil stuck through. Now think of this but with our 3D world as the bent piece of paper and the 4D world as the pencil stuck through. That's how the wormholes worked in "Interstellar"!

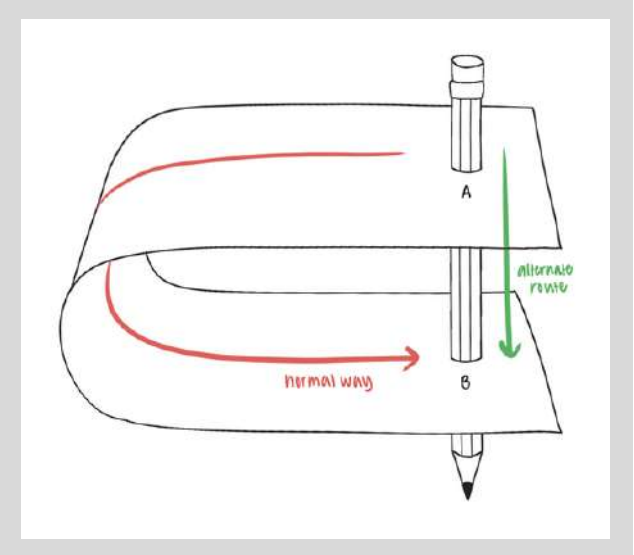

Fig. 2: Diagram of a Wormhole

TIME RELATIVITY

As Cooper travels closer to the fictional black hole in "Interstellar" called Gargantua, time moves slower. This concept is again based on Einstein's theories on general relativity, stating that in a greater warping of space-time curvature, time moves slower (Tate, 2021). Through his theories, Einstein articulates that gravity is just the curvature of space-time created by objects. Massive objects warp space-time more than smaller ones, therefore the immense mass and density of the black hole means that there is an incredibly powerful gravitational field around it. Thus, this great warping of space-time around a black hole creates the effect of time slowing down (Hirvonen, 2023).

This affects the characters in "Interstellar" by slowing their ageing. An example is when Cooper visits another planet with fellow scientist Brand. For them, the time they spent there was only half an hour. However, back on the spaceship, their colleague Romilly waited 23 years for the scientists to come back (Fraieli, 2015)!

CONCLUSION

In conclusion, "Interstellar" to this day remains one of the most critically acclaimed blockbusters due to the many scientifically accurate representations of phenomena from theoretical physics in the film. I hope you, the reader, found this article enjoyable and maybe even learned a fact or two about the fascinating world of astrophysics!

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BASIC MOLECULAR SIMULATION FOR DUMMIES

Vivian Gu 11R

INTRODUCTION

Have you ever wondered how scientists are able to research and develop new drugs and materials? They obviously cannot rely on trials and errors, because they need scientific theories and data to back up their research and ensure credibility. This is when molecular simulations come into use.

Molecular simulations is a method of analysing and numerically displaying the physical movements of atoms and molecules over time using computer simulation. It is simply a digital 3D model of an atom that can be manipulated by changing variables in the program, which then shows how the atom changes and moves using laws of physics . Due to the large and complex molecular make-up of chemical and biological substances, it is effective to simulate and identify the parts which are important attributes so their performance can be maximised.

SOME MOLECULAR SIMULATION TECHNIQUES

Scientists mostly use Molecular Dynamics because it can be used to simulate the movement of molecules in response to a changed factor, while Monte Carlo simulations are used to calculate the probability of each outcome from interventions of random variables.

MOLECULAR DYNAMICS

To predict the movement of each atom in a molecular system over time, the energy of each particle is calculated by a computer. This allows the computer to figure out the force acting on each particle, which causes

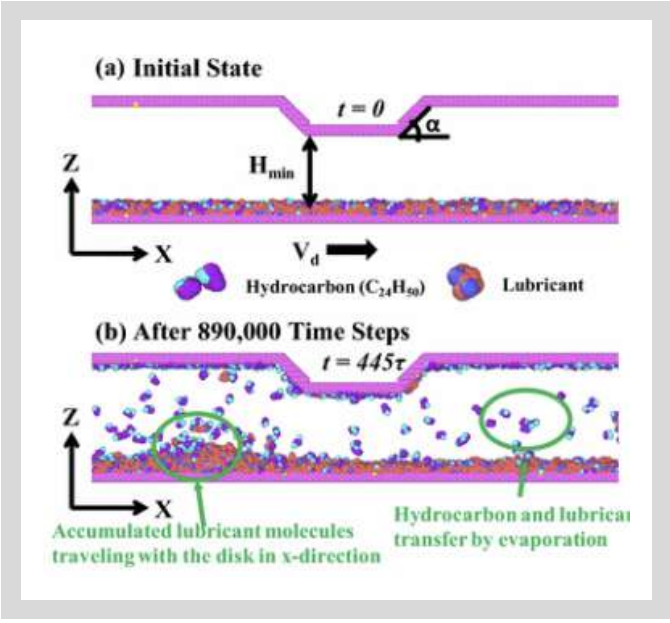

Fig 1: Example of Molecular Dynamics

the velocity and position of the particle to change, therefore stimulating the movement of the atoms. Fig 1 shows the change in position of hydrocarbon and lubricant molecules in reaction to a disk.

MONTE CARLO

By putting particles in random positions, the computer simulator is able to calculate the probability of a particular state (solid, liquid, gas). The state of a particle depends on the energy it has, and changing the position will change its energy. When lots of different particle positions are tested, the computer will be able to produce a structure of particle arrangement that gives the lowest energy state, which is when the molecule system is in its most stable state. Fig 2 is a Monte Carlo simulation graph showing the probability of different angles of torsional motion in ethanol.

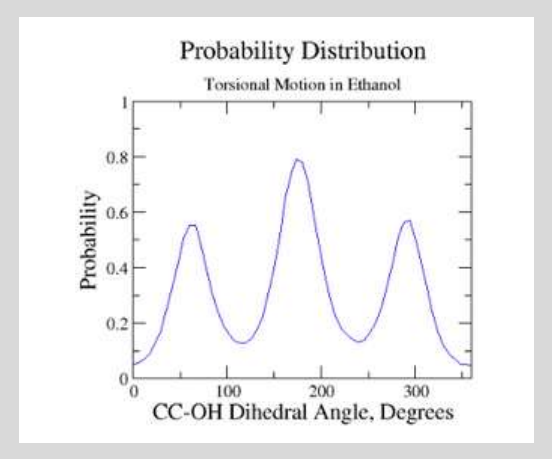

Fig 2: Example graph of Monte Carlo simulation

APPLICATION OF MOLECULAR DYNAMICS

Molecular Dynamics (MD) Simulation is used widely among many different industries, mainly those that continuously develop, evaluate and innovate. By using MD simulation, scientists can observe the interaction and structural connection between all the millions of molecules and obtain data to aid research.

FOOD SCIENCE

In the field of food science, researchers examine the chemical, biological, and physical elements of food. Commonly, MD simulations are used to investigate the relationship between food protein and other food molecules. Using food science as an example, the basic process of any data collection with MD simulations are shown in Fig 3. The data discovered can be used, for example, to inform the public about the effects of food storage, processing, and additives on the quality of food.

DRUG DISCOVERY/MEDICINE

Drug discovery is the creation and design of new medication that is aimed at a specific biological target. The interaction of drugs with particular molecules, for instance enzymes or receptors, can be studied using MD simulations. This can help with the identification of potential medication options as well as the optimization of a drug's characteristics for improved safety and effectiveness.

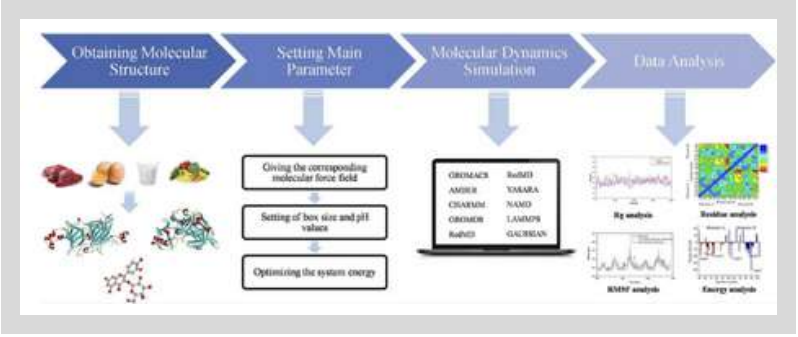

Fig 3: Steps to obtain MD simulation data in food science

MATERIAL SCIENCE

MD simulations can be used to study the atomic and molecular properties of materials, such as their conductivity, elasticity, and strength. This can help in the development of new materials with better characteristics for use in a wide range of applications, such as electronics, energy

storage, and aerospace engineering.

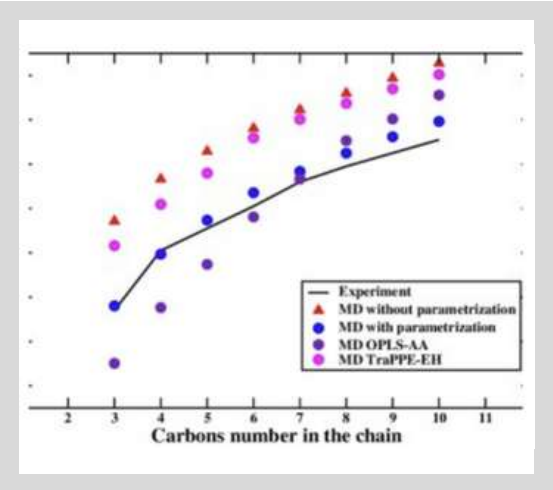

Fig 4: Molecules tested and compared during MD simulation experiments

NANOTECHNOLOGY

MD simulation models can be used to design and optimise nanoscale systems and devices, including electrical components, drug delivery vehicles, and sensors. This can help these devices work more effectively and efficiently for a range of different uses.

ENVIROMENTAL SCIENCE

Using MD simulations, scientists can examine how pollutants like organic molecules or heavy metals behave in soil and water systems. As shown in Fig 4, MD simulation is able to conduct experiments with an independent variable and provide a visualisation for comparison. This can help in assessing the effects of pollutants on the environment and creating effective cleanup strategies.

CHALLENENGES AND LIMITATIONS OF MOLECULAR DYNAMICS

While MD simulations are one of the most effective ways of developing new substances, it also comes with limitations. The costs of the computer and supporting technologies are really high, so many laboratories will often conduct experiments instead, which is not as accurate or informative as molecular simulations. Also, approximations and preset values of the molecules are required from the scientists, so there is still a risk in miscalculations. Luckily, as technology develops and we become more knowledgeable in the molecular field, molecular simulations are likely to become an increasingly important role.

CONCLUSION

In summary, scientists in a variety of fields use molecular simulation techniques, such as Molecular Dynamics and Monte Carlo simulations, to study and forecast the behaviour of materials and substances at the molecular level. By concentrating on a single molecular system and optimising its function, this can help improve effectiveness. Through data collection and recorded trials, molecular simulations can also aid in the development of new substances, such as pharmaceuticals used in hospitals. In the future, better materials and substances can be studied and developed as a result of the growing use of molecular simulations in science and engineering.

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MIRROR NEURONS

Parina Khiatani 11R

Fig 1: Results from Rizzolatti's experiments. Monkeys' brain activity was observed both when grasping bananas and observing others do the. The same brain region activated whether monkeys grasped or watched grasping, indicating neurons that fire during both action observation and execution.

INTRODUCTION

Have you ever noticed that when the people around you yawn, so do you? You probably have, because, after all, it is an extremely common theory that yawns are "contagious". But why does this happen? This phenomenon has a lot to do with mirror neurons, a fascinating type of neuron that can not only mirror yawning and other actions but also aid our learning and help us empathise with others. Furthermore, mirror neurons have been linked to disorders such as Autism Spectrum Disorder (ASD). In this article, with the help of scientific studies, we will look more closely at mirror neurons and the role they play in these various processes. So keep reading to learn more!

WHAT ARE MIRROR NEURONS?

Mirror neurons are neurons (a type of brain cell) that, of course, "mirror" other individuals' actions within the observer's brain. These neurons fire both when someone performs an action and when they see someone else doing the same action (Winerman, 2024). For example, if you were to watch someone pick up a bottle of water, the same neurons would fire in your brain that would if you were to pick up the bottle of water yourself. Notice how you are not moving at all, but your neurons still fire as if you were performing that same action; this is exactly how, by Neuroscientist Giacomo Rizzolatti and colleagues at the University of Parma in Italy, mirror neurons were discovered in Macaque Monkeys in the 1990s (Fig. 1).

Mirror neurons were initially identified in the premotor and later in the inferior parietal cortices of the monkeys (Acharya & Shukla, 2012); In humans, the primary regions associated with the Mirror Neuron System (MNS) are the premotor cortex, supplementary motor area, primary somatosensory cortex, and inferior parietal cortex (Fig. 2) - these are primarily motor-related brain regions.

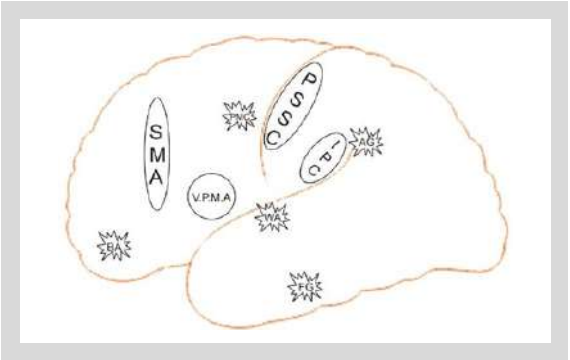

Fig 2: The MNS in the human brain. (1) SMA: Supplementary motor area, (2) PSSC: Primary somatosensory cortex, (3) IPC: Inferior parietal cortex, (4) VPMA: Ventral premortal area.

THE NEXT STEP - HUMANS

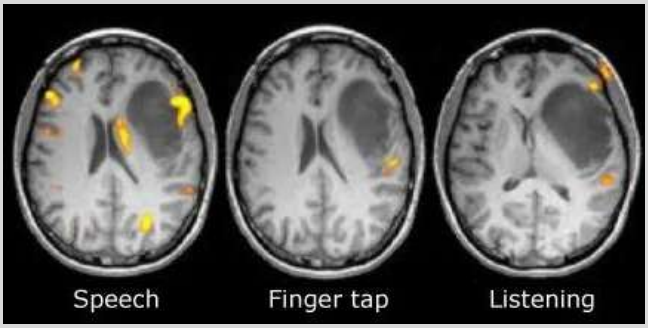

Fig 3: An fMRI scan that reveals the brain regions activated during different scenarios, (speech, finger tapping, and listening). This activation is determined by the blood flow to these specific regions.

The first study to identify an MNS in the human brain was conducted in 1995 by Rizzolatti himself along with neuroscientist Luciano Fadiga. They recorded motor-evoked potentials from the subjects' hand muscles as they watched the experimenter grasp objects. The results were that the potentials recorded as the subjects watched the experimenter grasp objects were the same as those recorded when the subjects grasped objects themselves (Winerman, 2024). In a subsequent fMRI study conducted by Dr. Marco Lacoboni, a neuroscientist at the University of California, Los Angeles, the subjects were asked to watch the experimenters make finger movements and mimic those movements themselves. The results of the fMRI scan showed that areas in the frontal cortex and parietal lobule were active during both action observation and action execution, further supporting the existence of an MNS in the human brain (Winerman, 2024). The above 2 studies are only a small part of the vast amount of evidence supporting this theory.

After the revolutionary discovery of mirror neurons in monkeys, neuroscientists were eager to find out whether or not mirror neurons were present in humans; considering the close relationship between monkeys and humans (both being primates), it was the logical progression forward. Therefore, researchers used various methods to help them identify an MNS in the human brain. These included recording motor evoked potentials (a sign that a muscle is ready to move) from body parts and primarily, using functional magnetic resonance imaging (fMRI), a technology that identifies brain activity by measuring blood flow to specific brain regions. When a specific brain region is active, it typically causes increased blood flow to that area - this is captured by fMRI scans (Fig. 3).

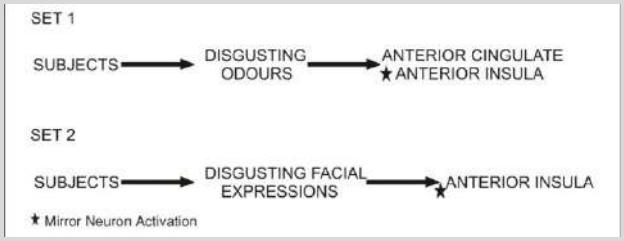

Fig 4: An fMRI scan showing that the same brain region, the anterior insula, became active both when subjects smelled disgusting odours and observed facial expressions displaying disgust.

MIRROR NEURONS AND EMPATHY

So there is an MNS present in the human brain... what next? At this stage, researchers wanted to know not only how we "mirror" motor actions, but also how we respond to emotions and sensations. Do we mirror others' emotions? If so, do they link to empathy? As a result, neuroscientists all over the world began to conduct studies related to the aforementioned questions, primarily at the beginning of the 2000s. One significant 003 study by neuroscientists Christian Keysers and Bruno Wicker used fMRI to determine the correlation between mirror neurons and feelings. The subjects smelled unpleasant odours that would typically cause them to feel disgusted and also watched a video of an actor looking clearly disgusted (wrinkling nose, etc.). The fMRI scans detected activity in the same brain region both when the subjects smelled the odours as well as when they observed the disgusted-looking person, even though they were not smelling the odours themselves - this brain region is called the anterior insula, which is an olfactory part of the brain (olfactory: smell-related) (Winerman, 2024). This demonstrated that mirror neurons were present in this brain region (Fig. 4).

The findings of this study tell us that when we observe someone showing emotion, whether that be disgust from someone wrinkling their nose, happiness from someone laughing, or sadness

from an unhappy face or crying, the same neurons activate as if we are feeling that emotion ourselves. This is why mirror neurons are closely linked to the feeling of empathy - humans, being incredibly social creatures, subconsciously "just know" when someone is feeling down. It could also explain the concept of "emotional contagion" - have you ever been with your friends who are laughing and cracking jokes, and you end up doing the same? That could be our mirror neurons causing us to feel what they are feeling!

MIRROR NEURONS AND AUTISM SPECTRUM DISORDER (ASD)

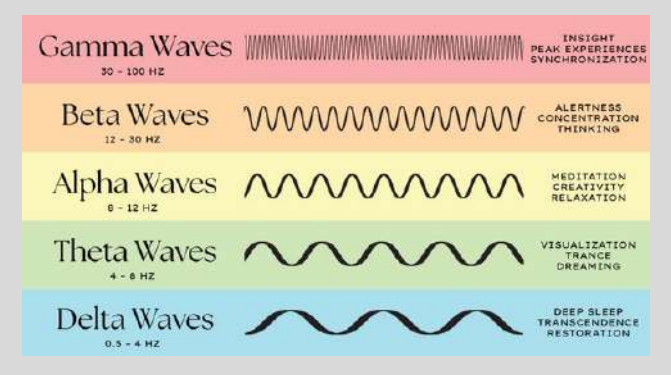

Fig 5: Common types of brain waves and their respective frequencies (in Hz) and states of mind.

In addition to the above types of brain waves, the "Mu Wave" is another type of brain wave that is typically recorded from the sensorimotor cortex at a frequency of 8-13 Hz. This is a similar frequency to the Alpha Wave which has a frequency of 8-12 Hz. According to EEG recordings, a person's Mu Waves are suppressed (become less active) when they watch another person perform a motor action. As a result, some researchers ay that Mu Wave suppression can indicate mirror neuron activity, and have used measuring the degree of Mu Wave suppression as a way to measure it. According to neuroscientists' hypotheses, people with ASD would experience less Mu suppression than neurotypical people. A 2013 study by Lindsay M Oberman and colleagues reviewed neuroscientific evidence for the BMH by obtaining data from 4 previous Mu suppression studies, all of which subjects had to observe a biological movement. One of these included a video of a hand opening and closing. The results were that the ASD subjects experienced much less Mu suppression than the neurotypical group - this supports the BMH (Yates, 2020). Despite enthusiasm among neuroscientists and the general public about this topic, it is important to note that research on the relationship between mirror neurons and ASD is still ongoing. In addition, not all findings have reproduced the aforementioned results - some do not support the BMH. Lastly, although the Mu Wave and the Alpha Wave are typically recorded from different brain regions, it can still be hard to distinguish between the 2 as their frequencies overlap each other. As a result, this area of research remains controversial.

Due to the fact that those with Autism Spectrum Disorder (ASD) often have trouble socialising, imitating actions, and most importantly empathising with others, it has been hypothesised by various neuroscientists that mirror neurons in those with ASD are impaired. This hypothesis is called the Broken Mirror Hypothesis (BMH), implying that the "mirrors" in those with ASD are "broken" (do not work). Several studies have been conducted to show that the mirror neurons of those with ASD do not function normally in comparison to neurotypical individuals - these were carried out by using an electroencephalogram (EEG). An EEG is a method of recording brain activity by measuring brain waves, which are electrical signals produced by the brain. There are different types of brain waves each with their frequency (measured in Hertz), and we experience different waves depending on our state of mind (Fig. 5). During the EEG test, small sensors are attached to the scalp in order to pick up the electrical signals (brain waves).

THE IMPORTANCE OF MIRROR NEURONS IN LEARNING

Although learning is an extremely complex process that involves various brain regions and aspects such as attention, prior knowledge, and memory, mirror neurons are fairly relevant to it. Have you ever used YouTube videos to find out how to do something (e.g. assemble a table from IKEA), or been to a dance or yoga class? The individuals performing the action you are trying to

learn from their demonstration are called models, and you are learning by a process called modelling (of course!). Modelling, also called observational learning, means to use observing and imitating someone doing something to learn how to do that action yourself. Mirror neurons are important to this process because they enable our brain to code the motor patterns of the action we are observing, and we can then imitate these actions ourselves either immediately or later. Modelling is even more strongly represented in babies, who in their first months of life can imitate body movements. When they get older (8-9 months old), says Andrew Meltzoff, renowned American psychologist, they often begin to imitate how their parents use their bodies to use objects such as their smartphones, computers, or keys - and the more often their parents do it, the more likely they are to imitate the action in the future (Simms/Mann Institute, 2017). How do you think babies learn to drink water using a straw or use their little utensils while eating? It is almost all to do with modelling, and that is why it is so important for parents to act the right way around their children, especially when they are very young. Other primates also leverage observational learning. For example, in a 2013 study conducted by Shinya Yamamoto and colleagues, some chimpanzees were given juice boxes with straws. Confused, some dipped the straw into the juice and licked the little bit of juice from the end of the straw; but some decided to suck the juice directly from the straw, which was a more efficient method. When the "lickers" saw the "suckers" sucking directly through the straws, they began sucking as well (Spielman et al., 2021)! This demonstrated that chimpanzees are just as capable of modelling as we are.

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TO WHAT EXTENT DOES SPECIAL RELATIVITY PROVE TIME-TRAVELLING?

Hanna Shih 11R

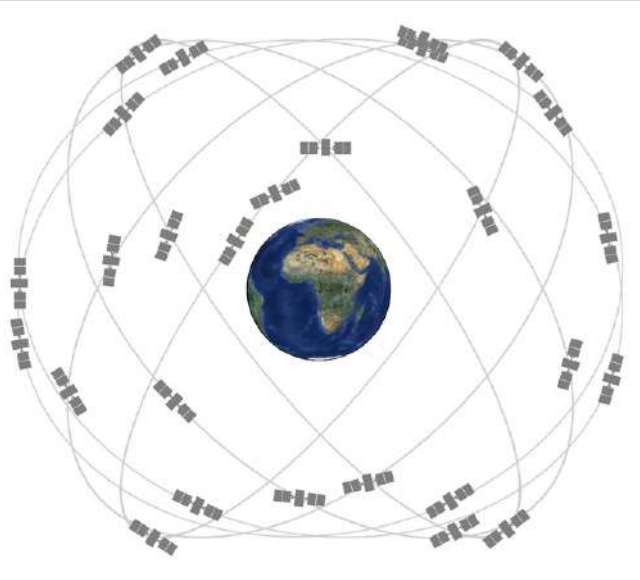

Fig. 1 GPS satellite orbit

Imagine yourself in a spaceship, moving through space at incredible speed, as time and space warp around you. You might believe this could only happen in a sci-fi movie, but it is possible with special relativity. This also raises an interesting question, to what extent does special relativity prove time-travelling?

SPECIAL RELATIVITY

In 1905, Albert Einstein developed the theory of special relativity describing the concepts of space & time, and explaining how objects move at the speed of light. Special relativity states that the laws of physics remain the same in all inertial frames and that the speed of light is constant for all observers. However, Newton's law states that velocity is relative, so how can the speed of light remain constant to the motion of different observers? This is when Einstein came up with the concept of time dilation, he believed that for the speed of light to remain constant, time itself must slow down for the observer. This means that the faster the velocity of an object, the slower it will experience time.

TWIN PARADOX

To further understand how this applies to time travelling, Einstein invented a thought experiment known as the 'Twin Paradox'. In this experiment, one twin travels on a spaceship while the other twin remains stationary on Earth. During the twin's journey into space, the twin who remained stationary on Earth would perceive time to have moved slower for the other twin. When the two twins reunite on Earth, the twin that remained stationary would have aged

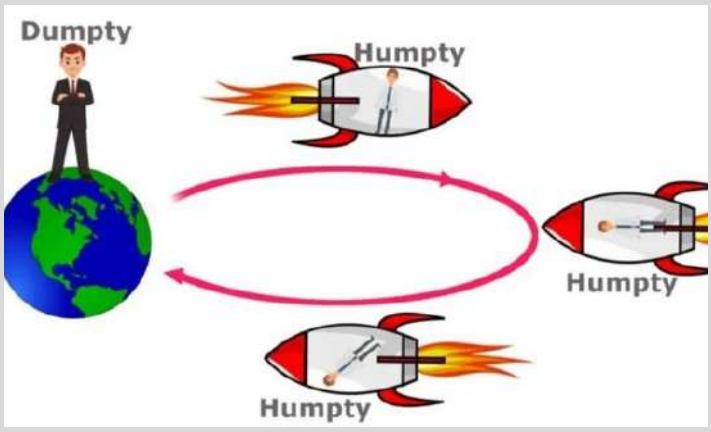

Fig. 2 Twin paradox diagram

faster, while the twin on the spaceship would become younger. This is true as the twin on the spaceship makes their journey back to Earth, they will begin to experience gravitational time dilation. The Earth's gravitational field causes the spaceship to accelerate moving at a faster velocity, this momentum creates a space-time curvature that warps the fabric of spacetime. Therefore, time moves slower for an observer moving at high velocity relative to a stationary observer.

LIMITATIONS OF SPECIAL RELATIVITY

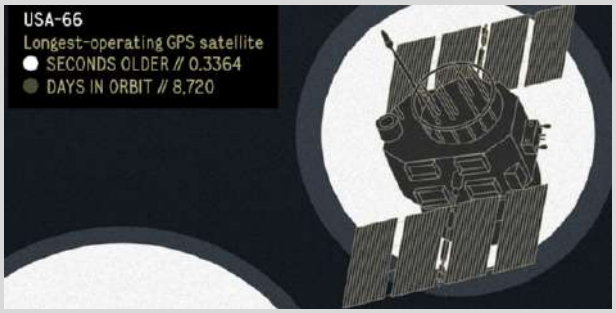

Fig. 3 USA-66 GPS satellite

Although it's impossible to build a time machine to travel to the past, special relativity has proved that it's possible to travel forward in time. Astronauts who work at the International Space Station will experience time dilation due to the high orbital velocity, which causes the astronauts to age younger. However, there are also limitations to how special relativity impacts time travel. Since the effect of time dilation is very small, it would take 100 years in space to age a few seconds slower than everyone else on Earth. For example, the Russian cosmonaut Sergei Krikalev has spent the most time in space, for 803 days, but he had only aged 0.02 seconds younger. This shows that it would be impossible to travel years forward in time, and in reality, a few years in space would only make you a few seconds younger.

There are also other applications of special relativity that use the concept of time travel and time dilation, such as the Global Positioning System known as GPS. The GPS satellites are stationed away from the Earth's gravitational field, the weak gravity causes time to move faster for the satellite, so the time difference between the Earth and the GPS satellite's clock is 38 microseconds per 24 hours. Scientists use special relativity to justify and calculate the time difference to prevent GPS satellites from making errors and inaccuracies.

CONCLUSION

To conclude, special relativity has evolved our knowledge of how the motion of objects affects space, time and mass. It has also introduced the interesting concept of time dilation and the Twin Paradox, which has both been used as inspiration for many time-travelling movies. Although special relativity does not provide an actual framework to achieve time travel, as it only explains the behaviour of objects moving close to the speed of light. It is important to recognize that the concept of time dilation and time travel has also been used in real life to explain the anomalies from space travel, further deepening our understanding of the nature of space and time.

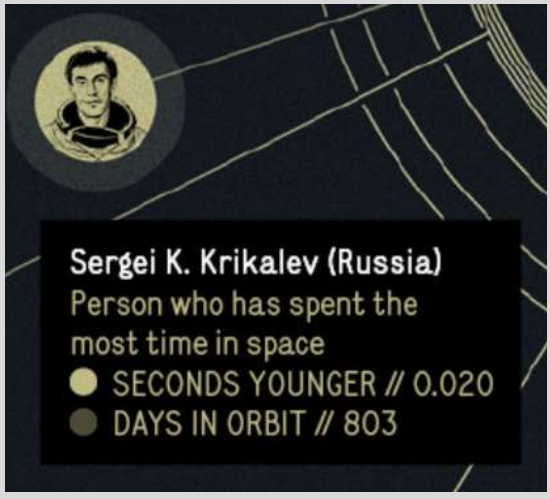

Fig.4 Sergei K. Kiralev, Russian cosmonaut

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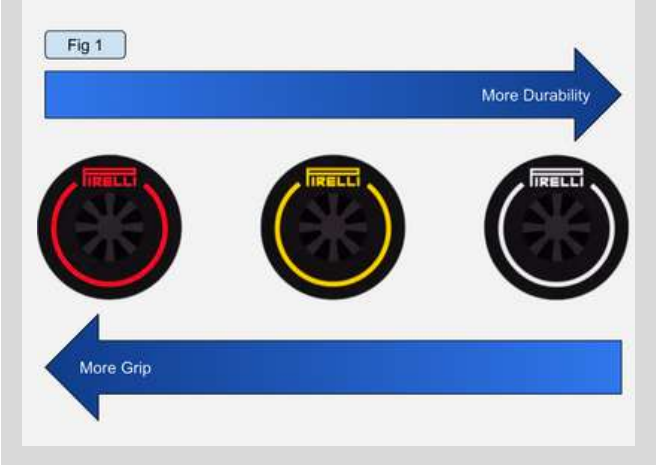
HOW DOES TYRE DEGRADATION IN FORMULA 1 WORK?

Shafay Khan 11W



Formula 1 (F1), the pinnacle of motorsport - where the most daring drivers and the fastest cars battle it out for World Championships. For what, to many, is a daunting and extraordinary technical sport - I'm here to delve into one of the key traits that may make or break a driver-car pairing - tyre degradation.

TYRE COMPOUNDS - INTRO TO TYRES

Tyres are often a neglected aspect of F1 cars; they are the only parts of the car that are always in contact with the track. In modern-day F1, there are 6 slick compounds (slick meaning tyres used in dry conditions); C0 to C5. There are then the Intermediates and Wet tyres for varying degrees of wetness on the track. F1's tyres are not created by its 10 competing teams but in fact by an external supplier, Pirelli. Pirelli chooses 3 tyre compounds each race weekend considering the track's conditions and climate. The highest numbered slick tyre will be marked as the soft, the middle choice as the medium and the lowest as the hard (Seymour, 2023). In Fig 1 the durability and grip of the tyres are seen, with 'softer' meaning more grip and less durability whilst 'harder' means less grip but more durability. No singular set of tyres is made to last the whole race distance, thus a mandate of one pit stop in each race and at least one tyre compound change. The main goal at the end of the day is to finish the race in the least amount of time, which they can project in the supercomputers they have at their factories off-track.

WHY DOES IT MATTER?

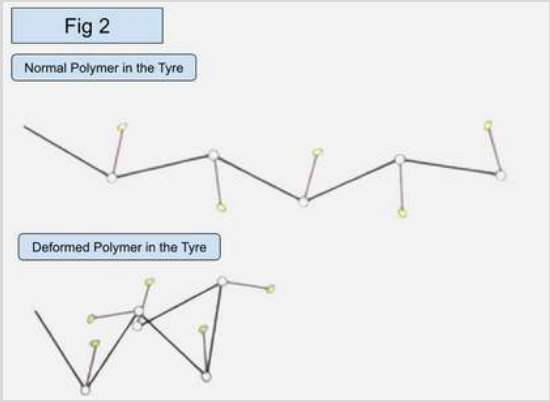
The idea behind the tyre strategies and the different compounds is to create exciting racing. Changing tyres means a pit crew with 14 different members at a time to change a set of four tyres in under sometimes 2 seconds! The overall idea is to finish ahead of your rivals and maintain the most amount of grip for longer than your competitors. Teams may use a strategy known as an undercut where they get onto a fresher, grippier set of tyres before their rivals to eventually create a delta large enough to pass them once they come into the pits. Alternatively, teams may use a strategy known as an overcut to stay out for longer as new tyres may take time to warm up and cars may lose lap time whilst being stuck in traffic behind slower cars - hence, giving them a net advantage.

HOW TYRE DEGRADATION IS MEASURED

Tyre wear is the measurement of how much tread (the material the tyre is made out of) is left on the tyre - with less generally meaning the car will go slower. Teams may use a heat gun and a metal scrape to take off any tread that has been picked up on the track from other cars or melted from the car itself. They analyse different locations on the tyre to measure area-specific levels of wear and graining. More on graining later. F1 cars are equipped with hundreds of sensors; infrared and pressure sensors are used by the teams on the pit wall to monitor the status of the tyres. Live driver feedback is also invaluable - as after all, they are the ones in the cockpit.

WHAT AFFECTS TYRE DEG

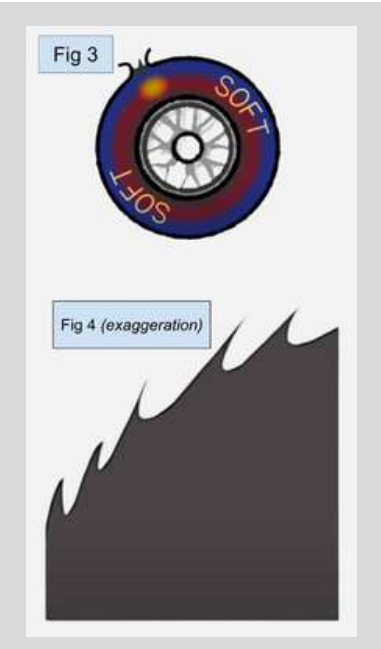
Tyres heat up most through corners as lateral forces are applied, which are forces 90 degrees to the direction of movement. For tyres to deliver the initial 'oomph' of performance, they must go through a heat cycle to get up into the right working window for the temperature of the tyre. A crude analogy of the lifespan of a tyre can be compared to a cookie, where it starts soft and malleable and turns harder and brittle as you continue to heat it.



Tyres heat up most through corners as lateral forces are applied, which are forces 90 degrees to the direction of movement. For tyres to deliver the initial 'oomph' of performance, they must go through a heat cycle to get up into the right working window for the temperature of the tyre. A crude analogy of the lifespan of a tyre can be compared to a cookie, where it starts soft and malleable and turns harder and brittle as you continue to heat it.

BLISTERING

When the inner tyre temperature is much hotter than the outer tyre temperature, a hot pocket of air can form between these two sections, which can cause a burst that blows a large chunk of the tyre off (Fig 3). It can be spotted as an anomalous, small blemish on the surface of the tyre as it flashes by during rotation of the tyre.



GRAINING

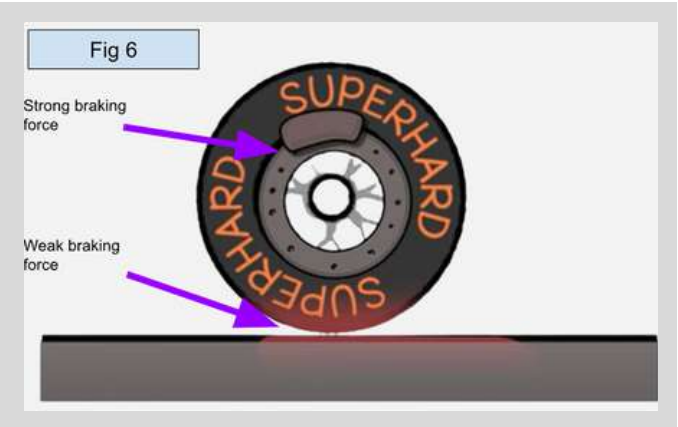
When the outer surface of the tyre gets much hotter than the inside of the tyre and the tyre undergoes heavy loads under cornering - especially through high-speed corners which put a lot of energy through the tyres. The tyre begins to deform in waves, where under some circumstances the peaks of these waves on the tread of the tyre begin to tear off (Fig 4), these are usually hot and sticky meaning they stick right back onto the tyre's surface. This causes an issue as the grippy part of the tread is no longer making full contact with the track and is being covered by the grainy texture of the pieces of the tyre breaking off. This reduces grip levels, as these bits of the tyres are not ideal for performance. This can also result in a phenomenon known as marbling on the track where the pieces are laid on the track on the outsides of the ideal racing line making it harder for cars to deviate off that line and complete overtaking manoeuvres, as there is less grip available.

HOW DO DRIVERS MANAGE TYRE DEGRADATION?

Before using a tyre for a competitive session, drivers will do something known as; 'scrubbing' where they put the tyres through a heat cycle to get the tyre in the optimal temperature range to offer the best performance. They do this as tyres aren't immediately ready to offer peak performance. A good driver is needed to maintain the optimum temperature within the tyre for longer longevity and increased grip levels of the tyre. As a track is used more and more and as competitive sessions go on rubber is laid on the ideal racing line through normal degradation (Fig 5) - this is beneficial as the coefficient of friction between the tyre and rubber is greater than that of the tyre and track meaning there is less friction and the tyres last for longer on these parts of the track. This is also why drivers may sometimes drivers may complete burnouts on their grid box and pit box prior to a race to ensure a speedy getaway off these lines. Drivers will often be less aggressive on throttle on the exit of corners and smoother on the brakes into a corner to reduce the energy put through the tyres - although this may be slower than pushing the car to its absolute limits, in the world of Formula 1 it is important to finesse the car over the finish line and ensure your race time remains lower than your competitors. They may also be smoother on the steering through turns

BRAKING

When braking it is fundamental that the wheels are still in rotation whilst brake pressure is applied to make steering into the corner easier, to be able to brake more efficiently and also prevent something called 'flat-spotting'. It is fundamental to note that there is more force available when the brake disc can rotate through the pad instead of the brake pad locking the brake disc and in turn having the braking force be the tyres sliding across the track, which is less efficient. Not only that, but it can wear a chunk off the tyre due to the sheer heat energy that is put through it, causing the polymers to break apart and flatten the curvature of the tyre. This is and also prevent something called 'flat-spotting'. It is fundamental to note that there is more force available when the brake disc can rotate through the pad instead of the brake pad locking the brake disc and in turn having the braking force be the tyres sliding across the track, which is less efficient. Not only that, but it can wear a chunk off the tyre due to the sheer heat energy that is put through it, causing the polymers to break apart and flatten the curvature of the tyre. This is



detrimental to the performance of a car as it will be much more prone to flat-spotting again as the tyre's surface isn't evenly round but will also cause vibrations in the car that could damage the suspension of the car. It will also result in reduced straight-line speed and cornering ability, all of which an F1 driver would want to avoid. Managing tyre degradation is an important factor in being fast lap after lap over a race distance, and is a skill that sets apart the greatest drivers from the rest. It's about ensuring the core of the tyre or the surface of the tyre doesn't get too hot or cold and that there is a consistent temperature through the depth of the tyre that is just right to ensure the tyres are in the correct temperature range or 'working window'.

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DO YOU GET DEJA VU?

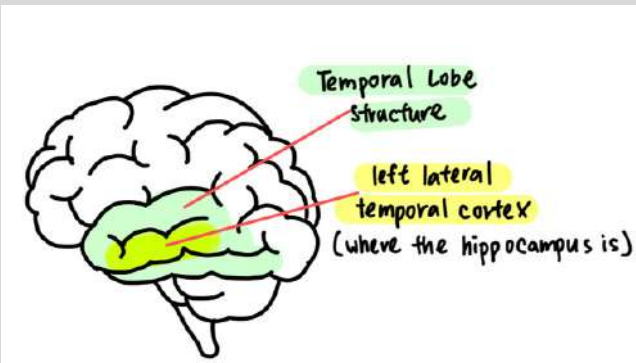
Zita Lok 11W

WHAT IS DEJA VU?

Have you heard of the lyric “Do you get deja vu?” by the American singer Olivia Rodrigo? “Deja vu” refers to the French word for “already seen”. The definition of the term is the feeling when they feel like they have already experienced this present scene or event before. Their body recognises the familiarity and confusion with the experience. It is rather common as a survey suggests 60-70% of healthy people have experienced deja vu in their daily lives.

CAUSES:

1. THE NEUROSCIENCE, TEMPORAL LOBE EPILEPSY



There is a part of the brain called the Temporal Lobes consisting of a brain structure called the hippocampus. It is responsible for our long-term and short-term memory. They can help us recall words, people and places. Some research suggests electrical malfunction might cause déjà vu events in the brain. Some nerve cell activity across the brain could disrupt the electrical impulses that ‘fire’ neurons, just like a glitch in the brain. These impulses can spread across the whole brain, signalling other brain tissues and the hippocampus which could cause mixed memories like deja vu. “This causes a disruption of recognition memory systems, which gives you that false sense of familiarity,” Dr Khoury says in an interview with Cleveland Clinic. This theory suggests that deja vu might be related to the temporal lobe and our brain's memory control, but it is not completely proven yet.

2. MEMORY-BASED EXPLANATION

Some individuals might experience deja vu because of temporary memory mismatch. Our senses could trigger it. Sometimes, we can recall memories in our brains through a small amount of sensory senses. For example, a familiar smell is enough for our brain to go through a whole data collection of similar things. Deja vu could be explained by this discrepancy in the memory system in which sensory data is collected from long-term memories instead of short-term memories.

Another example is the delay of data from the senses. Different senses are delivered to the hippocampus of the brain at the same time for its useful functions like memory, language, attention etc. Some theories suggest that when there is a difference in processing along the way to the hippocampus, it could disrupt the awareness in our senses and cause the messages to be sent and experienced separately. The brain might take the second vision as a whole different experience.

In both experiences, it could produce the weird feeling we get just like we have experienced or seen this new moment before.

It could also be explained by cryptomnesia which is closely related to our memory system. It refers to the memory in our brain that is forgotten. When our brain recognises some similarity related to the memory, it doesn't sense it as the return of the old memory but instead regards it as a new experience or idea. Sometimes, vivid experiences including emotions and senses create a great match between the present idea and the past experience. This gives the feeling of "deja vu" where you feel like reliving past experiences.

3. DREAM-BASED EXPLANATION

Some people experience deja vu in dream conditions. According to the survey done by Brown (2004), 20% of déjà vu experiences duplicate the situation in dreams instead of waking conditions. Dreams are often linked to the reconstruction of memory and other processes. Some researchers suggest that during the dreaming period of one's sleep, our brain replays bits of our life and consolidates memories including parts of prior experiences, emotions and ideas. The feeling of "deja vu" might happen when our brain mixes and matches these little bits together as memory blending. These several experiences might overlap and give the impression that one is reliving the past.

WHEN DEJA VU GETS PROBLEMATIC

In really rare cases, deja vu could be a sign of underlying health issues. Many neurodiseases might be related to seizure disorders that affect memory in our brains. They are caused by abnormal electrical impulses firing. It could be hard to recognise in our daily lives as it feels like having a staring spell or daydreaming.

However, if this is the case, usually other symptoms might come along with the deja vu as well. For example, motor feelings that affect your control of muscles. Also, sudden extreme emotions or feelings of joy, sadness, anger etc. If necessary, it is advised to consult your doctor or a neurologist for more professional advice.

CONCLUSION

To conclude, deja vu is a really common thing among us nowadays. It doesn't bring us any specific message or meaning, it could just be caused by different "glitches" in our brains including false or delayed electrical impulses and memory reconstruction. These are some theories and data that have been researched, but there is still a lot to learn and discover about deja vu.

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NEURAL MECHANISMS OF EMOTION REGULATION

Sania Mahita 11W

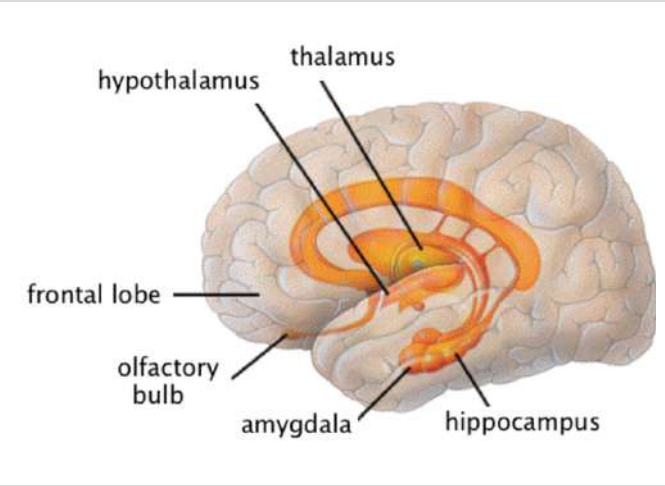

Fig 1: The limbic system

INTRODUCTION

Emotions are the body's complex responses to certain stimuli. When we are feeling scared or nervous, our heart rate increases, muscles become tense, and mouths get dry. This is an automatic, unconscious emotional response. Dr. Robert Levenson, a research professor, described emotions as "short-lived psychological-physiological phenomena that represent efficient modes of adaptation to changing environmental demands." (Haase et al., 2012)

NEUROANATOMY

The main important structures of the limbic system involve the hypothalamus, amygdala, thalamus, and hippocampus, which work together to regulate and manage emotions. These structures are all located closer to the base and center of the brain and share a fundamental kind of cortical structure in common. (The Limbic System, 2017) For example, the hippocampus helps in the retention and retrieval of memories and our understanding of the spatial components of our surroundings, whereas the amygdala manages reactions to emotional stimuli, especially those that trigger fear and anger.

In the brain, emotions are regulated by complex, interconnected networks. Emotions are the result of activity in different brain regions, and the brain uses these regions to process and control emotions. The first reflexive response that we have to something in our environment happens extremely fast and frequently escapes our conscious awareness. These reactions occur in the limbic system, which contains a few layers of neurons to process information and regulate emotions.

BRAIN MECHANISMS INVOLVED IN PROCESSING DIFFERENT EMOTIONS

Anthropologist Paul Ekman suggested in the 1970s that there are six primary emotions that people may experience: fear, anger, surprise, disgust, happiness, and sadness. Since then, scientists have disagreed on the number of human emotions, as some researchers state there

are only 4, while others believe there are as many as 27. The brain's several systems work together to link a stimulus to an association with feelings or emotions. The first system is the dopaminergic reward system, involving the ventral tegmental region and nucleus accumbens, which are located near the middle and base of the brain, around eye level. This system responds to rewards and encourages us to repeat actions make us feel "good." (Brain Reward System, 2023) The second system involves the circuits of the amygdala, which sit in each temporal lobe. These mostly act as regulators for mediating responses to anger, fear, and aggression. Deep within the brain, the paired, almond-shaped amygdala structure synthesises emotions and interprets fear. Other brain regions, such as the insula, are situated behind the frontal and temporal lobe folds on the side of the brain. The insula is the source of disgust.

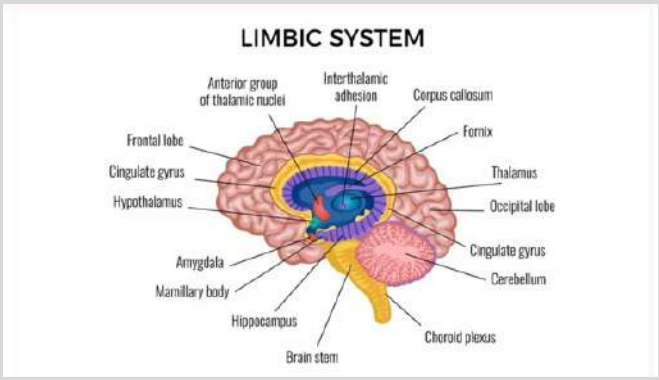

fig 2: amygdala, insula labelled

HOW THE BRAIN RECOGNISES EMOTIONS:

Once these structures associate a stimulus with a particular emotional value, a stereotyped response originates. For example, the amygdala is linked to the hypothalamus and can cause increased blood pressure or an increased heart rate, which are important factors demonstrating fear or anger. Our body picks up on these symptoms and identifies an emotion that is occurring. Centers of emotion go to regions of the brain that allow us to identify emotions as they are occurring, in addition to detecting physical changes in the body.

STAGES OF EMOTION REGULATION

The brain continuously receives signals from the body, recording what is happening internally. It then processes the signals in neural maps and then assembles them in the somatosensory centers. When the maps are interpreted and emotional shifts are noted, emotional changes arise as temporary reflections of our physical state

The brain goes through several stages while regulating emotions. These phases involve the identification of emotions, the choice of suitable techniques for regulating those emotions, and the execution of these techniques to effectively regulate the emotional reactions.

Emotional responses in the brain are flexible and can be manipulated. As mentioned above, some brain systems and complex networks, like the amygdala and prefrontal cortex, are crucial in the processing and regulation of emotions. Furthermore, the release of hormones such as dopamine, oxytocin, and vasopressin is associated with feelings of love, social bonding, trust, and calmness, indicating that the brain's hormonal reactions might affect emotional states.

WHY REGULATE EMOTIONS

In some situations, regulating one’s emotions becomes necessary. Since it enables people to better regulate their emotional reactions, maintain calm under pressure, and better handle stress, emotion regulation is a healthier alternative to bursting. Emotional regulation is linked to enhanced performance and overall emotional management. Practicing emotion regulation also contributes to better mental well-being, improved relationships, and overall emotional balance. To affect the intensity, duration, and quality of an emotional reaction, people can change the course of one or more of its individual components. (Lebow, 2022)

CONCLUSION

In conclusion, several mechanisms, such as the effect of certain brain structures, hormonal reactions, and the possibility of flexibility in attitudes and subjective decisions influenced by emotion, can be used to control the brain's response to emotions. It is not about eliminating emotions but about managing the emotions, adjusting their intensity or duration, and influencing behavior and emotional responses according to the circumstances.

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IS SNAKE VENOM THE FUTURE OF PROCOAGULANT DRUGS?

Natalie Healy 12D

INTRODUCTION

Snakebites are accountable for up to 63,000 deaths a year. These are mainly due to the life-threatening properties of their venom. Despite this, many of the proteins within their venom can be turned from fatal to lifesaving. This article explores how snake venom can be used to save lives in the event of heavy bleeding through procoagulant drugs. With 40% of deaths in trauma-related injuries being caused by uncontrolled heavy bleeding, these procoagulant drugs would greatly benefit paramedics to halt the bleeding. While this article is centred around procoagulant drugs, there are many other snake venoms which could make anticoagulant drugs and decrease the risk of strokes, heart attacks, and more.

HOW BLOODCLOTTING WORKS

To understand how these particular snake venoms work, hemostasis, or blood clotting must be discussed. In short, a blood clot is a platelet plug with strands of protein called fibrin. As the blood vessel gets damaged, inactive platelets otherwise known as thrombocytes in the bloodstream are activated by the exposure of surrounding tissue.

Primary hemostasis involves three basic steps. First, the platelets secrete serotonin to induce the blood vessels to constrict, which reduces blood loss. This process is called vascular spasm. After that, the activated platelets clump together and adhere to the endothelium, which produces a platelet plug. The platelets then secrete Thromboxane A2 and ADP, substances which draw other platelets to the plug. This is known as plug propagation. The third step involves the surface of the activated platelets to serve as an area for coagulation.

Secondary hemostasis involves the stabilisation of the platelet plug. Fibrin is the final product of a complex coagulation cascade, where one clotting factor activates the next in a pathway. Majority of blood clotting factors are precursors of proteases (zymogens) that flow in the bloodstream in their inactive form. There are 2 main pathways within secondary hemostasis which lead to a common pathway, where fibrin is produced as the end product. The extrinsic pathway begins with the exposure of a blood clotting factor to a tissue factor, which is produced by wound to the blood vessel. The intrinsic pathway reinforces coagulation by creating a positive feedback loop and only using clotting factors within the blood vessels. These two pathways merge to a common pathway which produces thrombin via serine proteases cleaving prothrombin, which splits the soluble fibrinogen in the bloodstream to insoluble fibrin. After this, a blood clot is formed to stop external bleeding.
After the blood clot has prevented blood loss during the wound healing, it must dissolve so it does not become problematic to the body. This is a process called fibrinolysis, which creates the enzyme plasmin. Plasmin cleaves fibrin and dissolves the clot, leaving the healed vessel.

HOW DOES SNAKE VENOM WORK?

here are 4 main different types of snake venom, however this article will be focusing on hemotoxic venom. Snake venom is a complex mixture of polypeptides and protein. Within hemotoxic venom, all of them affect the circulatory system, but there are many different kinds that can induce or prevent hemostatic procedures. The venoms that this article is focused around are commonly secreted by vipers, which exhibit procoagulant properties.

One such potent procoagulant is ecarin, which is an enzyme derived from the venom of the saw-scaled viper (echis carinatus). Ecarin activates prothrombin to thrombin, which cleaves fibrinogen, bypassing the activation of a sequence of clotting factors and directly creating a clot. Many other procoagulant venoms work in a similar manner as ecarin, and rapidly speed up coagulation time.

HOW CAN SNAKE VENOM BE UTILISED?

In the later stages, cancer cells may break away from the tumor where it first formed and spread to other regions of the body, which is known as metastasis. Most death-related cases of cancer are caused by cancer cells spreading and forming tumors in other regions of the body. There are 3 ways cancer cells can spread: Direct invasion is where the cancerous cells directly spread from the stomach onto the neighboring organs, including the liver, pancreas, and large intestines.

APPLICATION OF SNAKE VENOM IN MEDICINE:

Researchers have developed a hydrogel containing proteins in snake venom to rapidly speed up coagulation in the event of uncontrolled bleeding. The hydrogel contains ecarin from the venom of the saw-scaled viper (echis carinatus) and textilinin from the eastern brown snake (Pseudonaja textilis). The ecarin rapidly stimulates blood clotting, while the textilinin inhibits the disintegration of the blood clots and preserves the clot strength.

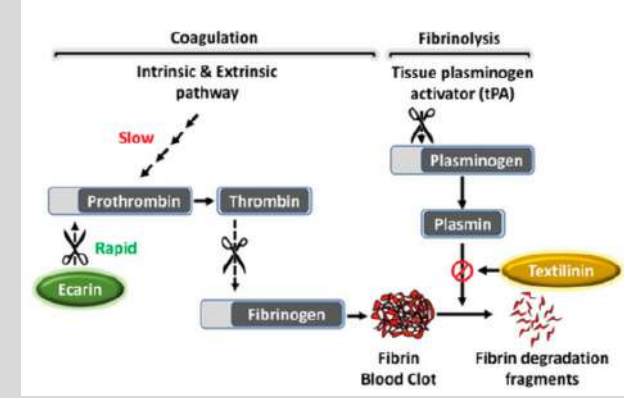

Fig 1: Ecarin, a procoagulant snake venom protein, rapidly activates prothrombin to thrombin, bypassing the activation of clotting factors and intiating the formation of a fibrin blood clot, while textilinin, an antifibtinolytic snake venom protein, inhibts the action of plasmin, stabilising the fomred flot (Ramanathan Yegannan et all. 2022)

When tested in vivo and in vitro, the hydrogel demonstrated remarkable efficiency, cutting the clotting time of 8 minutes to a mere 60 seconds. This cutting edge technology holds significant importance considering that uncontrollable bleeding is the cause of 90% of deaths within military contexts, and is the second leading cause of death in trauma related injuries. With this hydrogel, civilians, paramedics, and military personnel would be able to treat uncontrolled bleeding on site. Current technology used to stop blood flow cannot fully complete hemostasis, emphasising the importance of this new medicine.

The hydrogel that contains the proteins is a liquid until it contacts the wound site, where it then turns into a gel, offering better wound coverage. The gelatinous nature of the gel stops any infection from the outside reaching the wound and allowing the ecarin and textilinin to accelerate clot formation. As mentioned earlier, ecarin creates a clot rapidly through omitting the activation of a number of clotting factors. Textilinin helps to halt the breakdown of the blood clots by binding to the plasmin which blocks its fibrinolytic activity. Shown in the diagram to the left is how ecarin and textilinin can rapidly speed up the process of blood clotting.

LIMITATIONS TO USING SNAKE VENOM

Though snake venom shows potential, it has limitations as all medications do. The inherently venomous nature of snake venom means that an excessive amount could prove to be fatal. Additionally, there may be a stigma around using snake venom as medicine, rooted in the idea that venom is inherently dangerous, and people may be unwilling to use the medicine. The hydrogel mentioned above must still go through future developments as it has yet to be tested on humans and is still going through pre-clinical trials. Because of the physiological differences between humans and smaller animals, such as rats, the dosage of venom must be carefully controlled, and attaining the correct ratio of venom proteins may take years of research before it can be used on humans.

CONCLUSION

In conclusion, snake venom shows a promising future in medicine. If proved to be successful, the drugs could revolutionise medicine and reduce mortality rates due to uncontrollable bleeding. To develop and evaluate the safety and efficiency of snake venom-based procoagulant drugs, further research and rigorous testing, including human trials, are required. As researchers continue to advance their knowledge and continue to develop new drugs, the future of procoagulant drugs may lie with snake venom.

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PRECISION MEDICINE– HEALTHCARE'S REVOLUTION

Cyrus Ng 12F

INTRODUCTION

You are unique. Quite literally, unless you have an identical twin, because everyone has a different set of genes. Genes are the instruction manual of your cells. They determine characteristics from the color of your eyes to how likely you are to develop a disease to how you will react to a medicine. According to a study by Dr. Steven A. Schroeder, a professor at the University of California, 70% of our health is driven by our environment and clinical care, and 30% by our genetics (Schroeder, 2023). For thousands of years, humans have greatly improved our understanding and application of the former 70% but left the remaining 30% about genetics alone, believing them to be undiscoverable mysteries. However, since the human genome was sequenced in 2003 by the Human Genome Project, a new era of medicine began, seeking to venture into the last 30% of healthcare that eluded our understanding. As such, in the recent decade, the term "precision medicine" has become ubiquitous in the world of medicine. But what is precision medicine?

THE PROMISE OF PRECISION MEDICINE

In your home, there is probably a box of cough medicine. There are probably also thousands of people worldwide with the exact brand and box. But if everyone's genetics are different, how could this cough medicine possibly work for everyone? Such is the nature of today's healthcare. Due to our lack of understanding of genetics, we must take a one-size-fits-all approach to medicine, making pills that work decently for most of the population instead of ones that work perfectly for each individual. The result? It works well for some people and less well for others, but perfect for no one. In the case of cough medicine, the one-size-fits-all approach may be best to keep it cheap and simple for such a small problem. But what about more serious diseases like cancer? That is neither cheap, simple, nor small. Here is where precision medicine comes in. Precision medicine seeks to create individualized treatment according to one's genetics.

PRECISION MEDICINE & CANCER

Cancer is the uncontrollable division of cells caused by the accumulation of mutations in growth

genes. There are more than two hundred types of cancer, each with different genetic profiles, yet, cancer treatment is nearly always 1) surgery and 2) chemotherapy and radiation until all cancer cells are removed. The latter part of treatment is especially destructive because it kills both cancer cells and healthy tissue, causing side effects such as hair loss, nausea and trouble with memory.

Precision medicine can minimise these side effects. For example, researchers Dr. Kool et al. discovered a method to significantly reduce side effects for children with medulloblastoma, a malignant brain tumor (Kool et al., 2012). Pediatric medulloblastoma is a lethal cancer, with a sixty-eight month study in Southern Thailand demonstrating a nearly fifty percent death rate (Nalita et al., 2018). As such, this cancer is often battled with a bombardment of chemotherapy and radiation, causing long-term side effects children may never recover from. After using AI to analyse exomes, sections of the genome that control cell growth, precision medicine researchers discovered which type of medication best combats “wingless” medulloblastoma (brain tumor due to the mutation of what is known as the WNT gene), the most common type of cancer in children. Now, pediatric medulloblastoma can be cured with only surgery and chemotherapy, removing the need for radiation that can damage children for life. If precision oncology continues to expand, humans may eventually understand the genetics of all cancers, leading 18.1 million cancer patients worldwide to have a tailor-made treatment plan that maximises effectiveness and minimises damage.

PRECISION MEDICINE & REGENERATIVE MEDICINE

Precision medicine is also driving one of the most promising and revolutionary fields in healthcare: regenerative medicine. Regenerative medicine is the science of regrowing tailored tissue and cell components to heal the body. This type of treatment can treat diseases previously untreatable, such as blood disorders and brain degeneration, through its versatility. It can also lead to a more seamless recovery by mitigating the risk of rejection, where the immune system attacks a foreign object, by ensuring treatment has similar genetics with the patient. In essence, regenerative medicine is effective because it not only integrates but tailors to a given patient’s unique genetics.

In other words, precision medicine is the blueprint for regenerative medicine. In 2017, researchers from Stanford University conducted a clinical trial on four adults with recessive dystrophic EB, a genetic skin disease causing severe pain and blisters. The disease is caused by the inability of keratinocytes, a type of skin cell, to produce type VII collagen. The researchers extracted samples of each patient’s keratinocytes, inserted the collagen VII gene, and cultured them into skin grafts “the size of playing cards”. Treatment for each individual was specific to their genetics, removing the chance of organ rejection, the leading cause of failure in regenerative medicine. At the 3-month mark, 21 out of 24 grafts showed regeneration in collagen. Dr. Marinkovich, the director of the Stanford Blistering Disease Clinic, stated "If we can stop EB in young patients, we could spare these children from experiencing chronic wounds and scarring (Saltsman, 2017)." Many of these rare genetic diseases do not have sufficient research for an effective one-size-fits-all treatment; therefore, similar tailored genetic treatments can drastically improve the quality of life for the 1 in 21 people who have classified “rare” genetic diseases by reconstructing the genetics of relevant cells (INS Gene, 2013). By further advancing our understanding of genomics in regenerative medicine, humanity may eventually be able to regrow entire limbs for amputees, reverse organ failure and potentially extend human life expectancy to numbers never thought possible.

However, in the same experiment, only half of the grafts were intact by the 12-month mark, meaning significant progress is still needed for such treatments to be utilised on a large scale.

PRECISION MEDICINE & DIET

Lastly, precision medicine also plays a role in altering lifestyle treatment. Continuing along the lines of diabetes, high blood sugar can be mitigated by reducing one's sugar intake, which can come from a wide range of sources, from tomatoes to sodas. Scientists have attempted to log each food's effect on blood sugar levels through the "glycemic index", but like most medicines, it is a one-size-fits-all approach since each patient reacts differently to each food. Researchers found that every food impacts people in drastically different ways due to their genetics; for instance, white rice and watermelon have similar glycemic indexes of 73 and 76 respectively, but the blood sugar level rise of most patients is far higher for white rice (Manzella, 2023). In a study conducted by Dr. Zeevi et al., researchers conducted custom diets based on the participants' blood sugar responses. They concluded that the custom diet was as effective as diets constructed by proficient dieticians in regulating blood sugar. However, gathering the data required was painstaking, requiring the researchers to continually repeat tests to reliably predict the effect of each individual food item (Zeevi et al., 2015). Precision medicine can expedite this process because such traits are driven by genetics. For example, genes such as BMAL1 or circadian clock genes in the small intestine regulate glucose intake, and researchers are currently working to understand their variations and subsequent linkage to the blood sugar effect of different foods (Sussman, 2019). That way, instead of slowly testing the effect of foods on patients, a single analysis of one's genome can lead to an understanding of how each food affects them. These methods allow many more of the 200 million diabetics worldwide to have an expertly tailored diet in a simpler, more affordable way.

CONCLUSION & NEXT STEPS

Medicine is an unfortunate reality where they must priortise the majority over the minority by taking a one-size-fits-all approach to their products; in other words, ignoring the variation in genetics, which determines 30% of peoples' health. Precision medicine attempts to combat this Achilles' heel of healthcare but requires genetic data that is sorely lacking due to the field's novelty. In 2015, former US President Barack Obama started the "All of Us" initiative to jumpstart precision medicine, which aims to collect the genetic data of one million people and release it to the public. Nine years and 150 million USD later, scientists worldwide can now access a database with genetic data from over 187000 participants in a few clicks (Precision Medicine Initiative, n.d.) Although progress is swift, 187000 data units are insufficient if we are to extrapolate the results for the nearly 7.9 billion people worldwide. The next steps are integrating artificial intelligence to expedite data collection and analysis, convincing more medical professionals to rally behind the cause and having more patients understand precision medicine as a potential treatment option. The vision of precision medicine is a world where healthcare is not just aimed at curing most people, but all people.

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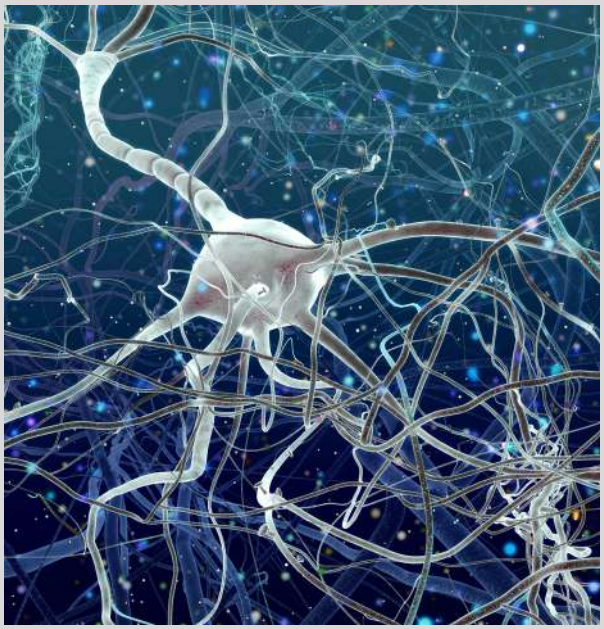
WHAT IS SYNESTHESIA?

Gigi Liu 12R



Synesthesia is a neurological condition where the brain routing sensory information through one sense involuntarily activates another sense, causing a person to experience multiple sensations at once. Synesthesia is not a medical condition nor a disorder, but simply an unexplained phenomenon concerning a sensory crossover. Experts have estimated that around 4% (Cleveland Clinic, n.d.) of the world's population have synesthesia, but also say that many different forms of synesthesia may not have been accounted for. They also say having synesthesia is natural for some people and many often don't realise they have the condition.

There are different types of synesthesia, developmental and drug-induced. Developmental synesthesia refers to the condition being an inborn trait. Scientists think the main cause is due to a slight difference in brain structure, wherein people with synesthesia have more connections between the different areas of the brain, hence leading to multiple sensory outputs.

Scientists also theorise that genetics and heredity play a part. A systematic survey to investigate familial patterns was conducted (Barnett and company, 2008), and the results showed around 42% of the survey's participants had a first-degree relative (a parent or sibling) who also had synesthesia, suggesting that the condition is highly inheritable. Another study was conducted aiming to shed light on the influence of genetics on synesthesia development (Asher and company, 2009). Out of 43 families (196 participants total), there were 121 synesthetes, with 68 non-synesthetes and 7 unknown. By analysing every participant's genetic information, it was highly suggested that 4 specific chromosomes were linked to the heredity of synesthesia, and this implies all the genes were inherited together by synesthetes within families.

Drug-induced synesthesia is the consumption of hallucinogens such as LSD or psilocybin which leads to synesthesia-like experiences. Drug-induced synesthesia lacks consistency in effect, does not occur automatically, and can be influenced by the mental state of the individual. In contrast, developmental synesthesia is consistent, automatic and unaffected by a person's state of mind.

There are many forms of synesthesia, such as:

- Auditory-tactile: Hearing sound triggers the feeling of touch.
- Day-colour: Colours are associated with certain days of the week.
- Grapheme-colour: Letters and numbers are associated with a certain colour.
- Hearing-motion: Hearing sound when seeing things move.
- Mirror-touch: Seeing something happen (e.g., a touch) makes you feel it too.
- Time-space: Sequences are visualised in a 3D form, such as a ring around them.
- Sound-colour: Seeing colours leads to hearing sounds.

There is no "cure" or "treatment" for developmental synesthesia, It is an in-born trait similar to eye colour. Many with synesthesia eventually learn to enjoy this condition, despite it occasionally being distracting. Moreover, many people with synesthesia have superior memory relating to their specific form. For example, those with grapheme-colour synesthesia can remember number and letter combinations better than the average person. Most synesthetes also tend to be more creative and gravitate towards artistic fields such as musicianship.

Billie Eilish is a 22-year-old singer/songwriter with synesthesia. Both her father and brother have this condition too, backing up the idea that it is inheritable. To Eilish, people she knows have a shape, colour and number associated with them. For example, her brother is an orange triangle and has a dark green name. She also perceives her songs as different colours and numbers, and can see and smell them. According to Eilish, "Bad Guy" "is yellow, but also red, and the number seven. It's not hot, but warm, like an oven. And it smells like cookies." Eilish also mentions how having synesthesia “inspires a bunch of stuff. Like all my videos, for the most part, have to do with synesthesia, all of my artwork, everything I do live, all the colours for each song, it’s because those are the colours for those songs specifically.”

To conclude, synesthesia is a neurological condition where the activation of one sense leads to the involuntary activation of another sense, and can manifest in numerous different forms, such as seeing colours from sounds. Synesthesia can be both inherited and induced, and many studies suggest strong correlations between the inheritance of certain genes and having synesthesia. Many synesthetes, such as Billie Eilish, learn to enjoy synesthesia and even leverage it to advance their professional development.

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ATTENTION DEFICIT HYPERACTIVITY DISORDER

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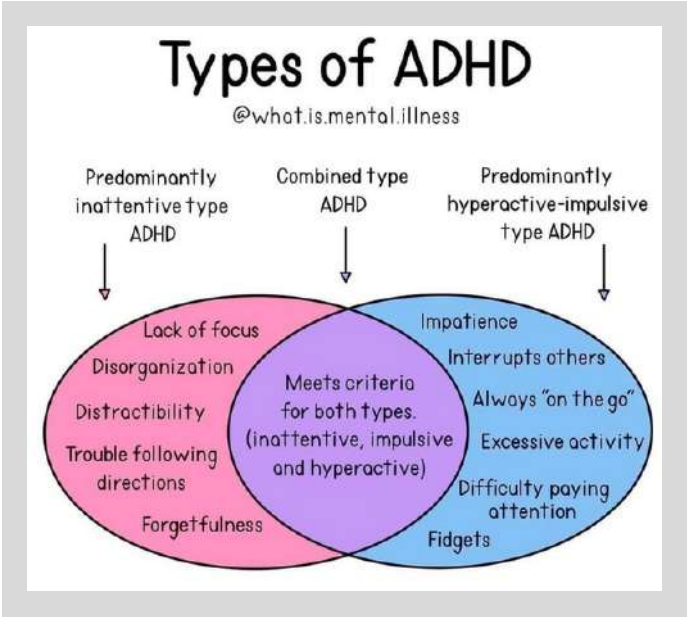

Fig. 1: Symptoms of ADHD and overlap between types (Taylor, 2022)

DEFINING ADHD AND COMMON SYMPTOMS

Have you ever noticed that when the people around you yawn, so do you? You probably have, because, after all, it is an extremely common theory that yawns are "contagious". But why does this happen? This phenomenon has a lot to do with mirror neurons, a fascinating type of neuron that can not only mirror yawning and other actions but also aid our learning and help us empathise with others. Furthermore, mirror neurons have been linked to disorders such as Autism Spectrum Disorder (ASD). In this article, with the help of scientific studies, we will look more closely at mirror neurons and the role they play in these various processes. So keep reading to learn more! ADHD is classified into three types: predominantly inattentive, predominantly hyperactive-impulsive, and combined. ADHD has a spectrum of different symptoms, but each type has different symptoms associated with them. According to the DSM-5 (the diagnostic tool published by the American Psychiatric Association), inattentive types are often linked with making careless mistakes in tasks, difficulty holding attention, trouble organising, and struggling with mentally strenuous tasks over a long period. Inattentive types are typically linked with procrastinating, getting easily distracted, or being forgetful. Hyperactive types are more commonly linked to fidgeting/being unable to sit down, needing to stand when seating is required, general restlessness, regularly "being driven by a motor," excessive talking, and interrupting others. Six of these symptoms must be "observed over at least half a year and disrupt academic/social/work function and their development" to be diagnosed with ADHD (CDC, 2023).

ADHD symptoms range from mild to severe, affecting daily life and affecting focus, addiction, and task completion. Diagnosis requires a significant negative impact on development and livelihood, with ADHD requiring more than just easily distracted or hyperactive behavior. While everyone suffers from some degree of executive dysfunction and being distracted, there is a clear boundary between normal levels and the problems it causes for people with ADHD.

NEUROSCIENCE OF ADHD

ADHD alters the brain on a neurobiological level, which means that ADHD patients have different brain chemistry, activity, and structure compared to those who don't.

Neurotransmitters are chemical messengers that relay information between neurons within the brain between the synaptic gap. It is believed that dopamine and norepinephrine are both affected by ADHD. Dopamine is the neurotransmitter responsible for feelings of reward and pleasure and is theorized to be lower in those with ADHD. This could be why it is difficult for them to concentrate on tasks that do not have immediate rewards, such as long and mentally challenging jobs, studying for exams ahead of schedule, or working on large projects. This is often why these are left to the very last second. Norepinephrine helps in the body's fight or flight response and is also at lower levels for those with ADHD. It makes it more challenging for them to retain information, impacts impulse control, and how well they can resist distractions and suppress non-productive behaviours (Sinfield, 2017).

In the brain, certain sections may be larger or smaller due to ADHD, which influences their ability to function. In a study by the international team ENIGMA, 3200 children and adults underwent an MRI brain scan to show the differences in brain size and function. Half of these participants were diagnosed with ADHD, while the other half were the control. In particular, the frontal cortex (responsible for attentiveness), the amygdala (responsible for emotional regulation and decision-making), and the hippocampus (responsible for the formation of memories) were found to be smaller in those with ADHD. In addition, it was also found that blood flow to these parts of the brain is also lower than those without ADHD, particularly to the prefrontal cortex areas, which handles executive functions such as organisation, memory formation, and emotional reactions (ADDA Editorial Team, 2023). These parts of the brain are responsible for what can be symptoms of ADHD, such as impulsive actions, a lack of control over emotions, and poor memory.

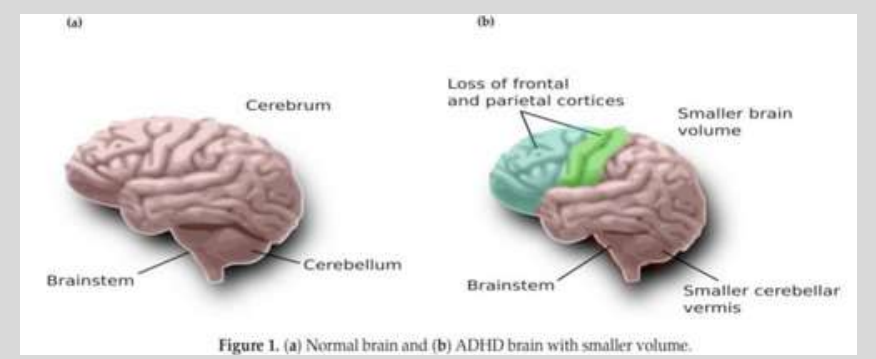

Fig 2.: Brain parts in patients without ADHD and those with ADHD (Barua et al, 2022)

MISCONCEPTIONS ABOUT ADHD

ADHD is often misunderstood as a lazy or unproductive disorder, with many individuals being labelled as lazy or unproductive. However, ADHD patients experience a dopamine boost when deadlines are near, increasing their productivity in the short term. This boost can make it difficult to complete long, arduous tasks, such as planning and executing a solo project on time. (Salari, 2023).

ADHD is not always a deficit of attention, but a lack of control with the regulation of attention span for normal tasks. While it can be challenging for someone with ADHD to focus on a mundane task, they may be too focused on something they enjoy, such as hobbies. This is commonly referred to as hyperfocus, where the person is completely absorbed in what they are doing, linked to a lack of control over attention span.

ADHD is often associated with excessive screen use and upbringing, but is primarily caused by

biological factors. It can be hereditary, with the exact genes responsible remaining unidentified. A family history of ADHD may increase the likelihood of a child developing the condition. However, tracking ADHD is challenging due to older populations being less likely to be diagnosed or unwilling to seek it. Other neurodevelopmental disorders may share common symptoms with ADHD, known as comorbidity, the presence of two or more medical conditions in an individual, making it difficult to link specific genes. Damage to the central nervous system may also contribute to ADHD onset before and after birth.(Web MD, n.d.)

ADHD is not directly caused by excessive screen usage, but it can affect brain neural activity. However, those with ADHD may struggle to limit screen time due to addictive applications like social media and video games, which engage the brain for dopamine release, forming bad habits and engaging the brain for dopamine release, which is unhealthy for people with ADHD and can form addictions.

ADHD is often misunderstood as a condition solely involving hyperactivity, but not everyone with ADHD exhibits hyperactivity, and this may vary in each individual or be expressed differently.

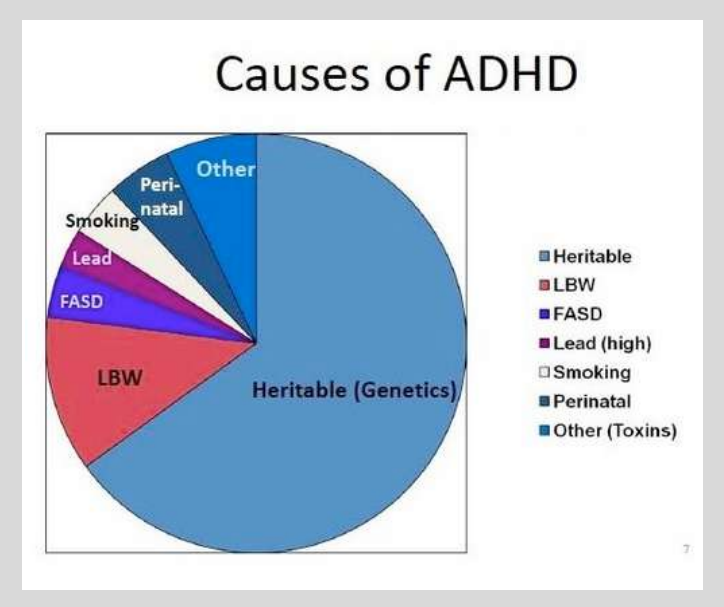

Fig. 3: Causes of ADHD (Lipping, 2020)

ADHD TREATMENT/ALLEVIATION

ADHD cannot be cured, but its symptoms can be managed in numerous ways. A patient can visit psychotherapy practices to learn how to manage their symptoms.

Medication – classified as stimulants or non-stimulants – is a common treatment for ADHD. Both can help with concentration on tasks, reducing impulsive action, and improving the livelihoods of those who take it. Stimulants increase the amount of activity within the brain to encourage certain behaviours, while non-stimulants such as Atomoxetine increase the amount of dopamine and norepinephrine in the synaptic gap so that there is more for neurons to absorb. It typically has less severe side effects and has longer-lasting effects than stimulants.

Methylphenidate (commonly known as Ritalin) and Adderall are both commonly prescribed medications for ADHD. Methylphenidate decreases the re-uptake rate of dopamine and norepinephrine, enhancing their effects and thus improving focus and attention. However, it can lead to sleep problems, decreased appetite, headaches, and the potential for habit-forming and addiction. Similarly, Adderall combines amphetamine and dextroamphetamine, which increases levels of dopamine, serotonin, and norepinephrine, enhancing attention in the short term. Yet, it also carries the risk of addiction and can cause drowsiness, and headaches, and contribute to mood disorders like depression and anxiety (NHS, 2018). The long-term effects of these medications are also under study, and there has been growing interest in other methods for alleviating these symptoms.

There are alternative methods for alleviating symptoms of ADHD, as the effects of ADHD often return when medications are not taken consistently. To make it easier for people with ADHD to live normal lives, many lifestyle changes and self-help methods such as planning and organising day-to-day activities, and blocking out time to do tasks. Prioritising and timekeeping skills can also help.

Two leading research sections are neurostimulation and changes to diet. Neurostimulation aims to improve neurotransmission through electrical stimulation of the brain. External trigeminal nerve stimulation targets the trigeminal nerve, which has connections to dopamine release. There have been studies on neurostimulation in this area over 4 weeks of treatment and has been shown to improve isolated neurobiological tasks, though further research is underway. (Universite De Geneve, 2023)

Diet can also potentially affect ADHD; there has been some research into the reduction of artificial food colouring and supplementation of Omega-3 fatty acids have shown small benefits to attention and general health. Some research also delves into the microbiome of the gut, and how it can influence the production of dopamine in the brain through the secretion of neuropeptides.

CONCLUSION

By covering the basics of ADHD, the neuroscience behind it, and the misconceptions behind the disorder, we hope to learn more soon and help those with ADHD live better lives. As with other mental health issues, the topic of ADHD and those affected by it should be treated with care to help accommodate those who have the disorder, especially in early childhood. With rising awareness and prevalence rates, it is important to negate the stigma and misconceptions surrounding the disorder.

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