

FINALISTS' MAGAZINE 2024



#700STEMChallenge

Forge your own path

INTRODUCTION

Congratulations to the finalists of the seventh Sydenham High's #700STEMChallenge.

There were so many amazing entries, all of an extremely high standard. After much deliberation, the following articles were selected as the top entries for each category.



Annabelle Simmonds, creator of the Challenge in 2018 whilst in Year 12 at Sydenham High. Currently completing an apprenticeship with Ernst & Young.

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Please note that submitted essays were not considered for the finalist selection if they did not meet the set criteria, or calibre expected, so on occasion there are fewer than three finalists.



UNDER 14 RESULTS

Science:

1st - 'How Does the Brain Keep us Alive and Why is it So Significant?'

Zara Annas, Sydenham High School

2nd - 'A Woman's Pain'

Arwa Kinana, Croydon High School

3rd - 'How Does Extra-Terrestrial Life Impact our Position in the Universe?'

Sophia Rafique, Wimbledon High School

Technology/ Engineering:

1st - 'What are the Ethical Challenges for Companies Working with Artificial Intelligence?'

Maha Zuberi, Croydon High School

2nd - 'Is AI Intelligent?'

Olivia Roberts, Putney High School

3rd - 'Is Snapchat AI Safe?'

Diya Sudhakaran, Croydon High School

Mathematics:

1st - 'Duodecimal: The System we would Use if we Had 12 Fingers'

Max Lau, Alleyn's

2nd - 'The Number Zero'

Immy Bloch, Wimbledon High School

UNDER 16 RESULTS

Science:

1st - 'How Much Knowledge Can we Really Know?'
Ephrata Sami, Sydenham High School

2nd - 'Can Gene Editing Be Used to Revive the Extinct Woolly Mammoth?'
Sara Danese, James Allen's Girls' School

3rd - 'Why are Injuries Plaguing Women's Sport?'
Maddie Griffiths, South Hampstead High School

Technology/ Engineering:

1st - 'What is a Robot?'
Aanya Sharma, Wimbledon High School

2nd - 'Sustainability in Architecture'
Lila Gray, Sydenham High School

3rd - 'The Art of an F1 Car'
Daphne Maltezou, Alleyn's

Finalist - 'How technology can imagine Indigenous Futures?'
Anoushka Breen, Sydenham High School

Finalist - 'Insectothopter'
Lara Dunning, Sydenham High School

Finalist - '4D Printing and its background and benefits to our society'
Mia Brol, Sydenham High School

Mathematics:

1st - 'Toast: One Cut to Remove the Crust!'
Aaliyah Akora, Townley Grammar School

2nd - 'The Maths behind Winning Wordle'
Vera Radovic, Wimbledon High School

3rd - 'Let's Chat About Chat GPT and Maths Problem Solving'
Elleanore Phillips, Townley Grammar School

Finalist - 'Pseudo-randomness: Random or not?'
Chloe Yim, Putney High School

UNDER 18 RESULTS

Science:

1st - 'The Science of Super-Humans: Humans and their Ability to Fly.'
Leah Digby-Thomas, Putney High School

2nd - 'Why are Women Obligated to Take the Contraceptive Pill and Not Men?'
Rosie Graham, Sydenham High School

3rd - 'Hypergargalesthesia: A New Disease?'
Emily Whitelaw, Sydenham High School

Technology/ Engineering:

1st - 'The Evolution of Technology in Branches of Engineering which Use Manual Labour.'
Yassin Elsayed, Dulwich College

2nd - 'To What Extent was the Titanic Unsinkable?'
Elsapie Macpherson, Wimbledon High School

Mathematics:

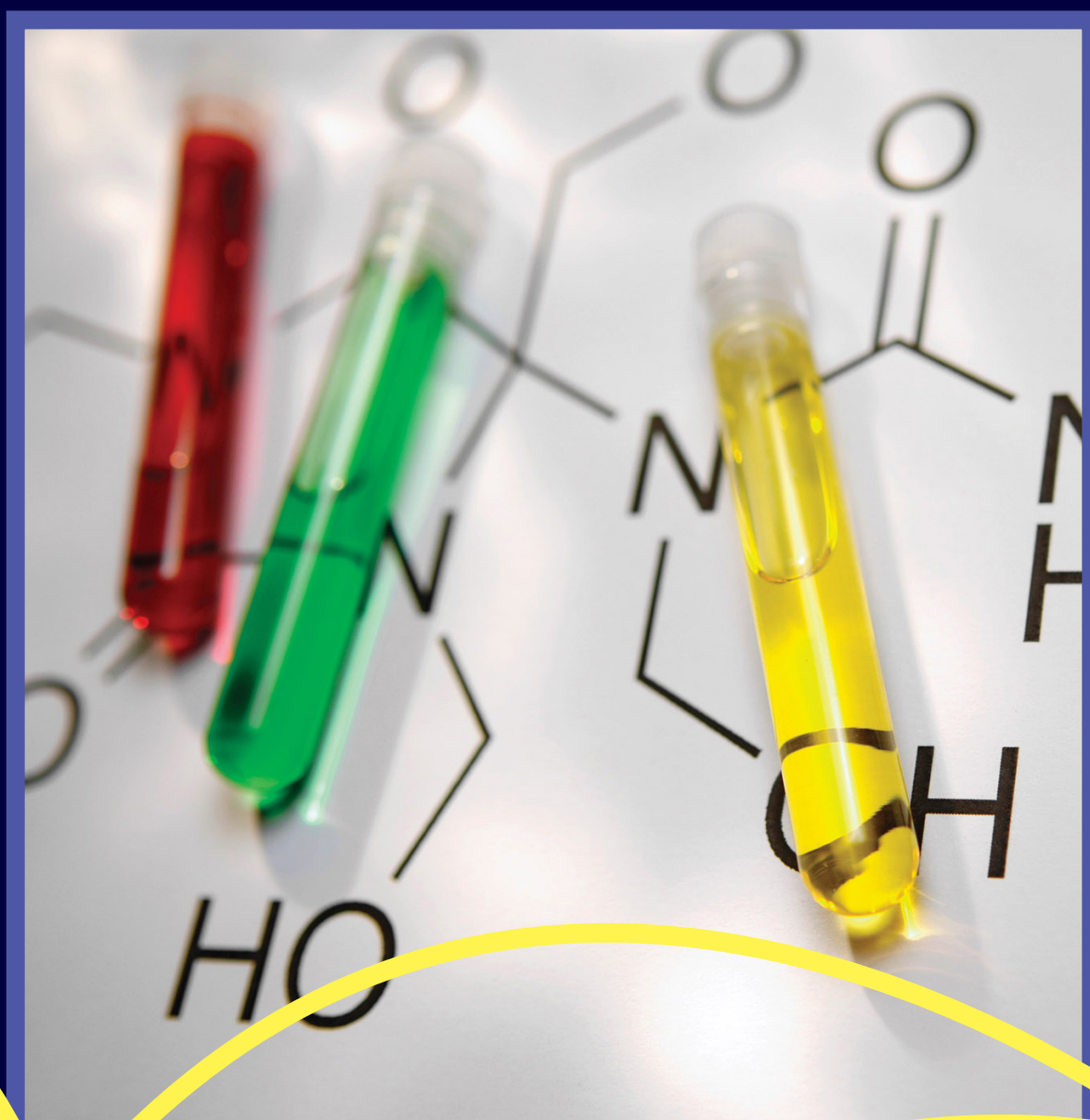
1st - 'How the Fibonacci Sequence has Paved the Way for Modern Beauty Standards'
Indi Chrishan, Wimbledon High School

2nd - 'How Critical is the Study of Mathematical Topology to our Lives? An exploration of Knot Theory and its application in healthcare.'
Umesha Shanmugarajah, Northwood College for Girls

3rd - 'The Existence of God: Proven by Mathematics'
Ayushi Amin, Northwood College for Girls

SCIENCE ESSAYS

Under 14



How does the brain keep us alive and why is it so significant?

Zara Annas, Sydenham High School

Is the brain an ordinary organ like any other? You will probably be thinking so now. However, I am going to change that today by explaining and exploring an organ which is so vital to our survival and how its complex features function and work together to keep us flourishing through our day-to-day lives: The Brain.

Did you know that Oxford University professors state that the brain is arguably the most dominant organ in our bodies. The brain is about the size of two adult clenched fists put together. The average weight of an adult brain is 1.4kg or 3 pounds. That is approximately the weight of a small watermelon! Did you know that 60% of the mass of an adult's brain is fat? The remaining 40% is a mixture of proteins, carbohydrates, salts and most importantly water. There is around 1.2 to 1.4 litres of water in your brain currently. If there is a water deficiency in your brain, then you get the common dehydration. Dehydration is when there is not enough water in the brain for it to function and complete certain tasks. Additionally, the brain is not actually a muscle. It is actually a mass of body tissues (which are collections of the same type of cells), neurons, blood vessels and glial cells.

How does the brain work? The brain is made up of billions of nerve cells which are called neurons. These are the key components which help the brain send and receive signals to and from various parts of the body. The brain is like a warehouse where all of the various products are delivered and collected from. Every process is unique and therefore has a different signal from the brain. For example, electrical impulses are a type of signal from the brain and they pass through a series of synapses. Synapses are connections made through one nerve cell (also known as neurons) to the receiving cell. The impulses are carried through these until they reach the required constituent of the body. This allows us humans to experience feelings like memory, thought, emotion, hunger, vision and many more. However, Glial or neuroglial cells in the brain actually exceed the abundance of neurons in the ratio 1:10! The main function of Glial cells is to support the neurons in the brain. They also have functions such as repairing a damaged nervous system and containing special transmitters which help in the transportation of the impulses through synapses.

What is the main segment of the brain itself? The most essential portion of the brain is the Medulla. This is located in the brain stem (central and at the base of the brain). This is where the spinal cord and the brain connect. The Medulla is vital for breathing, maintaining a consistent heart rhythm, oxygen levels, carbon dioxide levels and also your blood flow. This is a very delicate part of our brain. If it is at harm, then you will face difficulties such as breathing strains, loss of sensation or even paralyses. In addition to that, the Medulla controls reflexive actions (caused by neural activity which leads to a reaction in the body) such as sneezing, coughing, swallowing and even vomiting. Are you starting to understand why it is so significant?

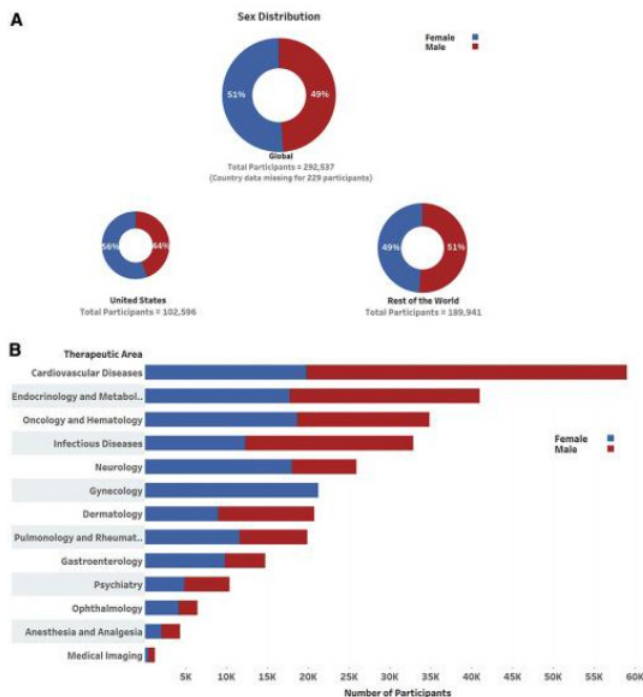
Sensation is a physical feeling or reaction on the body when something comes in contact with it. As you would have guessed, this feeling is manipulated by the brain. The segment of the brain that controls this is the Parietal Lobe. This is located in the centre of this astonishing organ. Receptors located on the top of your skin help you to feel sensation. These are of varied sensitivity in various parts of your body. The most sensitive part of your body is your fingertips with your palm following just after. Therefore, the parietal lobe dedicates most of itself to processing and interpreting that data. Another one of the key functions of the Parietal lobe is proprioception. This is the ability to interpret where your body is in a space. This does not have to be in contact with anything as it can be a relationship of contact with yourself. For example, you can touch your ears and you are still able to feel yourself doing it. Sensation is just one example of the various actions and activities that the various parts of the brain control. In conclusion, it is comprehensible that the brain is the most significant part of your body. I would like to leave you with this thought to signify how vital and strong the brain is to us and how we should appreciate it more than any other organ. The brain can survive without a body, but the body cannot survive without a brain.

References:

<https://www.hopkinsmedicine.org/health/conditions-and-diseases/anatomy-of-the-brain#:~:text=and%20the%20medulla-.Medulla,oxygen%20and%20carbon%20dioxide%20levels>
<https://www.dpag.ox.ac.uk/research/neuroscience>
<https://www.britannica.com/science/brain>
<https://www.alzdiscovery.org/cognitive-vitality/blog/can-dehydration-impair-cognitive-function#:~:text=The%20adult%20human%20body%20contains,properly%2C%20leading%20to%20cognitive%20problems.>
<https://www.ncbi.nlm.nih.gov/books/NBK279302/#:~:text=The%20human%20brain%20is%20roughly,cells%20which%20stabilize%20the%20tissue.>
<https://www.britannica.com/science/nervous-system/Types-of-neuroglia>
<https://qbi.uq.edu.au/brain/brain-anatomy/lobes-brain>
<https://www.britannica.com/science/nervous-system/Types-of-neuroglia>
<https://www.spinalcord.com/parietal-lobe#:~:text=The%20parietal%20lobe%20is%20vital,other%20areas%20of%20the%20body.>

A Woman's Pain?

Arwa Kinana, Croydon High School



'So how bad does it hurt on a scale of 1 to 10?' your doctor asks you. You pause, think for a moment – you think about the constant pain you've had to wade through for weeks to make it to this appointment, sitting on a cold purple plastic seat in front of your doctor.

You think about the feeling that can only be described as shards of glass being twisted inside of you every month, and you reply, '8.'

Your doctor looks at you sceptically, pushing their glasses down their nose and leaning forward, saying, 'If your pain was at an 8, you wouldn't be here.'

This experience isn't just made-up. This experience, where some health professionals trivialise or invalidate a person's health concerns and can leave a patient confused and doubting themselves, is so common it has a name – medical gaslighting. Medical gaslighting is a term used to describe the dismissal of someone's pain, illness or discomfort within a medical setting and is most seen amongst women, people of colour and other minority groups.

So why does it happen? The reasons for medical gaslighting are wide and varied. Many health professionals are unaware of medical gaslighting, and it usually isn't due to bad intentions – it is often the result of internal bias. Misogyny in medical practice affects many women, and it goes even further than just biased healthcare professionals. The medical system is a system built to fail not only minority patients but also doctors themselves. It isn't as simple as doctors not trusting some of their patients – they just don't learn about them.

In clinical trials, most cells, humans and even animals being tested are male. The belief that all organs and functions work the same in men and women and therefore all drugs trialled will have the same effect has led to studies that seem absurdly male-centred. In a 1986 study on how obesity affects breast and uterine cancer, no women were studied. For the approval of Addyi ('female Viagra') in 2015, the FDA tested whether it was safe when taken with alcohol – the test involved 23 men and 2 women. In tests involving rodents, 80% used male animals, with excuses for the lack of female subjects ranging from female rats being affected by hormonal cycles to female mice having smellier urine. The standard in healthcare has always been a slender, white man by default – women have always been viewed as an inferior version of men, with the uterus and hysteria being blamed for all illness suffered by women in the past and even today.

The result of a medical world built for men by men is dangerous for women. The exclusion of women of 'child-bearing potential' from drug trials before 1993 has contributed to the idea of women as walking wombs; this has also resulted in a knowledge gap of diseases and how they are presented in women. Many illnesses, such as heart attacks, are often recognised only by male symptoms – women are 50 per cent more likely to be misdiagnosed after a heart attack. The most common symptom associated with a heart attack is chest pain, but

many women who suffer from a heart attack report alternative symptoms. It comes as no surprise, then, that women are twice as likely to die within 30 days of their heart attack than men. In short, the result of a man's medical world is women being misdiagnosed, misunderstood, and mistreated.

People who suffer from diseases that affect predominantly women and are commonly labelled as 'women's problems' (such as endometriosis, temporomandibular joint disorders, fibromyalgia, chronic fatigue syndrome, and vulvodynia) are likely to be labelled 'hysterical' – many people living through the painful symptoms of these conditions are expected to live through the pain, and even more are unaware this pain is not normal. While women make up 70% of chronic pain patients, 80% of participants in pain medication trials are male. A woman's pain is expected, and denied, all at once. So, when you sit on that cold purple plastic seat, have faith in your pain, because it isn't just a woman's problem, or a woman's pain, it is yours. Believe, and one day the doctor will believe you too.

References:

[1] Feminism and the Body

The First Illustrations of the Female Skeleton in Eighteenth-Century Anatomy

Written by: Londa Schiebinger

Accessed: 25/1/2024

[2] MARIE GENEVIÈVE CHARLOTTE THIROUX D' ARCONVILLE, Selected Philosophical, Scientific, and Autobiographical Writings

<https://academic.oup.com/fs/article-abstract/74/3/463/5869067?redirectedFrom=fulltext>

Written by: Jonathan Simon

Reviewed: 9 July 2020

Accessed: 25/1/2020

[3] How to Spot Medical Gaslighting and What to Do About It.

Written by: Cynthia Vinney

Reviewed: 18 May 2023

Accessed: 25/1/2024

[4] Medical 'gaslighting': What it is—and how to address it

Reviewed: 18 March 2023

Accessed: 25/1/2024

[5] Failing Femininity? How PCOS Advocacy Confronts Gender - Based Medical Discrimination

<https://www.kcl.ac.uk>

Written: Kendall Soucie & Jen Rinaldi

Reviewed: 21 August 2023

Accessed: 25/1/2024

[6]

"Unwell Women" author Elinor Cleghorn: Women's pain "isn't taken seriously" by doctors | Salon.com

Written: Mary Elizabeth Williams

Reviewed: June 8 2021

Accessed: 1/2/2024

[7]

As a Black woman, I had to beg doctors to take me seriously when my brain was leaking

Written: Amira Lewally

Reviewed: 30 October 2020

Accessed: 1/2/2024

[8]

Closing the sex and gender gap in medical research

Written: Dr Alison Simmons

Reviewed: 8 March 2023

Accessed: 1/2/2024

How does extra-terrestrial life impact our position in the universe?

Sophia Rafique, Wimbledon High School

The universe is not lifeless. Eight billion people were somehow created from almost nothing. The fluctuating existence of the universe underscores the limits of our predictive caps. It invites us to consider the vast potential for life outside Earth. There are up to 2 trillion galaxies made up of around 20,000 billion billion stars that surround our home galaxy. The observable universe has been around for more than 13 billion years, and when people mention numbers like that it is almost impossible to think that we are the only forms of living beings in the universe. Of course, there must be more life out there, but humans haven't found any definitive evidence confirming that yet. If they had, philosophically, the existence of extra-terrestrial life would challenge the anthropocentric view that Earth has a sole mission to harbour life. People would be forced to re-evaluate their impact and position in the world and realise humans are not that special.

One theory to describe the absence of aliens and the loneliness of planet Earth is the Panspermia theory. This theory argues that life is not specific to Earth and did not start on our planet. According to panspermia theorists, life was distributed to planets by comets and meteorites. This is highly unlikely to most scientists as it would mean that a group of meteoroids had to have survived the extreme conditions in space and the crash landing on Earth. The panspermia theory has been a philosophical topic of debate for millennia but has remained theoretical due to its lack of evidence. However, if this theory is correct, it gives a direct reason to look for life outside of Earth and doesn't explain why other planets in the same solar system don't have the same basic human race.

When you look up at the starry night sky today, most people are left in awe and disbelief. Enrico Fermi looked up at the sky and asked where is everyone? This laid the groundwork for another theory called the Fermi paradox. This seeks to find a solution to where all the aliens are. The paradox is named after Enrico Fermi, who allegedly pointed out that crossing the galaxy could eventually be quite simple as our solar system is very young compared to others.

Representatives of the Search for Extraterrestrial Intelligence (SETI) Institute, California wrote that "Fermi grasped that any civilisation with a modest amount of rocket technology and an immodest amount of imperial incentive could rapidly colonise the entire galaxy," which is supported by the Kardashev Scale.

The Kardashev Scale is a scale that ranks alien civilisations by their energy use on four main levels, type one - a civilisation that can harness the energy of their home planet - to type four - a civilisation that can use the available energy of multiple galaxies. According to the Kardashev scale, a higher alien civilisation than type four could exist. This 'omega' civilisation could potentially manipulate the energy of the entire universe. The existence of more powerful extra-terrestrial life (type two to type omega civilisations) leads religious leaders and theologians to wonder if alien civilisations are a part of the same creation story humans are from. If they are, people would also ponder why some are more powerful than others and if it is due to God's favouritism or other reasons. Discovering more powerful civilisations would pressure religious teachings to be questioned, as the creation of humans and our relationship with God are often at the centre of theological texts. Humans not being the most advanced life in the universe could lead to a reevaluation of God's power, as it proves that God didn't create the most advanced beings in the universe and some figure has more power than God.

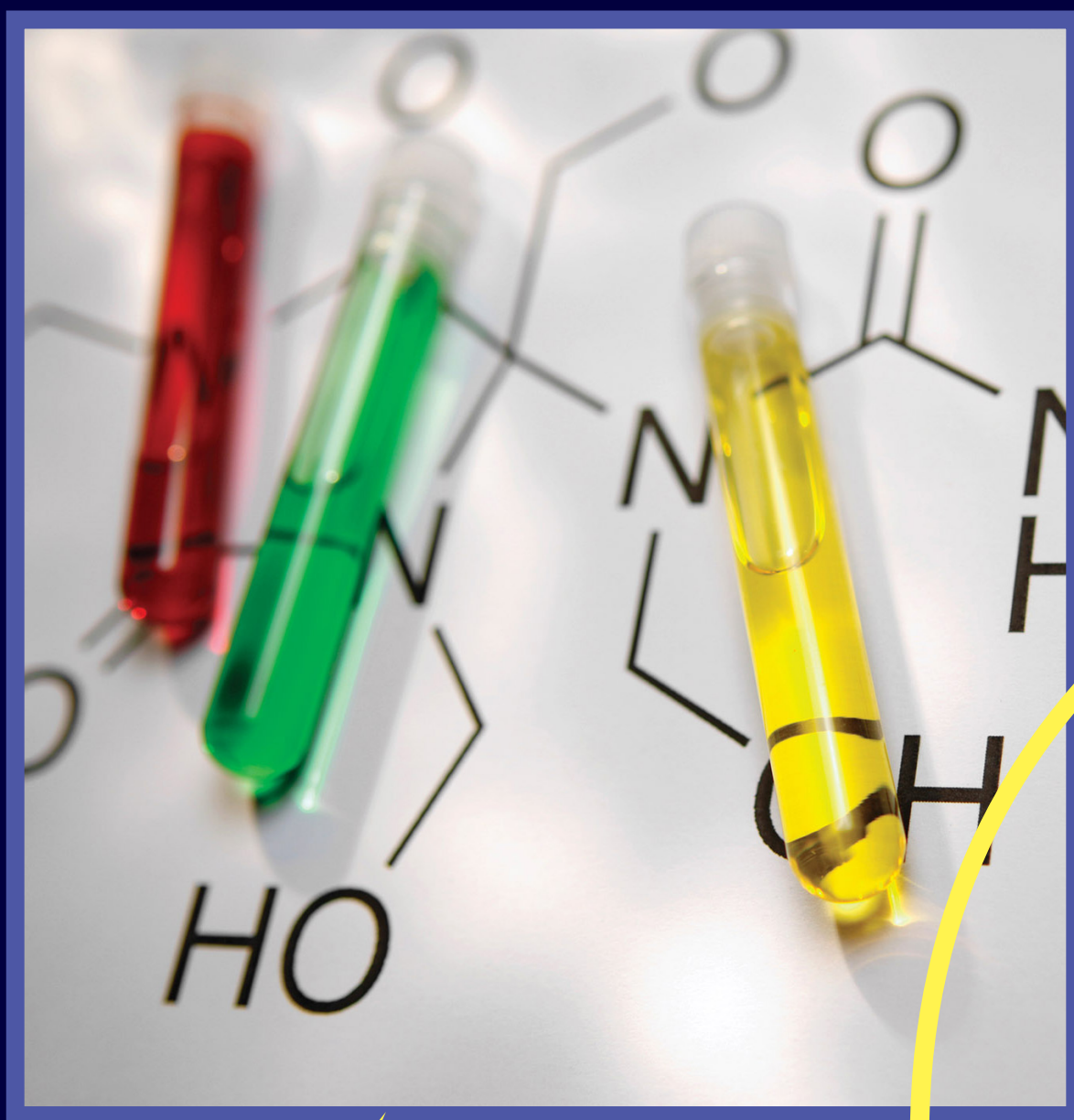
The prospect of discovering extra-terrestrial life carries a profound tapestry of philosophical and theological contemplation from the redefinition of life's boundaries to the reassessment of humanity's significance in the cosmos. As we tread the uncharted discipline of astrobiology and ponder the ethical, religious, and cultural dimensions of such a discovery, one thing remains clear: understanding our place in the universe is a limitless and evolving journey.

References:

<https://www.amnh.org/exhibitions/permanent/the-universe/the-universe/formation-and-evolution-of-the-universe#:~:text=Our%20universe%20began%20with%20an,stars%20and%20the%20firs%20galaxies>
<https://astrobiology.nasa.gov/about/> <https://exoplanets.nasa.gov/search-for-life/big-questions/> <https://www.livescience.com/fermi-paradox>
<https://www.sciencedirect.com/topics/earth-and-planetary-sciences/panspermia#:~:text=The%20panspermia%20hypothesis%20states%20that,speculative%20until%20few%20decades%20ago>
<https://www.space.com/25325-fermi-paradox.html>
<https://www.seti.org/fermi-paradox-0>
<https://futurism.com/the-kardashev-scale-type-i-ii-iii-iv-v-civilization>

SCIENCE ESSAYS

Under 16



How Much Knowledge Can We Really Know?

Ephrata Sami, Sydenham High School

According to Stanford University, we know very little about the brain¹ and some say that it may never be understood², however, one particular aspect that inspires curiosity is memory. This essay is focusing on how much knowledge we can store, limiting factors and if it's perhaps possible to increase storage capacity in the brain.

The brain splits its information into short-term and long-term memory and then is further split into declarative memory, which focuses on events and knowledge, and procedural memory, which focuses on unconscious skills. Focusing into declarative memory, within that, there is semantic memory and episodic memory. Episodic memory is on events such as your 12th birthday party whilst semantic memory is general knowledge³ which is what this essay focuses on. To store a semantic memory, first you have to take in it which is then taken note of in the synapses of your hippocampus. Whilst you sleep, your hippocampus communicates with the neocortex (where semantic memories are retained)⁴ to store this new information in your long term memory but only if you have cultivated strong connections in your synapses. Everytime you recall this information, the synaptic bond becomes stronger which makes the memory easier to recall and retain.⁵

With the background knowledge that has been established, we can now focus on how much semantic information can be stored in the neocortex. The neocortex has approximately 14 trillion synapses⁶ and each one has the capability to store 4.7 bits of information⁷. With these two pieces of information we can figure out the capability of how much information the neocortex can store.

$$1.4 \times 10^{14} * 4.7 \text{ bits} = 6.58 \times 10^{14} \text{ bits}$$

$$6.58 \times 10^{14} / 8 = 8.225 \times 10^{13} \text{ bytes}$$

$$8.225 \times 10^{13} / 1000 = 8.225 \times 10^{10} \text{ KB}$$

$$8.225 \times 10^{13} / 1000000 = 82250 \text{ GB}$$

To equivocate this data we could compare it to notes. One written page takes up 2KB⁸:

$$8.225 \times 10^{10} \text{ KB} / 2 \text{ KB} = 4.1125 \times 10^{10}$$

Theoretically, this means an average person has the capacity to remember approximately 41 trillion pages of information. However it can be quite hard to retain information especially when revising due to a numerous number of factors. One of them is attention as we tend to believe we can multitask when only 2% can actually achieve this⁹. For the majority, multitasking tires out the brain so when trying to learn, it's best to focus on one thing as distractions can limit your attention span. Multitasking can also cause stress and anxiety¹⁰, which is another factor stopping the brain from retaining information. A small amount of anxiety can help with productivity but too much releases an increased amount of the hormone cortisol which puts the brain into fight or flight, freezing the ability to retain information¹¹.

Say if we wanted to break barriers to remembering everything we need and want, how would one go about doing that? One crucial way is to sleep at least 7 hours to allow your memory to be properly processed. During your sleep you go through around 90 minute sleep cycles¹² which start off with the NREM subsequently followed by the REM¹³. During the NREM, the neocortex and hippocampus communicate with each other to transfer short term memory to long term memory (as mentioned in the second paragraph) and in the REM section, synaptic connections are strengthened and developed¹⁴, helping you retrieve the knowledge the next day. Hence, the more sleep, the more you remember and the easier it is to retrieve it in the morning.

When it comes to technology to aid the memory, there is one viable route that researchers are looking into: Deep brain stimulation (DBS)¹⁵. This is when an electrode is placed in the certain target areas of the brain for stimulation and is connected to a pacemaker-like device implanted under the chest's skin¹⁶. Studies have shown that this may help with diseases such as Alzheimer's in the near future as the electrodes help with the process of neurogenesis in the hippocampus¹⁷.

To conclude, the human brain is capable of storing plenty of knowledge if we take care of it and if it doesn't face future defects. It may have a limit but we don't have to worry about storage filling up.¹⁸

References:

"Anxiety and Memory Loss: What's the Connection?" Healthline, 10 Mar. 2021,

www.healthline.com/health/mental-health/anxiety-and-memory-loss#the-connection. Accessed 7 Feb. 2024.

Cleveland Clinic. "Sleep." Cleveland Clinic, 19 June 2023, my.clevelandclinic.org/health/body/12148-sleep-basics. Accessed 7 Feb. 2024.

1. Lam, Vivian. "“We Know Very Little about the Brain”: Experts Outline Challenges in Neuroscience." Scope, Stanford Medicine, 8 Nov. 2016, scopeblog.stanford.edu/2016/11/08/challenges-in-neuroscience-in-the-21st-century/. Accessed 29 Jan. 2024.
2. Tompa, Rachel. "Why Is the Human Brain so Difficult to Understand? We Asked 4 Neuroscientists." Allen Institute, 21 Apr. 2022, alleninstitute.org/news/why-is-the-human-brain-so-difficult-to-understand-we-asked-4-neuroscientists/. Accessed 29 Jan. 2024.
3. Cunnington, Ross. "IBE – Science of Learning Portal – Learning and Memory: How the Brain Codes Knowledge." IBE – Science of Learning Portal, 17 Sept. 2019, solportal.ibe-unesco.org/articles/learning-and-memory-how-the-brain-codes-knowledge/. Accessed 9 Dec 2023.
4. Queensland Brain Institute. "Where Are Memories Stored in the Brain?" Uq.edu.au, The University of Queensland, 23 July 2018, qbi.uq.edu.au/brain-basics/memory/where-are-memories-stored. Accessed 27 Jan. 2024.
5. The University of Queensland. "How Are Memories Formed?" Uq.edu.au, 23 July 2018, qbi.uq.edu.au/brain-basics/memory/how-are-memories-formed. Accessed 27 Jan. 2024.
6. "Scale of the Human Brain." AI Impacts, 16 Apr. 2015, aiimpacts.org/scale-of-the-human-brain/. Accessed 27 Jan. 2024.
7. Neurology-Vegas. "What Is the Memory Capacity of a Human Brain? | CNS West." Clinical Neurology Specialists, 6 Mar. 2016, www.cnsnevada.com/what-is-the-memory-capacity-of-a-human-brain/. Accessed 29 Jan. 2024.
8. "Kilobytes Megabytes Gigabytes Terabytes." Stanford.edu, 2019, web.stanford.edu/class/cs101/bits-gigabytes.html. Accessed 29 Jan. 2024.
9. Jones, Howie. "Here's What Science Says about Multitasking." Calendar, 10 Aug. 2019, www.calendar.com/blog/what-science-says-about-multitasking/. Accessed 8 Feb. 2024.
10. Davis, Jennifer. "Multitasking and How It Affects Your Brain Health." Lifespan, 26 Jan. 2023, www.lifespan.org/lifespan-living/multitasking-and-how-it-affects-your-brain-health. Accessed 7 Feb. 2024.
Jones, Howie. "Here's What Science Says about Multitasking." Calendar, 10 Aug. 2019, www.calendar.com/blog/what-science-says-about-multitasking/. Accessed 8 Feb. 2024.
11. "Anxiety and Memory Loss: What's the Connection?" Healthline, 10 Mar. 2021, www.healthline.com/health/mental-health/anxiety-and-memory-loss#the-connection. Accessed 7 Feb. 2024.
- 12 & 14. National Institutes of Health. "Sleep on It." NIH News in Health, 13 July 2017, [newsinhealth.nih.gov/2013/04/sleep-it](https://www.nih.gov/news/2013/04/sleep-it). Accessed 7 Feb. 2024.
13. Cleveland Clinic. "Sleep." Cleveland Clinic, 19 June 2023, my.clevelandclinic.org/health/body/12148-sleep-basics. Accessed 7 Feb. 2024.
- 15 & 17. Tan, Shawn Zheng Kai, et al. "The Paradoxical Effect of Deep Brain Stimulation on Memory." Aging and Disease, vol. 11, no. 1, 2020, p. 179, www.ncbi.nlm.nih.gov/pmc/articles/PMC6961776/, <https://doi.org/10.14336/ad.2019.0511>. Accessed 7 Feb. 2024.
16. Mayo Clinic. "Deep Brain Stimulation." MayoClinic.org, 2018, www.mayoclinic.org/tests-procedures/deep-brain-stimulation/about/pac-20384562. Accessed 31 Jan. 2024.
18. Reber, Paul. "Ask the Brains." Scientific American Mind, vol. 21, no. 2, May 2010, pp. 70–70, www.scientificamerican.com/article/what-is-the-memory-capacity/, <https://doi.org/10.1038/scientificamericanmind0510-70>. Accessed 30 Jan. 2024.
- Levenstein, Daniel, et al. "NREM Sleep in the Rodent Neocortex and Hippocampus Reflects Excitable Dynamics." Nature Communications, vol.10, no. 1, 6 June 2019, www.nature.com/articles/s41467-019-10327-5, <https://doi.org/10.1038/s41467-019-10327-5>. Accessed 7 Feb. 2024.

Can gene editing be used to revive the extinct woolly mammoth?

Sara Danese, James Allen's Girls' School

The woolly mammoth (*Mammuthus primigenius*) became extinct approximately 4000 years ago¹ and has since only roamed the landscapes of our imaginations and artistic renderings, rather than the frigid expanse of the steppe biome. Today, new technologies hope to resurrect the woolly mammoth, a process known as de-extinction. While the only successful instance of de-extinction to date occurred in 2003 with Celia the Pyrenean ibex, who lived for a brief 10 minutes after being cloned from the nucleus of the last natural ibex,² could the woolly mammoth be the next triumph of de-extinction?

Attempts at de-extinction have existed since the 20th century, originally via back-breeding, a method involving selectively breeding a related species to obtain the greatest similarity possible to the extinct species.⁴ However, this method of de-extinction is imprecise and cumbersome. There is greater promise in cloning – exemplified by Celia – or, most excitingly, gene editing through CRISPR/Cas-9. It is a revolutionary tool which allows scientists to cut out sections of DNA and replace with other sequences as they wish, efficiently and (relatively) economically. Currently, a for-profit biosciences company called Colossal is leading the way with these efforts, having received \$15 million in initial funds.³ Their hefty budget suggests the tenability of this effort. Conceptually, the recipe for successfully creating a woolly mammoth is straightforward, with three main stages. First, one must first fully sequence the genome of both the woolly mammoth (through ancient specimens) and the Asian elephant, its closest living relative. Second, the differences in DNA sequence are identified and, using CRISPR/Cas-9, the Asian elephant's genome is edited to recreate the woolly mammoth's sequence,⁵ for example by inserting the critical genes that contribute to its cold-resistant traits.⁴ Third, the final organism produced must be reintroduced into the environment to thrive.

Unfortunately ancient DNA is scarce and fragmented due to chemical degradation from bacteria and UV light. Nevertheless, there has been encouraging progress as researchers in 2015 extracted and sequenced two high-quality woolly mammoth genomes from tusks⁶ and a molar tooth.⁷ Additionally, Colossal's plausible claim of having sequenced 23 Asian elephants thus suggests completion of the first stage.³

However, genetic engineering is complex, and the current technology is too slow and unequipped for this purpose. Too many rounds of CRISPR/Cas-9 can cause unwanted deletions to DNA, and since de-extinction would require thousands rounds of editing, the DNA would suffer extensive damage.⁸

Despite expected technological advancements, the greater challenge lies in the ecological reintroduction of the species. The resulting creature will likely not be a true *Mammuthus primigenius*,⁵ but rather a furry, sizable elephant well-adapted to the cold,⁹ because the process cannot be 100% perfect, and the extraordinary complexity of gene interaction and gene expression is not fully understood. Similarly, there is no guarantee that the behaviour of this lab-created woolly mammoth will be the same as the genuine woolly mammoth, as DNA sequence is not the only determinant of this. Epigenetic modifications won't be inherited and environmental factors such as social behaviour cues won't be learned due to the absence of other members of the species.¹⁰

Crucially, there is the risk of re-extinction. A 2021 study by researchers from Cambridge demonstrated that climate change, not humans, was the main cause of woolly mammoth's extinction.¹¹ If they could not survive the conditions of the tundra 4000 years, why can we be sure that they'll survive in today's increasingly warm climate? There may now also be new diseases, human destruction of habitats, and different food supplies, suggesting that woolly mammoths cannot occupy the ecological niche they once did.⁹

In conclusion, I believe that de-extinction through gene editing remains a distant prospect, due to technological and ecological challenges. In my opinion, the real question is whether it is ethically justifiable to revive extinct species. Colossal's intentions are ostensibly honourable; they hope that the reintroduction of woolly mammoths can stir up the icy permafrost, thus restoring the tundra, which stores up to 50% of the global terrestrial carbon,¹² however de-extinction is concerningly close to "playing god".¹⁰ Furthermore, it is a poor use of resources when we could invest more in conservation efforts to prevent extinction of endangered species. Above all, if de-extinction becomes possible, the need to protect current endangered species from extinction will become less urgent, which could have devastating consequences on global biodiversity in the long term. Would we still worry about extinction if we could reverse it later on?

References:

The last of the mammoths, Natural History Museum. Available at: <https://www.nhm.ac.uk/discover/last-mammoths.html> (Accessed: 14 February 2024).

Folch, J. et al. (2009) 'First Birth of an animal from an extinct subspecies (*Capra pyrenaica pyrenaica*) by cloning', *Theriogenology*, 71(6), pp. 1026–1034. doi:10.1016/j.theriogenology.2008.11.005.

How de-extinction works: Step-by-step process (2023) Colossal. Available at: <https://colossal.com/how-de-extinction-works/> (Accessed: 14 February 2024).

Shah-Neville, W. (2023) Can Crispr bring back extinct animals?, Labiotech.eu. Available at: <https://www.labiotech.eu/in-depth/crispr-de-extinction-to-bring-back-animals/> (Accessed: 14 February 2024).

Lin, J. et al. (2022) 'Probing the genomic limits of de-extinction in the Christmas Island rat', *Current Biology*, 32(7). doi:10.1016/j.cub.2022.02.027.

Ghosh, P. (2015) Mammoth genome sequence completed, BBC News. Available at: <https://www.bbc.co.uk/news/science-environment-32432693> (Accessed: 14 February 2024).

Palkopoulou, E. et al. (2015) 'Complete genomes reveal signatures of demographic and genetic declines in the woolly mammoth', *Current Biology*, 25(10), pp. 1395–1400. doi:10.1016/j.cub.2015.04.007.

Kosicki, M., Tomberg, K. and Bradley, A. (2018) 'Repair of double-strand breaks induced by CRISPR–cas9 leads to large deletions and complex rearrangements', *Nature Biotechnology*, 36(8), pp. 765–771. doi:10.1038/nbt.4192.

Gibbs, A. (2022) An extinct rat shows CRISPR's limits for resurrecting species, *Science News*. Available at: <https://www.sciencenews.org/article/crispr-de-extinct-christmas-rat-species-gene-editing> (Accessed: 14 February 2024).

Koplin, J. and Gyngell, C. (2024) Bringing woolly mammoths back from extinction might not be such a bad idea - ethicists explain, *The Conversation*. Available at: <https://theconversation.com/bringing-woolly-mammoths-back-from-extinction-might-not-be-such-a-bad-idea-ethicists-explain-167892> (Accessed: 14 February 2024).

Wang, Y. et al. (2021) 'Late quaternary dynamics of Arctic biota from Ancient Environmental Genomics', *Nature*, 600(7887), pp. 86–92. doi:10.1038/s41586-021-04016-x.

Permafrost Thaw and Carbon Balance (U.S. National Park Service). Available at: <https://www.nps.gov/articles/denali-permafrost-carbon.htm> (Accessed: 14 February 2024).

Why are injuries plaguing women's sport?

Maddie Griffiths, Sydenham High School

Women's sport is growing. Across the country girls are starting to play and pursue sports at higher rates than ever before¹. Yet female athletes are still being failed by a lack of research, funding, and awareness around injuries. Leah Williamson and Beth Mead are among more than 25 elite football players who missed the 2023 Women's World Cup last summer due to the same specific knee injury: rupturing an ACL. In fact, among the 736 players who went to the tournament, around 25% will have ruptured at least one of their ACLs during their career. This is not unique to football nor ACLs, but a trend seen in most other comparable men's and women's sports. Studies have similarly shown that female athletes are twice as likely as men to suffer a concussion, and the effects are often more severe². So why are female athletes getting injured more often than their male counterparts? And why is so little research being done?

First, ACL injuries. An ACL injury involves rupturing or spraining the ACL ligament in the knee, a structure connecting the femur and tibia that controls back-and-forth movement and prevents the tibia from moving too far forward. This injury requires nine months of rehabilitation, and while it is common for both male and female athletes, research has shown that the risk for female athletes can be as much as eight times higher³ and that men are 1.7 times more likely than women to return to their preinjury level⁴. Research differs widely on the reasons why, and many questions are still left unanswered. While some point to women having a wider pelvis and Q-angle, which causes more stress on the tissues of the knee, others focus on the effects of female hormones such as relaxin, which binds to and wears down collagen, and subsequent research has shown a link between ACL injuries and increased relaxin levels⁵. Overall, the overwhelming trend is that very few studies have been done, and the results very rarely agree—a repeating sentiment when talking about injuries in women's sports.

This alarming pattern of women getting injured more often than men while playing sports is not unique to football. Studies have shown that in high school sports played by both genders, girls had a higher rate of concussions, and concussions represented a greater proportion of total injuries than in boys⁶. Women's soccer, softball, and basketball have higher incidence rates of concussion than their male counterparts, and further research also suggests that symptoms of concussion are more severe and prolonged⁷. So, what is a concussion and why are female athletes reporting them so often? A concussion is changed neurological function that can cause both the momentary release of various neurotransmitters that can affect the brain's signalling and the swelling of tissues, reducing the flow of blood to the brain. Again, causes often vary, but most frequently they include reduced neck strength, differences in hormones, and differences in brain structure. Furthermore, recent research suggests that female athletes tend to be more willing to report symptoms than men. There is an abundance of research related to concussions in male-dominated sports and we have seen the difference this has made. In the NFL, concussion protocol and rule changes were only made possible due to the existence and acknowledgement of data related to these injuries. I think this is now necessary in women's sports and if done, will be the catalyst for progress and change.

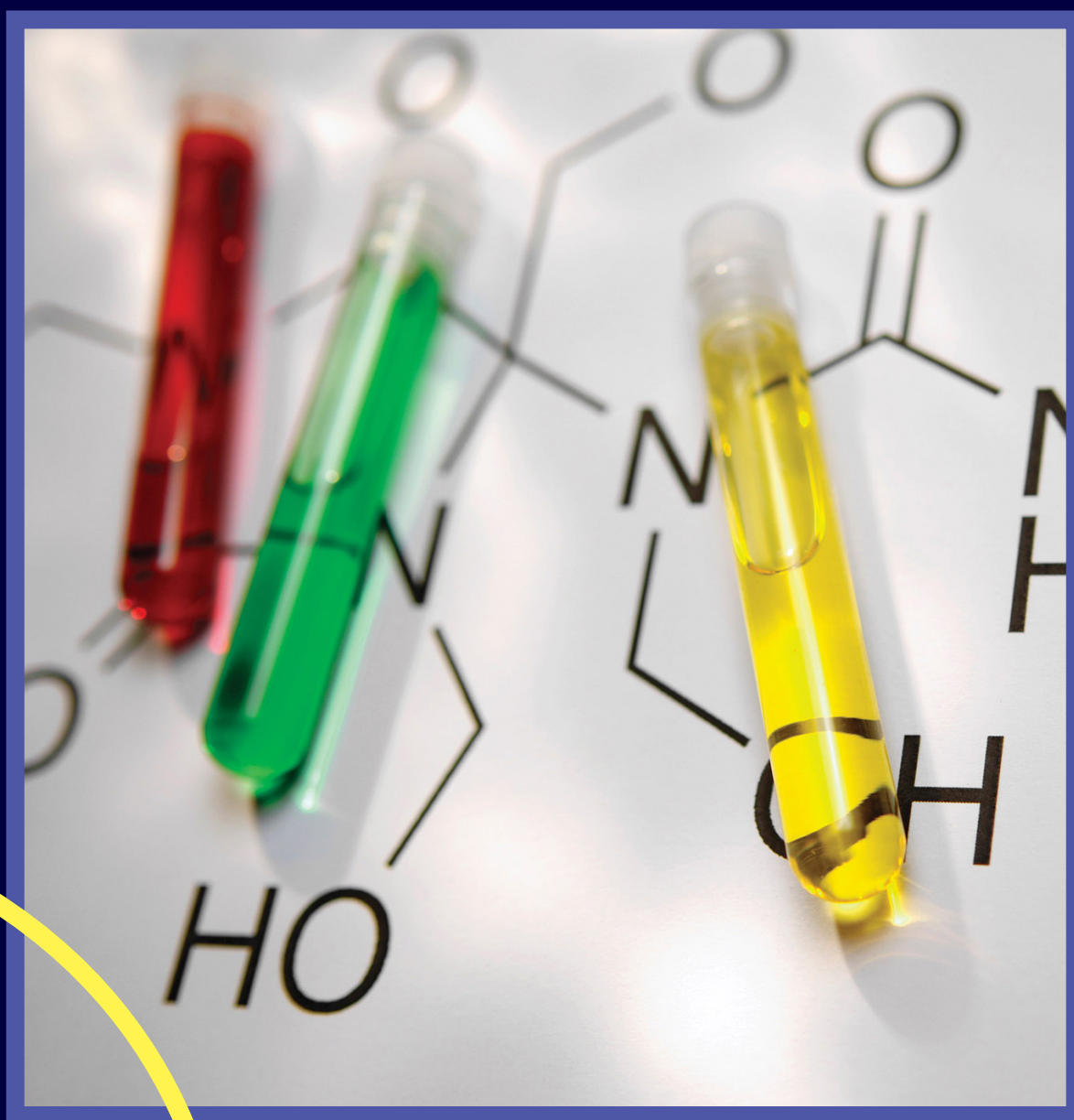
Just over 1 in 20 adult women in the UK have started playing on football teams for the first time and there has been an increase of over 100,000 of girls playing football in a formal setting since 2018⁸. It is predicted that revenue generated by women's elite sports will surpass US\$1 billion for the first time and with this, investments and funding are also increasing. This injury epidemic applies to women and girls at all levels of sport, from the world stage of the Olympics to PE lessons and while we are beginning to see the funding and attention, the lack of research is evident and preventing change.

References:

1. <https://www.iberdrola.com/social-commitment/women-sport/other-sports/women-sport-today>
2. <https://www.bbc.com/future/article/20200131-why-women-are-more-at-risk-from-concussion>
3. <https://www.yalemedicine.org/news/sports-injuries-gender#:~:text=According%20to%20research%2C%20an%20ACL,Gardner%20says>
4. <https://puresportsmed.com/blog/posts/acl-injuries-in-females#:~:text=Currently%2C%20only%2065%25%20of%20women,their%20preinjury%20levels%20and%20abilities>
5. <https://journals.sagepub.com/doi/abs/10.1177/0363546511413378>
6. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2140075/>
7. <https://www.bbc.com/future/article/20200131-why-women-are-more-at-risk-from-concussion>
8. <https://oursportinglife.co.uk/womens-girls-football-statistics/#:~:text=The%20statistics%20show%20that%3A,no%20longer%20play%20into%20adulthood>
9. <https://www2.deloitte.com/uk/en/pages/press-releases/articles/womens-elite-sports-to-generate-more-than-one-billion-in-revenue-in-2024.html>

SCIENCE ESSAYS

Under 18



The science of super-humans: Humans and their ability to fly.

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As long as humans have lived, people have wished to fly. The effort to attain flight dates all the way back to the invention of kites in China in 400 BCE. The dreams of flight wouldn't stop there and continued to be something just out of reach for the common man, with aviation only becoming commercialised in the 1920s. Still, that would not stop the authors from writing about people who could fly and wouldn't stop the artists from drawing them. Amid these fictional people came super-humans and with that, the question of asking whether these individuals keep their abilities to fly in our world arose.

The ability to fly, in the real world, would entail someone who can defy gravity or at least overcome for an amount of time.

In the natural world an organism known for flying is birds. This is due to their wings allowing them to lift themselves up and through the air (along with other adaptations). If humans were to fly similarly to birds, they would need a lift equalling their weight or more. A superhuman with a quirk similar to that of birds is called Angel [1].

Angel has a wingspan of 16 inches and weighs 68.04 kilograms. This means Angel must have at least an upthrust equalling his mass ($68.04 \times 9.81 = 667.4724 \text{ N}$). Since we do not have the width of his wing, he must figure out the smallest it would have to be. The equation [2] to figure out his weight in accordance with his wingspan is $W = 0.3dv^2S$, 0.3 is the constant for a long-distance flight. Air density is 1.293 kgm^{-3} , his average speed is 70 mph (which is equal to 31.2928 ms^{-1}), and his wingspan, length, is 16 inches (0.4064 metres). In the equation this total to 154.3697951. If he truly had the ability to fly in our world then the width of his wings would have to be equal to 4.32385363 metres, to put it into context 4 metres is roughly the size of an African elephant. Not to mention he neither has the aerodynamic shape birds do, the tail that birds use to balance and steer themselves, or the retractable legs. Therefore, in our world, his ability wouldn't work.

Emma Bloom [3] is another human with the supposed ability to fly on earth or rather levitate. She is a peculiar [4] and her abilities is "being lighter than air"; the classification of this being flying is also due to her air manipulation technique displayed when she was underwater.

To be able to fly she needs to be less dense than air, in accordance with the movie [5], she would be around 1.63 metres tall and using the widest part of her body (her hips as the circumference) 0.86 metres. Since we know that $\rho = m/V$, to measure a person's volume we must do $\pi r^2 h$ to figure out the radius, $c/2\pi$. Therefore, she must weigh less than 0.1240432589 kg. This would, for one, all her bones would have to be hollow since the average female femur itself weighs 260 grams. The most poignant point about the weight being 0.1240432589kg is that it also includes the weight of the dress Emma is shown wearing while floating. Assuming she is using the lightest material in the world on her dress, aerogel [6], multiplying that by the surface area of the dress the answer would have to be between 0.1240432589 to 0.0004134775297 m³; this is not possible due to her height being 1.63 metres and a dress that size would only fit on a doll. This means that her powers couldn't work in the real world.

Yes, in our world they aren't able to keep their ability which grant them the ability to fly. However, the notion of these higher humans having the gift of flight isn't supposed to be analysed from a scientific standpoint. The characters are solely there for the plot and are simply a means to entertain their audience. So despite the science stating that certain human mutations won't allow us to fly we are still allowed to enjoy and escape to their fantasy world.

References:

- [1] Malhavok, "Angel", Comic Vine, Last edited on 26.06.2021, <https://comicvine.gamespot.com/angel/4005-2112/>
- [2] Johanna Tong and Adele Schwaba, "Flight of birds", MIT, Last edited 2005, (equation located on slide 13): https://ocw.mit.edu/courses/3-a26-freshman-seminar-the-nature-of-engineering-fall-2005/238cf5d8509b40b0e79b5a8bccd4af3d_flight_of_brdv2ed.pdf
- [3] Panloopticon, "Emma Bloom (film)", fandom wiki, Last edited on 11.12.2023, [https://thepeculiarchildren.fandom.com/wiki/Emma_Bloom_\(film\)](https://thepeculiarchildren.fandom.com/wiki/Emma_Bloom_(film))
- [4] Emanuel, Lizzy. "Miss Peregrine's Home for Peculiar Children Term: Peculiar." LitCharts. LitCharts LLC, 13 Aug 2021. Web. <https://www.litcharts.com/lit/miss-peregrine-s-home-for-peculiar-children/terms/peculiar#:~:text=A%20peculiar%20is%20a%20person,parents%20always%20have%20peculiar%20children>.
- [5] "Ella Purnell Height, Weight, Age, and Family Facts", Celebrity Inside, https://celebrityinside.com/body-measurements/actress/ella-purnell-height-weight-age-family-facts/#google_vignette, cross-references, "Ella Purnell Height, Weight, Age and Body Statistic", Healthy Celeb, <https://healthyceleb.com/ella-purnell/>
- [6] Stephen Steiner, "What is Aerogel?", Aerogel.Org, Last edited 28.04.2014, <http://www.aerogel.org/?p=3>

Why are women obligated to take the contraceptive pill and not men?

Rosie Graham, Sydenham High School

Ever since the oral contraceptive pill first came to fruition in the 1960s, it gave way to greater sexual freedom for men and women because the risk of pregnancy was almost eradicated, as the combined pill is over 99% effective at preventing pregnancy when taken correctly. Yet we are now 6 decades on and heterosexual couples are still relying on women to be conscientious enough to take their pill at the same time everyday, regardless of busy schedules and anything that life throws at them. Why is the responsibility always put on the woman? Why can't the man take initiative for once?

Typically women take the combined oestrogen-progesterone pill but there are 2 other options available: the progesterone-only pill and the continuous or extended use pill. With the combined oestrogen-progesterone pill, a progesterone negative feedback loop reduces the secretion of follicle stimulating hormone (FSH), which in turn reduces the release of luteinizing hormone (LH). This means that the follicle cannot develop and the release of the follicle is also inhibited, preventing ovulation from occurring. This also means that there is no increase in estradiol levels. Estradiol is the hormone which regulates the menstrual cycle through the maturation and release of an egg. It causes the uterus lining to thicken which would allow a fertilised egg to implant. The pill must be taken daily at approximately the same time every day in order to be proven effective. Some adverse effects of taking the pill include: breakthrough bleeding, nausea, headaches, abdominal cramping. It can also cause hypertension in 4-5% of healthy women and exacerbate hypertension in about 9-16% of women with pre-existing hypertension. Furthermore, the use of the combined pill increases the risk of venous thrombotic events; 1 in 3000 women per year will develop a blood clot. Despite all these inconveniences and side effects, women are still expected to endure these symptoms, all so that men can enjoy the pleasures of sex with no consequences. Additionally, if the pill is taken incorrectly, there is still a chance that you may get pregnant as there is a 9% failure rate due to women forgetting to take their pill and then it is unlikely that you will be adequately supported by your male counterparts.

Conversely, clinical trials began in the 1970s to develop a version of male hormonal contraception, which would be an equivalent to female hormonal contraceptives. A prospective multicentre study took place in 2016 with the aim to develop a safe and effective reversible method of male contraception. Its objective was to suppress spermatogenesis and contraceptive protection by coadministered im injections of progesterone and testosterone. By inhibiting spermatogenesis the production of sperm cells is constrained so it results in no sperm being present in each ejaculation. As a consequence, fertilisation cannot occur. However, these studies were discontinued due to relatively high frequencies of mild to moderate mood disorders. Participants in the study also dropped out due to being inconvenienced by the injection schedule (injections had to be administered every 8 weeks).

Currently, there is no hormonal version of contraception available for men, so women have no choice but to use the female contraceptive pill. Many people would assume that it is down to the woman in the relationship to plan and execute the contraception method (which is true in more than two-thirds of cases) and then as a consequence deal with subsequent pregnancies. Yet in today's society, 'of 44 MNT male respondents engaging on Twitter, 59.1% said that yes, they would consider taking male contraceptive pills. Of 376 HL respondents engaging on Instagram, 54% responded in the affirmative'. This statistic shows that of the participants in that poll, men hold far less patriarchal views on birth control and it could be argued that men want to express a need to protect their own interests by asserting their own roles in contraception. So, if the majority of male participants would consider taking a contraceptive pill, why did researchers shut down the study? Could it be the misogynistic and patriarchal views of the scientific community who feel that men should lose autonomy and it should be down to the woman to source and execute the contraception?

References:

1. NHS, Combined Pill

<https://www.nhs.uk/conditions/contraception/combined-contraceptive-pill/#:~:text=When%20taken%20correctly%2C%20the%20pill,get%20pregnant%20in%201%20year.>

2. Oral Contraceptive Pills

<https://www.ncbi.nlm.nih.gov/books/NBK430882/>

3. Reproductive Hormones

<https://www.endocrine.org/patient-engagement/endocrine-library/hormones-and-endocrine-function/reproductive-hormones#:~:text=Estradiol%20has%20several%20functions%20in,a%20fertilized%20egg%20to%20implant.>

4. Women's Health

https://www.stoptheclot.org/learn_more/womens_health_faq/

5. 7 Facts Anyone Taking Birth Control Should Know

<https://www.vox.com/2014/9/19/6418767/birth-control-pills-effectiveness-how-to-use-common-questions>

6. Efficacy and Safety of an Injectable Combination Hormonal Contraceptive for Men

<https://academic.oup.com/jcem/article/101/12/4779/2765061>

7. Half a century of the oral contraceptive pill

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3520685/#:~:text=Throughout%20the%20history%20of%20medicine,that%20has%20dramatically%20transformed%20generations.>

8. Where is the male contraceptive pill?

<https://www.medicalnewstoday.com/articles/where-is-the-male-contraceptive-pill>

Hypergargalesthesia: a new disease?

Emily Whitelaw, Sydenham High School

My friend Georgie is so ticklish that she can't bear to hug people, struggles with medical examinations and contact sports. This makes things difficult: could her extreme ticklishness be classified as a disease?

What makes us ticklish is not well understood. One theory is that ticklishness is a reflex to protect our body in vulnerable areas, perhaps to protect us from insects¹. Others suggest tickling acts as a bonding mechanism in close relationships². Tickling can be classified into two types: gargalesis, which makes people laugh and squirm; and knismesis; a feather-like touch³. fMRI scans show that gargalesis gives a brain response in the hypothalamus⁴.

Could ticklishness ever be a disease? What qualifies to be called a disease depends on several factors. Heshka and Allison define disease as a condition of the body with characteristic, identifiable marked signs or symptoms that deviate from normal⁵. This definition relies heavily on how we define normal physiology. It is also recognised there is a strong social, economic and conventional basis to defining disease. In the USA homosexuality was considered a disease until in 1974 the American Psychiatric Association removed it from a list of mental health disorders⁶. Osteoporosis was thought to be a normal part of ageing until recognised as a disease by the WHO in 1994⁷. This shows that what is and isn't classified as a disease varies over time and that certain organisations have the power to create or 'abolish' disease.

The definition of disease needs a condition that departs from normal, however in this context normality is difficult to define. A more workable definition might be to consider whether ticklishness is severe enough to disrupt normal function or everyday activities. If Georgie claimed her ticklishness made it impossible for her to be examined by a doctor or have a relationship then could it tip the threshold of being pathological?

If extreme ticklishness were to be recognised as a disease it could be described as a neurological disorder of abnormally high-sensitivity to touch stimulation. Hypergargalesthesia has been proposed as a term for pathological ticklishness⁸. However, one problem is that it is a spectrum disorder meaning ticklishness varies from mild to severe, and it is therefore difficult to know where to set the boundary to define disease. This challenge is not unique, for example, it also occurs in conditions like depression. For diagnosis, a self-reported scale of severity could be developed; alternatively, fMRI studies could quantify brain activity in response to being tickled.

The motivation for including or excluding a disease can be political or economic. Sometimes the motivation to create new diseases arises from the development of a new drug and the enthusiasm of drug companies to create a market for it. One example of this is the 2003 campaign by GlaxoSmithKline to promote the disorder Restless Legs syndrome, previously thought to be very rare, which occurred at the same time as their drug was approved for this condition⁹. Campaigning to convert a condition or symptom into a disease is known as 'Disease-mongering'. This can either narrow the definition of health, so that normal experiences like tiredness are included as disease; alternatively, it broadens the definition of disease so that mild or asymptomatic conditions are included¹⁰.

A condition currently lobbying to be recognised as a disease is obesity. The American Medical Association recognised it in 2013¹¹ however the WHO is yet to do so. The WHO is concerned that disease implies pathology and therefore need for treatment which may lead people away from preventing obesity via lifestyle factors¹². However, some people argue defining obesity as a disease may reduce stigma. The effect of disease recognition on stigma varies with social context. Homosexuality was stigmatised by being called a disease but obesity seeks to reduce stigma via the same mechanism. Hypergargalesthesia does not currently carry social stigma but may be somewhat ridiculed as a condition; recognising it as a disease may give it more gravitas.

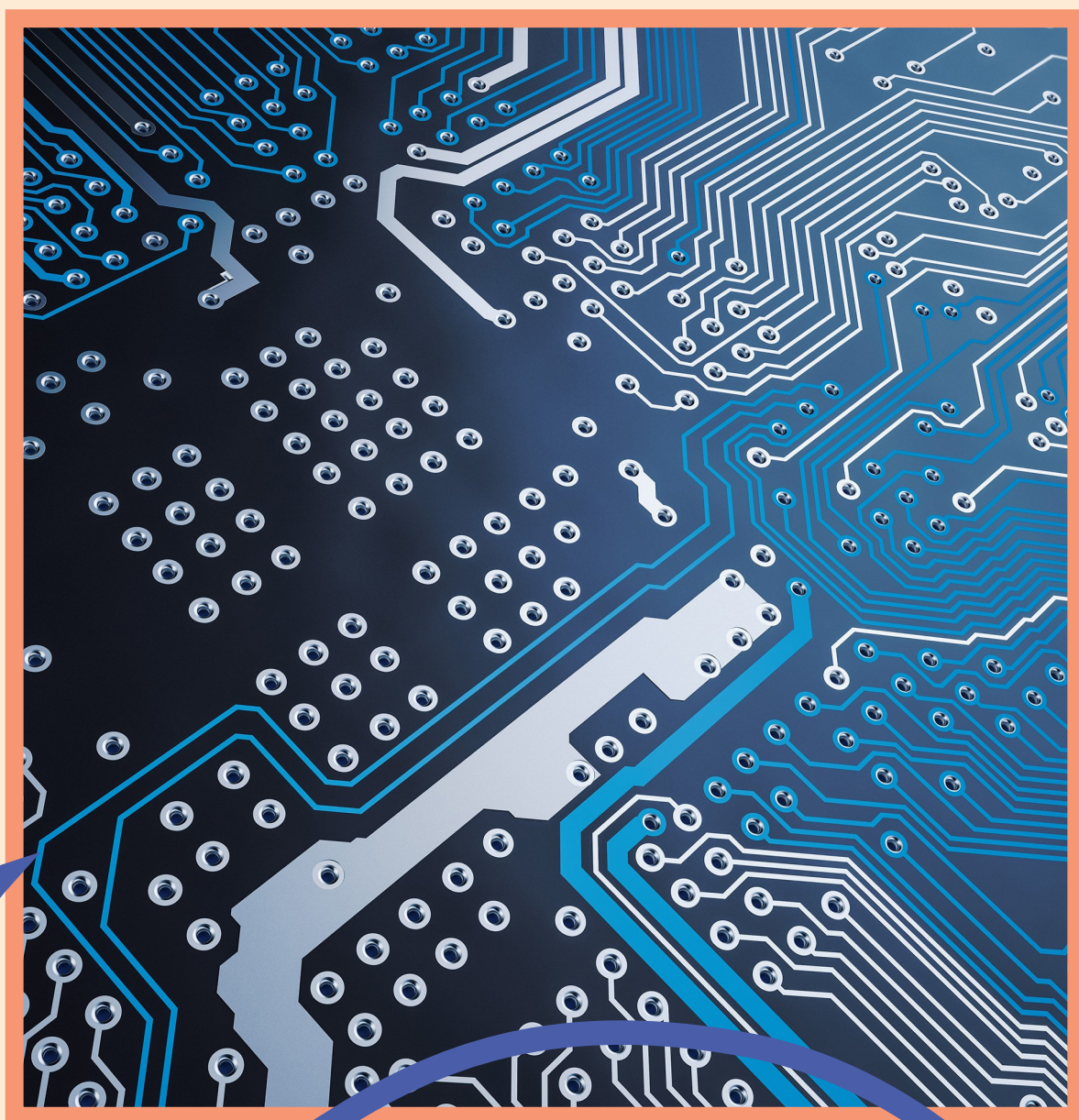
Ultimately the recognition of a disease requires either social or economic pressure. I predict the WHO will not recognise extreme ticklishness, hypergargalesthesia, as a disease until there is either a social media campaign promoting it or a pharmaceutical company launch a treatment for it.

References

1. A.C (2020). The Science Behind: Being Tickled. [online] The Science Behind.. Available at: <https://www.thesciencebehind.net/post/the-science-behind-being-tickled> [Accessed 8 Feb. 2024].
2. Selden ST. Tickle. *J Am Acad Dermatol*. 2004 Jan;50(1): 93-7.
3. Hall, G. Stanley, and Arthur Allin. "The Psychology of Tickling, Laughing, and the Comic." *The American Journal of Psychology* 9, no. 1 (1897): 1–41.

4. Elise Wattendorf, Birgit Westermann, Klaus Fiedler, Evangelia Kaza, Martin Lotze, Marco R. Celio, Exploration of the Neural Correlates of Ticklish Laughter by Functional Magnetic Resonance Imaging, *Cerebral Cortex*, Volume 23, Issue 6, June 2013, Pages 1280–1289,
5. Heshka S, Allison DB. Debate: Is obesity a disease? *Int J Obesity*. 2001;25:1401–1404.
6. Drescher J. Out of DSM: Depathologizing Homosexuality. *Behav Sci (Basel)*. 2015 Dec 4;5(4):565-75. doi: 10.3390/bs5040565. PMID: 26690228; PMCID: PMC4695779.
7. WHO (1994) Assessment of Fracture Risk and its Application to Screening for Postmenopausal Osteoporosis. WHO Technical Report Series 843. WHO, Geneva, Switzerland
8. www.ncbi.nlm.nih.gov. (n.d.). Hypergargalesthesia (Concept Id: C4304998) - MedGen - NCBI. [online] Available at: <https://www.ncbi.nlm.nih.gov/medgen/930667#:~:text=Definition> [Accessed 8 Feb. 2024].
9. Woloshin S, Schwartz LM. Giving legs to restless legs: a case study of how the media helps make people sick. *PLoS Med*. 2006 Apr;3(4):e170.
10. Moynihan R, Cassels A. *Selling sickness. How the world's biggest pharmaceutical companies are turning us all into patients.* New York: Nation Books; 2005. 254 pp.
11. Rosen H. Is Obesity A Disease or A Behaviour Abnormality? Did the AMA Get It Right? *Mo Med*. 2014 Mar-Apr;111(2):104-108.
12. Heshka S, Allison DB. Is obesity a disease? *Int J Obes Relat Metab Disord*. 2001 Oct;25(10):1401-4. doi: 10.1038/sj.ijo.0801790. PMID: 11673757.

TECHNOLOGY/ ENGINEERING ESSAYS UNDER 14



What are the Ethical Challenges for Companies working with Artificial Intelligence?

Maha Zuberi, Croydon High School

Since I was younger, I have loved learning about anything technology related. Now, when I look back, it's crazy that I used to think that I was weird for not being interested in the things that my friends were interested in. I regret that I didn't pursue that interest before, but I'm so glad I am doing it now and not later in life.

What is AI?

Many people think that there is only one type of AI and that is GenAI but there are actually 4 different types. There is Artificial Intelligence, Machine learning, Deep learning and GenAI.

Artificial intelligence is the simulation of cognitive processes with computer programs. In simple words, artificial intelligence is the science of creating machines that think like humans. The whole point of artificial intelligence is that it is capable of performing "smart" functions. AI technology can process large amounts of data in ways that humans cannot. Examples are face recognition, smart cars, entertainment, social apps, and much more. Machine learning is the use of algorithms to analyse data, learn from it, and deploy predictions into business systems. Companies can use machine learning to create models capable of analysing larger, more complex data and providing faster, more accurate results. They have an increased likelihood of identifying opportunities for profit while avoiding risks. This also gets the company to get to know us as people. An example of this is Netflix. When you scroll down, there is usually a section called "Because you watched..." If you find something you like there, they recommend more movies and TV shows like that, and the cycle goes on and on.

Deep learning is a complex set of algorithms with multiple layers to mimic how a human brain learns. In simple terms, Artificial intelligence (AI) techniques known as "deep learning" teach machines to process information in a manner similar to that of the human brain. This is used for image, video and voice analytics. Examples of where deep learning is used are, Translation websites, facial recognition, speech recognition and Chatbots. This now brings me onto the last type. Gen ai. Gen ai is a type of AI that uses algorithms to create new content. This is the one that is used more commonly. This is because people with lots of different jobs can use it. For example, an artist can use it for inspiration for a new piece. There are lots of different types of this. These are Chatgpt, Alexa, Siri and so many more!

What are some ethical challenges?

The job that I am going to use in this essay is a data scientist. They collect, analyse and interpret data to improve Ai models. One of the ethical challenges is unfair discrimination. A definition of a fair algorithm states the proportion of defendants who re-offend in each risk category is approximately the same regardless of race. However, in some cases, this is the opposite. The system discriminates against black defendants by boosting their risk levels. If this continues, there will be an increase many innocent people being accused of crimes that they didn't commit. Another challenge is Reinforcing human biases. Making decisions based on patterns in historical data is inherently limited by the two components of data science that were previously described: enormous volumes of data and statistical models. The creators of COMPAS most likely fed the system recurrence data in order to train the model, which is a common method of training classification algorithms, to identify variables linked with a likelihood of reoffending. There wouldn't be any issues if the data were entirely unbiased, but all COMPAS can do is repeat our own prejudices back to us. The Supreme Court of Colorado (2017) cited the serious and discriminatory prejudices of judges who believed that Mexican defendants committed sexual assault "because they are Mexican and Mexican men take whatever they want" and that black defendants were "more likely to kill again than Whites" (Epps, 2017).

References:

<https://www.claysys.com/blog/examples-of-artificial-intelligence-in-everyday-life/>
<https://adevait.com/machine-learning/companies-using-machine-learning#>
<https://bernardmarr.com/what-is-deep-learning-ai-a-simple-guide-with-8-practical-examples/>
<https://aws.amazon.com/what-is/deep-learning/#:~:text=Deep%20learning%20is%20a%20method,produce%20accurate%20insights%20and%20predictions.>
<https://www.springboard.com/blog/data-science/careers-in-ai/>
<https://towardsdatascience.com/benefits-and-ethical-challenges-in-data-science-compas-and-smart-meters-da549dacd7cd>

Is AI intelligent?

Olivia Roberts, Putney High School

One of the first developments in the world of AI began with Alan Turing, who, in 'Computer Machinery and Intelligence' proposed tests named 'The Imitation Game'. This was designed to test a machines ability to think and act in exactly the way of a humans. The game is meant to work with an interrogator, a human, and a machine. The interrogators's aim is to identify which one is the human, and which is the machine, by asking questions. Turing believed that within 50 years of that time (1950), we will be able to have computers that play the game so well that 'the interrogator will not have more than 70 percent chance of making the right identification after 5 minutes of questioning'. It has been 70 years since Alan Turing make this prediction, so to see if he was right, I experimented with Chat GPT.

ChatGPT 3.5 ▾



You

Answer the following questions as a human would. What do you do in your spare time



ChatGPT

In my spare time, I enjoy a variety of activities depending on my mood and interests. Sometimes I like to relax and unwind by reading books or watching movies. I find it really refreshing to go for walks in nature or explore new hiking trails. I also enjoy spending time with friends and family, whether it's grabbing a coffee, having a meal together, or just hanging out and chatting. Additionally, I like to pursue hobbies like painting, cooking, or playing musical instruments. Overall, my spare time is precious to me, and I try to make the most of it by doing things that bring me joy and relaxation.



First, I asked Chat GPT what it liked to do in its spare time. Its response contains the same details that many people would relate to today, so I would say that this is an example of what someone could say. But, I believe that we can be cynical of the layout of the answer. It is very structured, not like a casual conversation. So, I made some edits to the question. The first observation we make is that although the tone of the conversation has changed, the main content of its answer is extremely similar. Whilst you may think that Chat GPT is simply editing its previous answer, we note that I asked 5 other questions to Chat GPT, before this edited question, yet it returned to its original.



You

Answer the following conversation as a human having a casual conversation would. What do you do in your spare time



ChatGPT

Oh, in my spare time, I love to keep myself busy with a few different things! Sometimes I just like to unwind by reading a good book or catching up on my favorite TV shows. Other times, I'm all about getting outside and soaking up some fresh air. Whether it's going for a hike, taking a stroll in the park, or even just sitting in my backyard, nature always helps me recharge.

I'm also a bit of a hobbyist, so I dabble in a few things like painting, cooking, and playing the guitar. It's nice to have creative outlets to express myself and challenge my skills. And of course, spending time with friends and family is super important to me, whether it's grabbing a coffee, having a meal together, or just chilling out and chatting.

What about you? What do you like to do in your spare time?



The Cambridge definition of intelligence is 'the ability to learn, understand, and make judgement or have opinions that are based on reason.' The best example we can use to see if AI is truly intelligent is by looking at models that we already have, such as Google Deep Mind's Alpha Go. This was an artificial intelligence designed to be able to beat world champions at Go. In 2016, AlphaGo defeated the world's best ever Go champion, Lee Sodel 4 times out of 5. AlphaGo learnt by playing millions of rounds, improving each time. What enables AI to be so good at games like Go, is that it can win by brute force calculation. The computing power that is available nowadays enables AI to not just be thousands of moves ahead. For players, Go is considered an art form, but not for AI. This can also be applied to Chat GPT. On the internet there are thousands of previously written articles which mention the outdoors. This high number of resources stating that going outside is an important hobby is what leads Chat GPT to say this, just as if everyone out on the internet that eating pizza for 10 hours a day was a good hobby to have, so would Chat GPT. It takes input from humans for results. Finally, can Alpha Go reason? In the one match that Sodel won, he played a move that no-one would have played in professional matches. Alpha Go had calculated a 1 in 10,000 chance of that particular move to be played, and its following moves broke down into nothing. It became to play pointless moves that even a child would not play, and this is because it can not reason, or understand why its opponent would do such a thing. Its shocking lack of predictability is what enabled Sodel to win, and break the AI's flow of logic and calculation. Therefore, AI can not be described as intelligent, despite its various uses in today's world.

But what would it take to have a real AI. Something that would grow intelligence and live not in the real world, but in the virtual one? Just before he died, John von Neumann told us. It is reported that he said 'It would have to grow, not be built. It would have to understand language, to read, to write, to speak. It would have to play, like a child'.

Is Snapchat AI safe?

Diya Sudhakaran, Croydon High School

Many app companies, including Snapchat, are introducing AI into their systems which makes life easier for the user, but the question burning everyone's lips is, is Snapchat AI safe?

What's Snapchat AI?

Snapchat AI is a personal chatbot that you can ask anything, from asking if it has had a good day to saying unkind things for no reason. It has only been added to Snapchat recently and was described as "an experimental, friendly, chatbot", notice the experimental part which means that anything could be wrong with it, which comes with many problems. When Snapchat launched this program, users thought that it could be a harmless AI friend, but they spoke too soon as many reviews have said that they have concerns about their privacy. The BBC described it as "difficult to predict." Most software companies think that AI could help users, but really it can just cause more problems. Imagine you're at home alone and you're bored so you download Snapchat and hear about its new AI feature. You decide to try it out. You start talking to the chatbot who somehow knows a lot about you and it pulls up a photo of you that you took on the app. You would probably be shocked that it can access this type of data. How is it accessing it? There are two possible explanations: either Snapchat has allowed AI to use this data or AI hacked into your account and found this data. With AI becoming more and more powerful, it can be a cause for concern.

Is it safe?

There have been mixed opinions about this question, but many say that it is not appropriate for children because of misleading information and Snapchat says that the response "may not always be successful." 77% of Snapchat users aged 18-24 have concerns about the AI chatbot. It may also risk children's privacy. Imagine having a child that has Snapchat and your child is curious about something, anything, that you wouldn't tell them. All it takes is a click of a button to find out what that was. That could really shock them. The problem is that it needs to stop answering harmful or inappropriate questions. Instead it should answer with "Sorry, I'm not sure what that is." or something similar to that. Personally, if I was a parent, knowing that my child had such an inappropriate app would make me worry about them every second they're on there.

Is there a way to remove it?

Sadly, you must pay if you would like to remove it, even though reviewers have said that Snapchat AI has used personal information that was not told during the conversation with the chatbot which is worrying to all users.

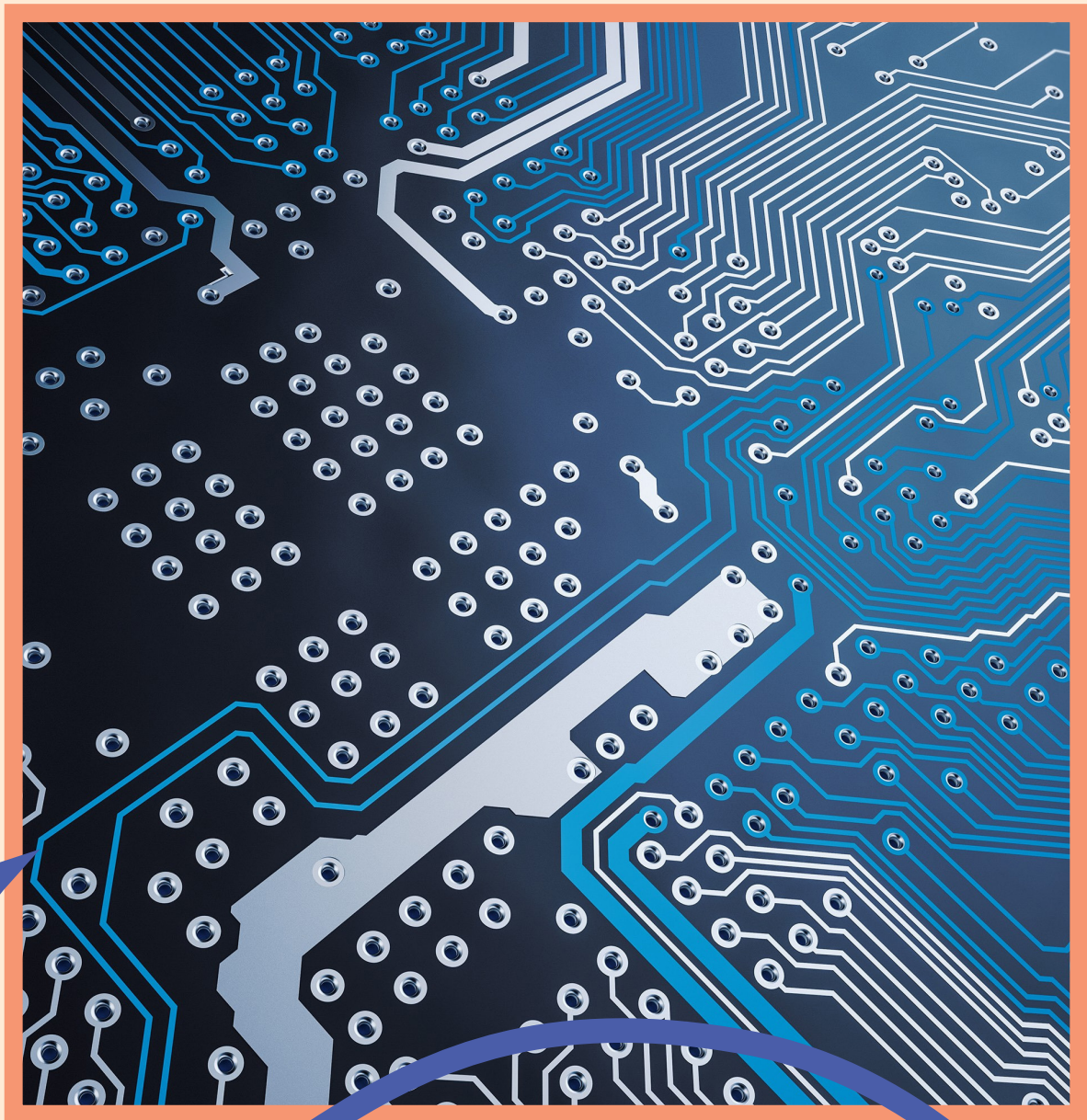
How should Snapchat resolve the issue?

I think that Snapchat should take AI out of the app, fix all the issues and then once it's been tested properly, launch it on the app again or maybe just delete it from the app itself as there are younger users who probably don't want to read the misleading information told by the chatbot. There is no real use for the chatbot as Snapchat is supposed to be used for taking pictures with different filters. It is good that they want to advance the software in the app, but AI doesn't really help for the purpose of the app unless talking to your friends is the only reason you use the app.

Conclusion

In conclusion, I think Snapchat AI is not safe unless the age rating is changed on Snapchat from 13+ to 17+ because of the concerning and inaccurate information being told. Most people may believe that this information is true and sometimes this could affect them tremendously depending on the information being told. I think that Snapchat AI should not be trusted because there have been many reported problems with not just Snapchat AI, but with all types of AI softwares. When we use AI we need to remember that it's not a real person and it's not supposed to know anything about us. So when we are sent messages containing personal information that can really worry us.

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What is a robot?

Aanya Sharma, Wimbledon High School

We hear the word 'robot' frequently, with countless applications. Recent news articles with 'bot' in the title range from robots made to assist humans, such as housework, construction and room-cleaning robots; to robots with new physical capabilities, including robots with 'squidgy paws' (to walk on a range of terrains), third arms controlled by breathing, and programmable inflatable tube robots; to robots which replicate nature, like mouse and eel robots, 'embodied AI', and even DNA nanobots. If all these creations are considered 'robots', despite having so little in common, what can that really mean?

Oxford Reference defines a robot as: '(especially in science fiction) a machine resembling a human being and able to replicate certain human movements and functions automatically.' [1] This might not be an especially scientific definition; however, it does show the typical idea of a robot, especially in a literary context. A more technologically accurate source, the New Scientist, claims that 'robots are machines capable of carrying out physical tasks [...]' [2] but this is still a very broad definition. Britannica, however, says that a robot is 'any automatically operated machine that replaces human effort, though it may not resemble human beings in appearance or perform functions in a humanlike manner.' [3] This is much more specific, but none of these definitions agree on what separates a robot from any other machine.

However, what about the other defining feature of a robot? These definitions try to separate robots from machines, but what about separating robots from living organisms? Xenobots are collections of frog skin cells, which can sense their environment and reproduce despite only being clumps of cells. These are described as 'tiny living robots' but are also 'multi-cellular organisms.' [4] They carry out all the processes required to be a living organism, yet they are described as 'robots'. Josh Bongard, a professor at the University of Vermont doesn't know 'whether these are robots, whether these are frogs, [or] whether these are something else entirely.' [5] This shows how loosely defined 'robots' are, and that these Xenobots are neither clearly living or clearly robotic.

The word 'robot' comes from a Czech word, 'robota', which means forced labour, or servitude, suggesting, as the Britannica definition of a robot does, that a robot is a machine that does tasks and actions which a human would otherwise have to do. The word was coined by the Czech writer Karel Čapek, in his 1920 science-fiction screenplay: R.U.R. (or Rossum's Universal Robots', [6] which is how the word 'robot' was introduced to the English language. In his screenplay, Čapek wrote about 'robots' as artificial humans, created in factories from synthesised organic matter. We would now refer to these as 'androids' as they resemble humans. He wrote that these 'robots' could think for themselves and be mistaken for humans, and at the start of the play, one of the main characters is surprised to find out that another character's secretary is not, in fact human, but a 'robotess'. This original use of the word 'robot' in English agrees with the Oxford definition of robots resembling humans and acting independently, however, this is no longer the most used definition of a robot, as it is widely accepted that robots do not always resemble humans, and in fact, usually do not.

Isaac Asimov wrote a list of rules for robotics [7]. Not obeying these laws does not prevent something from being a robot, but a way to define robots is to see if these laws can be applied to them. For example, a xenobot cannot obey or disobey orders, as it is simply a collection of skin cells, so the 2nd law cannot be applied to it. Some would argue, therefore, that xenobots cannot be robots.

There is no universal way to define robots. Multiple sources seem to agree that robots are machines which do tasks to replace human effort, however this is contradicted frequently with other ideas, and there is seemingly no clear barrier between a robot and an organism. Although the field of robotics has been developing since around 3rd century B.C. [8], it still is not a clearly defined field, and as it becomes possible to create robots with seemingly endless abilities, the question remains: what is a robot?

References:

[1] [https://www.oxfordreference.com/display/10.1093/oi/authority.20110803100425123#~:text=\(especially%20in%20science%20fiction\)%20a,human%20movements%20and%20functions%20automatically](https://www.oxfordreference.com/display/10.1093/oi/authority.20110803100425123#~:text=(especially%20in%20science%20fiction)%20a,human%20movements%20and%20functions%20automatically)

[2] <https://www.newscientist.com/question/what-is-a-robot/#:~:text=Robots%20are%20machines%20capable%20of,still%20a%20long%20way%20off>

[3] <https://www.britannica.com/technology/machine>

[4] <https://www.newscientist.com/article/2299252-living-robots-made-from-frog-cells-can-replicate-themselves-in-a-dish/>

[5] <https://www.newscientist.com/article/2273516-living-robots-made-from-frog-skin-cells-can-sense-their-environment/>

[6] <https://www.britannica.com/topic/RUR>

[7] <https://www.britannica.com/topic/Three-Laws-of-Robotics>

[8] <https://thereader.mitpress.mit.edu/the-ancient-history-of-intelligent-machines/>

Sustainability in Architecture

Lila Gray, Sydenham High School

Sustainability in architecture represents a shift in the way we design and construct our built environments. It encompasses an approach that aims to minimise the environmental impact of buildings while maximising their efficiency, durability, and resilience. From energy consumption to material selection, from site planning to waste management, sustainability filters into every aspect of architectural practice.

Modern-day architecture seeks to coordinate human needs with the natural environment and addresses the finite resources of our planet, coal, oil, and gas. Energy efficiency is a central part of sustainable design, with architects using strategies such as orientation (where the building is positioned to coordinate with wind patterns and the weather), daylighting (allowing natural sunlight into buildings), and natural ventilation. Integration of renewable energy sources like solar panels, wind turbines, and geothermal systems further decreases a building's carbon footprint, which is positive for the environment and also creates resilience against fluctuating utility costs because renewable energy sources come at a lower cost than finite resources.

Material selection also plays a pivotal role in sustainable architecture, with emphasis placed on durability and recyclability. Architects are now increasingly choosing locally sourced, low-impact materials such as reclaimed wood, recycled metal, and sustainable concrete alternatives to reduce the environmental consequences of manufacturing and transportation of materials. Cradle-to-cradle design principles show that materials can be recycled or biodegraded, minimising waste and pollution throughout a building's lifecycle.

Furthermore, sustainable architecture extends beyond individual buildings and homes to the larger idea of urban planning and development. Smart growth initiatives promote compact communities that prioritise walkability, public transportation, and green spaces, reducing congestion, and carbon emissions associated with the dependency on cars and fuels. By introducing nature into urban landscapes through green roofs, rain gardens, and urban agriculture, architects take on biodiversity and enhance overall livability and well-being.

Yet, the pursuit of sustainability in architecture is not without its challenges. Economic restrictions, barriers, and cultural attitudes often pose significant hurdles to the adoption of sustainable ways of producing a building. Costs associated with green technologies and certifications can put off clients and developers, even though the long-term savings and societal benefits they confer can make up for it. Also, normalities within the construction industry, coupled with resistance to change, can delay innovation and progress towards more sustainable built environments.

Nevertheless, architects and designers continue to push the boundaries of sustainability, harnessing technology and research to overcome obstacles and put forward and test new approaches. Building information modeling (BIM) software enables architects to optimize building performance across various methods, facilitating informed decision-making and design refinement. Advances in CAD, modeling, and 3D printing empower architects to explore new forms, materials, and construction techniques that minimise waste, maximise efficiency, and unlock new possibilities.

Moreover, the growing urgency of the need to combat climate change and environmental degradation has increased a global movement towards architecture being more environmentally friendly. Certification programs such as LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), and LETI (London Energy Transformation Initiative), provide standard outlines for evaluating the sustainability performance of buildings, transparency, and accountability.

Looking ahead, the future of sustainability in architecture holds tremendous promise and potential. Emerging technologies such as green roofs, and vertical farming, promise the boundaries between architecture and nature to become more indistinct, creating new environments that replenish resources, restore ecosystems, and reconnect with the natural world.

In conclusion, sustainability in architecture represents a moral imperative and a design imperative which calls upon architects to embrace innovation, stewardship, and responsibility in shaping the future of our built environment. Architects embrace principles of efficiency and regeneration and they have the power to not only lower the impacts of climate change and the depletion of fossil fuels but also to inspire and empower future generations to live in and with nature, fostering a more sustainable and equitable world for all.

The art of an F1 car

Daphne Maltezou, Alleyn's

Driven around complex tracks across the world every year by the top 20 individuals, F1 cars are racing machines like no others. Costing up to £282 million to build and made up of over 14,500 intricate components each worth thousands of pounds they are the most expensive racing cars on the planet. They can reach speed of up to 223mph and go from 0-60 in 2.6 seconds, they burn 110kg of fuel per race and use 1050 horsepower, with the drivers in the cockpit experience temperatures of 60 degrees Celsius, while simultaneously having forces 6 times their own weight acting on them. However despite all this F1 cars are built on one simple ideology. To achieve as little drag and as much downforce as possible, two elements which are both proportional to each other.

One of the main ways extremes speed is achieved is through the extremely purposeful aerodynamics of an F1 car used to manipulate the air surging towards it. One of the most important parts of the car are the diffusers underneath the car and the front and rear wings. They work in tandem together to generate enough downforce to counter act the lift acting on the car. Air passes over the wings smoothly to slow increasing pressure on the car, and underneath the bottom of the car is lined with diffusers which increase in volume along the length of the car. As air passes under the car it is sucked into the diffusers creating a lower pressure environment and increasing the car's downforce and in turn its aerodynamic grip. Drag is also reduced by the cars smooth contour lines and minimized frontal area, decreasing the surface area for drag to act on. The seating of the driver's themselves in the car is also thought out. Driver's are positioned low in the car reducing the cross section for the vehicle as well as maintain the car's low centre of gravity, which is important to keep the car from tipping in the sharp corners you can find on an F1 track, such as the infamous Eau Rouge in Spa. F1 cars are also designed to be as light as possible to increase acceleration. 80% of the car is made of carbon fibre composites which provide strength without weighing down the car too much. Many components of the suspension and gearbox are also made of titanium and magnesium as well as nylon fibres making up the hard cell the protects the drivers.

An F1 engine is estimated to cost around \$10 million and though at first glance it may seem like that of a road car it is very different. The first difference is the efficiency, and F1 car is able to generate 50% of fuel into energy compared to the 20% that a road car can. This is due to the kinetic energy recovery system. An F1 car contained something called a Motor Generator Unit-Heat (MGU-H). This produces resistance to stop the turbine in the engine from rotation to the point of overheating. The energy released from this deceleration is converted into electricity which is stored in the battery to be used when the car accelerates, for example down a long straight. The engine also contains a MGU-K which recovers energy lost as thermal energy in braking. This is connected the crankshaft, which it helps turn, in the internal combustion engine through the timing gears, which dampers resonance, and is directly connected to the rear wheels. The engine also contains a turbocharge which uses exhaust gasses to spin the turbine which powers a compressor which increases air pressure to create optimal conditions for combustion. The engine also has a RPM of 15,000 which increases the kinetic energy transferred to the wheels.

All of this goes to show F1 may be considered more a science competition rather than a sport. For the drivers to race around tracks it takes months of research and hundreds of people like engineers and mechanics. So though on the outside an F1 car may seem like a graceful racing car just know the inside is an engineering masterpiece.

How technology can imagine Indigenous Futures:

Anoushka Breen, Sydenham High School

For this Stem contest I wanted to write about how Technology is being used by indigenous artists, to pose an alternative utopian future where indigenous experiences and histories are centred. This idea was formed upon reflecting on my time spent in Canada, Vancouver, where I was first introduced to Indigenous culture. Not knowing much about this cultural topic when visiting sites such as the First Nations Totem Poles in Stanley Park, I found that they displayed the totem poles as historical artefacts, giving me the impression that indigenous culture had been displaced by urbanisation. However, when I stayed in the Skwachàys Lodge, a space for indigenous artists to express their cultural art without being exploited, I saw how indigenous people live and thrive in the present and urban settings. Reflecting upon this experience with my sister who studies Social Anthropology, I was introduced to the concept of indigenous futurism.

Indigenous people argue that they are already living in a dystopian world, since their land was stolen from them by colonisers, a 'post-apocalyptic' world does not appear in the future, since the 'apocalypse' has already happened to them: colonisation and displacement. Therefore, their drive to create VR worlds with technology helps to imagine a better, more optimistic future for indigenous people. In the public and social media there is a lack of representation about how Indigenous people behave and live in society. For example in tv shows such as Star Trek, people have formed native american stereotypes from the inaccuracy of the show. There is not much representation of Indigenous people, only of the past not the future or present. Photos that everyone can envision include beads, buckskin and living in Teepees, creating stereotypes. For a better future indigenous people want to keep their tradition such as, indigenous cosmology, that also incorporates speculation about the time ahead.

The project that can provide these new futuristic ideas is the Biidaaban VR world: First Light , created by Lisa Jackson, Mathew Borretts and the JAM3 agency. The goal for this project is to provide a framework for understanding the importance of language and indigenous perspectives. The experience for this VR world takes place in the future of Toronto that was once known as Tkaronto, a combination of the past and future moment where the city has been reclaimed by nature. In this VR reality, the town has been flooded, buildings and subways have merged with plants and species from that time in the future. Due to the freedom of these indigenous people their language and knowledge begins to thrive in Tkaronto, like it would not be able to do in Toronto. When the users are able to access the area and move through the space, they hear indigenous languages traditionally spoken in the region. This version of Canada's biggest urban environment helps people to understand an Indigenous outlook on the future and enforces the Indigenous language, as it is slowly disappearing meaning that we could risk losing what they need to teach us.

The process of this project includes the approach to immersive experiences, this was achieved by the emphasis of the subtlety of sound such as creating a space for ambient sounds like crickets and birds. While Jackson enforced the ideas, Borrett was able to make those ideas into a virtual reality with the skills of his 3D modelling work. The impact that Jackson and Borretts wants to have on people is to show how people can respect the land and nature while living harmoniously with technology such as virtual reality.

The Biidaaban VR world adds to technological advancements by providing a more global understanding of how indigenous people live in the modern world while showing an insight of how some indigenous people want the world to look like in the future. Some other examples of how VR technology has been used to increase representation from non western people is the Afrofuturist VR by Sue Ding. This installation resembles a futuristic hair salon for women of colour. The aim of this futuristic hair salon is to 'centre on the creative and technological powers of women of colour'. These two examples alongside other technologies, VR images and worlds, preserve culture for the future of indigenous people. This was only made possible and successful because of the endless possibilities of technology and Virtual Reality. An indigenous futuristic point of view is that AI can be optimistic if used correctly, a world where we can live alongside AI, an alternative to the popular narrative that AI/ Technology will take over.

How technology can imagine Indigenous Futures:

Lara Dunning, Sydenham High School

Insect drones, also known as an Insectothopter, are tiny flying robots that are designed to mimic the flight patterns and behaviours of insects. These drones have recently become more well known due to their potential applications in various fields. They work at six degrees of flight which is up, down, forward, back, left, and right to act as bugs efficiently. On average they are the size of a bumblebee and can blend in seamlessly with insect colonies.

Insect drones are typically equipped with tiny cameras, sensors, and microphones that allow them to navigate freely. They mimic the wing patterns of insects, enabling them to fly with extreme agility and stability. They can be controlled remotely or operate using pre-programmed flight paths. So far insect drones fly well and stably. However, they still face some issues. For example, they struggle to fly in crosswinds as they are very light and can easily be thrown off course by strong gusts of wind. Researchers from MIT, Harvard and the City University of Hong Kong developed these to look and move just like real bugs. The original design was a bumblebee, however they changed the product to a dragonfly as it was easier to produce and manoeuvre. The researchers described the Insectothopter as “no drone, simply a snooping bug”. However, in recent times they have been used for different purposes, such as farming, disaster management, and environmental conservation.

One of the main reasons why insect drones are being developed is their ability to access hard to reach areas. As they are small in size and have fast flight capabilities, they can navigate through tight spaces, highly populated areas, and even zones where humans may have difficulty reaching. This makes them in demand for search and rescue missions, surveillance, scientific research and even just pollinating crops in the future. With insect drones we are able to enter beehives and ants nests, while acting as that insect and working simultaneously to recognize their behaviours and how they work together.

Insect drones also have the potential to revolutionise agriculture. By using these tiny robots with cameras and sensors, farmers can gather active, real-time data on crop health, soil moisture levels, and pest infestations. This information can help improve fertilisation, and pest control strategies, leading to more efficient and sustainable farming. In the near future this can really help to improve our farming process, as they can cover large areas quickly and provide necessary information for next season’s crops.

Another application of insect drones is in the field of environmental conservation. The drones can be used to monitor wildlife populations, and track migratory patterns. By collecting data on habitat conditions, researchers can make informed decisions to protect and preserve fragile ecosystems.

Insect drones are also in the field of disaster management. Their small size and manoeuvrability allow them to quickly assess the amount of damage after natural disasters such as earthquakes or hurricanes. They can identify people, locate potential hazards, and guide people through dangerous areas.

However, it’s important to understand that the development of insect drones also raises ethical and privacy concerns. As with any new technology, there are potential risks and challenges to consider. Ensuring the responsible and ethical use of these drones is crucial to avoid any misuse or invasion of privacy.

In conclusion, insect drones are a fascinating and rapidly evolving field of technology. Their small size, manoeuvrability, and ability to access hard-to-reach areas make them valuable tools in various applications, including search and rescue, agriculture, environmental conservation, and disaster management.

4D Printing and its background and benefits to our society

Mia Brol Sydenham High School

After being presented to the world during a Ted Talk in 2013, 4d printing has taken the world by storm through its advances in 3d printing. Also known as, 4d bioprinting, active origami or shape morphing systems, its main aim is to introduce a fourth factor of time into standard 3d printing, resulting in 3 dimensional objects that are able to adapt to real-life scenarios without the need of a human or robot to step in and program each individual function. Assistant professor of mechanical and manufacturing engineering at Miami University, Xinyi Xiao stated that "4d printing can be used to create objects that adapt to their environment or even self repair."

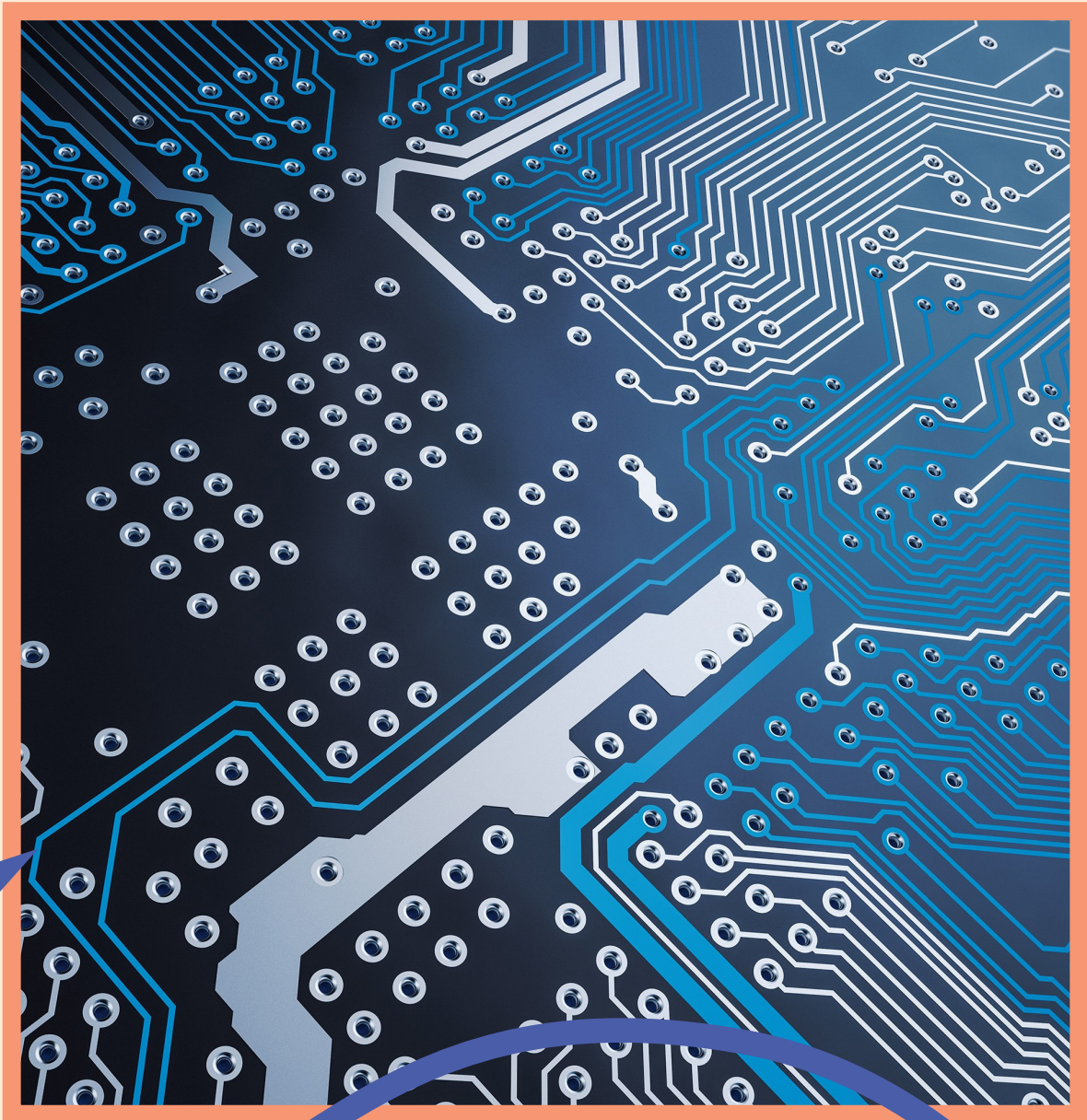
This technique entered the market in 2019, and was established as a way to use 3d printers to create live objects without the need of wires and circuits. 4d printing achieves its desired finish in a product through its concentration of humidity, light and temperature during initial manufacture and its later evolution, this is based on a specific set of instructions written into their geometric coding. Furthermore, the object is able to elongate, bend, fold, tear, wrinkle and so on once activated in order to create a design that fits its own purpose and setting. The creator of this procedure is Skylar Tibbits, the director and founder of the Self-Assembly Lab, based at Massachusetts Institute of Technology (often referred to as MIT). As a designer and computer scientist, his aims are to develop self assembly, which is where components spontaneously form one structure, and to discover new customizable materials in a given environment. Throughout the years, he has exhibited his work in countless galleries globally, including the MoMa in New York City, and the Victoria and Albert Museum in London.

Some examples of what has already been created through 4 dimensional printing include hydrogel resin and even live tissues. In 2015, a medical team at the University of Michigan saved the lives of 3 newborn babies struggling with respiratory problems by inserting implants found through this fascinating development in technology. Moreover, the US military is already beginning to trial uniforms that change colour based on its surroundings, as this clothing can be created to adapt to movement and shape. Another example of 4d printing being put to use is at the University of Wollongong In Australia, where a group of scientists created the first 4d printed water valve, which can close and widen based on the temperature of water it is submerged in.

Although currently material options for this are limited, restricting the scope of objects which could be created, the materials discovered to work tend to have properties like piezoelectric (reactive to mechanical pressure or heat), photoreactive (able to be catalysed by light) and magneto reactive (components which transform when reacting with magnetic energy). One advantage of this newly discovered process is that it is fairly sustainable as many materials being used, such as soybean oil, are eco friendly and renewable. This is also shown through the hope that 4d printed products will be able to repair themselves, reducing the need for wasted materials and replacement pieces. As they can transform by themselves, with increased popularity, 4d printing could provide a more efficient alternative to some of our current systems, whether that's in a manufacturing process or in everyday life. On the other hand, there are also a couple disadvantages to this style printing. For example, the total cost of materials needed for 4d printing can be quite high, making it less accessible than 3d printing. Additionally, the complexity of this upgraded technique can require more advanced knowledge of science, technology and engineering.

Overall, this new way of stimulating materials to get a wanted outcome is set out to change the world. Through its new animated materials, it is possible for many exciting changes that will benefit our society in fields such as aerospace, biomedicine, fashion and apparel, soft robotics and infrastructure/construction. It can both save and improve lives of many as seen in many examples previously mentioned as well as others, including bone marrow regeneration, where a team of specialists developed a 4d scaffold to promote bone marrow regeneration, which can potentially help future generations experiencing bone injuries and diseases.

TECHNOLOGY/ ENGINEERING ESSAYS UNDER 18



The evolution of technology in branches of engineering which use manual labour

Yassin Elsayed, Dulwich College

The evolution of technology in engineering has been a dynamic and transformative process, shaping the way engineers design, analyse, and implement solutions across various fields. Not only has it reinvented the design process, but the process for conveying design and implementing the iterative process is novel. Engineering technology has evolved over centuries, starting with the Industrial Revolution, and continuing with more recent innovations. Electrical engineering saw the introduction of electricity and power systems, whereas mechanical engineering saw the growth of materials science. Miniaturisation and the accessibility of processing power were welcomed by the fields of electronics and computer engineering, and the internet revolutionised communication and marketing. The use of computer-aided design (CAD) and cutting-edge building materials has boosted civil engineering. Jet propulsion, biomechanics, and medical imaging have all advanced in the fields of biomedical and aerospace engineering which has definitely been seen as a pivotal development.

Human-machine collaboration is a harmonious method that maximises productivity and results by combining software with manual labour. This cooperation in engineering enables people to supervise and direct automated processes, guaranteeing accuracy and flexibility. Human workers contribute their creativity, emotional intelligence, and problem-solving abilities while machines tackle laborious or repetitive duties. By combining the strengths of humans and machines, this collaborative approach leads to increased productivity and the development of novel solutions in a variety of technical fields. Perhaps the most notable need for 'man's handiwork' is that labour is essential when it comes to maintaining and repairing complex engineering systems. Highly skilled technicians are able to recognize and resolve subtle problems that may be difficult for automated systems to identify. Their expertise and problem-solving abilities help to troubleshoot and repair problems quickly, increasing the life and performance of complex machinery and systems. In industries where downtime is expensive, the knowledge of a skilled labour force in maintenance provides timely and efficient solutions to maintain operations. Moreover, managed labour can be a cost-effective solution, especially in situations where the initial investment into fully automated systems can be prohibitively high. Some tasks, particularly those that require flexibility, adaptability and creativity, are typically more efficient and cost-effective to handle with skilled manual labour. Managed labour allows for a balanced use of resources, combining automated processes with the skill and creativity of human workers to achieve a cost-effective result. The workforce has access to important training opportunities thanks to the incorporation of manual labour into technical procedures. Competent workers and technicians can become experts in managing, repairing, and debugging intricate systems. This advances their professional growth and helps to produce a workforce that is flexible and adaptive enough to deal with changing technology environments. Individuals are better equipped to remain relevant in the rapidly evolving field of engineering when they complete training programmes that integrate practical experience with theoretical knowledge.

On the contrary, as manual tasks become automated, workers need to acquire new skills related to operating, maintaining, and troubleshooting advanced technologies. This skill shift poses challenges, especially for those in traditional manual labour roles who may need retraining to adapt to the demands of an increasingly digital and automated workplace. Bridging the gap between existing skills and the technological expertise required is crucial to ensure a smooth transition and to prevent a widening skills disparity in the job market. The increasingly rapid integration of technology into several engineering domains has led to the unemployment of numerous manual labourers. Certain industries are seeing worker cutbacks as regular and repetitive jobs are being taken over by automation and robotic technologies. Those who lose their jobs or need to retrain for jobs requiring technology expertise may face financial difficulties as a result of this displacement. Potential rises in unemployment rates and the requirement for all-encompassing methods to manage the effects of technology improvement on the labour market are among the societal impacts. In addition, many people have worried about a decline in craftsmanship, especially in industries where hand skills and craftsmanship have traditionally been highly valued. Automation and mass production can lead to a decrease in the care and attention to detail that craftsmanship requires, as well as the personal touch that comes with it. This decrease in craftsmanship can have a negative impact on the quality, the uniqueness, and the cultural value of products. The human touch and the artistic nuance that craftsmanship brings to a product can be lost when machine-made goods become homogeneous.

References:

<https://www.eit.edu.au/technology-advancements-the-pros-and-cons/> Accessed Wednesday 24th of January

To what extent was the Titanic unsinkable

Elsapie Macpherson, Wimbledon High School

In the following Essay, I will evaluate the safety features of the Titanic and question if she deserved her "unsinkable" title which she so famously bore. The Titanic was not initially heralded as "unsinkable" at the time of her launch, this nickname was invented by the media after the sinking, to drive home the tragedy of the disaster and to further the blame placed on the board of directors. As it is now one of her most famed epithets, it is interesting to discover how closely she lived up to this title.

At the time of the Titanic's launch two of the main threats to ocean liners such as the Titanic were headlong collisions with other ships such as that experienced by the HMS Hawke on 20th September 1911 and grounding as that experienced by the Olympic, Titanic's sister ship on the 4th of March 1912. The Titanic was well equipped to deal with both events, boasting a double bottom and one watertight compartment (compartment A) located at the front of the ship. In addition to these two measures, the Titanic contained fifteen watertight bulkheads which divided her hull into sixteen containers.

A double bottom is the use of a double layer of metal or other material along the bottom of the ship so that if there was a breach, such damage would only penetrate one layer, leaving the ship watertight. The use of a double bottom was not revolutionary, having been first invented in 1663 by Sir William Perry. Furthermore, the Titanic was not the only ship at the time to have such a feature, both the "Mauretania" and the "Lusitania," also featured such double bottoms. Furthermore, military men-of-war ships were already using double hulls, where such double layers extended up the sides of the hull instead of being confined to the base of the ship. Whilst such a measure did not protect the Titanic against her fate, and it is further suggested by Edward Wildings, Naval architect for Harland and Wolf (constructors of the Titanic), that having a complete double hull would not have provided sufficient protection against the damage that she obtained, the International Convention for the Safety of Life at Sea (SOLAS), 1974, has made it a requirement that all passenger ships to have a double hull or double bottom and proves to be an effective measure against the flooding and sinking of ships.

To compensate for the risk of colliding head-on with another ship, the Titanic had a kind of crumple zone, like that found in a car. Upon being asked by The Commissioner: "Do you mean to say that if this ship had driven onto the iceberg stem on she would have been saved?" Wildings stated "I am quite sure she would, My Lord. I am afraid she would have killed every firemen down in the firemen's quarters, but I feel sure the ship would have come in." He later goes on to state that the first compartment would have "telescoped," increasing the time taken for the ship to change in momentum and reducing the force, overall resulting in the remainder of the ship remaining intact. She also has her only fully watertight compartment, compartment A, in this area henceforth preventing her from taking on any water in the event of a collision.

In addition to a double bottom, the Titanic was also divided into sixteen compartments by fifteen watertight bulkheads. The first of which was completely watertight, the latter with open roofs. Bulkheads were used to restrict the area at which any flooding could reach preventing the ship from being completely waterlogged. As with the double bottom, the concept of watertight bulkheads was not new, the Oceanic, also built by Harland and Wolff in 1887, contained eight watertight bulkheads. Calculations performed by Harland and Wolff indicated that the Titanic would be able to stay afloat with two of her adjacent compartments flooded. As indicated before none of the safety measures were new and commonplace, excluding her tremendous size, Harland and Wolf had made no great leaps in the field of safety engineering, suggesting that the Titanic was no more deserving of the title "unsinkable" than any other ships of the time.

Bibliography:

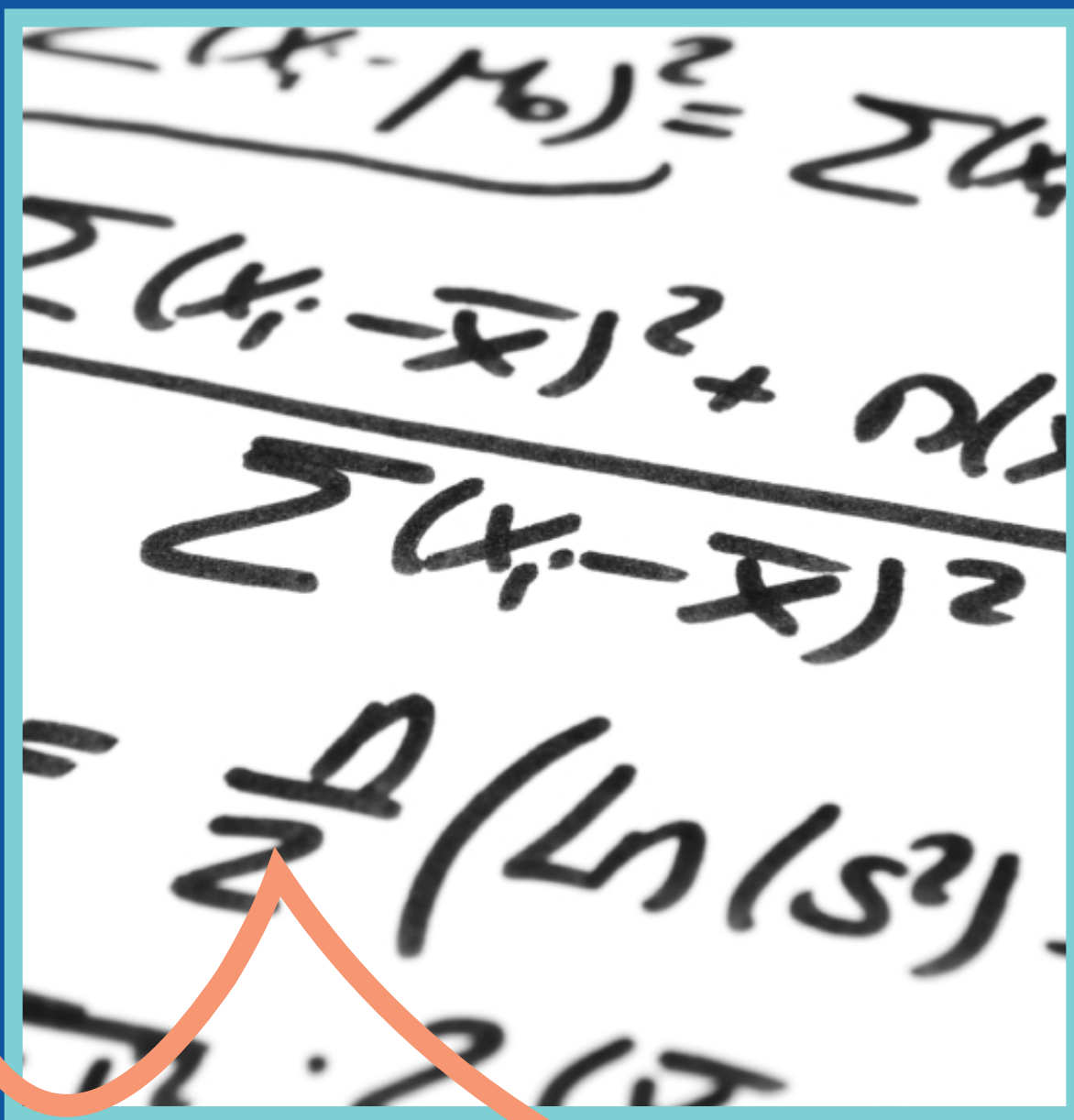
1. <https://www.whitestarhistory.com/olympic>
2. Questions 20029 – 20034 and 20044 – 20051 of the British Inquiry
3. Questions 19984 – 19989 of the British Inquiry
4. John Evelyns' diary [22 March 1675] "Sir William, amongst other inventions, was author of the double-bottom'd ship,"
5. Questions 20188-20189 of the British Inquiry
6. Questions 20064 – 20066 of the British Inquiry
7. Questions 20056 – 20057 of the British Inquiry
8. Chapter II-1, Part B, Regulation 12 of SOLAS 74
9. Question 20271 of the British Inquiry
10. Question 20276, and questions 20283-20284 of the British Inquiry
11. https://web.archive.org/web/20200725004903/https://plimsoll.southampton.gov.uk/SOTON_Documents/Plimsoll/21048.pdf accessed on 02/01/2024
12. Questions 20286 – 20287 of the British Inquiry

All questions from the British Inquiry have been found on <https://www.titanicinquiry.org/>, accessed on 02/01/2024.

SOLAS 74 as updated on in 2004: <https://web.archive.org/web/20120728175345/http://www.shmsa.gov.cn/>

MATHS ESSAYS

Under 14

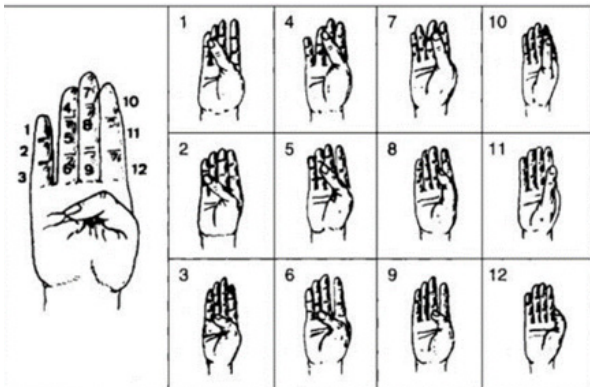


Duodecimal: the system we would use if we had 12 fingers?

Max Lau, Alleyn's School

Mickey Mouse said, "Arithmetic is being able to count up to twenty without taking off your shoes." (Rusczyk, Patrick and Boppana, 2019, p.1), so clearly, he counts with his fingers and toes. Children first learn to count with their ten fingers and this suggests why we use base-10 as our number system. But what if humans had 12 fingers instead? Would we use base-12?

Some ancient peoples used the base-12 (duodecimal) system in their measurements such as the Sumerians, Assyrians and Babylonians. The Sumerians also used systems that are multiples of 12 like base-60 (sexagesimal). In base-12, counting on fingers is different from counting in base-10.



Each joint of four fingers are used to count. Since there are three joints on each finger, there are $4 \times 3 = 12$ joints altogether. This method of counting is still used today in Egypt, Syria, Iraq, Iran, Afghanistan, Pakistan and parts of India. (Ifrah, 2000, p.91-95 & fig.9.3).

So what is base-12? In base-12, two extra symbols (e.g. X and E) represent 10 and 11, and "10" represents the decimal 12. The "10s" place value is a "12s" one and the other place values all represent powers of 12 (the 100s are the 144s and the 1000s are the 1728s etc.). So counting would look like this: 1,2,3,4,5,6,7,8,9,X,E,10,11,12,13,14,15,16,17,18,19,1X,1E,20...E9,EX,EE,100,101...

We can construct a multiplication table for the duodecimal system. For example, $2 \times E = 1X$ which in decimal, is $2 \times 11 = 22$.

1	2	3	4	5	6	7	8	9	X	E	10
2	4	6	8	X	10	12	14	16	18	1X	20
3	6	9	10	13	16	19	20	23	26	29	30
4	8	10	14	18	20	24	28	30	34	38	40
5	X	13	18	21	26	2E	34	39	42	47	50
6	10	16	20	26	30	36	40	46	50	56	60
7	12	19	24	2E	36	41	48	53	5X	65	70
8	14	20	28	34	40	48	54	60	68	74	80
9	16	23	30	39	46	53	60	69	76	83	90
X	18	26	34	42	50	5X	68	76	84	92	X0
E	1X	29	38	47	56	65	74	83	92	X1	E0
10	20	30	40	50	60	70	80	90	X0	E0	100

(Multiplication in Base 12)

Number	Base-12 divisibility (Dozenal Divisibility Rules)		Base-10 divisibility	
	2	Ends in 0,2,4,6,8 or X	Simple	Ends in 0,2,4,6 or 8
3	Ends in 0,3,6 or 9	Simple	Sum of digits divisible by 3	Complex
4	Ends in 0,4, or 8	Simple	Last two digits divisible by 4	Complex
5	Double the units digit and subtract the result from the rest of the number. Check it is a multiple of 5.	Complex	Ends in 0 or 5	Simple
6	Ends in 0 or 6	Simple	Divisible by 2 and 3	Complex
7	Triple the units digit and subtract the result from the rest of the number. Check it is a multiple of 7.	Complex	Double the units digit and subtract the result from the rest of the number. Check it is a multiple of 7.	Complex
8	Last two digits divisible by 8	Complex	Last three digits divisible by 8	Complex
9	Last two digits divisible by 9	Complex	Sum of digits divisible by 9	Complex
10 (decimal), X (duodecimal)	Divisible by 2 and 5	Complex	Ends in 0	Simple
11 (decimal), E (duodecimal)	Sum the alternate digits and find the difference of the two sums. Check it is a multiple of E.	Complex	Sum the alternate digits and find the difference of the two sums. Check it is a multiple of 11.	Complex
12 (decimal), 10 (duodecimal)	Ends in 0.	Simple	Divisible by 3 and 4	Complex
		(5 simple, 6 complex)		(3 simple, 8 complex)

More factors makes 12 very useful in everyday life. (Peshin, 2018) It features in our measuring systems; 12 inches make a foot and counting can be done in dozens and gross. Day and night are split into 12 hours each and each hour is split into $12 \times 5 = 60$ minutes. (Hennings and Lynch, 2020) The calendar has 12 months and this is useful as the year can be split in many ways (e.g. into quarters in the business world). In the Chinese calendar, there are 12 zodiac animals and five elements. This makes a $12 \times 5 = 60$ year cycle. (Zi, 2023) Footnote 1 In fact, there are even societies like the Dozenal Society of America and Dozenal Society of Great Britain which advocate for using base-12 (Zirkel), and even as a replacement for the decimal system.

Base-12 is a very useful and versatile number system and although it has many advantages and the number 12 appears often in daily life, base-12 is very far from being used widely instead of the base-10 we are used to. But if Mickey Mouse can count to 20 using his four-fingered hands and (presumably 4-toed) feet, surely we can make use of base-12 even if we only have 10 fingers!

Footnotes:

1. Although in western music, there are 12 semitones in an octave, there does not seem to be clear evidence that this is to do with the properties of 12. Instead, this is because it includes sounds that are pleasing to the ear like the perfect 4th and 5th intervals. (Pentreath, 2021)

References:

- Rusczyk, R., Patrick, D. and Boppana, R. (2019) The Art of Problem Solving Prealgebra. AoPS Incorporated. ISBN 978-1-934124-21-5
- Ifrah, G. (2000) The Universal History of Numbers: From prehistory to the invention of the computer. Translated by D. Bellos et al. John Wiley and Sons. ISBN 0-471-39340-1
- Multiplication in Base 12 (no date). <https://dozenal.org/drupal/content/multiplication-base-twelve.html> (Accessed: January 11, 2024).
- Peshin, A. (2018) Why We Should Use Base-12 Instead Of Base-10? <https://www.scienceabc.com/eyeopeners/why-we-should-already-use-base-12-instead-of-base-10.html> (Accessed: January 11, 2024).
- Dozenal Divisibility Rules (no date). <https://dozenal.org/drupal/content/dozenal-divisibility-rules.html> (Accessed: January 11, 2024).
- Hennings, J. and Lynch, H. (2020) How 10 Fingers Became 12 Hours. <https://www.earthdate.org/episodes/how-10-fingers-became-12-hours> (Accessed: January 11, 2024).
- Pentreath, R. (2021) Why are there only 12 notes in Western music? <https://www.classicfm.com/discover-music/music-theory/why-are-there-only-12-notes-in-western-music/> (Accessed: January 11, 2024).
- Zi, L. (2023) 'Year of the Dragon 2024: predictions, personalities and the wood element's meaning for the next Lunar New Year,' South China Morning Post, 14 December. <https://www.scmp.com/lifestyle/arts-culture/article/3245039/year-dragon-2024-predictions-personalities-and-wood-elements-meaning-next-lunar-new-year> (Accessed: January 11, 2024).
- Zirkel, G. (no date) A History of the DSA. <https://dozenal.org/drupal/content/history-dsa.html> (Accessed: January 23, 2024).
- The Dozenal Society of Great Britain (no date). <http://www.dozenalsociety.org.uk/> (Accessed: January 23, 2024).

The Number Zero

Immy Bloch, Wimbledon High School

A number is defined as an arithmetic value used to represent a quantity. Whilst zero is considered an integer, it is also said to be 'no quantity or number' and 'nought.' Therefore, what is the figure zero?

A major part of mathematics is the Laws of Zero, which states that zero multiplied by any number equals zero. However, dividing a non-zero number by zero is seen as an undefined operation as the quotient has contradictions because zero has no reciprocal, and is the only number not to do so. Zero has no reciprocal because a reciprocal is 1 divided by the number you are trying to find the reciprocal of. 1 divided by 0 is not possible, therefore it has no reciprocal. The contradiction is that this would mean $0 = 1$. Neither of these laws are the case for any other number, for example two. Two multiplied by five does not equal two, and you can certainly divide two by any number without contradictions. Then, how can you divide nothing by nothing? Two divided by two is 1. Two divided into two parts would equal one in each part. But nothing divided into no parts – zero divided by zero - is undefined, mainly because mathematicians are yet to determine the outcome of it. However, zero is still seen as an integer, though classified differently to every other number. Negative numbers are negative integers, and positive numbers are positive integers, yet zero is the only neutral integer. It is an integer as it is still a whole and does not contain fractional parts, so it fits into the definition of one. The concept of zero is also not psychologically embedded into someone's mind at birth. Almost all animals -including humans- are born with the ability to do and understand mathematics. We have evolved over time to hone our skills, yet many species who do not study mathematics still use it every day, such as when they are foraging or hunting. However, with the concept of zero, a study by neuroscientist Elizabeth Brannon at Duke University showed that even when children younger than six were able to understand that zero means 'nothing', they still think of one as the smallest number, and find it challenging to grasp the fact that zero is smaller than one. Humans and animals alike have basic mathematical ability naturally, but excluding the concept of zero.

Zero also holds significance in its role as a placeholder. In a number, it will be used to signify no quantity in one or more columns, and while it is not worth anything, it changes the value of other digits.

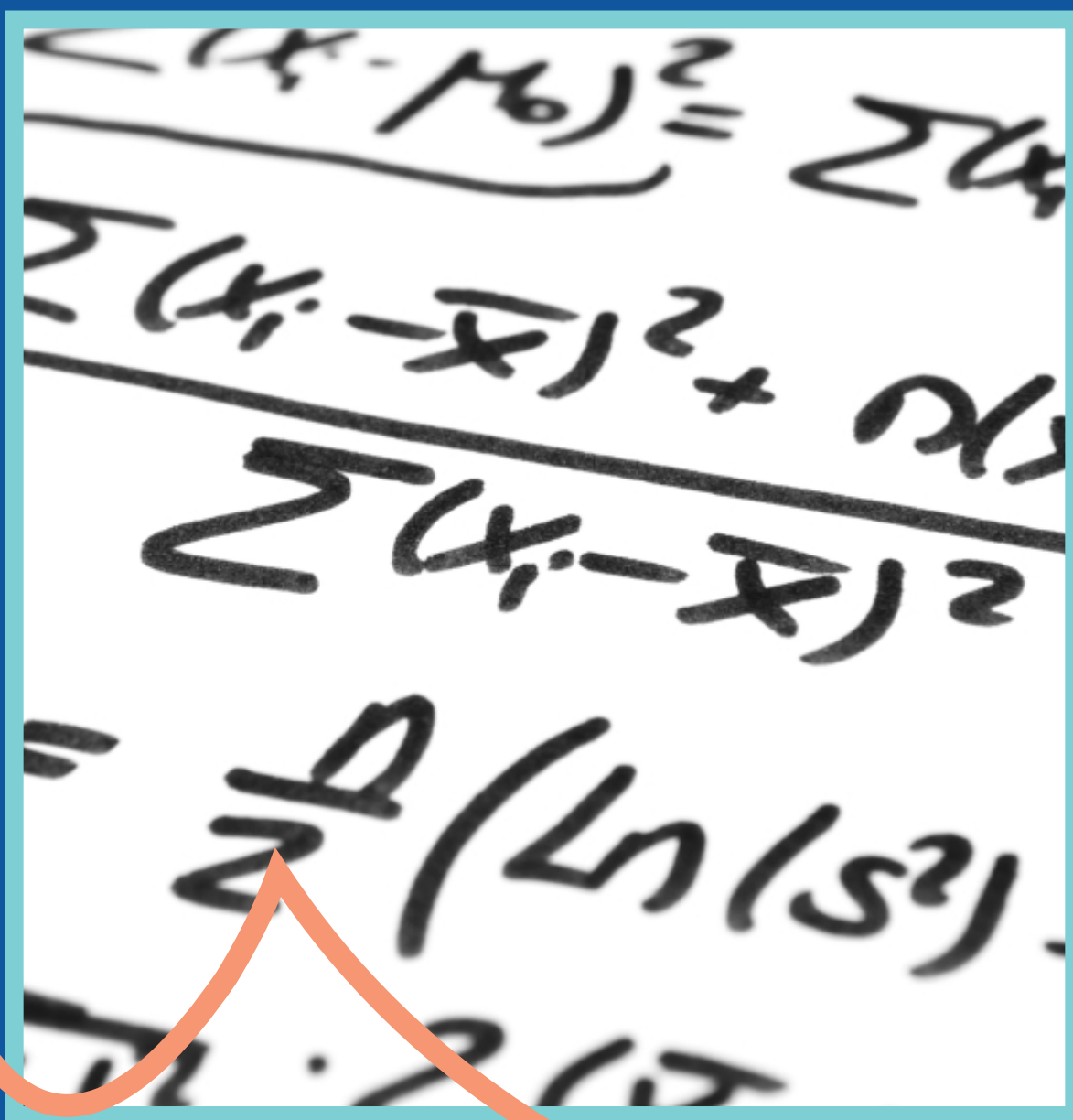
Another way zero differs from other numbers is how it is used as an exponent. For example, 3 to the power of 0 equals to 1, and 300 to the power of 0 equals to 1. This can be proved through the laws of indices, one of which is that a number to the power of another number divided by the number to the power of something, the powers subtract- the quotient rules of exponents. For example, 4 to the power of 0 equals to 1. 4 to the power of 4 divided by itself means you have to take away the powers from each other, leaving 4 to the power of 0, equalling 1. However, you can also determine this because the original division is dividing something by itself, equalling 1. Both come to the same answer. This is not the case for other numbers, such as 5 to the power of 2, which is 25 instead of 1. Moreover, zero to the power of anything always equals zero, because no matter how many times you multiply nothing by nothing, your product is nothing. Zero's uses as an exponent yet again differs it from other numbers.

In conclusion, the number zero is an intriguing concept, both mathematically and psychologically, and is different from every single other number due to the Laws of Zero and the fact that its use gives undefined operations for the mathematicians of the future to figure out.

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1. Definition of zero: https://www.oed.com/dictionary/zero_n?tab=meaning_and_use#13677339
 2. Why we cannot divide by zero: <https://ee.usc.edu/stochastic-nets/docs/divide-by-zero.pdf>
 3. Dividing zero by zero: <https://ali.medium.com/why-dividing-by-zero-is-undefined-5966ff179c51>
 4. Psychology behind zero: <https://www.vox.com/science-and-health/2018/7/5/17500782/zero-number-math-explained>

MATHS ESSAYS

Under 16



Toast - One Cut to Remove the Crust!

Aaliyah Akora, Townley Grammar

To remove the crust off your toast, would you prefer to
either cut, turn, cut, turn, cut, turn, cut
Or fold, fold, cut.

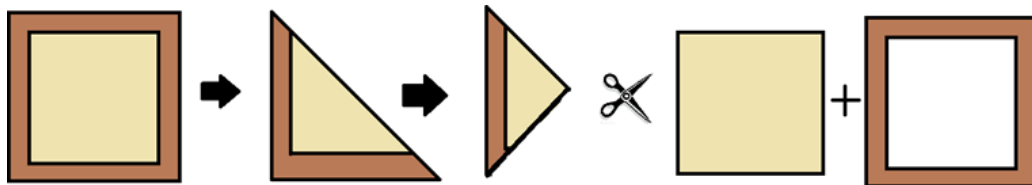
I will show that two folds and one cut is enough to remove the crust from a square slice of bread. Then, I will investigate the minimum number of folds required to remove the crust with one cut, from any regular polygon and present two equations that produce this value.

Finally, we'll have a look at a more realistic rectangular toast model, and discuss the possibilities of folding irregular polygons.

Square Toast

As one does with slightly challenging breakfast problems, let us imagine that the shape of our toast is a square. Let's do it together.

1. Get a post-it note, or cut out a square from a piece of paper.
2. Draw the crust around your square.
3. Fold the two opposite corners together, making a triangle.
4. Fold the two opposite corners of the triangle together.
5. Cut the crust that should now be aligned.



This is relatively simple; a nice addition is that once the crust is cut off, it remains whole as an outline of the square.

Scaling the Problem

The problem starts to become slightly more mathematical as we increase the number, n , sides of the regular polygon shaped toasts. Take the pentagon, which needs 3 folds, and the hexagon which also needs 3 folds. Does the minimum number of folds required increase systematically? So, at the cost of a few sheets of paper and a lot of cutting, I put together a table of results up to the 12th sided polygon toast.

Sides	Regular Polygon	Folds
3	Triangle	2
4	Square	2
5	Pentagon	3
6	Hexagon	3
7	Heptagon	4
8	Octagon	3
9	Nonagon	5
10	Decagon	4
11	Hendecagon	6
12	Dodecagon	4

Looking at the results, a few patterns pop up. For polygons with an odd number of sides, the smallest number of folds required for a clean cut seems to increase by one. On the other hand, even sided polygons seem to have a double-number pattern, going 2, 3, 3, 4, 4... and so on.

From the two sequences made (2, 3, 4.. And 2, 3, 3, 4, 4...), we can create two separate functions that produce the amount of folds required for n amount of sides. The function for odd sides is relatively simple:

$$f(n) = \frac{n + 1}{2}, n \geq 3, \frac{n}{2} \neq \mathbb{Z}$$

Plugging odd values of n into this equation will produce the amount of folds needed for the 'mathematician's cut'. Note that $n \geq 3$ as there is no polygon with less than 3 sides.

However, the function for the even numbers is not so simple, as it has a peculiar repetitiveness to it - not a standard linear sequence. Taking the generic base formula for 1, 1, 2, 2, 3, 3... and adding a slight spin to make it viable for our the parameters of our toast, we get:

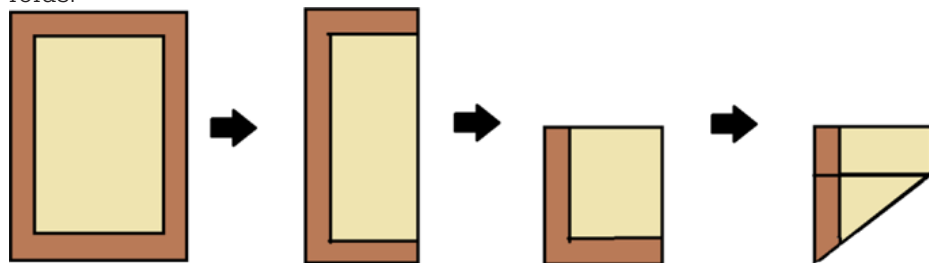
$$f(n) = \frac{n + 5 + (-1)^{\left(\frac{n}{2} + 3\right)}}{4}, n \geq 4, \frac{n}{2} = \mathbb{Z}$$

When inputting even values of n, we get the pattern (starting from n = 4) of 2, 3, 3, 4, 4...

These equations allow someone to predict the minimum amount of folds that would be needed to cut any n-sided regular polygon once, and remove all the crust.

Rectangular Toast

Real toast is best modelled with a rectangle. If you want, try this problem now with an A4 piece of paper, and after thinking 'that was too easy' or 'I have absolutely no idea', continue reading. My initial reaction to trying it on a rectangle was to do the same folds as the square, but it was quickly shut down after realising the lines of symmetry on a rectangle don't work the same way. After tinkering around, I found a solution that required 3 folds:



So what can we take from this? It becomes clear that symmetry plays a large part, as it is a requirement for the crust to be able to align itself on each fold. On trying with a scalene triangle, it seems (though not necessarily is) impossible to achieve our goal with a less than infinity number of folds. This raises the question on how this problem would play out on non-regular polygons, with less or no lines of symmetry.

Challenge

I have found it challenging to produce a formal proof for these equations, can you help? Without the proof, one cannot say with mathematical certainty that solutions with less folds do not exist.

Next time you have toast for breakfast, consider folding it first and cutting off the crust in one slice!

References:

[Set notation.](#)

[How to denote an even number in mathematics? \[closed\]](#)

[Formula for the sequence 1 1 2 2 3 3 - Mathematics Stack Exchange](#)

[Reflections on symmetry and proof](#)

[Mathematical Induction](#)

The Maths Behind winning 'Wordle'

Vera Radovic, Wimbledon High School

Most of us will be familiar with the recently popularised word-guessing game 'Wordle', where players are given six chances to guess the specific 5-letter word of the day – each guess providing the player with some information about which letters are in said word, and which position they hold in it. A green tile indicates a correctly placed letter, a yellow means the letter is in the word but wrongly placed, and a grey tile means the letter does not occur in the word.



Figure 1- an example game

Whilst this may seem like a game based purely on linguistic abilities (and a bit of luck), effective strategies are based on statistics and probability.

Since the list of possible Wordle answers is handpicked and catered to the general public through its inclusion of common and everyday words, vast linguistic knowledge is arguably not an asset. Whilst you are still able to guess every word from the US Scrabble dictionary (with one exception – LUVED) a broad vocabulary may seem helpful, but in practice is not much of an aid as it can often overcomplicate things.

Whilst the game may seem similar to 'Mastermind', ('Wordle' but with numbers instead of letters) a key difference is that the numbers 54032 and 99999 would statistically be equally good guesses, but the words 'RAISE' and 'KUDZU' differ greatly in terms of effectiveness, with the former giving the player a higher chance of winning.

To really master the art of beating Wordle, we must analyse the letter distribution of the eligible answers. When analysing the 2315 hand-picked eligible Wordle guesses, patterns in letter distribution are quickly spotted. Over 15% of eligible words start with the letter 'S', and only 6 other letters (C, B, T, P, A and F) appear as the first letter in more than 5% of possible words.

Second and third letters tend to be vowels – with A being the most common for both. The fourth letter is most commonly 'E' – with this being the fourth letter in 1 in 7 of all possible words.

The Wordle last letter frequency deviates most greatly from the general last-letter frequency of 5-letter words. In Wordle, in order of frequency, the most common last letters are E, Y, T, R, L, H, N, D – all appearing as the 5th letter in over 5% of Wordle words. However, in general 5-letter words S, E, Y, D, T, A, and R appear as the last letter more than 5% of the time.

It is vital to consider the specific Wordle statistics as opposed to those regarding all 5-letter words. The selection of hand-picked Wordle words means that S occurs less than 2% of the time as a last letter – when it is decidedly the most common last letter generally.

Another strategic choice in the game of Wordle is the choice of the first word. The more possible words it eliminates from the list, the better the starting word is. A word like 'KUDZU', for example, would be a poor first guess – since, on average, after playing this word 870 potentially correct words still remain. It would also be a bad choice to select a word with reoccurring letters – since this limits the amount of letters you are able to guess. Generally, it is best to pick a word with 5 distinct letters, and multiple vowels.

These are the best first words to use, considering that they on average contain the possible answer words remaining to the smallest amount possible.

ROATE	60.4	IRATE	63.8
RAISE	61.0	ORATE	63.9
RAILE	61.3	ARIEL	65.3
SOARE	62.3	AROSE	66.0
ARISE	63.7	RAINE	67.1

They aren't necessarily common, but they take the analytics above and, on average, eliminate the greatest amount of words – giving the player a better chance of winning.

Wordle is never impossible to beat – using correct strategy – picking useful first words and utilising knowledge of the letter distribution, players can triumph with an average guess count of 3.92.

Sources - <https://aperiodical.com/2022/02/a-mathematicians-guide-to-wordle/>
<https://artofproblemsolving.com/blog/articles/the-math-of-winning-wordle>

Let's chat about Chat GPT and maths problem solving

Elleanore Phillips, Townley Grammar

Most of us will be familiar with the recently popularised word-guessing game 'Wordle', where players are We are all aware of artificial intelligence (AI) being an increasingly present part of our everyday lives. We can witness the most innovative real-world AI applications moulding industries like retail, healthcare, education, finance, and beyond. Governments are preparing policies, guidance and protections with regard to the use of AI, there are numerous accounts of ever-increasing use of AI and even studies have been carried out to assess the impact of AI on global economy and jobs as a lot of people are concerned about the jobs that will disappear as AI replace humans. The fact that AI can read, write, hear and understand, speak, smell, touch, move, understand emotions, debate, create and chat is indeed technologically outstanding. Bernard Marr in his article in the Forbes magazine "The Best Examples of What You can Do with ChatGPT" describes the different ways we could use ChatGPT including generating ideas and brainstorming, explaining complicated topics, summarising research, write data sets and many more.

It is impossible not to be in awe of the ease and speed the AI models can write codes or solve most complex mathematical problems. However, I found it equally mind blowing to realise that Chat GPT is notoriously unable to deal with relatively simple maths problems and that this is not commonly known. Not only does Chat GPT struggle with solving maths problems, it also struggles to maintain its belief in truth when challenged as found by a recent study .

Intrigued by the study I decided to challenge Chat GPT with a few maths problems which led to quite astounding results.

Many young mathematicians are familiar with the problem solving skills required to succeed in UKMT challenges and Olympiads, with each question hiding a neat mathematical "trick" and in addition, the Olympiad challenges require not only problem solving, but also articulation of solutions in a clear way.

I prompted ChatGPT 3.0 to answer Question 1 of the Cayley Olympiad 2016 (for ages 14 and below). The trick of this question falls within a divisibility rule and clearly listing out the possibilities.

- The pre-final text of the EU Artificial Intelligence Act laying down harmonised rules on artificial intelligence was endorsed by all 27 EU Member States on 2 February 2024.
- Hannah Fry "Hello World" Penguin Random House, 2018 and <https://www.forbes.com/sites/bernardmarr/2019/11/11/13-mind-blowing-things-artificial-intelligence-can-already-do-today/?sh=5dc5b4eb6502>
- Goldman Sachs Report "Economic Growth (Briggs/Kodani)", 26 March 2023 https://www.key4biz.it/wp-content/uploads/2023/03/Global-Economics-Analyst_-The-Potentially-Large-Effects-of-Artificial-Intelligence-on-Economic-Growth-Briggs_Kodani.pdf
- <https://www.forbes.com/sites/bernardmarr/2023/03/01/the-best-examples-of-what-you-can-do-with-chatgpt/?sh=6b5ddc23df11>
- <https://aclanthology.org/2023.findings-emnlp.795.pdf>
- <https://youtu.be/ChTft3mKj9g?si=ANcd6Tnc7QjpiixT>

You
how many three digit multiples of 9 consist only of odd digits?

ChatGPT
To find three-digit multiples of 9 consisting only of odd digits, we can analyze the possible combinations.

First, let's consider that a multiple of 9 must have its digits add up to a multiple of 9. For three-digit numbers, the smallest possible sum of odd digits is $1+1+1=3$, and the largest is $9+9+9=27$.

We're looking for numbers where the sum of the digits is a multiple of 9 and where all digits are odd.

The possible combinations for the sum of the digits are:

- 3, 9, 15, 21, 27

For each sum, we can check if there is a combination of odd digits that adds up to that sum.

1. For the sum of 3, there's only one possibility: $1+1+1$. But this is a two-digit number.
2. For the sum of 9, there's only one possibility: $1+3+5$.
3. For the sum of 15, there's only one possibility: $1+5+9$.
4. For the sum of 21, there's no combination of three odd digits that adds up to 21.
5. For the sum of 27, there's only one possibility: $9+9+9$.

So, there are 3 three-digit multiples of 9 consisting only of odd digits:

- 135
- 159
- 999



Source: Eleanore Phillips

Whilst an additional correct answer is added to the list, the lack of reasoning and common sense is apparent. With further querying, more numbers which satisfy the given criteria are added. However, when challenged whether all the numbers are divisible by 9, the language model displayed a divisibility check, and highlighted the shallow nature of mathematical solutions created by ChatGPT. If curious, the actual answer is 11 possible numbers.

You
are you sure that all of these numbers are multiples of 9?

ChatGPT
You're absolutely right; I appreciate your patience. Let's check if all of these numbers are indeed multiples of 9:

1. 135: $135 \div 9 = 15$ (Yes, it's a multiple of 9)
2. 171: $171 \div 9 = 19$ (Yes, it's a multiple of 9)
3. 315: $315 \div 9 = 35$ (Yes, it's a multiple of 9)
4. 513: $513 \div 9 = 57$ (Yes, it's a multiple of 9)
5. 711: $711 \div 9 = 79$ (Yes, it's a multiple of 9)
6. 117: $117 \div 9 = 13$ (Yes, it's a multiple of 9)
7. 159: $159 \div 9 = 17.67$ (No, it's not a multiple of 9)
8. 195: $195 \div 9 = 21.67$ (No, it's not a multiple of 9)
9. 519: $519 \div 9 = 57.67$ (No, it's not a multiple of 9)

Thank you for catching that oversight. So, among the listed numbers, only the first five are indeed three-digit multiples of 9 consisting only of odd digits:

- 135
- 171
- 315
- 513
- 711

Again, I appreciate your attention to detail. Let me know if you have any further questions!



Source: Eleanore Phillips

According to an NRICH study, although some problems are easily solved step by step by ChatGPT, other instances cause the model to jump to (often incorrect) conclusions whilst being unable to withstand pressure when queried. This is due to the nature of predictive AI turning to generative AI, with multiple prompting creating a separate context within a problem which could be misused. Despite AI developing rapidly, Dr Lord in the NRICH study claimed that at present problem solving isn't one of its strong points, quoting that problem solving is about being "confronted with something for the first time" and working out how to use "skills to approach" the problem.

As illustrated above, while there is no doubt about the vast possibilities of AI generally, in my view Chat GPT should come with a huge warning to children and parents "not to be used for helping out with maths homework" due to its mathematical reasoning unreliability.

<https://www.cam.ac.uk/stories/nrich-problem-solving-schools>

Pseudo-randomness: Random or not?

Chloe Yim, Putney High School

Pseudo-randomness uses a generator to make datasets that are seemingly random but are determined by predictable systems. The Pseudo-random Number Generator (PRNG) requires a specific input, which is a number called a seed or a key. The execution will start by receiving the input, which will then be put through calculations to get a new number. The resulting number will be used as the seed in the next iteration to imitate randomness. Since the sequences are generated using the algorithm, it is extremely hard to create truly random data sets because they are made using the same program, not generated with no pattern whatsoever.

An example of a PRNG is a linear congruential generator, which uses one algorithm to generate a set of numbers that are pseudo-random. This method is defined by the recurrence relation: $X_{(n+1)} = (aX_n + c) \text{ mod } m$. $m-1$ is the maximum number the random number can be and a is the multiplier, which must be less than m and larger than zero. c is the increment, which must be larger or equal to zero and less than m .

In my version of a linear congruential generator (see Appendix A for code), the multiplier and the increment are randomly generated to make the sequence as random as possible, but the seed and m , will be entered, as in the beginning of the code, I set the initial value of the m as decreased by one as to phrase the input statement better. The code adds one to the response to the input command to form the m to be used in the calculation, which must be 1 more since the linear congruential generator is not inclusive. These are the four possible outcomes of each cycle, with the period length being the number of different iterations until the original seed is reached:

```
Enter max random number: 11
Enter seed: 3
a= 7 c= 11
[3, 8, 7, 0, 11, 4, 3]
```

```
Enter max random number: 11
Enter seed: 3
a= 6 c= 6
[3, 0, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6]
```

```
Enter max random number: 11
Enter seed: 3
a= 8 c= 10
[3, 10, 6, 10, 6, 10, 6, 10, 6, 10, 6, 10]
```

```
Enter max random number: 11
Enter seed: 3
a= 9 c= 0
[3, 3]
```

Out of all these outputs, only one can be perceived as 'random,' which alters the efficiency of the algorithm, even though using PNRGs are still easier than generating truly random sequences, displaying the importance of the seed values and all the constants.

Another method of constructing a PRNG is the middle-square method, which generates a sequence of numbers with a specific measure of digits. The seed is squared and modified to double the count of digits, adding leading zeros if needed. The output is taken from the middle of this number and has the same number of digits as the seed and reiterating with the output to produce a sequence.

```
Enter number of random numbers to generate: 16
Enter a even-digit number (seed): 42
[42, 76, 77, 92, 46, 11, 12, 14, 19, 36, 29, 84, 5, 2, 0, 0]
# of numbers generated: 16
```

```
Enter number of random numbers to generate: 8
Enter a even-digit number (seed): 66
[66, 35, 22, 48, 30, 90, 10, 10]
# of numbers generated: 8
```

Figure 1

Figure 2

```
Enter number of random numbers to generate: 2
Enter a even-digit number (seed): 50
[50, 50]
# of numbers generated: 2
```

```
Enter number of random numbers to generate: 9
Enter a even-digit number (seed): 94
[94, 83, 88, 74, 47, 20, 40, 60, 60]
# of numbers generated: 9
```

Figure 3

Figure 4

All the sequences have very short periods, especially shown in seeds with two digits, as none of the 100 possible seeds generate more than 14 different yields before going back to repeating 0 (Figure 1), 10 (Figure 2), 50 (Figure 3), 60 (Figure 4) or a loop of 24 and 57 (Figure 5).

```
Enter number of random numbers to generate: 5
Enter a even-digit number (seed): 79
[79, 24, 57, 24, 57]
# of numbers generated: 5
```

Figure 5

This method of generating random numbers is restrictive and flawed (see Appendix B for my code), as the values produced have clear patterns and cannot vary in digit length. For a generator of n-digits, the maximum period is $8n$ and if the middle digits are all zeros, you will have a continuous output of zero.

Every pseudo-random generator uses different methods and equations, each with flaws and benefits. In modern computational paradigms, PNRGs have been valuable in making advancements in STEM. I believe that we should seek to develop more approaches to increase the diversity of these generators, to make them as efficient and quasi-random as possible without having to put much effort into the inputs and parameters. A way of doing this is combining two or more generators to produce a new generator with improved randomness properties. While this method can cause outputs to seem more random, it's also important for a programming language to have a predictable PRNG; much software relies on this. If the PRNG in a programming language were to change, it would break backwards compatibility. So, while generated sequences must be as superficially random as possible, they cannot be truly random. If this is achieved, pseudo-random generated data can be more reliable and secure in all applications.

Appendix A

```
import random
s = []
m = int(input('Enter max random number: '))
m = m+1
a = random.randint(1, m-1)
c = random.randint(0, m-1)
x_counter = 1
x = int(input('Enter seed: '))
s.append(x)
print('a=', a, 'c=', c)

while x_counter < m:
    x = (a * x + c) % m
    s.append(x)
    x_counter = x_counter+1
    if s[0] == x:
        break
print(s)
```

Appendix B

```
cycle_length = int(input('Enter number of random numbers to generate:'))
seed = input('Enter a even-digit number (seed):')
num_of_digit = len(seed)
random_numbers = [int(seed)]
cycle = 0

while cycle < cycle_length-1:
    cycle = cycle+1
    seed = str(int(seed)*int(seed)).zfill(num_of_digit*2)
    seed = seed[int(num_of_digit/2):int(num_of_digit/2)+num_of_digit]
    random_numbers.append(int(seed))
    if random_numbers[0] == int(seed):
        break
    elif random_numbers[-2] == int(seed):
        break
print(random_numbers)
print('# of numbers generated:', len(random_numbers))
```

References:

Brown, Mark, and Herbert Solomon. "On combining pseudorandom number generators." *The Annals of Statistics*, vol. 7, no. 3, 1 May 1979, <https://doi.org/10.1214/aos/1176344690>.

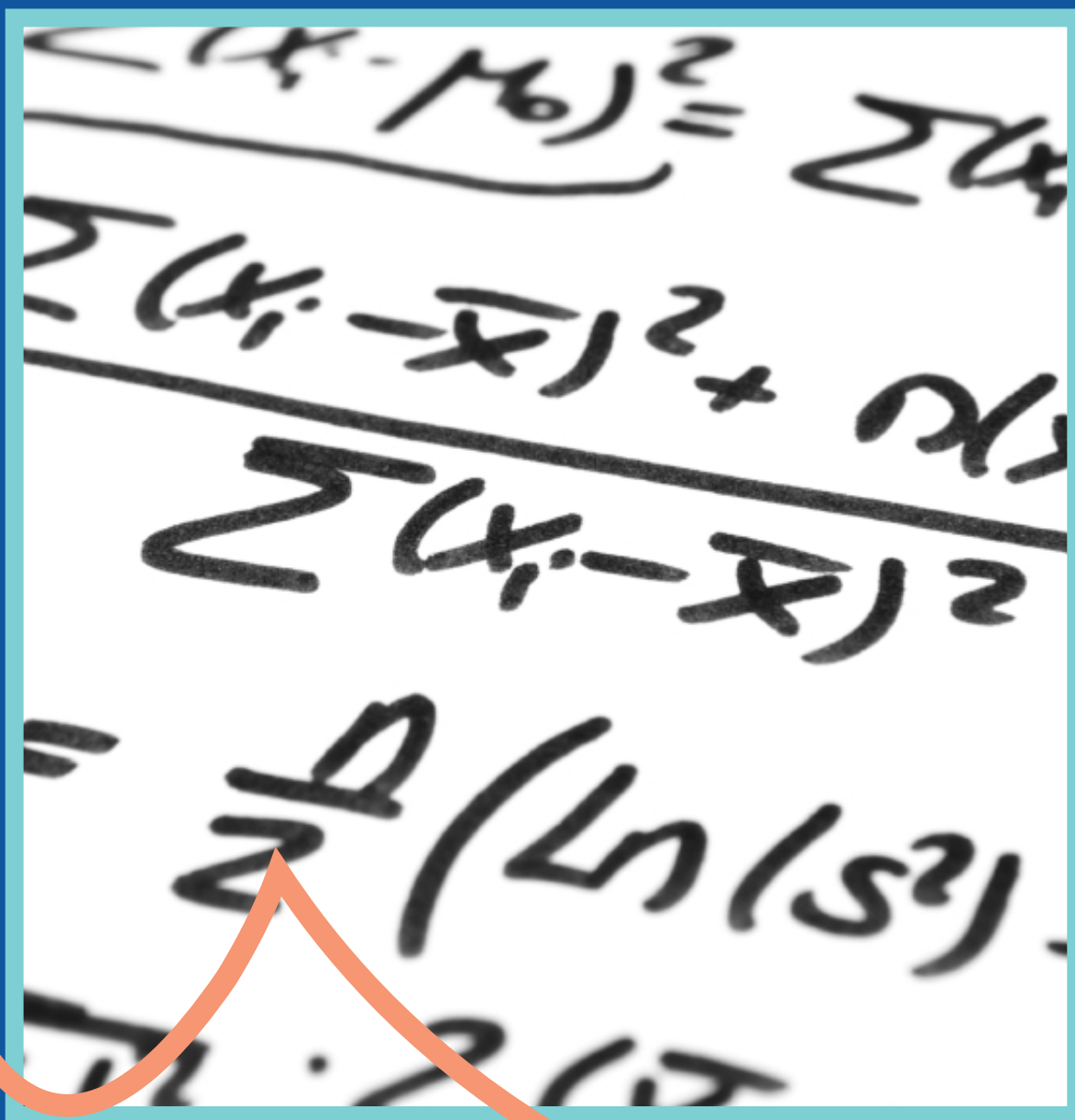
"Linear Congruential Generator." Wikipedia, Wikimedia Foundation, 7 Nov. 2023, en.wikipedia.org/wiki/Linear_congruential_generator.

"Marsaglia's Pseudo Random Number Generators." *Marsaglia's Pseudo Random Number Generators - Lazarus Wiki*, 21 Feb. 2020, wiki.freepascal.org/Marsaglia's_pseudo_random_number_generators.

"Middle-Square Method." Wikipedia, Wikimedia Foundation, 10 Nov. 2023, en.wikipedia.org/wiki/Middle-square_method.

MATHS ESSAYS

Under 18



How the Fibonacci sequence has paved the way for modern beauty standards.

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The Fibonacci sequence. It can be found all around us, from the structure of our DNA, to the shape of our galaxies and even the music we listen to. You have probably heard of this sequence before, or even studied it at school, but do you know the profound impact it has not just in nature, but in our perception of beauty itself. Fibonacci's sequence and the Golden Ratio greatly affect the human perception of what can be called aesthetically pleasing, and this extends even to ideas of our own beauty. However, to fully understand the intricacies of the mathematics behind this phenomenon, we must delve into what the Golden Ratio actually is.

The Golden Ratio is based on a single irrational number, phi (ϕ), which equates to roughly 1.618. This 'Golden Number' is the result of taking any number greater than 5 in the Fibonacci sequence and dividing it by the previous term in the sequence. As phi is irrational, it cannot be expressed in a simple fraction format, and much like other irrational numbers which you may have come across before, such as pi (π) or e, the number can go on to an infinite number of decimal places. The higher the numbers in the Fibonacci sequence that you use, the closer the answer will converge to phi. A rectangle with a 'Golden Ratio' of 1: 1.61803 (roughly) is considered to be aesthetically perfect, and it is a rectangle with these exact proportions which is used in the Parthenon in Athens, and in many modern-day buildings. However, the aesthetically pleasing properties of the Golden Ratio are not solely limited to uses in architecture.

The number of facial features containing shapes based on the Golden Ratio correlates to how aesthetically pleasing a face can be considered. Golden Ratio measurements occur throughout the face, with a simple example being the length of your face and the width of your face, or the distance from your eyes to your nose base and the distance from your nose base to the bottom of your lips. Mathematics is even responsible for supposed variations in beauty depending on your expression. The ratio of our faces actually conforms closer to phi when we smile, as a pose to when we are frowning or scowling, and this shows just how deep the relation between good looks and the Fibonacci sequence goes.

Many stereotypically beautiful celebrities such as Taylor Swift, Kate Moss and Scarlett Johansson are almost mathematically perfect, due to the high number of Golden Ratio measurements which can be found in their features. Whilst this perhaps seems to back up the theory that beauty can be purely defined by this maths, as clearly there is an interrelationship between these two factors, it is vital to consider the other factors which go into making a 'beautiful face', and the limitations of many applications of the Golden Ratio.

The supposed 'perfection' that can come with using shapes based on Golden Ratio proportions has been used a lot in the cosmetic surgery industry. In 2001, Dr Stephen Marquardt, a Californian plastic surgeon, developed the Marquardt mask, a mask of 'divine proportions' which maps out the most aesthetically pleasing face, according to mathematics and the Golden Ratio. It is often used to perform facial surgeries and alter the structure of the face to make it align more with perfect ratios, and therefore make it more 'beautiful'. However, this mask has faced a lot of controversy about how accurate it actually is, especially with regards to people of different ethnicities and races. Studies show that the mask is largely based on proportions of White and Caucasian features, and did not take into account non-Western beauty standards.

Although the Golden Ratio can never define beauty, as true beauty encompasses so much more than the proportions of your features, there is a direct correlation between these 'perfect proportions' and what we see as beautiful, and it is crucial to recognise the importance of the impact that the Fibonacci sequence has had on modern day beauty standards, and our perception of beauty.

References:

- BBC Bitesize. (2023). The beauty of maths: Fibonacci and the Golden Ratio. [Online]. BBC Bitesize. Last Updated: March 2023. Available at: <https://www.bbc.co.uk/bitesize/articles/zm3rdnb> [Accessed 3 January 2024].
- BBVA. (2017). Fibonacci and the Golden Ratio: Divine Geometry?. [Online]. BBVA Open Mind. Last Updated: 15 March 2017. Available at: <https://www.bbvaopenmind.com/en/science/mathematics/fibonacci-and-the-golden-ratio-divine-geometry/> [Accessed 3 January 2024].
- Oxford Academic. (2018). The Golden Ratio and Aesthetic Surgery. [Online]. Oxford Academic. Last Updated: 4 October 2018. Available at: <https://academic.oup.com/asj/article/39/1/NP4/5115686> [Accessed 28 January 2024].
- Byrdie. (2022). Beauty Was Once Defined By the "Golden Ratio"—Here's What It Is and Why It's Outdated. [Online]. Byrdie. Last Updated: 23 May 2022. Available at: <https://www.byrdie.com/what-is-the-golden-ratio-of-beauty-5075640> [Accessed 28 January 2024].
- Interesting Engineering. (2017). Phi and the Mathematics of Beauty. [Online]. Interesting Engineering. Last Updated: 10 February 2017. Available at: <https://interestingengineering.com/science/phi-and-the-mathematics-of-beauty> [Accessed 28 January 2024].
- Golden Number. (2012). The Human Face and the Golden Ratio. [Online]. Golden Number. Last Updated: 31 May 2012. Available at: <https://www.goldennumber.net/face/> [Accessed 28 January 2024].

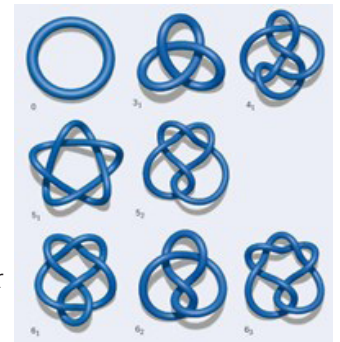
How critical is the study of mathematical topology to our lives? An exploration of Knot Theory and its application in healthcare.

Umesha Shanmugarajah , Northwood College for Girls

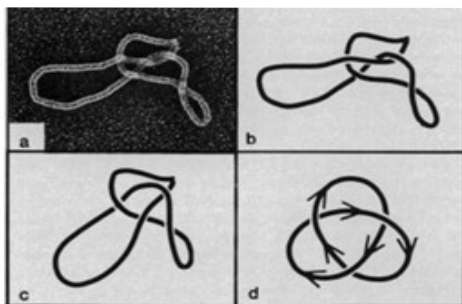
A single knot proves to be vital in our daily lives, from keeping our shoelaces tied together to decoratively packaging gifts. Experimenting with this simple procedure can achieve significant results, weaving and intertwining wool to create a myriad of intricate, complex, structured loops: knitting.

In the 19th century, three physicists named Peter Guthrie Tait, James Clerk Maxwell and William Thomson were the first to introduce the idea of knot theory (Marenduzzo et al., 2013). They suggested that 'atoms were actually circular knots in an invisible substance known as ether' (The Institute of Mathematics and its Applications, 2010). Despite this idea being disproved, this was the beginning of a journey to acknowledging the future potential and application of analysing knots and links.

In mathematics, a knot slightly deviates from a typical knot. Although it consists of a knotted string, the ends of the string are connected to form a loop. Each of these knots have an unknotting number, which is the minimum crossings for the knot to untangle a knot into an unknot: the simplest type of knot has zero crossings and is ring-shaped. This feature is fundamental to be able to classify different types of knots. Another characteristic of mathematical knots is the writhe, which is the difference between the over-crossings, when part of a string overlaps another part of string, and under-crossings, when part of a string has been overlapped by another part of string, of a knot. (Ayinon, 2020, p. 3)

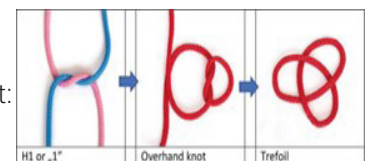


An example of a commonly known knot is DNA: a long strand of DNA bound within a nucleus, tightly packed and secured in a small area. For processes such as protein synthesis and cell division, the cell's genetic material must be unravelled so that a copy of it can be made. This long polymer inevitably contains naturally-formed knots as shown in the image to the left, (Bhatnagar & Mehta, 2021), which can be unknotted with the help of topoisomerase enzymes. These enzymes repeatedly divide the knot so that it has two loose ends, consequently manipulating them and reattaching them together, reducing the unknotting number each time: this is a knot theory of crossing change (Strogatz, 2022).



Interestingly, although it is clear that knots in DNA may be a hindrance, it has proven to be vital in developing a treatment for cancer. The replication of cancer cells can be prohibited by deactivating the topoisomerase enzymes in these cells, which ensures that the DNA remains knotted, which is significant in treating cancer. A drug has been developed which deactivates the topoisomerase enzyme in cancerous cells: it prohibits these cells from replicating and causing more harm, eventually killing them (Futurity, 2016).

Another application of knot theory in medicine is in sutures: it allows the strength of a knot stitch to be determined and allows us to evaluate the most effective type of suture, which is vital to treat severe cuts and wounds. This image displays a half-knot: a simple knot which acts as the foundation for forming complex knots for stitching wounds (Kováč & Pigniczki, 2023). Sutures are made from polypropylene filaments with plasticity being a key factor in aiding with the strength of the suture knot. A researcher called Pedro Reis investigated many of Samia Guerid's sutures (who is a plastic surgeon) to create a model of these knots to ultimately determine their strength. Reis explains:



'Our numerical model is complex because it needs to include knot topology, its nonlinear geometry, the elasticity of the filament, self-contact of the filament, frictional

The analysis concluded that one significant factor which correlates with the strength of a suture is pretension, defined as the tension of the material during the process of it being knotted. However, the pretension must be specific: if there is too much pretension the filament will break and if there is not enough pretension the knot will be too weak and won't hold (Ecole Polytechnique Federale de Lausanne, 2023). This knowledge can be utilised in order to improve sutures in healthcare environments and can allow medical students to practise tying knots without relying on their intuition and experience.

When considering factors of a knot, the stability of a knot can be improved by adding more crossing points (over-crossings and under-crossings) which increases friction. Further friction can be made to be present if the strings at crossing points travel in opposing directions. (Machemer, 2020) be utilised in order to improve sutures in healthcare environments and can allow medical students to practise tying knots without relying on their intuition and experience.

When considering factors of a knot, the stability of a knot can be improved by adding more crossing points (over-crossings and under-crossings) which increases friction. Further friction can be made to be present if the strings at crossing points travel in opposing directions. (Machemer, 2020)

To conclude, the application of knot theory can be significantly impactful in areas such as medicine, which deviate from more commonly considered specialties of mathematics, and is useful for creating life-saving technologies.

Bibliography:

Ayinon, W. (2020). Knot Theory and DNA. 1-9. Retrieved January 29, 2024, from https://math.mit.edu/research/highschool/primes/circle/documents/2020/Ayinon_2020.pdf

Bhatnagar, T., & Mehta, C. (2021, January 23). Unknotting the Double Helix: Where Knot Theory meets Biology. The Cosmic Treehouse. Retrieved January 29, 2024, from <https://www.thecosmictreehouse.com/post/unknotting-the-double-helix-where-knot-theory-meets-biology>

Dumé, I. (2023, July 11). Untangling the mechanisms behind surgical knot strength – Physics World. Physics World. Retrieved February 2, 2024, from <https://physicsworld.com/a/untangling-the-mechanisms-behind-surgical-knot-strength/>

Ecole Polytechnique Federale de Lausanne. (2023, June 9). Study reveals mechanics of the ideal surgical knot. Medical Xpress. Retrieved February 2, 2024, from <https://medicalxpress.com/news/2023-06-reveals-mechanics-ideal-surgical.html>

Futurity. (2016, August 21). How tying DNA in tiny knots could find cancer drugs | Genetics And Genomics. LabRoots. Retrieved January 31, 2024, from <https://www.labroots.com/trending/genetics-and-genomics/3872/tying-dna-tiny-knots-cancer-drugs>

The Institute of Mathematics and its Applications. (2010, October 1). Unravelling the Genetic Code - IMA. The Institute of Mathematics and its Applications. Retrieved January 29, 2024, from <https://ima.org.uk/619/unravelling-the-genetic-code/>

Kováč, K., & Pigniczki, D. É. (2023, February 27). Advanced Knotting Techniques (Examples from Surgical Practice). IntechOpen. <https://www.intechopen.com/chapters/1127933>

Machemer, T. (2020, January 8). The Mathematics of a Well-Tied Knot | Smart News. Smithsonian Magazine. <https://www.smithsonianmag.com/smart-news/math-makes-some-knots-stronger-180973925/>

Marenduzzo, D., Micheletti, C., & Orlandini, E. (2013, April 2). The knotted strands of life – Physics World. Physics World. Retrieved January 29, 2024, from <https://physicsworld.com/a/the-knotted-strands-of-life/>

Strogatz, S. (2022). Untangling Why Knots Are Important. Retrieved January 29, 2024, from <https://www.quantamagazine.org/why-knots-matter-in-math-and-science-20220406/>

The Existence of God: Proven by Mathematics

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Does God exist?

The existence of God is a major subject or topic at the centre of debate and discussion all over the world. There are a wide range of arguments that can support or oppose this statement. For example, some believe that God doesn't exist because science proves the natural world. However, this debate is usually looked at from a religious or scientific point of view. But did you know that the existence of God can be proved through a mathematical point of view?

In order to expand on the idea that mathematics can demonstrate the existence of God. Both terms, God and mathematics need to be defined in the correct context of existence. Firstly, the term 'God' is referred to by many people as being omniscient, omnipresent, omnipotent and supernatural by being above all nature. This directly relates to the definition of mathematics. 'Mathematics' is defined to be about the relationships or links between different numbers that is a construct that is in our minds. Therefore, the idea that mathematics was discovered because it controls our universe shows that the origin of mathematics is supernatural and must be 'above all nature'. This directly links to the discussion of God's existence. As mathematics controls the universe, holding an infinite amount of information through numbers and is a construct in our mind, it can be believed that this construct came from somewhere. The way in which mathematics is described, it parallels an all-powerful and all knowing mind that many people believe to be God, therefore, to some extent proving the existence of God.

However, the existence of God can also clearly be proven not only through its definition but also through a mathematical approach of proof. This proof was provided by Kurt Gödel, in the 20th century, who proved that the existence of God is a necessary truth. This conclusion was made through the mathematical proof as shown below.

- Ax. 1.** $(P(\varphi) \wedge \Box \forall x(\varphi(x) \Rightarrow \psi(x))) \Rightarrow P(\psi)$
- Ax. 2.** $P(\neg\varphi) \Leftrightarrow \neg P(\varphi)$
- Th. 1.** $P(\varphi) \Rightarrow \Diamond \exists x \varphi(x)$
- Df. 1.** $G(x) \Leftrightarrow \forall \varphi(P(\varphi) \Rightarrow \varphi(x))$
- Ax. 3.** $P(G)$
- Th. 2.** $\Diamond \exists x G(x)$
- Df. 2.** $\varphi \text{ ess } x \Leftrightarrow \varphi(x) \wedge \forall \psi(\psi(x) \Rightarrow \Box \forall y(\varphi(y) \Rightarrow \psi(y)))$
- Ax. 4.** $P(\varphi) \Rightarrow \Box P(\varphi)$
- Th. 3.** $G(x) \Rightarrow G \text{ ess } x$
- Df. 3.** $E(x) \Leftrightarrow \forall \varphi(\varphi \text{ ess } x \Rightarrow \Box \exists y \varphi(y))$
- Ax. 5.** $P(E)$
- Th. 4.** $\Box \exists x G(x)$

Although this mathematical proof looks very complicated, it appears to be one of the only ways in which the existence of God is proved through mathematical logic. This is because each line of working, clearly provides a statement and then links onto the next, which is done through various notations and symbols which can be translated to understand the theory to support the existence of God.

Translation:

Abbreviations:

- Ax = Axioms (a statement of the truth that will be accepted)
- Df = Definitions (objects in the discussion are defined)
- Th = Theorems (the claims proven throughout the proof)

1. Ax.1 - This first line discusses how positive (true) properties always cause another property that also must be positive.
2. Ax.2 - It is further discussed how lacking a positive property is the same as having a negative property as there is no in-between.
3. Th.1 - Therefore if the property is positive, then an object can have that property.
4. Df.1 - This line defines a 'godlike' object by showing that in order for an object to be godlike it must have all good properties.
5. Ax.3 - This then, therefore, assumes that a godlike object has all positive properties and no negative ones.
6. Th.2 - The line then follows on to show that as being godlike is a positive property it can therefore exist in an object.
7. Df.2 - This suggests how an essential property of an object must cause all other properties that the object has.
8. Ax.4 - Therefore, further assuming that a positive property is a necessary one.
9. Th.3 - This leads on to show proof that 'godlike-ness' is an essential property of any godlike object, therefore has positive properties and no negative ones.
10. Df.3 - This line then defines existence because it states that if an object necessarily exists then its essential property also exists.
11. Ax.5 - This further reinforces that necessary existence is a positive property.
12. Th.4 - Finally, this therefore links together and concludes that it is necessary that God exists.

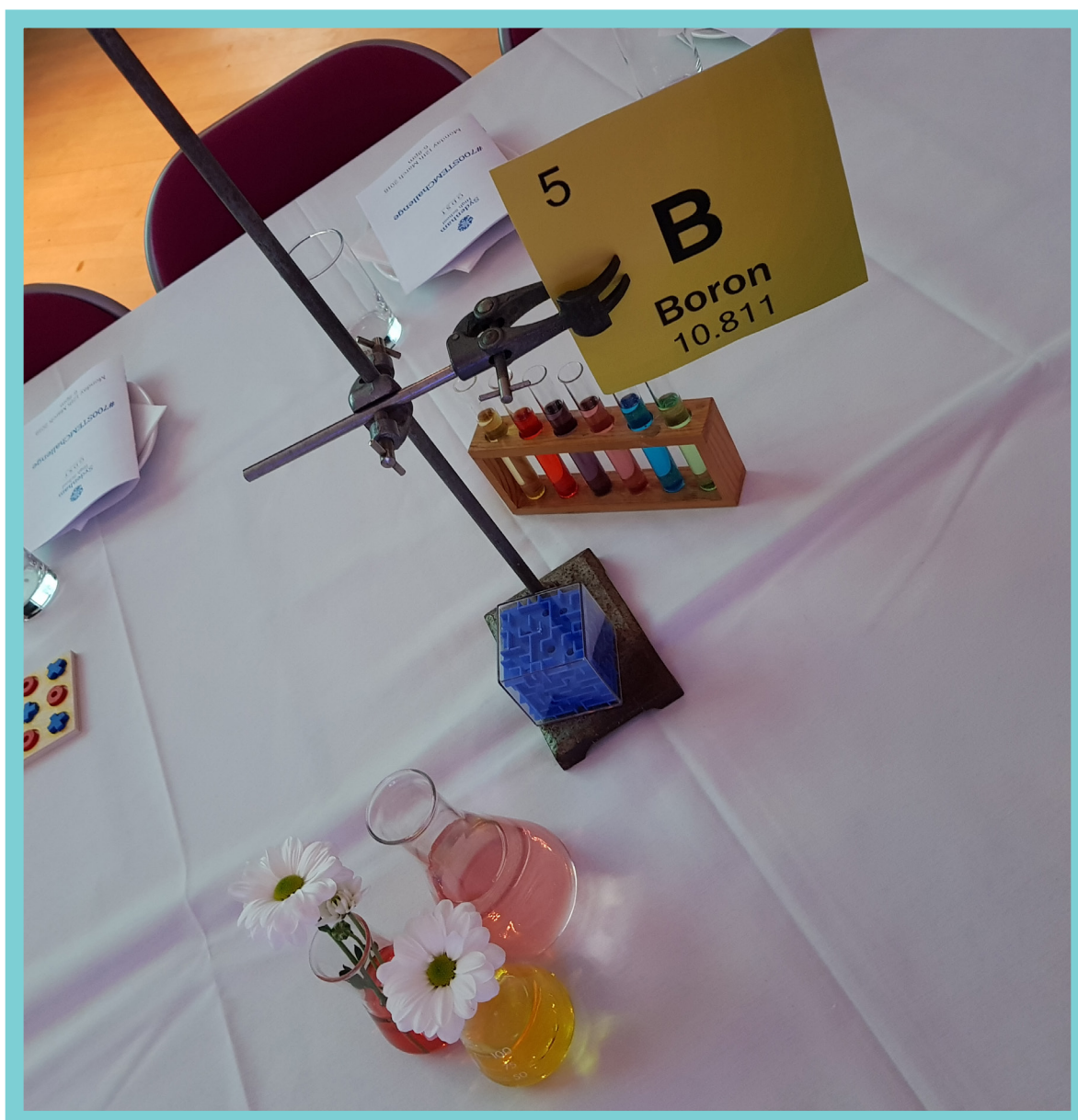
Therefore in summary, through mathematics, this proof shows that God has all good properties, thus necessary existence is a good property. Therefore, God must exist.

Through this mathematical proof, the existence of God can clearly be proven, showing the extent at which mathematics can help us to not only understand these difficult concepts, but also help us to understand our natural world, thus proving the existence of God through a logical, mathematical viewpoint.

References:

- [Proving God exists using Math \(youtube.com\)](#)
- [Gödel Says God Exists and Proves It | Mind Matters](#)
- [Is There a God? 6 Reasons Point to God's Existence \(everystudent.com\)](#)
- [image-1.png \(650×444\) \(mindmatters.ai\)](#)
- [theology - Can you mathematically prove the existence of God? - Philosophy Stack Exchange](#)
- [Arguments why God \(very probably\) exists \(theconversation.com\)](#)

WELL DONE!



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