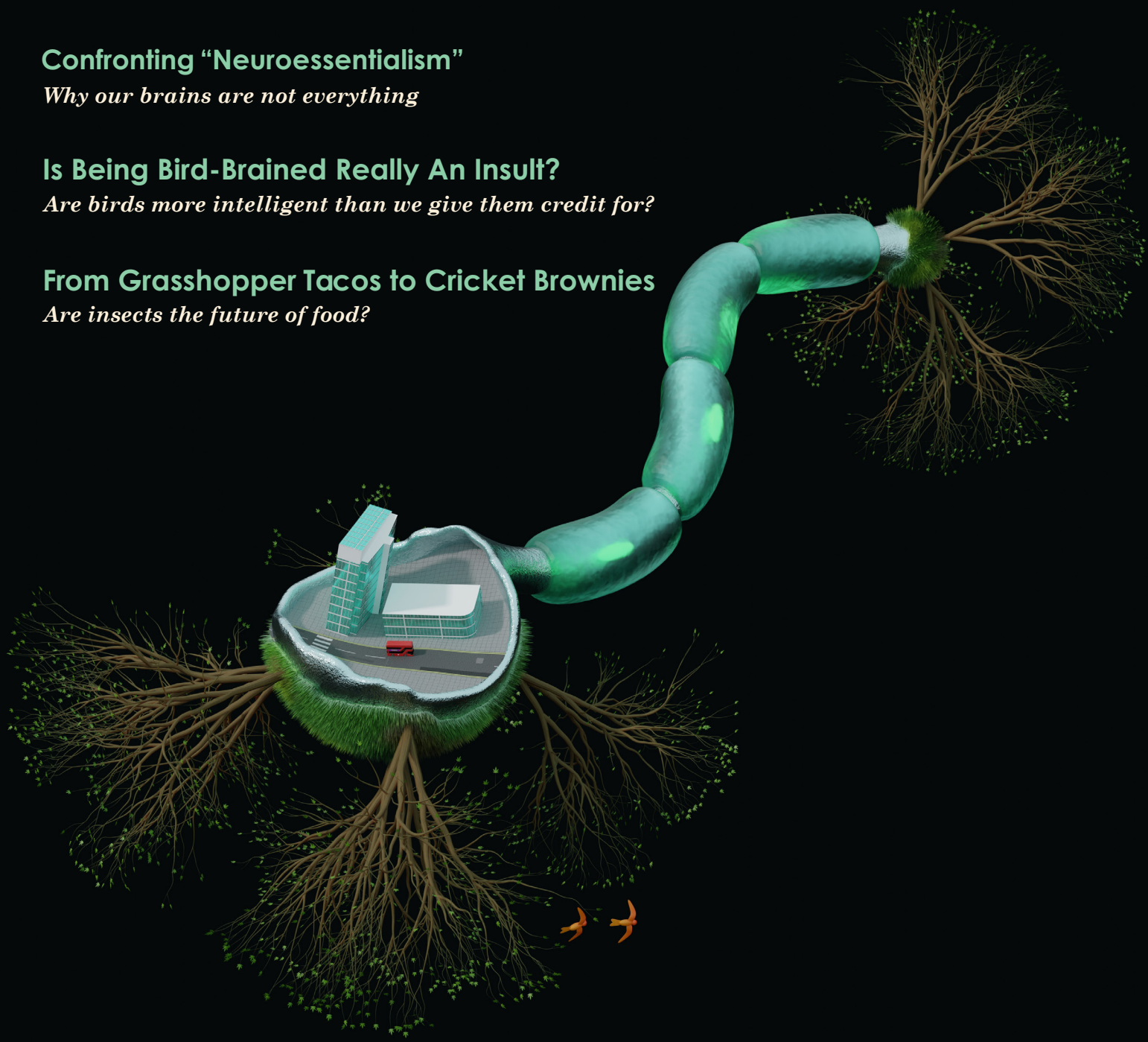
KINESIS
magazine

Confronting "Neuroessentialism"
Why our brains are not everything

Is Being Bird-Brained Really An Insult?
Are birds more intelligent than we give them credit for?

From Grasshopper Tacos to Cricket Brownies
Are insects the future of food?



ISSUE 9

CONTENTS

EVOLUTION & EXTINCTION

De-Extinction: How to Bring Back an Extinct Species? 1
Is Being Bird-Brained Really an Insult? 3
Ocean Giants 5
The Evolution of Humankind 7

MIND & BRAIN

Where Is My Mind? 9
Keeping Astronauts Sane: A Psychological Insight into Space Travel 11
Picture a Scientist: Thoughts from a Neuroscience Student a Year On 13
Brain Organoids: A Controversial Yet Promising Discovery 15
Confronting “Neuroessentialism”: Why Our Brains Are Not Everything 17

ENVIRONMENT

Hot and Bothered: The Side Effect of the Climate Change Debate 19
Tempering with Lies 21
From Grasshopper Tacos to Cricket Brownies: Are Insects the Future of Food? 23
The Short and Storied Life of Synthetic Textiles 25

HEALTH & MEDICINE

Cuba’s Medical Diplomacy and its Global Implications 27
Does Smoking Really Cause Cancer? 29
Spider-Man’ and ‘Pac-Man’ Immune Cells Fight Against Invasive Bacteria 31
Could an Aspirin a Day Keep the Doctor Away? 33
Malaria: Is the End in Sight? 35
HPV and Cervical Cander: a (Very) Brief Reflection on the Strides in Prevention 37

BIOTECHNOLOGY

How Can We Resolve the Inequities in Medical Nanotechnology? 39
Brain Implants 2.0 41

A LETTER FROM THE EDITOR

Issue 9 is finally here - Kinesis Magazine's first print issue in almost two years. In the time since we last printed our magazine, our society has seen substantial change. We have a new and bigger committee, podcast and podcast subcommittee, many new members and above all, fresh ideas and perspectives on our creative process. It has been incredibly gratifying and inspiring to watch. This issue is a product of members both new and old to our society, and it is something for all of us to be proud of. This is a truly exciting time to be a part of Kinesis Magazine.

In our excitement, I want to remind you of our purpose: engaging, informative and accessible science communication. As science and technology continue to develop at breakneck speed, the gap between a scientist and a lay person's understanding of the world increases every day. In the face of global issues like climate change denial, vaccine hesitancy and the mass hysteria and fear around each successive variant of the COVID-19 virus, we can already see the consequences of failed science communication. Further inequality of knowledge can only fuel the growing distrust of science, medicine and healthcare. Clear and effective science communication is becoming more crucial than ever.

Although not all of us may go on to pursue science communication, I hope we can carry the spirit of it with us in our future careers. Most vitally, an appreciation for the art of patiently explaining science to those who have not had the opportunities for education that we have. To abstain from interpreting distrust of science as malice or even stupidity, but rather as fear created by a powerful and dangerous system that doesn't communicate itself well. In my opinion, true science communication must be grounded in compassion. I hope our magazine gives you a space to practice this.

Thank you once again to our contributors for your wonderful creations and all the work put in! From malaria vaccines to de-extinction of species to Cuban medical diplomacy, I hope you enjoy reading this issue as much as we enjoyed making it.

Priyanka Peres
(Managing Editor)

DE-EXTINCTION How to Bring Back an Extinct Species?

From Jurassic Park to reality, bringing back extinct species seems fascinating. How is it possible and why should(n't) we do it?

In 2000, the last living Pyrenean ibex, nicknamed Celia, died crushed by a tree. The species became extinct. In 2003, scientists cloned Celia and, after many attempts, the Pyrenean ibex was reborn. Sadly, Celia 2.0 had difficulties breathing, dying only 10 minutes later. These two deaths make the Pyrenean ibex the only species in the long history of the natural world to have gone extinct twice.

What are different methods to bring back species from extinction (also known as de-extinction)?

Doing nothing might work. Certain ecological niches will refill and, through convergent evolution, similar species could reemerge. Another method is breeding and artificial selection. In the Quagga Project, this is done by breeding wild zebras, making them look like quaggas with very few stripes on their back. Both of these methods are not real de-extinction, though, as they only recreate a similar looking animal.

To actually bring back species we need to work with their DNA. For Celia, the method used was cloning: the nucleus of a cell of the extinct species is injected into a cell of a close relative, which will then let the genome of the extinct species express itself.
This is a promising technique to save existing species, although it only works if there are refrigerated remains of the species.

It was thought that cells would survive in the permafrost, making the de-extinction of mammoths easier; however, mammoth DNA is very degraded. So, a project by George Church aims to create a hybrid genome. He started by sequencing the mammoth's DNA, then replaced the 1% genetic difference between Asian elephants and mammoths by adding the ancient mammoth genes using CRISPR Cas-9 technology. After injection into an elephant cell, this hybrid DNA could birth a hybrid mammoth.

Why do all of this?

First of all, it is certainly exciting to bring back ancient species. But humanity might also want to make an excuse for itself: we caused their extinction but *"hey we can bring them back"*. Also, proposals have been made to restore ancient ecosystems such as transforming the Siberian taiga back into steppes, which may help fight climate change – mammoths would be some sort of climate activists.

For the non-avian dinosaurs there are again conservation issues. The half-life of DNA is only 521 years, so nothing exploitable survives from 66 million years ago. A paleontologist, Jack Horner found an alternative way: turning chickens into velociraptors by influencing the expression of the genes, especially in the early stages of the embryo. Regrow teeth? Done. Turn the beak into a flatter muzzle? Done. Bring back the tail? Not easy but advancing. Prolongate the legs? Progressing. Although it would look like a dinosaur, it would remain a chicken with a strange body: again, this isn't real de-extinction.

Maybe de-extinction should show more of what it actually does: creating animals transformed by technology, human creations that mirror our relation to nature, instead of resurrecting extinct species.

Written by Patrick Marenda
Art by Lucie Gourmet

Is Being Bird-Brained Really an Insult?

Are birds more intelligent than we give them credit for?

Written by Sharif Khalid Art by Alia Mustafa Kamal

If you call someone a bird brain, they are likely to be offended. Birds, such as pigeons and chickens, are often thought of as dim in popular culture. However, should a class that has inhabited every continent and occupied a wide variety of niches be thought of as simple and mindless? This article explores various examples that demonstrate that birds are more intelligent than often believed, proving that intelligence is widespread amongst birds and not limited to corvids and parrots.

Social Intelligence

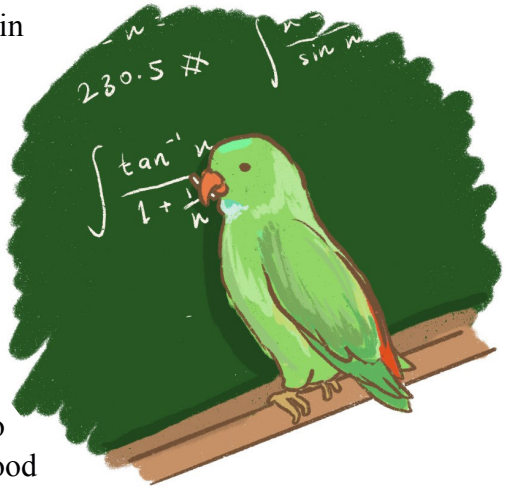
Complex social structure necessitates a high level of intelligence because social interactions require higher levels of communication and development of roles. Social cognition is a unique trait amongst limited numbers of vertebrate species, as brain tissue is metabolically expensive. Corvids and parrots are amongst bird families known to possess high levels of social intelligence.

Other birds exhibit complex social structures as well, including domestic chickens. Chickens are seen to have unique personalities within their groups which leads to a social hierarchy. Evidence shows that chickens remember distinct individuals within their group (provided they were exposed to them enough), understanding where individuals lay within the hierarchy. They were also able to be in multiple groups, having a different status in each. Chickens use a wide range of visual and chemical cues to establish hierarchy, including physical features and stances. This hierarchy influences sexual behaviour, to the extent that males can become “psychologically castrated” by other males, refusing to mate with hens even after the removal of the dominant males.

Numeracy

While mathematical ability is seen as a uniquely human trait, aspects of basic numeracy are also seen in birds. For example, pigeons can count in order to receive food. The pigeons are able to correctly match up relevant numbers to the correct visual stimuli, as well as perform simple algebraic skills such as subtraction. Pigeons are also able to sort numbers ordinally, a trait previously thought to be unique to primates.

Recent studies suggest that crows are familiar with and can use the concept of zero - a concept which was only recently discovered in human history. Crows were observed to discriminate between empty and numerical sets, thus conceptualising zero. Particular neuron sets also fire when conceptualising the empty set, further showing abstract visualisation of zero. Crows understood the concept of a null set far before humans defined zero.



Tool Use

Tool use is another indication of intelligence. Woodpecker finches for example have been known to utilise different tools to hunt various prey. They used cactus spines and twigs to access food in hard-to-reach areas, increasing their feeding range to encompass more nutritional prey, such as spiders. This allowed them to remain in arid environments in the dry season by exploiting a wider range of resources. When presented with novel challenges, these finches were able to adapt their available tools to solve tasks, in ways that were analogous to those studied in primates.

Other forms of tool use are also seen in food acquisition such as the use of items to bait prey. For example, burrowing owls spread dung around their burrows in order to entice dung beetles, a source of food. This behaviour is not coincidental, since the owls replaced dung if it was removed and remained at a spot until prey arrived. Similarly, many species of heron use bait to attract fish. Black herons often make bait out of bread to catch fish. Bait fishing is seen to be a distinctive behaviour that herons learn and adapt.

Conclusion

Birds demonstrate markers of intelligence. Things that we take for granted, such as numeracy and tool use, are not common within the animal kingdom, yet birds seem to utilise these skills to become successful in their ecology. There is much more to be learned about these remarkable animals, which may also help us understand the origins and capabilities of human intelligence.

Ocean Giants

Whales, gliding beneath the dark surface of the ocean, have millions of years' worth of stories to tell.

70% of Earth is made up of ocean–this is an unfathomable concept with many mysteries still to be uncovered.

Can you imagine that there are ocean-dwelling creatures a hundred times bigger than elephants?

Written by Sijia Yu
Art by Amaranta Chavez

Taking its place among some of the biggest animals to ever have existed on Earth, the whale has its own fascinating evolutionary story.

Evolution

Scientists have proven that hippopotami are the closest relatives of whales. Both whales and hippopotami evolved from four-legged, even-toed, hoofed artiodactyl ancestors that lived on land around 50 million years ago. However, around 8 million years ago, the ancestors of whales moved to the ocean and evolved into the marine animals we see today. In early times, they lived in the near-shore environment, but as they spent more and more time in the water, their feet were slowly replaced by flippers and their tails became stronger, enabling them to swim. What's more, their fur turned into thick blubber in order to overcome the massive heat loss in water, which could explain how whales can grow so big.

One of the earliest marine mammals is the Basilosaurus, a prehistoric archaeocete whale that existed around around 41 to 34 million years ago. This presents a connection between the whale and its ancestor, although compared to current whales, Basilosaurus had sharp teeth to chew food rather than swallowing it whole like the blue whale. Understanding the evolution of whales is a complex challenge which still poses several questions for scientists to answer.

The Sperm Whale

The term "sperm whale" is derived from the semi-liquid, waxy substance found within the whale's head. These whales have a unique appearance, flaunting a large head which contains the largest brain in the world; the mass of an adult sperm whale's brain is 7.8 kg. However, almost counterintuitively, the intelligence of sperm whales is generally lower than that of other whales. This colossal brain plays an important role in producing sound. Sound is generated by air passing through a pair of phonic lips at the front end of the nose. Researchers found that sperm whales can emit sound at 230 decibels, which is the loudest sound produced by any animal in the world. Sperm whales rely on sounds to communicate with other whales and echolocate food.

Sperm whales mainly feed on giant squid, which they usually dive 1 to 2 kilometres underwater to hunt for, using strong sounds to identify their location before stunning them. If you see white scarring on a sperm whale, it usually means they have experienced an intense fight with a giant squid. Squid beaks are hard to fully digest, so they accumulate in the intestine as the sperm whale digests food, stimulating the intestine to generate a waxy substance called ambergris. Ambergris is usually excreted as faeces or vomit from the mouth of the whale, but is in fact a rare and valuable material. When it is dried, it can serve to stabilise fragrance so it is often used in the perfume industry–sometimes, at a cost up to two times higher than that of gold.

How does a sperm whale reproduce? Females usually become fertile from 9 years old, with their pregnancy period lasting between 14-16 months, culminating in the birth of a lone calf. They give birth once every 4-20 years. The birth of the calf is a social event in the sperm whale society due to the vulnerability of the newborn to predation. As a result, other adults will protect the calf by encircling it, providing a shield from predators, such as killer whales. Various other examples of social behaviour provide evidence to show that sperm whales are social animals, often living and travelling together in groups of 6-9.

Around the 19th century, whales experienced a massive culling –known as whaling– with sperm whales being one of the main targets for their meat and blubber. The hunters usually used grenade harpoons to hunt whales. The development of motorised ships boosted the whaling industry, bringing huge profits to merchants and hunters alike. However, as an increasing number of whale species are being hunted and even being driven to extinction, various nations have finally launched the much overdue international convention for the regulation of whaling, which determines catch limits for merchant whalers to protect whale populations. Luckily, in the face of international action, whale populations are generally beginning to recover in numbers, however there is still a long way to go before numbers are fully restored.

Whales, one of the most impressive ocean-dwellers on Earth, have millions of years of untold history. Luckily, by exploring the extensive history of these creatures, researchers are determining and promoting limits on whaling and the sale of whale-derived products, so whale populations may one day return to normal levels. Hopefully, in light of recent international action, progress will continue trending upwards.

The Evolution

How Homo Sapien morphologies

Written by Grace Birkett

Homo sapiens, or humans, are the most abundant and competent primate in the natural world, and the only extant species of their genus. Their profound interactions with other hominids pose the question of how they alone among the *Homos* were able to survive, let alone thrive. The *Homo* genus originated from ape-like hominids known as the *Australopithecus*. Circa 2 million years ago, *Australopithecus* experienced several periods of peripatric speciation via natural selection. The varying climates between continents, ranging from taiga biomes scattered across Northern Europe to humid rainforests dispersed throughout Indonesia, gave rise to varying selection pressures and propelled the formation of archaic species, such as *Homo neanderthalensis*, *Homo floresiensis*, and ourselves. For example, the demands of Eurasia required a species that possessed a higher muscle mass and a stocky form. As well as this, they developed a peculiar rib cage that removed the presence of a waist, providing sufficient levels of insulation and defining the short and compact torso we have come to associate with *H. neanderthalensis*. Similarly, the warm African savannahs ultimately shaped the morphology and anatomy of modern humans, as a tall and slender physique allowed us to be more evolutionarily equipped to its conditions. Speciation can also cause great changes in morphology in a short amount of time. Consider *H. floresiensis,* which underwent a period of mass dwarfism when sea levels rose and restricted islander access to the mainland for nutrients. Consequently, those that required fewer nutrients (the smaller and lighter individuals) were more likely to survive, with most of these individuals clocking in at an astonishing 1 meter tall and a maximum of 25 kilograms.

With each hominid so finely adapted to its niche, what made *H. sapiens* the most abundant primate, outcompeting other human species, in particular *H. neanderthalensis*? When they interacted, it became clear that *H. sapiens* had the upper hand in terms of cognitive function, division of labor, and communication. Neanderthals had greater visual acuity, but it came with the expense of lower language processing abilities. This is in contrast to *H. sapiens*, who attained biological success from gaining extensive language skills, allowing flexible cooperation in large numbers, and sharing common myths. It could also be possible that different religious beliefs between these hominids resulted in violence, contributing to the eventual downfall of Neanderthals.

# of Humankind

influenced their biological success

Furthermore, Neanderthals' erroneous division of labor posed a huge disadvantage to their population as their reproductive core, the women and children, would cooperate in hunting large game. This, combined with their tendency to ambush and hunt within a close range to prey, resulted in copious fractures among many Neanderthal skeletons and would've most likely participated in their extinction. On the contrary, *H. Sapiens'* division of labor was composed of males who would violently hunt large prey and females who would participate in gathering smaller foods and bear children. Additionally, differences in pelvic anatomy show that Neanderthals' center of gravity passes vertically through the hip joints and the legs.

Modern humans have a center of gravity in zigzag configuration, creating a cantilevered, shock-absorbing body structure that enhances propulsion during movement. Such pelvic anatomy aided *H. sapiens* when hunting and fleeing from predators. Other features, such as the domestication of the dog, may have added benefits when hunting. Evidence for this was found in the Razboinichya Cave located in the Altai Mountains, where morphological criteria were used to identify a canid skull. The creature was more similar to a domesticated dog from Greenland than a wolf. In one layer of the cave were small charcoal pieces and burnt bones, signs that hominids, perhaps *H. sapiens,* visited the cave at least occasionally.

Features such as an enhanced division of labor, finer pelvic anatomy and visual acuity ultimately enabled modern humans to exploit their environment, cultivate the land, develop trade, create art, and even study life. Studies into the history of our evolution and the processes that drive it can be applied to sustain not just our species, but the great diversity of species that surround us too.

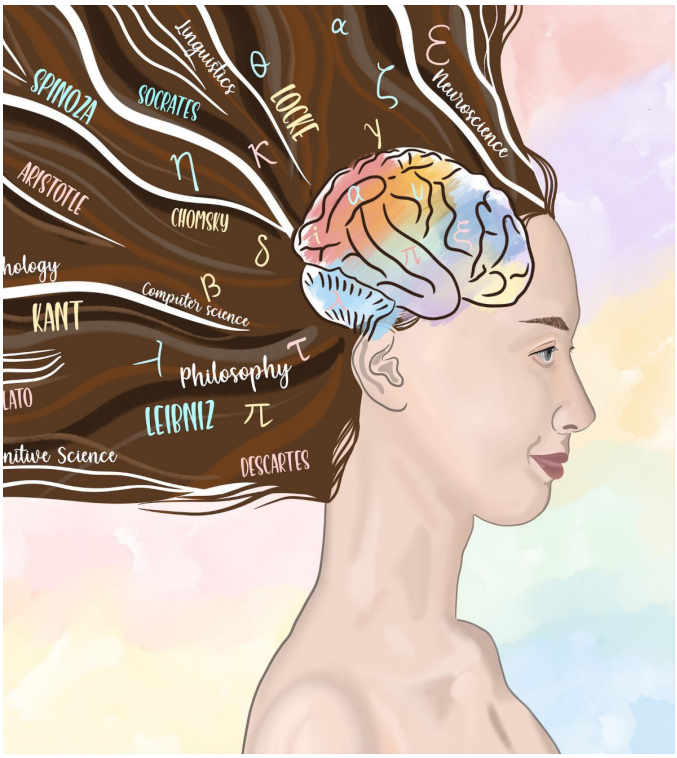
Art by Lucie Gourmet

The long standing philosophy and science behind the question

Where Is My Mind?

Written by Sermila Ispartalıgil

Art by Sophie Maho Chan



"With your feet on the air and your head on the ground/ Try this trick and spin it…/ Your head will collapse/ If there's nothing in it / And you'll ask yourself/ Where is my mind?" As the 1988 Pixies song suggests, the questions concerning the mind are endless, but where do they begin, and where are they now?

Long before empirical fields emerged, philosophy was concerned with the nature of the mind, its features, mental states, relationship to the body, and learning processes. Exploring the workings of the mind traces back at least to Ancient Greece. While Socrates focused on finding definitions of our concepts, Plato claimed that knowledge is about abstract ideas instead of things. Plato's *Theory of Ideas* and his suggestion that knowledge of them is innate has left a lasting influence in both philosophy and other fields in cognitive science. Aristotle, like current cognitive scientists, looked at the ways in which objects are represented in our thoughts, with his theory of perception in which the Form defining objects is transmitted to the perceiver's consciousness. Although these ideas of the Ancient Greek philosophers are no longer recognised as they were, they still influence research in cognitive science.

While the rationalists relied on reason to understand the world, which is adopted by many cognitive scientists, empiricists placed sensory perception over reason. John Locke's ideas regarding how the mind works primarily through linking basic concepts by experience has formed the foundation for a long-standing tradition known as Associationism in cognitive science. Even though Kant would not have accepted cognitive science, his beliefs, which may be thought of as incorporating both empiricism and rationalism, are the most closely matched with those presented in modern cognitive research. Philosophy before Kant presumed that the world "exist[s] independently of us" and questioned the ways in which we might learn about it, whereas Kant argued that cognition was only partially constitutive of the world around us. To him, uncategorized sensory experience and the objects that they spring from (which he called things in themselves) cannot be known by us. His ideas can be seen as part of a turning point in philosophy: what we know about the world depends on how we construct it.

Until the nineteenth century, when experimental psychology emerged, the study of the mind was confined to philosophy. Wilhelm Wundt and his students studied the mind more systematically in the laboratory, before behaviorism started to dominate experimental psychology. This was followed by the abandonment of the debates around consciousness and mental representations, but arguments against the premises of behaviourism still remained, in regard to treating language as merely a learned habit, as criticised by Noam Chomsky. With pioneers such as psychologist George Miller, Chomsky, and computer scientists Allen Newell and Herbert Simon, the field of cognitive science started to emerge, as an interdisciplinary endeavor, incorporating philosophy,

psychology, artificial intelligence, neuroscience, linguistics, sociology and anthropology.

Philosophy remains deeply interconnected to both the theoretical and experimental paradigms within which cognitive science works. In his paper, Paul Thagard explores the ways in which both fields can inform one another. One idea that is recurrent throughout the paper is that not taking philosophy into account would in fact simply mean adopting a certain philosophical view without ever questioning it. He makes use of well known phrases to adapt them to philosophy: "Those who ignore philosophy are condemned to repeat it… Those who believe themselves to be exempt from philosophical influence are usually the slaves of some defunct philosopher." Seen under this light, avoiding philosophy seems impossible, as it leads to doing it implicitly and ineptly.

Thagard focuses on two ways in which philosophy is relevant in cognitive science: generality and normativity. Generality aids research in areas like psychology, neuroscience, linguistics, anthropology, and artificial intelligence, which is often undertaken within a narrow framework or aims to address highly niche and specific questions. The generality of philosophy also works as a unifier in cognitive science which is very multidisciplinary. Normativity, on the other hand, helps consider how things ought to be and not just how they are. While scientific research within cognitive science is mostly concerned about reaching descriptive claims, normative ones should also be in the picture to assist the ways in which those descriptive claims are reached.

Similarly, philosophy also needs cognitive science. In order to support its theories and claims about the character and workings of the mind, knowledge, and morality, philosophy should utilize the discoveries of disciplines like psychology, neuroscience, and linguistics. While thought experiments can sometimes be helpful by themselves, they are most often not enough in supporting hypotheses without scientific support. Not a priori conjecture, but a reflection on scientific advancements in domains like psychology, neurology, and computer science will lead to metaphysical conclusions regarding the nature of thought. In parallel, epistemology is based on and benefits from scientific findings about mental structures and learning mechanisms, while ethics can make use of the psychology of moral thought.

To conclude his paper, Thagard makes use of an analogy to explain the nature of the relationship between philosophy of mind and cognitive science. "The men of experiment are like the ant; they only collect and use. The reasoners resemble spiders who make cobwebs out of their own substance. But the bee takes a middle course. It gathers its material from the flowers of the garden and of the field, but transforms and digests it by a power of its own." What he hopes to see in philosophy of mind and cognitive science is that honey of the bee, which is the mixture of the experimental and the rational.

Therefore, to answer the challenging questions posed by the lyrics of our favourite songs, we might find it most helpful to consult both philosophical theories and scientific findings, as the answers to where our mind is might be hidden somewhere underwater in philosophy of mind, cognitive science, or their interconnections.

KEEPING ASTRONAUTS SANE:

Houston, we have a problem!

Our continual fascination with the universe has led humanity to explore it through spaceflight. For this, astronauts must endure an extremely isolating environment that they are not biologically suited for. They spend months on end in order to bring us closer to the origins of Earth and the universe. What us earthlings tend to forget is that space is an unforgiving environment that does not spare any liberty to human or mechanical errors. Loneliness coupled with high-energy, ionizing cosmic ray nuclei - astronauts often face severe biological and psychological consequences in space.

To begin with, space missions are stressful. When changing environments so intensely, there needs to be psychological adaptation. Reports from Russian long-duration space missions suggest that this can be sequenced into 4 stages.

Stage 1: An astronaut must get used to microgravity. This leads to vestibular (inner ear) discomfort and decreased work capability.

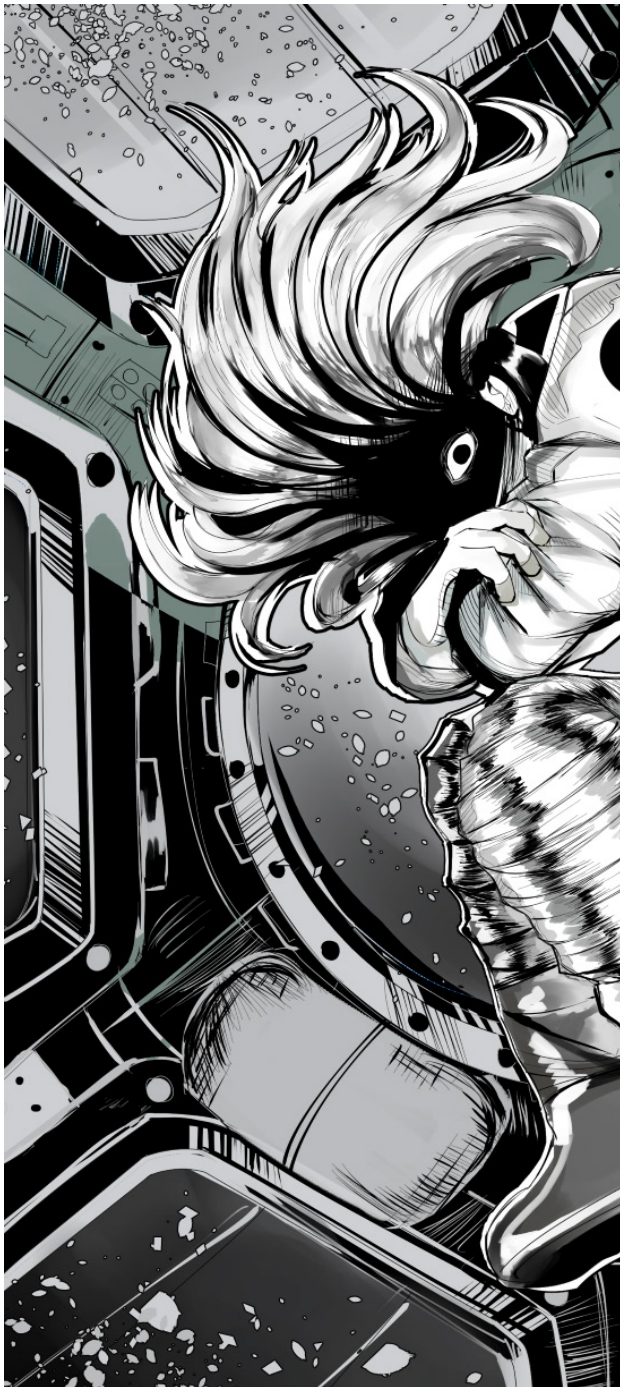
Stage 2: At this point, the astronaut is in a period of temporary, but complete adaptation.

Stage 3: The period of complete adaptation is interrupted as insomnia and irritability set in. Astronauts have a narrowed sphere of interest and are quite fatigued.

Stage 4: In this last stage, everything flips as astronauts enter a state of euphoria and have diminished self-control.

Clearly, astronauts go through a galactic rollercoaster of emotions. In spite of this, their ability to maintain positive psychological outlooks and interpersonal relations are crucial for mission success and personal health. Sure, there is a specialist psychiatric team on-ground, but with a 20-minute lag in communication each way, it's not effective. These various psychological states can lead to, and perhaps predict, certain psychopathologies like depression.

Take Stage 3, whose defining characteristic is sleep disturbances. There is plenty of evidence that highlights a correlation between insomnia and psychiatric disorders. Ford and Kamerow (1989) reported a correlation between sleep disturbance, specifically insomnia and hypersomnia, and Diagnostic and Statistical Manual of Mental Disorders, 3rd ed, (DSM-III) psychiatric disorders. Findings showed cross-sectional associations between sleep disturbances and major depression, anxiety disorders and substance use disorders.



A Psychological Insight into Space Travel

To combat this, space agencies like NASA make sure to look for the "right stuff" in an astronaut. They use current behaviour to predict future behaviour. Their rigorous astronaut selection program aims to find astronauts who can not only survive, but thrive up in space. With such a highly selective process an astronaut candidate must go through, it seems that it should be sufficient to eradicate any chance of a mental disorder from arising. However, we cannot say that with certainty because although psychotic episodes or other mental health issues have not frequently been (or ever) reported, it could be due to their unpredictability and the small literature available. One such example of literature is the medical debriefs following Space Shuttle missions where two psychiatric events affected 7 American astronauts who flew on the Mir Space Station between 1995 and 1998. These ranged from anxiety and depression to memory and interpersonal conflicts.

Both crew and ground personnel need to be aware of the potential damage that psychological problems may induce in long duration missions. As we move into the next era of space travel, increasingly large numbers of people will travel into space for increasingly long distances. Crewmembers on interplanetary missions such as a trip to Mars will have to deal with psychiatric problems themselves with no possibility of evacuating an affected individual. For these reasons, it is imperative that treatments are designed and utilised to maintain the psychological safety and wellbeing of the explorers who devote and risk their lives for further research into the unknown.

Written by Ebani Dhawan
Art by Summer Chiuh

PICTURE A SCIENTIST

In June 2020, "Picture A Scientist" was released. A year later I reflect on the prominent message of the documentary.

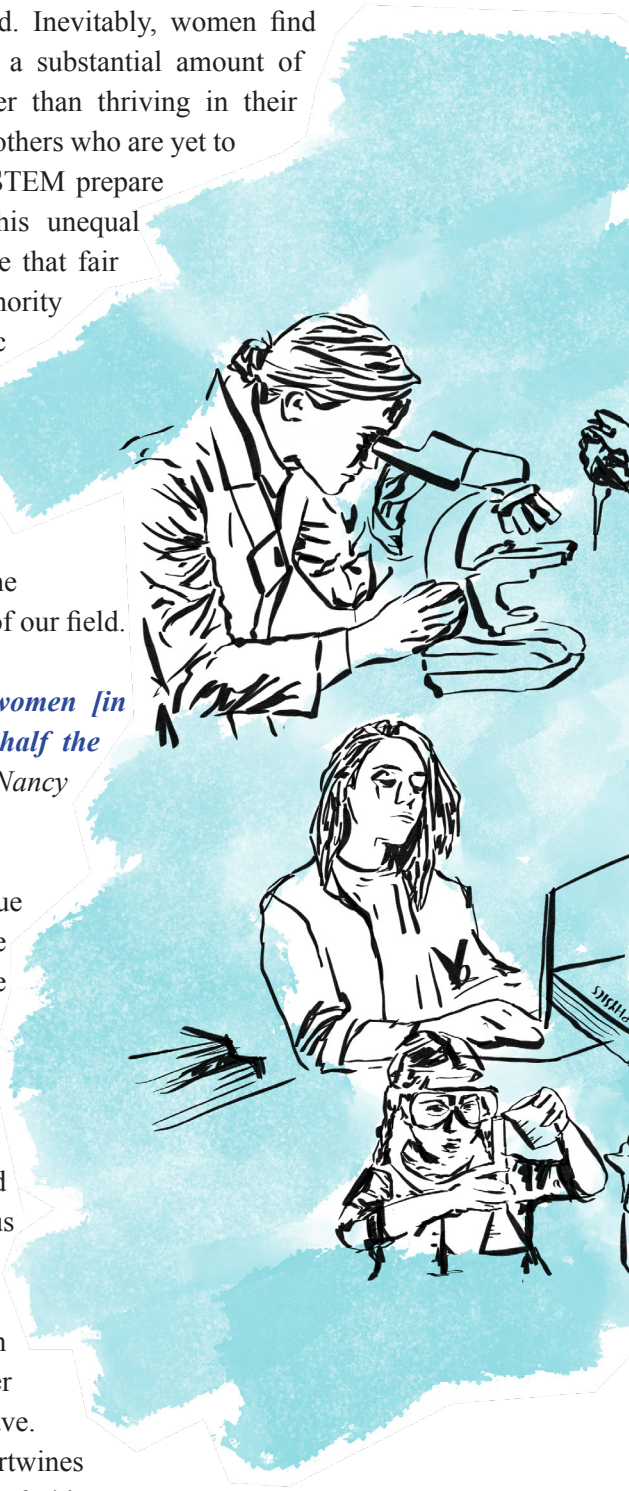
Written by Perside Ngani
Art by Lola Artiles

Picture A Scientist spotlights the challenges that Jane Willenbring PhD, Nancy Hopkins PhD, and Raychelle Burks PhD faced in STEM, interspersed with cameos from a range of individuals encouraging inclusivity. As a third-year neuroscience undergraduate watching the documentary for the first time, the discrimination and sexual harassment experiences were hard to listen to. Even so, the resilience these women displayed in fighting for their accomplishments has not only inspired me but a generation of aspiring STEM enthusiasts. The documentary touches on the existing disproportionate attrition seen in academia and the workplace, and outlines the events and brave individuals that contributed to the trailblazing 1999 MIT report. With the help of memorable quotes, I share a personal reflection on these issues, their persistence in the present day, and how we can continue to fight against them.

"How many great discoveries have just been lost to us because we didn't have the eyes to see?" *- Mahzarin Banaji, PhD*

The disproportionate attrition of women in STEM describes the decline in numbers of those who stay in higher academia and obtain employment. Studies evaluating higher education (HE) in the UK have reported an increase in women pursuing and qualifying for STEM subjects, yet they are still underrepresented in higher-academic positions. In 1994, a committee of MIT faculty headed by Nancy Hopkins reported discrepancies across the science departments, including the number of female faculty members (22) versus male faculty members (252). The findings were subsequently accepted by the provost and the MIT report was born.

Common events like being overlooked for higher positions and having contributions discredited reflect the systemic problem in science: it is historically biased. Inevitably, women find themselves dedicating a substantial amount of time "surviving" rather than thriving in their careers. How do I and others who are yet to start their journey in STEM prepare for the realities of this unequal playing field? I believe that fair representation of minority groups in academic and research positions, as well as mentoring programmes, can empower aspiring scientists to weather the discriminatory nature of our field.



"If you don't have women [in science], you've lost half the best people…" *- Nancy Hopkins, PhD*

I believe that true inspiration can be derived from the "Eureka" moment of seeing someone you see yourself in achieving something you hadn't considered possible, thus "inspiring" you to attempt to do the same. It serves as a revelation of the dreams you never knew you could have. Representation intertwines with inspiration in this fashion, which is why it is an important strategy in diversifying STEM. As a black chemist and professor, Raychelle Burks recalls not having any black female chemistry professors as a student. Recently, the Royal Society reported that in the UK, only 3.5% of black

academics hold a professor post in STEM. Dr Burks provides a way to rectify this by inspiring young black children with science videos showing black scientists like herself. In need of inspiration, I eventually had my "eureka" moment when I discovered Alexa Irene Canady, M.D. She was the first African American woman to become a neurosurgeon in 1981. Indeed, Alexa faced racial discrimination, but her passion paved the way for the next generation of black female neurosurgeons. Although we were miles apart, her achievements spoke volumes to me as a young black undergraduate and proved that inspiration had no boundaries.

"...mentoring is to be someone that I needed when I was younger…" *- Jane Willenbring, PhD*

A teacher who believes in a student's potential can be a powerful force. Whether it be a bachelor's degree, a master's degree or a PhD, a good teacher can have a profound effect on a student's academic journey. As the Director of Student Experience in Life Sciences, and a senior lecturer, Dr Zahid Pranjol from the University of Sussex sat down with me and shared his own experience with memorable teachers. With great admiration and respect, he shared how he remains in regular contact with several of his mentors, and even his high school teacher. But Professor Amin Hajitou (Imperial College London) taught him the true meaning of mentorship:

"...he gave me the confidence to know that even if I was wrong, he wouldn't put me down, but re-direct me to achieve better results...".

Professor Hajitou gave him the space to share his hypotheses, alongside a dose of encouragement and guidance, which eventually led to a publication. Now, as a mentor himself, Dr Pranjol has helped shape the ideas of several undergraduate students and guided them towards publishing novel academic research papers.

Every student deserves such a tribe in higher academia but unfortunately, not every student knows what this feels like. Negative experiences with mentors are common causes of attrition. For example, Jane Willenbring filed a Title IX sex discrimination complaint against her former teacher; although she went on to become a professor, many are discouraged by these experiences. As a result of this, the National Science Foundation in the US implemented a new sexual harassment policy.
In essence, when done wrong, mentoring can cause a dramatic change in a student's career path. However,when done right, mentoring can allow the student to flourish.

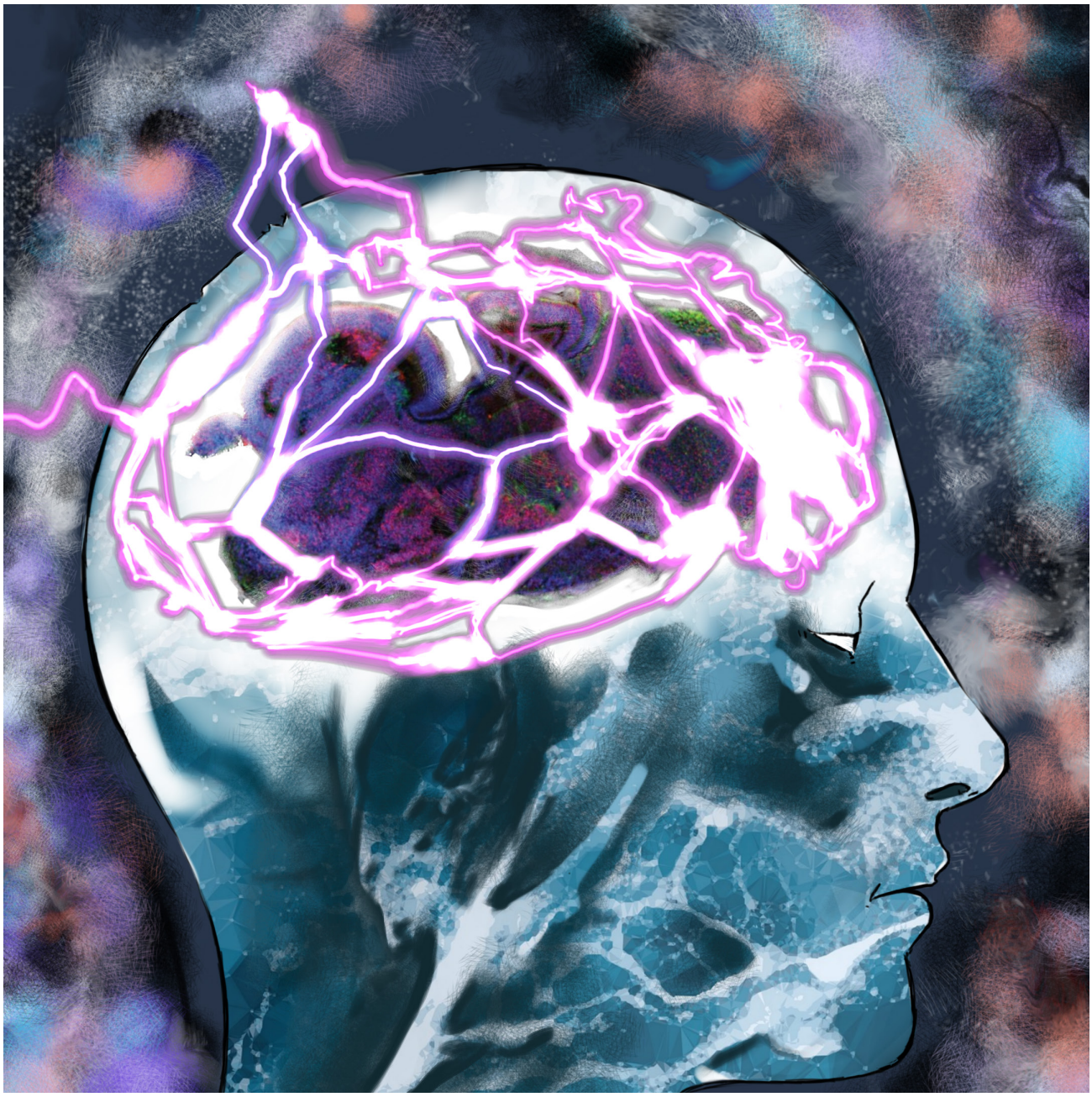
"Science is a human endeavour that contains and is subject to all of our brilliance and bias" *- Raychelle Burks PhD*

Despite the progress being made, reversing attrition in STEM remains an ongoing mission. A collective effort is needed to inspire young women through supporting dedicated social enterprises and charities targeting stem enthusiasts. Mentorship, especially during their formative years, is essential. Dr Pranjol shared that good mentoring is "giving students a platform to share their ideas and moulding their passions into something greater and impactful." This provides students with the confidence to keep going. Lastly, ensuring that young women feel safe in academic settings with strict no-tolerance policies for abuses of power is equally important. Although I present a select few from an exhaustive list of actions, these serve as active steps to widening the inspiration to all women, wherever they are in their STEM careers.

Brain organoids

a controversial yet promising discovery

This technology is a milestone for research, but is it ethical?



Organoids are 3D cultures of cells that aim to mirror the characteristics of human organs. They are created by the differentiation of human pluripotent stem cells (hPSCs); cells reprogrammed from somatic cells that can become almost any cell in our body.

In the last few years, organoids have been increasingly used by researchers in disease modelling. Their differentiation also mimics the organ development of human embryos in vitro, showing that organoids can be used in a broad scope of research.

Written by Justine Stanley Art by Zach Ng

The discovery of organoids has enabled big advancements in fields such as drug testing and implant production. They provide a more complete and accurate version of the 2D model, allowing researchers to explore different features of the organs. But how complicated is it to make these organoids?

Undifferentiated induced pluripotent stem cells (iPSCs) are "forced" through different signalling pathways until it reaches a "tailored" cell type. They are then controlled and developed using specific factors until they reach a mature stage. Differentiated iPSCs are a useful tool for human disease modelling. As they are derived from human cells, there are fewer chances of dissimilarities arising due to the difference in metabolism between the testing subject and the patient.

Certain organoids can be used to model brain diseases. Researchers can investigate neurodegenerative diseases in a way that the live human brain doesn't allow for as they can observe pathogenic cells while they survive in culture. This research would be physically and ethically impossible to do so on a live brain. iPSCs also enable the study of early stages of brain development, which is interesting given that lots of errors and mutations can take place in the embryonic brain and then cause abnormalities that affect the individual for life. These embryonic brains are like "black boxes."

But are these new 3D brain models truly the answer to everything? There is always a limit to how far we can go in the search for answers. When does an experiment become ethically "compromising" and rejected by society? This is a very fine line to tread on and neuroscientists developing brain organoids must step along it every day. Various therapeutic applications make the research worthwhile but the extent to which brain organoids can be used is not infinite.

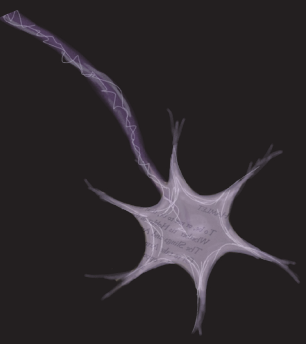
One of the scenarios imagined by researchers is the transplantation of iPSC-derived therapies into animals or even humans. As we cannot predict the result of transplantation, it could have serious consequences for these individual's behaviours and actions.. There is also the issue of the origin of organoids. If the stem cells sampled from a patient aren't used for tailored treatment but for research, is the patient aware of what experimentation will be conducted on the cells and how they will be disposed of once the project is over? All human tissue is governed under the Human Tissue Act 2004. Unfortunately, even though stem cells can't be sampled without consent, individuals are often not told what specific experiments are undertaken.

Another issue raised is organoid consciousness. How does communication work between two organoids? Some believe that there is some sort of exchange between them, while others argue that organoids would not have a conscience and could not acquire one. Even though we are still at the genesis of organoid research, and they are still far away from meeting their full potential, it is thought by scientists in the field that it will only be a short number of years before the organoids are more developed. Organoid production will evolve to produce more complex and realistic versions of the target organs, and many scientists argue that boundaries should be established now before it is too late.

However controversial this new technique is, some surgeons see its benefits. As Dr O'Rourke explains when discussing his research on treatments for aggressive brain cancer, "I'm dealing with a deadly disease that kills people in 15 months," he says. "Here, we've developed an advanced diagnostic tool to evaluate in real time what therapies might be beneficial.". In this case, being able to trial potential drug therapies on the brain organoids justifies the means. So organoids either have a very bright future ahead of them or perhaps they will be rejected due to the ethical considerations they pose. But one thing is for certain: major advances have already been made thanks to brain organoids and many developments are yet to come.

Confronting "Neuroessentialism":
Why our brains are not everything

Written by George Williams
Art by Lia Bote



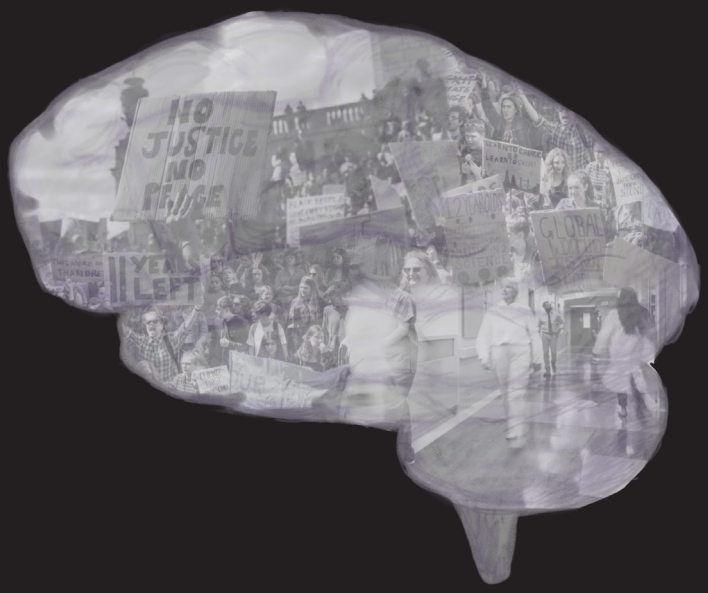
Of all our organs, few would dispute the preeminence of the brain. For centuries, we have accepted its intimate connection to thought, perception, and emotion. Recent advances in technologies such as EEG, functional MRI, and genetic engineering have affirmed this knowledge and allowed us to view it at work, making neuroscience more relevant than ever. The importance of the field gives it weight in the public sphere: in the words of three UCL psychologists in 2014, *"Brain-based information possesses rhetorical power: logically irrelevant neuroscience information imbues an argument with authoritative, scientific credibility."* But this rhetorical power carries the possibility of harm: overstating the role and relevance of the brain and insisting upon a dangerous form of biological determinism.

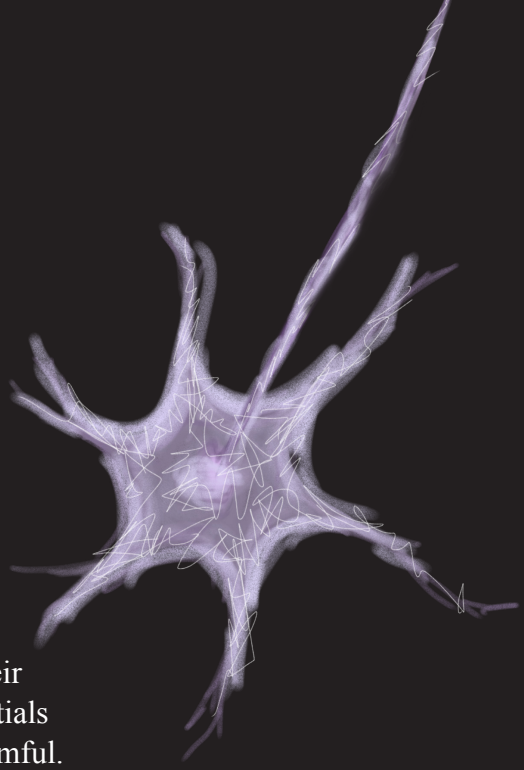
"Brain-based information possesses rhetorical power: logically irrelevant neuroscience information imbues an argument with authoritative, scientific credibility."

The study of mental health is especially prone to this. Addiction and depression are common conditions and profoundly damaging to sufferers and society. To the casual observer, neuroscientific study of these conditions appears to have been a great success. Human and animal experiments have revealed that changes in the mesolimbic dopamine signalling pathway in the brain, which normally contributes to decision making, are associated with addiction. Meanwhile, depression is often popularly described as a "chemical imbalance in the brain," drawing upon a theory first developed in the 1960s. However, mechanistic biological accounts may obscure more than they illuminate. Aside from questionable clinical applicability, they crowd out understanding of social, economic, and psychological elements which also determine health. The simplistic narrative of cellular dysfunction requires no difficult psychological theorising, and the imprimatur of science renders the complex diagrams and annotated brain scans naturally convincing. Yet in reducing people to atomised individuals with unsettled brains rather than participants of a broader harmful socioeconomic order, we strip them of agency as well as obscure the causes of our society's predicaments.

Brain characteristics are not merely used to explain mental illness.

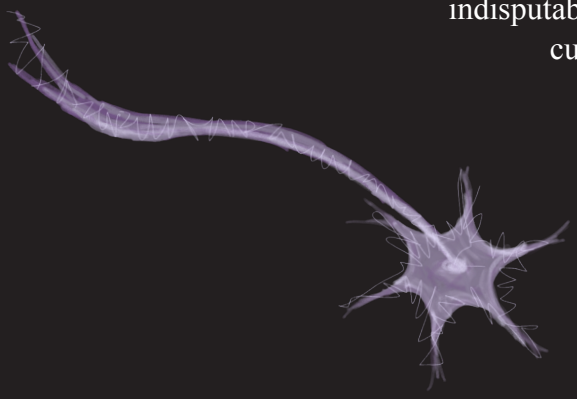
Essentialism – the idea that particular groups have certain innate and immutable characteristics which the social order reflects – has always used biology in its justification.



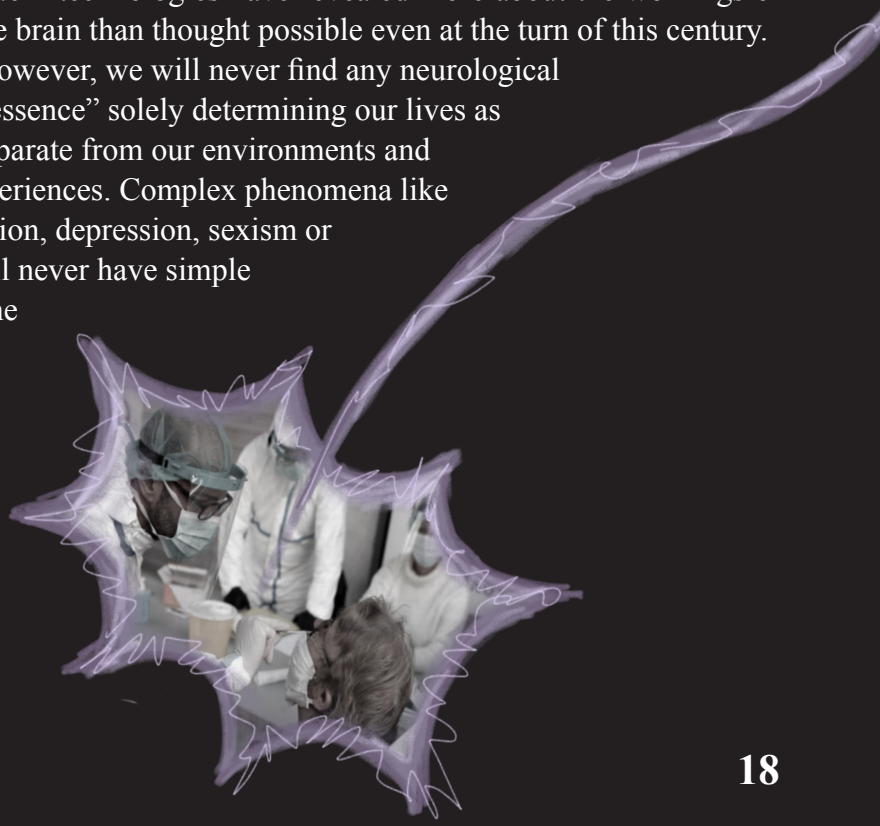


As Stephen Jay Gould showed in his influential 1981 book The Mismeasure of Man, data about brain size and anatomical features were used as far back as the nineteenth century to justify existing prejudices about intelligence, race, and gender. And though scientists today are rarely so brazen as their forebears, their underlying conclusion – that power and wealth differentials reflect inborn and unchanging differences in brain structure – is no less harmful.

Those who seek to explain away gender pay gaps wield a catalogue of brain differences between men and women as their argument, such as changes in size and connectivity of different anatomical areas. These supposedly leave women more oriented to "empathising" rather than "systematising," and thus better suited to low-paid caring work than highly-paid jobs in STEM or finance – but there are several flaws in this explanation. For one, the huge complexity of analysis means that researchers must make numerous choices of how to interpret and analyse raw numbers which can all alter the eventual result. Even if the identified differences are real and not overlapping between sexes, they may be consequences–rather than causes–of gendered differences in social interactions. In any case, barely detectable differences in the sizes of anatomical regions are unlikely to explain variation in broad combinations of traits like empathy or analytical thinking. The appeal of an indisputable scientific explanation risks marginalising more informative social, cultural, and economic explanations.



Modern technologies have revealed more about the workings of the brain than thought possible even at the turn of this century. However, we will never find any neurological "essence" solely determining our lives as separate from our environments and experiences. Complex phenomena like addiction, depression, sexism or racism will never have simple explanations in the distribution of white matter or the spiking of neurons alone. Only once we appreciate that our brains exist within larger systems will we truly appreciate their role.



HOT and BOTHERED

The side effect of the climate change debate

While discussing the long-term effects of climate change has raised awareness and encouraged action on a larger scale, it has also inspired individuals to implement changes in their everyday routine, ranging from biodegradable alternatives for household items to using more ecologically friendly means of transport. However, there are downsides to the constant exposure to the media coverage of environmental disasters. A survey by Bath University from September finds that young people specifically experience high levels of distress in regards to climate change, with almost 50% expressing that their everyday lives are affected by climate-related worries. The study reveals further tendencies: 40% of those questioned are uncertain about having children out of concern about what life for the next generations will look like. More than half agreed that the future is frightening, with some even stating the human race is irrevocably doomed. This study demonstrates a phenomenon referred to as "eco-anxiety," a term that has been used since 2005.

So what does eco-anxiety actually look like?

Symptoms may include: guilt about one's negative impact on the environment, post-traumatic stress disorder (PTSD) after experiencing effects of climate change, depression, anxiety, obsessive thoughts about climate change, existential panic, and environmental grief. Affected individuals may also harbour resentment towards people who deny climate change, are reluctant to take action, or have contributed to climate change in the past.

Health geographer Ashlee Cunsolo affirms the significant impact of environmental change on mental health by explaining its connection to personal identity: "People have a sense of identity in relation to nature and the natural world, much like their cultural identity or their gender identity or their ethnic identity." She explains that when something we value is threatened–in this case, our connection with nature–we feel grief and anxiety; hence it is simply a natural reaction.

Written by Leonie Hellwich
Art by Amaranta Chavez

Eco-anxiety being a relatively new phenomenon, its definition and impact on mental health are still unclear. As of yet, eco-anxiety is not officially included in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) which comprises all currently diagnosable mental health conditions. Nevertheless, the American Psychological Association (APA) recognizes various ways in which climate change can impact mental health. These include depression, PTSD, and feelings of helplessness. The sudden increase in globally experienced concern about the planet's future and the next generations comes with many challenges. Research suggests that it leaves many therapists worried about lacking sufficient resources and preparation. However, it is likely that the integration of climate change-specific practices into training will become increasingly common with growing demand.

Fortunately, there are promising strategies with which to tackle eco-anxiety. Eco-therapists recommend reconnecting with nature to alleviate feelings of anxiety and discomfort. Spending time outdoors as well as practicing mindfulness has been proven to lower stress, anxiety, and fatigue. Adopting ecologically friendly habits such as recycling or using public transport is also encouraged by experts as it can help decrease feelings of shame and guilt. Making such changes, however small they are, can be beneficial to mental health and have a calming effect. Cunsolo emphasizes that dealing with eco-anxiety is largely about adopting a different mindset; she highlights how young people and their climate activism can be inspiring in that way:

"This is a normal response to losing things we love in this world… the planet is suffering and of course we're going to suffer and that's normal and healthy and we've got to be motivated by it."

TEMPERING THE LIES

Are Google's recent steps to ban climate misinformation too little, too late?

Written by Altay Shaw **Art by Rahel Kiss**

In early October, Google announced an ambitious plan to challenge climate change misinformation. As part of this plan, ads and accounts promoting fake news about deforestation and habitat loss would be struck. Representatives and activists alike responded warmly to the announcement, but the ban itself will not prevent the uploading of false information onto YouTube or other associated Google products.

The potential abuse of the new rules, which prohibit ads that go against the scientific consensus, gives weight to the fact that there is still a long way to go before we are able to fully tackle fake news in general. Since videos can still be uploaded without going through a verification process, what is the technology giant doing to ensure that our digital and physical environment is protected?

Public perception of climate change

Previous years have seen a rebound in the number of individuals who accept and understand the urgent need to act. Even with this—albeit small—increase, the number of people cognizant of the need for climate action hasn't reached 2008 levels, when they were at their highest. This statistic provides a worrying insight into the increasing momentum of misinformation, especially as we are now approaching a point of no return in trying to keep the global temperature increase at 1.5 degrees Celsius.

In the UK, studies conducted in 2008 and 2011 showed that those who were affected by "once in a lifetime events" were more likely to be concerned with climate change. Flooding is a key example of this. Individuals were more likely to engage in energy-saving behaviours if they had lost personal possessions or had loved ones affected by extreme rainfall patterns. With studies showing changes in local weather patterns, we might soon see a shift in public perception as more people become affected by extreme weather events.

Damage caused by misinformation

Whilst patterns of behaviour can be altered in some groups within the UK, it should be noted that separate long-term studies found evidence that in the USA, people use personal experiences to either strengthen their own scientific basis, or further feed their misled notions. As a society, to have some coherency in our worldviews, our immediate impulse is to protect the status quo at any cost, meaning any change or upset to our already-held beliefs is perceived as dangerous. This also translates to misbeliefs about climate change: individuals are more likely to be fixed in their beliefs about the climate according to their political alignment.

As such, individuals are more likely to have a mistrust in science, which doesn't necessarily stem from a doubt of the scientific method itself. Instead, this mistrust is a result of individuals identifying themselves with a minority opinion and needing to strengthen their overall views. So, when these individuals are exposed to fake news on climate, even for brief periods of time, they are more likely to engage and share the information than if they were in the majority.

Why do activists not trust Google's efforts?

Google has been faced with an uphill battle from the start. Despite launching a $300 million push to support journalism and tackle fake news, the company has come under heat for its practices in regards to advertising revenue.

Campaign for Accountability, a non-profit watchdog that exposes misconduct by large corporations, provides evidence that Google had still been placing advertisements on fake news sites, despite having vowed to suspend the practice after the spread of misinformation seen in the run-up to the 2016 election. Despite promises and removal of news labels from sites promoting fake news, it has taken Google until now to introduce bans on climate misinformation.

Given the number of times that Google has come under public scrutiny for refusing to make changes and providing false promises in several interviews and press releases, it is not surprising that Google has started to inch towards making positive changes. In 2019, Google came under fire for supporting climate change deniers by providing millions in funding to conservative groups. Despite Eric Schmidt, then CEO of Google, promising that previous decisions to support such groups were a mistake, even under his leadership, such promises were ignored.

A reason that Google turns a blind eye to the undermining of scientific methods may rest in its desire to ensure that section 230 of the Communications Decency Act is kept in place. This obscure law is what allowed Google, and other technology giants such as Facebook, to become what they are today. As Google was legally deemed to be "neutral," it was not placed under strict regulations. In recent years, leading Republicans have been called for the law to be repealed due to Google's alleged bias towards left-leaning publications, but no firm steps have been made to revoke the law.

How can the impact of fake news be limited?

While Google's current course of action does provide some promise for the future, it does not help to tackle the damage it has already caused. Therefore, the burden falls on people to acquire the proper skills needed to identify fake news columns and pieces. In 2016, Finland introduced new measures in cross-subject support to ensure students were capable of identifying false information. This included teaching students to challenge, read, and question material presented to them, rather than accepting it on face value.

In addition, some researchers have suggested the idea of having multiple layers of defence against fake news. In 2020 Sander van der Linden et al. proposed the idea of providing "inoculation" against false news through coding fail-safes and identifying key terms that are against the scientific consensus. This would help to weed out any harmful material that could adversely affect the public's perception of a number of matters, including vaccine misinformation.

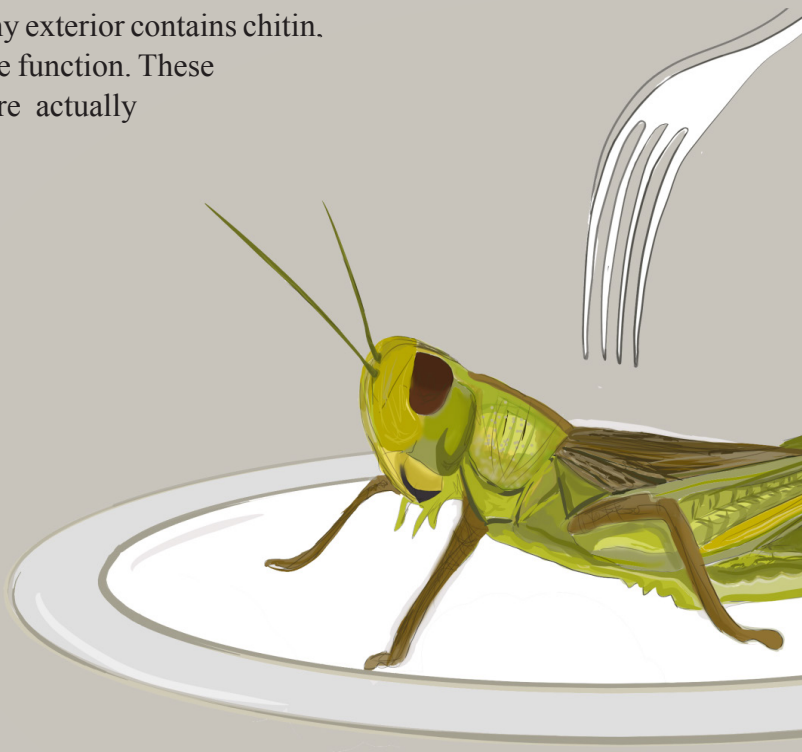
Going forward

Whilst Google is now taking the right steps to ensure the scientific consensus on climate change is being shared and upheld, in the grand scheme of things, these actions may be too little, too late. Google has the ability to make substantial changes to the content it promotes, and it must do so if it wishes to turn the tide against climate misinformation.

From Grasshopper Tacos to Cricket Brownies, are Insects the Future of Food?

Insects are a nutritious, sustainable food enjoyed across the world. In light of the current climate crisis, is it time for the West to embrace insects?

Despite their frightening appearance, edible insects provide many health benefits. They are a rich source of protein and easily meet the human bodily requirements of essential amino acids. Insects also contain vitamin B12, iron, and fatty acids. Their crunchy exterior contains chitin, which is abundant in fibre and thought to boost immune function. These creatures, often associated with dirt and disease, are actually surprisingly good for us.



Entomophagy, the practice of eating insects, is also beneficial for the environment. Producing 1kg of cattle uses 3000 times more water than the equivalent amount of crickets. Insects also require less space and produce fewer greenhouse gas emissions. Furthermore, insects do not require large amounts of feed. Grain, which is currently fed to cattle, could be used to feed the growing human population. After all, why should high-quality food be wasted on cattle so that a small minority of people can devour hamburgers whilst the majority face growing food insecurity?

The advantages of eating insects are so obvious that you might be wondering why our fridges are not full of insects already.

In fact, insects have been a part of the human diet for many centuries. In Ancient Rome, edible insects were considered a delicacy. The famous scholar, Pliny the Elder, described the aristocracy's love of "beetle larvae reared on flour and wine".

Nearly 2 billion people across 130 countries still include insects in their diets today. Chapulines, a species of grasshopper, are a popular snack across Mexico, particularly in the Oaxaca region. These are harvested in the rainy season and cooked with lime juice and chilies. Across much of southern Africa, the mopane caterpillar is widely consumed and generates up to $85 million a year in trade in South Africa alone.

In Europe and the United States, however, insects are rarely thought of as food. In the westernised mind, an insect is a disease-carrying, crop-destroying pest. It is most certainly not dinner.

As the climate emergency escalates, we must become more flexible as a society. Diets in the West have already changed drastically in recent years due to the growing popularity of veganism, with supermarkets

Written by Clara Wilkinson Art by Olivia Bowen

and businesses designing new products to match it. Nearly 600 new vegan products were released in UK supermarkets in January 2021 alone. This makes veganism more accessible and lures even more consumers towards plant-based diets.

Similar projects to make insects palatable to Western tastes are already underway. Horizon Insects is a small farm in West London that offers a range of products, from grow-your-own mealworm kits to cookery courses preparing cricket bruschetta. These courses are sold out for the rest of 2021. Another example is Eat Grub, a UK-based company whose mission is "to convince the West to embrace insects." Their bright-coloured packaging and mouth-watering recipe collection help to make edible insects appetizing and accessible.

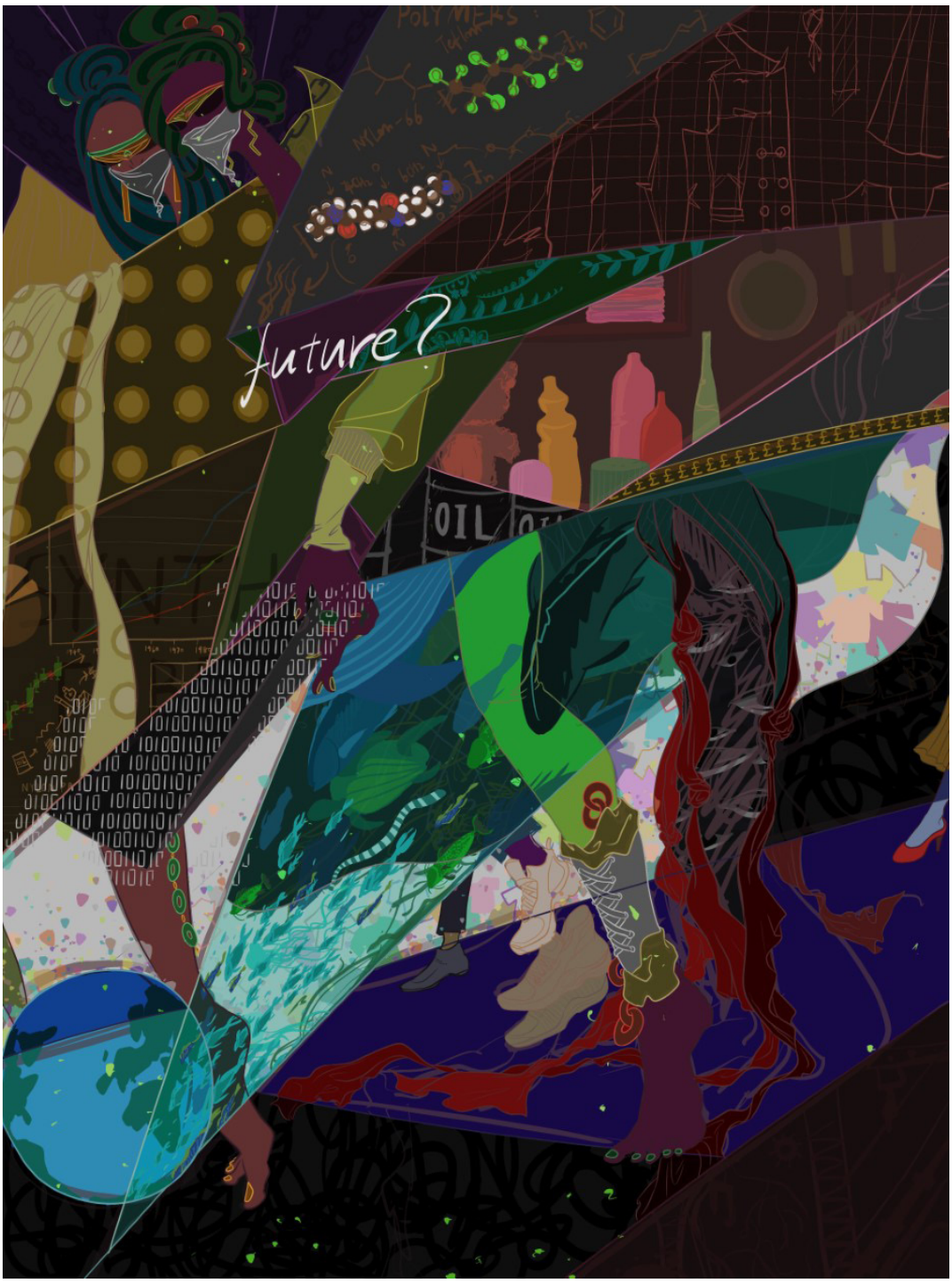
On a recent visit to the Mexican restaurant Wahaca, I was offered their special starter of cricket salsa. This being my first experience of entomophagy, **I was understandably nervous while taking the first bite, with images of crickets leaping around my mind.** I was pleasantly surprised by the flavour and the plate was soon scraped clean. I look forward to a time when seeing insects on the menu is not so unusual.

This process is not going to happen overnight; we are not going to wake up tomorrow to see Costa serving chocolate mealworm cupcakes. Yet there is little doubt that bringing insects into our diets is healthy and sustainable. So, the next time you bake brownies, why not use cricket flour? Or when you head to the gym, why not enjoy an insect-based protein shake? The ways to incorporate insects into our diet are endless. If we are all prepared to make these small changes, insects have a chance to be the future of food.

The short and storied life of synthetic textiles:

How plastics have forever changed our economies and oceans

Written by Miranda Hitchens
Art by Qiwen Liu



In October of 1938, DuPont Chemical unveiled its newest invention: Nylon. A product of early man-made materials devised throughout the late 19th century, the 11-year project to perfect a synthetic silk came to commercial fruition with the nylon stocking, hitting the US consumer market in 1940. They were a near-immediate success and saw a surge in demand among women due to the rapid decline of Japanese silk imports as the Second World War progressed. However, their production all but ceased following the United States' official entry into the war effort.

Despite this commercial void, nylon production skyrocketed, as infrastructure was swiftly developed to mass-produce the fibre for parachutes, tow ropes, and other military supplies. Synthetic alternatives to other materials, such as rubber and plastic, also became highly sought-after, replacing more expensive resources used in everything from weapons to food packaging. Teflon, now used to make non-stick pans, originally lined the valves and seals of the atomic bomb. As a result, plastic production nearly quadrupled during the war, inciting the advent of its mass production that has continued growing in scale to this day.

Postwar, plastic began to dominate the fashion industry. Synthetic materials are not only cheaper, but more versatile in their properties than traditional fabrics. This enabled retailers to scale up production exponentially and sell clothes at lower price points, creating the economic prerequisites for what is now known as the "fast fashion" industry. Nowadays, around 60% of textiles used in clothing are composed of synthetic materials. By condensing trend cycles and decreasing the durability of accessible clothing, the rising prevalence of synthetic alternatives has disincentivised the reuse and retention of clothes. Unsurprisingly, this generates vast amounts of waste, with an average of 37kg of clothing thrown away per person each year in the United States.

Despite how ubiquitous plastics are in the modern world, only 4% of all petroleum extracted annually is used to produce these plastics–and of that, only 14.5% is used in textiles. In fact, outside of the more apparent environmental damage brought on by petrochemical extraction, synthetic fibres present a whole new method of destruction.

When synthetic fibres are machine washed, thousands of microscopic to centimeter-length microplastics break off from the fibres, evading filtration and eventually draining into rivers and oceans with treated wastewater. Although it is near impossible to quantify the pollution entering marine ecosystems, recent data conservatively estimates around 35,500 tonnes of microplastics are floating in the world's oceans, originating from textiles as well as other plastic waste discarded into the sea.

The Great Pacific Garbage Patch, an estimated 1.6 million square kilometre mass of floating plastic in the North Pacific, consists mainly of microplastics and commercial fishing nets accumulating on and below the water's surface. It acts as a thick translucent layer, almost invisible at first, but blocking sunlight from reaching the plankton and algae that depend on it to photosynthesise. Microplastics ingested by these organisms pass along food chains, and thus are found in the stomachs of marine life around the globe. They have reached every corner of the natural world, from Arctic ice to the Mariana Trench, and account for 85% of man-made material found along beaches. Even perched at the top of the food chain, a human ingests an average of 5,800 synthetic fibres a year. Recent studies have even found microplastics in human placentas and lung tissue, though it isn't yet known what specific health effects this may incur.

What's particularly ominous about the ever-growing presence of microplastics is their near-invisibility to the naked eye, and in turn, the public's image of plastic pollution. The idea that washing your clothes releases plastic waste, or that a country-sized aggregation of it would barely be visible from the ocean's surface, is difficult to comprehend, even to the environmentally conscious. Meanwhile, there is no large-scale, efficient way to remove or mitigate microplastic pollution, so it will continue inundating our ecosystems, all while there is no existing method with which to understand the long term ramifications of this contamination.

This story is one with no end in sight, as plastics have become indispensable to the fashion industry and inescapable in the environment. Industry standards have become so interwoven with plastic production that decoupling them would require complete restructuring of manufacturing processes globally. In parallel, societal norms have been inexorably grafted onto consumerist ideals. Cheap clothes are a necessity, both to sustain the way our economy is organised and the lives we expect to live. Nylon put silk in the hands of every woman, and the synthetic materials that followed gave the expectation of an endless choice of products to every customer.

In order to confront the growing threat of unchecked plastic pollution, how much of our definition of modern life must we uproot? Like every aspect of this story, there aren't any concrete answers, but we may come to find ourselves unwittingly fulfilling the ever-prescient myth of Hubris–we thought it possible and necessary to mold ourselves a new world of infinite possibilities to consume, only to find it hurtling towards potential catastrophe.

UNA MANZANA CADA DÍA, DE MÉDICO TE AHORRARÍA: CUBA'S MEDICAL DIPLOMACY AND ITS GLOBAL IMPLICATIONS

International medical cooperation has far more potential than we give it credit for

Written by Maria Stoica
Art by Patrick Marenda

Potentially one of the largest medical schools in the world, the Latin American School of Medicine (ELAM), calls Havana, Cuba home. The achievement may come as a surprise given the small size of the island; however, its promotion of healthcare has large implications on the global stage.

The origins of Cuba's medical diplomacy—the intersection between health policy and foreign policy—are rooted in the nation's revolutionary project dating back to 1959. Above all else, international solidarity supposedly underpins Cuba's medical diplomacy. A solidarity so intimately linked to the saving of lives is difficult to dismiss, especially when Cuba's global medical efforts have achieved great successes. One of Cuba's first formal deployments of medical diplomacy was in response to Hurricane Georges and Mitch in 1998. The nation sent 107 healthcare personnel to Honduras where they visited 1,300 remote villages which otherwise had no access to health services.

ELAM's opening in 1999 was no coincidence either—the medical school was built upon the premise that it would ultimately streamline Cuba's ability to export medical care to rural areas both at home and across the globe. To date, some 29,000 students from over 100 nations have received their medicine diplomas from ELAM, signifying the extent to which Cuba has institutionalised its medical diplomacy. Additionally, such a solid foundation for the education and training of future medical practitioners has translated to Cuba having the highest number of physicians per capita in the world. This foundation has also served as a springboard to medical work on the international scene.

The success of Cuba's medical diplomacy has been two-fold: firstly, the state has built a reputation for successfully responding to global calls for aid, and secondly, its international efforts can address problems of healthcare worker shortages. In April 2020, Cuba sent 200 doctors to South Africa to help with COVID-19 relief efforts. These doctors, along with an additional 1,200 healthcare workers living and working in 22 countries, are part of Cuba's expansive international medical coalition fighting COVID-19. Cuba's medical diplomacy is not without flaws, however. Its global success has overshadowed a system predicated on poor working conditions for doctors, with some having testified that they are prevented from publicly speaking up. If Cuba's medical diplomacy efforts are to be replicated at an even greater scale, the system must be restructured to the benefit of doctors. International solidarity cannot come at the cost of exploiting healthcare professionals.

Additionally, Cuba's ability to export medical care through the deployment of health workers tackles an intensifying issue on the global health agenda. The World Health Organization (WHO) estimates that 18 million more health workers are needed by 2030, most notably in low and lower-middle income countries. Cuba's past history of effective medical diplomacy and its ongoing efforts during COVID-19 offers a compelling reason for increased international medical cooperation. Although the scale of the health worker shortage is far greater than what the Cuban revolutionary leader Fidel Castro could have envisioned, his expansion of Cuba's medical diplomacy efforts was motivated by enabling low and lower-middle income countries to have access to healthcare. The success of collaborative initiatives

such as Operation Miracle, launched by Cuba and Venezuela in 2004, demonstrates that international cooperation is completely possible. Tens of thousands of Latin Americans have had their eyesight restored and repaired as a result of this programme.

Another positive global implication of Cuba's medical diplomacy is that countries have the potential to send bright students for training at ELAM on Cuban-sponsored scholarships and bursaries. This effectively pre-empts a situation NIAID Director Dr Fauci has warned against: resource-poor countries completely relying on richer countries for healthcare instead of having a sustainable health infrastructure of their own. The process of foreign students receiving their medical education at ELAM and returning to their home countries precisely counteracts this dilemma, leading to the development of a durable health infrastructure. Therefore, a project that started in Cuba largely as a political tool can now be leveraged to lessen the burden of a shortfall of 18 million health workers by 2030. In fact, the WHO sees international cooperation in foreign training as a powerful solution to this issue.

Cuba's ability to export medical care at the scale and the speed that it has presumes a favorable prognosis for global medical diplomacy. Collaborating with other countries and providing accessible medical training to foreign students are just a few of the ways countries can begin to build a global network of healthcare. With healthcare systems around the world predicted to face increasing strain, we need an international network now, more than ever. And if there is one country that is a testament to the potential that expanded international medical cooperation has, it is Cuba.

DOES SMOKING REALLY CAUSE CANCER?

This question strikes at the heart of the tenuous link between statistics and causality in science

Written by Dan Jacobson Art by Zach Ng

How would you prove that smoking causes cancer?

You could say that heavy smokers are 25 times more likely to get lung cancer than non-smokers, but you'd be told that 30% of lung cancer patients are non-smokers. You could mention that lung cancer rates quadrupling in the early 20th century coincided with the explosion of the tobacco industry, but then be told that it also clashed with more pollution, road tarring, and two World Wars. You could run a randomised controlled trial, but asking thousands of healthy volunteers to smoke cigarettes for thirty years isn't exactly ethically, or indeed logistically, viable.

Proving that smoking causes cancer not only requires navigating the lack of one-to-one relationship between the two, but also convincing both a $1 trillion industry, and one billion smokers worldwide. That tobacco causes lung cancer has since been proven, but confirming this took decades.

In her book p53: The Gene That Cracked The Cancer Code, Sue Armstrong attributes confirming this link to biochemists providing a mechanism by which it occurs. In the 1990's, Gerd Pfeifer and Mikhail Denissenko demonstrated that BPDE, the transformed product of a substance found in tar called benzo(a) pyrene, caused alterations in the p53 gene which were only observed in smokers, demonstrating that smoking causes cancerous mutations.

However, in The Book of Why, the computer scientist and philosopher Judea Pearl suggests that this causal association had been demonstrated decades earlier, by the statistician Jerome Cornfield. Until the 1950s cynics of the smoking-cancer hypothesis, most notably the UCL-based professor Ronald Fisher, attributed the link to unmeasured 'confounders' - factors which separately influence both smoking and cancer. Incidentally, Fisher also smoked like a chimney.

Cornfield's genius was to disprove Fisher's hypothesis from a mathematical perspective. Consider for a moment, a hypothetical confounder, such as a 'smoking gene'. For this gene to disprove the smoking-cancer hypothesis, it must be at least as strongly associated with both cancer and smoking individually as they are with each other. Therefore, due to the strength of correlation between smoking and cancer, the possibility of a confounder becomes highly unlikely.

The issue is that common statistical techniques assess correlation, not causation, making raw numbers insufficient for proving and analysing these relationships. This is intriguing, as modern statistics arose from fundamentally causal questions being asked by the UCL-affiliated statisticians Francis Galton and Karl Pearson, even if these 'questions' amounted solely to eugenics and scientific racism.

We know that correlation does not imply causation, but the implications of this adage extend beyond how we interpret results. Instead, it should inform the way questions are asked by researchers. Consequently, this should ensure that research priorities are grounded less in the final results, and more in the contexts which provide their significance.

“SPIDER-MAN” and “PAC-MAN” immune cells fight against invasive bacteria

Written by Sara Maria Majernikova
Art by Eshka Chuck

Humans may never notice this superhero germ-fighting duo, yet they work wonders in the immune system. Spider-Man-like immune cells sling webs to seize invasive bacteria and keep supervillains restrained until Pac-Man-like cells come to gobble them up.

A primary role of immune cells and proteins is to defend living organisms from invasions. Firstly, there are neutrophils, which make up more than half of our white blood cells. These cells are often the first to arrive at the infection scene and attack invaders by gobbling up the intruders or 'inviting' other immune cells to fight. However, occasionally neutrophils pull a Spider-Man maneuver, meaning they shoot sticky DNA webs and toxic proteins which ensnare pathogens and prevent them from spreading. Because neutrophils die when engaging in this process, researchers consider the webs a cellular version of suicide bombing. On the other hand, macrophages (white blood cells' "munching" bacteria) are known for their ability to gobble up cellular debris and pathogens to thwart infection, being the "Pac-Man" of the immune system and forming the body's first line of defence against invasion. They indiscriminately engulf and eat almost anything deemed a dangerous trespasser, whether it's a bacterium or cellular debris from deceased tissue. In these cells' ultimate superhero crossover, Spider-Man-like immune cells sling webs to capture and kill invasive bacteria in order to keep those supervillains restrained until Pac-Man-like cells come to gobble them up, according to new research by Monteith et al.

In 2018, Zychlinsky and colleagues discovered neutrophil extracellular traps (NETs), which carry chemical red flags prompting macrophages to spark inflammation at an infection site, The Scientist reports. Conversely, Monteith et al. suggests that the two cell types also team up to launch coordinated attacks against invasive microbes. Skaar claims neutrophils cast their NETs to immobilize the "bad guys." Then, macrophages swoop in and swallow the bugs whole, not unlike how Pac-Man devours ghosts. "While gobbling down its catch, the macrophage is actually taking this giant bite out of the NET," Skaar informs. The antimicrobial proteins from the NET then mix with antimicrobial proteins already in the macrophage's stomach, thus together, the two cell types degrade bacteria more effectively than either cell could alone. Due to low levels of antimicrobial proteins, Monteith's research team explored how neutrophils come into contact with staph bacteria and their mitochondria. They discovered that this contact generates harmful free radicals in the cell, which drives the cell to self-destruct and release its NETs more quickly than it would otherwise. This speedy NET casting boosts the ability of neutrophils and macrophages to clear staph from the body, as a germ-fighting duo.

In their recent mouse studies, researchers led by Monteith found that some neutrophils release their NETs quicker than others when chasing down staph bacteria. Specifically, a protein (called S100A9) dictates how quickly neutrophils sling their webs. Mice with low levels of this protein seem to survive better against methicillin-resistant S. aureus (MRSA), the team confirmed in a 2017 study published in the journal Cell Host & Microbe. The same held true when the team pitted the immune cells against Streptococcus pneumoniae and Pseudomonas aeruginosa, both of which can infect many organs in the body, including the lungs and brain. The research by Monteith et al. was conducted in mice and mouse cells, but it still may help to explain how neutrophils fight off infections in humans and why they sometimes fail. It turns out that these spidery cells may not work well in people with autoimmune conditions, such as lupus, making those individuals more susceptible to staph infections. When a staph infection first begins to take hold in the body, the 'friendly neighbourhood neutrophils swoop in as first responders to help fight the Staphylococcus aureus bacteria, as senior author Skaar revealed to Live Science. These neutrophils have a secret weapon: they can self-destruct and eject a sticky web from their ruptured membranes. This web, named a NET, contains neutrophil DNA studded with proteins degrading bacteria.

According to Skaar, having research based only on mice is a major limitation. Additionally, people suffering from certain autoimmune conditions, such as lupus and rheumatoid arthritis, produce more of the S100A9 protein than people without these conditions. Thus, in theory, those neutrophils may release their NETs slower than average, Skaar informs. This could explain why these individuals are more susceptible to illness than the general population. However, researchers need to confirm their theory in humans. On top of exploring this potential link to autoimmune diseases, the team plans to study exactly why S100A9 influences the speed at which neutrophils deploy their sticky NETs. Scientists could then boost the web-slinging abilities of neutrophils, to supercharge their infection-fighting abilities.

Could an aspirin a day keep the doctor away?

We have all heard the famous saying that “an apple a day keeps the doctor away”, however, is this to be replaced with “an aspirin a day keeps the doctor away”?

Written by Anna Wiecek
Art by Eshka Chuck

Despite its humble beginnings as an ancient herbal pain medication, the development of aspirin showcases one of the first and biggest success stories in the pharmaceutical industry, which transformed our approach to modern medicine. An expanding list of benefits of this drug has previously triggered its repurposing as a preventative treatment for heart attacks and strokes. Currently, aspirin could once again be reincarnated, this time as a cancer treatment.

The story of how the modest aspirin pill ended up on supermarket shelves across the world spans centuries. Dating back to 4000 BCE, the practice of using herbal extracts from myrtle, meadowsweet, as well as willow tree bark, to treat pain, inflammation, and fever was common across many ancient civilizations. Unbeknown to the people at the time, salicin, the raw ingredient of aspirin, present in these herbal concoctions, infused the medical traditions around the world.

By the 18th century, the first scientific study of the benefits of willow bark was performed by an English clergyman called Edward Stone. The positive outcome of this study led to a cascade of scientific achievements including the modification of salicin to acetylsalicylic acid, now known as aspirin, by Charles Gerhardt and by Bayer Industries in 1899. In a testament to the age of aspirin, Bayer Industries, now a multinational pharmaceutical company, still functioned as a dye factory at the time. By reducing stomach irritation, a major side-effect of salicin, this modification allowed aspirin to become the first mass-marketed pain medication available over-the-counter. It instantly became a household name. Not only did it change people's relationship with pain, but it also changed our approach to drug development. It was the first time we could manipulate the structure and properties of a compound for medical purposes.

However, despite the initial success, aspirin has faced many ups and downs. Even before the discovery of its mechanism of action, the popularity of aspirin began to decline after the development of newer painkillers with decreased side effects, such as paracetamol. Ironically, it was the off-target action of aspirin as an anti-clotting agent that brought about its resurgence. In line with current clinical guidelines, prescribed at low doses to individuals with cardiovascular disease, aspirin graduated from its job as a mere painkiller to life saving medicine. By stopping platelet cells from clumping together inside blood vessels, aspirin now prevents blood clots from forming in at-risk individuals.

Today, once again, aspirin has been thrown back into the limelight, this time as a potential cancer treatment. While it is already prescribed to patients at high risk of developing colon cancer, there are increasing links between aspirin consumption and reduced risk of other malignancies such as breast and prostate cancer. This seems to boil down to the anti-inflammatory action of aspirin. Inflammation does play an important part in the immune response during infection and injury. However, recent research has highlighted that various lifestyle factors such as diet, stress, disturbed sleep, and physical inactivity can contribute to a state of chronic inflammation in our bodies which encourages the development of cancer and other inflammatory diseases such as cardiovascular disease and diabetes. Therefore, it is easy to speculate that aspirin could have wider applications than currently appreciated.

So, after reading this should you rush to the local shop to get some aspirin?

Probably not, unless your doctor told you to do so. Throughout its history, aspirin has become a lifesaving drug that has informed us of the approaches we can take to treat major health problems. However, like any drug, aspirin has adverse side effects. Therefore, identifying which individuals are likely to benefit and with which doses is key. Time will also tell if aspirin will be replaced by newer and improved anti-clotting and anti-inflammatory medications. Regarding cancer treatment, the world's largest clinical trial looking at whether aspirin can prevent cancer recurrence is underway until 2023, so the jury is out until then. Regardless, miracle drug or not, it's important to acknowledge the progress in medicine made since its development.

MALARIA: IS THE END IN SIGHT?

Written by Priya Ord
Art by Lia Bote

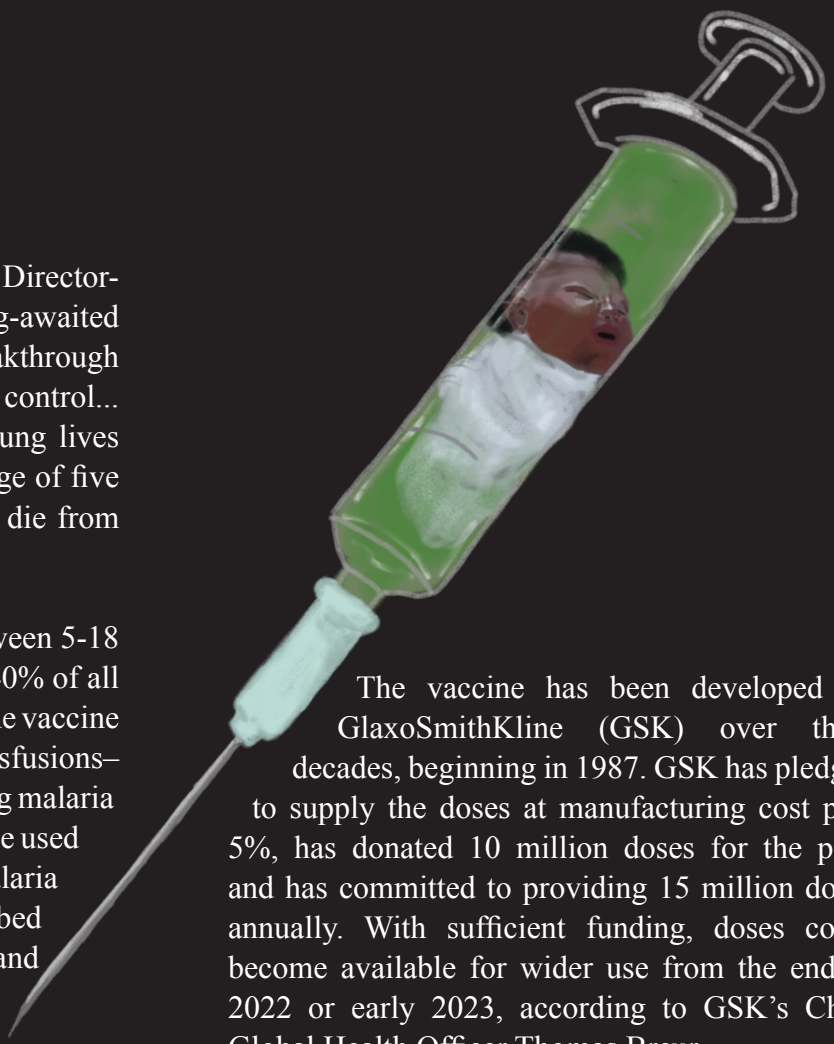
The world's first malaria vaccine has been approved for use in sub-Saharan Africa.

In a historic breakthrough, the World Health Organization (WHO) has approved the world's first malaria vaccine (RTS,S or Mosquirix) for use in children in sub-Saharan Africa and other regions with moderate to high P. falciparum malaria transmission. In 2019, nearly half of the world's population was at risk of contracting malaria, with some groups facing a much higher risk of developing severe symptoms. These groups include children under five years of age, pregnant women, patients with HIV/AIDS, and people with low immunity who move to areas with high malaria transmission.

The vaccine approval follows an ongoing pilot implementation of the RTS,S vaccine in Africa. Launched in April 2019 in Malawi, Ghana and Kenya, the project has seen more than 800,000 children receiving at least one dose. Financing for the WHO Malaria Vaccine Implementation Programme (MVIP) has come about through the collaboration of Gavi, the Vaccine Alliance; the Global Fund to Fight AIDS, Tuberculosis and Malaria; and Unitaid.

Dr. Tedros Adhanom Ghebreyesus, Director-General of the WHO, said "The long-awaited malaria vaccine for children is a breakthrough for science, child health and malaria control... [It] could save tens of thousands of young lives each year." African children under the age of five are most at risk and more than 260,000 die from malaria annually.

RTS,S, which is given in four doses between 5-18 months of age, prevents approximately 40% of all malaria cases and 30% of severe cases. The vaccine also reduces the need for blood transfusions– which are required to treat life-threatening malaria anaemia–by approximately 30%. It will be used alongside other measures to control malaria transmission such as insecticide-treated bed nets, as well as more public education and training of health workers.



Malaria parasites infect female Anopheles mosquitoes and are transmitted via their bite. When infected mosquitoes bite humans, they inject their saliva into the bloodstream which inhibits blood coagulation and allows the parasite to enter the body. The parasite then travels via the bloodstream to the liver, where it reproduces asexually and the infection develops. Then, the parasites re-enter the bloodstream and invade healthy red blood cells, causing them to burst. Malaria symptoms include a high temperature, feeling hot and shivery, headaches, vomiting, muscle pains, diarrhoea and death in severe cases.

This vaccine contains part of a parasite protein bound to part of another protein from the hepatitis B virus, which helps immune cells recognise the parasite protein and stop the parasite from maturing and multiplying in the liver. Because of this, RTS,S also helps protect against infection of the liver with the hepatitis B virus, but should not be used only for this purpose.

The vaccine has been developed by GlaxoSmithKline (GSK) over three decades, beginning in 1987. GSK has pledged to supply the doses at manufacturing cost plus 5%, has donated 10 million doses for the pilot and has committed to providing 15 million doses annually. With sufficient funding, doses could become available for wider use from the end of 2022 or early 2023, according to GSK's Chief Global Health Officer Thomas Breur.

In January 2021, PATH, GSK, and Bharat Biotech (BBIL) announced that BBIL will take over the production of RTS,S, and will become the only company to supply the vaccine by 2029. This product transfer agreement will help to ensure the long-term, widespread supply of the vaccine.

The next steps for this vaccine will include the acquisition of further funding in order to enable a broader rollout. Individual countries also have to decide whether to use the vaccine alongside other malaria control measures. Vaccination is one of humanity's main weapons against infectious diseases and recent successes pave the way for the future of the fight against malaria.

HPV AND CERVICAL CANCER: A (VERY) BRIEF REFLECTION ON THE STRIDES IN PREVENTION

Did you say cancer? Eliminated?

WRITTEN BY JASMINE LAI ART BY ZACH NG

Personified as 'the emperor of all maladies', cancer is a process of mutation and evolution, making it the disease that is most intimate to human history and life, unrivalled by any other. With estimates that one out of every two people will receive a cancer diagnosis in their lifetime, the possibility of eliminating a type of cancer sounds almost unthinkable.

ALMOST.

Just a year ago, the World Health Organization (WHO) launched a global strategy to accelerate the elimination of cervical cancer as a public health problem by 2030. This ambitious target hopes to achieve '90% of girls fully vaccinated by 15 years of age; 70% of women screened using a high-performance test by age 35, and again by age 45; and 90% of women identified with preinvasive and invasive cervical cancer properly managed'.

Whereas many common types of cancer are closely tied to our recent urbanised lifestyle choices, human papillomaviruses (HPV) have been in existence for millions of years and are responsible for almost all cases of cervical cancer. Yet not many other cancer interventions have made an impact as dramatic as the cervical cancer intervention as it takes a life course approach. Primary prevention begins in young girls (and gradually in boys too) through education and the three-dose HPV vaccination. Secondary prevention of cervical screening is through Pap smears, HPV testing or Pap/HPV cotesting, and tertiary treatment sees the typical range of surgery, chemotherapy, radiotherapy and palliative care.

BUT HOW DID WE GET HERE?

In 1941, Georgios Papanikolaou published his work on the Pap smear 10 years after recognising its role in detecting cervical carcinogenesis. The Pap smear marked the first form of widespread cancer screening, but was only the second runner-up for a Nobel Prize. These cervical smears allowed for the identification of koilocytes and gradually led to identifying the cytopathic effect of an HPV infection and linking it to a causal agent. However, as this was against the central dogma of the time, after exhausting resources and finding little evidence, the scientific community had shifted its attention away from viruses and to environmental and genetic agents.

While some researchers focused on the herpes simplex virus, Harald zur Hausen pursued HPV based on anecdotes of genital warts becoming malignant carcinomas, despite initial scepticism and disregard. Hausen successfully demonstrated the presence of HPV DNA in cervical cancer cells in the early 1980s, winning him the 2008 Nobel Prize in Physiology or Medicine. Fast forward to 2006, Gardasil, the first HPV vaccine was approved, providing the tool we know to be most effective in eliminating disease. By covering the two strains that cause 70% of cervical cancer cases and two additional strains that cause 90% of genital warts, not only was direct prevention achieved, but herd immunity effects have also been observed through vaccination of both males and females.

Yet the history of HPV and cervical cancer is also a history of social, ethical and gender issues. Hausen found the cancerous HPV-18 strain from the immortalised HeLa cell line that was taken from Henrietta Lacks without consent. The vaginal speculum currently used in pelvic exams and pap smears was initially revived by male doctors to check prostitutes for venereal disease, and was not permitted for midwives to use despite their being responsible for medical intervention in women's reproductive problems. And prevention itself has impediments. The stigma of HPV being a sexually transmitted

disease, the taboo topic of the vagina and common harmless HPV infections are just a few of a whole host of factors that inflict psychological impacts and uncertainty on individuals on top of a potential cancer diagnosis.

In just eight years since implementing the vaccine, Scotland has reached near elimination of cervical cancer. But no party can be left behind as the burden of disease now resides in low- to middle-income countries. Global access to infrastructure, health education, vaccination, screening and primary healthcare have the potential to either alleviate or exacerbate inequalities. Interestingly, the measures put in place for COVID-19 vaccinations may provide an opportunity to improve HPV vaccination access.

For now, let's take a moment to appreciate how far we have come since the beginning of cancer treatment and prevention: in scientific advancement, medical technology, united intervention strategies and public understanding.

AND GET VACCINATED!

How Can We Resolve the Inequities in Medical Nanotechnology?

Medical nanotechnology is a promising area of research, but lack of equity poses problems

Written by Similoluwa Ayeniyegbe Art by Vedika Rajavat

Most of us have heard of nanotechnology - the science and technology of materials smaller than 100 nanometres. Think around 1,000 times smaller than the thickness of a human hair. You may be surprised to hear that the Pfizer/BioNTech and Moderna COVID-19 vaccines both use nanoparticles to cage, stabilise and transport mRNA molecules.

But what is the problem?

The COVID-19 nanovaccines must be stored at temperatures as low as -80 °C, which is problematic if developing countries lack operational cold chains. Such barriers could include minimally trained personnel or the lack of clean water supplies. In general, when medical nanotechnologies are developed without considering infrastructural barriers in lower-middle income countries, their use is limited nanotechnologies are developed without considering infrastructural barriers in lower-middle income countries, their use is limited.

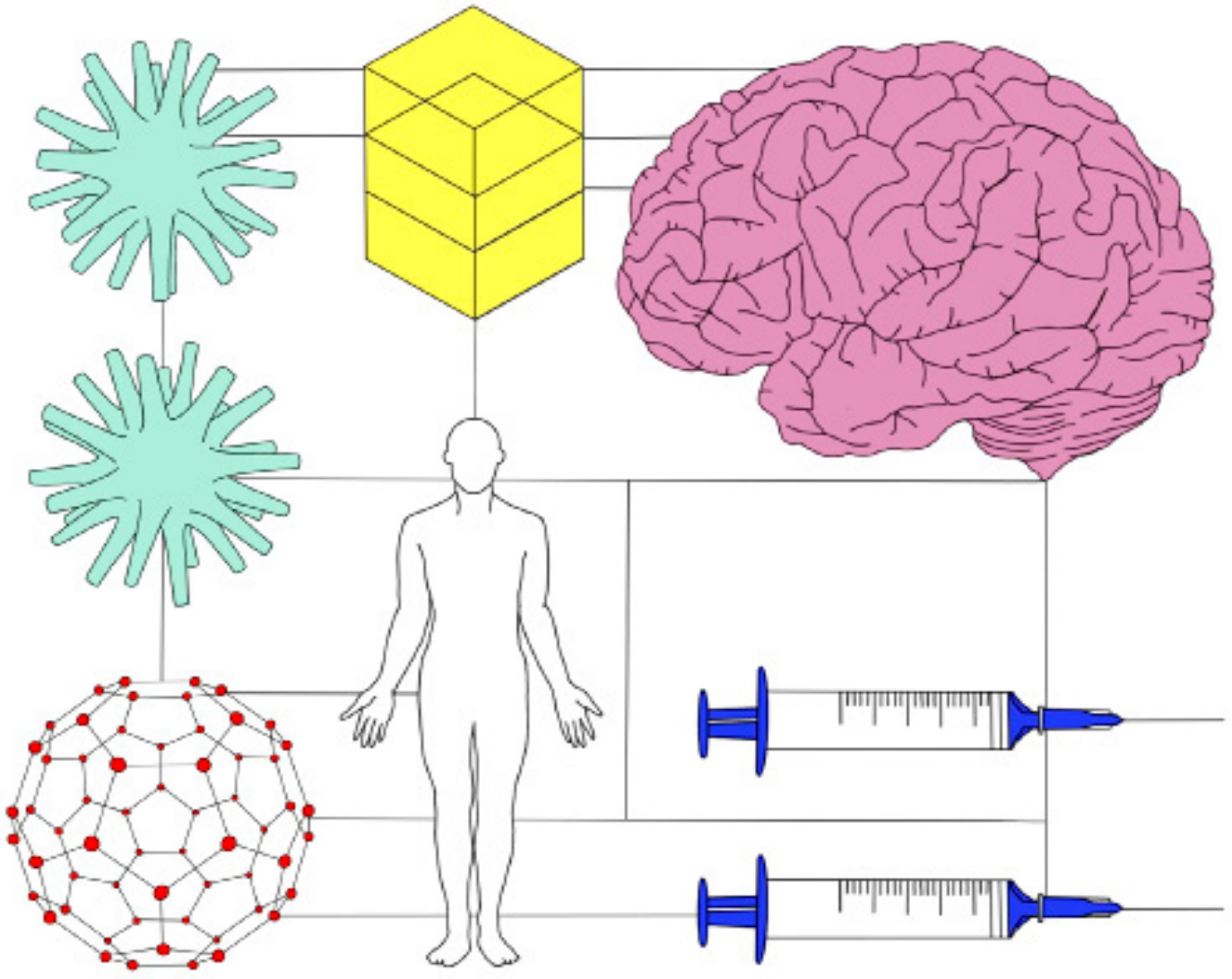
The use of nanomaterials and nanoproducts in lower-middle-income countries is not just limited by infrastructural barriers. Some may not desire to use unfamiliar novel medical nanotechnologies if they clash with local beliefs. For example, some religious concerns are that medical nanotechnologies may modify the body until it's no longer 'natural.' Therefore, it is important to bear in mind the social and cultural contexts in which such nanotechnologies will be used.

In order to overcome the infrastructural barriers, local nanotechnology industry sectors need to be strengthened by establishing manufacturing operations in these countries. These medical nanotechnologies also needed to be tested for efficacy in the local areas and their cultural accessibility should be assessed. As a result, medical nanotechnology will be able to reach its full potential in these countries.

Of course, cultural beliefs won't change overnight, but educating local communities about the benefits of nanotechnology would be impactful. Education and training needs to be available for nanotechnologists, healthcare professionals and government decision-makers. Culturally sensitive public engagement strategies could be developed to encourage local communities to have open-minded discussions about the potential benefits of medical nanotechnology. However, these conversations should also acknowledge the risks and legitimate concerns about this technology. If medical nanotechnologies were developed considering their target context, this would resolve some of the equity issues, but could reduce their versatility.

Besides vaccines, there is ongoing research about using nanoparticles for cancer diagnosis and in antiviral treatments. Clearly, nanotechnology has the potential to revolutionise healthcare globally. Nonetheless, if the majority of medical nanotechnologies focus on diseases that are common in wealthier countries, poorer countries would be severely disadvantaged.

Although the use of nanotechnology to combat disease sounds tempting, it poses a threat to already underprivileged communities. Thus the question remains: **is nanotechnology worth the risk of worsening differences in health outcomes between rich and poor countries?**



BRAIN IMPLANTS 2.0

From wireless charging to seizure forecasting, exciting advancements are taking brain implants to the next level

If your patient was presenting with depression, how would you attempt to treat it?

Cognitive behavioural therapy?

Antidepressants?

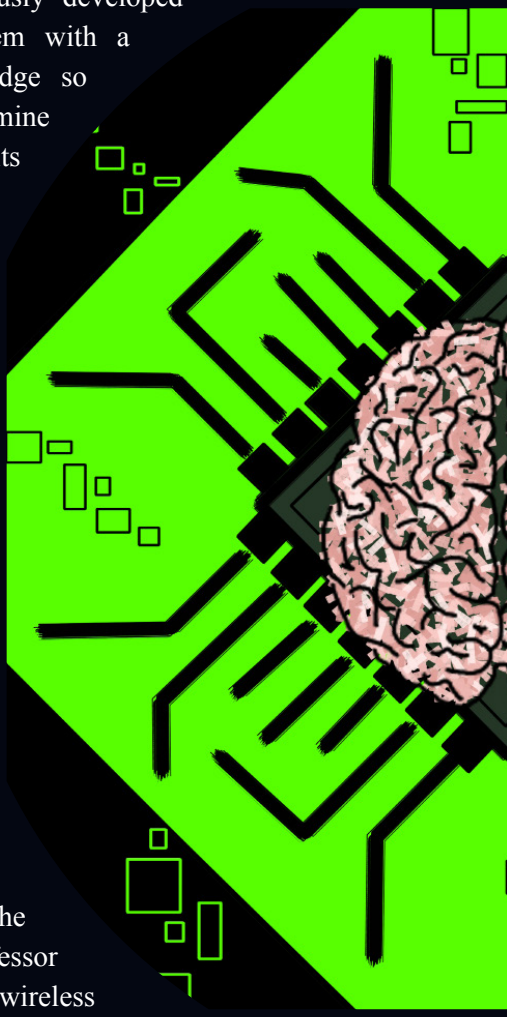
Or directly stimulating the ventral striatum with thin wire electrodes inserted into their brain?

Neural implants are devices placed in the body to interact with neurons, cells that transmit electrical impulses – they are often inserted through a process called deep brain stimulation (DBS). Recent advancements in brain implant technology allow conditions like major depressive disorder (MDD) to be treated without chemical or therapeutic intervention. Though DBS is still in its infancy, the procedure has been used widely for the past twenty years to treat epilepsy, Parkinson's disease, obsessive-compulsive disorder (OCD), and several other conditions.

In recent years, there have been several innovative advancements in brain implant technology. Researchers at UC San Francisco found a way to alleviate treatment-resistant MDD through a process called closed-loop neuromodulation, where the stimulation depends on electroencephalogram (EEG) changes, as opposed to open-loop neuromodulation, where intermittent or continuous electrical stimuli are applied. Other innovations include: the wireless recharging of neurostimulators; the prediction of seizures several days in advance; and the use of sugar to reduce the foreign body response.

BLUETOOTH BRAINS

Wireless implants eliminate the risks and inconveniences associated with traditional, tethered implants (such as stress and inflammation) and allow patients to lead more comfortable lives. However, there is a simple but major problem associated with wireless neural implants– the battery needs changing. Normally this requires regular, painful surgery but a team at the Korea Advanced Institute of Science and Technology (KAIST) have engineered an implant that can be recharged wirelessly from outside the body, allowing surgery to be avoided altogether. The researchers previously developed an optoelectronic system with a replaceable drug cartridge so researchers could examine the same brain circuits for months without additional drug delivery, all of which can be controlled on a smartphone app.

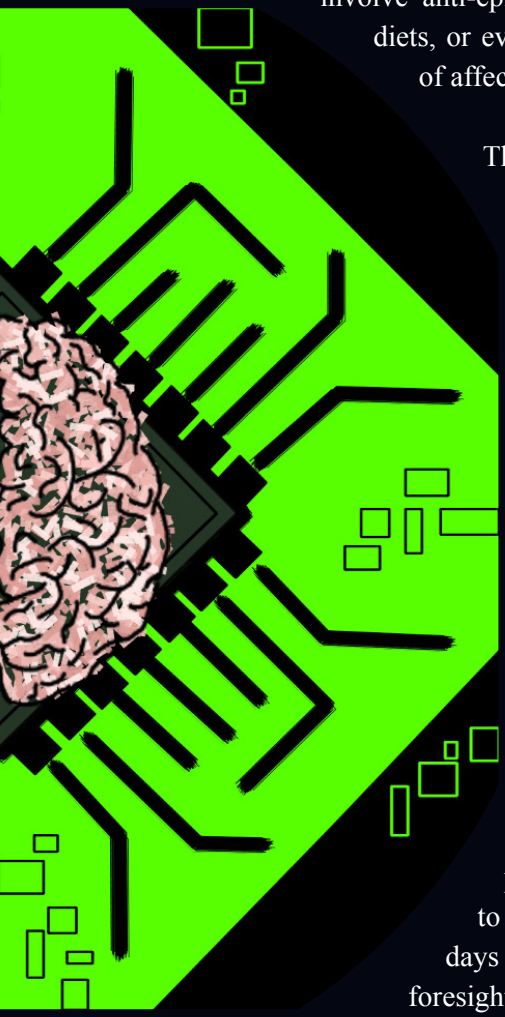


The KAIST team integrated a low-energy Bluetooth chip with a circuit consisting of a flexible coil antenna and a rechargeable lithium polymer (LiPo) battery. An alternating magnetic field generated by the system induces a current in the device, charging the battery. The lead, Professor Jeong added that this wireless recharging technology can be applied beyond neuroscience, and be used in "cardiac and gastric pacemakers to reduce the burden on patients for long-term use in the body."

TOMORROW'S FORECAST: LIGHT RAIN AND POSSIBLE SEIZURES

Epilepsy is a neurological condition characterised by, typically idiopathic, disturbances in electrical activity in the brain, called seizures, where a group of neurons begins firing abnormally triggering a depolarising shift. A third of epileptic people worldwide have to live with uncontrollable seizures because no current treatment

method works for them. Seizures can result in jerking movements ("fits"), muscle twitching, and a range of non-motor symptoms, such as gastrointestinal sensations, behaviour arrest, and waves of heat or cold. Treatment can involve anti-epileptic drugs, ketogenic diets, or even the surgical removal of affected brain areas.



The NeuroPace RNS system is a neural implant that can study seizure-related activity in the brain, terminate seizures by stimulating the appropriate neurons, and even predict seizures days in advance. Using statistical models, the UC San Francisco team was able to identify when patients were most likely to have a seizure, and in 40% of patients they were able to predict seizures several days in advance. This kind of foresight allows medication to be taken in smaller, targeted doses rather than be administered regularly, thereby lowering the risk of side effects. Although a prediction from the system does not mean that a seizure will definitely occur, these advancements will help reduce the uncertainty harboured by patients -- as lead researcher Vikram Rao put it: "currently, patients have absolutely no information about the future".

JUST ADD SUGAR

All implants suffer the flaw of being harder than the brain tissue itself therefore stress causes inflammation and scar tissue around it. This can reduce the effectiveness of the implant over time and cause harm to the patient. To mitigate the natural immune response to a foreign body, researchers have used silicone polymers to produce a 0.2mm-thick device as soft as the brain itself. Unfortunately, this was so fragile it was practically useless – until they added sugar. Molten sugar is easily moulded and when cooled, the mould contains high-fidelity (ability to accurately replicate a template) features. Why sugar? Sugar is non-toxic and naturally metabolises in the brain. Lead researcher Edward Zhang explained that the technology "could make brain implants a more viable medical treatment."

IT'S A NO-BRAINER

These advancements offer an exciting opportunity to expand the role of neurotechnology in healthcare, with modern innovations improving the design, functionality, and efficiency of implants. The list of people who could be helped by investing in and expanding research is endless, ranging from the epileptic to the paralysed whose motor functions can be simulated through the brain-computer interface. For the millions suffering from neurological conditions around the world, the future is getting a little brighter thanks to the incredible innovations in neural implant technology.

Written by Omar Khan
Art by Patrick Marenda

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